Rice Husk Energy Technologies in Bangladesh

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ABSTRACT

Bangladesh is an agriculture based country and the major food comes from rice. The rice plant also produces a significant amount of byproduct which is used as energy. The production of rice husk is steady and increasing in trend in Bangladesh. This biomass energy is playing a significant role in the country energy use. This study was conducted to focus on the improvement of rice husk energy and constraints for technologies dissemination in Bangladesh. The performances of the rice husk energy technologies were studied. The benefits of the use of rice husk energy technologies were analyzed and the constraints to its dissemination were found out during this study. The main consumer of the rice husk energy is the rice milling sector. About 70% of rice husk energy is consumed by the rice parboiling system. The wastes of rice husk energy can be reduced by replacing the improved system and CO level in flue gas can be reduced as well. The surplus rice husk is converted to rice husk briquette fuel which is used for cooking in small restaurant and poor household sector. The solid fuel is used as an alternative of wood fuel. The rice husk briquetting could generate employment and play a great role to reduce the CO_2 reduction. Several constraints were identified for the dissemination of rice husk energy technologies viz. policy and regulation; official recognition, attitudinal barrier, loan facility, ownership, raw material availability etc.

Keywords: Rice husk energy, boiler efficiency, parboiling, rice husk briquette, emissions

1. INTRODUCTION

Biomass is by far the dominant energy source in Bangladesh, accounting for approximately 67% of the country total energy consumption (RWEDP 2000). The per capita energy consumption in Bangladesh is one tenth of world average i.e. 6.27 GJ/year (Ellery et al. 2000). Biomass fuels are using beyond their regenerative limits (6% deforestation rate) due to high pressure of population (Janakontha 2005). There is a severe shortage of wood fuel in Bangladesh amounting 2.1 million cubic meters (RWEDP 1996). The traditional biomass is not in an organized form specially, the loose biomass material is difficult to use as fuel. Bangladesh is an agriculture based country and rice is the main crop accounting 76% of total agricultural cropped area and contributing 95% of cereal food for the nation. There are main three biomass byproduct comes from rice viz. rice straw, rice husk and rice bran. Rice straw and rice bran are used as feed for cattle, poultry, fish etc. and the rice husk is used as energy. A significant amount of total national energy comes from rice biomass. Fung and Jenkins (2003) reported that rice husk is abundant biomass resources in Philippines, offering much potential for energy generation and biomass-to energy projects could create sustainable enterprises, protect the environment, and reduce poverty and improve the quality of life for the rural poor. Jain (2006) reported that rice husk fired gasifier performed well and showed the gasification efficiency as around 65% in the capacity range of 3 to 30 kW.

Most of the energy is being using in a conventional way although there are several efforts were given for the development of the biomass energy technologies in Bangladesh. This paper analyzed the technological improvement, potential benefits and constraints for dissemination of the rice husk energy technologies in Bangladesh.

2. METHODOLOGY

This paper is comprised of the study results on biomass energy utilization from rice byproduct. Rice mills were surveyed to know the consumption pattern of rice husk for parboiling purposes. The performances of rice husk energy technology were studied. Performance study of newly designed boiler by BRRI (Bangladesh Rice Research Institute) and NRI (Natural Resources Institute, UK) was studied to show the comparative performance of new system. A detail survey was conducted on value added rice husk briquette fuel production and consumption system. Benefits of improved technologies such as time saving, employment generation and environmental benefits are discussed in the study. Future potential and constraints of the rice biomass uses and the promising areas for the further development of rice husk energy are discussed. GEMIS (Global Emission Model for Integrated Systems) software was used to find out the environmental impact the biomass energy use.

3. RESULTS AND DISCUSSION

3.1 Trends of Biomass Energy Use

There is an increasing trend of biomass fuel supply in Bangladesh. The total supply of biomass fuel was 236.08 PJ in 1980 and this supply increased to 356.66 PJ (1.73% growth) during last twenty years shown in Figure 1. Traditional fuels come from mainly three sources viz. crop residues, animal dung and trees. The major share of biomass energy supplied comes from rural areas of Bangladesh.

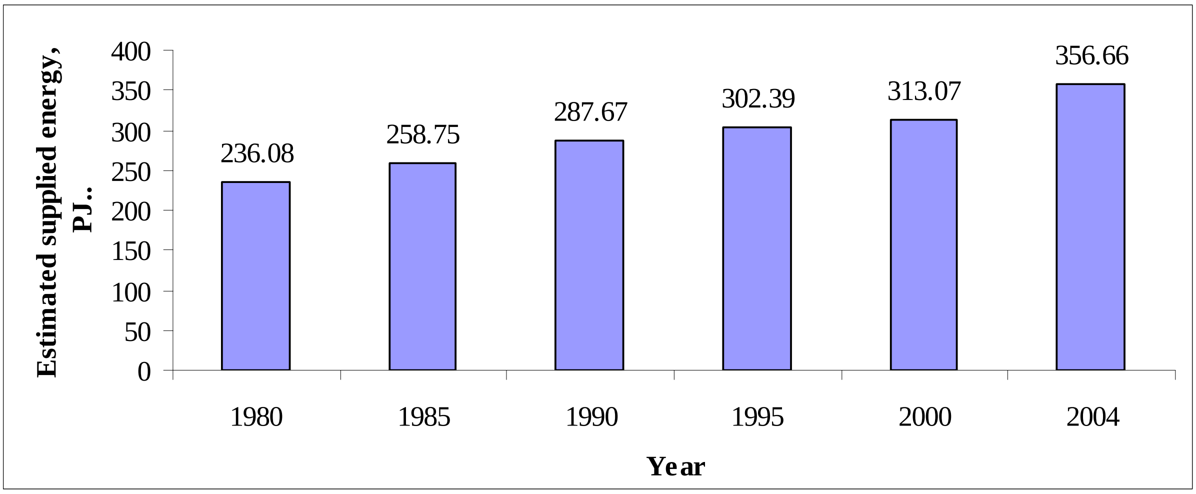

Figure 1. Trends of traditional fuel supplied during 1980 to 2004
(Source: BBS 1999 quoted in Akhter 2002 and BBS 2004)

The shares of different type of traditional fuel in terms of PJ are shown in Figure 2. The percentages of different traditional energy were as follows: cow-dung 20.4%, jute stick 7.5%, rice straw 11.6%, rice husk 23.3%, bagasse 3.2%, fire wood 10.4%, twigs and leaves 12.5% and other wastes 11.1%. Rice husk contributes biggest share of biomass energy and it was 83.04 PJ in 2003-2004 (BBS 2004).

3.2 Rice Husk Energy

Production of rice husk energy is steady over decade and day by day it is increasing in trend. In 1991, the production of rice husk energy was 76.35 PJ and it increased to 106.1 PJ in 2004 (Figure 3). The growth of rice the husk production is calculated as 2.57% which is higher than the overall growth of traditional fuel (1.73%).

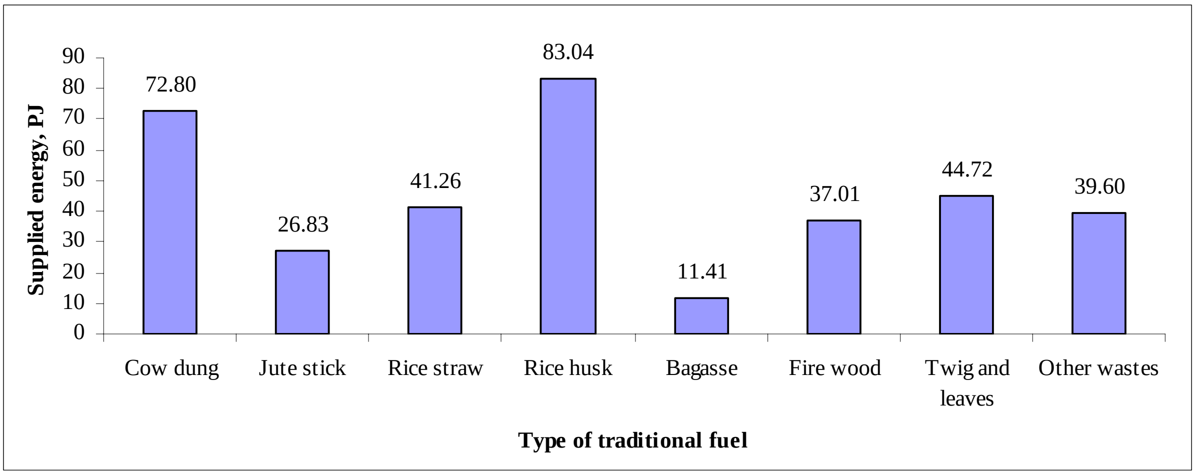

Figure 2. Estimated traditional energy supplied in the financial year 2003-2004 in Bangladesh *(Source: BBS 2004 and own calculation and plotting)*

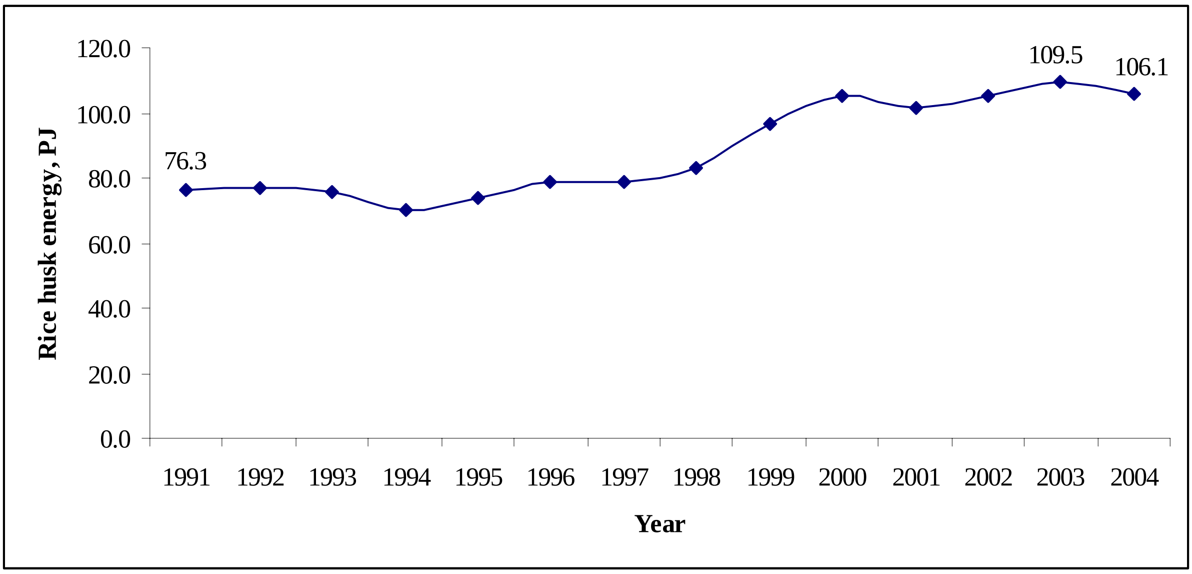

Figure 3. Trends of rice husk energy production during last decade in Bangladesh

Source: http://www.irri.org/science/ricestat/pdfs/WRS2005-Table01.pdf, printed on 03.02.06 Low heating value (LHV) of rice husk = 14 MJ/kg (Quaak et al. 1999), Rice husk and paddy ratio = 0.2

3.3 Present Use of Rice Husk Energy

3.3.1 Rice Parboiling

Rice husk was used as only fuel for parboiling throughout the country. The average husk production from the rice mills was calculated as 187 kg/ton of paddy. The consumption of husk ranged from 32% to 100% of the produced husk. The mill owners used primitive boiler and furnace exerting heavy smoke into environment (Photo 1) and the average consumption of husk was found to be 70%. The CO (carbon monoxide) level in the flue gas was found greater than 10000 ppm (parts per million) which was higher than that of the industrial air standard 5000 ppm (DoE 2003). The rest 30% of husk was surplus and used for other purposes like briquetting, poultry bed etc. The husk could be saved by increasing the efficiency of combustion and steam production unit of parboiling system.

3.3.2 Use of Rice Husk Briquette for Cooking Purposes

Tea stalls, small retailers and poor household were the users of rice husk briquette in some urban areas of the country. The main reason for this shift is that firewood has been reducing alarmingly and briquette is smokeless and provides higher temperature more quickly than that of coal and wood. The households who could not avail the gas or grid connection were using rice husk briquette fuel. A typical household cooking with rice husk briquette fuel is shown in Photo 2.

Photo 1. Traditional boiler and furnace producing heavy smoke

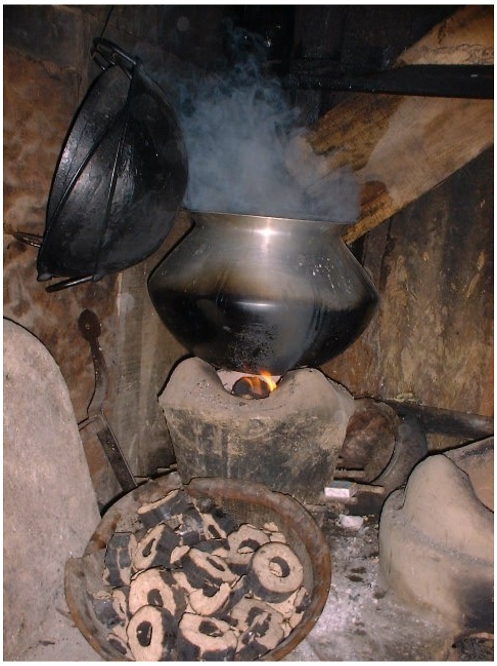

Photo 2. Showing the use of rice husk briquette fuel in household cooking

3.3.3 Other Use of Rice Husk

Some people use rice husk directly for cooking. Rice husk is also burnt for bitumen melting in road construction work. Further more, some non-energy uses of rice husk were found in the poultry bed and as reinforce material in low cost mud-house construction.

3.4 Improvement of Rice Husk Energy Technologies

3.4.1 Improved Boiler System for Rice Parboiling

At present rice mill owners use primitive rice parboiling systems which causes just waste a lot of energy and emitting non-CO_2 gases into air. To solve this problem, BRRI and NRI jointly designed an efficient low pressure (2 kg/cm^2) boiler system. The new boiler showed the efficiency as high as 46% which can reduce the rice husk consumption to about 50% of the primitive one. This system also reduced the length of parboiling time and the level of the CO in the flue gas. The CO level in flue was found to be 3500 ppm which is below the industrial standard (Table 1 and Table 2).

Table 1. Comparative results of flue Gas analysis of improved and conventional system

Sl No.	**Component**	**Improved system**	**Conventional system**
1	Ambient temperature	28^{o}C	27^0 C
2	Flue gas temperature	460^{o}C	725^{0}C
3	CO	3500 ppm	>10,000 ppm
4	O2	4.0	Nil

Table 2. Comparative performance results of improved and conventional system

Sl No.	**Component**	**Improved system**	**Conventional system**
1	Husk feeding rate (kg/h)	120	320
2	Steam production rate (kg/h)	330	410
3	Specific fuel consumption(SFC) (kg husk/kg steam)	0.40	0.77
4	Efficiency (%)	46	24

3.4.2 Rice Husk Densification Technology

The waste loose biomass materials are compressed into solid fuel by densification process or briquetting process. The most widely used densification process in the developing countries is screw extrusion process, known as heated die screw press briquetting. Compaction ratio ranged from 2.5: 1 to 6:1 or even more (Reed et al. 1978 quoted in Moral 1999).

"During this process the biomass is forced into intimate and substantially sliding contact with the barrel walls. This also causes frictional effects due to shearing and working of biomass. The combined effects of the friction caused at the barrel wall, the heat due to internal friction in the material and high rotational speed (~600 rpm) of the screw cause an increase in temperature in the closed system which helps in heating the biomass. Then it is forced through the extrusion die, where the briquette with the required shape is formed." (*Grover et al. 1996*).

The raw material rice husk has a low bulk density (117.0 kg/m³); whereas, after densification its bulk density raised to 825.4 kg/m³. This higher bulk density ensures the easy handling, storing and transportability of this resource (Photo 3). The energy consumption by briquette machine was found to be about 175 kWh (field survey in 2006) to produce one metric ton (about 4200 kWh) of rice husk briquette fuel at producer level. Dasgupta et al. (2003) conducted a field survey in 2001 and found that the energy consumption for briquette production in producer level was quite high 250 kWh/ton. These results show that the system performances are improving day by day in production level. In laboratory research, average energy consumption was to be 116 kWh/ton only. This indicates there is a scope to find out the problem why the energy consumption in producer level is high and proper corrective measures can be undertaken to overcome this problem. Total rice husk is available for densification is estimated and 1.0462 million metric. Total production of rice husk briquette fuel was estimated as 0.942 million metric ton (Table 3) equivalent to 0.493 million ton of coal which is 2.34 times of imported coal (0.211 million ton) in the year 2002-2003 in Bangladesh (BBS 2004).

Photo 3. Showing rice husk briquette fuel in a factory

Table 3. Total estimated production of densified biofuel in Bangladesh at present scenario

1. Total rice production in 2004-2005, million ton (mt)[1]	= 39.33
2. Total rice husk available for densification at present situation of rice processing system, mt	= 1.0462
3. Total potential production of densified biofuel at present situation (90% conversion efficiency), mt	= 1.0462*0.90 = 0.941580

[1]BCA (Bangladesh Country Almanac) Database 2005

3.4.3 Gasification as New Option

Gasification could be better technology for the development of rice husk energy in to gaseous form (Jain 2006). Presently there is no gasifier operating in Bangladesh. Whereas, there are several units of gasifier are running in the region viz. India, Thailand etc. Therefore, the experience from the region could be used for commissioning gasifier technology in Bangladesh.

3.5 Potential Benefits of Using Improved Technology

3.5.1 Time Savings for Collection of Fuel

The time spent for collecting the rice husk briquette ranged from one sixth to one third an hour. The amount of time saving for collecting rice husk briquette over firewood was calculated as 24 mad-day/year which could save almost one month labor cost in a small restaurant (1 man-day = 8 hr works by a person or 1 labor working in a day).

3.5.2 Direct Employment Generation

The employment generated due to production and use of densified biofuel is calculated as 3.73 man-day for producing each ton of densified biofuel (Table 4). Another study on techno-economical aspects of biomass densification in India was conducted by Ghosh et al. (2002) and they estimated that about 4.32 man-day employment could be generated for producing each ton rice husk densified fuel which is almost similar to the results obtained in this study. Fung and Jenkins (2003) also reported that biomass energy projects could create employment for rural people. The total employment generated was estimated as 14048 employees for whole year in Bangladesh.

Table 4. Employment generated in densified biofuel flows

Raw material collection, *man-day/ton	0.75
Production process, man-day/ton	2.40
Transportation, man-day/ton	0.25
Trading, man-day/ton	0.33
Total employment, man-day/ton product	3.73
Total potential production of densified biofuel at present situation, million ton	= 0.942
Total number of employee for a year, man-year	= 14048

*One man-day = 8 hr; *(Field survey report, Oct-Dec 2005)*

3.5.3 Environmental Benefits

The data were analyzed using the GEMIS (Global Emission Model for Integrated Systems) to compare the CO_2 reduction with rice husk briquette fuel over firewood in Mymensingh district town (Table 5). It was found that about 1.81 kg CO_2 could be saved for each kg rice husk briquette fuel use over each kg of non-sustainable firewood use and about US$ 65.65 thousand could be achieved. If it is considered as whole country this figure would be raised to US$ 6.84 million from the existing production of rice husk briquette in Bangladesh. Fung and Jenkins (2003) also reported that biomass energy projects could protect environment.

Table 5. Global emission CO_2 saving with rice husk briquette fuel options over wood fuel in Mymensingh district, Bangladesh

Option	Annual demand $\times 10^6$	CO_2 equivalent $\times 10^6$ kg/year	CO_2 emission, kg/unit	CO_2 saving over 100% fuel wood system $\times 10^6$ kg/year	Return from CO_2 $\times 10^6$ BDT/year	Return from CO_2, $\times 10^3$ US$/year
1. 100% rice husk briquette	9.039 kg	0.954	0.105	16.42	4.33	65.65
2. 100% wood	14.244 kg	17.37	1.219	0	0	0

CO_2 reduction trade, US$ 4.00/ton (Sohel 2002, p.266), 1 US$ = 66 BDT

3.6 Constraints to Dissemination of New Technologies

3.6.1 Official Recognition

The recognition of technological improvement is influenced by its extent of compliance to specified safety, environmental and technical standards. There are no such standards for low pressure boiler used in small rice mills in Bangladesh. Hence, official recognition of these technical improvements will be constrained as there are no bases on which to judge the compliance of the improved technology.

3.6.2 Structure of Policy and Regulation

Rice mill sector requires a prior approval for replication of the new improved furnace system. It involves a complex structure of policy and regulation through several departments/players. Existing boilers related act is very old and not updated, despite the improvement in technologies and new requirements and standards.

3.6.3 Attitudinal Barriers to Shift

There is a psychological barrier to shift from conventional system to the improved system. A psychological perception/mindset on certain concepts of the conventional furnace may take time to change the users. The lack of awareness and low levels of education/technical knowledge is an added factor for shifting to new system.

3.6.4 Loan Facility

The rice mills do not come under the Small Industries category because of its rural location. This means that subsidized credit for capital investment, available to other small enterprises, is not available to rice mills owners. This is also a constrain to uptake of new technology.

3.6.5 Ownership

The profit realized by the owners may not be shared with the firemen and furnace operators. So the interest to shift to a new technology at the worker level could be low. The benefits of husk saving needs to be shared with the workers involved in the furnace operation to overcome resistance at the worker level. This has to be sorted out at the user level by the policy makers

3.6.6 Raw Material Availability for Densification

Major portion of rice husk was burnt for rice parboiling with primitive system. Therefore, a limited amount of rice husk was available for densification/briquetting. If the primitive parboiling system is replaced by the improved system then more rice husk will be available for densified solid fuel production.

4. CONCLUSION

The rice husk contributes a significant role for processing the main food of the people of the country. The energy is used in a primitive way which causes the wastes of this valuable resource. The use of this energy also puts a positive impact on the employment generation and environment by replacing non-sustainable firewood. The technological improvement is going on; however, there are some constraints for dissemination of the new technologies. The policy makers, technologists, extension personnel of government and non government organization need to give an urgent thrust for enhancing the dissemination of new renewable energy technologies among the stakeholders.

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