Technological Prospects of Electricity Self Sufficiency at Rice Mill Community through Rice Husk Gasification: A Case Study for Belcon Company Ltd.

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Abstract

Biomass currently supplies 14% of the worldwide energy consumption whereas in Bangladesh 68-73% with conversion efficiency of less than 10%. The potential of improving its efficiency through novel technologies is very high. Bio energy has significant potential contribution for sustainable energy systems, especially when converted to modern energy carriers such as electricity, gaseous or liquid fuels. On the other hand, it has an important part of today's imperfect energy systems in many sectors that slow development of the society.

Maximum rice husk produced by milling process of rice mills in Bangladesh usually burned in the mill boilers to produce process heat for parboiling of paddy rice and excess husk are sold to the market as fuel for cooking purposes and a considerable portion is misused. This husk burning is incomplete, very inefficient as well as not practiced in an environment friendly way. The study recently carried out to find out technological prospects of electricity generation by gasification of extra rice husk at an automatic rice mill with crushing capacity 150 tonnes per day in Naogaon District of Bangladesh. Using 14 tonnes of excess rice husk at studied mill, 470 KW electrical power generation capacity achievement is possible through rated 470 KW rice husk gasifier in combination with dual fuel internal combustion engine. For 10 years project lifetime, considering 350 days yearly operation, the plant can generate 39.48 GWh electricity and cumulative CO_2 emission reduction through this project will be 12236 tonnes. Moreover, surplus power can be sold to local community for community development and thereby considerable revenue earning is possible.

Keywords: Biomass, Boiler, Electricity Self Sufficiency, Gasification, Rice Husk, Pyrolysis, Proximate and Ultimate Analysis.

1.0: Introduction: At present, bio energy plays an important role in the global energy scenario. Biomass currently supplies 14% of the worldwide energy consumption whereas in Bangladesh 68-73% with conversion efficiency of less than 10%**[1].** On the other hand, presently, biomass to electricity conversion efficiency 30% is proven **[2].** Electricity generation from rice husk through novel technologies is now in use in several developing countries like India, Thailand, China etc. For example, up to 1996 in India's provinces, Andhra Pradesh and Madhya Pradesh's existing cumulative capacity of rice husk gasifiers was 1700 KW and 1740 KW respectively **[3].** In case of small-scale biomass gasification, India has made significant developments in technology. A total of 42.8 MW biomass gasifier power capacity has so far been installed in India. In India, biomass gasifiers capable of producing power from a few kilowatts up to 500 kW have been successfully developed indigenously. Such examples include the installation of rice husk-based gasifier in a rice mill in Andhra Pradesh, and a 5 × 100 kW biomass gasifier on Gosaba Island in the Sunderbans area of West Bengal, which is being successfully run on a commercial basis **[4].** In Thailand, the number of rice husk based gasification units exceeds 25 numbers already **[5].** On the other hand, maximum rice husk produced by rice mills in Bangladesh usually burned in the mill boilers to produce process heat in very inefficient way respect to modern technologies. Moreover, excess rice husk is sold to others people or entrepreneur and a considerable amount is misused. How can this excess rice husk be used in an efficient and economical way to produce electricity for fulfillment of the rice mill's electricity demand and surplus electricity can supply to local community for socio-economic development is still seems in hindrance. The study was recently carried out to find out technological prospects of rice husk based gasification for electricity generation at rice mill community considering electricity self sufficiency at local community.

A remarkable numbers of people in Bangladesh rely on rice husk as an important source of fuel. However, its use is often inefficient, with adverse effects on the health of the users and workers involved with it. This wasteful use continues due to unavailability of relatively improved technology that can make more efficient use of rice husk as a fuel. In addition, rice husk briquetting what is now practiced in Bangladesh is very much electricity consuming. So, alternative use, electricity generation through rice husk gasification in rice mill compounds could be a good option to develop the situation. Implementation of comparatively more sophisticated technologies, rice husk gasifier with combination with dual fuel IC Engine or single fuel SI (gas) engine can be a good solution while it improving efficiency and safety.

In Bangladesh, rice is a staple food and accounts for about 93 % of the total food produced in the country. Bangladesh produces on an average 28 million Metric Tonnes (MT) of paddy per year, giving approximately 6 million MT of risk husk and thereby causing some sorts of disposal problem. Rice husks make up apparently one fifth (by weight) of the dried paddy rice. Presently it uses as a source of heat energy in Bangladesh and it is the largest source of biomass, contributing 22 per cent of the 39 million tones of total biomass produced in Bangladesh **[6].** In Bangladesh usually 10 per cent of the rice produced is hulled immediately, while the remaining 90 per cent is parboiled and then hulled. The by-product from rice hulling (rice husk) is then used as a fuel to generate steam to parboil the paddy and rests are sold to others or misused.

Necessity of rice husk gasification: In maximum rice mill in Bangladesh excess rice husk disposal problem is a common factor. Also, in these mills by using conventional indigenous type boilers and furnaces the rice husk burning is inefficient, incomplete and thereby black smoke generating. So, to avoid much environmental pollution, improved technology like gasification for improvement of environment and efficiency is necessary. Because, in energy terms, the conversion efficiency of the gasification process is in the range of 60%-70% and thereby biomass to electricity generation conversion overall efficiency using dual fuel engine is minimum 20% **[7].**

Moreover, presently access to electricity services stands only around 32% of the total population of Bangladesh and per capita electricity consumption is 129kWh/year **[8].** Furthermore, due to power crises in Bangladesh, frequent (5/6 times per day) load shedding is usually occurred in the studied area that results unstable and unreliable power system. So, rice husk gasification based power generation in rice mill communities can be treated as nation's interest. Because, the gasification plants could also assist in increasing power quality (i.e. voltage, power factor) and network reliability as it could be use as a captive power source. In North Western part (North Bengal) of the country where hundreds of rice mills situated, present electricity demand is about 800 MW whereas installed capacity is around 555 MW. As a result low voltage occurred in distant districts from generation ends up to 90 kv on 132kv transmission lines. Also power has to import from other parts of the country. Moreover, upon an appraisal of the fallout of the single-fuel (natural gas) power plants, the annual report for 2002-2003 of

Bangladesh Power Development Board (BPDB) itself has said, “although Bangladesh has gas reserves, the resource is destined to be exhausted by 2015 if new gas fields are not put into operation”. So, alternative fuel such as rice husk based power generation could be an alternative source of power supply.

1.1 Application status of biomass gasification technologies in Bangladesh: Although there is good potential of biomass gasification projects in the country, little has been done to harness this potential. There is no plant in operation today. Implementation of 250 kW capacity Updraft Gasifier at M. R. Rice Mill, Basherhat in Dinajpur district is under process by Local Government Engineering Department (LGED). In addition, a 40 KW (150 KWth) capacity biomass gasifier at the Faridpur Muslim Mission for cooking heat supply purpose also under process by LGED.

1.2 Study area: This study was carried out for the automatic rice mill, Belcon Company Ltd., installed in the year 2000 at Thatta Sahapur in Naogaon District of Bangladesh, one of the most paddy growing areas of the country and its surrounded community.

2.0 Methodology: This study was based on both quantitative and qualitative information through interviews, observation for the studied mill and publications, Internet sources etc. To assess sustainability, electrical demand side scenario of local community, availability of rice husk etc., unstructured interviews were conducted for mill officials, technical personnel, workers and surrounded community members. Moreover, some important information regarding LGED supervised rice husk gasification projects was collected by author.

2.1 Limitation of the study: Advanced gasification power system technologies regarding improved power generation from biomass, like Biomass Integrated Gasifier -Steam Injected Gas Turbine (BIG/STIG)**,** Biomass Integrated Gasifier–Inter-cooled Steam Integrated Gasifier (BIG/ISTIG), Biomass Integrated Gasifier - Gas Turbine Combined Cycle (BIG/GTCC), Circulating Fluidized Bed Gasifier (CFBG) were not considered for this study due to economical commercialization of these systems have yet not started.

3.0 Present rice processing at studied mill and rice husk utilization: Presently, at the studied automatic rice mill, produced rice husk generated by milling operation is partially (around 56%) utilizes for rice processing heat requirement. Excess 14 MT per day rice husk (from cumulative both parboiled and un-perboiled) is sold to others or misused and that results disposal problem as well as environmental pollution. At present, the Belcon Company Ltd. is producing 110 MT rice, 6.5 MT bran (25% oil potent), 1.5 MT broken grains and 32 MT rice husk per day using 150 MT paddy rice processing. Usually 90% rice is parboiled and the rest is un-perboiled in the studied mill. Out of this 32 MT rice husk, 18 MT husk is utilizing for heating purpose of 3 tonne per hour capacity boiler water to generate saturated steam that is using for boiling rice as well as drying parboiled rice. In parboiling, the rice is steam soaked, dried and then milled. Rice husk is generated during the milling process when the grain is separated from the outer covering (husk). Additionally, the grain is polished to remove the bran covering. In the studied mill the composition of the final by-products are found three separate streams of pure husk, broken grain particle and bran, including rice polish. Most of the husk is used in mill boilers. And surplus is sold to others for cooking purposes, briquetting and some are misused. Bran and rice polish mix are sold to entrepreneurs for cattle/poultry feed. Mixed husk is more prevalent in rural areas and usually the surplus is used by farmers in the vicinity of the mills. Poor households also use husk as a fuel for cooking. Demand for mixed and pure husk is

Photo: Conventional rice boiling

Source: Author

Photo: Belcon Company Ltd.

Source: Author

rising. The mill authority used to sell rice husk: @ Taka 50/sack (67Taka = 1 US$), Bran: @ Taka 580/sack (or, 55kg). The husk generated in un-parboiled processing is separated from bran and polish. There is no husk briquetting machine in operation in the studied mill. Although high silica (95%) ash from rice husk has many potential uses, currently it finds few uses and is an environmental pollutant due to dumping at the mill premises.

The particulars of boiler and generator of the studied mill are as following;

Boiler (Single unit): Pressure 10 kg/cm^2, Capacity: 3 tonnes per hour, Origin: Thermax, France

Generator (Single Unit): Rating 345 KVA diesel generator, Origin: Cater Pillar, USA. The generator is usually on an average in operation for 50 hours per month and thereby consuming about 2400 litres of diesel fuel monthly. So, 28800 litres of diesel consumption for the existing generator at present.

Electricity bill: Average Taka 500 thousands monthly electricity bill for about 125000 units has to pay by mill authority to electricity service provider.

3.1 Suitability of rice husk for gasification: Rice husk is one of the most commonly available lignocellulosic materials that can be converted to different types of fuels through a variety of thermo-chemical conversion processes. The average calorific value of rice husk in natural state and dry state is 14700 KJ/Kg **[9].** The moisture content of rice husk ranged from 8.68 to 10.44%, and the bulk density ranged from 86 to 114 kg/m3. Its energy content is rather low due to the high fixed carbon values of the product. This implies that large quantities of the carbon remain ungasified during gasification that leading to the production of large quantities of ash. The resulting ash requires constant removal from the gasifier bed and this slows the working process. To overcome the situation, presently circulating fluidized bed technology is developed. Despite these limitations, the energy value of the charred product is higher than that of the raw husk. Therefore, gasification of biomass is an ideal utilisation pattern despite its operational limitations. Moreover, energy generation from rice husk gasification is treated as sustainable energy if used sustainably. It is environment-friendly because of the firewood savings and reduction in CO_2 emissions. Net atmospheric CO_2 emissions are avoided if growth of the biomass is managed to match consumption. The process increases the net calorific value per unit volume, i.e. it is more efficient.

Furthermore, conversion of solid biomass into combustible gas has all the advantages associated with using gaseous and liquid fuels such as clean combustion, compact burning equipment, high thermal efficiency and a good degree of control. In the studied area as well as North Bengal region of Bangladesh, rice husk is already available at reasonable low prices (e.g. Taka 50/55 Kg). So, gasifier systems offer definite economic advantages. In addition, biomass gasification technology has the potential to replace diesel and other petroleum products in several applications as well as save foreign currency. The proximate and ultimate analysis results of risk husk are as follows;

Proximate analysis results of rice husk by

Fixed Carbon, %	Volatile, %	Ash, %	Moisture, %
19.70	58.90	13.20	8.20

Ultimate analysis result of rice husk

Carbon, %	Nitrogen, %	Chlorine, %	Sulfur, %	Hydrogen, %	Oxygen, %	Moisture, %	Ash, %
39.10	0.18	0.09	0.04	4.59	34.70	8.20	13.20

[10]

The lower heating values of rice husk ranged from 13.24 to 16.20 MJ/kg (dry weight basis) **[11].** Power generation by using rice husk gasification can not only save expenditure in electricity tariff in the production cost of rice mills but also can bring benefits by means of selling surplus electric power to the local community or power grid. Due to the higher conversion efficiency of the gasifier equipment, every KWh power generation consumes only 1.6~1.8kg of rice husk **[12].**

3.2 Electricity generation potential through excess risk husk gasification for studied mill:

The rice paddy of 1 ton consumes approximately 30 – 60 kWh to give 600 – 700 kg of rice and the rice husk as a residue of 220 kg, which, equivalent to power generation of 90 – 125 kWh. Generally rice husk constitutes about 23 percent of the paddy weight **[13].**

The energy potential of the rice husk residual resource for the studied mill estimated as below;
Considering gasification efficiency 70% and rice husk to electricity conversion efficiency 20%, electricity generation potential by 14 ton excess rice husk = (14X1000X0.20)/(24X3600)

= 0.47638 MW = 470 KW (Say)

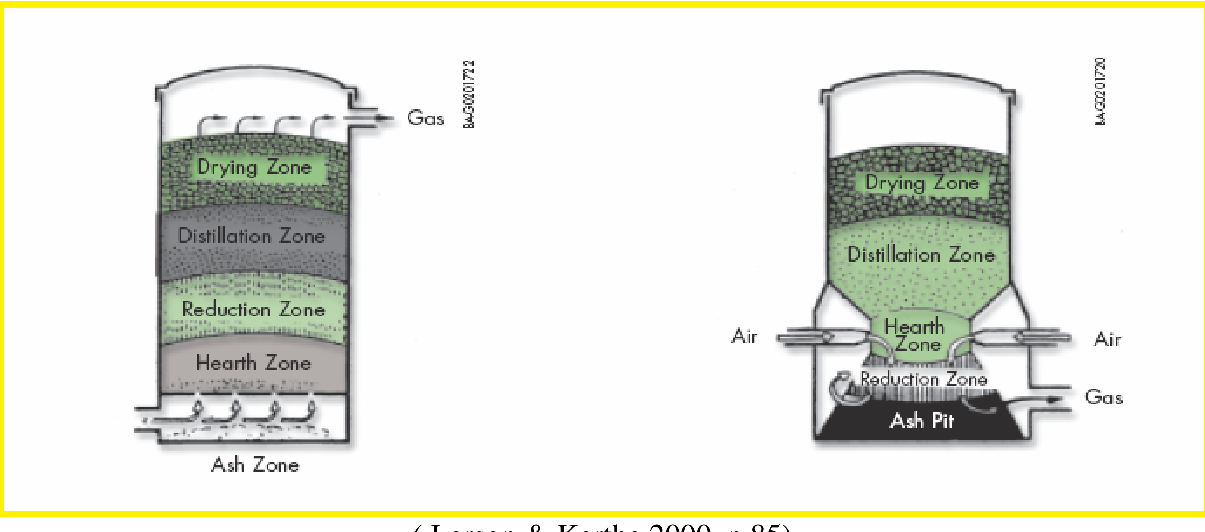
The project capacity is 470 KW for the studied mill and out put of the plant will be = (470X350X24)/1000000 = 3.948 GWh/year (Considering 350 days operation). The project lifetime is 10 years considered. Therefore, for project lifetime, 39.48 GWh electricity generation is possible.

3.3 Technological prospects and choice of technology:

Rice husk gasifier: Gasification has become more and more significant in biomass utilization. A numbers of types of gasifiers have been developed to meet the different needs. Biomass gasification is a process of converting solid biomass fuel to gaseous combustible gas called producer gas through a sequence of complex thermo-chemical reactions by means of partial oxidation at elevated temperature (about 800°C) in a reactor called gasifier. In the first stage, partial combustion of biomass to produce gas and char occurs along with heat generation. This heat is used in drying of biomass to evaporate its moisture as well as for pyrolysis reactions to bring out volatile matter and to provide heat energy necessary for further endothermic reduction reactions for production of producer gas. High temperatures and a controlled environment lead to virtually maximum of the raw material being converted to gaseous fuel. It takes place in two stages. In the first stage, the biomass is partially combusted to form producer gas and charcoal. In the second stage, the $C0_2$ and H_2O what are produced in the first stage are chemically reduced by the charcoal by forming CO and H_2. The composition of the producer gas consists of carbon monoxide, hydrogen, carbon dioxide, methane and nitrogen.

Down draft (Co-current) gasifier: In the co-current moving bed reactor, the air entrance at middle level of gasifier above the grate and the resulting mixture of air and gas flows down co currently through the gasifier reactor. All the decomposition products from the pyrolysis reaction and drying zones are forced to pass through the oxidation zone. This leads to thermal

Updraft fixed-bed gasifier (left) and Downdraft fixed-bed gasifier (right)



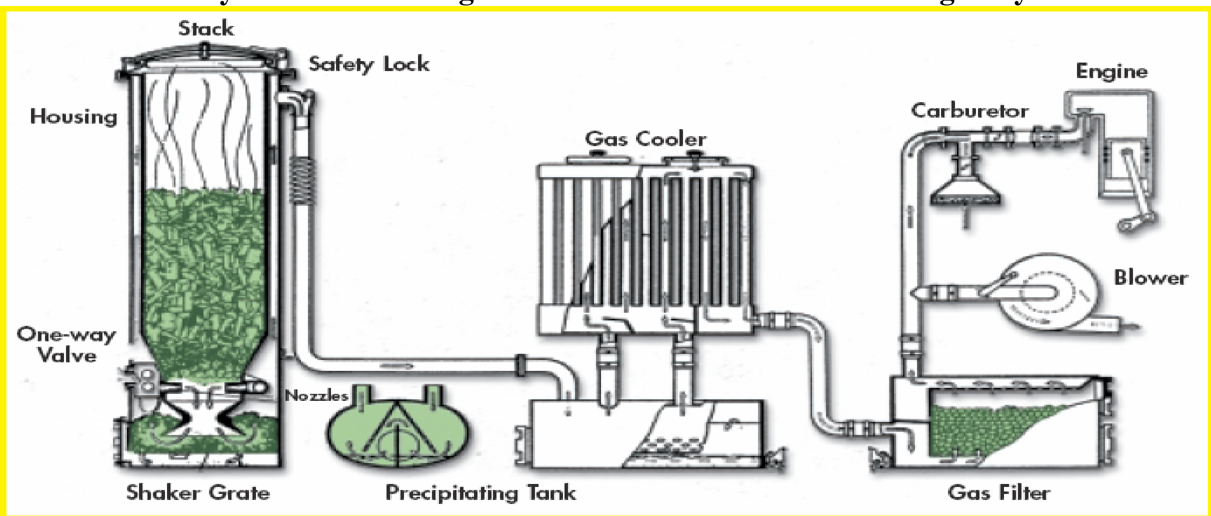
(Larson & Kartha 2000, p.85)

cracking of the volatiles that results reduced tar content in producer gas. For this reason, it is very attractive to use this gas for engine operation. On the other hand, tar production by up draft gasifier is higher than down draft one. So, extra care is needed in feeding the fuel to the stoker to maintain proper combustion conditions. The higher level of unburnt carbon in the stoker ashes makes the ash less suitable for profitable uses. Moreover proper tar handling is the most important task for smooth gasifier operation **[14].**

Proposed gasifier project components:

a) A down draft gasifier of 470 KW capacity coupled with diesel generator (suitable for gas and diesel fuel operation) to produce electricity around the year for the studied mill is considered.

Basic layout of a biomass gasifier international combustion engine system



(Larson & Kartha 2000, p.86, National Research Council, 1983)

b) One new dual fuel generator of 200 KW capacity. Existing 345 KVA diesel generator has to be used by simple modification to convert it for running suitably using diesel and producer gas to generate 270 KW power.

Proposed Gasifier system consists of automatic screw feeder, gasifiers, wet filter, bowler cyclone, dry filter, carburetor, engine and generator. It is designed to operate on a constant load and can feed the excess power to the local community.

Choice of technology: The combined heat and power generation via biomass gasification techniques connected to gas-fired engines or gas turbines can achieve significantly higher electrical efficiencies between 22 % and 37 % compared to biomass combustion technologies with steam generation and steam turbine (15 % to 18 %) **[15].** Due to good efficiency (60-70%) of biomass gasifier, the author has considered rice husk gasifier option to replace existing power supply by BPDB as well as three-forth portion of diesel consumption by rice husk for existing 345 KVA diesel generator. The producer gas generated from rice husk gasification has low a calorific value (1000-1200 Kcal/Nm3), but can be burnt with a good degree of control without emitting smoke. Each kilogram of air-dry biomass (10% moisture content) yields about 2.5 Nm3 of producer gas. This gasifier can be operated at atmospheric pressure or higher. The proposed plant can meet round the year electrical demand for the studied rice mill and surplus electricity can be sold to other mill or at local community. More over, the author has chosen down draft gasifier to avoid much tar and to get good quality producer gas that will be suitable for dual fuel internal combustion engine, diesel generator. Furthermore, average yearly solar insolation for Naogaon District is 5 Kwh/m^2 recorded from 1988-1998 and moisture percent in rice husk is less than 30% which is suitable for gasification.

3.4 Green house gas abatement by proposed project:

Energy consumed for 3.948 GWh by burning natural gas with an average conversion efficiency of 35% = 3.94×10^9 Wh $\times \frac{3600 \text{ sec}}{\text{hr}} \times \frac{1}{0.35}$ = 40.608 TJ

CO_2 emission by 470 KW natural gas based plant of BPDB

= 40.60 TJ × 56.1 tonnes/TJ

= 2278.10 Tons …………….(I)

For the project diesel needed for dual fuel engine = 378000 Litre/year

= 378000X 0.87 = 328860 kg

(1 litre diesel = 0.87 kg)

CO_2 Emission by this diesel fuel = 0.0000433X328860X74.06 = 1054.58 Tons/year …(II)

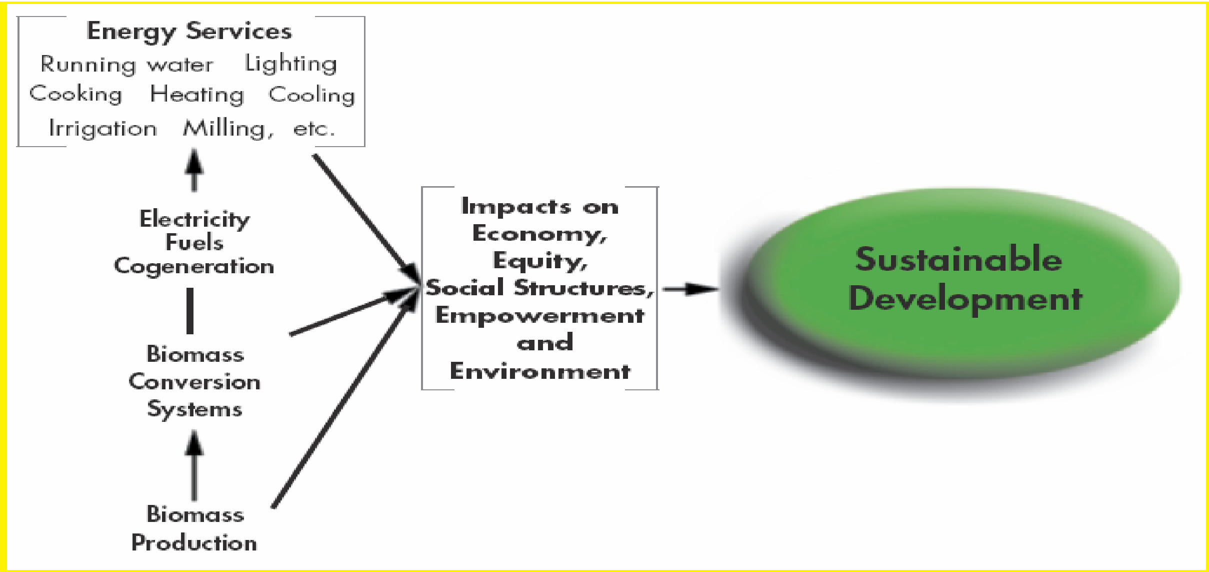
Less CO_2 emission = 2278.1088-1054.58 = 1223.528 Tons/year

So, for project lifetime CO2 emission abatement will be 12236 Tonnes.

(Considering heating value of diesel 0.0000433 TJ/kg and CO2 emission factor of diesel fuel = 74.06 Ton CO_2/TJ and CO_2 emission factor for natural gas in Bangladesh is 56.1 per TJ) **[16].**

3.5 Biomass energy system and linkage to rice mill community for sustainable development

The proposed project can significantly improve the studied rice mill community's socio-economic situation. Now a days electricity is one of the most important factors for development



(Larson & Kartha 2000, p.13)

for the education sector, food and agriculture, security, safety and environment, industrialization as well as human resource development. After fulfilling the electricity requirement of the studied mill, about 200 KW power can be supplied to local community's 'electricity ill fated' people, who showed demand for electricity and thereby community development can be achieved.

4.0 Conclusion: Implementation of improved rice husk gasification system in the rice mill can produce electricity above the mill's process requirement and that might reduce CO_2 emission significantly. Therefore, as per Clean Development Mechanism (CDM) project guideline, the proposed project could achieve international grants for CO_2 abatement credit. For sustainability of rice husk gasification based electricity generation, ensured supply of paddy rice to rice mills, supplement of other biomass (if necessary), quality fuel (husk), demand for electricity and proper management of system, i.e., ensured good plant operation and management are the key factors. The rice processing industry can sell a notable amount of electricity to local communities or to the grid and thereby can earn a considerable amount of revenue by introducing improved biomass to electricity conversion technology. Furthermore this project could be a demonstration project to other rice mills in Bangladesh and thereby technology transfer can be occurred.

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