

Viability of Rice Husk Ash Concrete Brick/Block from Green Electricity in Bangladesh

Mohammad A. N. M. Shafiqul Karim

Abstract—As a developing country, Bangladesh has to face numerous challenges. Self Independence in electricity, contributing to climate change by reducing carbon emission and bringing the backward population of society to the mainstream is more challenging for them. Therefore, it is essential to ensure recycled use of local products to the maximum level in every sector. Some private organizations have already worked alongside government to bring the backward population to the mainstream by developing their financial capacities. As rice husk is the largest single category of the total energy supply in Bangladesh. As part of this strategy, rice husk can play a great as a promising renewable energy source, which is readily available, has considerable environmental benefits and can produce electricity and ensure multiple uses of byproducts in construction technology. For the first time in Bangladesh, an experimental multidimensional project depending on Rice Husk Electricity and Rice Husk Ash (RHA) concrete brick/block under Green Eco-Tech Limited has already been started. Project analysis, opportunity, sustainability, the high monitoring component, limitations and finally evaluated data reflecting the viability of establishing more projects using rice husk are discussed in this paper. The by-product of rice husk from the production of green electricity, RHA, can be used for making, in particular, RHA concrete brick/block in Bangladeshi aspects is also discussed here.

Keywords—Project analysis, rice husk, rice husk ash concrete brick/block, compressive strength of rice husk ash concrete brick/block.

I. INTRODUCTION

BAKGLADESH is a developing country in the world, located in south Asia and covering a total area of 143,998 sq km (55,598 sq miles). The world population as of 2015 is 7.3 billion, of which Bangladesh contributes 152.4 million [1] By 2050, the world population is expected to be much higher, and while some countries will control population growth, for countries like Bangladesh, nothing will change. Bangladesh is expected to face a more complicated situation with its estimated population of 202 million by that time [2].

In 2015, 34.3% of the total population in Bangladesh resides in urban areas, and the annual rate of urbanization is 2.4% (2010-15 estimate) [3].

To resist urbanization and develop the backward population is a major challenge for Bangladesh. The country's urban areas currently do not have the resources to fulfill the basic needs of its citizen in the face of an increasing rate of urbanization. To promote decentralization and rural development, it is important to create new entrepreneur at

rural area to remove poverty and ensure their financial security. When rural communities are content with their level financial security, there is less interest in urbanization.

Generally, when the financial development of backward populations exists, overall national development must also exist. The rural development process can be accelerated through the contribution of government and private organizations. The poverty headcount ratio of Bangladesh is in Fig. 1 [4].

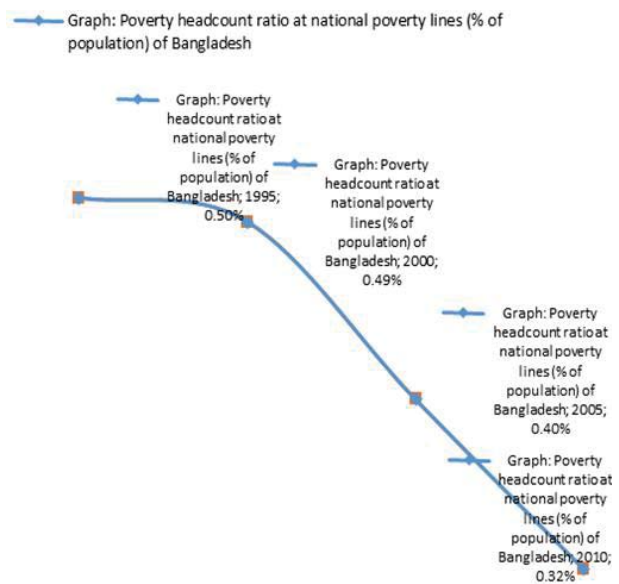


Fig. 1 Poverty Head Count Ratio at National Poverty Lines (% of Population) of Bangladesh

II. RICE HUSK IN BANGLADESH

Total rice production in Bangladesh was about 10.59 million tons in 1971 when the country's population was only about 70.88 millions [5]. Out of 722,718,631 tons of paddy rice produced in the world, Bangladesh contributed about 50,627,000 tons as of 2011 [6], yielding approximately 10 million tons of rice husk.

In Bangladesh, 64% of the total energy production comes from biomass. Rice husk plays the vital role, contributing 22% of the total of biomass resources. Bangladesh has the great opportunity to ensure the maximum effective use of available rice husk. However, in Bangladesh, less than 20% of the rice is milled in large units. Overall milling is typified by a vast predominance of small mills. Some 90% of these rice mills are

Mohammad A. N. M. Shafiqul Karim, Materials Engineer, is with the Grameen Telecom Trust, Bangladesh (phone: +8801717-624423; fax: 880-2-9023916; e-mail: engr.anmshafiqul@gmail.com).

located in four cluster areas– i) Dinajpur, ii) Sherpu, iii) Ishwardi, and iv) Kaliakoir [7].

A. Rice Husk Production

The ratio of rice husk to rice grain of the paddy is governed by the following factors:

- (i) The soil productiveness.
- (ii) The characteristics of paddy.

(iii) Paddy to Rice conversion process.

(iv) Rice husk collection process.

Since there are several factors influencing the rice husk to paddy ratio, there is a large variation of husk production from the paddy. Average rice husk production works out at 220 kg/ton of paddy processed [8].

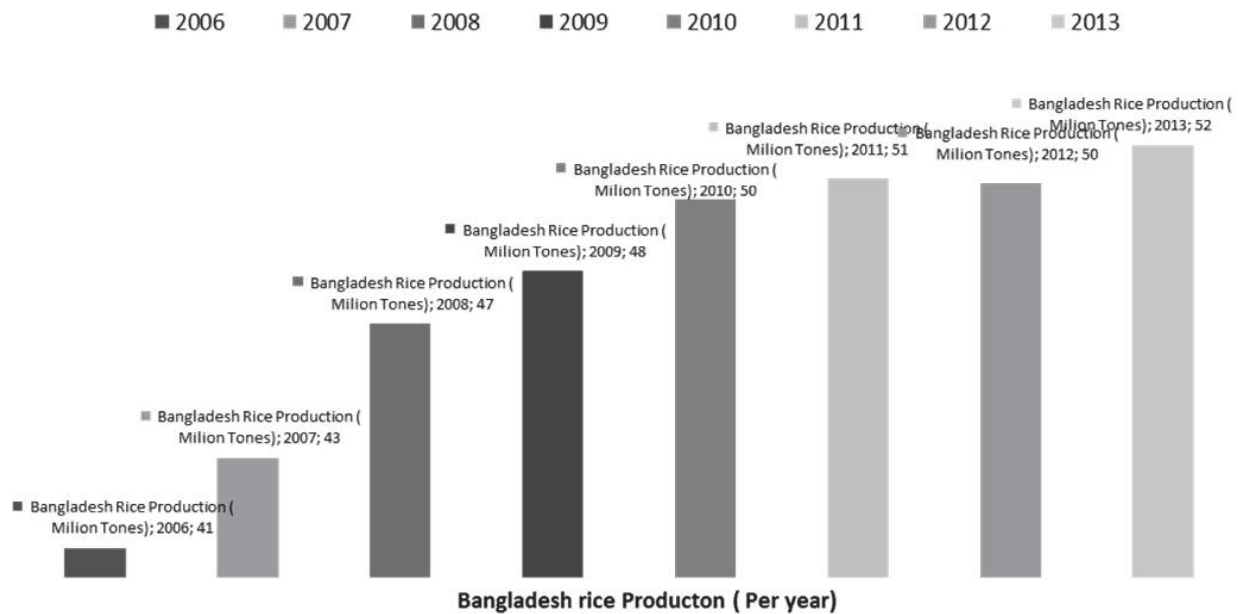


Fig. 2 Rice production in Bangladesh [6]

III. GREEN ELECTRICITY

Almost 1.5 billion people around the world survive without electricity, with the majority resides in rural areas. Bangladesh faces a huge shortfall between electricity demand and production, and sizeable remote villages in Bangladesh, for example, have no sufficient source of electricity. The real scenario is more pathetic for the nation when people are

deprived of basic healthcare due to the absence of electricity. The United Nations estimates that on average, US\$35-40 billion needs to be invested every year until 2030 for everyone to have access to a reliable electricity supply.

Per capita energy consumption in Bangladesh is lowest in the Indian subcontinent, as is given in Fig. 3 [3].

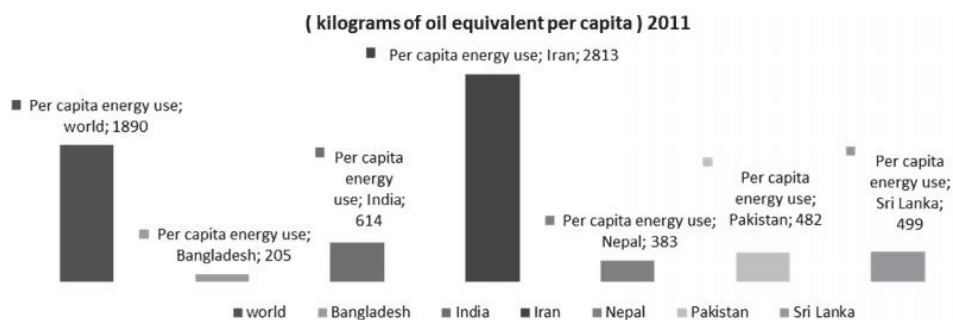


Fig. 3 Per capita energy consumption of Bangladesh

Considering the 7% GDP growth rate, peak demand was 10,283 MW in 2015, according to the PSMP- 2010 (Power System Master Plan) of a Bangladesh Power Development Board study, but the reality is different. According to the

forecast of the Bangladesh Power Development Board, maximum generation was 8,177 MW on 13th August 2015. The country remains far meeting its real electricity demand, and a large percentage of the popular continues to exist

without electricity, which can create a sense of despondency. According to the PSMP- 2010 (Power System Master Plan) of

a Bangladesh Power Development Board study, year-wise peak demand forecast is given below [9]

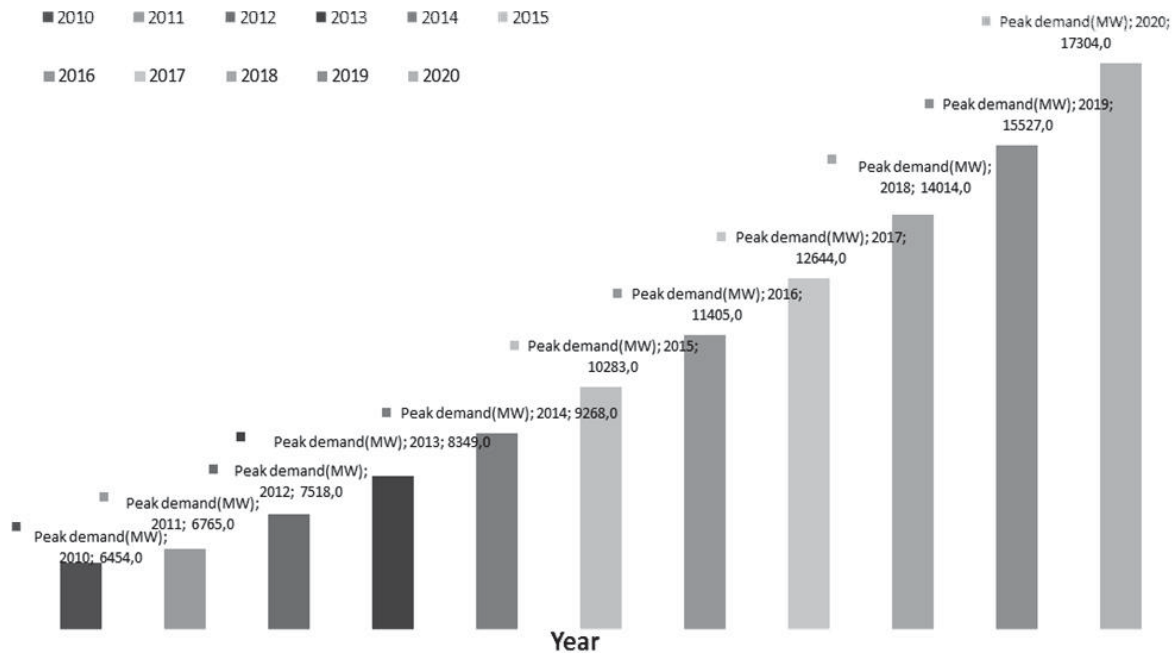


Fig. 4 Peak demand in Bangladesh

The crisis has been identified as the Social Darkness of rural Bangladesh. Diesel generators are the most common way to generate electricity in rural communities, costing the country huge losses in foreign currency exchange, as all fuels is imported from abroad. Diesel generators also generate environmental pollution. Per capita carbon dioxide emissions will continue to rise with the use of diesel generators.

A. Solar Home System (SHS)

Solar home systems are a great way to ensure renewable electricity supply to every home; however, the price ranges from 95.74-574.4 USD depending on the system capacity. Although households can pay for a SHS by regular instalments, many rural families are reluctant to buy them due to the high repayments, and hence, the high total costs of installation. Presently, SHS alone produces 45 MWe in Bangladesh [10].

B. Rice Husk Based Biomass Power System

Small size rice-based biomass power plant (capacity 50 - 100 kW) installing local materials and operated by local skill people is a new business concept in Bangladesh. The raw materials contributing to the power system are biomass wastes (e.g. rice husk, mustard husk /stem, corn cob, certain grass, etc.). It can show itself as a business model which can also generate revenue. Solar panels and Solar Home Systems continue to be popular small power generators in Bangladesh, but are battery dependent and costly to install. Moreover, a Rice Husk-based power system is more suitable for rural

areas, especially those located near the main clusters of rice mills in Bangladesh.

1. Supplying Reliable Electricity to Households and Small Businesses

As mentioned above, households and small businesses pre-pay for supplied power. Each household will be connected to the grid through a programmable smart pre-paid meter and pre-pay BDT 250 per month for a package of 3/4 -LED Lamps and unlimited cell phone charging.

2. Monetization of Rice Husk Char (RHC)

RHC plays an important role in the biomass gasification process and depends on requirements, almost 20% of RHC, which is produced from rice husk, supply into the Rice mill boiler reactors.

IV. PROJECT ANALYSIS

Some organizations in Bangladesh believe that greater innovation is required, including research and experiment for new projects in the field of RHA brick from green electricity. Using By-Product of Rice Husk Based Power Generation, here we show the project analysis of the first established RHA brick project in Bangladesh, developed by Nobel Laureate Professor Muhammad Yunus. The company, Green Eco Tech Limited, was registration on 13 May 2015, and is joint venture agreement between Grameen Telecom Trust and Sarkar Ardhendu Ripon, which was signed on March 2015 to develop the Rice Husk-based Biomass Power System with Eco-Friendly Rice Husk Ash Concrete Block/Brick Project.

This is a social business project, including two linking projects, which are:

1. Rice husk-based biomass power generation project.

2. RHA brick manufacturing project, where the main raw material is RHA.



Fig. 5 Rice husk-based power plant, Bangladesh

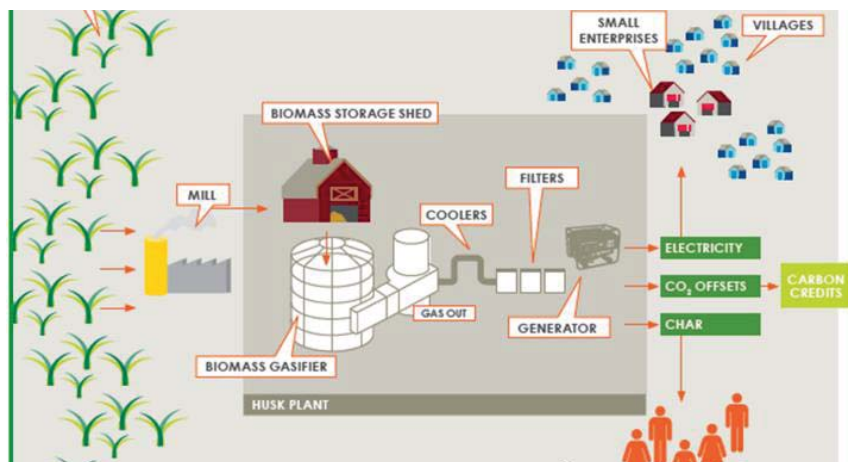


Fig. 6 Rice husk-based biomass power plant system

A. Introduction to the Proposed Experimental Project

- Ownership - Grameen Telecom Trust - 90% and Mr. Sarkar Ardendu - 10%
- Working Area - Boalmari, Faridpur and Lohagara, Norail.
- Total of six plants will be established, each with a capacity to produce 50 KW of electricity.
- Technical Partner: Husk Power Systems of Bihar, India. Since 2008, this company has successfully installed more than 80 plants.

B. Economic Viability of the Project

Total Project Value – BDT 108,500,000 (\$1,391,026) (\$ 1 = BDT 78.00)

Payback Period: Approximately 5.18 years.

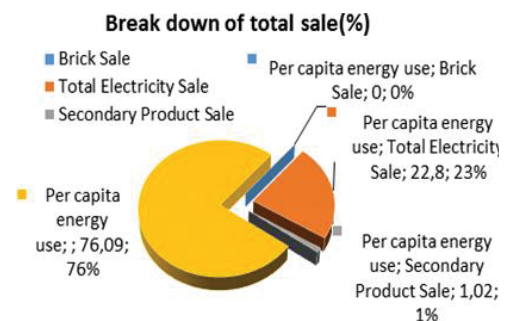


Fig. 7 Breakdown of First Year Total Sale (%)

TABLE I
SALES CALCULATION OF RATED CAPACITY

Sl.	Total Production	Unit	Rate in Taka		Total sales in Taka	Year-1 Capacity Utilization 80%	% of total Sale
Basic Connection - 40 watt (300 Connection x 6 Plant)	1,800	Nos.	4200	Per Year	7,560,000	6,048,000	
Additional Elec. Unit (kWh)	490,560	per Unit	22.20	Per Year	10,890,432	8,712,346	
	Total Electricity Sale					14,760,346	22.86%
Husk Char from 6 Plants	93	M.T.	2000	Per MT	186,300	149,040	
Rice Husk Briquettes	82	M.T.	7000	Per MT	573,804	459,043	
Fly Ash Sale to Brick Plant	460	M.T.	350	Per MT	161,000	128,800	
	Secondary Product Sale					736,883	1.14%
Brick Sale	8,970,000	PCS.	7200	Per 1000 PCS.	64,584,000	49,083,840	76.00%
	Total Sale				83,955,536	64,581,069	100%

TABLE II
ECONOMICAL VIABILITY CALCULATION

Particulars	1st Year			
	Electricity		Brick	
	Monthly	Yearly	Monthly	Yearly
Sales	1,230,000	14,760,000	4,090,320	49,083,840
Other Sales (By Product)	-	-	55,021	660,247
Net Sales	1,230,000	14,760,000	4,035,299	49,744,087
Less: Variable Cost:				
Production Cost	827,313	9,927,760	1,719,008	20,628,096
Total Variable Cost	827,313	9,927,760	1,719,008	20,628,096
Contribution Margin (CM)	402,687	4,832,240	2,316,291	29,115,991
Fixed Cost:				
Salary & Bonus				
Admin Overhead (E 30% B 70%)	200,688	2,408,250	643,771	7,725,250
Selling & Distribution	16,100	193,200	37,567	450,800
Selling & Distribution Exp (B)	-	-	53,667	644,000
Depreciation	163,388	1,960,656	381,239	4,574,865
Total Fixed Cost (FC)	387,509	4,650,106	1,127,243	13,526,914
Net Profit	15,178	182,134	1,189,049	15,589,077
Tax @ 35 %		63,747		5,456,177
Net Profit after Tax		118,387		10,132,900

C. Measuring Social and Economic Impacts

1. The Social Impacts of this project will be:
 - i) To create affordable, reliable and environmentally friendly bricks made from fly ash.
 - ii) To create a brick that is twice as strong, but weighs almost 30% less than a conventional clay brick.
 - iii) To reduce the brick work costs by almost 25%.
 - iv) To recycle material previously considered waste material.
 - v) To reduce the dead weight of a building.
 - vi) To reduce the demand of conventional paving bricks.
 - vii) To reduce deforestation for conventional clay brick works.
 - viii) An estimated reduction in the use of timber and coal for fuel of 380 tons per year and 700 tons per year, respectively.
 - ix) To reduce land excavation for conventional paving bricks and mud consumption by 9,000 tons per year.
 - x) Less heat transfer due to hollow brick structure.
 - xi) Combined, these two projects will create employment for 75 employees in the areas of Production, Administration and Maintenance.

2. Economic Impact of the Project: To bring affordable, reliable and environmentally sustainable energy to some of the 60% of rural households who do not have access to the national electricity grid. With six plants, the aim is to provide electricity to between 10,000 and 15,000 energy-deprived households. To replace expensive, polluting diesel-based generators (to generate electricity) and/or kerosene (for lighting), which will reduce the kerosene expense by about 350 Taka per month for each family. As well as to create additional income for farmers supplying rice husk, which is currently an under-used by-product. Rice mill owners use of improved rice husk combustion to reduce the demand of rice husk as fuel.

D. Business of RHA Production

This second project is a link project to the first. As the Bio gas plants will produce 70% fly ash from consuming biomass, this project plans to convert the RHA into RHA concrete bricks by mixing it with sand and cement. Utilizing ash from every plant will also solve the environmental issues associated with dumping the ash.

V. MANUFACTURING OF RHA CONCRETE BLOCK/ BRICK

TABLE III
PROPOSED MIX RATIO

1.	RHA	65%
2.	Sand	25%
3.	Cement	08%
4.	Stone Chips	02%
	Total	100%



Fig. 8 Different types of RHA concrete block/bricks

A. Process Flow Diagram for the Manufacture of Flyash-Sand-Cement Brick

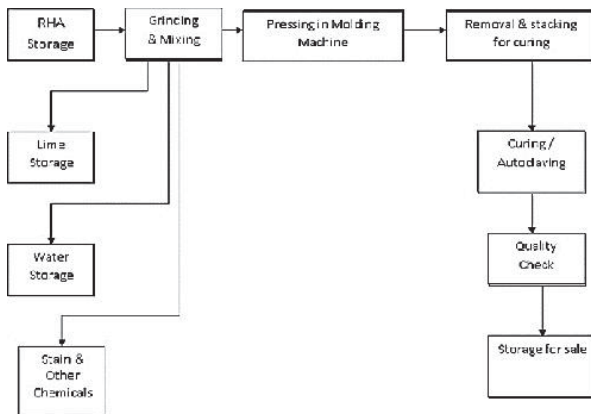


Fig. 9 Flow diagram for the manufacture of Fly ash-Sand-Cement Brick

B. Compressive Strength of RHA Concrete Block/Brick

TABLE IV
RHA CONCRETE BLOCK/BRICK'S COMPRESSIVE STRENGTH TEST RESULTS IN 28 DAYS

Batch No.	Failure Loads [KN]				Compressive Strength [N/mm ²]			
	RHA 65%	RHA 60%	RHA 55%	RHA 50%	RHA 65%	RHA 60%	RHA 55%	RHA 50%
1	203	242	282	311	15.09	17.99	20.96	23.12
	208	245	284	315	15.46	18.21	20.98	23.17
	205	247	281	309	15.24	18.35	20.95	23.09
	209	244	286	318	15.45	18.18	21.18	23.19
	218	242	279	319	16.10	17.96	20.92	23.21
2	211	249	280	316	15.58	18.38	20.93	23.14

As per the Bangladesh National Building code, the crushing strength of conventional brick must not be less than 12 N/mm².

C. Highly Monitoring Component

Cement compressive strength is dependent on its practical surface area. The particle size of the cement is about 35 μm . A similar principle is applicable for RHA; a higher fineness allows it to react with $\text{Ca}(\text{OH})_2$ to produce more calcium silicate hydrate (C-S-H) bond. This bond creates higher compressive strength. While finer RHA acts as a micro filler to enhance the cement pore paste structure. If the particle size of the RHA is finer than the cement, at about 25 μm , it will play an important role in ensuring high strength concrete.

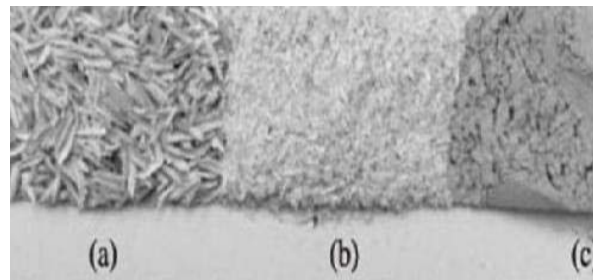


Fig. 10 (a) Rice husk, (b) Burnt RHA and (c) RHA after grinding

The burning temperature of the Rice Husk is also an important factor in the creation of the best quality RHA. Thus, the discovery of the highly effective burning temperature to get the best quality RHA is also a tremendous achievement.

It is important to undertake a market survey to assess the future viability of alternative sources of Rice Husk to ensure the sustainability of the project.

The silica content of the raw materials used in the power system (e.g. rice husk, mustard husk /stem, corn cob, certain grass, wood, etc.) differs for every case, and thus, controls for the varying levels are required to ensure a consistent strength of RHA Brick.

VI. RESTRAINTS / FURTHER INVESTIGATION

The total amount of RHA which is created by the previously mentioned Rice Husk-based Biomass Power System is not sufficient to supply the needs of the Rice Husk Ash Brick manufacturing project, contributing an estimated 40%-50% of building project requirements. To meet the remaining demand, it is important to establish a dependable, cost effective source for this project.

Long-term trials and testing are required to determine the best mix design that is economically sustainable, as the compressive strength and water absorption capacity of the concrete is greatly affected by various factors. Without research and development, it will be impossible to meet the commercial demand, in terms of the quality of the RHA concrete block/brick.

VII. CONCLUSION

The study results conclude that Rice Husk-based Biomass Power Systems with Eco-Friendly Rice Husk Ash Concrete Block/Brick Project is an important and feasible concept to meet the current rural electricity and sustainable development

demands. However, its viability depends on the availability of rice husk in selected rice processing zones in Bangladesh. Such projects are expected to have a positive social economic impact on rural development, and will help to ensure available and reliable electricity, which will boost local development.

Secondly, the findings confirm that the compressive strength of RHA concrete brick/block is better than that of clay bricks, and therefore, can easily replace the conventional clay brick in building construction.

According to the project information, theoretically, the second linking project (RHA concrete brick/ block project) is highly profitable compared to first linking project (rice husk-based biomass power generation project). However, the reality is quite different because of the insufficient quantity of available RHA. The linking project is capable of becoming approximately 100% efficient depending on the availability of RHA. In order to meet the energy target, it will be necessary to establish more Rice Husk-based Biomass Power Generation projects. It is worth mentioning that RHA quality will vary depending on the type of furnace system used by the rice mills providing the Rice Husks.

RHA is a versatile by-product that can be used in a number of different products or processes including soil development, organic fertilizers, green concrete, silica precipitation, and is a high quality super-plasticizer. It is time to begin the proper implementation of the above projects to bring reliable electricity supply to rural communities, which in turn will allow for improved healthcare and education, greater opportunities for business, as well as the introduction of new technologies and the Internet, adding to future prosperity.

http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=12&Itemid=126 (viewed on 5th September, 2015).

- [10] "Bioenergy Consult", The online version available at <http://www.bioenergyconsult.com/tag/rice-husk/> (viewed on 4th September, 2015)

REFERENCES

- [1] "BBC", Bangladesh country profile, BBC Asia, The online version available at <http://www.bbc.com/news/world-south-asia-12650940> (viewed on 30 December 2015)
- [2] "2015 World Population Data Sheet", The online version available at <http://www.prb.org> (viewed on 30th August 2015).
- [3] "Population, Consumption and the Environment 2015", by United Nations Population Division, Department of Economic and Social Affairs, The online version available at <http://www.un.org/en/development/desa/population/publications/pdf/environment/PopulationConsumptionEnvironment2015.pdf> (viewed on 28th August 2015).
- [4] "World Development Indicators", Poverty headcount ratio at national poverty lines (% of population), The online version available at <http://databank.worldbank.org/data/reports.aspx?source=2&series=SL.P.OV.NAHC&country=BGD> (Viewed on 19th December 2015).
- [5] "Rice in Bangladesh", Bangladesh Rice Knowledge Bank (BRKB), The online version available at <http://www.knowledgebank-brii.org/riceinban.php> (Viewed on 1st September 2015).
- [6] "Food and Agriculture Organization of The United Nations, Statistics Division", The online version available at <http://faostat3.fao.org/download/Q/QC/E> (viewed on 4th September, 2015).
- [7] Risat Abedin, M., & Shekhar Das, H. (2014, July 4). "Electricity from Rice Husk: A Potential Way to Electrify Rural Bangladesh." International Journal of Renewable Energy Research IJRER Vol.4, No.3, 604-609, July 2014.
- [8] "Rice Knowledge Bank", Accessed at September 2015, The online version available at <http://www.knowledgebank.irri.org/rkb/rice-milling/byproducts-and-their-utilization/rice-husk.html>. (viewed on 4 September, 2015).
- [9] "Generation Planning BPDB", viewed on August 2015, The online version available at