Agricultural wastes as a supplementary source of energy: an economic assessment of a briquette making facility

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ABSTRACT

For commercialization of crop based biomass briquetting technology and alternate source of energy model, is essential to know whether the technology is economically viable or not. In view of this, an attempt was made to analyze the economics of the biomass briquettes prepared by utilizing unused agricultural byproducts and other selected biomass produced from different crop residues. Biomass briquetting is one among the processes of converting low bulk density biomass into high density and energy concentrated fuel referred as briquette and has scope to use as fuel energy for food preparation by the rural households. India continued to roll its economy with agriculture whose energy requirement is increasing day by day with the progress made in agricultural sector. Under the existing situation, day to day's demand for fuel energy for food preparation at rural households observed to be very high and women folk struggle hard to gather fuel for food preparation. On the other hand, in India plenty of biomass is available due to vast agricultural based crop production systems. The per annum current availability of biomass in India is estimated at 1,249 million tons. With this advantage, to minimize the drudgery of rural women folk and to fulfill rural house hold demand for fuel energy required for food preparation, could only be addressed by the means production of biomass briquettes which provides cost effective and good fuel energy source for rural households for cooking food every day. The economics of biomass briquettes production indicated per month average net return of INR80,000 to the briquette machine owner. The project appraisal with other financial indicators for biomass briquettes production had indicated desired, the Net Present Value, Internal Rate of Return, Benefit-Cost Ratio and Payback Period were observed to be INR3931, 245, >30 per cent, 2.21 and 3.00 years respectively.

Key words: Economics, NPV, IRR, BC ratio, PBP.

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INTRODUCTION

Energy plays a critical role in the development process of a country. Further, the economic prosperity and quality of life of a country are closely linked to the level of its per capita energy consumption (Singh and Sooch, 2004). It was also suggested the provision of reliable, secure and affordable energy services is a key factor in providing basic human needs that not only improve the quality of life but ensure sustainable development (Amigun *et al.,* 2011). Access to energy or the lack of it affects all aspects of development, including livelihoods, access to water, agricultural productivity, health, population levels, education and gender-related issues (Amigun *et al.,* 2011).

In developing countries, a large portion of households rely wood is the most common example, but the use of animal dung and crop residues is also widespread. Approximately 60% of the world's total wood removals from forests and outside forests are used for energy purposes (IEA, 2006). While, the developed countries use only 30% of wood for energy, the developing countries use 80% for the same purpose (IEA, 2006). The overdependence on fuel wood and other forms of biomass as the primary source of energy has adverse effects on forest resources and on people's health as burning biomass causes indoor air pollution. On the realization that deforestation and fuel wood shortages are likely to become pressing problems in many low-income countries, has spurred significant interest in other waste to-energy business models. Waste processing business models such as dry fuel manufacturing (briquetting), biogas and gasification or energy service company models have the potential to counteract many adverse health and environmental impacts connected with traditional biomass energy.

In the existing situations in developing countries, most of the domestic and agro-waste in developing countries ends up in open dumps and in the natural water bodies. This act would leads to severe environmental and health problems. On the other hand these waste streams have resources such as nutrient and energy that can be valorized by transforming them into valuable products. With the challenge of energy security, recovering energy from biomass waste offers dual benefits – a) improved waste management, and b) provision of reliable energy to households, institutions and commercial entities. Hence, the energy recovery from organic fractions of different waste streams has the dual advantage of solving the prevailing waste management problems while providing sustainable energy solutions to the different sectors of the economy. The need for alternative sources of energy has been recognized not only in developed countries but also in developing countries. The briquette making option suggests for considering on the quality and sustainability of any environment, the efficiency and productivity of the urban and rural economy and the health and well-being of the public are determined by the existing waste management systems in the region (Schubeler *et al.*, 1996). Looking to the existing gap between convention and renewal energy sources, India has vast potential for the creation of renewable energy resources and facts have indicated on the utilization of which amounts to only a small portion. Further, in India the total potential for renewable power generation is estimated at 89,774 MW. To address this issue with the help of available biomass potential, about 17,538 MW (11.88 %) of renewable energy could be created (Sharma and Sharma, 2015).

The potential economic, environmental and social impacts of waste-to-energy models need to be assessed to ensure their sustainability and to justify their development and promotion. The present study analyzes financial feasibility of a briquetting machine using unused agriculture based byproducts. It is hoped that the analytical methodology used and the result outcomes of this study conducted in India can be useful to researchers and policy makers in other such developing countries where substantial agricultural residues are produced in the normal process of agricultural crop production and these agro-wastes end up polluting local environment.

MATERIALS AND METHODS

(a) Description of briquette making process

The dry fuel manufacturing processes use agricultural residues to produce biomass briquettes which can be used for cooking or heating in households, institutions or commercial enterprises. The machine used to produce biomass briquettes is assumed to have a capacity of producing 150 tons of non-carbonized biomass fuel briquettes/year. Under this source of energy, fuel wood is the most widely used energy source. By the biomass briquettes produced the fuel wood is replacement for heating and cooking. For the agricultural residue used as input in briquetting process. We assumed that under the scenario, these residues are burnt in open fields during land preparation for planting next crops and are not used for any other purpose. When a suitable price is offered to them farmer of the neighboring area can bring this waste to the briquette making machine's location.

(b) Sources of data for the study

The required data were obtained from the owner of one briquette machine operating in Belagavi district of Karnataka state of India. Initial cost of the new machine was INR 3,250,000 with a useful working life of 10 years. Salvage value in the end of working life of machine was estimated as INR 325,000. Based on the information gathered from cross section data the bank interest rate on loan and the operating cost were assumed at an average interest rate of 12% per annum and average of INR7080,000 per annum respectively. While, on the experience of briquette machine owner the annual machine maintenance cost of INR54,000 was increase by 10 per cent every year. The achieved working capacity of the machine was assumed to be 130 ton of briquettes per month. The briquettes made by the machine had bulk volume density of 1.0 -1.2 ton per cubic meter.

(b) Raw materials used for briquette production

The raw material inputs used for briquetting were agricultural residues such as coffee husks, rice husks, wheat straw, groundnuts husk and sawdust. The list of raw materials supply for biomass briquettes production could be modified based on the local farming system pattern. These items are sourced from farmers in the surrounding area.

At the plant, the agricultural residues were pulverized using a hammer mill, sieved and dried to reduce moisture content of 13% using a flash drier. After that these materials were blended to get a homogeneous mixture of different materials. Finally, the mixed biomass was fed into a briquetting machine to be compacted. The machines involved use of a hammer mill to pulverize the raw materials, flash drier to dry the material and piston presses to compact the mixed raw materials into briquette. In this process care to be taken while obtaining suitable biomass raw materials which should have a low moisture content (10-15%), low ash content (4%) and uniform or granular flow of the raw material (Tripathi *et al.,* 1998).

Briquette machine owner procured biomass from the farmers. While, sawdust and bagasse procured from local saw mill and sugar factory unit respectively. Similarly, the manufactured briquettes transported to the briquettes consuming units. Hence, these two cost items were accounted as transport cost of product.

(d) Data Analysis

This study assesses economic feasibility of investment in briquette making system by using three standard methods of project appraisal, the Net Present Value, Benefit-cost ratio and payback period (Berry and Ellinger 2012).

(i) Net Present Value (NPV):

The net present value represents the discounted value of the net cash inflows to the project. In the present study, a discount factor of 12 per cent was used to discount the net cash inflows representing the opportunity cost of capital. It can be represented by;

$$NPV = [\sum_{i=1}^{n} Y_n (1/(1+r)^n] - I$$

(ii) Benefit Cost Ratio (BCR):

The Benefit Cost Ratio (BCR) was worked out by using following formula

$$\text{Beneft cost ratio, BCR} = [\sum_{i=1}^{n} Y_n (1/(1+r)^n] / I$$

It measures the present value of returns per rupee of invested and it is a relative measure. The decision rule is that, accept the project, when BCR is greater than one, and reject it when BCR is less than one.

Where,

Y_n = the net cash inflows (net returns) in the year n

r = the discount rate or yearly interest rate

I = Initial investment

n= Number of working years of machine

(iv) Payback Period (PP):

Payback period represents the length of time required for the stream of cash proceeds produced by the investment to be equal to the original cash outlay *i.e.* the time required for the project to pay for itself. In the present study, payback period was calculated by successively deducting the initial investment from the net returns until the initial investment is fully recovered.

$$\text{Payback period} = \frac{\text{Initial investment}}{\text{Average annual net cash inflow}}$$

According to the payback criterion, the shorter the payback period, the more desirable is the project.

RESULTS

Result on per month average cost and return of using briquette machine for 8 hrs. is presented in Table 1. The total cost incurred in the production of 130 tons of biomass briquettes, the operational cost items such as labor (INR54,000), electricity charges (INR84,000), lubricants (INR2,000), agricultural raw materials (INR390,000), maintenance and repairs (INR45,000) and transport cost (INRINR60,000) together amounted to INR635,000. On the other hand for this incurred operational cost and from the sale of 130 tons of biomass briquette the machine owner had realized the average per month gross returns of INR715,000. The average per month net return was observed to be INR80,000.

From the Table 1 was also observed that, of the total operational cost maximum of 61.42 per cent of cost incurred on the purchase of agricultural biomass raw material. This was followed by 13.23 per cent, 9.45 per cent, 8.50 per cent, 7.09 per cent and least of 0.31 per cent of operational costs were incurred on electricity, transportation, labor, machine maintenance an lubricants respectively.

Table 1: Per month costs and return of briquette machine; Initial investment = INR3250,000

Sl. No.	**Particulars**	**Amount (INR)**	**Percentage to total (%)**
A	Operational and Maintenance cost		
	1. Labor:		
	a. Skilled (2 no. @ INR 9000/month)	18,000	02.83
	b. Unskilled (6 no.@ INR 1,200/month)	36,000	05.67
	Sub Total:	**54,000**	**8.50**
	2. Electricity Charges	84,000	13.23
	3. Lubricants	2,000	00.31
	4. Agricultural Raw Material Cost:		
	a. Groundnut Shell (60T @ INR 4000/T)	240,000	37.80
	b. Sawdust (30T @ INR 2000/T)	60,000	09.45
	c. Sugarcane Bagasse (45T @INR 1333.33/T)	60,000	09.45
	d. Tamarind Shell (25T @ 1200/T)	30,000	04.72
	Sub Total	**390,000**	**61.42**
	5. Maintenance and Repairs	45,000	07.09
	6. Transport Cost (to using sites; 130T @ INR 461.54/T)	60,000	09.45
	Grand Total: (1+2+3+4+5+6)	**635,000**	**100.00**
B	Monthly Gross Returns (Briquettes 130T @ INR 5500/T)	715,000	
C	Monthly Net returns (B – A)	80,000	

Of the total operational cost incurred on the purchase of agricultural biomass raw material the maximum of 37.80 per cent accounted towards the groundnut shell. This item was followed by the 9.45 per cent of each cost incurred on the sawdust and sugarcane bagasse. The share of the tamarind shell amounted to only 4.72 per cent in the total cost incurred on the procurement of raw material. Further, to operate the biomass briquettes machine the expenditure incurred in employing unskilled and skilled labor was observed to be 5.67 per cent and 2.83 per cent respectively.

Information on the annual gross returns, costs for the briquette machine under each year and initial cost of briquette machines presented in the Table-2. It was observed that, the aggregate present value of the net returns from the sale of briquette at the end of tenth year was amounted to INR7181,245. On the other hand after deducting initial investment of INR3250,000 in the present value of net return, the biomass briquette machine owner had realized the net present value of INR3931,245.

Table 1 Annual net returns and costs for briquette machine initial cost of INR 3,250,000

Year	Gross returns (INR)	Operating cost (INR)	Maintenance cost (INR)	Total operational & maintenance cost (INR)	Net returns (Y) (INR)	DF at 12% $(1/1.12)^t$	Present value of net returns (INR)
1	**2**	**3**	**4**	**5 (3+4)**	**6 (2– 5)**	**7**	**8 (6x7)**
1	8580,000	7080,000	54,000	7134,000	1446,000	0.8929	1291,133
2	8580,000	7080,000	108,000	7188,000	1392,000	0.7972	1109,702
3	8580,000	7080,000	162,000	7242,000	1338,000	0.7118	952,388
4	8580,000	7080,000	216,000	7296,000	1284,000	0.6355	815,982
5	8580,000	7080,000	270,000	7350,000	1230,000	0.5674	697,902
6	8580,000	7080,000	324,000	7404,000	1176,000	0.5066	595,762
7	8580,000	7080,000	378,000	7458,000	1122,000	0.4524	507,593
8	8580,000	7080,000	432,000	7512,000	1068,000	0.4039	431,365
9	8580,000	7080,000	486,000	7566,000	1014,000	0.3606	365,648
10	8580,000	7080,000	540,000	7620,000	960,000	0.3220	309,120
S*					325,000	0.3220	104,650

S* = Scrap value; DF (discount factor) = $[1/(1+r)^t]$; PV= Present value; NPV = Net present value;

Average annual return = Total net return / working life years of machine = INR 14,355,000 /10 = INR **1,435,500**

Payback period = initial investment / average annual return = 3,250,000 / 1,435,500 = 2.26 years

Net present value = PV of net returns – initial cost = 7,181,245 – 3,250,000 **= INR 3,931,245**

Benefit cost ratio = PV of net returns / Initial cost = 7,181,245 / 3,250,000 = **2.21**

The year wise financial analysis for the project indicated that, the biomass briquette machine owner had gathered the uniform annual gross return of INR8580,000 from the sale of 1560 tons of briquette per annum. To produce this quantum of biomass briquettes, the machine owner's per annum operating and maintenance costs under first year were observed to be INR7080,000 and INR54,000 respectively. Over the period biomass briquette machine maintenance costs had increased from INR54,000 to INR540,000. With this pattern of annual returns and cost structure the biomass briquette machine owner had realized total net benefits of INR1435,500 per annum. The information on the financial feasibility of biomass briquette machine in the study area indicated the net present value, the B: C ratio, and payback period as INR3931,245, 2.21 and 2.26 years respectively.

DISCUSSIONS

The information furnished in the Table-1 suggested that, in the total biomass briquette production the share of agricultural raw materials cost was observed to be maximum (61.42%) and followed by the costs incurred on electricity (13.23%), transport (9.45%), labor (8.50%), maintenance and repairs, and the least on lubricants (0.31%). From this it could be inferred that the cost associated with the purchase of agricultural raw material mainly depends on the production of biomass briquette with desired density level (1.0 to 1.2t/m³), heat content (19.3 to 20.5 MJ/kg) and ash content ranging from 00.5 to 1.5 per cent (Tripathi et al. 1998).

Keeping this information as base to produce quality biomass briquettes the maximum quantity of groundnut shell (720 T/annum) was combined with other agricultural raw material such as tamarind shell (300 T/annum), sugarcane bagasse (540 T/annum) and sawdust (36 T/annum). Accordingly, without compromising on the quality of biomass briquettes the agricultural raw materials procurement costs were varied to keep biomass briquettes production cost at minimum level. In addition to this the costs incurred by the machine owner on the other resources utilized in the production of biomass briquettes were carefully managed and targeted biomass briquettes production at 130 tonnes per month.

With an initial invest (INR3250,000) made in establishing the biomass briquette production by using agricultural raw materials the annual net cash flows (Table-2) were discounted (12%) and obtained the positive net present value of returns at the end of tenth year (INR7181,245). Based on this financial analysis it could be inferred that under the study area the investment on the biomass briquette production was observed financially viable.

Another financial indicators such as discounted benefit-cost ratio (B: C ratio) for the investment made on biomass briquette production also positive and cold be concluded that, entrepreneur’s investment in biomass briquette observed economically feasible. The payback period for biomass briquette was 2.26 years. Hence, the investments made in the biomass briquetting machines and infrastructure, the entrepreneurs had recovered all investment in a relatively short span of time and observed to be less than three years (Sengar *et al.,* 2013). With this biomass briquette startup production the entrepreneur achieved the objective of creating employment for 720 man days/annum skilled and 2,160 man days/annum unskilled labors (Marina Petrovska et al. 2011). In addition to this, the biomass briquette production system was successful in binding total of 169,000 MJ heat content per annum from the 1560 tons of biomass briquettes produced in each year which had ensured on the supply of energy to the rural house hold day to day needs (Singh and Sooch 2004). This system had helped in following effective handling procedures in disposing off agricultural biomass (Okello *et al.* 2013).

CONCLUSIONS

For converting agricultural biomass waste as a supplementary source of energy providing production mechanism and its distribution needs to be placed in the system. This mechanism could be very well adopted wherever large quantities of different biomasses are available and considered to be the waste materials. This supplementary source of energy production system can be strengthened by integrating with agricultural production system (Mark and McHenry, 2009). For addressing the issue, identify the situation where huge quantities of biomass resources available and converting the agricultural biomass waste into supplementary source of energy would, help in improving the energy supply, energy mix and net energy balance (Simonyan and Fasina, 2013). To tap this untapped energy potential created each year as biomass renewable energy source placing the suitable biomass briquettes production unit would contribute in achieving sustainable development, green jobs employment and production efficiency in agricultural sector in rural areas (Marina Petrovska *et al.*, 2011). Hence, biomass briquette production should be popularized in the areas with maximum availability of agricultural by-products by the line departments and biomass briquette manufacturing companies. This biomass briquette alternative energy business model offers a unique opportunity for investors in realizing higher returns on their initial capital investment. Thus, biomass briquette alternative energy business model could be viewed as an advanced fuel because of its clean burning nature and the fact it could be stored for a longer time without degradation. Therefore, a micro enterprise can be formed since an individual entrepreneur can produce biomass briquette from agriculture wastes and sell them in a local market which can generate additional income. Looking to the biomass briquettes economic production feasibility, the availability of large amount of biomass waste in the region and the house hold cooking energy requirements under South Pacific situation this micro enterprise set up may be encouraged. This action would help in paving the way for the conservation of natural forest cover and to keep environment intact for the future generation use.

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