Economic Feasibility of Bagasse Charcoal in Haiti

By

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ABSTRACT

The economics of implementing bagasse-based charcoal manufacturing in Haiti was investigated. From these main inputs, three different manufacturing economic scenarios were modeled using a simple, dynamic excel spreadsheet. The first model reflects single family implementation, which reasonable found that a family would be able to make back their start up costs within a month of production. The second model examined sugarcane bagasse charcoal production as an entrepreneurial endeavor for a small community. The third model is similar to the second model, but reflects large-scale factory production. The potential of the second and third models primarily depend on the cost of raw materials and transportation. These models are easily adjusted to reflect market rates and can be generalized to address similar start-up economies.

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I.0 Introduction

Research and development has been underway to create a device for making sugarcane bagasse-based charcoal briquettes in Haiti. This project has environmental, health, and economic implications. An economic model of bagasse-based charcoal manufacturing was developed to predict manufacturing economics and scale for the new type of charcoal in Haiti. The economic models developed are used in the planning phase of development to forecast the cost of starting up such a project. Three different models were researched and formulated to reflect different production scenarios. The first scenario reflects the effect on a single family, the second for a small scale entrepreneurial endeavor, and the third for implementing large-scale factory manufacturing.

2.0 Background

Sugarcane bagasse charcoal is produced by first drying sugarcane bagasse in the sun. Bagasse is the waste byproduct of sugarcane after it has been processed. The bagasse is then carbonized by placing it in a sealed container and ignited. The bagasse stops burning when the oxygen is container is completely used, and the leftover material is thereby carbonized. This carbonized bagasse is mixed with water and a sticky cassava binder to create a fibrous moist consistency which is then compressed in the shape of a briquette. These briquettes are dried in the sun for a week. Carbonized sugar charcoal briquettes have burning performance similar to wood charcoal, but without a standardized process for forming the briquettes the burning performance is inconsistent. A device that would easily and uniformly compress the briquettes is currently under design. (2.009, 2004; Ramirez, 2005; Vechakul, 2005) Currently, Haiti has an estimated 3,000 sugar cane mills out of which 1,000 are in working condition. This number includes 250 to 500 motorized mills and between 200 and 600 mills powered by animals. (Block, 1997) Agriculture represents 28% of Haitian industry, with the top agriculture products coming from sugarcane at 1,040,000 metric tons, and cassava in second with 340,000 metric tons. (FAO, 2005)

3.0 Research

An economic model for sugarcane bagasse charcoal was developed based on existing charcoal production models and computer economic programs. Specifically, the development of community based wood charcoal production, the Long Range Energy Alternative Planning System, and Chardust Ltd. Corporation were analyzed. (Forestry Department, 1987; Chardust, 2005; and LEAP, 1995) Although the LEAP system was much more complex than necessary for our model, it provided the essential elements in calculating the effect of economic endeavors.

3.1 Simple technologies for wood charcoal making

The Simple Technologies for Charcoal Making handbook for implementing wood charcoal production was used as a guide for creating an economic model for sugarcane bagasse based charcoal production. (Forestry Department, 2005) This handbook based its data from a wood charcoal manufacturing venture in Africa. The main steps in producing wood charcoal are growing the fuel wood, wood harvesting, drying and preparation of wood for carbonization, carbonizing the wood to charcoal, and finally screening, storage and transport to the warehouse or distribution point. Based on this production process, the main costs include the cost of fuel wood, carbonization labor costs, transporting the charcoal, working capital, and fixed investment costs. Table 1 highlights the main charcoal production costs.

Table 1: Unit costs expressed as a percentage of the cost of delivered charcoal (Forestry Department, 2005)

Cost of wood at kiln	60%
Kiln labor costs	9%
Working capital costs	3.5%
Fixed investment costs	1.5%
Transport costs of charcoal	26%
Total	**100%**

The main cost, 60%, charcoal production comes from the raw materials, with transportation in second at 26%. In sugarcane bagasse charcoal production, the material costs should initially be significantly lower because bagasse is thought of a waste product that is generally useless and purged by burning. For our modeling purposes, the main cost is expected to come from transporting the bagasse and finished charcoal briquettes.

3.2 LEAP Computer Program

The Long Range Active Economic Planning System computer program is an environmental database forecasting tool that is able to assess the economic-environment policy planning. (LEAP, 1995) Although the primary purpose of LEAP is to model environmental effects, the economic ramifications are also present. This program is specified for a large area, and would best be applied to the charcoal production of the entire area of Haiti over a long period of time. This tool would be useful as Haiti becomes more industrialized and more conscious of the balance between the charcoal harvest rate and the rate of deforestation.

3.3 Chardust Ltd.

Chardust Ltd. is a commercial briquette operation in Nairobi, Kenya with a purpose of "producing viable substitutes for charcoal on a commercially sustainable basis." Chardust recycles biomass waste and converts it into charcoal using a similar process as bagasse based charcoal manufacturing. Producing and selling over 8 tons of charcoal daily, they are proven to be a real competitor in the African charcoal industry. (Chardust, 2005) Chardust uses sophisticated charcoal briquette making equipment from India that is not readily manufactured or obtained in India. For this reason, Chardust provides an interesting forecast scenario for the manufacturing potential in Haiti.

4.0 Modeling Approach

4.1 Economic Inputs

The main economic inputs include fixed investment, transportation, material, labor, and miscellaneous costs.

Fixed Investment

The fixed investment costs for charcoal production include the land and associated costs for use of the workplace area, a compactor machine, and a carbonizing container. In small scale production, the carbonizing container is generally a scavenged oil drum, but larger scale productions utilize a more sophisticated earth kiln. The parts, manufacturing, and maintenance costs associated with the carbonizing container are factored into the fixed investment cost. The charcoal compacting device is assumed to be made in Haiti with local materials and technologies for less than US$50. (Vechakul, 2005) Land is leased at about US$25 per hectare per year. (Casey, 2003)

Transportation Cost

In Haiti, the most common mode of transportation to the marketplace is walking which commonly takes up to 2 - 3 hours (10 miles). Public transportation costs approximately 3 Haitian dollars (about 42 cents) per person and 2 Haitian dollars (about 28 cents) for each large bag of charcoal. A large bag of charcoal is essentially the size of a large person and weighs approximately 50 lbs. A used pickup truck costs around $1,000 (40,000 gourde), while large used pickup truck costs $5,000 (200,000 gourde) with gas prices currently at 17 Haitian dollars per gallon. (Smith, 2005) For economic modeling purposes, the most practical and widely used mode of transportation is the donkey. The donkey is worth about $100, and requires no maintenance costs. Each donkey is able to transport approximately 5 large bags of charcoal. For large scale charcoal production, the associated transportation costs would also include (Forestry Department, 2005):

-Felling and bucking to required lengths; splitting may be required
-Primary transport to secondary collection point
-Drying of fuel wood in the forest.
-Secondary transport to the carbonization unit.
-Drying and storage of wood at the charcoal-making centre

Similar to wood charcoal production, transportation is expected to be a primary cost concern in bagasse charcoal production. (Table 1) The overall transportation cost is dependent on the distances between the bagasse source area, production site, and marketplace.

Materials Cost

Charcoal production is dependent of the amount of charcoal material available. The main materials cost includes sugarcane bagasse and cassava. Agriculture represents 28% of Haitian industry, with the top agriculture production from sugarcane with 1,040,000 metric tons, and cassava in second with 340,000 metric tons. (FAO, 2005) Based on the assumptions that bagasse comprises 25% of the total sugarcane production and the carbonization process reduces to 10% of its original mass, there is potential for 26,000 metric tons of sugarcane bagasse charcoal. In the model, the obtained sugarcane bagasse is assumed to have been dried in the sun.

Research from wood charcoal production shows that the primary cost of production in Table 1 is derived from materials. At the present time, sugarcane is viewed as a waste product that is removed by burning the harvested sugarcane fields. The specific cost for large quantities of sugarcane is undetermined. It is expected that the cost of sugarcane bagasse will increase as bagasse based charcoal becomes more popular.

Labor Cost

More than two thirds of Haiti is unemployed, but the average wage is currently at $.75/hr. (CIA, 2005) The average annual income or Gross National Income in Haiti is $380. (CIIA, 2005) The amount of charcoal produced is directly related to the number of labor hours, not the number of workers. This is because the manufacturing process could be modeled as a job shop production where everyone works on one process at a time, or line production which would require workers at every step in the process. While having many people work on the same task is less efficient than line production, there large waiting times between processes since not every step of production takes the same amount of time. In the end, the amount of hours for small scale production would be approximately the same for job shop production and assembly line production.

Miscellaneous Costs

Miscellaneous costs include all items not mentioned in the above categories. Further factors which cannot be overlooked include infrastructure and shelter for workers and animals, packaging costs, unforeseen fees, and price changes in items.

4.2 Potential Production

Agriculture represents 28% of Haitian industry, with the top agriculture production from sugarcane with 1,040,000 metric tons, and cassava in second with 340,000 metric tons. (FA0, 2005) Based on the assumptions that bagasse comprises 25% of the total sugarcane production and the carbonization process reduces to 10% of its original mass, there is potential for 26,000 metric tons of sugarcane bagasse charcoal. Haiti uses 720,000 metric tons of firewood and/or wood converted to charcoal annually. With each large bag of charcoal weighing approximately 50lbs, at a market rate of $22 for 3 bags, there is a market potential of US$420 million.

4.3 Other Assumptions

On average, each person in Haiti consumes about 1,000 lbs of wood charcoal annually. (Sunoven, 2005) Haitians can typically live on $.32 a day for food and water, which means that 75% of their annual income is spent on basic necessities. Lastly, on average sugarcane is harvested twice a year. For modeling purposes, a sugarcane bagasse production season is 6 months.

5.0 Models

Three potential bagasse based charcoal production scales were modeled. The first model examined the feasibility of charcoal production as an alternative to paying for wood charcoal. The second model looked at a small community based production as a means for extra income, and the third model examined large scale factory production. These models were constructed using an excel spreadsheet and researching existing cost values for various inputs. It was assumed that the bagasse received would be dried and ready for carbonization. The calculations assumed that the mass of the carbonized bagasse was equal to the charcoal production mass. These models can be found at: http://cadlab.mit.edu/~wallace/charcoalEconomics.

5.1 Model 1: Single-Family Production

The first model examined would be applied for a single family up to multi-family use. This model is applicable to families that simply want an alternative and cheaper source of cooking fuel. The total fuel cost per family can be found by knowing the number of people in the family, and plugging the number into Eq. (1).

$$Cost_{charcoal} = (\#\,people) \cdot \left(\frac{1000\,lbs/person}{50\,lbs/bag} \right) \left(\frac{\$22}{3bags} \right) \tag{1}$$

Assuming that cassava powder, bagasse, and an oil drum are obtained at no charge, the number of months it takes to make back initial investments can be calculated as a function of the fixed investment costs and the annual family fuel costs. Equation 2 shows this equation.

$$t_{payback} = \left(\frac{FI}{Cost_{charcoal}} \right) \cdot \left(\frac{12months}{1year} \right) \tag{2}$$

An average family of five spends $750 annually on energy costs. If this household obtains a charcoal extruder for about $50 and a donkey at $100 that they use once a week for charcoal production related tasks, their fixed investment cost would be $64.28, which has a payback period of 1.03 months. The compactor machine throughput is calculated by inputting the nozzle area, the output rate, and output density of the charcoal briquettes. Multiplying these inputs together gives you the total throughput of the machine.

$$(TP)_{compactor} = (A_{nozzle}) \cdot (R_{output}) \cdot (\rho_{output}) \tag{3}$$

Multiplying the throughput rate by the operating time of the compactor machine gives the weight of briquettes produced. The market value of the briquettes is a function of large bags produced, which is approximated as 50 lbs. Every 3-50 lb. bags produced are assumed to have the market value of US$22. Therefore, the market value of charcoal production as a function of throughput and operation time is in Eq. (4).

$$NetMarketValue = (TP) \cdot (t_{opeartion}) \cdot \left(\frac{1bag}{50lbs} \right) \cdot \left(\frac{US\$22}{3bags} \right) \tag{4}$$

Equations 3 and 4 allow the user to estimate the time it would take to the desired amount of charcoal.

5.2 Model 2: Small Community Production

The second model examined applies to a small scale business model. An entrepreneur would gather together a community or group of families that want to supplement their income. This model is very similar to the single-family production model, but includes the cost of sugarcane bagasse and cassava. The model takes into consideration startup costs and models one sugarcane harvest season. The Model 2 excel spreadsheet calculates the net profit. (Appendix A1) By inputting the amount of sugarcane bagasse, number of oil drums, sugarcane bagasse, cassava, and the number of mules, the total costs, net production, market value, and net profit can be calculated. Land was neglected in this model because it is assumed that the community will use their homeland for this project.

The total cost is a function of the fixed investment, transportation, materials, and miscellaneous costs. In Model 2, the user inputs the desired amount of units in the yellow highlighted column. Table 2 shows these items, from which the cost/unit column would be multiplied by the number of units the total. The sum of these totals equals the total production costs.

Table 2: Total costs of implementing large scale sugarcane bagasse production at a factory level.

	ITEM	**Cost/Unit**
Fixed Investment Costs	Oil drum	
	Compactor Machine	$50/machine
Transportation	Donkey	$100/donkey
	Small truck	$1,000/truck
	Large truck	$5,000/truck
	Gasoline	$0.45/gallon
Materials	Sugarcane bagasse	
	Cassava	
Miscellaneous		

The transportation units do not necessarily need to be a whole number. The use of a donkey could be borrowed once a week, in which case the units would be 1/7. Alternatively, the truck use could be used for tasks other than charcoal production. For this reason, the units can be less than one. The net potential profit is the market value of total production minus the amount consumed by the families. Combining Eq. 1 and 4, and subtracting the total costs in Table 2, yield the net profit in Eq. 5.

$$Net\,\Pr ofit = (NetMarketValue) - (Cost_{charcoal}) - (Cost_{total}) \qquad (5)$$

In small and large scale factory production, theft and vandalism are real threats to this profit since charcoal is the most valuable product in Haiti. Under miscellaneous costs, security guards and security measures such as barbed wire are possible costs. Due to the high value placed on charcoal, the cost benefit analysis between protecting charcoal products and producing the charcoal briquettes needs to be carefully analyzed before implementing production.

5.3 Model 3: Large Scale-Factory Production

The third model examined the feasibility of implementing a large scale bagasse charcoal production factory, similar to the Chardust Ltd. Corporation in Kenya. This model looked at short term expenses and profit and did not account for maintenance or repair. Launching an official business in Haiti requires 12 government approval steps that take over 200 days and at about $650 in fees and taxes. (World Bank, International Finance Organization, 2005) This model accounted for the start up of a factory-scale facility and only accounted for one growing season of sugarcane bagasse harvest. Long term forecasting could be modeled using Model 3, but eliminating fixed investment and transportation costs while factoring maintenance and repair into miscellaneous costs. In Model 3 of the excel spreadsheet, the inputs include the amount of land bought, number of kilns, number of compactor machines, number of mules obtained, amount of sugarcane & cassava, and the total number of labor hours. From these inputs, the total cost, net production, market value, and net profit can rudimentarily be deduced. Table 3 reflects Model 3 total costs, with the units needing to be multiplied by the cost/unit column to get the totals. Summing the totals yield the overall total costs of investing in bagasse based charcoal production.

Table 3: Total costs of implementing large scale sugarcane bagasse production at a factory level

	ITEM	**Cost/Unit**
Fixed Investment Costs	Land	$25/hectacre/year
	Kiln	
	Compactor Machine	
	Fees/Taxes	$641.88/one time fee
Transportation	Donkey	$100/donkey
	Small truck	$1,000/truck
	Large truck	$5,000/truck
	Gasoline	$0.45/gallon
Materials	Sugarcane bagasse	
	Cassava	
Labor	Total Labor Hours	$0.75/hr
Miscellaneous		

Table 3 doesn't specify the cost of the kiln or compactor machine. Based on the degree of complexity and output desired, the cost of these items will be variable. Constructing a kiln is limited in the building resources and space available. The compactor machine cost for large scale production is based on how the amount of power available to run the machine. A human powered machine will be significantly cheaper and smaller than a donkey driven device.

6.0 Development

6.1 Variables

Haiti is both politically and economically unstable. (CIA, 2005) Therefore, sensitivity analysis on variables such as taxes and other types of business protection fees were neglected in the model. In addition, it is very difficult to measure the effect of sugarcane bagasse charcoal production in forecasting fees, takes, and other associated costs. The models are based on current prices and indexes. All assumptions and models are subject to change without advance warning.

The demand for the charcoal could be hindered by substitute product such as the sun oven. Sun ovens are gaining popularity because of their environmental and health benefits, relatively low maintenance cost, and ease of use. (Sun, 2005) The downside of using the solar ovens is that they have a slower heating time, with performance is relative to the solar isolation. Overall, these ovens provide a cheaper alternative to paying the high cost of fuel.

6.2 Financing Options

The feasible modes of funding for implementing sugarcane bagasse-based charcoal production are micro-financing, international aid projects, and government resources. (IMP-Act, 2005) Micro-financing involves an entire community coming together to take out a bank loan and starting an entrepreneurial endeavor. Worldwide, micro-financing projects have been widely successful in creating jobs, improving troubled communities, and promoting social economy values and lasting development. (Maekawa, 2005) Ultimately, the financial success of micro-financing reflects the degree of community integration. (Lebosse, 1997) Unfortunately, the interest rates on loans in Haiti are currently at 19%. With compounded interest, this makes any type of large scale production facility almost impossible without the aid of government or international aid grants. Several micro-financing options have been proven widely successful in Africa, and provide an excellent model of financing for Haiti. (BRAIN, 2005) These resources can be found at: *http://www.brain.org.za/FINANCING/micro.html*

International aid agencies and groups throughout the world are lending their expertise and knowledge to help Haiti slow the rate of deforestation and find alternative fuel sources. For example, Belgium's CODERT is assisting in refurbishing existing sugar cane mills. (CODERT, 2005) The US Agency for International Development is governmental aid group that is assisting Haiti in economy recovery through environmentally sustainable agriculture initiatives. (US A.I.D., 2005)

6.3 Applications

These models can be applied to other agriculture waste products. Bagasse-based charcoal briquettes can be manufactured using almost any type of carbon-based product. These materials include but are not limited to corn husks, coconut and macadamia nuts shells, cereal straw, and bamboo. (Kammen and Lew, 2005)

These models are extremely flexible which means the prices of the goods and materials can be easily changed to reflect the market. In addition, this tool is also very useful to determine potential cost savings. For example, it is widely known that charcoal production costs can be decreased by improving transportation of sugarcane bagasse to the production site, and the ease of transport of the finished bags of charcoal to market. (United Nations, 2005. pp.47) The user would be able to determine if the added cost of mule would be worthwhile based on the potential profit or payback time. Furthermore, the entrepreneur would be able to determine if it is more cost effective to build a large compacting machine or manufacture several smaller machines.

All three models take into consideration the density and throughput of the compacted charcoal. This type of quality control ensures that the charcoal produced has a certain level of integrity such that it maintains its competitiveness with the wood charcoal market. The first model of single family production allows the user to determine the effect of adjusting fuel usage. By changing the annual fuel use per person, Eq. (1) can be modified to reflect the total fuel cost per family. If the annual savings is significant, the family would be able to allocate additional items into their budget. The second model of small community production is applicable to any type of small scale home business. By varying the inputs, this model can reflect artisan crafts or simple services business. Comparing various types of businesses allow the user to determine which business is most profitable. The third model is similar to Model 2, but on a larger scale. An artisan craft factory or manufacturing plant would most likely be applications of Model 3.

7.0 Conclusion

This project examined wood charcoal manufacturing, the Chardust Ltd. Corporation, the Sun Ovens project, and LEAP computer program to model the economics of sugarcane bagasse-based charcoal manufacturing in Haiti. From these references, the main economic inputs were determined to include fixed investment, transportation, material, labor, and miscellaneous costs. Based on these inputs, the total costs, machine throughput rate, net market value, and net profit were derived. These values were applied and modeled to fit three different manufacturing scenerios. It was determined to be economically feasible for small families to invest in sugarcane bagasse charcoal production and expect returns in a month. In a larger scale, it is also economically reasonable to expect a small community to supplement their income by devoting a small portion of their time to sugarcane bagasse production. At the factory level scale, the sustained success is unclear due to variables such as substitute products such as sun ovens, unknown cost of bagasse, kiln building materials, fees and taxes. The three models presented provide a tool to assist the user in making wise investing decisions prior to implementing sugarcane bagasse charcoal production in Haiti. These models can easily be applied to any type of carbon based material waste, and therefore has various applications.

Improvements in the models include factoring more detailed transportation costs. The distance between the bagasse source, production site, and marketplace could be calculated in the transportation and labor costs. Also, providing a more detailed list of potential miscellaneous costs would allow the user to better forecast costs. These improvements would provide a more accurate cost model. Furthermore, Julius Kaoma of the Nakambala Sugar Mill in Ambia has written a paper concerning the economics of sugarcane bagasse based charcoal production in Africa. He found that his sugarcane bagasse charcoal production is economically feasible and worthwhile. (Lazarus, 2005) Unfortunately, his original paper had not been obtained at time of this publication. Future work in verifying the models include comparing his work with the models presented.

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Appendix

Appendix A:

Models I, II, and III are available at: http://cadlab.mit.edu/~wallace/charcoalEconomics