Biomass Briquettes: A Sustainable and Environment Friendly Energy Option for the Caribbean

Dr. Musti KS Sastry[1], **Dr. Jacqueline Bridge**[2], **Alvin Brown**[3], **Renee Williams**[4]
University of the West Indies, St Augustine Campus, Trinidad and Tobago

[1,3]Department of Electrical and Computer Engineering, [1]Email: Musti.Sastry@sta.uwi.edu;
[3]Email: Alvin.L.Brown@gmail.com
[2,4]Department of Mechanical &Manufacturing Engineering, [2]Email: Jacqueline Bridge@sta.uwi.edu;
[4]Email: renzi_w@yahoo.com

ABSTRACT

Since the beginning of the 21st century the cost of energy has been a significant percentage of countries' production cost. For most countries their main source of energy has been fossil fuels. The use of fossil fuels is not sustainable as this is a non renewable source of energy. This paper outlines the adoption experiences of biobriquetting industry across the globe and current experimental investigations carried out by us. It then goes into detail about a relatively untapped option in the Caribbean – biomass briquettes, specifically countries like Jamaica where the energy import bills are very high. Biomass briquettes have been successfully used as alternative form of fuel in a number of countries. The overall bio-briquetting process from production to end-use offers solution to the disposal of harmful waste, results in a cheaper form of energy, creates new employment/ business opportunities and is very eco-friendly.

Keywords: Biobriquettes, Caribbean, Alternative Energy Resources, Waste to Energy

1. INTRODUCTION

With the exception of Trinidad and Tobago, all Caribbean countries are net importers of oil and gas products. To reduce the negative effects importing oil and gas on their foreign exchange balance, many of these island nations are investigating the use of alternative energy sources. Biomass briquettes (also known as biobriquettes) have emerged as an attractive option. Furthermore, the production of biomass from yard-waste can assist in the alleviation of another problem in urban areas of the Caribbean – waste disposal.

A sustainable model for employing yard-waste bio-briquettes will have many facets: efficient collection of the waste, effective production of the briquettes and an appropriate low pollution use for the briquettes. Biomass briquettes are formed by compressing pre-processed bio-waste, thereby increasing specific density and calorific value. Briquettes give off more heat energy with far less air pollution than uncompressed bio-waste. In attempting to develop an effective production system, the optimal choice of process parameters must be considered during the actual engineering design of the machine.

Several factors that affect the quality of the briquettes produced were investigated, namely, compaction pressure, compaction temperature, the ratio of the yard waste to binder, the moisture content of the constituents and the particle size of the yard waste (Ashden, 2012). The calorific value of the briquette was chosen as the performance characteristic. Experiments were conducted using the well known Taguchi orthogonal designs. This is to ensure the use of least possible number of tests to determine the operating conditions for producing the most consistent briquettes. The results of these experiments will be used to ensure that a robust briquetting machine is designed.

2. INTERNATIONAL PERSPECTIVE OF BIOBRIQUETTING INDUSTRY

Biomass Briquettes are not only used in developing countries, they are used and endorsed by developed countries as well (Mishra and Grover, 1994). The Biomass Energy Centre (BMC, 2011a) stated that "An EU-wide suite of standards for solid biofuels, including pellets, covering both the properties of the fuels, and also how they are to be evaluated, is being developed". To accomplish this, specific fuel specifications and classes are defined (BMC, 2011b). The United Nations Development Program is supporting a biomass briquetting projects in various countries, including Nepal (CNN, 2009). Infact, CNN has reported that instead of cutting down trees the women in some communities in Nepal are using a weed that has become a pest. The weed is burnt in a pit to make charcoal the charcoal is grounded and mixed with water and dirt squeezed in a mould. These moulds are then dried and resulting briquettes are used for cooking. This has become a business for many with at least 60 communities in Nepal involved at production level. In many areas the forests are coming back to life and wildlife is returning.

3. BIOBRIQUETTING INDUSTRY IN CARIBBEAN REGION

There is no evidence of existence of biobriquetting industry in the Caribbean. However, research investigations in this area have been taken up. Roxanne and Johan (2011) investigated the creation of biomass briquettes from Trinidad and Tobago's local agricultural waste. The solid wastes included coconut shell, cocoa shell, and newspapers. Briquettes were developed and tested for calorific value, ash content, and hardness. In their experiments they discovered briquettes with the composition 75/20/5 coconut shell/cocoa shell/newspaper were the best combination in terms of heating value, low ash content, and resistance to shock and impact which could occur during handling and transportation. A cost evaluation was done on the production of biomass briquettes and it was ascertained that a small plant producing briquettes at a rate of 500 tons/year at cost of 1 USD/kg would have a payback period of fourteen months (Roxanne and John, 2011). As of now, biobriquettes may not attract the consumer market in Trinidad and Tobago, due to very low oil/ gas prices. However in the years to come, Trinidad's natural energy resources may deplete. Hence, a good business strategy is important to push the idea of creating a sustainable market for bio-briquettes.

Brown (2012a, 2012b, 2012 c) has focussed specifically on the energy needs and importance of creating biobriquette market in Jamaica (and the Caribbean). It is important that the Jamaican government considers environment friendly alternative sources of energy and the option of bio-briquettes is the best for the retail consumer segment to meet the domestic energy levels as a first and quick step. In fact, the Jamaican government cited plans to allow energy providers to choose what energy sources they would use to power their plants: one option cited was coal (Brown, 2012a). Coal-based electricity plants are one of the oldest forms of electricity generation. However, electricity generation using coal, though stable, would provide a number of challenges including significant increase in the pollution the environment. Brown (2012c) stated there are many by-products of coal that are harmful to our health and environment including mercury, sulfur dioxide and particulate matter (PSR, 2009). The salient points raised by PSR(2009) are:

> *The link between burning coal and adverse health was made strikingly clear in Dublin, Ireland in the 1990s. Because of increases in the cost of fuel oil in the 1980s, Dubliners switched from oil to bituminous coal to heat their homes and provide hot water. Subsequent increases in air pollution were associated with an increase in in-hospital deaths due to respiratory diseases. This led the Irish government to ban the marketing, sale, and distribution of bituminous coal on September 1, 1990. In the year that followed, black smoke concentrations declined by 70% (35.6 µg/m3), respiratory deaths fell by 15.5%, and cardiovascular deaths fell by 10.3%. Approximately 450 lives were calculated to be saved that year by this measure, and hundreds of acute illnesses were prevented. Although burning coal was not the only cause of these illnesses, burning coal was clearly a major factor in the production of the complex mixture of airborne pollutants that had protean adverse effects on human health.*

According to Jamaica's National Energy Policy 2009-2030, Jamaica intends to get 20% of its energy from renewable sources by 2030 (MME, 2009). The vision of Jamaica's energy sector is "a modern, efficient,

diversified and environmentally sustainable energy sector providing affordable and accessible energy supplies with long-term energy security and supported by informed society on energy issues and an appropriate policy, regulatory and institutional framework". This national outlook and circumstances naturally point to the use of cheaper, environmentally friendly fuels such as bio-briquettes for obvious reasons.

It is not possible to reduce the carbon footprint while employing coal as a fuel. Coal technology is banned in a number of countries. The use of coal technology is one of the reasons China and America have not yet signed the Kyoto Protocol because they have a large amount of their electricity generation done in coal factories. Biobriquette option provides a great relief to countries such as Jamaica where waste (bagasse, coconut shells, grass and newspapers) management is an issue. Specifically in case of Jamaica, rat and rodent infestation in many parts of the corporate area is a big menace. Major reason attributed to this issue is the irregular scheduling of garbage collection (Edwards 2012). It can be easily understood that the biobriquette making option is indeed sustainable, environment friendly, solves existing problems and also creates jobs.

4. BIOBRIQUETTE MACHINE DESIGN AND EXPERIMENTAL INVESTIGATIONS

Two aspects play major role in the overall process of biobriquetting. The first aspect is the briquette making machine and the second aspect is the components (or ingredients) that make up the biobriquette (Mishra and Grover, 1994; REC, 2012; Ashden, 2012). These two factors influence the final calorific value to a greater extent. At the University of the West Indies, St Augustine Campus, Trinidad, investigations have been undertaken to design and build a biobriquette making machine and component selection. There have been several machine designs, shapes and sizes have been reported thus far. Composition and compression of the briquette making material are the essential aspects of the bio-briquette. For the current investigations, locally available material is considered, grass and waste paper, though bagasse and banana leaves can raise the calorific value of the briquette significantly. It should be noted that bagasse and banana leaves are available in abundance in Jamaica and Grenada.

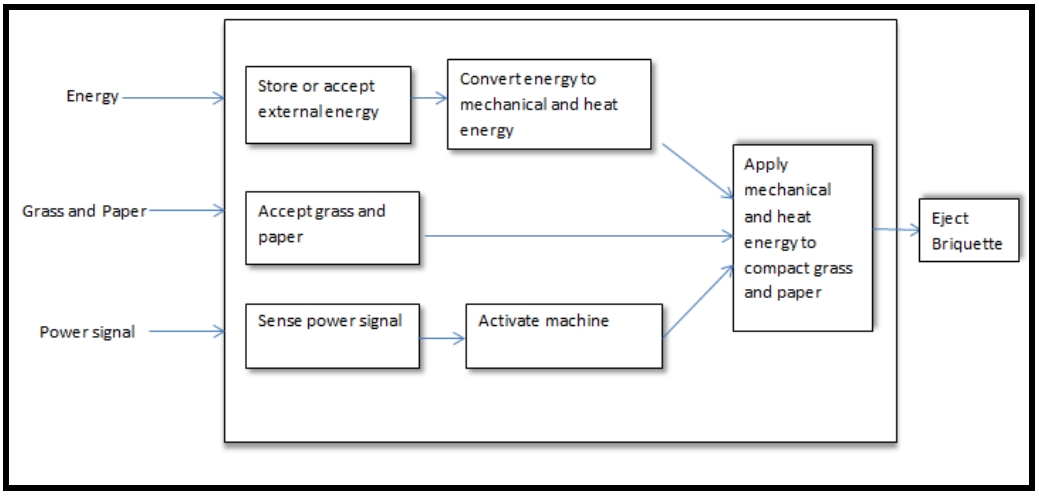

Figure 1: Functional Design of the Bio-briquette making process

Experiments were conducted to find the best ratio for grass and paper biomass briquettes. These Briquettes were formed by sieving, shredding, adding binder and water, compacting and cooling. The functional design is shown in Figure 1. There are three inputs to the briquette machine to be designed, energy, feedstock (grass and paper) and the power signal. The machine will detect a power signal and will be activated. The machine will store or accept external energy and convert this into mechanical and heat energy. The Mechanical and heat energy will be applied to the feedstock and the grass and paper will be compressed into briquettes.

To implement the functional design and to build a suitable briquette making machine, several design alternatives have been considered. Three important design alternatives are presented in this paper. Figure 2 shows the design for Concept A involved input power that was electrical, its drive system was hydraulic, its compaction method was a piston press and its feed system a screw feed.

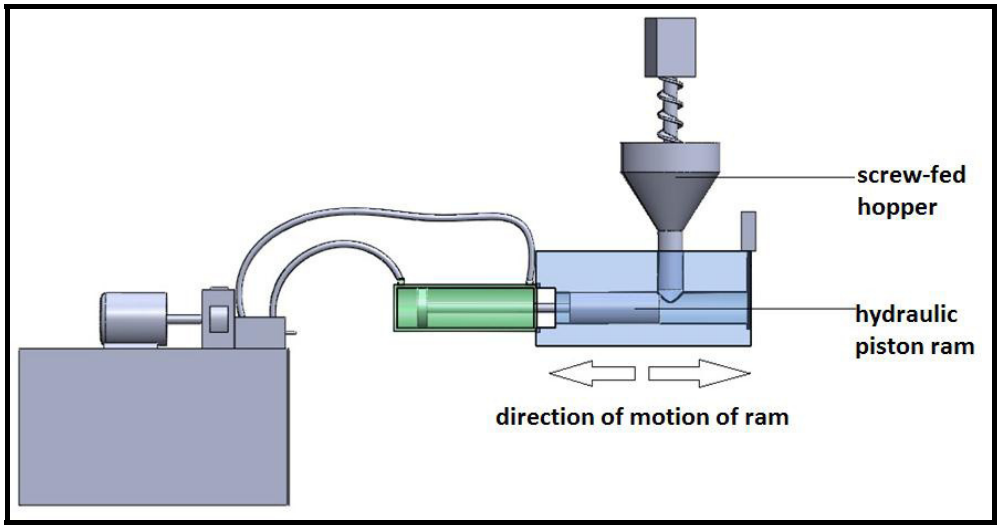

Figure 2: Concept A Design

Figure 3 shows Concept B's design. Its input power was also electrical and had a mechanical drive system. A roller press was used for compaction gravity feed for feed method.

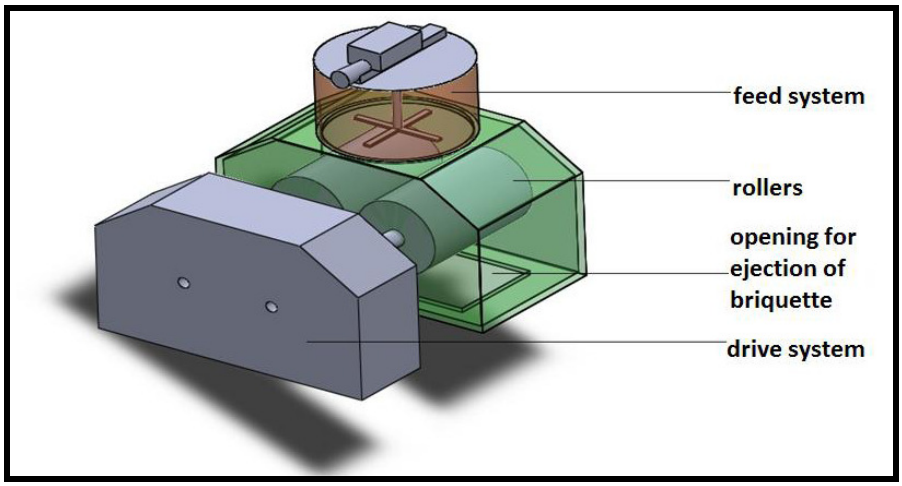

Figure 3: Concept B Design

Figure 4 shows Concept C's design. It had electrical input power and a mechanical drive system. A screw extruder was used for compaction and gravity feed was used for its feed method.

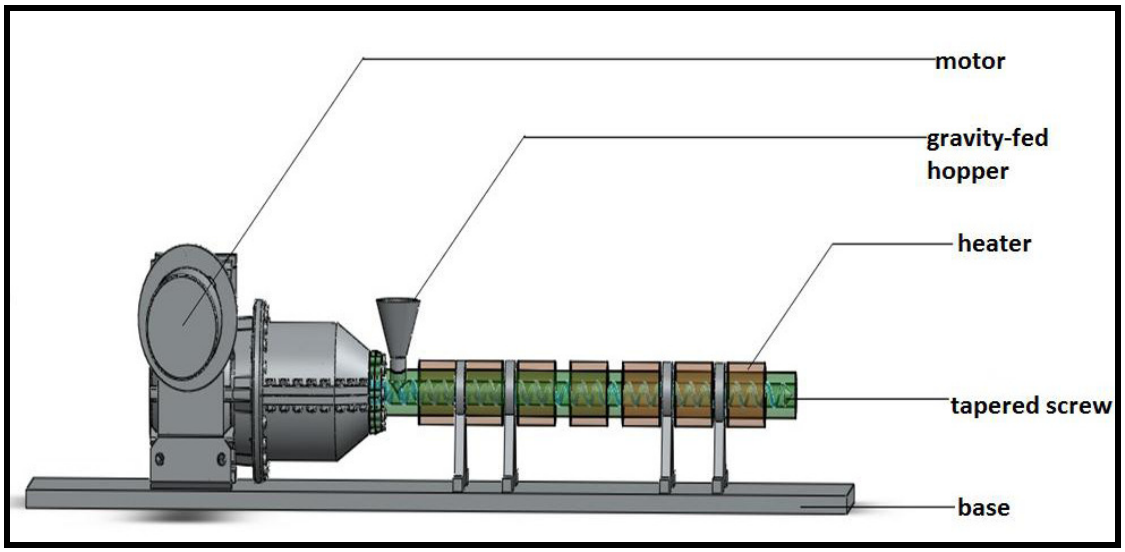

Figure 4: Concept C Design

A selection matrix table was used to ascertain the best design suited for the briquette making. The designs have been reviewed based on two main measures, performance characteristics of briquettes and machine characteristics. The criteria used in performance characteristics of briquettes were:

- Homogeneity of briquette
- Combustion performance of briquette
- Briquette density.

The criteria used in performance characteristics of briquettes were:

- Wear of contact parts
- Method of output from machine
- Specific energy consumption
- Throughputs
- Maintenance
- Ease of manufacture
- Ease of use
- Portability

The design labeled concept C (the screw) was used as the reference in both sections. If any other concept design, (A or B) had a similar performance to Concept C they were given a mark of zero (0). If concept A or B had better performance in said criterion they were given a plus (+) if they were less suited they were given a negative (-). The pluses, negatives and zeroes were added and a net score was taken for both sections. When evaluated based on the characteristics of the briquettes produced, Concept Design C was found to be the most appropriate option. However, when evaluated based on the characteristics of the machine, Concept Design A proved to be the most feasible design option. Based on the overall rank, Concept Design A was deemed the most appropriate and thus was selected as the final concept.

As our investigations have just begun, market research, feasibility of biobriquettes for island nations, design alternatives and design analysis have been completed. The final machine is yet to be build.

5. CARIBBEAN ENERGY SCENARIO AND THE OPTION OF BIOBRIQUETTES

Both the global and local economic systems are filled with risks and uncertainty. These risks include environmental change, reduced availability of resources, climatic and political changes. The Caribbean region with differently structured island economies is more susceptible to the volatility of the world economy than larger countries, though Trinidad and Barbados have relatively stable economic systems. Expenses towards energy imports (such as crude, natural gas etc) and energy dependence are the major aspects that affect any nation.

Grenada like Jamaica imports energy. Currently the Grenadian government has problems paying their civil servants. In the last three months payments to their civil servants have been paid late twice. (Caribbean Analysis 2012) Additionally the Grenadian government has been unable to repay a soft-loan received from the Taiwanese Government for the construction of a stadium. Their failure to repay the soft-loan from Thailand has led to the temporary seizure of the only Grenadian port by Thailand. Currently this port is one of the few means by which the Grenadian government earns foreign exchange. Whilst they have regained the control of their port through international arbitration it is evident that Grenada is in serious economic straits. Grenada and Barbados have similar physical layouts and both have limited natural resources. However, Barbados has a lucrative off shore banking sector and a successful tourism sector and it is is the only Caribbean country that has acquired first world status. They have invested heavily in education and by providing free education and a low interest loan to university students studying in the Caribbean. The Barbados government has also promoted the use of renewable energy by encouraging the use of solar water heaters to limit their energy bill, and this is a very wise move and indeed stands as an example to other countries including the first world and energy rich nations.

The Jamaica Public Service Company (JPSco) is responsible for island wide distribution of electricity. Its customers have seen regular increases in their electricity bills as high as 18% in recent years (Jamaica Observer, 2012). There are many factors which affect the price of electricity generation in Jamaica these include the value of the Jamaican dollar and the price of oil. Oil prices generally fluctuate based on global climate, economic uncertainties of oil producing nations and even natural disasters. Jamaica had enjoyed significant revenues in bauxite industry, however those revenues have declined significantly after 2007 (MME, 2006). Hence, island nations such as Jamaica or Grenada cannot continue to rely on fossil fuels as main source of energy. In Jamaica for the years 2000 – 2004 there has been an increase of 6.5% in volume for petroleum imports, equivalent to 1.6 million barrels oil and on February 20, 2006 oil imports value mushroomed to US $255 M. The oil bill which accounted for 24% of merchandise exports in 1998 increased to 66% in 2004, causing an increase of export earnings used to cover the cost of energy. Every dollar of merchandise exports, 66 cents is needed to meet the oil import bill, which is very significant (MME, 2006). On the other hand, the Jamaica Energy Policy envisages the main characteristics of energy and its relationship with the Jamaican economy can be summarized as follows:

- Excessive dependence on imported primary energy
- Low energy supply self-sufficiency due to a lack of indigenous energy resources, and low utilization of available sources, namely wind, hydro, solar and biomass
- High petroleum consumption that is concentrated in alumina, power generation and transport sectors
- Low levels of the refinery utilization, operating below 60% since 1983
- High systems losses in the electricity industry, which has been deteriorating since 2001 and which reached 20% in 2004.

For a sustainable economic development, Caribbean island nations such as Jamaica must to look to cheaper forms of energy than hydrocarbons. There are many alternative energy sources that can be considered. This paper recommends bio-briquetting sector due to well known advantages and experiences from many countries. Most importantly society involvement, sustainable development and energy independence are specific advantages of bio-briquetting sector, at least for domestic and retail consumer segment. The next step is to take this initiative further and see the opportunities of power generation with bio-briquettes. Several researchers are investing currently on medium to large power plants powered by biofuels such as biogas, biodiesel and biobriquettes. A resent project undertaken by government of Zambian illustrates wide ranging aspects of biobriquettes (EGZ,

2012), which is very positive and encouraging for many including enthusiastic entrepreneurs who may would like to about setting up biobriquette producing plants.

Specifically in case of Jamaica, government may wish to encourage the use of bio briquetting technology by subsidizing businesses and training interested persons as was the case in India. Abandoned plant locations such as Goodyear plant, which is currently not in use at Morant Bay, St Thomas can be used to set up bio-briquetting producing plants. Table 1 provides suggestions for some of the aspects of biobriquetting industry.

Table 1: Suggestions for Biobriquette Industry

Considerations	**Proposed Solutions**
Project site selection	Area should be selected close to targeted market and raw materials
Raw Material	Apart from many other waste material, bagasse and banana leaves could be used
Equipment and spare parts	Can be manufactured locally
Trainee selection and group formation	Skilled and unskilled workers
Market	Industrial, Commercial, Small scale businesses and homes
Stakeholder participation	Private sector funded, government should encourage, train

6. BIOBRIQUETTES AS SEEN BY CRITICS

Biomass briquetting is not without its disadvantages (Spartan, 2012). These include high investment cost, input energy, large storage space, emission of greenhouse gases though very negligible and the disposal of the residue. There is a high energy consumption input to the process of briquetting. Biomass briquettes require large amounts of storage space in relation to the amount of energy produced by the briquettes. The power plants using biomass briquettes require large areas to store the feedstock and the residue after processing. Renewable energy sources like Wind or Solar energy do not have any emissions however without proper filtration; however both require much more land space. Burning of briquettes can produce Nitrogen oxides and Carbon monoxide which both reduce air quality and are greenhouse gases. Residents close to a proposed briquetting plant site may oppose the building of a plant due to the feeling that their air quality will be reduced. It should be noted however that emissions from burning biomass briquettes are significantly less than that of fossil fuels.

7. CONCLUSION

There are many economic effects of implementing a sustainable renewable energy model in the Caribbean. A need currently exists for a cheaper fuel alternative for energy starved island nations of the Caribbean. It can be seen that biobriquette industry is new to the region, but this industry is functioning very well in many countries across the globe and widely supported by United Nations. Preliminary results of the design alternatives, design analysis of biobriquette making machine are presented. By producing their own energy, which is different from conventional fossil fuels, this region can create jobs, reduce the impact to the environment of waste, and improve waste management. The opportunities include manufacturing of biobriquette machines, marketing, research on power generation using biobriquettes. Caribbean Governments and policy makers should take initiative on encouraging the entrepreneurs and researchers in this sector for sustainable growth.

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