Prospect of biomass briquette as renewable energy source in Assam, India

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Shortage and limitations in the availability of fossil fuels demand focus on the usage of renewable energy in order to shorten the gap between demand and supply. Replacement of non-renewable resource like fossil fuels with briquette making from farm waste helps to lower carbon footprints. Looking at the abundance of annual farm waste accumulation in Assam, this is essentially an unexplored new horizon of energy industry. Therefore, this study was undertaken to see the prospects of biomass briquette making for commercial purpose. The assessment of thermal efficiency showed that calorific values of briquettes made from different agro wastes ranged from 3370 to 4115 Kcal/kg. The residual ash content ranged between 7 and 8.6% of briquettes' weights. The benefit cost ratio of 1.80 is indicative of a positive net benefit indicating a better prospect of commercial production of biomass briquettes in Assam.

Keywords: Benefit cost ratio, briquettes, calorific value, commercialization, residual ash.

GROWING energy demands have resulted in the production of electricity from fossil fuel based power plants that release ample amount of green house gas and carbon into the atmosphere contributing towards climate change and global warming. The shortage and limitations in the availability of fossil fuels also demand focus on the usage of renewable energy including wind power, biomass and solar power in order to shorten the gap between demand and supply. A huge percentage of Indians use traditional fuels – fuel wood, agricultural waste and biomass cakes – for cooking and general heating needs. Burning of biomass and firewood will not stop unless electricity or clean burning fuel and combustion technologies become reliably available and widely adopted in rural and urban India. Nearly 81% of rural households use solid fuels as compared to 26% of urban counterparts, because these are readily available and at lower cost[1]. A huge population thus use traditional fuels like fuel woods, agricultural waste and biomass cakes which are burnt in cooking stoves known as chullahs, for cooking and general heating needs. World Health Organization (WHO) claims that nearly 300,000 to 400,000 people die of indoor air pollution (IAP) and carbon monoxide poisoning every year because of biomass burning and use of traditional chullahs[2]. It was reported that if the current pattern continues, around 2.3 billion people would still be using biomass in 2030 globally[3]. The replacement of non-renewable resource like fossil fuels with biological waste helps to lower the carbon footprints. With proper initiatives, waste biomass can be successfully converted into a source of energy by making biomass compressed briquettes. Waste biomass kept for long becomes nesting ground for bugs, rodents that destroy the new crops in fields or grains during storage. To prevent this, some farmers burn these waste biomass that release smoke, or otherwise bury them which leads to soil degradation[4]. Waste biomass of the field and home yards were found to be a very efficient source of energy, if utilized will minimise continual trouble in the farms like pest infestation, etc. along with other benefits. Biomass briquettes, an alternative low cost but concentrated source of energy, are ecofriendly low smoke emitting fuel, and their performance is better than firewood. These compressed compounds are mostly made from green waste and other organic materials and are commonly used to heat industrial boilers in order to produce electricity and also as cooking fuel. The composition of briquettes varies by area due to the availability of raw materials. Raw materials that are gathered and compressed are easier to store, transport, more convenient to use and burn at a more steady, controlled and longer rate than loose biomass. These briquettes are very different from charcoal because they do not have large concentrations of carbonaceous substances and added materials. Compared to fossil fuels, briquettes produce low net total greenhouse gas emissions because the materials used are already a part of the carbon cycle. Kyoto protocol allows for users to get carbon credits; the use of biomass briquettes is strongly encouraged by issuing carbon credits. One carbon credit is equal to one tonne of carbon dioxide that can be freely emitted into the atmosphere. Thus, briquettes could potentially offer a means of waste management while providing a new fuel business opportunity for the local economy. Calorific value is an important characteristic of fuel which is the amount of energy released per kg when burnt. This is probably the most important factor which can be used to assert the competitiveness of a processed fuel in a given market situation, and also to be considered in selecting the raw materials input. Assam has high humidity level in the atmosphere with intermittent rain. The present study was undertaken to see the prospects of biomass briquette making for commercial purpose to utilize huge amount of agro wastes produced every year throughout the state. Following are the objectives of the study: (1) Estimation of agro wastes accumulated per year in the farming families; (2) Calorific value of biomass compressed briquettes made from combination of different agro wastes and ash contents of the briquettes; (3) Cost analysis of briquette making.

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Table 1. Thermal efficiency and residual ash content of biomass briquettes

Composition of the sample briquettes	Gross calorific value (Kcal/kg)	Residual ash content per cent with respect to weight of briquette samples
Rice husk	4080	8.4
Saw dust	3965	7.6
Areca nut plant wastes	4115	7
Mixture of various weeds, areca nut plant waste, sugarcane bagassae, sawdust and rice husk	3370	8.6
Areca nut plant waste, rice husk and straw	3535	8.1
Sugarcane bagassae and rice husk	3890	7.9

For fulfilling the first objective, a well structured interview schedule was administered on hundred rural households to conduct a survey on biomass accumulation. To determine the calorific value which was the second objective, six different briquette samples were prepared using – (i) rice husk, (ii) saw dust, (iii) areca wastes, (iv) mixture of various weeds, areca nut plant waste, sugarcane bagassae, sawdust and rice husk, (v) areca nut plant waste, rice husk and straw, (vi) sugarcane bagassae and rice husk. Raw materials were accumulated and the materials other than rice husk and saw dust that required to be made small were chaffed in chaffing machine. All the materials were then separately pulvarised in pulvarising machine, and dried in flash drier. Each of these materials was kept separately, and based on the type of samples to be prepared, was fed into the screw type briquetting machine using extrusion production technology. This technology does not require any binder and briquettes are the extrusion screw wastes under high pressure. Those samples which were mixtures of more than one type of raw materials were mixed in equal proportion by weight to make the briquettes. The gross calorific values were determined in Bomb Calorimeter (model: Leco, USA) using standard ASTM method[5]. The powdered biomass briquette sample (~1 g) was used in the bomb for combustion under oxygen gas[5]. For determining the residual ash content of the samples, briquettes burnt in stove in equal weight of 500 g each was measured in electronic balance. To calculate the cost analysis of the process of briquette making, all the expense heads (fixed and variable) were taken into consideration to determine the benefit cost ratio (BCR).

The survey undertaken in the rural areas revealed that majority of the respondents were literate, and they cultivated paddy as monocrop. However *rabi* and *kharif* vegetables were also grown depending upon the land situation. Data revealed that 10,396 quintals of rice straw, 18,193 quintals of rice husk, 2004.64 quintals of water hyacinth and 12,000 numbers of areca sheaths were produced as underutilized wastes among the 100 households in a year. The income supplementation of farm based rural households was not adequate; many of them were involved in petty income generating activities apart from farming. They were not aware about the economic use of the agro waste available in their habitats.

The assessment of thermal efficiency indicated that the calorific value of the briquettes made from some of the agro wastes such as saw dust, areca palm sheath waste, rice husk, sugarcane bagassae, weeds like water hyacinth, fallen leaves, etc. were quite high and encouraging.

The thermal efficiency of briquettes made from areca nut wastes (Table 1) was 4115 and that of rice husk was 4080 Kcal/kg, whereas briquettes made from several mixture of wastes was 3370 (lowest among the samples). In general, calorific value of biomass briquettes which are used as fuel also, called as ‘white coal’, ranges between 3200 and 4200 Kcal/kg depending on the raw materials used. Calorific value of the six briquette samples (Table 1) tested during the study ranged from 3370 to 4115 Kcal/kg. One of the earlier studies revealed that the calorific value of fire wood was 3300 Kcal/kg and that of grade C coal was 4500 Kcal/kg, but the carbon content was less in firewood. Hence it emitted less pollution upon combustion than coal[6]. The residual ash content percentage of the burnt briquette samples were almost equal and ranged between 7 and 8.6 of briquette’s weights (Table 1). Thus, the result of the tests indicated that such briquettes can be quite efficient and can be utilized as alternative fuel which is environment friendly and has high viability for commercial production in Assam. The use of these kinds of biofuel could be widely popularized for domestic cooking, grills, in heating spaces in restaurants, as well as in brick kilns and other commercial units where firewood/coal are used.

For price rating of briquettes, raw materials of equal weight such as rice husk, areca nut waste and sugarcane baggasse were taken. Areca sheath and sugarcane baggasse were chaffed. After that all the three materials were pulverized and dried in pulverizer and flash drier. These materials were then fed into the screw type briquetting machine to produce briquettes. Readings of unit costs of the electricity were taken prior to starting of the machines and after completion of the work. The unit cost for chaffing, pulverizing, drying and briquette making was calculated. The labour charge, raw material cost, depreciation cost of equipment, interest on capital were considered for analysing.

Details of expenditure	Cost (Rs)
(a) *Capital investment*	
Price of screw type briquette machine along with chaff cutter, pulverizer, flash drier	938,300.00
Total cost including tax, excise duty and installation charge	1,207,629.00

(b) *Time required for various operations*

Chaffing	=	0.63 h
Pulverizing	=	0.83 h
Drying	=	0.74 h
Briquette making	=	3.70 h
Total		5.90 h

(c) *Fixed cost*

Depreciation, 10% of the capital investment
= 120,762.90/(24 × 365) = Rs 13.78/h

So, depreciation for total operation time of 5.90 h
= Rs 81.30

Interest on capital @ 5% = 60,381.00/(24 × 365)
= Rs 6.89/h

So, interest for total operation time 5.90 h
× Rs 6.89/h = Rs 40.65/h

Therefore, total fixed cost = Rs 121.95/h

(d) *Variable cost of raw material used (for production of 100 kg briquette)*

Rice husk	=	44.44 kg
Sugarcane bagasse	=	44.44 kg
Areca nut sheath	=	44.44 kg
Total raw material	=	133.32 kg

Cost of raw material @ Rs 1/kg = Rs 133.32

(e) *Electricity consumed for various operations*

Chaffing = 1.85 kwh/h × 0.73 h = 1.35 kwh
Pulverizing = 2.76 kwh/h × 0.73 h = 2.02 kwh
Drying = 2.85 kwh/h × 0.73 h = 2.09 kwh
Briquette making = 3.00 kwh/h × 3.70 h = 11.11 kwh

(f) *Cost of electricity for various operations (@ Rs 7.00/kwh)*

Chaffing	1.35 kwh × Rs 7	= Rs 9.45
Pulverizing	2.02 kwh × Rs 7	= Rs 14.14
Drying	2.09 kwh × Rs 7	= Rs 14.63
Briquette making	11.11 kwh × Rs 7	= Rs 77.77
Total cost		= Rs 115.99

(g) *Cost of man power*

Wage for labour = Rs 250.00/man-day (8 man-hour @ Rs 31.25/man-hour)
Man-hour required for total operation = 5.90 man-hour
Cost through wages (total) = 5.90 × 31.25 = Rs 184.37

(h) *Total variable cost*
(d + f + g)
= Rs 133.32 + Rs 115.99 + Rs 184.37 = Rs 433.68

(i) *Total cost for production of 100 kg briquette*
(c + h) = Rs 121.95 + Rs 433.68 = Rs 555.63
(i) Quantity of briquette produced = 100 kg
(ii) Cost of production of 100 kg briquette = Rs 555.63
(iii) Cost of production per kg briquette = Rs 555.63/100
= Rs 5.55/kg

(j) *If selling price per kg is considered to be Rs 10 then profit will be 55.5%*

(1) Sale price of 100 kg briquette	= Rs 1000.00
(2) Profit in 100 kg of briquette is	= Rs 555.00
(3) Time taken to produce 100 kg briquette	= 5.90 h
(4) Briquette produced per hour	= 16.95 kg

(h) *BCR is 1.80*

The BCR value of Rs 1.80 is indicative of a positive net benefit.

The present study thus revealed that the economic conditions of rural families were not good and the farmers were not aware of proper utilization of agro wastes for economic benefits. Calorific values of the briquettes showed impressive thermal efficiency potential. Therefore, briquettes can be quite efficient and can be utilized as alternative fuel which is environment friendly, which helps to prevent deforestation, reduce greenhouse effect, helps in the management of waste and also is viable for commercial production in Assam. Thus, there is a tremendous scope for development and propagation of these non-conventional compressed biomass briquettes to meet the energy requirements with available agro wastes from farm lands. It has attractive potentials for large-scale industries and community-level enterprises. The cost analysis asserted that if briquettes made from agro wastes as shown in the preceding discussion, are sold @ Rs 10/kg, the BCR of 1.80 is indicative of a positive net benefit. It is worth mentioning that briquetting sector in India is growing gradually despite some failures. As a result of promotional efforts by the Indian Renewable Energy Development Agency Limited (IREDA's), more and more entrepreneurs are successfully and confidently investing in biomass briquetting. These entrepreneurs are also making arduous efforts to improve both the production process and technology[7]. Such efforts can also be taken up in Assam to improve the scenario of renewable source of energy and help in economic empowerment as well as to avoid adding fossil's carbon to the atmosphere.

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Non-timber forest products as a means of livelihood in Mon district, Nagaland, India

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The Konyaks in Nagaland, India, since time immemorial have been dependent on the forest and its products for their sustenance and economic growth. The use of non-timber forest products (NTFPs) in Mon district, Nagaland, was studied through surveys and interviews with vegetable vendors in Mon and Aboi town markets, and villagers of Chingkao, Tangnyu, Sheanghah-Lampong, Wakching and Hongphoi. Forest resources and their products have been a source of livelihood providing the local inhabitants with food, medicine, construction materials and other utilitarian items, especially for the economically marginal people residing in and around the forest. This study covers 43 plant species belonging to 26 families that are used by the tribals of Mon district. Family Asteraceae was dominant in yielding forest products followed by Arecaceae and these resources are used with the traditional knowledge passed down from generations. The study shows the diverse NTFPs that fulfill the needs of a thriving Naga tribe.

Keywords: Livelihood, non-timber forest products, traditional knowledge, tribes.

FORESTS provide the richest natural resources that are complex and include both timber and non-timber forest products (NTFPs). NTFPs are the resources or products that can be extracted from the forest ecosystem and are utilized for household purposes or are marketed, or have social, cultural or religious significance[1,2]. NTFPs include plants and animals that are utilized as medicine, fuelwood, fodder, house-building material, spices and condiments, fibres, etc.[3]. The utility of NTFPs is based on the traditional knowledge that has been orally transmitted from one generation to the other. Several studies conducted by various organizations reveal that a significant proportion of the world's rural population living near forests area is highly dependent on forest resources[4–6]. The efficient extraction of NTFPs can add value to the forests and also provide an incentive for their conservation and sustainable management[7]. Konyaks, one of the major tribes of Nagaland predominantly inhabit Mon district and adjoining regions of Arunachal Pradesh and Assam, India, and Myanmar. Mon is reported as one of the backward districts of Nagaland owing to its remoteness, mountainous terrain and lack of basic amenities. The traditional

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