EXPLORING THE FEASIBILITY OF A BIOMASS BRIQUETTE ENTERPRISE WITH A YOUTH COOPERATIVE IN NAIROBI

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December 2017

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Acknowledgements

I would like to thank my supervisor, Dr. Lynda Gagne, for her help, guidance, support, ideas and suggestions for completing this project. Her quick feedback, thorough reviews, and sharing of resources has been invaluable from day one.

Thank you to my client, Nancy Njeri, Program Director of VAP, for providing the opportunity for this research, for sharing office space, ideas, knowledge and staff resources in the commencement of this project.

I would also like to thank my partner, Andrew Logway, for his help and support in completing this project.

Executive Summary

Introduction

This report presents the results of research on a feasibility study of a biomass briquette production youth cooperative based in Nairobi. The research was conducted on behalf of VAP (Vijana Amani Pamoja), a local NGO, working to empower Nairobi's youth in terms of health, knowledge, and livelihoods. A biomass briquette production enterprise offers a promising solution to Kenya's youth unemployment problem and to the negative implications of the current charcoal industry.

The feasibility study was broken down into several business planning questions[1].

1. Technical specifications: What are the technical requirements of such an enterprise?
2. Market viability: Are there sufficient markets for the inputs and outputs of such a cooperative based in Nairobi?
3. Business model viability: How would the cooperative generate revenue and what would a competitive business model look like?
4. Promising management practices: What are promising practices for organizational structure, governance and sustainability?
5. Economic and financial viability: Can a Nairobi-based biomass briquette cooperative generate sufficient profits to provide a living income to members and sufficient retained earnings to finance future capital and operating requirements?

Methodology

The research for this report took place between April 2017 and August 2017. The research objectives were primarily achieved through a literature review, market research, and financial projections. The literature review included peer reviewed journals, industry and technical reports, government publications and statistics, industry websites, feasibility studies and cooperative case studies. Market research included feasibility studies, case studies, government publications, business directories, business websites, industry statistics, and technical reports. The financial projections, using the information acquired through both the literature review and market research, include a start-up budget, cash flow projections, and a pro forma income statement.

Findings

The evidence gathered suggests that a Nairobi-based biomass briquette enterprise could generate sufficient profits to provide a living income to its members and to finance future capital and operating requirements. However, numerous challenges associated with this industry have been identified. The findings are broken down by the research questions below.

Technical Specifications

The production of biomass briquettes is characterized by comparatively low barriers to entry. Nonetheless, it still requires knowledge, machinery, government approval, and sufficient human and financial capital. The process of producing biomass briquettes is labour intensive and involves the collection of biomass, followed by drying, grinding and pyrolysis. Mixing the

[1] The categories were based on Appendix 1 "Business feasibility outline", from Thompson (2005, p. 186). The research questions are original.

biomass with a binder, followed by compression, more drying and packaging concludes the process. Production requirements include a grinder, briquetting machine, and adequate space (at least .25 acre) for drying and storing the briquettes. Several approvals are also needed before start-up and two months should be provided for the completion of required clearances.

Market Viability
The literature review and market research uncovered sufficient markets for the inputs and outputs of a biomass briquetting enterprise in Nairobi. Biomass, packaging materials, equipment and briquette machine manufacturers are all available within Kenya. The principal challenge is to obtain enough biomass, at a low enough price, to produce a sufficient volume of biomass briquettes (i.e. 21 tons per month). While there is a reportedly significant market opportunity for the outputs of biomass briquettes, the comparative low cost of biomass in Kenya presents a constraint.

The market research also shows that there are already many biomass briquette producers (both producing green and carbonized biomass briquettes) based in or near Nairobi. While most producers are small-scale and output quality varies, some producers manufacture in excess of 100 tons per day. While difficult to establish, market saturation is a risk.

Business Model Viability
A business model was developed for the sale of biomass briquettes. The business model follows the business value chain consisting of inputs, operations, outbound logistics, marketing and sales, and services. The model distinguishes itself from competitors on two levels: price point and community focus. By focusing on a lower price point for small quantity purchases, an unoccupied space for biomass briquettes is open for the domestic market. In addition, by focusing on community outreach, offering free samples, partnerships, and free training, consumer trust and awareness regarding the product and its benefits will grow.

Promising Management Practices
A cooperative organizational structure was chosen for its social and financial benefits. Cooperatives work to alleviate poverty (ILO, 2009, p. 12), empower women (Njenga et al, 2013, p. 27), provide a great platform for ideas and innovation (Smith and Rothbaum, 2013, p. 9), and have an impressive track record in Kenya (Tshishong and Okem, 2016, p. 61). They also fare well compared to private entities in their ability to engage youth in active citizenship and participation (2013, p. 350).

Many different cooperative models and financing structures could be applied to a biomass briquetting enterprise. When choosing the appropriate model, one must consider the business itself, member years of experience and networks established, member demographics, and available financing. There is also an opportunity to evolve from one form of cooperative to another as the organization grows, changes, and new opportunities become available.

Ultimately, the success or failure of this enterprise will depend on the cooperative members and their governance structure. The research suggests that the cooperative adopt values of transparency and equality. In addition, financial training, regular meetings, transparent decision making, and ensuring all voices are heard can help to alleviate start-up challenges pertaining to member retention, and long-term sustainability. Finally, skilled managers using a collaborative approach, who are adept at encouraging and motivating cooperative members, are invaluable for ensuring growth and innovation.

Economic and Financial Viability

At the end of year one, the cash-flow projection shows a cash balance of $10,478. This is a based on a production volume of 21 tons per month. However, over $35,000 in start-up funding needs to be raised. Positive year-end cash balances continue through year 2 at $14,974 and more than double when production is doubled in year 3 at $37,782. The cash flow projection does not account for the cooperative's distribution of dividends at year end.

The pro forma income statement shows similar results with a net income of $4,235 in year 1, $7,107 in year 2 and of $26,108 in year 3. The difference in net income between a production of 21 tons per month and a production of 42 tons per months is significant. Moreover, producing 21 tons per month yields an operating profit margin of 18%, which increases to 28% when production doubles. The pro forma income statement demonstrates that scaling-up would provide a significantly higher operating profit margin, accompanied by a higher margin of safety, lower risks, and substantially greater net income.

The financial forecasts include a salary of approximately 10,500 KES ($127) per month for 9 members to undertake part-time work (up to 6 hours per day for 21 working days a month). The salary for the manager is slightly higher at 14,700 KES per month ($177). In addition, members would receive dividends at year-end in proportion to their patronage. In a worker cooperative, patronage may be defined as the number of hours worked each year (Kustov, 2012, p. 18). Dividends may then be distributed according to hours accumulated.

Recommendations

The following sub-recommendations were developed to ease the implementation process, enhance sustainability, and ensure a high-quality product and service; all the while, taking into consideration the limitations of both start-up and operating capital for Nairobi-based youth groups.

Technical specifications – as a means to enhance product quality:

- Ensure the biomass briquettes have a calorific value of at least 15 Mj/kg to provide enough energy output for cooking or heating;
- Develop a minimum table of quality standards that will be used to test biomass briquette quality on a weekly basis;
- Conduct continuous research and field trials on alternative biomass options as a means of continual product improvement; and
- Purchase a briquetting machine with a motor of at least 22.5 kW and a capacity of 250 kg per hour.

Market viability – as a means to enhance marketing and sales:

- Restrict the target market to Nairobi-based consumers where they are used to paying a higher price for biomass; and

- Direct marketing efforts to appeal to target consumer groups based on their product preferences: domestic consumers must be aware of the product quality and availability; institutional and industrial consumers should be made aware of the low price, and same-day deliveries.

Business model viability – as a means to develop a unique business model that differentiates itself from the competition:

- Set repeat customer retail prices at 70 KES for 2 kg, 130 KES per 4 kg, 750 KES per 50 kg and 1300 KES per 90 kg with additional discounts for buying in bulk or factory direct;
- Adopt a community based focus that partners with youth garbage collectors, community leaders, and the main consumers, women, to provide an opportunity for free advertising and establishing consumer trust.

Promising management practices – as a means to maximize worker motivation and cooperative sustainability:

- Clearly communicate the cooperative's benefits, member roles, expectations and vision for the future before members commit to joining;
- Develop the cooperative as a workers' cooperative; workers' cooperatives provide employment for their members (Government of Canada Co-operatives Secretariat, n.d.); and
- Model the cooperative structure after the traditional cooperative; in this type of cooperative, ownership rights are restricted to members, and year-end member dividends are distributed based on patronage (Lund, 2013, p. 7); and
- Agree on the definition of patronage as a means to enhance worker productivity and dividend distribution fairness, such as number of hours worked.

Economic and financial viability – as a means to enhance positive cash-flow and organizational sustainability:

- Begin operations on a small-scale with a production rate of 21 tons per month with plans to scale up as soon as it is economically feasible;
- Purchase all briquette equipment locally due to its lower cost and local repair outfit availability; and
- Recruit on the basis of start-up salaries of 10,500 KES ($127) per month for 9 members and 14,700 KES ($177) per month for 1 manager, with plans to increase salary contingent with scale up.

While a biomass briquette enterprise is a promising venture to consider, it will require investment, hard work, and continuous innovation to emerge as a profitable enterprise in a competitive market. It is recommended to document any challenges or necessary deviations from the project design to help other youth or organizations considering similar ventures. A brief summary of the next steps is included below.

Next Steps

1. Recruit members through VAP's well-established network of recent secondary school graduates in Eastlands Nairobi. Up to twelve members may be recruited.
2. Organize a meeting and agree on a group name.

3. Register the group name with the Ministry of Industry, Trade and Cooperatives.
4. Write a letter to the Commissioner of Cooperatives and invite the District Officer of Makadara to attend an official group meeting.
5. Conduct the group meeting where applications are filled out, the cooperative board is elected and members are designated to write the bylaws (or the district cooperative officer is paid to write the bylaws).
6. Open a bank-account with the Cooperative Bank of Kenya and inquire about loans.
7. Apply for grants. Possibilities include the UNDP Small Grants Program (SGP)[2], Canada Fund for Local Initiatives[3], and Finland Fund for Local Cooperation (FLC)[4].
8. Search for a plot to rent and procure equipment from established suppliers.
9. Procure raw biomass from established biomass sources and establish a contract for continuing supplies.
10. Contact the National Environment Management Authority and inquire about conducting an Environmental Impact Assessment and land use clearance.
11. Conduct field trials for establishing a quality biomass briquette.
12. Contact the National Bureau of Standards and inquire about obtaining product certification.
13. Commence operations.

[2] More information regarding the UNDP SGP can be found here: https://www.sgp.undp.org/
[3] More information regarding the Canada Fund for local initiatives can be found here: http://www.canadainternational.gc.ca/kenya/development-developpement/cfli-fcil-2017_2018.aspx?lang=eng
[4] More information about the Finland FLC can be found here: http://www.finland.or.ke/public/default.aspx?nodeid=46399&contentlan=2&culture=en-US

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Terms and Definitions

Biochar	biomass that has been pyrolyzed or carbonized
Biomass	any hydrocarbon material that mainly consists of carbon, hydrogen, oxygen and nitrogen (Yaman, 2004, p. 651)
Biomass briquettes	biomass that has been mechanically compressed into densified matter that is easily handled
Carbonize	the process of burning biomass without oxygen for the purpose of obtaining biochar or charcoal
Charcoal	wood that has been pyrolyzed or carbonized for the purpose of heat energy
Firewood	wood that is used for cooking, heating or thermal applications
Green briquettes	biomass briquettes that are not carbonized or pyrolyzed
Jiko	Swahili word for stove
KES	Kenyan shillings
Pyrolyze	the process of burning biomass without oxygen for the purpose of obtaining biochar or charcoal

1.0 Introduction and Background

This research report is a feasibility study of a youth biomass briquette production enterprise intended to replace charcoal. An introduction to the scope of youth unemployment and specific details regarding the client, Vijana Amani Pamoja, are presented below. The research objective and specific research questions are provided next. Relevant background information regarding the current charcoal industry, and its implications for Kenya concludes this section.

1.1 Problem Definition and Project Client

In Kenya, there are an estimated 13 million youth between the ages of 18 – 35, making up 37% of the population (Simeyo, Martin, Nyamao, Patrick & Odondo, 2011, p. 8291). The Kenyan Ministry of Youth estimates that more than 50% of these youth are unemployed or underemployed (Simeyo et al., 2011, p. 8291). According to Chigunta, Schnurr, James-Wilson, and Torres (2005, p. 41) "[y]oung people thus find themselves trapped in a no-man's land looking back towards school systems that offer no real opportunity, and looking forward towards formal sector jobs and stable self-employment options that seem hopelessly out of reach".

Vijana Amani Pamoja (VAP) is a Nairobi-based NGO whose mission is "to integrate social and economic values through football by creating a pro-active health environment" (VAP, 2016, para. 1). VAP (2016, para. 2) envisions "a society that is socially, economically, and [physically] empowered", and operate several different programs to achieve this. Programs include sexual and reproductive health education, vocational skill programs, and entrepreneurial training (VAP, 2016). The demand for youth employment and entrepreneurship opportunities exceeds the supply that VAP is able to provide. This research was conducted for the purpose of potentially providing another means of youth employment and training from VAP.

1.2 Research Objectives and Questions

The goal of this research is to explore the feasibility of creating a youth-run enterprise that produces biomass briquettes using renewable agro-waste in Nairobi. On behalf of VAP, the elements of a business plan for such an enterprise are analyzed. Pending the results, VAP plans to commence the enterprise working with youth from the surrounding community. Producing employment and/or livelihood opportunities through an environmentally sustainable enterprise will provide VAP with another means of empowering Nairobi's impoverished youth. The feasibility question can be broken down into several business planning questions[5].

1. Technical specifications: What are the technical requirements of such an enterprise?
2. Market viability: Are there sufficient markets for the inputs and outputs of such a cooperative based in Nairobi?
3. Business model viability: How would the cooperative generate revenue and what would a competitive business model look like?
4. Promising management practices: What are some of the promising practices in terms of organizational structure, governance and sustainability?

[5] The categories were based on Appendix 1 "Business feasibility outline", from Thompson (2005, p. 186). The research questions are original.

5. Economic and financial viability: Can a Nairobi-based biomass briquette cooperative generate sufficient profits to provide a living income to members and sufficient retained earnings to finance future capital and operating requirements?

1.3 Background

There is a strong demand in Kenya and all Sub-Saharan Africa for environmentally friendly and affordable cooking fuel. As an alternative to charcoal, biomass briquette production relies on unused agricultural or industrial residues, and therefore does not contribute to deforestation. In addition, biomass briquettes are also documented to release 60% less carbon dioxide, 72% less carbon monoxide, and 88% less PM 2.5 into the atmosphere when burning (Njenga et al., 2014, p. 86). The production of biomass briquettes, therefore, presents an opportunity to create jobs for youth, reduce pollution, reduce dependence on forests, and improve health outcomes.

The current charcoal industry employs over 500,000 Kenyans (Ministry of Environment, Water and Natural Resources, 2016, p. 37) consisting of producers, transporters, middlemen and charcoal vendors. In fact, wood and other biomass resources generate at least 20 times more local employment in the economy than any other form of energy (Rural 21, 2011, p. 27). However, production is often conducted illegally and operates using very inefficient technologies (p. 28). Due to the informal and sometimes illegal nature of the sector, producers cannot access loans to invest in more efficient carbonization technologies (27). This results in major environmental, health, and economic implications for Kenya.

1.31 Environmental Implications

Approximately 60% of charcoal production in Kenya is illegal (Stockholm Environment Institute, 2016, p. 1), which has serious implications on the sustainability of the industry. According to the Stockholm Environment Institute (2016, p. 1) the demand for wood charcoal is 16.3 million m^3 whereby the demand for fuel wood is 18.7 million m^3. Only 31.4 million m^3 of Kenyan forest can be harvested sustainably (p. 1) leaving a deficit of 3.6 million m^3 for charcoal and fuel wood alone. This does not even consider all the other industries dependent on timber. Consequently, Kenya has been losing tropical forest at a rate of 3% per year (Wachiye, Kuria & Musiega 2013, p. 169). Currently, Kenya's forest canopy has been reduced from 12% to only 2% of the country (The REDD desk, 2011, para. 1).

1.32 Health Implications

Particulate matter with an aerodynamic diameter of 2.5 microns and below ($PM_{2.5}$) are linked to respiratory and cardiovascular disease (World Health Organization, 2016, p. 6). The World Health Organization's air quality guidelines recommend a $PM_{2.5}$ no higher than a mean of 25 $\mu g/m^3$(microgram per cubic meter) (p. 8). Burning wood charcoal for cooking has been reported to exceed these health standards. A recent Kenyan study measured the amount of $PM_{2.5}$ in households cooking with charcoal in 2 urban slums of Nairobi (Korogocho and Viwandani) and found a mean of 126.5 $\mu g/m^3$ in Korogocho and 75.7 $\mu g/m^3$in Viwandani (Muindi, Kimani-Murage, Egondi, Rocklov and Ng, 2016, p. 7).

Charcoal fuel will continue to have serious health implications on the Kenyan population resulting in a shortened life span. It is estimated that "[l]ong-term exposure of $PM_{2.5}$ is associated with an increase in the long-term risk of cardiopulmonary mortality by 6-13% per 10 ug/ m^3 of

$PM_{2.5}$" (World Health Organization, 2016, p. 6). With an estimated 82% of the urban and 34% of the rural Kenyan population relying on charcoal for cooking (Ministry of Environment, Water and Natural Resources, 2016, p. 9), this puts a significant proportion of Kenyans at risk of an early death.

1.33 Economic Implications

The United Nations Environment Programme (2012, p. 39) reports that charcoal's contribution to deforestation and forest degradation has binding effects on the Kenyan economy resulting in estimated annual losses of 3,650 million shillings (KES) per year. This includes, but is not limited to a 1.5 billion KES loss in the agriculture sector due to lack of irrigation water, 12 million KES loss from reduced hydropower generation, 82 million KES loss from a reduction in inland fish catching (p. 39).

1.4 Report Overview

The remainder of the report consists of the following chapters. The Methodology chapter discusses the research techniques and methods used to gather information for this report. The Technology chapter reviews current briquetting materials, methods and processes used for biomass briquette manufacturing. The Production and Operations chapter includes a discussion on the input and output materials, equipment, and resources. The Market Environment chapter discusses the consumer groups that the biomass briquette enterprise may target, and the characteristics and preferences of these groups. The next chapter reviews the competition and top briquetting companies in Kenya. A chapter on Organizational Structures and Promising Practices are then presented for the enterprise. The Business Model chapter describes the value chain of the business. The Regulations chapter discusses the regulatory requirements for a briquetting enterprise. This is followed by a chapter on the critical risks of starting this type of enterprise in Kenya. The last chapter provides financial projections including a start-up budget, cash-flow projections and an income statement. The report concludes with a summary analysis and recommendations.

2.0 Methodology

2.1 Methods

This research for this report took place between April 2017 and August 2017. The research objectives were primarily achieved through secondary data analysis, using the following research methods:

- Literature review
- Market research
- Financial projections

2.2 Literature Review

A literature review was conducted to address the following research questions:

1. Technical specifications

Information regarding current briquetting technologies derived from Sub-Saharan Africa and other developing countries including production, briquetting materials, and biomass briquette making methodology was collected from peer reviewed journals. Next, required inputs (including packaging, machinery, facilities, operational requirements, etc.) was identified. Sources for the required inputs include peer-reviewed journals, feasibility studies, and government and non-profit energy initiative documents.

2. Market viability

An online search was conducted to identify individual suppliers of inputs necessary to start a biomass briquette enterprise. This search included supplier websites, business directories, and published biomass briquette feasibility studies. Input suppliers included, but are not limited to, companies with excess agri-waste, landlords, equipment suppliers, equipment repair outfits, and suppliers of packaging materials. This review helped to identify whether there are sufficient markets for the inputs of producing biomass briquettes in Kenya.

In order to determine whether there were sufficient markets for the outputs of a biomass briquetting enterprise, the review investigated the current charcoal and biomass briquette industry in Kenya. This included a search of biomass briquette producers, products offered and characteristics regarding their respective sales and distribution strategy. The review also identified potential markets for biomass briquettes. Potential markets were identified through previous feasibility studies, peer reviewed journals, government statistics, and market assessment reports.

3. Business model viability

The literature review regarding the current charcoal industry in Kenya, competitors and consumers were used to construct a potential business model. This combined with the literature review identifying the required inputs, potential suppliers, outputs, and potential markets was used to create a business value chain including the inputs, outputs, outbound logistics, marketing strategy and services offered.

4. Promising management practices

Policy research was conducted to explain the unique benefits of cooperatives, cooperatives in Kenya, and alternative cooperative structures. Understanding how cooperatives function in Kenya, as well as different types of cooperative structures provides a guideline for the optimum organizational structure. In addition, key recommendations, common challenges, and lessons learned for youth cooperatives will provide key information on enhancing sustainability. Finally, recommended governance practices, including challenges, was used to highlight promising practices for cooperative governance. This review was conducted through international cooperative reports, peer reviewed journals, cooperative case studies, and Kenyan government websites.

5. Economic and financial viability

The entire literature review regarding technologies, inputs, outputs, operations requirements, potential markets, the business model, and organizational structure was used to determine the quantity of product that could be produced, the costs of production, member income, and product selling price. This information was used to evaluate the financial viability of the enterprise.

2.3 Market Research

Market research was conducted to answer the following research questions:

- Market viability
- Business model viability

1. Market viability

Market research was conducted to obtain information on individual charcoal consumers and institutional charcoal consumers. Market research included published biomass briquette feasibility studies, published case studies of biomass briquette enterprises, government publications, industry statistics, consumer reports, local supermarket outlets, and local outdoor market venues. This helped to reveal consumer product preference, willingness to pay, payment method preference, preferred retail locations, and suggestions regarding the biomass briquette product. Market research also helped to reveal the size of the biomass industry, the market trends, product movement, perception of product quality, and successful sales strategies. This research provided useful information for product development, sales strategy, market saturation, emerging markets, and expected challenges.

An online and on-foot search sought out existing Kenyan biomass briquette producers. The search included biomass briquette producer websites, business directories, products retailing at various Nairobi markets, Facebook business pages, news articles, and industry publications. This search provided an indication of the number of competing companies, the scale of the industry, range of biomass briquette prices, retail locations, required inputs and offered outputs. It also helped to reveal the target market for biomass briquette companies, market saturation, market opportunities, successes and challenges. This search provided information on whether there are sufficient markets for the inputs and outputs of a biomass briquette cooperative.

2. Business model viability

Market research conducted on consumers and competitors was used to generate the potential business model. As previously mentioned, consumer product preference, willingness to pay, payment method, preferred retail locations as well as market trends, current retail price of biomass briquettes, competitor sales strategies and product demand was used to generate the product price, sales and market strategy, and services that could be offered.

2.4 Financial Projections

Financial projections were conducted to answer the economic and financial viability research question. These were broken down into three financial forecasts:

- Start-up costs;
- Cash-flow projections; and
- Pro forma income statement.

The literature review was used to provide information regarding regulatory and input requirements. Consultations with suppliers revealed input costs. This information was used to populate start-up costs for the biomass briquette enterprise.

Cash flow projections and the pro forma income statement used information collected from the literature review and market research. Input costs, regulatory costs, cost of resources, cost of services and employee salary was quantified in Canadian dollars and used to populate cash flow projections and the income statement for the first three years.

This analysis will provide information for the financial and economic viability component: Can a Nairobi-based biomass briquette cooperative generate sufficient profits to provide a living income to members and sufficient retained earnings to finance future capital and operating requirements?

2.5 Limitations

This research was limited through its methods. It would have been valuable to conduct personal interviews with charcoal producers and existing cooperatives in Kenya. Charcoal producers may have been able to provide first-hand information regarding market conditions, industry challenges, equipment maintenance, and advice or recommendations for other individuals looking to get into this industry. Existing cooperatives in Nairobi may have been able to provide experience-based information on Kenyan cooperative models, governance structure, sustainability issues, lessons learned, and recommendations or advice for newly formed cooperatives. However, due to a costly and time-consuming ethics process required from the Kenyan government, it was decided to use only publicly available information.

3.0 Biomass Briquetting Technology

Biomass is "any hydrocarbon material which mainly consists of carbon, hydrogen, oxygen and nitrogen" (Yaman, 2004, p. 651). Burning of biomass for cooking is very inefficient; however, pelletization or briquettization into condensed matter is a good alternative energy fuel (Obi & Okongwu, 2013, p. 449). This next section reviews the literature for briquetting materials, processes, and physical properties.

3.1 Briquetting Materials

Biomass briquettes can be made from an almost unlimited number of agricultural residues and wastes. Industrial waste (i.e. charcoal dust), forestry products (i.e. wood), and agricultural residues (i.e. corn cobs) make up the categories of biomass briquette materials. Commonly used materials in sub-Saharan Africa include sawdust, coffee husk, nut shells, sugarcane bagasse, crop residues, and charcoal dust (Mwampamba, Owen & Pigaht, 2013, p. 161).

There are both low and high-pressure briquetting technologies, with and without a binder (a starchy glue that holds the biomass briquette together). Manual or low-pressure briquetting requires a binder to keep the biomass briquette from falling apart. Binder-less briquetting is an option if using high compression machinery (Hood, 2010, p. 18). According to Obi and Okongwu (2013, p. 450) some biomass may act as a natural binder such as palm oil mill sludge (POMS). This is a waste that is generated during the processing of palm fruit for palm oil production. Other possibilities are cited by Azeus (2012, paras. 2 – 6) and include clay, food starch, molasses, and arabic gum. Azeus notes that food starches may come from corn, rice, potatoes, and cassava.

3.2 Briquetting Processes

Depending on the type of biomass, the following 3 processes are usually required (Hood, 2010, p. 16):

A. Sieving – drying – preheating – densification – cooling – packing
B. Sieving – crushing – preheating – densification – cooling – packing
C. Drying – crushing – preheating – densification – cooling packing

Most biomass briquette production researchers start the process by drying the agro-residues (Imoisili, Ukoba, Daniel & Ibegbulam, 2013; Onchieku, Chikamai & Rao, 2012; Ramírez-Gómez, Gallegoa, Fuentesa, González-Montellano, & Ayuga, 2014) to reduce the moisture content. Next, the agro-residues are chopped or ground before mixing with a binder (Sellin et al., 2013; Oladeji, 2010; Ndindeng et al., 2015; Lela, Barišic´, & Nizˇetic´ 2016; Ramírez-Gómez et al., 2014). If a binder is used, binders are mixed with the agro-residues to help the biomass briquette mass stick together. Binding media include cassava starch gel (Oladeji, 2010), palm press sludge (Ndindeng et al., 2015), molasses (Onchieku et al., 2012; Haykiri-Acma & Yaman., 2010), clay (Onchieku et al., 2012), water (Obi & Okongwu, 2013), recycled paper (Ngusale, Luo & Kiplagat, 2014, p. 751), and the liquid product of carbonization (Haykiri-Acma & Yaman, 2010). If the agro-residues are going to be carbonized, carbonization occurs before grinding (Haykiri-Acma & Yaman, 2010; Onchieku et al., 2012; Saenger, Harge, Werther, Ogada & Siagi, 2000). The agro-residues are then compressed into biomass briquettes.

3.3 Physical Properties

The physical properties of a biomass briquette are an important consideration. A quality biomass briquette has low-moisture and ash content, high compression strength, high density, high hydrogen content and a high heating value, also known as calorific value (Oladeji, 2010, p. 102). The total volatile matter is proportional to biomass content and worth noting. Volatiles make ignitability easy and increase the burning rate. The following discusses research findings on biomass briquette physical properties.

Ash content is generally low (2 – 21%) for all biomass briquette types (Sellin et al., 2013, p. 351; Obi & Okongwu, p. 452; Imoisili et al., 2014, p. 1534; Oladeji, p. 104; Ndindeng et al., p. 29; Saenger et al., 2001, p. 114; Haykiri-Acma, p. 2; Lela et al., 2016, p. 238) except carbonized rice husks (68.8%) (Ndindeng et al., 2015, p. 29) and carbonized sugarcane bagasse briquettes (36.40%) (Onchieku et al., 2012, p. 485). The higher quantity of ash in the carbonized rice husks and sugarcane briquettes directly relates to the lower quantity of volatiles (as ash does not burn).

Higher hydrogen content is related to a higher heating value (Mitchual, Frimpong-Mensah, & Darkwa, 2014, p. 6). The amount of hydrogen is sufficient and steady amongst biomass briquettes at approximately 5% for POMS and rice husk (Obi & Okongwu, 2013, p. 454), rice husk alone (Oladeji, 2010, p. 104), and coffee husks (Saenger et al., 2000, p. 107). Banana leaf briquettes have a slightly higher hydrogen content of 6.23% and banana stem biomass briquettes have a hydrogen content of 5.58% (Sellin et al., 2013, p. 351). Hazelnut shells' hydrogen content is even higher at 6.7% (Haykiri-Acma, 2010, p. 2). Corncob biomass briquettes have a much higher quantity of hydrogen at 15.56% indicating the potential for a higher heating value (Oladeji, 2010).

Heating value or net calorific value measures how much heat is released after complete combustion (Gemco Energy, 2016, para. 1). For standardization, results are converted to megajoules per kilogram, Mj/kg. The calorific value for sawdust and sorghum dust biomass briquettes ranges from 3.83 Mj/kg to 10.43 Mj/kg (Imoisili et al., 2014, p. 1537). As sorghum dust increases, heating value decreases (p. 1537). The next lowest heat value was carbonized rice husks at 9.66 Mj/kg (Ndindeng et al., 2015, p. 29). Similarly, Obi and Okongwu (2013, p. 454) identified a low heat value for rice husks at 13.45 Mj/kg, but found they could increase it to 21.68 Mj/kg as they increase the ratio of POMS from 1:10 to 1:1. Ndindeng et al., (2015, p. 29) also found higher heat values when the rice husk is mixed with rice bran (16.87 Mj/kg), rice bran and palm press fibre (18.47 Mj/kg) and rice bran and palm press sludge (19.23 Mj/kg). The calorific value for banana leaves is 17.6 Mj/kg (Abdullah & Taib, 2013, p. 327). The calorific value for carbonized sugarcane bagasse ranges from 11.25 - 18.38 Mj/kg[6] depending on the ratio of molasses and soil to bagasse (Onchieku, et al., 2012, p. 485). Onchieku et al., found that the optimum ratio of bagasse to molasses and soil is 40:1:1. Binderless carbonized sawdust briquettes were found to have a calorific value of 20.18 Mj/kg[7] (Akowuah, Kemausuor, &

[6] Results were presented as 2.684 Kcal/g – 4.390 Kcal/g and converted to Mj/kg using online conversion calculator: http://www.webconversiononline.com/energy-mass-conversion.aspx?number=4.39&from=kilocaloriepergram&to=megajouleperkilogram

[7] Results were presented as 4820 kcal/kg and converted to MJ/kg using online convertor calculator: http://www.webconversiononline.com/energy-mass-conversion.aspx?number=4820&from=kilocalorieperkilogram&to=megajouleperkilogram

Mitchual, 2012, p. 5). The highest heat value is found from carbonized biomass briquettes made with hazelnut shells at 28.7 Mj/kg[8] (Haykiri-Acma, 2010, p. 3).

Density and hardness is measured in different ways making comparisons difficult and therefore only studies that used the density units of g/mm^3 or g/cm^3 are included. Kuhe, Ibiang and Igbong (2013, p. 5) compared green palm fibre, rice husk and sawdust biomass briquettes[9]. Density is lowest for the sawdust biomass briquettes at .208 – .264 g/cm^3, palm fibre density varies between .278- .293 g/cm^3 and density is highest for rice husk biomass briquettes at .351 – .43 g/cm^3. Ramírez-Gómez et al. (2014, p. 103)[10] found a density of .680 g/cm^3 for cereal straw, .9142 g/cm^3 for rice husk, 1.003 g/cm^3 for rape straw, 1.01 g/cm^3 for vine shoots, and 1.03 g/cm^3 for maize stalk mixed with pine wood. Similarly, the density for banana waste biomass briquettes is 1 g/cm^3 (Stellin et al., 2013, p. 351).

3.4 Summary

Quality biomass briquettes can be made from a variety of biomass and binder options. Corn cobs make strong biomass briquettes with exceptional hydrogen content (Oladeji, 2010, p. 104). However, corn cobs are an animal feed in Kenya and therefore quantities may be limited. Sugarcane bagasse is available in large quantities in Kenya, though with its high ash content (Onchieku et al., 2012, p. 485), machinery maintenance costs must be factored in. Rice husk on its own does not hold up well in terms of heat value; though this can be improved by mixing it with a quality binder (Obi & Okongwu, 2013, p. 454; Ndindeng et al., 2015, p. 29). However, its high ash content means burn time is comparatively low (Chardust Ltd., 2004, p. 40). Banana waste makes an attractive material for biomass briquettes due to its availability. It performs sufficiently well in terms of quality indicators, though more field tests should be done. Hazelnut shells perform very well amongst biomass briquette quality indicators (Haykiri-Acma, 2010, p. 3). Though hazelnuts are not grown in Kenya, further investigations of biomass briquettes made from peanut, macadamia or cashew shells might yield similar results.

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[8] Results were presented as 6864 Kcal/Kg and converted to Mj/kg using online conversion calculator: http://www.webconversiononline.com/energy-mass-conversion.aspx?number=6864&from=kilocalorieperkilogram&to=megajouleperkilogram

[9] Results were presented as 2.08 – 2.64 g/mm^3 x 10^{-4} 10. This is equivalent to .000208 - .000264 g/mm^3. This was then converted to g/cm^3 using online conversion calculator: http://www.unitconversion.org/density/grams-per-cubic-centimeter-to-grams-per-cubic-millimeter-conversion.html

[10] Results were presented as 914.2 kg/m^3 for rice husk, 1010.8 kg/m^3 for vine shoots, 1003 kg/m^3 for rape straw, 1017 kg/m^3 for maize stalk and 965 kg/m^3 for sawdust. The units were converted to g/cm^3 using online conversion calculator: https://www.convertunits.com/from/kg/(meters+cubed)/to/g/(centimeters+cubed)

4.0 Production/Operating Requirements

The production and operating requirements for commencing a biomass briquetting enterprise are detailed below. This includes an overview of required inputs for biomass briquetting. This overview is then followed with a review of biomass options in Kenya, including estimated cost and proximity to Nairobi. Briquetting machinery focusing on grinders, briquetting machines and kilns, is next presented. The discussion includes equipment options, costs, suppliers, capacity and other relevant characteristics. The operations site requirements and estimated cost conclude this section.

4.1 Inputs Overview

Two feasibility studies (Hood, 2010, p. 18 and 77; Kalita, 2016, pp. 63 – 69) detailing the required inputs for biomass briquette operations are summarized in Table 1 below. Information regarding kilns for carbonization was derived from the Kenyan Forest Service (n.d., p. 9), Chris Adam, founder of the Adam-retort®, (personal communication, December 11, 2016), and CarbonZero Consulting (2016).

Table 1: Required Inputs for Biomass Briquetting

Inputs	**Options**
Biomass options	Raw material supply: Agricultural residues Forest residues Bamboo and grasses Municipal solid wastes
Storage of biomass that is fully protected from rain and run-off	Covered shelves or bins
Kiln for carbonizing biomass (optional)	CarbonZero kiln – small scale but efficient Kon-Tiki kiln – low-cost, fast acting, though not very efficient Adam-retort® – decent kiln, varying efficiency, also small scale Commercial ring kiln – only works for specific types of biomass (not great for agricultural residue) Horizontal bed biochar reactor – high efficiency and capacity but requires high capital investment
Hammer mill or grinder to reduce biomass particle size to 6 – 8 mm	Clippers – cutting of biomass with similar sized particles Hammer mills – blunt hammers on a rotating drum, making particles of irregular size Combination type – combines both features of clippers and hammer mills
Drying compartment	Passive drying – relies on ambient temperatures and air flow Active drying – assisted flow of air
Intermediate storage bin - Raw material to be held in storage after leaving the dryer	Shelves or bins
Pre-heater and furnace (optional) - Feed material is dropped into a chamber that pre-heats the material	
Briquetting equipment	Piston press Screw press Roll press Pelletizing Low pressure/manual presses

Cooling racks - Need a place for storage where biomass briquettes can cool down prior to packaging	Shelves or bins
Ventilation hoods – smoke and fumes coming off the hot biomass briquettes need to be extracted to the outside of the operation site buildings.	

4.2 Biomass Options

The biomass material forms the base of the entire briquetting enterprise, and many businesses have failed simply for overestimating its availability (Hood, 2010, p. 44). Charcoal dust, coffee husks, peanut shells, sisal bole and stems, sugarcane bagasse, coconut husks, sawdust, and banana leaves and stems, were investigated as potential materials for biomass briquettes. Based on availability, the Low Heat Value (LHV)[11], cost, labour time, and transport distance, only charcoal dust, sawdust, and banana waste are determined feasible for a Nairobi based biomass briquette enterprise at this time. See Table 2 below, and for a detailed review, see Appendix 1.

Table 2: Agricultural and Industrial Residues for Biomass Briquettes

Biomass Type	Total biomass waste produced	Current use of biomass waste	Cost of biomass	RPR[12]	LHV[13]	Labour and Time[14]	Pick-up location	Risks
Charcoal dust	70 tons per day in Nairobi	Sold to biomass briquette producers	200 KES/ 50 kg	N/A	24.5[15]	1 -2 hours for filling sacs and loading into pick-up truck + transport time.	Multiple pick-up locations in Nairobi wherever charcoal is sold.	Already many producers using charcoal dust. The buyer market is saturated.
Coffee husks	8000 tons per year	Compost, fertilizer, biomass briquettes	2.5 - 5 KES/kg	0.24	14.10	1 - 2 hour for filling sacs and loading into pick-up truck + transport time.	Kiambu county coffee dry mill	Coffee husks are reported difficult to carbonize, and are expensive.
Peanut shells	300 kg day	Organic manure	5 KES/kg	N/A	N/A	30 minutes for manual loading of peanut shells already sorted in 50 kg sacs +transport time	Embakasi at food manufact-uring factory	Groundnut shells are expensive with limited quantities.
Sisal boles and stems	425,700 MT of sisal post-harvest waste per year	None	N/A	19.8	14.85	Excessive	Sisal estate in Kilifi	The labour and transport required is excessive and cost prohibitive

[11] The Low Heat Value (LHV) is the energy content of a fuel, defined as the amount of heat released per mass of fuel burned during combustion (IEE, 2016, p. 9). This is the same value as the calorific value discussed in chapter 3.
[12] RPR was identified by an Intelligent Energy Europe (IEE) report (2016, p. 28 – 32). The RPR shows how much residue is generated per amount of final product under the same units of mass (IEE, 2016, p. 9).
[13] The LHV figure was identified by an IEE report (2016, pp. 28 – 32).
[14] This is based on the estimated labour and time it will take to pick up one ton of the specified biomass.
[15] The LHV for charcoal dust briquettes was identified by Njenga et al. (2014, p. 7).

Sugar-cane bagasse	2,695,955 MT/year	Biomass briquettes, fuel fired furnace, none	N/A	0.38	12.93	N/A	Sugar company in Western Kenya	Transport remains a consideration as sugarcane bagasse is 400 km away.
Coconut husks	70,400 MT/year	None	3 KES/ kg	1.1	17.66	1 – 2 hours to manually load coconut husks into truck and trailer + transport time	Coconut processing plant, Kilifi	Coconut husks are reported difficult to pyrolyze. The transportation costs are also excessive.
Sawdust	N/A	Biomass briquettes, animal bedding, boilers	0.35 KES/ kg	N/A	20.18 [16]	1 – 2 hours to shovel sawdust into 90 kg sacs + transport time (130 km round trip)	Makuyu	Transport costs and time are considerable.
Banana stems and leaves	N/A	Animal feed	Free	N/A	17.86 [17]	1 – 2 hours to load 1 ton of loose banana waste into truck and trailer + transport time	Toi market, Kawangware market, Gikombe market	Less is known about this biomass option and trials should be conducted to ensure good ignition and burning values.

4.3 Briquetting Machinery

The equipment used to manufacture biomass briquettes will influence the biomass briquette quality, materials that may be used, and organizational budget. Below is a discussion of potential biomass briquette machinery, supplier location, equipment cost, and equipment capacity. Equipment identified includes grinders, briquetting machines, and kilns.

4.31 Grinders

A grinder will improve the efficiency of both kilns and briquetting machines if using biomass with a particle size over 10 cm. Grinders are available locally with a price ranging from $925 - $1200 (personal communication with biomass briquette machine manufacturer, June 17, 2017). According to the manufacturer, the grinders come equipped with different sieve options depending on the desired end product size and can handle from 1 – 2 tons per day.

4.32 Briquetting Machines

The researchers studying quality biomass briquettes (from chapter 3) make use of the following biomass briquette equipment: a hydraulic press (Sellin et al., 2013, p. 350; Lela et al., 2016), Goldmark MB-4 (Ramirez-Gomez et al., 2014), piston press, and a screw briquetting machine (Balasubramani, Anbumalar, Nagarajan, & Prabu et al., 2016). Regardless of the model used, Balasubramani et al. (2016, p. 862) recommends that the press has a capacity of at least 250 kg/hr, a speed of 270 rpm, and a motor of at least 22.5 kW. Researchers Lela, et al., (2016, p.

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[16] The LHV was obtained from Akowuah, Kemausuor and Mitchual (2012) study on sawdust biomass briquettes. However, the value was presented as 4820 kcal/kg and converted to MJ/kg using online convertor calculator: http://www.webconversiononline.com/energy-mass-conversion.aspx?number=4820&from=kilocalorieperkilogram&to=megajouleperkilogram
[17] LHV was obtained from Abdullah and Taib (2013).

237) found that biomass briquette compaction should be at a minimum of 100 kN. The following discussion includes available biomass briquette machine options.

4.321 Local Briquetting Machines

In Kenya, only screw extruder briquetting machines are offered for sale. Two biomass briquette machine manufacturers were found within close proximity to Nairobi. According to the manufacturers (personal communications, May 10, 2017; June 17, 2017), these briquetting machines are intended to manufacture carbonized biomass. The manufacturers suggest that although they are not intended for green biomass briquettes, field tests may reveal whether pulverized raw biomass with the use of a binder, will work. They run on engines ranging from 3 HP to 7.5 HP. The cost of these machines range from $1500 - $7500 CAD and can produce from 500 to 4000 kg per day (personal communications with biomass briquette machine manufacturer, May 10, 2017; June 17, 2017). To the left is a photo of a locally manufactured machine[18].

4.322 International briquetting machines

For higher volume production of 4 tons+ per day, or uncarbonized briquetting, international companies must be consulted. Briquetting manufacturers are primarily found in India, China and Europe. Costs vary with the most expensive equipment and highest quality coming from Europe (i.e. C.F. Nielson) and cheaper options available from India (i.e. Faciliation India PVT) and China (i.e. Zhengzhou AIX Machinery Equipment Co). All types of briquetting machines can be found internationally. A quote from C.F. Nielson revealed that the cheapest, smallest model (that can briquette up to 200 kg/hr) is available for 50,000 Euro (personal communications, September 18, 2017).

4.4 Kilns

The process of pyrolysis, or carbonization is labour intensive and expensive. One either needs to use charcoal dust, or invest in a quality kiln/s to carbonize the biomass. Below is a summary of available and affordable options.

4.41 Closed chamber brick kilns

The Adams retort and other closed brick kilns, such as the Carbonzero experimental kiln, have recently gained in popularity. These kilns are approximately $500 - $5,000 to build depending on size and quality of products purchased. These are thought to be efficient at a rate of up to 35% but the results vary widely from project to project (Adam, n.d.). Dr. Chris Adam, founder of the

[18] Photo was taken by the author on June 17, 2017.

Adams retort, suggests they can produce a maximum of 1125 kg of biochar a week and each batch takes approximately 2 days to pyrolyze (personal communication with Chris Adam).

A simple brick kiln (pictured left)[19] was built to establish the cost, quantity and time to carbonize biomass. A kiln such as this may be built for $500, with a carbonization period of at least 3 hours, and will produce a maximum of 50 kg of biochar. It includes a steel barrel enclosed by fire brick insulation. Unless one purchases a very high-grade steel barrel, a used steel barrel will burn out after 20 – 30 batches (personal communication with Carbonzero Consulting, December 15, 2016). The methodology for building this retort kiln was obtained from CarbonZero Consulting (n.d.).

4.42 Ring kiln

A slightly higher cost kiln is the commercial ring kiln. The cost of a ring kiln, manufactured through CarbonZero Consulting, is 7,500 Swiss Francs (2016, para. 19), which equates to approximately $10,120 dollars. These kilns can process up to 100 kg/char a day. However, there are various requirements for using these kilns and one needs to break up biomass particles to equal sizes before burning to ensure equal carbonization (personal communication with CarbonZero, December 15, 2016).

4.43 Open-flame and Kon-Tiki kilns

The Open-flame or Kon-Tiki kiln is one of the newest and cheapest options available for producing biochar. Wilson reports (2017, p. 4) that the flame is supposed to burn off the smoke, resulting in a very small amount of emissions (p. 4). A container is used to exclude air from the bottom of the pile of burning biomass. As the pile is reduced to coals, a new layer of biomass is added on top. Once all the biomass has been reduced to char, water or soil is used to quench the flames (Wilson, 2017, p. 8). The Kon-Tiki kiln has a lower efficiency rate that varies from 20% - 26% (Wilson, 2017). An 800 litre Kon-Tiki is reported to make 280 kg of charcoal in under 5 hours (Ithaka Institute, n.d., p. 42). Costs range from $50 CAN - $7500 CAN depending on size and materials used (Cornelisson et al., 2016, p. 3). Below are some photos of open-flame kilns of varying sizes. The last photo is a Kon-Tiki kiln[20].

[19] The photo was taken by the author February 11, 2017.
[20] The first two photos were obtained from Wilson's publication "Converting shelterbelt biomass to biochar. A feasibility analysis for North Dakota Forest Service" (2016, pp. 8, 10); the second photo was obtained from the Ithaka Institute's publication on Kon-Tiki kilns (n.d., p. 2).

4.5 Operations Site

The site for biomass briquette operations must be removed from residential areas but close enough to Nairobi to reduce unnecessary transport costs. It must be large enough to dry the biomass and store the biomass briquettes (minimum of .25 acre). It must have both electricity and water hook-ups available. An on-site building is preferred with a small budget to upgrade the building and fencing to accommodate simple warehouse operations and storage. A quick search of online land plots for rent revealed that one can be obtained on the outskirts of Nairobi for 20,000 – 25,000 KES ($250 - $300 CAD) per month (OLX, 2017).

4.6 Summary

The required inputs for biomass briquetting have been presented with an emphasis on biomass options in Kenya, biomass briquette machines, and kilns. Both local and international supplier information has been included for the biomass briquette equipment. Various kiln types have been included and most models may be manufactured locally.

5.0 Market Environment

Biomass briquettes can be used as a substitute for both wood and charcoal. Carbonized biomass briquettes are intended for domestic or institutional clients and may be used to replace charcoal. These may be manually broken to fit small jikos (stoves) or can be used for large scale heating or commercial cooking operations. Green biomass briquettes are intended for industrial consumers and replace wood or other raw biomass used in thermal applications. Green biomass briquettes can generate steam for electricity in an industrial boiler. They can also be used for institutions, such as schools, hotels, or any large-scale kitchens.

This remainder of this section discusses the prevalence of biomass briquette use in Kenya, its cost, and its potential markets.

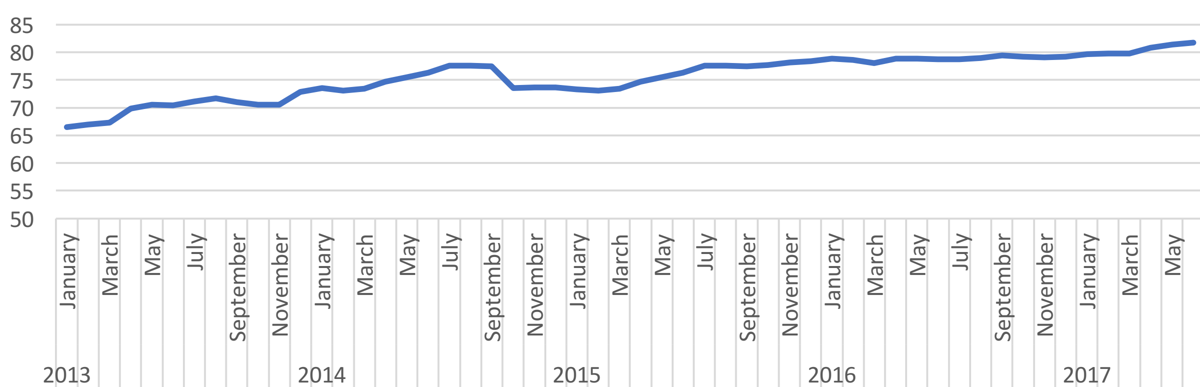
5.1 Prevalence of Biomass Use in Kenya

According to the Kenyan Energy Regulatory Commission (ERC) (2012, para. 24), "[b]iomass contribution to Kenya's final energy demand is 70 per cent". This statistic illustrates the huge market potential for biomass briquettes. Not surprisingly, the ERC lists the main sources of biomass to include charcoal, wood, and agricultural waste (para. 24). They also report that developing the biomass energy sector is a focus of the government to combat its declining resources, and the high cost of fossil fuels (para. 26).

5.2 Comparative Cost of Biomass Energy Alternatives in Kenya

One of the largest inhibitors to the successful scale-up of many biomass briquetting companies involves competing with the low cost of firewood and charcoal. Firewood can be obtained for free in rural Kenya and forested areas of the city. Though firewood is frequently for sale in markets and crowded residential areas, costs vary depending on location. However, it is almost always cheaper than charcoal. The price of charcoal is much lower in rural Kenya than in the country's capital, Nairobi. Figure 1 shows the historical average prices of charcoal in Kenya. The most current figure prices 4 kg of charcoal at 81.7 KES.

Figure 1: Charcoal Price in Kenya per 4 kg (KES)



Source: Kenya Bureau of Statistics (2014, March; 2015, January; 2016, January; 2017, June)

In Nairobi, a foot search revealed the current price of a 4 kg tin of charcoal is 100 KES ($1.23) in Kibera, Kawangware, and other low-income areas. In slightly more affluent neighborhoods (i.e.

Buruburu), the price increases to 140 KES ($1.73). This is significantly higher than the national average presented in Figure 1.

5.3 Potential Markets

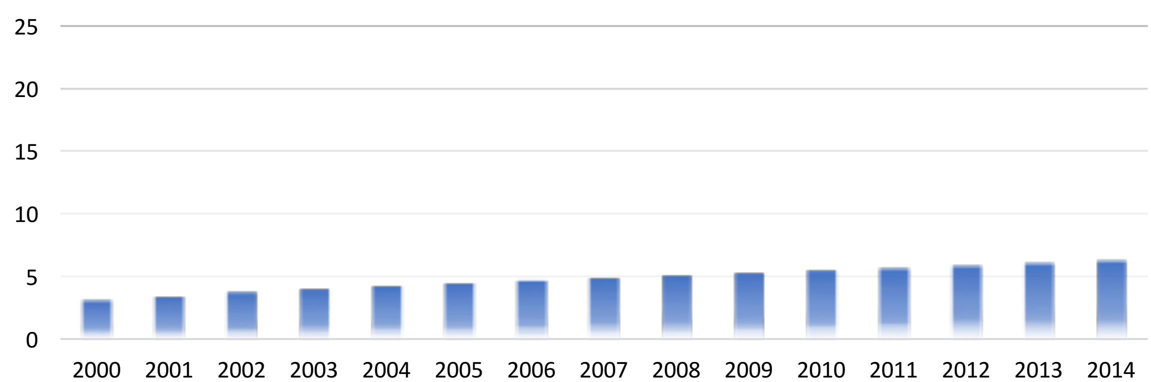
Nairobi's high altitude, cool temperatures, dense population (Cohen and Marega, 2013), reduced trees and forests, coupled with the higher retail price of charcoal (Kung et al., 2015, p. 97), make it an ideal market for biomass briquettes. A biomass briquette enterprise could potentially sell to two types of customers. The domestic customer who cooks for their own and their family's consumption, and the industrial or institutional customer, which is made up of schools, hotels, restaurants and businesses using thermal applications for their cooking and/or processing needs.

5.31 Domestic Customer

According to the Ministry of Environment, Water and Natural Resources (2016, p. 9), charcoal is the preferred cooking source for 34% of the rural population and 82% of the urban population. Though this seems like an overestimate given the availability of kerosene and LPG (liquefied petroleum gas), Oduor, Ngugi and Gathui (2012, p. 4) report that the demand for charcoal as a fuel for cooking is unlikely to decrease and is forecasted to grow, primarily due to population growth and urbanization.

This appears to be in line with a recent World Bank report (2017a) that highlights the proportion of the Kenyan population who primarily cook with clean cooking fuels. The most recent data point from 2014 reports that only 6% of the population is cooking with clean fuels. This assumes that over 45 million Kenyans are cooking with harmful fuel, including kerosene (World Bank, 2017a), firewood, charcoal, crop wastes and animal dung (World Bank, 2017b, para. 4). According to the World Bank, unclean cooking fuels are defined as those associated with indoor air pollution (2017b, para. 4).

Figure 2: Access to Clean Cooking Fuels and Technology in Kenya (% of population)



Source: The World Bank (2017a)

The majority of domestic charcoal consumers are the urban poor who do not have the income to access more expensive and cleaner forms of cooking such as electric stoves or LPG (Yonemitsu, 2015, p. 1). According to Kung et al. (2015, p. 90), they are likely to use a combination of charcoal and kerosene, or charcoal and gas due to variable cooking time of different foods. A foot search revealed that most charcoal vendors are selling in the 2kg size revealing that most household consumers buy only enough supply to last a few days. Kung et al., reports (p. 96) that households buy their charcoal according to proximity and from a vendor “whom they know and trust.” In addition, during times of cash shortages, they will often buy on credit (p. 96).

Kung et al., (2015, p. 90) estimates that low-income households will spend up to 43% of their income on cooking fuel. This causes “significant economic distress” (Kung et al., 2015, p. 92) and is a major contributor to food insecurity (Kimani-Murage, 2014, p. 1106). Kimani-Murage, who undertook a study in 2 urban Nairobi slums (Korogocho and Vewandani) found that food insecurity was severe for 50% of respondents, moderate for 35% of respondents, and non-existent for only 15% of respondents (p. 1102).

A Nairobi study of low-income charcoal users (Kung et al., 2015) asked consumers what qualities they look for when purchasing charcoal. Consumers first reported weight, followed by size. Less important factors included burning quality, speed of lighting, smoke, hardness and cost (p. 91). Kung et al., suggest that consumer’s willingness to pay for charcoal biomass briquettes is determined by “fuel economics”, the perceived energy characteristics of the biomass briquette (i.e. weight) coupled with how the price compares with conventional charcoal (p. 95).

While various attempts have been made to sell biomass briquettes to domestic consumers, market penetration remains a long-standing challenge (Hood, 2010, p. 44). In fact, studies show that consumers lack knowledge regarding the existence of biomass briquettes and even if they are aware of biomass briquettes, they often do not know the difference between biomass briquettes and charcoal (Ngusale et al., 2014, p. 757). Given the fact that nearly all biomass briquettes in Nairobi are priced higher than charcoal, little incentive remains for the consumer to switch products and buy biomass briquettes.

Nonetheless, studies show that when consumers are aware of the biomass briquette quality and price is competitive, the product is positively received. A recent study testing the market potential of sawdust briquettes in Kumasi Metropolis, Ghana (Akowuah, Kemausuor and Mitchual, 2012) found that participants positively reported the easy ignitability, long burning time, and good heat output. Participants also reported less smoke and ash content compared to the traditional charcoal (pp. 4 – 5). In all, 93% of participants agreed to buy the sawdust briquettes if offered at a comparable price to charcoal (p. 5).

Unfortunately, not all biomass briquettes are created equal. It is estimated by those in the biomass briquette industry, that there are 40 - 50 charcoal biomass briquette companies in Nairobi offering a product of varying quality (personal communications with established biomass briquette entrepreneur, July 7, 2017; personal communications with biomass briquette machine manufacturer, June 17, 2017). Two studies (Cohen & Marega, 2013, p. 33; Kung et al., 2015, p. 95) assessing the biomass briquette market in Kenya both found that while significant potential exists with domestic consumers, consumer confidence has been eroded by poor quality biomass briquettes. Therefore, in order to sell to the domestic consumer, it is important that the price be similar to that of charcoal, and that consumers be aware of the quality of the product and of the benefits of using the biomass briquette over charcoal.

5.32 Institutional and/or Industrial Customer

Institutional customers include hotels, safari and tour companies, restaurants, small-scale cooked food vendors, schools, poultry farmers, and bakeries. Cohen and Marega (2013, p. 33) suggest that there is a definite potential to scale up sales to this consumer group if the enterprise is located within close proximity to potential customers, or can sell to traders who supply these types of companies. In terms of poultry farms, although there are many, it is reported that this market is highly competitive and already well served (Cohen & Marega, 2013, p. 33).

Industrial consumers make up a completely different market, and, according to Hood (2010, p. 87) have a much higher success rate in terms of consumer acceptance compared to the domestic market. Researchers report (Marega & Cohen, 2013, p. 33; Kalita, 2016, p. 49) that green biomass briquettes make a great substitute for wood and coal in industrial size furnaces for a variety of functions, and that there is significant opportunity to tap into this market due to the scarcity of wood. Sharma, Priyank, and Sharma suggest that the following industries can make good use of green biomass briquettes:

- Ceramic and refractory industry;
- Solvent extraction plant;
- Chemical units;
- Dyeing plants;
- Milk plants;
- Food processing industries;
- Vegetable plants;
- Spinning mills;
- Lamination industries;
- Leather industries;
- Brick making units;
- Other industries having thermal applications;
- Gasifies system in thermal; and
- Textile units (2015, pp. 47 – 48).

However, Cohen and Marega (2013, p. 33) caution that industrial consumers require much higher volumes than most small-scale briquetting enterprises can produce. Therefore, they recommend that in order to approach these consumers, an enterprise would need to have a guaranteed supply of 5,000 mt/yr to appeal to this segment (p. 33). In addition, a survey of 10 green biomass briquette producers in Kenya (Kung et al., 2015, p. 97) found that these industries place less emphasis on quality (i.e. smoke) and more emphasis on the price. Therefore, any biomass briquettes targeted at this segment must be able to compete with the current wholesale price of wood, and must be able to produce in high quantities. Though it was not possible to obtain statistics regarding the volume of industrial biomass use in Kenya, it appears that significant potential exists for the established biomass briquette producer. As business expert, Gladys Mugo, in the Kenyan Digital Standard goes on to say “I know the demand for environmentally-friendly industrial fuel in Kenya is huge” (Abuga, 2016, June 13, para. 14).

5.33 International Market

It is reported that market potential also exists among charcoal traders from other countries, such as the Middle East and North Africa. Green charcoal operators in Kenya report frequent contact from this market segment (Kung et al., 2015, p. 96). However, very little information could be found about this market opportunity.

5.4 Summary

It is clear that significant market potential exists for biomass briquettes. The majority of Kenya's energy needs are satisfied through the consumption of biomass; and therefore, providing biomass in a compact biomass briquette should naturally link to various markets. However, the challenge remains with the low (sometimes free) cost of the two most predominant biomass sources in Kenya: charcoal and firewood. In order to compete with these two sources, and attract domestic and institutional consumers, the cost will have to be very low, no higher than the current cost of charcoal in Nairobi.

6.0 Competition

Traditional wood charcoal is sold throughout Nairobi and is expected to remain the primary competition in the domestic consumer market. On the other hand, institutional and industrial consumers have begun to buy biomass briquettes on a large scale and the competition for this market segment is from other biomass briquette producers. This next section identifies the scale of the competition, the comparative retail price of biomass briquettes, and then takes a closer look at the major competitors in the biomass briquette market who are producing high volume supply.

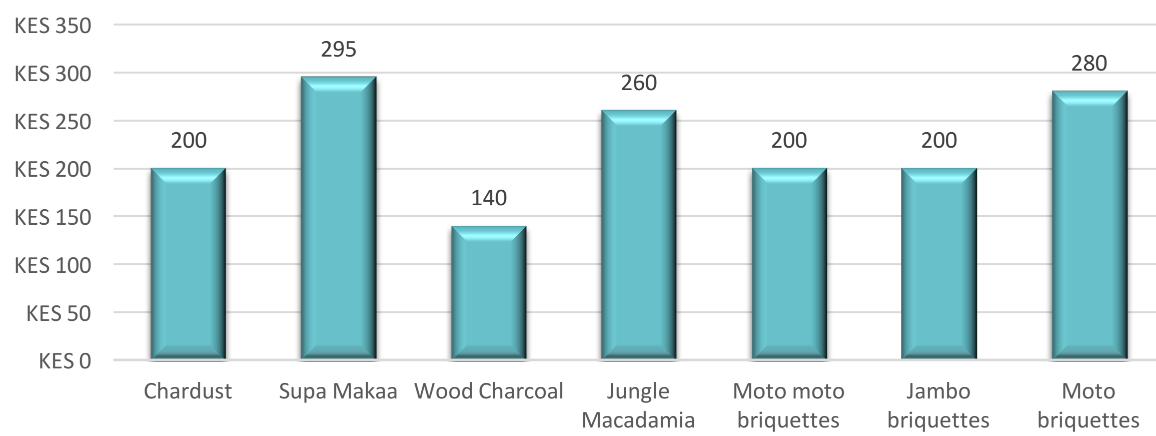
6.1 Scale of the Competition

Though comparatively small relative to charcoal, biomass briquettes are now being produced by a significant number of companies in Kenya. In Nairobi alone, it is estimated that there are 40 – 50 producers (personal communication with established biomass briquette entrepreneur, July 7, 2017; personal communication with biomass briquette machine manufacturer, June 17, 2017). Though demand is high, the majority of production is low with most businesses operating with small, manual machinery and limited capacity ("Biomass briquettes eat into", 2015, January 19, para. 9).

6.2 Comparative Cost of Biomass Briquettes

Price can vary considerably depending on the quality of the biomass briquette, scale of the company, and retail location. A search was conducted for phone numbers of carbonized biomass briquette companies with a Facebook business page or website. Following the search, a phone call was made to each of the businesses to determine the retail price of 4 kg of charcoal[21]. The cheapest price for 4 kg of charcoal is 200 KES, offered by 3 of the biomass briquette companies. See Figure 3 below.

Figure 3: Retail Price of 4kg of Carbonized Biomass Briquettes in Nairobi



Source: personal phone calls to each of the companies

[21] For companies that do not sell 4 kg, the price of 2 kg was doubled.

6.3 High Volume Biomass Briquette Producers

The next part of this section focuses on well-established companies producing at least 500 kg of biomass briquettes per day. Some of the most well-known companies include Global Supply Solutions, Brightgreen Renewable energy, Jungle Macadamia, Greenchar, iCoal, Chardust, Hermisons Green Energy Solutions and Lean Energy. Below is a summary table and review of biomass briquette producers who have an online presence.

Table 3: Biomass Briquette Producers in Kenya

Company name	Material used	Price (50 kg)	Location	Production capacity	Target market
Chardust	Charcoal dust and gum arabic	900 KES	Gataka	3 – 7 tons per day	International, poultry, hotels, lodges and restaurants.
Global Energy Solutions	Pineapple waste, leaves and stem	2300 KES	Thika	55 tons per day	Industries with boilers, schools and colleges, African Breweries, Bamburi Cement.
iCoal Concepts Ltd	Charcoal dust	N/A	Dagoretti	3 tons per day	5 star hotels, poultry and pig farmers
Jungle Nuts	Macadamia nuts, rice husks and sawdust	2000 KES	Thika	N/A	Supermarkets, domestic consumers
Greenchar	Sugarcane bagasse	1000 KES	Western kenya	1 ton per day	Both institutional and domestic consumers.
Brightgreen renewable energy	Paper and other waste from Nairobi	1700 KES	Karen	N/A	N/A
Lean Energy	Sugarcane bagasse	600 + VAT	Limuru	100 tons per day	Industrial customers including coca-cola bottling and other major industries.

6.31 Chardust

Chardust Ltd. is one of the oldest large scale carbonized briquetting companies in Kenya beginning production in 2000 (Chardust, 2016b). It is based in Gataka, Nairobi and produce charcoal using a combination of charcoal dust and gum arabic (Chardust, 2016a). According to its website, production is approximately 7 tons per day, and the company's target customers include institutions (chicken farms, hotels, etc.) and the urban mid-scale market (Chardust Ltd., 2016b). A 50 kg sac retails for 900 KES, with a minimum order of 20 bags (Chardust, 2016a). However, the company is evolving and beginning to place more emphasis on a new product: seedballs. Seedlings are placed in a nutrient rich mixture of biochar. This product does not need to be planted, but can be dropped virtually anywhere, and when moist, the seed will germinate (Chardust, 2016c).

6.32 Greenchar

Greenchar is a green and carbonized biomass briquette producer, based in western Kenya (Carraro, 2015, October 24). Its primary product is called LongBurn, which is a green biomass briquette made of sugarcane waste called bagasse, sold primarily to schools, hotels and institutions (Greenchar, 2017). Greenchar also sells a carbonized sugar bagasse biomass briquette, distributed through various community based organizations (Greenchar, 2017). The most current figure regarding production capacity, found in the Daily Nation (Angote, 2016, May 6, para. 13) reports that Greenchar produces 1 metric ton of biomass briquettes per day. Their green biomass briquettes retail for 20 KES/kg with a minimum order of one ton (personal communications with Greenchar, August 26, 2017).

6.33 Lean Energy Solutions

Lean Energy Solutions is an Energy Management consultancy service in East Africa. It specializes in carbonized biomass briquettes manufactured in Limuru, Kenya (Lean Energy Solutions Ltd., 2016). It also conducts energy audits and converts oil fired furnaces and boilers to fuel biomass briquette fired furnaces and boilers (Lean Energy Solutions Ltd., n.d., p. 1). Lean Energy uses sugarcane bagasse from the Muhoroni sugar company ("Firm's investment in…", 2014, para. 13). The company is large with over 200 staff ("Firm's investment in …", 2014, para. 8) and notable clients include Coca-cola bottling, Flamingo tiles, Universal Corporations Ltd (medical manufacturing), Spin Knit, Spinners and Spinners (textile producers), and Osho Chemicals Ltd (agro-chemical producer) (Lean Energy Solutions Ltd., n.d., pp. 8 – 10). It has also conducted feasibility studies and implemented, commissioned and installed briquetting machinery for companies looking to produce biomass briquettes, including Nairobi-based Sasini tea and coffee company (Lean Energy Solutions Ltd., n.d., p. 6). Lean Energy Solutions manufactures over 3000 tons per month with a retail price of 12 KES + VAT per kg with a minimum order of 1 ton (personal communications with Lean Energy Solutions Ltd, September 15, 2017). The range of expert services it offers, and the large industrial clientele it has attracted, demonstrates its sustainability and success in the industry.

6.34 Global Supply Solutions

Global Supply Solutions is one of the largest green biomass briquette producers in Kenya. The company has partnered with Del Monte plantations in Thika (Global Supply Solutions, 2016a, para. 1) and has invested in high capacity briquetting production technology from a danish company (Thairu, 2016, para. 5). Its primary clientele involves industries with thermal processing needs. The company is currently investigating the use of carbon credits for customers who purchase their product (Global Supply Solutions, 2016a, para. 4). Thairu (2016, para. 6), a journalist from the Kenyan Star, reports that Global Supply Solutions now produces over 70 metric tons a day and has announced scale up plans as its customer base continues to grow. As a start-up, they sourced funding from ICDC, African Enterprise Challenge Fund, Energy and Environment Partnership and Kenya Climate Innovation Centre, who provided 230 million KES in loans and grants (Thairu, 2016, para. 4). Their products retail on the expensive side of the spectrum, with 50 kg of biomass briquettes retailing for 2300 KES (Global Supply Solutions, 2016b).

6.35 Hermisons Green Energy Solutions
According to the website (Hermisons Green Energy Solutions Ltd., n.d.), Hermisons Green Energy Solutions is another green biomass briquette producer, and, similar to Lean Energy, it also specializes in converting oil fired broilers to biomass briquette fired broilers. The founder, Paul Mworia, started off as a middleman selling biomass briquettes to processing firms that he had contracted from western Kenya. He then came up with the idea of producing his own biomass briquettes in Kiambu (Abuga, 2016, June 13, para. 4-5). The website (Hermisons Green Energy Solutions Ltd., n.d.) reports that it operates in 5 locations around the country producing over 50 tons per day and that the biomass briquettes are made from sugarcane bagasse and lantana trees from 2 plantation projects from over 2000 acres. The company is supported by the UNDP, in partnership with communities in Kitui and Kajiado (Hermisons Green Energy Solutions Ltd., n.d.). Unfortunately, retail information could not be found[22]. The main clients are industrial Kenyan processing plants including Bata shoes, All Packs Ltd., Kenya Tea Development Agency and Kenya Breweries (Abuga, 2016, June 13, para. 8).

6.36 iCoal
Though iCoal lacks a website, the company is quite well known amongst the biomass briquette community in Nairobi. The company began in Dagoretti, Nairobi, in 2012 ("Biomass briquettes eat into…", 2015, para. 5). It collects charcoal dust from community centers to make the biomass briquettes and produce 3 tons per day (para. 5). iCoal Concepts Ltd. received support from the Kenya Climate Innovation Centre (KICC) to scale up production, strengthen distribution and access financing (para. 11). Unfortunately, further information regarding its production capacity, or retail price of biomass briquettes, could not be found.

6.37 Moto Biomass Briquettes
Moto biomass briquettes, otherwise known as Brightgreen Renewable energy, is a new company. Its founder, Chebet Lesan started the company in late 2014 (Brightgreen Renewable Energy, n.d.). The company website (Brightgreen Renewable Energy) reports that it uses "industrial waste" from around Nairobi from paper mills, charcoal vendors and printing presses. The website also advertises its work with local communities and women groups to educate, monitor and enhance transition to cleaner fuels. A phone call to Moto Biomass Briquettes, revealed that their 50 kg biomass briquette product retails for 1700 KES (personal communications with Moto Biomass briquettes, July 17, 2017).

6.38 Jungle Nuts
Jungle Nuts is a nut processing company. It sells biomass briquettes made from macadamia shells, rice husks and sawdust, but also sell macadamia nuts, macadamia oil and cashew nuts (Jungle Nuts, 2017). The company is at a clear advantage as the biomass is a by-product of their main business; however, biomass briquettes are not their main focus. It has recently diversified its products and is now selling pillows, and mattresses using recycled plastics as a means to scale up revenues (Maichuhie, 2017, paras 1-2). Personal communications with the company (July 18, 2017) revealed that 50 kg of Jungle Brickets retail for 2000 KES. Though production capacity is not available on their website, according to a recent news article (Maichuhie, 2017, paras 4 -6) they work with over 50,000 nut farmers and employ 300 staff.

[22] Their website, where the original company information was found, is no longer working.

6.4 Retail and Distribution

Personal calls to each of the companies regarding retail locations reveal that most sell direct from their factory location or deliver on request. Jungle Nuts is the only company that confirmed their availability at supermarket locations. However, even with that confirmation, a foot search revealed that most supermarkets did not sell any biomass briquettes. In addition, a foot search revealed that none of the biomass briquette companies had consistent presence at the main open air low-income urban markets including Toi market (Kibera), Kawangware market (Kawangware), Mtindwa market (Buruburu), and Gikomba market (Nairobi town). While charcoal is sold in all open-air markets, busy streets, and crowded residential areas, biomass briquette producers rely on a system of loyal customers, many of whom order in bulk.

6.5 Summary

It is apparent that biomass briquette production has gained in popularity in Kenya in the last 20 years, starting with Chardust in the early 2000s, and rapidly evolving from there. Estimates of 40 – 50 producers in Nairobi alone provides evidence that market saturation is a risk. Though many companies are reportedly small-scale, several large-scale companies also exist, producing up to 100 tons per day. A comparative price analysis reveals that 4 kg of biomass briquettes retail for 200 – 295 KES. This is double the cost of charcoal, which retails for 100 – 140 KES. A review of some of the major biomass briquette suppliers found that 50 kg sell for a price ranging from 600 KES to 2300 KES. In addition, many companies have a diversified portfolio to appeal to a range of audiences. From energy audits, boiler conversions and carbon credits, to seedballs and mattresses, this may be indicative of a saturated market.

7.0 Organizational Structure and Promising Practices

The organization will be developed as a cooperative. The definition of a cooperative and cooperatives in Kenya begin this section. Next, the rationale behind choosing a cooperative over other organizational forms is established. Succeeding this, different models of cooperatives are briefly discussed. A review of youth cooperative case studies and lessons learned conclude the section. Potential staffing and management models may be found in Appendix 2.

7.1 Definition of a Cooperative

A cooperative is defined by the International Labour Organization (ILO, n.d., para. 8) as an "autonomous association of persons united voluntarily to meet their common economic, social and cultural needs and aspirations through a jointly owned and democratically controlled enterprise". It is characterized by its "distinct bottom-up decision making process" (ILO, 2009, p. 2) and its ability to improve access to "goods and services" to businesses or individuals (p. v). Cooperatives are member owned and member controlled businesses (Shaw, Alldred & Romenteau, 2015, p. 9). Every member has a voice, and contributes to major decisions, as well as obtains a share in the cooperatives' profits (p. 9). Cooperative members are also the organizations' "key stakeholders" (Ruostesaari & Troberg, 2016, p. 43).

7.2 Cooperatives in Kenya

The "Kenyan co-operative movement is currently ranked 1st in Africa and 7th internationally" (Ministry of Industry, Trade and Cooperatives, 2014, p. 6). In fact, research has suggested that 20% of Kenyans are cooperative members (Zaalouk, 2013, p. 347). According to Steinman (2017, p. 2) cooperatives in Kenya account for 45% of GDP, which he claims is larger than the public or the private sectors. In 2012, there were over 14,000 registered cooperatives in Kenya (Nyagah, 2012; as cited in Tshishonga & Okem, 2016, p. 59).

In Kenya, the Savings and Credit Cooperatives, SACCOs, are the fastest growing cooperative sector (Softkenya, 2013). Other cooperatives include agricultural marketing cooperatives, housing cooperatives, service cooperatives, industrial cooperatives, consumer cooperatives and multipurpose cooperatives (Kenya Legal Resources, n.d.). Limited information was available, at the time of writing, about worker cooperatives in Kenya. However, a meeting with the Deputy Commissioner of Registration uncovered that worker cooperatives do exist in Kenya, and are eligible for registration (personal communication, November 23, 2017). A worker cooperative is owned by its employees where "members obtain jobs and control the management and administration of their enterprise" (Government of Canada Co-operatives Secretariat, n.d., p. 3). For more information regarding cooperatives in Kenya, please see Appendix 3.

7.3 The Benefits of a Cooperative Organizational Structure

Because of the multi-roles undertaken by cooperative members, there are numerous accompanying benefits. Some of the benefits include access to training, information, networking opportunities, new markets (Shaw et al., 2015, p. 13), financial assistance, skills acquisition, job opportunities and self-reliance (Abbas, 2016, p. 273). Zaalouk (2013, p. 350) suggests that cooperatives represent a learning opportunity and a building of human capital for its members.

The ILO (2009, p. 12) also suggests that cooperatives may help prevent poverty by creating a platform for community self-help projects, and the creation of jobs for the lowest income earning members of society. A study in Nigeria (Abbas, 2016, p. 264) confirmed this suggestion. The study interviewed 150 cooperative members randomly sampled from the state of Yobe (p. 269). Overall, they found that the living standard for its members improved (p. 273). Birchall (2003) researched the correlation between poverty reduction and cooperatives through 11 case studies (pp. 31 – 62) from around the world. Overall, he found that not only did cooperatives improve outcomes for the poorest members of society, it is also a superior organizational form to the for-profit entity in terms of helping the most vulnerable (p. 62).

Zaalouk (2013, p. 350) believes that cooperatives are particularly important for youth in terms of participation and active citizenship. He also believes they have the "potential of fostering inclusiveness and staving off the sense of youth alienation". In his review of cooperative case studies, one particular cooperative, the Subeng Dinosaur Youth Cooperative in Lesotho, report similar sentiments. Its members attribute the cooperative with meaning and focus for their lives (p. 14). The youth reported that in the absence of the cooperative, they would be more likely to exhibit unsafe behavior such as drug and alcohol abuse (Shaw et al., 2015, p. 14).

Research also highlights the connection between women empowerment and cooperative membership. The Institute of Labour Economics (IZA) suggests that a cooperative organizational model is thought to better utilize the productive capital of women in comparison to private companies (Smith & Rothbaum, 2013, p. 11). Further, they link women's role in leadership positions to increased profits and positive outcomes in both children's education and health (Smith & Rothbaum, 2013, p. 13).

Cooperatives also fare well in comparison to private companies in regard to employment conditions, worker morale and productivity. A study by Burdin and Dean (2009) compared cooperatives with private companies in Uruguay from 1996 to 2005. Overall, they found average employment and wages were greater in cooperatives, and that during times of financial crises, cooperatives were better able to protect employees and employee wages by accepting lower earnings (p. 522). Further, the Government of Canada Co-operatives Secretariat (n.d., p. 13) reports that worker cooperatives are superior to private enterprises in regard to lower absenteeism and higher quality products and services. Worker cooperatives create direct reward systems for their worker-members through its' year-end dividend distribution. Gagne (2013, p. 9) suggests productivity-based reward systems gives cooperatives an "efficiency advantage" over private entities. Finally, a cooperative offers its members more incentive to suggest new ideas (Smith & Rothbaum, 2013, p. 9). When workers feel they have control of their business and contribute to important decisions, their motivation also increases.

Cooperatives are also thought to be an ideal organizational structure for the energy sector, and biomass in particular. According to Balasubramani et al., (2016, p. 860), a cooperative consisting of locals can maximize community benefit, negotiating power, and access to resources in a biomass manufacturing company. Further the researchers suggest the cooperative is at an advantage because they are able to pool resources to invest in production technologies, equipment, and storage (p. 860): "[s]mall scale renewable energy technology under the control of local communities can make substantial impact on the overall energy consumption of the country” (p. 860).

Due to the unique control structure of a cooperative, they are better equipped to implement egalitarian principles (Burdin & Dean, 2009, p. 526). In fact, according to Lund (2013, p. 5), all cooperatives abide to a common set of principles that outline their values of “democracy, equality, equity, self-help, self-responsibility and solidarity”. The embodiment of these principles make a cooperative an ideal choice for empowering local entrepreneurs in sub-Saharan Africa, with additional protection from potential economic shocks and recessions.

7.4 Cooperative Models

Various types of cooperative models exist in nearly every industry (Lund, 2013, p. 4). There are two broad categories of cooperative structures. In the first category, ownership rights are restricted to members. This category includes the traditional cooperative, proportional investment cooperative, member-investor cooperative and new generation cooperative (Chaddad and Cook, 2004, p. 352). In the second category, ownership rights are open to external players. This includes cooperatives with capital-seeking entities, and investor share cooperatives and investor-oriented firms, also known as a limited cooperative association (LCA) (Chaddad & Cook, 2004, p. 352; Lund, 2013, p. 15). A summary of these is presented below.

A traditional cooperative restricts ownership rights to members. According to Lund (2013, p. 7), the cooperative operates for the benefit of members, and those benefits are distributed in proportion to each members’ patronage with the cooperative. Patronage refers to a members’ use or support of the cooperative (Government of Canada Co-operatives Secretariat, n.d., p. 1). In a worker cooperative, patronage can be defined as the number of hours that a member has worked (Cooperative Development Institute, n.d., para. 9). Lund also reports that most cooperatives require members to pay their member share at the time they join. However, she acknowledges that if the cost of membership is significant, many allow payment to be made over time (p. 12). This model is the only cooperative model that allows members full control, and does not require upfront member capital investment. However, the cooperative must have another means of raising start-up capital.

Chaddad and Cook (2004, p. 353) describe a proportional investment cooperative as one that restricts ownership to members; however, members are expected to invest in proportion to their use. This can be done through strategies such as a base capital plan (Chaddad & Cook, 2004, p. 353). According to Royer (2003, para. 4), with a base capital plan, members’ required contributions are set every year according to the cooperative’s financial needs and the members’ average support over a certain period of time (usually the last three years). The proportional investment cooperative has the advantage of ensuring dividends are distributed based on patronage and investment, which is clearly defined from the start of the year. However, Royer (2003, para. 8) cautions that this model brings extra complexity, especially in a cooperative with frequent member turnover or changes in patronage.

Somewhat similar, Chadad and Cook (2004, p. 354) describe the member-investor cooperative as one that also restricts ownership rights to members; however, net earnings of the cooperative are distributed in proportion to member shareholdings rather than patronage. They suggest this can be done through participation shares, capital units and redeemable preference shares (p. 354). This model requires members to have upfront capital for investing. It provides members with incentive to invest in the cooperative, and helps ensure the cooperative has sufficient operating capital.

New generation cooperatives (NGC) also restrict ownership rights to members. However, in an NGC, rights are provided as tradeable delivery rights that members' must invest in at the time of joining (Chaddad & Cook, 2004, p. 355). The equity to fund an NGC comes directly through the sale of delivery rights to members (p. 355). A delivery right is "a members' right to deliver a specific amount of commodities to the cooperative" (Hackman, 2001, para. 2). This model is appropriate for cooperatives where members are selling a good or service directly to the cooperative. Members must also be aware of the volume of their good or service from the start of the year.

Cooperatives with capital seeking entities do not restrict ownership rights to members. Chaddad and Cook (2004, p. 355) explain that outside equity is acquired by a separate legal entity, which could be a "strategic alliance, a trust company or a publicly held subsidiary". The legal entity is either fully or partly owned by the cooperative (Chaddad and Cook, 2003, p. 7). In this way, the cooperative obtains external capital in exchange for a portion of its profits and divided control (Chaddad and Cook, 2004, p. 356). This model works well for established cooperatives with the experience and networks to restructure their organization and develop a separate entity that is attractive to outside investors or stakeholders.

Chaddad and Cook (2004, p. 357) also define the investor share cooperative. They describe the investor share cooperative as one where non-member equity capital can be acquired by individual investors. The co-op can then issue separate classes of equity shares. Chaddad and Cook suggest that they "may bundle different ownership rights in terms of returns, risk bearing, control, redeemability and transferability" (p. 357). "Investor shares include preferred stock, nonvoting common stock and participation certificates" (p. 357). This results in shared ownership control between the cooperative members and outside investors (Chaddad and Cook, 2003, p. 7). While an attractive option for raising capital, the shared control may also result in a conflict of interest between members and investors.

Finally, the investor-oriented firm (IOF), as described by Chaddad and Cook (2004, p. 358) redistributes residual claims and control rights to the organization's stakeholders. Cooperative ownership rights are then transferred to common stock (p. 358). The IOF represents a conversion from a cooperative to a private corporation. It may be used as an exit strategy for a cooperative looking to disband (Chaddad & Cook, 2004, p. 358).

7.5 The Youth Cooperative: Lessons Learned

Youth cooperatives have emerged all over Sub-Saharan Africa. The literature collected for lessons learned features youth cooperative challenges, successful case studies, lessons learned, and common themes. This next section will summarize some of these features.

Cooperative case studies in Sub-Saharan Africa (SSA) from the ILO (2016, pp. 14, 20) show that one of the biggest challenges faced by youth cooperatives is member retention. This is especially true in the formative stages of cooperative development, as it takes time to generate sufficient member income (p. 20). Therefore, before youth are empowered to unify, there must be an awareness about how forming a cooperative can make a significant difference to individual entrepreneurs (Kutywayo, 2015, p. 64). Chigunta et al., (2005, p. 54), calls this stage engagement and may also include "outreach services, relationship building and inviting others to participate".

Once the organization has formed and members come together, governance is a key issue (Booyens & Crause, 2009, pp. 163-164). Through democratic decision making (Kutywayo, 2015, p. 79), the governance body should be selected and roles or positions may vary depending on need and size. However, according to Booyens and Crause, the governance body must be supported by all members, and decisions of the board must be transparent with regular updates to all members (pp. 164 – 165). In short, members must feel like they have ultimate control of the cooperative (Sumelius et al., 2014, p. ii) to increase the likelihood of sustainability and success.

Many cooperatives have reported start-up funding and growth as major challenges (ILO, 2016, p. 20). Managing finances is key to successful enterprise development. Some cooperatives accomplish this by hiring full-time bookkeepers (Booyens & Crause, 2009, p. 165) and/or financial managers to keep all transactions transparent and ready for audit (Kutywayo, 2015, p. 86). In addition, early research should be done to provide the cooperative with access to introductory finance services, micro-finance, and ongoing financial training and support (Chigunta et al., 2005, p. 54).

A case study report of five cooperatives in South Africa (ILO, 2016) unveiled an interesting theme. Cooperatives often made major gains by obtaining publicity. Two examples, provided by the ILO, are illustrated here. The Masisizane Women's Housing Cooperative (pp. 30 – 33) started out as a small brick making enterprise that took pity on a woman whose house was ruined by flooding. They built the woman a four-bedroom house and invited the media and Provincial Department of Housing to the presentation of the house event. Through this presentation they were contacted by a commercial housing company and offered free training. They were also awarded a large contract by the Department of Housing. Similarly, a recycling cooperative called Hout Bay (pp. 38 – 41), staged a community protest against the current company contracted to collect garbage, due to their lack of recycling. Through this event, they were offered a contract with the city and now generate steady revenue through both the collection of garbage and sale of recyclable waste.

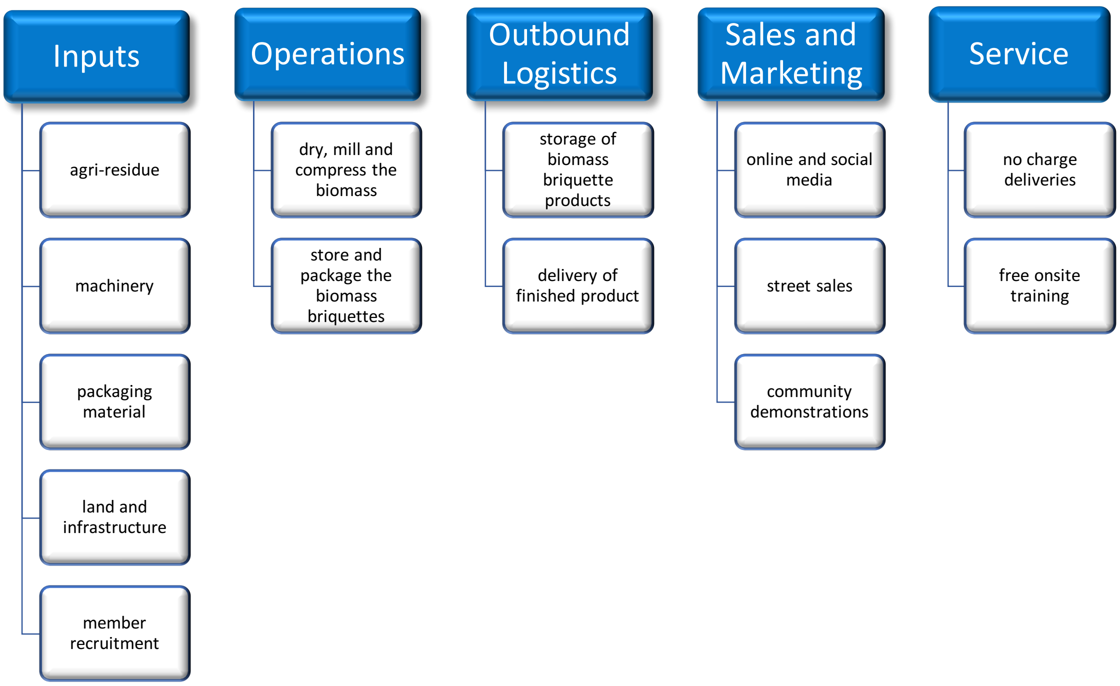
7.6 Summary

A cooperative is a collectively operated and owned business where major decisions and ideas come directly from its members. Cooperatives have been very successful in Kenya and contribute a major proportion of the country's GDP. The benefits of a successful cooperative are endless ranging from poverty reduction, to increases in individual members' quality of life, capital and knowledge acquisition. Benefits are also realized for the cooperative itself, as worker cooperatives are suggested to enhance product quality, motivation and productivity. Cooperatives are also able to take on many different forms or models according to the sector, context, demographics, and economic needs. The literature has outlined some key challenges and means to alleviate these in terms of member turnover, start-up, and scale up. Studies show that putting certain steps in place, such as knowledge building and communication, financial training and democratic decision making, are fundamental to a successful cooperative enterprise.

8.0 Business Model

Based on the literature review and market research, this chapter provides a potential business model that is differentiated from other biomass briquette competitors. The business model begins with the value chain analysis outlining the key inputs, operations, outbound logistics, sales and marketing and service (adapted from Porter, 1985). Each link in the value chain is discussed below with an emphasis on how value is created in each step.

Figure 4: The Value Chain



8.1 Inputs

The cooperative could work with individuals, youth garbage collection organizations, and/or communities to salvage useable waste from urban dumping piles in high density living areas. High quality briquetting machinery would be purchased to ensure high quality biomass briquettes. In addition, branded packaging materials could be used to advertise the biomass briquette brand. A plot can be rented in proximity to urban waste and member residence to reduce transport and fixed costs. Members could be recruited to run the cooperative with an emphasis placed on women from low-income areas that are in need of work experience, income and opportunity.

8.2 Operations

At the operations site, the waste would be transformed into energy via biomass briquettes using high quality briquetting machinery and adequate storage space to ensure raw biomass and biomass briquettes have been thoroughly dried.

8.3 Outbound logistics

Finished biomass briquettes could be packaged in 2 kg, 4 kg, 50 kg and 90 kg sacs. Biomass briquettes could be sold direct at the operations site, online, via charcoal vendors, and via 4 part-time marketing and sales officers.

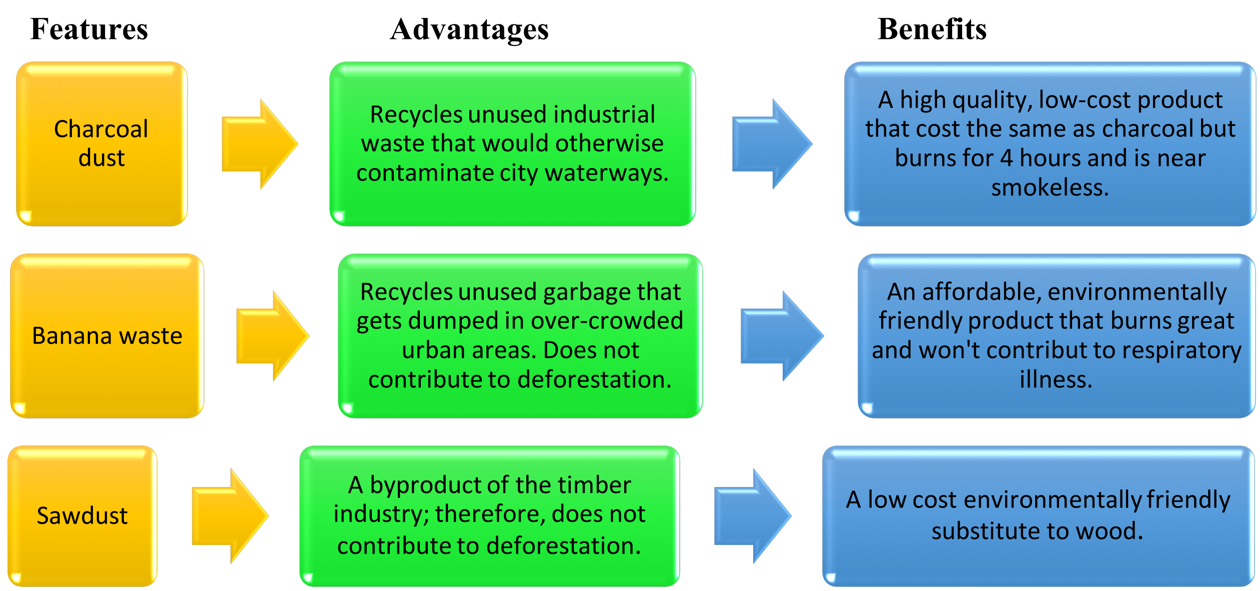
8.4 Sales and Marketing Strategy

According to Enterprising Non-profits and Octopus Strategies (n.d.a), there are five essential elements to the marketing plan. This includes product, place, promotion, price and positioning. The following section will outline each element and a potential strategy behind it.

8.41 The Product

Below is a potential chart outlining the features, advantages and benefits of buying a biomass briquette from this cooperative. The actual ingredients are the product features. The advantages represent the value added through each ingredient. Finally, the benefits, represent the reason behind why a customer should buy the product (Enterprising Non-profits and Octopus Strategies, n.d.a).

Figure 5: Product Feature



8.42 Place

Marketing messages could occur at a variety of locations. The cooperative could have an online presence with a website and Facebook business page. The product could also be advertised via a sales agent through live demonstrations in the community. Introductions could be made to the community chief in targeted communities known for domestic charcoal use, and the agent will request a live demonstration at an upcoming community meeting. In addition, the sales agents could personally visit charcoal vendors and street food entrepreneurs to provide samples and share information regarding the product. Two kg samples could be given out for free in exchange for customer contact details. These details could then be used to obtain product feedback and build up a relationship with the customer.

In order to enhance efficiency, institutional and/or industrial client outreach could focus on a small number of clients with high energy needs. Research could be conducted on institutional/industrial consumers within a 30 km radius of operations. Outreach could be conducted to schools, hotels, safari companies, food processing companies, hospitals and tea companies regarding their energy needs with an introduction to the company. Similar to the domestic consumer strategy, free samples could be offered in exchange for product feedback information and client details.

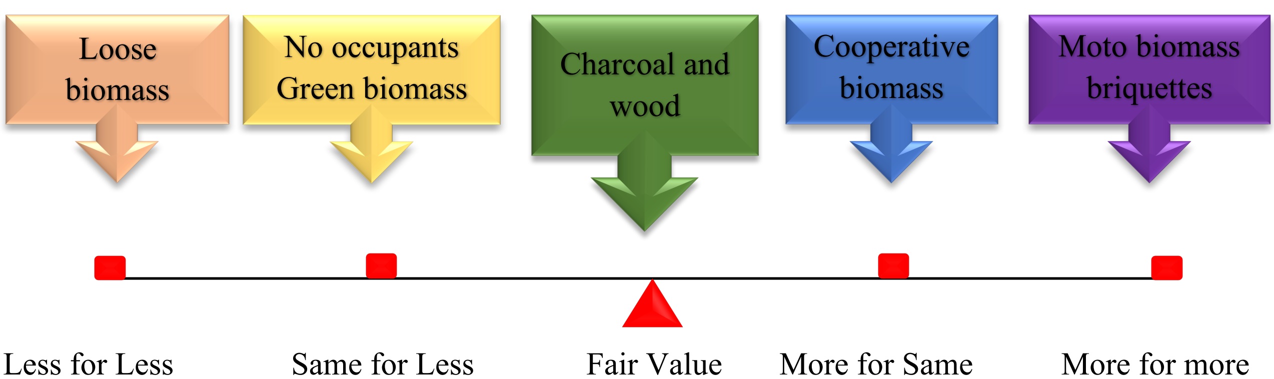
8.43 Promotion

For a successful promotion strategy, messages must be targeted at the correct audience (Enterprising non-profits & octopus strategies, n.d.a). Research has shown that in order to enter new markets, considerable awareness regarding the biomass briquette product is needed (Cohen and Marega, 2013, p. 39). Therefore, messages could promote the product quality that is valued by domestic clients including the product's density and weight, and its characteristics of easy ignition, long burn-time and minimal smoke. Following these messages, the low price would be made aware to all clients. Messaging geared for industrial clients could emphasize price, burning properties and delivery services.

8.44 Price

As a means to compete with traditional charcoal, it is essential to keep prices comparative. Domestic consumers represent the urban poor who do not have surplus disposable income and are already struggling to keep up with the cost of cooking fuel. Institutional consumers value low-cost above all other factors. Therefore, all possible means to keep costs low will be used in manufacturing the product. The biomass briquettes could be priced according to value based pricing (Enterprising non-profits & octopus strategies, n.d.b). Below is a value spectrum outlining where the Cooperative's biomass briquettes, traditional charcoal, and two top competitors, align.

Figure 6: Value Based Pricing



Fair value is the industry standard and is the price value point for charcoal. The less for less value point is occupied by free or low-cost forms of loose biomass. The same for less value point has no occupants. Biomass briquettes produced by the cooperative could align with the more for same value point. The more for same value point costs the same as fair value, but provides superior quality. Some of the leading competitors, Chardust, Moto Biomass briquettes, etc. fit into the more for more category. Their biomass briquettes are priced higher, but the quality is also superior to charcoal.

To encourage customer retention and recurring revenue, additional discounts will be offered for repeat customers, direct purchase from the warehouse, and bulk orders, see Figure 7.

Figure 7: Pricing and Discounts

8.5 Service

While service is not a large part of the biomass briquette enterprise mandate, some perks could be provided to customers including free delivery and training. Deliveries could be provided free of charge with bulk deliveries (over 90 kg) to occur same day. Small order deliveries will occur the same week to give time to organize area level deliveries. In addition, individuals who want to learn to manufacture biomass briquettes themselves, are welcome to attend the factory at any time. Cooperative members already working on production can explain the briquetting process as they work, and entertain any questions or comments from interested guests.

8.6 Summary

This business models shows that a business advantage could be derived primarily through the low price of the biomass briquettes. However, a community approach involving member recruitment, biomass procurement, and community outreach provides another niche to not only advertise the biomass briquettes, but spread the benefit of this product. The benefits include the reduced emissions for consumers, community recycling, convenience (through free deliveries) and free training for community members looking to manufacture their own biomass briquettes.

9.0 Regulations/Environmental Issues

This chapter outlines the regulatory requirements for a cooperative biomass briquette enterprise. It begins with a discussion of the cooperative registration and audit process. Next, it discusses the Environmental Impact Assessment and land use clearance required under the Energy Regulatory Commission (ERC, 2012a). A discussion regarding the Kenya Bureau of Standards standardization mark is then presented. Finally, Kenya's Value Added Tax (VAT) and how it applies to biomass briquettes, concludes the section.

9.1 Kenyan Cooperative Registration Requirements

The prescribed requirements for cooperative registration were not available at the time of writing; therefore, a visit to both the Registry office at the Social Security House, and a meeting with a Makadara District Cooperative officer revealed the necessary steps for registration. The following details the registration process.

To register a cooperative, a full list of members must be provided to the Ministry of Industry, Trade and Cooperatives, where a name search is conducted at the Registry office, costing less than three dollars (personal communication with Registry officer, Ministry of Trade and Development, June 22, 2017). Once a name has been approved, at least 10 individuals sign a letter to the district outlining their intention to register a cooperative. The District officer then undertakes a feasibility analysis to ensure the cooperative will be financially sustainable. Following a positive assessment, the group then invites a District Cooperative Officer to their first meeting where the bylaws will be determined and written. The District Cooperative Officer may charge fees up to $250 dollars for this service. The cooperative is then registered with the city of Nairobi ($34), and with the Ministry of Industry, Trade and Cooperatives ($43) (personal communication, Makadara District Officer, July 27, 2017).

Tax information for cooperatives was not available online from the Kenya Revenue Agency, or the Ministry of Industry, Trade and Cooperatives. Therefore, a visit to a cooperative auditor was conducted on July 25, 2017 to obtain more information. According to the cooperative auditor, profits and/or surpluses earned by the cooperative are not taxed the same way as those of a private entity. Cooperative profits are not taxed; instead, any interest earned on cooperatives' savings are subject to taxes. However, member dividend distribution at year end is subject to income tax (personal communication, July 25, 2017). Member dividends are subject to income tax at the same rate as employee income tax (Income Tax Act Cap. 470 Section 3(2)(b)). In addition, all employees of the cooperative are required to pay income tax on their earnings from the cooperative and subject to the same rate as all workers in Kenya. Monthly income tax rates are available through the Kenya Revenue Authority (2017, p. 5).

9.2 Environmental Impact Assessment

The Environmental Management and Coordination Act of 1999 (EMCA) established the National Environmental Management Authority (NEMA), which is the authority on the environmental management of Kenya (National Environment Management Authority, 2017a, para. 12). The EMCA requires that new investment in Kenya (including medium- and large-scale biomass briquette manufacturing) be screened through an Environmental Impact Assessment (EIA) and periodical environmental audits (EA). The EMCA stipulates that a briquetting organization must hire a licensed EIA expert to conduct the EIA, and the fee is 0.1% of the project cost (National Environment Management Authority, 2017b, para. 1).

9.3 Land Use Clearance

According to the ERC (2012b), land use for the generation of energy must be approved by the local government. The approval process is outlined by the ERC: the investor must first pay a fee and give a notice of 14 days in the local daily news. The investor must then put a sign on the land indicating intention to change its use. The county government receives submissions from the general public on any oppositions to change of use, which is then assessed. The license is then issued or denied.

9.4 Standardization Mark

The Kenya Bureau of Standards (KBS) (2014) has issued the “Standardization Mark”, a mandatory product certification scheme for locally manufactured products. Charcoal biomass briquettes fall under this standard, and the mark must be secured in order to sell through the formal market. The Kenya Bureau of Standards website reports that applications can be made to the Kenyan Bureau of Standards and the cost of each sticker is .49 KES (KBS, 2014).

9.5 VAT

VAT is not imposed on biomass briquettes. This is legislated under the VAT Act and subsidiary legislation of 2009 under the second schedule (Energy and Environment Partnership, 2013, pp. 25 – 26). In the VAT Act (2012), second schedule, tariff No. 4402 – 4402.90, wood charcoal (including shell or nut charcoal) is exempt from VAT.

9.6 Summary

Registration, taxation, public audits, environmental assessments and certification of product standards all apply to a cooperative biomass briquette manufacturing enterprise. These regulatory requirements have both time and cost implications.

10.0 Critical Risk Factors

Starting up and operating a new business has inevitable risks. This section discusses the main risks of commencing a biomass briquette cooperative in Kenya. The discussion is limited to risks associated with market demand, briquetting technology, personnel requirements, and corruption.

10.1 Market Demand

The low "wholesale market price of charcoal and availability of firewood creates structural constraint to the adoption of biomass briquettes and investment in higher quality machines" (Cohen & Marega, 2013, p. 37). While biomass briquettes are ultimately a replacement for charcoal, most domestic consumers do not account for the additional quality (Ngusale et al., 2014, p. 757) (i.e. longer burn time and smokeless characteristics) of biomass briquettes when making their product choice. While all attempts have been made to keep prices low for the cooperative biomass briquettes, it is unknown whether the domestic market will perceive them as higher quality and start buying in enough quantity to ensure the enterprise is profitable.

Little information could be obtained regarding the industrial market for biomass briquettes. It is relatively unknown whether this market is saturated, or whether demand still exists. Therefore, it is a business risk to assume that the cooperative will be able to sell all of the green biomass briquettes it can produce.

10.2 Briquetting Technology

Relatively little is known about using banana stems and leaves as carbonized biomass briquettes. Cited studies for this paper only tested green banana waste to obtain the calorific value. Though this still offers an indication of quality, more testing is needed. In addition, while the literature reports an average efficiency rate of carbonization for kilns, every agri-residue will differ. Therefore, further field tests are needed to measure the exact efficiency rate to carbonize banana waste into biochar.

10.3 Personnel Requirements

One of the main challenges reported for youth cooperatives is member turnover. The proposed start-up salary for the cooperative is relatively low, yet fair at 500 KES per 6 hour day ($6.00). Recruitment efforts will target woman from low-income areas who do not have advanced education or other employment opportunities. Therefore, they will need training and excellent quality management. In order to run a successful enterprise with high volume production coupled with high volume sales, employee motivation is essential. Unmotivated staff will result in the failure to meet forecasted volumes, which will ultimately prevent the enterprise from being profitable or sustainable.

10.4 Corruption

Kenya ranks 145 out of 174 countries, with 1 being the best, on Transparency International's corruption index (Transparency International, 2016); its score out of 100 dropped from 27 in 2012 and 2013 to 26 in 2016. The wood charcoal industry has long reported corruption as an inherent problem in transporting charcoal to market. Traffic police and local authorities capitalize on the industry by demanding bribes from those transporting charcoal (Stockholm Environment Industry, 2014, p. 2). Corruption does not impact the charcoal industry alone; many small business owners and entrepreneurs regularly report the Kenyan police and Nairobi City Council as their main impediments to running a profitable business (Schifrin, 2016).

10.5 Summary

Market demand, briquetting technology, personnel requirements, and corruption all present significant risks to the success of a biomass briquette enterprise. More information could have been obtained regarding the scale of these risks by interviewing other biomass briquette producers. However, it may have been challenging to obtain truthful answers from potential competitors; further, this form of inquiry was outside the scope of this research.

11.0 Financial Projections

Financial projections include start-up costs, year 1 – year 3 cash flow projections, and a pro forma income statement. The start-up budget, cash flow projections and income statements were created with guidance from Alter (2000). Spreadsheet templates for both the income statement and cash flow projections were adapted from Futurpreneur Canada (2017).

11.1 Start-up Budget

The start-up budget for the enterprise is just over $31,000 including a contingency of 10% of non-contingency costs or $28,361. It includes the registration costs, equipment, one year plot lease, and site construction costs. Nearly half the start-up budget is due to the cost of both a pick-up truck and trailer, which are necessary for both picking up the raw biomass (banana waste, sawdust and charcoal dust), and making deliveries of finished biomass briquettes. See Appendix 4 for the entire start-up budget.

11.2 Cash-flow Projections

The cash flow projections include the first 3 years of operations. Table 4, below for year 1, only includes the first five months of operations and the year-end total. It is assumed that the fourth month is when both production and sales reach their peak (21 tons per month). The remaining 7 months are identical to the fourth month. In order to produce 21 tons, the following biomass quantities are needed: 20 tons of banana waste (which will be reduced to 5 tons of biochar), 5 tons of charcoal dust, and 11 tons of sawdust. Additional detail regarding how costs were estimated may be found in Appendix 5. For the entire year 1 – year 3 cash-flow projections, see Appendix 6.

According to the cash flow projections, $35,000 Canadian dollars will need to be raised to keep the cash balance positive. The cash flow assumed a grant of $15,000 and a three-year loan with 10% interest of $20,000. Another option for raising start-up capital, if business loans and grants are not available, involves micro-finance loans. Individual members could apply for these loans and pool their resources. Micro-finance is available through various banks and institutions within Kenya.[23]

The cash-flow projections show a positive cash balance of $10,478 at the end of year 1. Cash flow projections for year 2 and 3 do not include any other financing except membership fees. According to the Co-operative Societies Act (1998, CAP 490) section 22(b), members must buy shares or make any other payments provided for in the by-laws. Year 2 assumes production and sales of 21 tons per month and year 3 assumes production and sales of 42 tons per month. The resulting cash balance is $14,974 at end of year 2 and $37,782 at the end of year 3. The cash-flow does not account for year-end member dividend distributions. The cooperative must

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[23] Microfinance is available from various institutions. Some possibilities include Equity Bank: http://ke.equitybankgroup.com/business/products/business-loans/micro-finance-loans; Faulu Microfinance http://www.faulukenya.com/; Musoni Kenya: https://musoni.co.ke/, and Kenya Women Microfinance Bank: https://www.kWftbank.com/

collectively decide how much money is needed to reinvest back into the cooperative to account for all expenses and potential risks, before excess profits are divvied out.

Table 4: Cash Flow Projections Year 1 Canadian Dollars[24]

	Start-up	Jan 2018	Feb 2018	Mar 2018	Apr 2018	May 2018	Total[25]
Equipment costs	**27,391**						
Kiln * 4	2,000						
Briquetting machine	4,819						
Grinder	1,205						
Drying racks for biomass briquettes	500						
Drying racks for biomass	500						
Plastic crates	100						
Electrical chords	50						
Cleaning supplies	50						
Promotional materials	75						
Safety equipment	200						
One year rent down payment[26]	2,892						
Infrastructure adaptations to operations site	1,000						
Truck	10,000						
Trailer (3 tonne) [27]	4,000						
Production Supply costs		**328**	**328**	**492**	**656**	**656**	**7,048**
Banana waste (need to buy 20 tones to make 5 tons biochar)	$.24/kg	60	60	90	121	121	**1,295**
Charcoal dust (need to buy 5 tons to make 5 tons of biochar)	$.48/kg	121	121	181	241	241	**2,591**
Sawdust (need to buy 11 tons to make 11 tons green briquettes)	$.12/kg	67	67	101	134	134	**1,445**
Gunia bags (236 per month)[28]	$.33 bag	38	38	58	77	77	**825**
Paper bags (1251 per month)[29]	$.66 bag	41	41	62	83	83	**891**
Total kg produced		10,500	10,500	15,750	21,000	21,000	**225,750**
Banana waste kg produced		2,500	2,500	3,750	5,000	5,000	**53,750**
Charcoal dust kg produced		2,500	2,500	3,750	5,000	5,000	**53,750**
Sawdust kg produced		5,500	5,500	8,250	11,000	11,000	**118,250**
Resources		44	88	132	176	176	1,844
Electricity[30]		41	83	124	165	165	**1,733**
Water[31]		3	5	8	11	11	**111**
Admin Supply Costs		**47**	**47**	**47**	**47**	**47**	**564**
Receipt Books		11	11	11	11	11	**130**
Phone/Internet Credit		36	36	36	36	36	**434**

[24] Cash flow projections were obtained in the local currency and then converted to Canadian dollars based on the assumption that 1 Canadian dollar is equivalent to 83 Kenyan shillings.
[25] The total column includes the entire first year of operations. For full cash-flow projections, see Appendix 6
[26] An entire year's rent is required for lease arrangements in Kenya
[27] Trailer cost based on Quantum trailer ltd. (2016)
[28] It is assumed that an estimated 88% of sales will be in 50 – 90 kg sizes. Therefore, an estimated 236 90 kg sacs are needed per month.
[29] It is assumed that 12% of sales will be in the 2 – 4 kg sizes. Therefore, an estimated 1251 2 kg bags are needed.
[30] Estimated based on kW use.
[31] Estimated base on litre use.

Licensing and Regulations	368	4	7	11	15	15	155
Cooperative name search	3						
Cooperative registration	337						
Product certification (standardization mark)[32]		4	7	11	15	15	**155**
Environmental Impact Assessment (.1% of total project cost)	28						
VAT application for cooperative							
Human Resources	602	4	697	1,046	1,395	1,395	**14,540**
Staff training[33]	602						
NSSF Contributions[34]		0	39	59	79	79	**809**
Manager salary[35]		1	89	133	177	177	**1,816**
Employee salary[36]		3	569	854	1,139	1,139	**11,674**
Year-end accounts audit							**241**
Maintenance and insurance		131	172	213	255	255	3,107
Car insurance (5% of vehicle value) [37]		33	33	33	33	33	**391**
Vehicle maintenance and repairs[38]		50	50	50	50	50	**600**
Machine maintenance and repairs [39]		0	0	0	0	0	**300**
Vehicle diesel [40]		41	82	124	165	165	**1,732**
Garbage disposal fees [41]		7	7	7	7	7	**84**
Sub-total	28,361	557	1,339	1,941	2,542	2,542	**27,017**
Contingency costs [42]	2,836	56	134	194	254	254	**2,702**
Other Disbursements		646	645	645	645	645	7,745
Cooperative Bank Loan Interest Payment[43]		168	163	159	155	155	**1,734**
Cooperative Bank Loan Principal Payment		479	483	487	491	491	**6,011**
Total Cash outflows	**31,197**	**1,258**	**2,119**	**2,780**	**3,442**	**3,442**	**37,464**

[32] Standardization stickers cost .01 per sticker.
[33] The training is for 10 days for 10 staff at 500 KES per day (approximately $6 Canadian dollars per day)
[34] The employer is responsible to pay half of the National Social Security Fund contributions which is 6% of total salary (National Social Security Fund, 2017).
[35] There will be one manager who will receive a salary of 700 KES per day worked.
[36] Each employee will be paid 500 KES per day worked until organization scale up. There will be 9 employees. Employees are subject to 10% income tax; however, due to a salary of only 10,500 KES per month, they are entitled to personal relief of 1280 KES which covers their entire monthly income tax (Kenya Revenue Authority, 2017, p. 21). Employees must also contribute their own health insurance at a cost of 400 KES per month for regular staff and 500 KES per month for the manager (Classified African Ventures Ltd., 2017) and pay the remaining 6% if their NSSF contributions.
[37] Vehicle insurance cost based on estimate provided by Britam Insurance Providers (personal communication, August 22, 2017).
[38] According to an article in the Standard newspaper, at least 24,000 KES should be put aside each year for maintenance and repairs: https://www.standardmedia.co.ke/article/1144019015/the-cost-of-owning-a-car due to inflation, and the additional cost of a commercial vehicle.
[39] The corrosive nature of compressing carbonized biomass briquettes means the machine will inevitably need repairs and maintenance. The same estimate used for vehicle repairs is used for the machine, which is likely an overestimate. There is a warranty for the first 6 months.
[40] Based on driving 75 km per work day, and a mileage of 10 km/litre (Fuelly, 2017) which is 7.5 litres. Cost of diesel is an estimated 86.86 KES/ per litre, meaning daily cost is approximately 651.45 KES per day or $7.84 per day and $165 per month. This does not include the cost of picking up the sawdust, which has already been factored into the price of sawdust.
[41] Based on current cost of garbage disposal fees in Buruburu.
[42] Contingency costs are 10% of project cost and monthly costs.
[43] Loan principal payment and interest payment schedule adopted from monthly loan calculator: http://www.kahnawake.com/org/sdu/housing/calculator/CalcWithAmort.htm

Cash Inflows							
Funding sources							
Cooperative Bank of Kenya loan	**20,000**						
International grant [44]	**15,000**						
Membership join-up fees [45]	**241**						
Membership monthly dues[46]		**60**	**60**	**60**	**60**	**60**	**723**
Total kg sold		5,246	10,491	15,737	20,982	20,982	**190,071**
Total kg given away (free samples)		600	600	313	313	125	**2,200**
Total kg produced		10,500	10,500	15,750	21,000	21,000	**225,750**
Remaining inventory (kg)		4,655	4,064	3,765	3,470	3,363	**3,239**
Proportion of full production		50.0%	50.0%	75.0%	100.0%	100.0%	**90.9%**
Assumptions, number of units sold (by size)							
2 kg products given away as free samples		**300**	**300**	**156**	**156**	**63**	**1,100**
2 kg sales		156	313	469	625	625	**6,563**
4 kg sales		78	157	235	313	313	**3,287**
50 kg sales		17	35	52	69	69	**725**
90 kg sales		32	64	95	127	127	**1,334**
450 kg sales (bulk)		2	4	6	8	8	**84**
Revenue from sales ($)	**0**	**1,028**	**2,056**	**3,084**	**4,112**	**4,112**	**43,175**
2 kg products given away as free samples		**0**	**0**	**0**	**0**	**0**	**0**
2 kg sales		132	264	395	527	527	**5,535**
4 kg sales		123	245	368	490	490	**5,148**
50 kg sales		156	312	468	623	623	**6,547**
90 kg sales		497	995	1,492	1,989	1,989	**20,886**
450 kg sales (bulk)		120	241	361	482	482	**5,060**
Total cash inflows	35,241	1,088	2,116	3,144	4,172	4,172	**43,898**
Cash balance beginning of period		4,044	3,874	3,871	4,235	4,966	
Cash balance, end of period	**4,044**	**3,874**	**3,871**	**4,235**	**4,966**	**5,696**	**10,478**

11.3 Income Statement

According to the pro forma income statement, at the end of year 1, a net surplus of over $4,200 will be obtained. Year 2, ends with a surplus of $7,100. Finally, year 3, doubles production to 2 tons per working day, which also doubles operating expenses and doubles the staff salary. The net surplus finishes at $26,000 demonstrating that scaling up will more than triple the profits. See Table 5 below. The pro forma income statement does not include start-up costs and purchases; however, it does include machine and asset depreciation (included in the production costs). To see the depreciation calculation, please refer to Appendix 7. To see all items factored into the production costs, see Appendix 8. The income statement does not include the estimated $15,000 grant, as no repayment is expected nor is the grant earned income (Deloitte, 2016, p. 5). The operating profit margin is comparatively low in year 1 at only 15%; however, it increases to 18% in year 2 and is a very respectable 28% in year 3. The pro forma income statement clearly demonstrates that scale-up is necessary to obtain adequate year-end surplus for operating capital and member dividend distributions.

[44] It is hoped that the cooperative will be able to obtain an international grant of at least $15,000.
[45] Membership join up is $25. It is not necessary to pay it all at once, members may pay through installments.
[46] 500 KES per month, which is approximately $6 Canadian dollars, is paid on a monthly basis as member dues.

Table 5: Pro Forma Income Statement Canadian Dollars

	Year 1	Year 2	Year 3
Revenue			
Gross sales	43,175	49,343	98,686
Monthly membership dues	723	723	1,446
Total revenue	**43,898**	**50,066**	**100,132**
Cost of goods sold			
Beginning inventory	0	101	108
Purchases or production costs (raw materials)	25,226	27,715	47,756
Total cost of all goods available for sale	25,226	27,816	47,864
Ending inventory (unsold finished product)	101	108	121
Cost of goods sold	**25,125**	**27,708**	**47,742**
Gross profit	18,774	22,358	52,390
Operating expenses			
Marketing and sales			
Staff salary + training (marketing and sales related)	7,046	7,894	15,787
Promotional materials (signs, pictures, advertisements, business cards)	75	75	75
Legal and administrative			
Cooperative name search	3	0	0
Cooperative registration	346	0	0
Environmental Impact Assessment (.1% of total project cost)	28	0	0
Year-end accounts audit	241	241	241
Interest on borrowed capital	1,734	1,099	404
NSSF contributions	809	947	1,894
Operations and maintenance			
Truck insurance (5% of vehicle value)	391	391	391
Vehicle maintenance and repairs	600	600	600
Office supplies			
Receipt book	130	130	130
Phone/internet credit	434	434	434
Total operating (non-production) expenses	**11,837**	**11,812**	**19,956**
Contingency costs (estimate)	2,702	3,439	6,325
Total net income/(loss)	**4,235**	**7,107**	**26,108**
Operating profit margin[47]	**15%**	**18%**	**28%**

11.5 Summary

The start-up budget, cash-flow projections and pro forma income statement suggest that the cooperative could generate sufficient revenues to finance operational and capital needs and provide a living income to its members. Over $35,000 in capital will be needed to start-up the enterprise. The operating profit margin, based on 21 tons per day is just over 18%; and therefore, careful monitoring of the budget and cost management will be necessary for maintaining a

[47] The operating profit margin was calculated by dividing the net profit by total revenue. It does not include interest on borrowed capital or NSSF contributions.

positive cash flow and ensuring the sustainability of the enterprise. The cash flow projections and pro forma income statement provide evidence that scale-up is essential for increasing the profit margin, staff salary and net profits.

12.0 Summary and Recommendations

The results of the feasibility study provide evidence that a Nairobi based cooperative could generate sufficient profits to provide a living income to its members and enough retained capital to finance future operating requirements. It is recommended that VAP follow-through with establishing the biomass briquette cooperative. However, numerous challenges associated with this industry have been identified. The findings and associated sub-recommendations are broken down by the research questions below.

12.1 Technical Specifications

The production of biomass briquettes is characterized by comparatively low barriers to entry. Nonetheless, it still requires knowledge, machinery, government approval, and sufficient human and financial capital. Many studies have been written regarding the biomass briquette quality using different biomass. The material should have a LHV or calorific value of at least 15 Mj/kg to ensure enough energy output for cooking or heating is given off. A minimum table of standards should be developed and used to test biomass briquette quality on a weekly basis. It is also advisable to conduct continuous research and field trials on alternative biomass options.

Many options are available both locally and internationally for manufacturing briquettes. While grinders are not essential, their use with bulky or awkward biomass will greatly reduce labour costs and improve the efficiency of the briquetting machine. The briquetting machine itself should have a motor of at least 22.5 kW and a capacity of 250 kg per hour. Screw extruder machines capable of producing up to 375 kg/hour using a 7.5 HP engine, are available in Kenya, which is sufficient for biomass briquetting start-up. Due to the lower cost of local machines and the convenience of having local repair outfits, it is recommended to purchase local machinery first. However, following successful biomass briquette production of 3 - 5 years, international companies may be contacted to scale-up operations.

Several regulations apply to the start-up of an enterprise. The cooperative, as a new enterprise, needs to go through several stages of registration and approval. Before it can be registered, at least 10 members must be committed. In addition, before the enterprise can produce biomass briquettes, several environmental assessments including an EIA, and land clearance, must be conducted. Following that, standardization certification is needed, and finished product must be branded with standardization stickers. At least 2 months should be allowed for regulatory requirements to be addressed.

12.2 Market Viability

According to the literature review and market research, there are sufficient markets for the inputs of a biomass briquetting enterprise in Nairobi. Available biomass, packaging, machinery and materials are all available in Kenya. The fundamental challenge remains with obtaining enough biomass, at a low enough price, to produce a sufficient volume of biomass briquettes (i.e. 21 tons per month). Based on the review of biomass options, it is recommended that the enterprise commence operations using banana waste, sawdust and charcoal dust.

The comparative cost of biomass in Kenya is very low. The national average price is 81 KES per 4 kg. Fortunately, in Nairobi, the retail price is nearly double that ranging from 100 – 140 KES per 4 kg. Therefore, it is recommended to restrict the target market to Nairobi based consumers.

There is a reportedly significant market opportunity for the outputs of biomass briquettes. The ERC (n.d., para. 1) reports that biomass makes up 70% of the country's energy needs. Charcoal is reported by the Ministry of Environment, Water and Natural Resources (2016, p. 9) to be used by 80% of the urban population. Though this is likely an overestimation, charcoal vendors are visible at every major market and busy street, which provides an indication that it is still a highly sought-after energy fuel. While anecdotal reports suggest that significant potential markets also exist for institutional and industrial consumption, no statistics quantifying this potential are available.

Marketing messages should appeal to consumer groups based on their product preferences. Consumer preference research found that the domestic market values weight and size over other qualities (including smoke and burn-time). Domestic buyers usually have comparatively low-income and buy charcoal in small quantities from a nearby vendor that they know. Institutional and industrial consumers value price above all other characteristics. Further, industrial consumers often make bulk purchases and need a guaranteed supply to satisfy their production before becoming regular buyers. Limited information was available on export potential; however, this may also present an opportunity.

The market research also shows that there are already a significant number of biomass briquette producers (both producing green and carbonized biomass briquettes) based in or nearby Nairobi. While most producers are small-scale of varying quality, some producers manufacture in excess of 70 tons per day. While difficult to establish, market saturation is a risk at the price point of 200+ KES per 4 kg. The competitor price than varies considerably for 50 kg (ranging from 600 – 2300 KES).

12.3 Business Model Viability

A potential business model was developed for the sale of biomass briquettes. Taking into consideration competitor producers and the charcoal industry, a low price coupled with aggressive marketing, is recommended. Repeat customer retail prices should be set at 70 KES for 2 kg, 130 KES for 4 kg, 750 KES for 50 kg and 1300 KES for 90 kg. In order to enhance this business model, considerable community outreach is recommended. A community based focus that partners with youth garbage collectors, community leaders, and our main consumers, women, would be of value. Free training for those wanting to learn this green technology, is also advised. It is also recommended that the cooperative start out on a smaller scale and scale up as networks, clientele, and expertise within the industry grow.

12.4 Promising Management Practices

A Cooperative organizational structure was chosen for its social and financial benefits. Cooperatives work to alleviate poverty (ILO, 2009, p. 12), empower women (Njenga et al, 2013, p. 27), provide a great platform for ideas and innovation (Smith and Rothbaum, 2013, p. 9), and have an impressive track record in Kenya (Tshishong and Okem, 2016, p. 61). They also fare well against private entities in their ability to engage youth in active citizenship and participation (2013, p. 350).

It is recommended, as a means of keeping the cooperative simple and locally run, that ownership rights be restricted to members. Each member should have an equal vote in the cooperative decision-making process. In addition, it is advised that the cooperative be developed as a worker cooperative; worker cooperatives provide employment for their members (Government of Canada Co-operatives Secretariat, n.d.). This model of a worker cooperative where members not only obtain a daily wage, but also have the opportunity to cash in on the enterprise's profits, should help to maximize worker motivation.

As a start-up small-scale cooperative, assuming outside grants and loans are available, it is advised to initiate a traditional cooperative. The fee for joining the cooperative could be set at 2000 KES and will provide each member with one share. Shares may be redeemable to the cooperative. Year-end surpluses, after subtracting operating capital needed for the following year, may be distributed to members based on their patronage. Commonly used definitions of patronage for a worker cooperative refer to number of hours worked; however, this may be altered to include other benefits or criteria (Cooperative Development Institute, n.d., para. 8, 11). Members must agree on the definition of patronage. Finally, there is always an opportunity to evolve from one form of cooperative to another as the economic environment changes.

The success or failure of this enterprise will ultimately depend on the members themselves and the governance structure. Before members commit to joining the cooperative, it is essential to clearly communicate a cooperative's benefits, member roles, expectations and visions for the future. Once formed, decisions should be made in a transparent way and members should feel in control of the enterprise by enjoying their voting rights, having their ideas heard, and electing the board. In addition, it will be important to find members who already have some experience in the charcoal industry, or other renewable energy field.

12.5 Economic and Financial Viability

Start-up costs, cash-flow projections, and a pro forma income statement was undertaken to explore the economic viability of the enterprise. The results are as follows, at the end of year one, the cash-flow projection shows a cash balance of $10,478. However, in order to keep the cash on hand positive over the first year of operation, an estimated $35,000 in start-up funding should be raised. It is expected that an international grant may be awarded that can raise at least $15,000. The remaining amount will need to be secured through a bank loan. The cash balance at the end of year 2 is $14,974, and this number more than doubles when production is doubled in year 3 at $37,782. The cash flow projection does not account for member dividend distribution.

The pro forma income statement shows a net surplus of $4,235 after the first year and $7,107 after the second year (based on a production rate of 21 tons per month). When production is doubled in the third year, the net surplus more than triples to $26,108. The operating profit margin is comparatively small at 15% for the first year and 18% for the second. Therefore, turning a profit and maintaining sufficient capital to fund the cooperative may be a challenge should unforeseen challenges or costs emerge during the first 2 years. By doubling production, the operating profit margin is significantly increased to 28%. Therefore, it should be a goal of the cooperative to scale up as soon as it is economically feasible. Doubling production is a first step towards scale-up, but in order to capitalize on net profits and member dividend distribution, further growth should be a major priority of the enterprise.

Every attempt was made to ensure estimates were as accurate as possible. Estimates were derived from online publications, manufacturer publications, personal communications with input suppliers, current prices, currency rates, and advisers in the field. However, they remain estimates only, and may differ from real-life events. However, to provide a cushion, contingency costs of 10% of the monthly cash outflows was added to the budget. Though there are several risks apparent in starting this enterprise, and field tests should be conducted before formally registering and commencing operations, the benefits should exceed the costs.

The financial forecasts include a salary of approximately 10,500 KES ($127) per month per member to undertake part-time work (up to 6 hours per day for 21 working days a month) and a salary of 14,700 ($177) for 1 manager. In addition, members will receive dividends at year end contingent on their patronage. However, the cooperative board should approach dividend distribution very conservatively in the first year, especially if a grant was obtained, to ensure enough operating capital is available for year 2. While member earnings are relatively low, the cooperative is targeting impoverished women, and with a national poverty rate of 45.5% in Kenya (United Nations Development Programme, 2017), it presents them with an opportunity to increase their income.

12.6 Next Steps

During the implementation process, it is recommended to document any unforeseen challenges or necessary deviations from the project design as a means to help other youth or organizations planning to start-up similar enterprises. A summarized outline for the next steps for this enterprise are included below.

1. Recruit members through VAP's well-established network of recent secondary school graduates in Eastlands Nairobi. Up to 12 members may be recruited.
2. Organize a meeting and agree on a group name.
3. Register the group name with the Ministry of Industry, Trade and Cooperatives.
4. Write a letter to the Commissioner of Cooperatives and invite the District Officer of Makadara to attend an official group meeting.
5. Conduct the group meeting where applications are filled out, the cooperative board is elected and members are designated to write the bylaws (or the district cooperative officer is paid to write the bylaws).
6. Open a bank-account with the Cooperative Bank of Kenya and inquire about loans.
7. Apply for grants. Possibilities include the UNDP Small Grants Program (SGP)[48], Canada Fund for Local Initiatives[49], and Finland Fund for Local Cooperative (FLC)[50].
8. Search for a plot to rent and procure equipment from established suppliers.
9. Procure raw biomass from established biomass sources and establish a contract for continuing supplies.

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[48] More information regarding the UNDP SGP can be found here: https://www.sgp.undp.org/

[49] More information regarding the Canada Fund for local initiatives can be found here: http://www.canadainternational.gc.ca/kenya/development-developpement/cfli-fcil-2017_2018.aspx?lang=eng

[50] More information about the Finland FLC can be found here: http://www.finland.or.ke/public/default.aspx?nodeid=46399&contentlan=2&culture=en-US

10. Contact the National Environment Management Authority and inquire about conducting an Environmental Impact Assessment and land use clearance.
11. Conduct field trials for establishing a quality biomass briquette.
12. Contact the National Bureau of Standards and inquire about obtaining product certification.
13. Commence operations.

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Appendix 1 Biomass Options in Kenya

A report conducted by Intelligent Energy Europe, IEE (2016, pp. 28 - 32) summarizes surplus biomass availability by county in Kenya. They also identify the residue to product ratio (RPR) and low heat value (LHV), which is equivalent to calorific value. The table below is based on the data[51] from the IEE report (2016, pp. 28 – 32). The proximity to Nairobi was calculated using the directions function of Google Maps (Google, 2017). The table is followed by a detailed discussion regarding biomass materials in Kenya.

Table 6: Biomass Surplus by Region

County	Biomass	Proximity to Nairobi	RPR	LHV (Mj/kg)
Bungoma and Kakamega	Sugarcane bagasse Sugarcane stalk and leaves	(400+ km from Nairobi)	0.38 0.22	12.93 16.61
Narok and Nakuru	Timber	(143 and 160 km from Nairobi)	Not available	20.18
Kiambu	Coffee husks	(16 km from Nairobi)	0.24	14.10
Kirinyaga	Rice husks Rice straw	(119 km from Nairobi)	0.29 2.19	16.17 13.45
Taita Taveta	Sisal ball Sisal bogas	(330 km from Nairobi)	4.10 19.80	14.85 14.85
Kwale	Coconut husk Coconut pulp	(500 km from Nairobi)	1.10 2.42	17.66 0.01
Kilifi	Sisal and Coconut	(500 km from Nairobi)	See above	See above
Nairobi	Banana waste	0 km	N/A	17.6
Nairobi	Charcoal dust	0 km	N/A	24.5

Charcoal dust

Charcoal dust accumulates at all charcoal vendors throughout Nairobi. In fact, it is estimated that over 700 tons of charcoal is consumed every day in Nairobi leaving about 70 tons of dust per day (Ngusale et al., 2014 p. 750). Though 70 tons is a lot, it is spread amongst charcoal middlemen, charcoal vendors and charcoal consumers, over hundreds of locations. In Buruburu, the dust is sold by charcoal vendors for 200 KES per 50 kg, equivalent to 4 KES/kg (personal communication with charcoal vendor, June 10, 2017). The price is a little lower at lower income areas such as Kibera or Kawangware at 150 KES per 50 kg (personal communication with Kibera charcoal vendor, June 20, 2017). Charcoal dust accumulates on the roadside and therefore mixes with garbage, metal bits, dust and other debris. One has to carefully sort through the charcoal dust before loading it into the briquetting machine. Further, there is much

[51] Banana waste was added to the table

competition for charcoal dust and therefore, sources and quantities should be secured before deciding on this biomass option.

Coffee husks

Various dry coffee mills are in close proximity to the city. These include Fairview Coffee estate, Sasini Coffee Factory, Ndumberi Coffee farm, Kigutha Coffee farm, Tropical Farm Management, and Kofinaf Mills (Kenya Coffee Traders Association, 2012, pp. 42 – 144). According to one coffee miller (personal communication, June 10, 2017), during the milling season the coffee husks are auctioned off to organizations and/or companies looking to use the husks for briquetting, compost or fuel. One can usually obtain the husks at a price of 2.5 – 5 KES per kg (personal communication with coffee mill manager, June 10, 2017). In Kiambu County alone, it is estimated that over 8000 tons of husk and pulp are generated every year (Kanyiri & Waswa, 2017, p. 201). Coffee husks are in demand for use as biomass briquettes, fertilizer and compost; however, significant quantities of coffee husks are still leftover as waste (p. 201).

Peanut shells

Peanuts are commonly grown in Kenya; and as a result, the groundnut shells are available at peanut processing plants in Nairobi. Greenforest Foods (2014), Tropical Heat (2017), and Jetlak Foods (2017) all manufacture peanut butter and were contacted regarding the sale of their shells. Only one company replied with affirmation of peanut shells for sale. However, there is a limited quantity and the price is set at 5 KES per kg which is comparatively expensive (personal communication with management of peanut butter manufacturers, May 5, 2017). Though volumes are expected to increase, currently only about 300 kg of shells can be sourced per day. In addition, at 5 KES per kg, the price is cost prohibitive.

Sisal stems and boles

Sisal is grown in Kenya, primarily in Kilifi and Taita Taveta region (IEE, 2016, p. 28). Though actual production could not be found, over 21,500 tons of sisal was sold in 2016 (Kenya Bureau of Statistics, 2017, p. 152). Using the RPR value from IEE (2016, p. 32), 425,700 tons of sisal bogas and 88,150 tons of sisal ball are generated every year. However, sisal is not grown near Nairobi and based on their region of growth (IEE, 2016, p. 28) need to be shipped a distance of at least a 330 - 500 km. Recent discussions with a manager from a major sisal estate suggests that there is considerable available biomass for purchase; however, boles must be manually extracted from the fields (personal communications with sisal estate manager, June 10, 2017), which would result in significant labour costs and time. Sisal boles are quite large, with a mean weight of 38.8 kg (Naik, Dash & Goel, 2016, p. 2005). Uprooting the entire sisal plant would take considerable time, or additional investment in machinery.

Rice husks

Due to the reportedly high silica content in rice husks making it highly corrosive to briquetting machinery (Regional wood energy development programme in Asia, 1995, pp. 22), this type of biomass was not considered. In addition, rice husk biomass briquettes are often reported to be of lower quality than other biomass (Ndindeng et al., 2015), likely due to their high ash content and lower volatile matter.

Sugarcane bagasse
Sugarcane bagasse is available in large quantities throughout western Kenya. In 2016, over 7,094,619 tons of sugarcane was produced (Kenya Bureau of Statistics, 2017, p. 154). Using its RPR value of .38, there is approximately 2,695,955 tons of bagasse produced every year. A list of some of the major sugar companies was obtained from the Kenya Sugar Board (2017). Emails were sent to the following major sugar companies to obtain prices per kg: Kibos and Allied Sugar Company, Butali Sugar Company, SOIN Sugar Company, West Kenya Sugary Company, Nzoia Sugar Company, Sony Sugar Company, Muhoroni Sugar Company, and Chemelil Sugar Company. No response was obtained, and due to the high transport costs, this biomass was not pursued further.

Coconut husks
Coconuts are produced in excess of 64,000 tons per year (Kenya Bureau of Statistics, 2017, p. 163) and the husk is relatively low in moisture and ash (Chardust, 2004, p. 12). Based on the RPR value, there is 70,400 tons of coconut husk produced per year. Processing companies in Kilifi were contacted regarding possible use of the coconut husk. One company responded and were willing to sell the husks at 3 KES/kg, and had an excess of 150 MT/month (personal communication with coconut products employer). Though coconut husks are known to produce quality biomass briquettes, they are reportedly difficult to carbonize (Chardust, 2004, p. 31). In addition, due to their coastal location and subsequent transport costs, they were disregarded as a biomass option at this time.

Sawdust
Sawdust makes excellent biomass briquettes (Akowuah et al., 2012) and is also a useful material for mixing with other biomass to improve the biomass briquette quality. Sawmills are located all throughout Kenya. Thus far, the closest sawmill with a surplus of sawdust available for purchase, is located in Makuyu. Makuyu is located about 63 km from Nairobi (Google, 2017). They have confirmed the availability of sawdust, over 1 ton per day, at a retail price of 350 KES/ton (personal communications with estate manager, September 18, 2017). This is an excellent price for a quality biomass material.

Banana leaves and stems
Banana stems and leaves are not commonly used for briquetting. However, two studies (Sellin et al., 2013; Abdullah and Taib, 2013) show that they can be used and have a comparatively good heat value. A foot search revealed that banana stems and leaves are an attractive biomass option because they are available in mass quantities throughout the urban city markets, and while small quantities are saved for animal feed, most end up in the city's growing garbage heaps. Currently they are available for free; however, a small fee of 500 KES per ton could be paid to providers to supplement gathering and storing until pick-up.

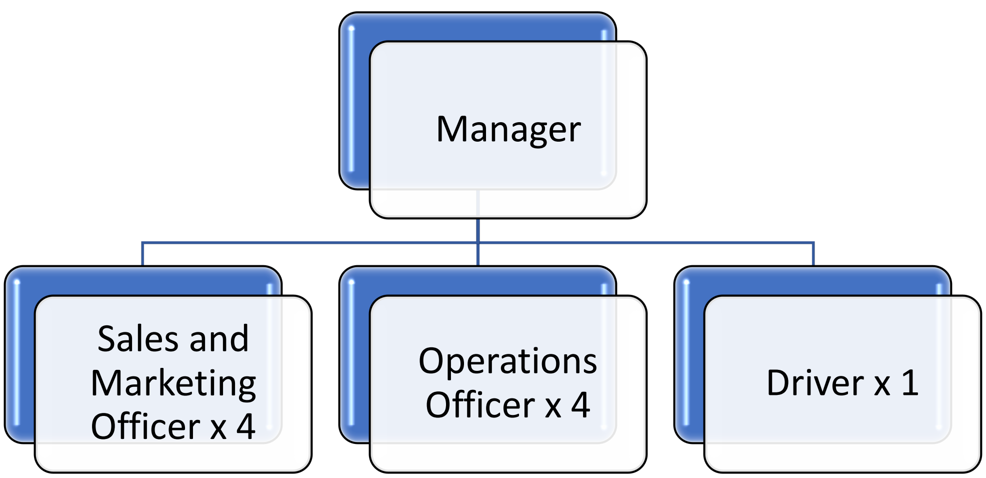
Appendix 2 Staffing and Management Model

The Management of the cooperative is three-fold: it includes the members, the manager, and the Cooperative's Board of Directors. Commonly held Board positions include a President, Vice-President, Secretary, Treasurer and a certain number board members (ILO, 2016, pp. 11, 24; United States Department of Agriculture and Rural Development (USDA), 1994, p. 3). These will be elected on an annual basis where the President may hold office for 3 consecutive years. While members are the true owners and decision makers, it is not possible for them to make all decisions, and therefore, the elected Board of Directors represent members in many operational decisions (USDA, p. 2). Members attend monthly meetings, are aware of the cooperative bylaws of incorporation, hire cooperative employees and management, and adopt general policies. They are responsible for business strategies, financial reports, year-end meeting and determining year end dividends (USDA, p. 3).

Employees and Personnel

The following chart represents a simple organogram for staffing the Cooperative. As the Cooperative scales up, additional positions, such as Sales Manager and Operations Manager, may emerge. It is expected that employee positions will be filled by cooperative members. Cooperative members are not restricted to any one position, and may work in both operations and sales. Careful balancing of positions will ensure that everyone is offered the opportunity to be trained and actively work on both operations and sales and marketing positions, should they desire. Management level positions may not serve on the Board of Directors to avoid any conflict of interest. Ultimate employee decisions will be made by the Board of Directors.

Figure 8: Cooperative Organogram



Manager

The Manager will provide oversight for all functions of the cooperative. He or she will determine the details regarding how the Board policies will be implemented. The Manager will be responsible for reporting on all production and sales activities to the Board of Directors. He or she will monitor and evaluate progress against the business plan and implement any required corrective action plan to meet objectives. He or she will complete performance appraisal for all employee positions, and report results to the Board. He or she must coordinate production, biomass pick-ups and product deliveries.

Sales and Marketing
Sales and marketing officers are responsible for introducing the product to community chiefs and requesting for community meeting demonstrations. They are also responsible for finding target markets for product sales (i.e. charcoal vendors, street food sellers, institutions, industrial operations, etc.). They will update social media and maintain product online presence. Each sales officer will directly report their sales achievements to the manager.

Operations Officers
Operations officers are responsible for producing the biomass briquettes. They may also assist in picking up biomass, and delivering biomass briquette orders. Operations officers will be trained on all machinery including carbonization. They will also work in product development and conduct pilot trials for new agri-residues and binders. Operations staff will conduct quality assurance testing in accordance with a table of minimum quality standards. They are responsible for ensuring production is sufficient for biomass briquette orders.

Appendix 3 Cooperatives in Kenya

In Kenya, the cooperative sector is set apart by its "presence of both horizontal and vertical networks" (Tshishonga & Okem, 2016, p. 60). There are four tiered levels of cooperatives:

Table 7: Cooperative Tiers in Kenya

Cooperative Tiers	**Nature of co-op and membership**
The first tier	Primary co-operatives with membership consisting of individuals within a given area
The second tier	Composed of secondary co-operatives or unions whose membership is restricted to primary co-operatives that operate at the district level
The third tier	Formed by national co-operative organizations whose membership is drawn from the secondary and primary co-operatives not affiliated to the union
Fourth tier	This tier consists of the apex organization, called the Cooperative Alliance of Kenya (CAK)

Source: (Muthuma, 2011; as cited in Tshishong and Okem, 2016, p. 57)

Several organizations help to regulate and promote cooperative development in Kenya. The Cooperative Alliance of Kenya Limited (CAK) is the National Apex organization for the cooperative movement of Kenya. They work to promote cooperative development and unite the cooperative movement. They also represent cooperative interest on policy and legislation (Co-operative Alliance of Kenya, 2014). The Ministry of Industry, Trade and Cooperatives is the official authority on cooperatives in Kenya, and its Commissioner for Cooperative Development oversees cooperative registration and inspections (Ministry of Industry, Trade and Cooperatives, 2016, para. 1). Registration requirements are available in Part 3, Registration of Co-operative Societies, in the Co-operatives Societies Act (1998). The Cooperative college in Kenya plays a critical role in educating cooperative members (Tshishong and Okem, 2016, p. 61).

Appendix 4 Start-up Costs

Table 8: Start-up Costs Canadian Dollars [52]

Start-up and equipment costs	**27,391**
Kiln * 4	2,000
Briquetting machine	4,819
Grinder	1,205
Drying racks for briquettes	500
Drying racks for feedstock	500
Plastic crates	100
Electrical chords	50
Cleaning supplies	50
Promotional materials (signs, pictures, advertisements, business cards)	75
Safety equipment (gloves, fire extinguisher, outer clothing, etc.)	200
One year rent downpayment	2,892
Infrastructure adaptations to accommodate briquettes	1,000
Truck	10,000
Trailer (3 tonne)	4,000
Licensing and Regulations	**368**
Cooperative name search	3
Cooperative registration	337
Product certification (standardization mark)	
Environmental Impact Assessment (.1% of total project cost)	28
VAT application for Cooperative	
Human Resources	**602**
Staff training	602
Sub-total	28,361
Contingency costs	2,836
Total	**31,197**

[52] All Costs were based on local currency KES (Kenyan shillings) and converted to Canadian dollars based on 1 Canadian dollar is 83 KES. Rates fluctuate from 80 to 84 Kenyan shillings per Canadian dollar http://www.xe.com/currencyconverter/convert/?Amount=1&From=CAD&To=KES

Appendix 5 Operations and Running costs

Every month, 20 tons of banana waste biomass (to produce approximately 5 tons of charcoal), and 5 tons of charcoal dust will be bought, to produce 10 tons of carbonized biomass briquettes. Pyrolyzing the biomass considerably reduces its mass with yields ranging from 20 % (kon tiki kilns) up to 40% (retort kilns) (Cornelissen et al., 2016, p. 6). Therefore, in order to produce 1 ton of biochar, approximately 2.5 to 5 tons of raw biomass is required. Banana waste is free, but labour to source and pile the banana waste will cost approximately 500 KES ($6.02) per ton. Charcoal dust is already carbonized, and can be obtained for 200 KES ($2.41) per 50 kg sac.

In addition, 11 tons of sawdust will be sourced to produce an additional 11 tons of green biomass briquettes. Sawdust can be procured for 350 KES per ton. However, the sawdust is available 65 km from Nairobi. Assuming, the purchase of a 2005 Nissan Navara pickup truck, a mileage of 10 km/litre (Fuelly, 2017), and standard cost of diesel at 86.86 KES/per litre (ERC, 2017), the cost can be estimated. A reduction in mileage of 15% is added to allow for the additional towing of 2.5 tons (Adkins, 2017) to result in a mileage of 8.5 km/litre and a cost of 1328 KES per trip. Assuming 2 tons could be procured per trip, the cost of sawdust is 1014 KES per ton, approximately 1 KES per kg.

A 7.5 horse power (HP) screw extruder briquetting machine purchased from a local machine manufacturer will be used to compress the biomass into biomass briquettes. A grinder will also be sourced from the same manufacturer to chop the banana waste into workable pieces. The biomass briquette machine cost 400,000 KES ($4819) and the grinder is available for 100,000 KES ($1205 CAN). The briquetting machine can compress a maximum of 2000 kg of biomass briquettes per 8 hour day. The grinder can grind a maximum of 2000 kg of biomass per day (personal communications with biomass briquette machine manufacturer, July 7, 2017).

A used pick-up truck will be purchased for biomass pick-up, product deliveries, and other logistical requirements of the Cooperative. A used truck with the capacity to pick up 1 ton of product will be sought with a budget of approximately $10,000 dollars. Nissan Navarra pickup trucks can be found for sale with a price ranging from 600,000 – 1,200,000 (approximately $7000 - $15,000 Canadian dollars). Assuming a 2.5 L diesel engine (or bigger), this make and model was used for the mileage projections. In addition, once all biomass contracts are in place, a trailer will be purchased that has the capacity to haul another 2 – 4 tons at $4000 dollars (Quantum trailers ltd., 2016).

Brown bags may be sourced from Mafuco company (Paperbags Ltd., 2005), and will be used to package the biomass briquettes in 2 kg bags. Two kg brown bags sell for 4.7 KES + .75 KES VAT, equaling 5.5 KES each, which includes company branding (personal communication with Mafuco sales agent, July 25, 2017). Gunia sacs will be bought from distributors in Nairobi's industrial area to package the biomass briquettes of 50 – 90 kg. Gunia sacs are available for 27 KES per sac (OLX, 2017b).

The biomass briquettes will be produced at an operating plant located on the outskirts of Nairobi. A search of online land plots for rent revealed that one can be obtained, with access to both electricity and water, on the outskirts of Nairobi for approximately 20,000 – 25,000 KES ($240.96 – 301.20 CAD) per month (OLX, 2017a).

Cooperative membership is open to everyone without discrimination. The pay is minimum wage, or approximately 500 KES ($6.00) per 6 hour day take home salary (The Regulation of Wages, 2017). However, the focus of member recruitment will be on women, specifically women in their youth (between 20 – 35). The research recommends older youth as a means of reducing turnover (Chigunta et al., 2005, p. 26). In addition, women already working in briquetting, charcoal, or any type of energy, will be of value to the Cooperative. Members' working in energy, of any type, should make up at least 20% of the Cooperative. A minimum of 10 members is required for cooperative registration (personal communication with Registry officer, June 22, 2017).

Both the briquetting machine and the grinder operate on electricity. The briquetting machine uses approximately 1 kW of electricity for every 50 kg of biomass briquettes produced (personal communications with biomass briquette machine manufacturer, July 7, 2017). The machine manufacturer reports that the grinder uses less electricity, at a rate of approximately half that of the briquetting machine (1 kW electricity per 100 kg of agri-residue). Charcoal and/or biomass briquettes are "low margin, high volume commoditie[s]" that in order to be profitable, must be produced at a minimum level of 500 kg/day (Kung, Kamil, Ratti and McDonald, 2013, p. 8). Therefore, the aim is to produce 1 ton of biomass briquettes per day using banana waste and charcoal dust for the carbonized biomass briquettes, and sawdust for the green biomass briquettes. Grinding up to 1 ton of green banana waste per day, will take 10 kW. Briquetting 1 ton of biomass briquettes per day, will take approximately 20 Kw per day. Accounting for 21 working days, a total of 630 kW per month will be consumed, which will cost approximately 13,698 KES per month ($165) according to Regulus Limited (2017).

Briquetting the biomass can take significant quantities of water. Up to 20 liters of water may be used per 50kg bag of biomass briquettes (personal communication with biomass briquette machine manufacturer, July 7, 2017). Therefore producing 1000 kg of biomass briquettes may take 400 liters of water per day, a maximum of 8400 liters per month. Nairobi water and sewerage company (2017) charges 64 KES per meter cubed. 8400 liters is 8.3 cubic meters, which will cost 439 KES ($5.28) per month. This figure was doubled to $10.58 to allow for other purpose water use including drinking water, flushing toilets, and water for quenching charred biomass.

One staff member will be dedicated to driving the vehicle and delivering packaged biomass briquettes. They will also transport the sales agent/s with product for demonstrations, samples and sales. It is estimated that the vehicle will be driven an average of 75 km per day. According to Fuelly (2017), mileage will be approximately 10 km/l with a diesel price of 86.86 KES/litre (ERC, 2017) resulting in 651 KES per day ($7.84 Canadian).

Appendix 6 Cash Flow Projections

Table 9: Cash Flow Year 1 Canadian Dollars

	Start -up	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Start-up and equipment costs	**27,391**													
Kiln * 3	2,000													
Briquetting machine	4,819													
Grinder	1,205													
Drying racks for biomass briquettes	500													
Drying racks for biomass	500													
Plastic crates	100													
Electrical chords	50													
Cleaning supplies	50													
Promotional materials (signs, pictures, advertisements, business cards)	75													
Safety equipment (gloves, fire extinguisher, outer clothing, etc.)	200													
One year rent downpayment	2,892													
Truck	1,000													
Trailer (3 tonne)	10,000													
Infrastructure adaptations to accommodate biomass briquettes	4,000													
Biomass briquette supply costs		**328**	**328**	**492**	**656**	**656**	**656**	**656**	**656**	**656**	**656**	**656**	**656**	**7,048**
Banana waste		60	60	90	121	121	121	121	121	121	121	121	121	**1,295**
Charcoal dust		121	121	181	241	241	241	241	241	241	241	241	241	**2,591**
Sawdust		67	67	101	134	134	134	134	134	134	134	134	134	**1,445**
Gunia (237 month)		38	38	58	77	77	77	77	77	77	77	77	77	**825**
Paper bags (1249 month)		41	41	62	83	83	83	83	83	83	83	83	83	**891**
KG produced		10,500	10,500	15,750	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	225,750
Banana briquette kg produced		2,500	2,500	3,750	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	**53,750**
Charcoal dust briquette kg produced		2,500	2,500	3,750	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	**53,750**

Sawdust briquette kg produced		5,500	5,500	8,250	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	**118,250**
Resources		44	88	132	176	176	176	176	176	176	176	176	176	1,844
Electricity		41	83	124	165	165	165	165	165	165	165	165	165	**1,733**
Water		3	5	8	11	11	11	11	11	11	11	11	11	**111**
Admin Supply Costs		**47**	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**564**
Receipt books		11	11	11	11	11	11	11	11	11	11	11	11	**130**
Phone/internet credit		36	36	36	36	36	36	36	36	36	36	36	36	**434**
Licensing and Regulations	368	4	7	11	15	15	15	15	15	15	15	15	15	155
Cooperative name search	3													
Cooperative registration	337													
Product certification (standardization mark)		4	7	11	15	15	15	15	15	15	15	15	15	**155**
Environmental Impact Assessment (.1% of total project cost)	28													
VAT application for Cooperative														
Human Resources	602	4	697	1,046	1,395	1,395	1,395	1,395	1,395	1,395	1,395	1,395	1,395	**14,540**
Staff Training	602													
NSSF Contibutions		0	39	59	79	79	79	79	79	79	79	79	79	**809**
Manager salary (1)		1	89	133	177	177	177	177	177	177	177	177	177	**1,816**
Employee salary (9)		3	569	854	1,139	1,139	1,139	1,139	1,139	1,139	1,139	1,139	1,139	**11,674**
Year-end accounts audit													241	**241**
Maintenance and insurance		131	172	213	255	255	255	305	305	305	305	305	305	3,107
Car insurance (5% of vehicle value)		33	33	33	33	33	33	33	33	33	33	33	33	**391**
Vehicle maintenance and repairs		50	50	50	50	50	50	50	50	50	50	50	50	**600**
Machine maintenance and repairs		0	0	0	0	0	0	50	50	50	50	50	50	**300**
Vehicle diesel		41	82	124	165	165	165	165	165	165	165	165	165	**1,732**
Garbage disposal fees		7	7	7	7	7	7	7	7	7	7	7	7	**84**
Sub-total	28,361	557	1,339	1,941	2,542	2,542	2,542	2,592	2,592	2,592	2,592	2,592	2,592	**27,017**
Contingency costs	2,836	56	134	194	254	254	254	259	259	259	259	259	259	**2,702**
Other Disbursements		646	645	645	645	645	645	645	645	645	645	645	645	7,745
Cooperative Bank loan Interest Payment		168	163	159	155	155	146	142	138	134	130	125	121	**1,734**
Cooperative Bank loan principal payment		479	483	487	491	491	499	503	507	512	516	520	524	**6,011**

Total Cash outflows	**31,197**	**1,258**	**2,119**	**2,780**	**3,442**	**3,442**	**3,442**	**3,497**	**3,497**	**3,497**	**3,497**	**3,497**	**3,497**	**37,464**
Cash Inflows														
Funding Sources														
Cooperative Bank of Kenya loan	**20,000**													
International grant	**15,000**													
Membership join-up fees	**241**													
Membership monthly dues		**60**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**723**
Total Kg sold		5,246	10,491	15,737	20,982	20,982	20,982	20,982	20,982	20,982	20,982	20,982	20,982	**190,071**
Total kg given away		600	600	313	313	125	125	125	0	0	0	0	0	**2,200**
Total kg produced		10,500	10,500	15,750	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	**225,750**
Remaining inventory (kg)		4,655	4,064	3,765	3,470	3,363	3,256	3,149	3,167	3,185	3,203	3,221	3,239	**3,239**
Proportion full production		50.0%	50.0%	75.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	**90.9%**
Assumptions, number of units sold														
2 kg products given away as free samples		**300**	**300**	**156**	**156**	**63**	**63**	**63**	**0**	**0**	**0**	**0**	**0**	**1,100**
2 kg sales		156	313	469	625	625	625	625	625	625	625	625	625	**6,563**
4 kg sales		78	157	235	313	313	313	313	313	313	313	313	313	**3,287**
50 kg sales		17	35	52	69	69	69	69	69	69	69	69	69	**725**
90 kg sales		32	64	95	127	127	127	127	127	127	127	127	127	**1,334**
450 kg sales (bulk)		2	4	6	8	8	8	8	8	8	8	8	8	**84**
Revenue from sales ($)	**0**	**1,028**	**2,056**	**3,084**	**4,112**	**4,112**	**4,112**	**4,112**	**4,112**	**4,112**	**4,112**	**4,112**	**4,112**	**43,175**
2 kg products given away as free samples		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0	**0**
2 kg sales		132	264	395	527	527	527	527	527	527	527	527	527	**5,535**
4 kg sales		123	245	368	490	490	490	490	490	490	490	490	490	**5,148**
50 kg sales		156	312	468	623	623	623	623	623	623	623	623	623	**6,547**
90 kg sales		497	995	1,492	1,989	1,989	1,989	1,989	1,989	1,989	1,989	1,989	1,989	**20,886**
450 kg sales (bulk)		120	241	361	482	482	482	482	482	482	482	482	482	**5,060**
Total cash inflows	35,241	1,088	2,116	3,144	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	**43,898**
Cash balance beginning of period		4,044	3,874	3,871	4,235	4,966	5,696	6,427	7,102	7,778	8,453	9,128	9,804	17,930
Cash inflows - cash outflows	**4,044**	**3,874**	**3,871**	**4,235**	**4,966**	**5,696**	**6,427**	**7,102**	**7,778**	**8,453**	**9,128**	**9,804**	**10,479**	**10,478**

Table 10: Cash Flow Year 2 Canadian Dollars

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Start-up and equipment costs	3,036												3,036
Kiln * 3													
Briquetting machine													
Grinder													
Drying racks for biomass briquettes													
Drying racks for biomass													
Plastic crates													
Electrical chords													
Cleaning supplies													
Promotional materials (signs, pictures, advertisements, business cards)	75												
Safety equipment (gloves, fire extinguisher, outer clothing, etc.)													
One year rent downpayment	2,961												
Truck													
Trailer (3 tonne)													
Infrastructure adaptations to accommodate biomass briquettes													
Biomass briquette supply costs	656	656	656	656	656	656	656	656	656	658	656	656	7,871
Banana waste	121	121	121	121	121	121	121	121	121	121	121	121	**1,446**
Charcoal dust	241	241	241	241	241	241	241	241	241	241	241	241	**2,892**
Sawdust	134	134	134	134	134	134	134	134	134	134	134	134	**1,613**
Gunia (237 month)	77	77	77	77	77	77	77	77	77	77	77	77	**925**
Paper bags (1249 month)	83	83	83	83	83	83	83	83	83	85	83	83	**995**
KG produced	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	**252,000**
Banana briquette kg produced	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	**60,000**
Charcoal dust briquette kg produced	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	**60,000**
Sawdust briquette kg produced	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	11,000	**132,000**
Resources	176	176	176	176	176	176	176	176	176	176	176	176	2,107
Electricity	165	165	165	165	165	165	165	165	165	165	165	165	**1,980**
Water	11	11	11	11	11	11	11	11	11	11	11	11	**127**
Admin Supply Costs	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**564**
Receipt books	11	11	11	11	11	11	11	11	11	11	11	11	**130**
Phone/internet credit	36	36	36	36	36	36	36	36	36	36	36	36	**434**
Licensing and Regulations	15	15	15	15	15	15	15	15	15	15	15	15	177
Cooperative name search													
Cooperative registration													

Product certification (standardization mark)	15	15	15	15	15	15	15	15	15	15	15	15	**177**
Environmental Impact Assessment (.1% of total project cost)													
VAT application for Cooperative													
Human Resources	**1,395**	**1,395**	**1,395**	**1,395**	**1,395**	**1,395**	**1,395**	**1,395**	**1,395**	**1,395**	**1,395**	**1,636**	**16,976**
Staff Training													
NSSF Contibutions	79	79	79	79	79	79	79	79	79	79	79	79	**947**
Manager salary (1)	177	177	177	177	177	177	177	177	177	177	177	177	**2,125**
Employee salary (9)	1,139	1,139	1,139	1,139	1,139	1,139	1,139	1,139	1,139	1,139	1,139	1,139	**13,663**
Year-end accounts audit												241	**241**
Maintenance and insurance	305	305	305	305	305	305	305	305	305	305	305	305	3,655
Car insurance (5% of vehicle value)	33	33	33	33	33	33	33	33	33	33	33	33	**391**
Vehicle maintenance and repairs	50	50	50	50	50	50	50	50	50	50	50	50	**600**
Machine maintenance and repairs	50	50	50	50	50	50	50	50	50	50	50	50	**600**
Vehicle diesel	165	165	165	165	165	165	165	165	165	165	165	165	**1,980**
Garbage disposal fees	7	7	7	7	7	7	7	7	7	7	7	7	**84**
Sub-total	5,629	2,592	2,592	2,592	2,592	2,592	2,592	2,592	2,592	2,594	2,592	2,833	**34,388**
Contingency costs	563	259	259	259	259	259	259	259	259	259	259	283	**3,439**
Other Disbursements	645	645	645	645	645	645	645	645	645	645	645	645	7,744
Cooperative Bank loan Interest Payment	117	112	108	103	99	94	90	85	80	76	71	66	**1,099**
Cooperative Bank loan principal payment	529	533	538	542	547	551	556	560	565	570	575	579	**6,645**
Total Cash outflows	**6,837**	**3,497**	**3,497**	**3,497**	**3,497**	**3,497**	**3,497**	**3,497**	**3,497**	**3,499**	**3,497**	**3,762**	**45,570**
Cash Inflows													
Funding Sources													
Cooperative Bank of Kenya loan													
International grant													
Membership join-up fees													
Membership monthly dues	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**60**	**723**
Total Kg sold	20,982	20,982	20,982	20,982	20,982	20,982	20,982	20,982	20,982	20,982	20,982	20,982	**217,224**
Total kg given away (free samples)	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Total kg produced	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	21,000	**252,000**
Remaining inventory (kg)	3,257	3,275	3,293	3,311	3,329	3,347	3,365	3,383	3,401	3,419	3,437	3,455	**3,455**
Proportion full production	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	**100 %**
Assumptions, number of units sold													

2 kg products given away as free samples	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
2 kg sales	625	625	625	625	625	625	625	625	625	625	625	625	**7,500**
4 kg sales	313	313	313	313	313	313	313	313	313	313	313	313	**3,756**
50 kg sales	69	69	69	69	69	69	69	69	69	69	69	69	**828**
90 kg sales	127	127	127	127	127	127	127	127	127	127	127	127	**1,524**
450 kg sales (bulk)	8	8	8	8	8	8	8	8	8	8	8	8	**96**
Revenue from sales ($)	**4,112**	**4,112**	**4,112**	**4,112**	**4,112**	**4,112**	**4,112**	**4,112**	**4,112**	**4,112**	**4,112**	**4,112**	**49,343**
2 kg products given away as free samples	0	0	0	0	0	0	0	0	0	0	0	0	**0**
2 kg sales	527	527	527	527	527	527	527	527	527	527	527	527	**6,325**
4 kg sales	490	490	490	490	490	490	490	490	490	490	490	490	**5,883**
50 kg sales	623	623	623	623	623	623	623	623	623	623	623	623	**7,482**
90 kg sales	1,989	1,989	1,989	1,989	1,989	1,989	1,989	1,989	1,989	1,989	1,989	1,989	**23,870**
450 kg sales (bulk)	482	482	482	482	482	482	482	482	482	482	482	482	**5,783**
Total cash inflows	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	4,172	**50,066**
Cash balance beginning of period	10,478	7,814	8,489	9,164	9,839	10,515	11,190	11,865	12,540	13,215	13,888	14,564	
Cash inflows - cash outflows	**7,814**	**8,489**	**9,164**	**9,839**	**10,515**	**11,190**	**11,865**	**12,540**	**13,215**	**13,888**	**14,564**	**14,974**	**14,974**

Table 11: Cash Flow Year 3 Canadian Dollars

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Start-up and equipment costs	3,036												3,036
Kiln * 3													
Briquetting machine													
Grinder													
Drying racks for biomass briquettes													
Drying racks for biomass													
Plastic crates													
Electrical chords													
Cleaning supplies													
Promotional materials (signs, pictures, advertisements, business cards)	75												
Safety equipment (gloves, fire extinguisher, outer clothing, etc.)													
One year rent downpayment	2,961												
Truck													
Trailer (3 tonne)													
Infrastructure adaptations to accommodate biomass briquettes													
Biomass briquette supply costs	**1,312**	**1,312**	**1,312**	**1,312**	**1,312**	**1,312**	**1,312**	**1,312**	**1,312**	**1,312**	**1,312**	**1,312**	**15,739**
Banana waste	241	241	241	241	241	241	241	241	241	241	241	241	**2,892**
Charcoal dust	482	482	482	482	482	482	482	482	482	482	482	482	**5,784**
Sawdust	269	269	269	269	269	269	269	269	269	269	269	269	**3,226**
Gunia (237 month)	154	154	154	154	154	154	154	154	154	154	154	154	**1,850**
Paper bags (1249 month)	166	166	166	166	166	166	166	166	166	166	166	166	**1,986**
KG produced	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	**504,000**
Banana briquette kg produced	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	**120,000**
Charcoal dust briquette kg produced	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	**120,000**
Sawdust briquette kg produced	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	**264,000**
Resources	351	351	351	351	351	351	351	351	351	351	351	351	4,215
Electricity	330	330	330	330	330	330	330	330	330	330	330	330	**3,961**
Water	21	21	21	21	21	21	21	21	21	21	21	21	**254**
Admin Supply Costs	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**47**	**566**
Receipt books	11	11	11	11	11	11	11	11	11	11	11	11	**132**
Phone/internet credit	36	36	36	36	36	36	36	36	36	36	36	36	**434**

Licensing and Regulations	30	30	30	30	30	30	30	30	30	30	30	30	**354**
Cooperative name search													
Cooperative registration													
Product certification (standardization mark)	30	30	30	30	30	30	30	30	30	30	30	30	**354**
Environmental Impact Assessment (.1% of total project cost)													
VAT application for Cooperative													
Human Resources	2,789	2,789	2,789	2,789	2,789	2,789	2,789	2,789	2,789	2,789	2,789	3,030	**33,709**
Staff Training													
NSSF Contibutions	158	158	158	158	158	158	158	158	158	158	158	158	**1,894**
Manager salary (1)	354	354	354	354	354	354	354	354	354	354	354	354	**4,248**
Employee salary (9)	2,277	2,277	2,277	2,277	2,277	2,277	2,277	2,277	2,277	2,277	2,277	2,277	**27,325**
Year-end accounts audit												241	**241**
Maintenance and insurance	470	470	470	470	470	470	470	470	470	470	470	470	**5,635**
Car insurance (5% of vehicle value)	33	33	33	33	33	33	33	33	33	33	33	33	**391**
Vehicle maintenance and repairs	50	50	50	50	50	50	50	50	50	50	50	50	**600**
Machine maintenance and repairs	50	50	50	50	50	50	50	50	50	50	50	50	**600**
Vehicle diesel	330	330	330	330	330	330	330	330	330	330	330	330	**3,960**
Garbage disposal fees	7	7	7	7	7	7	7	7	7	7	7	7	**84**
Sub-total	8,035	4,998	4,998	4,998	4,998	4,998	4,998	4,998	4,998	4,998	4,998	5,239	**63,254**
Contingency costs	803	500	500	500	500	500	500	500	500	500	500	524	**6,325**
Other Disbursements	645	645	645	645	645	645	645	645	645	645	645	645	7,744
Cooperative Bank loan Interest Payment	61	56	51	46	41	36	31	26	21	16	11	5	404
Cooperative Bank loan principal payment	584	589	594	599	604	609	614	619	624	629	635	640	7,340
Total Cash outflows	**9,483**	**6,143**	**6,143**	**6,143**	**6,143**	**6,143**	**6,143**	**6,143**	**6,143**	**6,143**	**6,143**	**6,408**	**77,324**
Cash Inflows													
Funding Sources													
Cooperative Bank of Kenya loan													
International grant													
Membership join-up fees													
Membership monthly dues	**120**	**120**	**120**	**120**	**120**	**120**	**120**	**120**	**120**	**120**	**120**	**120**	**1,446**

Total Kg sold	41,964	41,964	41,964	41,964	41,964	41,964	41,964	41,964	41,964	41,964	41,964	41,964	**503,568**
Total kg given away (free samples)	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Total kg produced	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	42,000	**504,000**
Remaining inventory (kg)	3,491	3,527	3,563	3,599	3,635	3,671	3,707	3,743	3,779	3,815	3,851	3,887	**3,887**
Proportion full production	200 %	200 %	200 %	200 %	200 %	200 %	200 %	200 %	200 %	200 %	200 %	200 %	**200 %**
Assumptions, number of units sold													
2 kg products given away as free samples	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
2 kg sales	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250	**15,000**
4 kg sales	626	626	626	626	626	626	626	626	626	626	626	626	**7,512**
50 kg sales	138	138	138	138	138	138	138	138	138	138	138	138	**1,656**
90 kg sales	254	254	254	254	254	254	254	254	254	254	254	254	**3,048**
450 kg sales (bulk)	16	16	16	16	16	16	16	16	16	16	16	16	**192**
Revenue from sales ($)	**8,224**	**8,224**	**8,224**	**8,224**	**8,224**	**8,224**	**8,224**	**8,224**	**8,224**	**8,224**	**8,224**	**8,224**	**98,686**
2 kg products given away as free samples	0	0	0	0	0	0	0	0	0	0	0	0	**0**
2 kg sales	1,054	1,054	1,054	1,054	1,054	1,054	1,054	1,054	1,054	1,054	1,054	1,054	**12,651**
4 kg sales	980	980	980	980	980	980	980	980	980	980	980	980	**11,766**
50 kg sales	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,247	**14,964**
90 kg sales	3,978	3,978	3,978	3,978	3,978	3,978	3,978	3,978	3,978	3,978	3,978	3,978	**47,740**
450 kg sales (bulk)	964	964	964	964	964	964	964	964	964	964	964	964	**11,566**
Total cash inflows	8,344	8,344	8,344	8,344	8,344	8,344	8,344	8,344	8,344	8,344	8,344	8,344	**100,132**
Cash balance beginning of period	14,974	13,835	16,036	18,237	20,438	22,639	24,841	27,042	29,243	31,444	33,645	35,846	
Cash inflows - cash outflows	**13,835**	**16,036**	**18,237**	**20,438**	**22,639**	**24,841**	**27,042**	**29,243**	**31,444**	**33,645**	**35,846**	**37,782**	**37,782**

Appendix 7 Calculating Depreciation on Fixed Assets

Table 12: Calculating Depreciation on Fixed Assets Canadian Dollars [53]

Asset	Item cost[54]	Item salvage value [55]	Useful life	Calculated depreciation [56]	Average investment[57]	Interest on average investment [58]	Insurance and Taxes [59]	Total fixed cost [60]
Truck	$10,000	2000	10	$800.00	$6,000.00	$600.00	$8.40	$1,408.40
Trailer	$4000	1500	20	$125.00	$2,750.00	$275.00	$3.85	$403.85
Biomass briquette Machine	$4819	1000	5[61]	$763.86	$2,909.64	$290.96	$4.07	$1,058.89
Biomass briquette grinder	$1204	0	10[62]	$120.48	$602.41	$60.24	$0.84	$181.57
Kilns	$2000	0	4	$500.00	$1,000.00	$100.00	$1.40	$601.40
Drying racks for biomass briquettes	$500.00	0	10	$50.00	$250.00	$25.00	$0.35	$75.35
Drying racks for biomass	$500.00	0	10	$50.00	$250.00	$25.00	$0.35	$75.35
Plastic crates	$100.00	0	10	$10.00	$50.00	$5.00	$0.07	$15.07
Electrical chords	$50.00	0	10	$5.00	$25.00	$2.50	$0.04	$7.54
Cleaning supplies	$50.00	0	2	$25.00	$25.00	$2.50	$0.04	$27.54
Safety equipment (gloves, fire extinguisher, outer clothing, etc.)	$200.00	0	5	$40.00	$100.00	$10.00	$0.14	$50.14
Infrastructure adaptations for building	$1,000.00	0	10	$100.00	$500.00	$50.00	$0.70	$150.70
Total	**$24,624**	**N/A**	**N/A**	**$2,629.34**	**$14,562.05**	**$1,456.20**	**$20.39**	**$4,055.79**

[53] Calculations were derived from Lacy (n.d.) from http://caes2.caes.uga.edu/commodities/fieldcrops/forages/events/GS10/notebook/Cheat%20Sheet%20for%20Calculating%20Fixed%20and%20Other%20Costs.pdf
[54] Based on start-up budget
[55] Salvage amount after useful life
[56] Depreciation is calculated by (cost – salvage value)/useful life
[57] Average investment is calculated by (cost + salvage value)/2
[58] Calculated by multiplying average investment by current interest rate in Kenya (10%)
[59] Insurance and taxes is calculated as a percentage of investment (1.4%)
[60] Total fixed cost is the calculated depreciation + Interest on average investment + Insurance and Taxes
[61] Biomass briquette machine average life based on manufacturer's suggestion
[62] Grinder average life based on manufacturer's suggestion

Appendix 8: Production Costs for Income Statement

Table 13: Production Costs for Income Statement Canadian Dollars[63]

	Year 1 Total	Year 2 Total	Year 3 total
Briquette supply costs			
Banana waste	1,295	1,446	2,892
Charcoal dust	2,591	2,892	5,784
Sawdust	1,445	1,613	3,226
Gunia (237 month)	825	925	1,850
Paper bags (1249 month)	891	995	1,986
Resources			
Land rent with building (deposit)	2,961	2,961	2,961
Electricity	1,733	1,980	3,961
Water	111	111	254
Product certification (standardization mark)	155	177	354
Human Resources			
Employee salary production related[64]	6,745	7,894	15,787
Staff training production related	301	0	0
Machine maintenance and repairs	300	600	600
Vehicle diesel	1,732	1,980	3,960
Garbage disposal fees	84	84	84
Equipment Depreciation costs			
Truck	1,408	1,408	1,408
Trailer	404	404	404
Briquette Machine	1,059	1,059	1,059
Briquette grinder	182	182	182
Kilns	601	601	601
Drying racks for briquettes	75	75	75
Drying racks for feedstock	75	75	75
Plastic crates	15	15	15
Electrical chords	8	8	8
Cleaning supplies	28	28	28
Safety equipment (gloves, fire extinguisher, outer clothing, etc.)	50	50	50
Infrastructure adaptations for building	151	151	151
Other Disbursements			
Total production related costs	**25,226**	**27,715**	**47,756**

[63] Table figures are derived from cash-flow projections year end totals for year 1, 2 and 3.
[64] Production related staff salary costs make up half of all paid salaries.