REPORT

Urban Briquette Making Pilot

Briquette Production Manual (part 4 of 5)

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Acronyms

BMC	Business Model Canvas
CBO	Community Based Organisation
CTCN	Climate Technology Center and Network
EEP	Energy Environment Partnership
KeBS	Kenya Bureau of Standards
KES	Kenya Shillings
KIRDI	Kenya Industrial Research and Development Institute
LMC	Lean Model Canvas
NAWASSCO	Nakuru Water and Sanitation Services Company Limited
NCCAP	National Climate Change Action Plan
NCSP	Nakuru County Sanitation Programme
NDC	National Designated Contribution
NDE	National Designated Entity
SNV	Netherlands Development Organization
UBPA	Kenya United Briquette Producers Association
USD	United States Dollars

1 Introduction

1.1 Background

Municipal waste (such as paper and organic waste), agricultural and forestry residue have been used as potential sources of energy through various approaches such as the briquetting technology. Increase in population results in an increase in the amount of waste generated in urban areas. In Nakuru County for instance, a 2017 feasibility report by the World Bank[1] found that the county generates an average of 523 tonnes of waste per day of which 80% is biodegradable material (e.g. organic waste, paper, cardboard). Nairobi County on the other hand is estimated to produce about 2,400 tonnes of waste per day; Kisumu County produces 500 tonnes and Mombasa County 875 tonnes of municipal solid waste per day. Recognizing that most urban areas are limited in their capacity to collect and manage waste, this is a resource that could be utilized to address the increasing energy demand driven by population growth and the need for a cleaner environment. Briquettes have been promoted as alternative fuels to charcoal at the household level and firewood or furnace oil in thermal intense industries such as tea factories. Use of charcoal and firewood is a major contributor to environmental degradation through deforestation and greenhouse gas emissions (GHG) as it is mainly sourced unsustainably. Furnace oil is a fossil fuel and therefore also contributes significantly to greenhouse emissions. In addition to addressing the energy and environmental concerns, development of sustainable briquette production businesses could potentially contribute to job creation along the value chain. This include suppliers of raw materials, manufacturers of the briquetting technologies, employees at the production site, and distribution agents.

Being cognisant of the environmental and social-economic benefits that can be accrued from the use of briquettes, Kenya, through its National Designated Entity (NDE), has sought technical assistance from CTCN to support the development of the briquetting sector as part of its objectives under the Nationally Determined Contribution (NDC) and National Climate Change Action Plan (NCCAP). Production of briquettes is viewed as an opportunity to sustainably address the increase in demand for energy and the need to effectively manage solid biomass waste from the growing urban populations. This request requires an evaluation of the sector with a focus on charcoal dust, sawdust, agricultural waste and organic municipal solid waste and their potential as viable feedstock options to produce briquettes. Based on the Technical Assistance Response Plan – Terms of Reference submitted by the NDE, this assignment also aims to assess the briquetting value chain ranging from sourcing of raw materials, briquette production technologies, supply chains, the policy environment in the sector and develop a briquette production manual. For each of these tasks, the output is a standalone report. This briquette production manual is part 4 of a series of 5 reports under the technical assistance.

1.2 About the manual

Objectives

[1] World Bank. (2017). *Nakuru Integrated Solid Waste Management PPP Project: Feasibility Study Report and PPP Implementation Plan*

The main objectives of this manual are;

i. Contribute to the production of quality briquettes by guiding the briquette producers to choose the most suitable briquette making technology and equipment.
ii. Guide briquette producers in determining the viability of their businesses before setting up and guide existing business on identifying opportunities to improve their businesses.
iii. Point briquette producers to local fabricators, importers and distributors of briquetting machines while providing a guide on how to import the briquette machines.

Scope

i. Steps in the production of the two main types of briquettes are discussed with the various technologies under each process compared (in terms of merits, demerits and cost) to enable the producer select the most suitable briquetting equipment and techniques for producing quality briquettes.
ii. Business models for start-ups and existing businesses. The Lean Canvas Model (LCM) is a tool for start-ups to quickly and effectively develop suitable business models and a Business Model Canvas (BMC) for already existing briquetting businesses to assess opportunities for improving their business models.

Target audience

The manual is designed to be used for training aspiring briquette producers and already existing producers who would wish to improve and scale their briquette production processes. This manual covers the production processes for both carbonized and non-carbonized briquettes using varied raw materials such as charcoal dust, sawdust, bagasse, municipal waste etc.

1.3 Introduction to briquettes

The term "briquette" is a composite term used to identify a wide range of biomass-based fuels that vary in terms of composition, shape, size, energy density and price[2]. Various types of feedstock can be used to create briquettes and can be classified into four main groups:

i. Organic municipal waste (e.g. waste paper, sludge)
ii. Agricultural residue (e.g. coffee husks, sugarcane bagasse, rice husks, and macadamia nuts),
iii. Forestry residue (e.g. sawdust, chips, offcuts)
iv. Charcoal dust

There are two types of briquettes;

Carbonized briquettes made from biomass that has undergone pyrolysis. The feedstock is mixed with a binding agent then pressed to form briquettes. Carbonized briquettes have a higher calorific value, burn with minimal smoke, contain lower ash content, and cannot be destroyed by insects such

[2] Ministry of Energy (2019). *Kenya Household Cooking Sector Study: Assessment of the Supply and Demand of Cooking Solutions at the Household Level.* https://www.eedadvisory.com/wp-content/uploads/2019/11/moe-2019-cooking-sector-study-.pdf

as termites[3]. For these reasons, they are preferred for use by households for cooking and space heating (e.g. poultry farming).

Non-carbonized briquettes processed directly from biomass sources through various casting and pressing processes also known as compaction or solidification using high-pressure machines. They are cheaper (per unit mass) and burn longer (up to 6 hours)[4] as compared to carbonised. Therefore, industrial and institutional users such as factories, schools, hospitals and prisons prefer them.

While recognizing the diversity of input materials, types of producers, process of production and scale of production, this manual outlines the production processes for the two main types of briquettes; carbonized and non-carbonized briquettes with a focus on mechanised technologies (e.g electrical machines) that have a higher production output (from 500-7,000 kg/hour) and produce well compacted briquettes. The main processes are divided into; i) pre-processing, ii) pyrolysis and carbonization, iii) mixing, iv) binding and compaction and v) drying as shown in Figure 1 below.

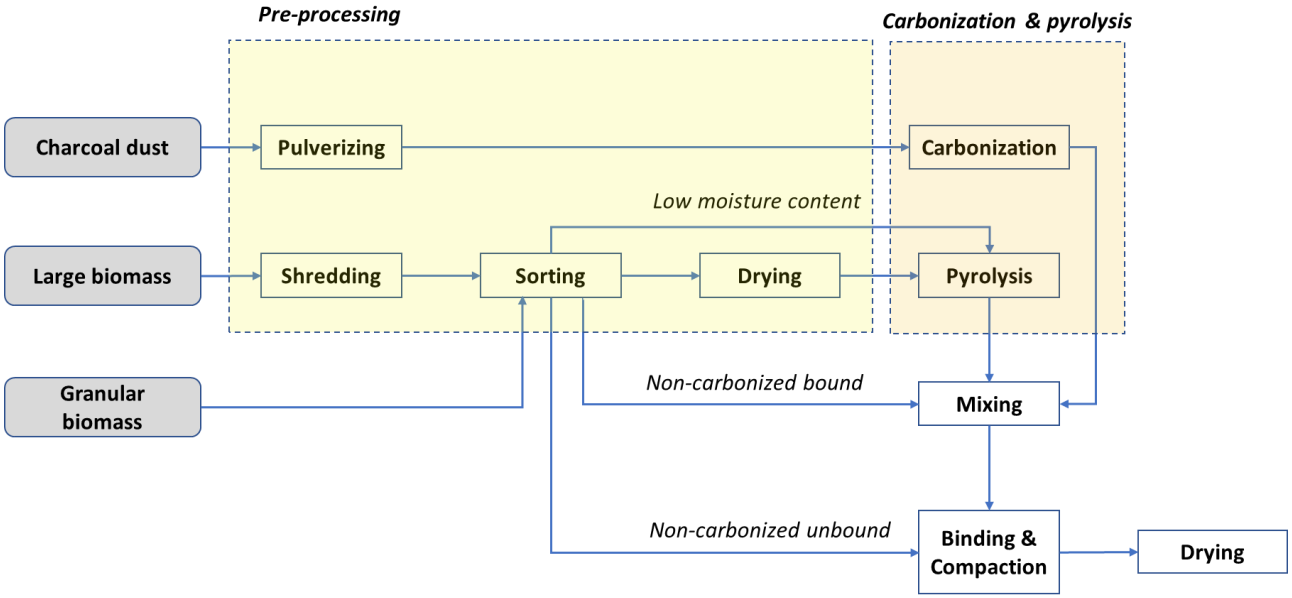

Figure 1: Main step along the production process (EED Advisory)

[3] Hu, J., Lei, T., Wang, Z., Yan, X., Shi, X., Li, Z., He, X., Zhang, Q. (2014). Economic, environmental and social assessment of briquette fuel from agricultural residues in China – A study on flat die briquetting using corn stalk. *Energy 64,* 557 -566.

[4] Key informant Interview

2 Production processes

2.1 Activities before production

2.1.1 Selecting a briquetting enterprise

The first step before setting up a briquette production unit is to decide on the type of briquettes to produce. As discussed earlier there are two main types of briquettes; carbonized and non-carbonized and their production processes differ slightly. The determinant factor of the type of briquette to produce is the target market. The business has to be demand-driven as opposed to supply driven. It is highly recommended that the producer first identify potential buyers of the briquettes before setting up the business. Non-carbonized briquettes are recommended if the target market is institutions (schools, hospitals, prisons) or for industrial use and carbonized briquettes for households, space heating in hotels and poultry farming. For new enterprises, it is recommended to begin with small-scale production and gradually grow their production capacity as demand increase. Figure 2 and Figure 3 below show the different types of briquettes.

Figure 2: Carbonized briquettes for households, poultry farming and hotel industry

Figure 3: Non-carbonized briquettes for industrial and institutions

2.1.2 Guidance on site selection

To identify the ideal site to set up the production unit, these factors should be put into consideration;

i. Location of source of the raw material and the briquette consumers – the ideal location would be one that is near the raw material and consumers. However, this may not be possible to attain and the producer has to decide between transporting the raw material and transporting the briquettes based on the cost associated with each of the two activities.
ii. Availability of water- water is very important in the production of carbonized briquettes during the mixing of a binder and the raw material. The producer must therefore ensure that there is access to a constant water supply at the site.
iii. Site should have adequate space for the set-up of briquetting production line, storing the feedstocks and briquettes. Figure 4 below[5] provides an illustration of how the production site would look like.

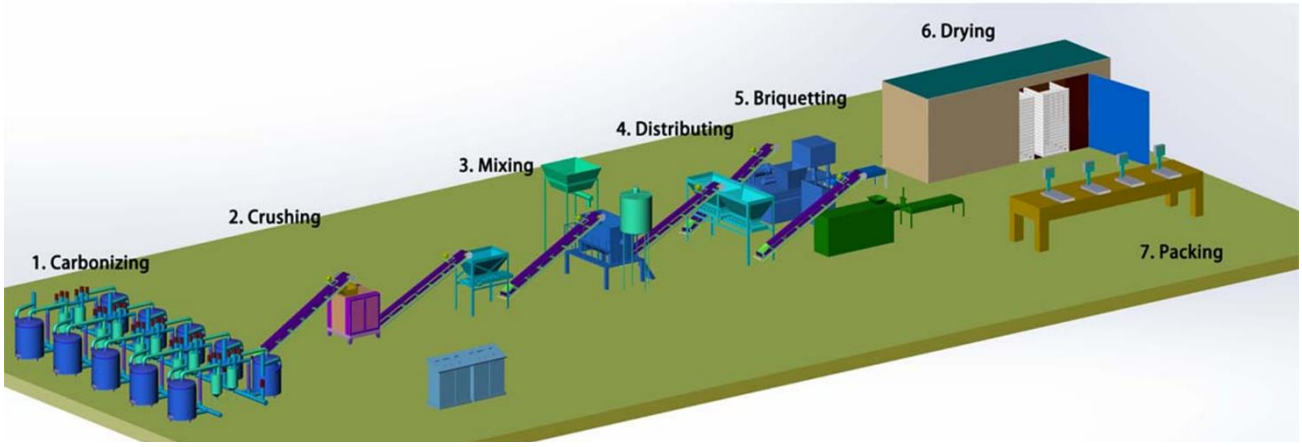

Figure 4: Example of a site layout adopted from FUYU Machinery Co.Ltd

2.1.3 *Layout and construction of briquetting structures*

The briquetting production line is to be arranged in an east-west direction if possible, for efficient aeration[6]. The ideal structure plan comprises of security fence and flood lights, lawns, offices, shade for raw materials, crushing/milling unit, maintenance workshop, cloak rooms, power room, storage facility, sanitation rooms, internal gangways, and pathways and automobile routes/ parking bays, and a security gate room.

In the case of meeting production requirements, the whole production line should be tidy and machinery/equipment well installed than being spread far apart to reduce walking and waste of production time. However, there should be safe space to ensure equipment maintenance and smooth movements during maintenance/servicing of machinery/equipment.

Construction plans for a briquettes manufacturing factory is a major undertaking that requires special attention since the structure will be housing machinery/equipment and human activities. The plan should have a budget and timeline when all construction activities are to be completed. The facility needs to be environmentally sound (orientation towards natural light, sound proof the machine room to avoid noise pollution, waste collection and management unit in place etc.), accessible and safe to use. The key to its successful completion relies on engaging an experienced

[5] FUYU Machinery Co.Ltd. https://www.fuyu-machinery.com/
[6] Charcoal Briquette Machinery. (nd) Retrieved from https://www.charcoalbriquettemachine.com/news/biomass-briquette-plant-design.html

factories designer and construction team. It is also important for the producer acquaint him/herself with the design plan for purposes of managing the budget and ensuring the construction remains as per the design plan. Poor design plans and budgetary planning can lead to high construction costs, delays, re-scheduling of issues, and costly changes to the design plan. The recommended building material is steel metal and iron sheets designed for construction of factories to withstand machinery/equipment vibrations. It should adhere to all the standard factory regulations and health and safety guidelines. These guidelines are public and are easily accessible.

2.2 Raw materials for briquette production

2.2.1 Sourcing of the raw materials

Identification of suitable feedstock is a key step in production of briquettes. The choice of a particular feedstock is driven by various factors including; (i) proximity to a source, (ii) quantities available (iii) cost considerations and (iv) quality. The selected feedstock should meet the following characteristics;

i. Available throughout the year to ensure that production is not interrupted
ii. Low cost (transport cost and actual cost of the raw material. A cost KES 0-3 per Kg is ideal
iii. Low moisture content to reduce the cost of transporting bulky raw materials and drying.
iv. Quality in terms of calorific value, ash content and volatile matter

For production of carbonized briquettes, purchasing already carbonized materials is ideal as carbonization of the raw material leads to 50-80 % loss of raw material, which is not economical for feedstock that has an attached cost and is available in limited quantities. Where the quantity of quality briquettes materials is lacking, there is a possibility of blending low quality with high quality raw materials to realise the expected quality.

Collection and processing of centrally located feedstock is preferred although if the quantities from one supplier are not enough to meet the production capacity then you can source from several points. In that case, plan the logistics, which may be tedious and costly. Table 1 below shows possible sources of raw materials that are commonly used in briquettes production in Kenya.

Table 1: Potential sources of raw materials

#	Type of waste	Possible sources of the waste	Region
1.	Baggase	- South Nyanza Sugar Company, Transmara Sugar Company, Nzoia Sugar Company, West Kenya Sugar Company, Kibos Sugar and Allied Industries Limited, Butali Sugar Mills, Sukari Industries Limited, Kisii Sugar Factory, Sony Sugar	- Western Kenya
		- Kwale International Sugar Company	- Coastal Region
2.	Sawdust	- Along Naivasha-Nakuru highway	- Central Kenya & Riftvalley
		- Timber yards	- Urban and Peri-urban areas

		- furniture workshops	- Urban and Peri-urban areas
3.	Charcoal dust	- Charcoal wholesalers and vendors in urban areas	- Urban and Peri-urban areas
4.	Coffee husks	- Kofinaf	- Central Kenya
		- Central Kenya Coffee Mill	- Central Kenya
		- Thika Coffee Mill	- Central Kenya
5.	Macadamia waste	- Equatorial Nuts	- Central Kenya

2.2.2 *Pre-processing of the raw materials*

The preparation of raw materials includes drying, sorting and separation, shredding, grinding, pulverizing and milling. This is determined by the condition of the feedstock.

i. Drying

This step is aimed at expelling moisture for the wet raw materials. The recommended moisture content is between 6% - 16%[7]. This is important to allow complete compacting of the raw materials and to ensure the briquettes do not disintegrate soon after extrusion from the briquetting machines. Common drying methods include; solar drying (greenhouse and open air-drying) and use of driers. The scale of production and cost of each method are key factors to consider when deciding which type of drying technique to settle for. The merits, demerits and cost of each method are discussed below to determine the most suitable method to employ for your business.

[7] Nikolaisen, L.S., and Jensen, P.D. (2013). Biomass feedstocks: categorisation and preparation for combustion and gasification. Biomass Combustion Science, Technology and Engineering (pp. 36 -57). Woodhead Publishing Series in Energy. https://doi.org/10.1533/9780857097439.1.36

Table 2: Drying options

Drying of raw materials	
Technology/ Appliance	**Description**
Drier for drying feedstock  Source: Acacia Innovations	Feed the raw material into the drier and run the machine by connecting to power. Once the producer purchases the drier, the manufacturing company installs the drier and trains the employees on how to operate the machine. **Merits** - Ideal for large-scale production of briquettes - High efficiency can dry 15-20 tonnes of raw materials in 1-2 hours (37KW rating) - Reduced floor space compared to open-air drying where the raw material is spread out in field **Demerits** - Not available locally - High upfront cost - Operation cost i.e. electricity bills **Cost** - Cost ranges based on output (USD 10,000-100,000)
Solar drying-greenhouse  Source: Nawasscoal	Channel the raw material into the greenhouse. Leave for 1-3 days. Ideal for drying waste with high moisture content such as sludge. Various greenhouse installers in Kenya e.g. PEGWA Enterprises and Amiran **Merits** - Available locally - No electricity cost - High efficiency for waste with high moisture (1- 3 days for waste with 98% moisture content e.g sludge) **Demerits** - Efficiency is reduced during cloudy days - More space is required for setting it up compared to the driers **Cost** - Cost is dependent on size of the greenhouse for example; 6M by 12 M - USD 1,500 and 24M by 12 M- USD 8000

Drying of raw materials	
Technology/ Appliance	**Description**
Solar-drying (Open-air)  Source: Kofinaf Coffee Mill	The feedstock is spread out on an open field to dry. In case it rains, it's covered with a polythene paper or tent-like material. **Merits** - Available locally - No cost of setting up **Demerits** - Efficiency is reduced during cloudy days - More space is required to spread out the waste **Cost** - No cost of setting up but may require to hire labour to spread the raw material out

Some materials have low moisture content and hence require no drying e.g. macadamia nuts and charcoal dust. In other instances, the supplier can dry the feedstock at source. The only limitation with this is the increased cost per kilogram of feedstock. For example, sawdust that is dried goes for KES 5-8 per Kg compared to wet sawdust that goes for KES 3 per Kg.

ii. Sorting of raw materials

Sorting or waste separation is required under the following circumstances;

i. The feedstock has high levels of foreign materials and other impurities that may interfere with the briquetting process
ii. The feedstock has large particles that require milling in order to achieve uniform particle size for briquetting

If the scale of production is small and the feedstock does not have high levels of foreign matter, handpicking would suffice to separate the waste. However, use of sieves and sorting machines is recommended for large-scale production because of its increased efficiency. Table 3 below provides details of a sorting option.

Table 3: Details of the sorting machine

Sorting of raw materials	
Technology/ Appliance	**Description**
Sorting machine  Source: Alibaba.Com	This is ideal when small size raw materials of 2mm are required. The raw material is fed to the machine from the top then the machine is rotated side to side. The small particles are sieved out and large particles are retained at the top of the sieve. **Merits** - Enclosed structure reduces noise and dust - The mesh can be easily replaced in case of damage - Simple operations - No professional training is required to run the machine **Demerits** - Cost is high for informal briquette producers **Cost** - Cost range is USD 1,050 – 3,350
Sorting sieves 	These are fabricated by mounting a coffee mesh roll on a rack. The roll is purchased from local stores. This is ideal for when small size raw materials of 2mm are required. Large particles are sorted and then crushed. **Merits** - The raw materials to fabricate the equipment can be sourced locally - Less costly compared to imported sorting machines in relation to upfront and operation cost (no electricity cost) - Ideal for small-scale production - No professional training is required to operate the machine **Demerits** - Operated manually and therefore less efficient compared to automatic machines. **Cost** - The coffee roll, which is the main component of the sieve, is purchased per meter. I Meter- USD 3

Sorting of raw-materials	
Technology/ Appliance	**Description**
Hand-picking  Source: www.Pixabay.com	This type of sorting is done manually. No cost of machine and technical skill required. This is used mainly to remove foreign materials from the waste. **Merits** - No cost of setting up - Ideal for small-scale production - No professional training is required to sort by hand picking **Demerits** - Low efficiency compared to an electric machine **Cost** - The only cost associated with this method is cost on labour

iii. Milling and Shredding

Raw materials with a hard outer shell such as the macadamia nuts require crushing or milling to facilitate proper compaction. Milling is also done to ensure even particle sizes of the raw materials. Uneven sizes of the materials will result in mal-formed briquettes. Paper waste, wheat straws and sugarcane bagasse may require shredding depending on the desired particle size. Below are the equipment that a briquette producer can employ to execute these two tasks.

Table 4: Details of the sorting and shredding machine

Milling of the raw materials	
Technology/ Appliance	**Description**
Hammer Mill  Source: Alibaba.Com	This is used for crushing or milling raw materials to achieve the desired particle sizes and to reduce the size of the hard-raw materials such as macadamia nuts, wood chips etc. The raw material is fed into the machine through the feeding inlet and the equipment is run by connecting the machine to electricity. **Merits** - Simple to operate - Less noise pollution because of low vibrations - Low investment on energy consumption **Demerits** - Requires electricity to run. The producer has to be connected to electricity. **Cost** - Dependent on the output - The cost ranges from USD 900-1,500
Twin shaft agricultural waste shredder  Source: Alibaba.Com	Used to reduce waste to the desired size particles. The raw material is fed into the machine through the feeding inlet and the equipment is run by connecting the machine to electricity. **Merits** - Low noise, less dust and high capacity - High efficiency - No professional training is required to run the machine **Demerits** - Requires electricity to run. The producer has to be connected to electricity. **Cost** - Cost is determined by capacity and power rating USD 4,000-50,000

iv. Carbonization of the raw material (for carbonized briquettes)

Carbonization or pyrolysis of the biomass feedstock, which is the conversion of raw materials into carbon in the absence of air, is only done in the production of carbonized briquettes. The aim of the process is to increase the energy content of the raw material. Not all raw materials have to go through this process as some like charcoal dust are already carbonized. Before carbonization, ensure that raw material is dried. If not, some of the material will have to burn to produce the energy for drying feedstock before carbonization begins resulting to high loss of raw materials[8].

High temperatures are a requirement for pyrolysis, but because most of the biomass is both a fuel and the material that is being carbonized, there is need to maintain a balance between producing

[8] Wondwossen Bogale. (2009). *Preparation of Charcoal Using Agricultural Waste*. file:///C:/Users/TBC/Downloads/56314-Article%20Text-95679-1-10-20100708.pdf

heat and releasing carbon material. For example, at 270ºC[9] most of the agricultural waste remains unburned (sawdust is 250^{0}C) and can be converted to carbonized briquettes[10].

Table 5: Summary of the carbonization options

Carbonizing of the raw materials (for carbonized briquettes)	
Technology/ Appliance	**Description**
Drum kiln Carbonizer  Source: Hubpages Link	Load the raw material into the drum and close the lid. Place the drum on a three stone open fire and leave for material to carbonize. It takes 4 hours to carbonize the material. Merits - Affordable to small-scale briquette producers - Locally available - No professional training is required on how to use the technology **Demerits** - Low capacity (50Kgs) for large-scale producers - Uses firewood as source of heat **Cost** - Recycled oil drum can be bought from local jua Kali markets - Cost is between USD 10-15
Carbonization Furnace  Source: Alibaba.com	Load the raw material into the drum and close the lid. Introduce an external source of heat (firewood or gas) leave for material to carbonize. Depending on capacity can carbonize 3-12 tonnes per hour. **Merits** - Ideal for a large-scale production site - High carbonization ratio of 99% - Shorter carbonization time (6 hours from 24 hours) **Demerits** - High upfront cost compared to the drum carbonizer - Use of firewood as source of heat contributes to forest degradation Cost **Cost** - Cost is determined by the capacity (tonnes that can be carbonized) of the furnace USD 4,500-6,500

[9] Ibid
[10] KII with the briquette manufacturers

2.3 Briquette Production

i. Mixing

This step only applies to the production of carbonized briquettes. A binding agent is added to the raw materials in the presence of water to enhance bonding and to attain stable briquettes. A good binder has the following characteristics;

- Effective in holding the briquette together
- Produces low ash content after burning
- Burns without smoke

Examples include gum Arabica, fine clay, cassava flour, wheat flour, molasses, soaked wastepaper and red soil. Poor quality binders such as clay, red-soil and waste papers that produce smoky briquettes should be avoided. Binders made from molasses and gum Arabica are preferred because of their strong gelling characteristics and form quality briquettes due to low ash content. Options for mixing include manual mixing where a producer uses a drum and stirs the different components or the use of an electric mixer, which is automatic once, connected to power and more effective compared to the manual mixing.

Table 6: Details of the raw material mixer

Mixer (for carbonized briquettes)	
Technology/ Appliance	**Description**
Electrical mixers (Wheel mixer)  Source: Alibaba.com	Load the raw material, water and the binder into the mixer. The mixer has spindles that move from side to side to enhance the mixing of the raw materials **Merits** - No professional training required on how to use the machine - The rolling wheel increases production efficiency with the raw materials fully mixed. - Simple operation **Demerits** - Cost may be high for small-scale briquette producers - Operational cost is higher due to use of electricity compared to manual mixing **Cost** - Cost is determined by the output capacity (tones that can be mixed) and ranges from USD 1,200-3,400

Rotating Mixer  Source Nawasscoal	Raw materials are added to the rotating drum from the upper end, heat is introduced in the low side, which forms the countercurrent contacting allowing the materials to mix to form the briquettes. Varying production capacity that can go up to 1,000 Kgs a day **Merits** - Available from local fabricators e.g. Jaffidian Enterprise Limited. - Less expensive compared to the electric mixer **Demerits** - Efficiency is reduced as mixing is done manually **Cost** - Cost is determined by the capacity of the mixer. A capacity of 1,000 Kgs per day go for USD 2,500
Manual Mixing  Source: Practical Action	Used for small-scale production. The raw material is mixed with the binder using hands or using a spade to stir the mixture in a container. **Merits** - Low or no initial cost as you may use hands for mixing the feedstock and the binder - Low running cost as there is no electricity bills to run the machines or maintenance costs for associated with the use of mixing equipments - Ideal for small-scale production **Demerits** - Low efficiency as mixing is done manually - Mixing may be uneven compared to electric mixers

ii. Compacting

Compacting is key to dispel entrapped air, which is the main cause of loose briquettes. Loose briquettes tend to disintegrate easily. The consideration to be made when deciding on the type of compacting machine to purchase is the type of briquettes to be produced. Non-carbonized briquettes require machines that can attain high temperature and pressure. On the other hand, carbonized briquettes use machines that are of low-medium pressure and temperature to avoid combustion of the carbonized materials.

These machines are available locally and through importation, (a list of local fabricators and importers of briquette machines is provided at the annex). Imported machines are from either Europe, India or China. Although the machines from Europe are expensive compared to the rest of the machines in the market, they have several advantages including: high quality, high efficiency, less breakdowns and they can be automated reducing the number of employees required in a production site. The cost of the machine is mainly dependent on their production capacity per hour and quality. The merits and demerits of the different compacting technologies are discussed below to guide the producer in selecting the most suitable technology for compacting.

Table 7: Types of compacting machines (medium-pressure machines)

Medium-pressure compacting machines (for carbonized briquettes)	
Technology/ Appliance	**Description**
Motorized screw press (fitted with a gear)  Source: Kendubay Machinery	The machine is fitted with a gear to improve compatibility of the raw material. Demonstration by the machine fabricator is sufficient to be able to use the machine. Local fabricators include Kendubay Machinery, Kejofra Engineering and Benmah Product Company. **Merits** - Locally manufactured and readily available in the market - Spare parts can be sourced locally - Local expertise available to deal with breakdowns. - Affordable compared to imported machines **Demerits** - Frequent breakdowns if poorly fabricated - Informal produced hence difficult to identify the fabricators **Cost** - Cost USD 850-4,500 depending on the power rating.
Motorized Screw Press  Source: Kencoco Limited	Imported machine. Use of the briquette manual is sufficient to operate the machine. **Merits** - Less breakdowns **Demerits** - Importing process is long and small-scale producers may not be aware of the process - Expertise to repair the machines may not be available locally in case of a breakdown. **Cost** - Cost USD 2,500-5,000

Table 8: High pressure compacting machines

High pressure machines	
Technology/ Appliance	**Description**
Extruder Briquetting Press  Source: C.F. Neilsen	Manufactured and distributed in Kenya by C.F. Neilsen. Production Capacity of 500 Kgs per hour. Used to produce household briquettes. The machine distributor provides training during installation on how to use the machine . **Merits** - Available at different capacities - High efficiency - High quality i.e. less breakdowns **Demerits** - High upfront cost - Operational cost of electricity is high compared to locally fabricated machines **Cost** - Cost USD 2,500-5,000
Hydraulic Briquette Pressing Machine  Source: C.F. Neilsen	Manufactured and distributed in Kenya by C.F. Neilsen. Production capacity of 30kg to 1,500 Kgs per hour. The machine distributor provides training on how to use the machine during installation. The machine is electric and therefore the producer must be connected to the grid **Merits** - Available at different capacities - High efficiency - High quality i.e. less breakdowns **Demerits** - High upfront cost - Operational cost of electricity is high **Cost** - 500 Kgs per hour capacity is USD 70,000

iii. Drying Briquettes

This applies to carbonized briquettes. Several drying options exists that a producer can select from. The main ones are solar drying and use of driers. Solar drying can be done by placing the briquettes on drying racks, on laying them gently on the ground or through racks placed in a greenhouse. The drying racks can be built to allow stacking of several trays thus saving on floor space or can be made using simple material e.g. wire mesh. Advanced drying methods include the use of driers (e.g. flash driers) which is highly efficient taking up to 1-2 hours to dry briquettes compared to solar drying which can take between 1-3 days.

Table 9: Types of drying options

Drying techniques	
Technology/ Appliance	**Description**
Solar drying-(greenhouse)  Source: Nawasscoal Limited	Place the briquettes on drying racks inside a greenhouse. There are various greenhouse installers in Kenya e.g. PEGWA Enterprises and Amiran. **Merits** - High efficiency compared to open air drying - Low operational costs such as electricity bills **Demerits** - Costly compared to open air drying **Cost** - Cost is dependent on size of the greenhouse for example; 6M by 12 M - USD 1,500 and 24M by 12 M- USD 8000
Open Air Drying of Briquettes  Source: Eversafe Ltd	Place the briquettes on drying racks in an open field. **Merits** - Low upfront cost compared to use of greenhouses - Low operational costs since electricity is not used. **Demerits** - Dependent on weather conditions and producers have to have a shed during the rainy seasons **Cost** - The coffee mesh roll, which is the main component of the sieve, is purchased per meter. I Meter- USD 3 in hardware shops.

Table 10: Advanced drying methods

Drying techniques	
Technology/ Appliance	**Description**
Driers- e.g vertical driers  Source: Maxton Engineering	The briquettes are conveyed to the top of the dryer by belt conveyor and evenly distributed on the across section by a distributing device. As the cone rotates, the water vapor is evaporated from the briquettes. **Merits** - High efficiency for large scale production of briquettes - Reduced floor space - Not dependent on weather conditions **Demerits** - High upfront cost - High cost of operation compared to solar-drying (i.e. cost of electricity) - Must be imported **Cost** - Cost ranges based on power ratings (USD 10,000-100,000)

How to purchase the machines

Most of the machines used in the different briquetting processes are imported but others are locally fabricated. Annex 2 provides contacts to local machine fabricators and distributors of imported machines.
In case the briquette producer would wish to import the briquettes directly from the manufacturers, the section below provides guidelines on how that can be achieved.

Guidelines on how to import briquette-making machines

The first step is to identify the type of machine to be purchased from an established platform like Alibaba. Since this is heavy machinery, sea freight is ideal and is cheaper compared to airfreight but much slower. It can take up to 45 days or more depending on the port of departure. There are several means of payment including; (i)PayPal, (ii) Online payments using a card (if buying off an online platform and (iii)Wire transfer (for huge amounts of 2500 USD and above bank wire transfers are feasible while for anything under USD 2500 PayPal or card are more cost effective)
Once the merchandise has left the port of departure, a tracking number is issued through the contact email address provided to help with tracking the shipment. On arrival, package goes through the custom for clearing. This can be done through clearing and forwarding companies at a fee.

In addition to the cost of the machine, the following costs are incurred at the port of entry;

- VAT (14% currently but usually 16% of Cost Insurance and Freight value (CIF)
- Customs duty (0-35% of CIF) depending on the tariff used for the item. Different items have different HS codes and different countries charge different amount. (EAC external tariff has information on Harmonized System codes and corresponding duty rates)

- Import Declaration Fee from 3.5% of CIF value
- Railway Development Levy (2% of CIF)
- Kenya Bureau of Standards
- Agency fees (depends on the clearing agent)

For large value items where value is 500,000 KES or above there is need to do an inspection at source. After inspection, you are issued with a certificate of conformity (COC) and there after you can ship. Failure to inspect at source attracts a 25% penalty by KEBS

Maintenance of the Machines

A series of activities are performed towards the preservation and restoration of mechanical machines, or equipment/tool to make it sound for efficient and effective work performance. Maintenance may involve regular routine cleaning (dusting and wiping), checks, servicing, repair, and replacement of worn out or non-functioning parts of the machines. The machine can be manual (simple), or mechanical (complex) within a manufacturing enterprise. The purpose for maintenance of machines, equipment and tools in briquette production is to prevent damages to the machines, enhance their performance, and also ensuring that they remain conditionally fit at all times. Maintenance falls into three categories:

1. ***Routine Maintenance*** **–** This is an activity done on a regular basis while the machine, equipment, or tool is in service. It involves from cleaning by dusting or wiping, and checking for any defects and fixing them, checking oils and greasing.
2. ***Diagnostic Testing*** – This is done to ascertain the condition of a machine, equipment or tool due to failure to perform, deterioration, suspicion or fault.
3. ***Maintenance Testing*** **–** This is an activity performed to a machine, equipment, or tool to assess its condition in an off-motional state.

The maintenance activities must be well recorded and the records kept for references. Machines are like motional automobiles whenever they are serviced; a tag is hanged or recorded somewhere to provide maintenance information when needed. Steps to take for quality maintenance of a machine include:

Note

- Servicing machines must be done by only qualified and authorized personnel
- Electrical power to mechanical machines and equipment/tool must be disconnected before servicing or cleaning begins.
- Electric machines should have a voltage stabilizer to ensure that a constant voltage is delivered to the machine even during power surges.
- In regions with unreliable power or off grid areas, diesel generators can be utilized. However, this would increase the carbon footprint of the business as emissions from diesel are higher compared to electricity[11]
- Always read the machines' instructions Manual for guidance on servicing

[11] More than 80% of electricity in Kenya is from clean sources (hydro, geothermal and wind)

- Let authorized and qualified personnel operate machinery and equipment/tools to minimize faults and accidents.

Measures to reduce carbon foot printing at production level

Various carbon footprint reduction approaches can be employed at the different stages of briquette production. The first avenue to reduce carbon emission is in the selection of the type of raw material to be used for briquette production. For example, charcoal dust is sourced from charcoal that may be unsustainably produced which may be contributing to carbon emissions. Although it is difficult for the producer to ascertain whether the charcoal was sustainably produced, the government can regulates the charcoal production sector to ensure that the charcoal in the market is sustainably produced.

The second approach in reducing the carbon footprint in the production of briquettes is in choosing the type of machines to be utilized under the various stages of the production process. Out-dated technologies have low efficiency and thus high consumption of electricity, which results to greenhouse emissions. Briquette producers can also ensure technologies that have low emissions and environmentally friendly are employed under the various production processes. For instance, for milling of the raw materials, a hammer mill that is powered by electricity has low emissions compared to one that runs on diesel. In drying of the raw materials and briquettes, use of solar drying (greenhouses) is more environmentally friendly due to low emissions compared to the as use of driers which require electricity for operation. Carbonization of the raw materials should be done using cleaner sources of heat as opposed of firewood that is unstainable harvested from natural forests. The producers can identify private farms that grow the trees sustainably to be their sources of firewood.

Measures of reducing carbon emissions in the daily operation of the production site should be implemented. These measures include; use of Light-emitting diode (LED) which has reduced energy consumption and an extended lifespan compared to fluorescent lighting fixtures thus reducing the carbon emissions. Other practices that can be implemented at the production level include, switching off machines that are not in use, switching off light bulb during the day and relying on natural light, frequent servicing of the machines, and continuous monitoring of energy use in the business to identify areas to reduce energy consumption.

Finally, the producers can explore ways to reduce carbon emission in the transportation of the raw materials to the production site and the briquettes to the end-users. The production site can either be close to the source of the raw materials or to the end-users. This will reduce the distances to be covered, which will aid in mitigating carbon emission from the use of fossil-based fuels. Bulk delivery of briquettes and purchase of raw materials is recommended to reduce the number of trips that have to be made in a day.

iv. Testing and quality assurance of briquettes

Briquette producers must ensure that the briquettes meet the minimum quality standards that fulfil the customer's expectations. The quality of briquettes is defined in terms of the following parameters; smoke emissions, moisture content, density, calorific value and ash content. Other

characteristics to consider include performance, reliability, safety and appearance for convenience reasons.

The Kenya Bureau of standards adopted the ISO standards on solid biofuels Part 1-7 in 2015 to provide additional guidelines covering the non-carbonized briquettes from both wood and non-wood-based feedstocks and standards for briquette and the standards on carbonized briquettes are being finalized. However, currently the KEBS uses the South Africa briquettes standards for carbonized briquettes and the ones under development have borrowed heavily from South African ones. In Kenya, we have two main testing centers that briquette producers can have their briquettes tested. These are; University of Nairobi and Kenya Industrial Research and Development Institute (KIRDI). Kenya Bureau of Standards tests products to ensure that they meet the minimum requirement for use. If the briquettes meet the stipulated criteria then a permit of sale is provided to the producer and a mark of standardization provided for the label of the briquette package. This mark is very important to win consumer confidence and if you want to sell through supermarkets then the standardization mark is a mandatory requirement. Below are steps to follow to acquire the KEBs label of quality;

- The producer initiate the process with KEBs
- Make payment (KES 5,000 for SMEs)
- The product is tested
- If the briquettes meet the specified criteria, a permit is provided within 2-3 months
- If the briquettes do not meet the requirements feedback is provided to the producer and the process starts again
- KEBs schedules for annual surveillance visits to ensure that the briquettes still adhere to the standards

v. *Packaging*

The type of end-users determines the type of packaging to be employed by the producers. Large-scale briquettes users (non-carbonized) such as industries and institution require no defined packaging as the fuel is loaded to either the pick-ups or the Lorries and are measured in tonnes. Briquettes for end users are mainly packed in 2 kg, 5kg and 10 kg bags (brown bags). The briquettes are weighed (using a weighing scale) and packed manually for small-scale producers. The producer can compare the cost of buying and operating a packaging machine versus hiring employees to pack the briquettes manually.

Table 11: Types of packages

Type of Package	Description
Household Briquettes   Source: Kencoco Limited and Nawasscoal	- This package is for household briquettes - The packages can range from 2-25 Kgs - The KEBs mark of quality is affixed/written to the package to build the conumer confidence
Institution/Indusrial Briquettes  Source: Acacia Innovations	- This package is for large-scale briquettes end-users such as institutions - The packages can range from 25-50 Kgs - The KEBs mark of quality is affixed/drawn to the package to build the conumer confidence

vi. *Storage*

Dried briquettes should be stored in a warehouse at room temperature of 20◦C within the production site awaiting for sales and distribution. The size of the storage house is dependent on the scale of production. The storage must be free of water and insects such as termites. The briquettes can also be protected from moisture by wrapping them with a polythene bag, putting them off the floor and away from leaking roofs or pipes.

2.4 Briquette Marketing and distribution channels

Marketing

Marketing is a very important component of any business. Without good marketing strategy, it is difficult for your product to be known and get the right traction. Therefore dependent on the size of the business, the target market, size of the business and the marketing budget will determine the approach and the technique to be used. There are two main approaches to marketing that can be adopted.

Above the line marketing (ATL) campaign- This type of marketing is broad and not targeted to a specific audience. The main aim of this approach is to create brand awareness and customer good will. Examples include advertisements on television, radios and billboards. Since this approach is costly, it can be used at the start of business. After people are aware of the briquettes and consumer loyalty has been built, the producers can resort to other forms of marketing that are more affordable.

Below the line, marketing (BTL) campaign- This type of marketing is targeted to a given audience and it is direct. It includes the following:

i. **One on one meetings** –This is ideal for end-users such as industries and institutions. The producer can arrange for face-to-face meetings with the administration of these institutions and introduce their products and businesses. Products for trial can also be provided.
ii. **Door to door campaigns**- This approach is for household briquettes. The producer can identify his/her target area and hire personnel who can provide brochures about the business to the potential end-users. The brochures can have information about the products and benefits that the household would accrue from using the briquettes. Door to door, approach is ideal for marketing briquettes in densely populated areas such urban and peri-urban areas. To reach a wider audience, especially in rural areas and in low-income areas such as Kibera, Community-Based Organizations (CBOs) such as women groups and youth groups can be used as avenues for awareness creation.
iii. **Roadshows**- This approach can be employed for large-scale producers of household briquettes. The roadshows can hold demonstration on how to use the briquettes e.g. quick ways of lighting the briquettes, what type of stoves burn briquettes well, which type of foods can be cooked with briquettes etc. To reach a wider audience, the roadshows are recommended for urban areas where the population is concentrated per unit square.

Distribution

i. Direct distribution - this is directly from the producer to consumer
ii. Indirect distribution - through intermediaries such as supermarkets, general retails outlets,

Concerning distribution of the briquettes, various approaches can be employed. Direct distribution applies to households close to the briquette business and is commonly used for institutional and industrial consumers through contracts arrangement. Indirect distribution uses intermediaries to reach out to consumers such as supermarkets, general retail outlets, mobile distribution trucks, digital platforms and commission agents. In urban areas, supermarkets (for briquettes to be sold through supermarket, they must have a Kenya Bureau of Standard mark), mini-shops are common and evenly distributed compared to rural areas allowing briquette distribution to reach a wider market. Households are also concentrated per unit area in urban and peri-urban areas making door-to-door sales or a mobile distribution truck ideal for reaching the end-users. The businesses can try

out the different approaches and evaluate over a specified period, which is the most effective in terms of sales and cost.

2.5 Environmental and Social-economic Benefits of production and Uptake of Briquettes

It is estimated that 2Mton of charcoal are consumed annually at the household level[12]. Most of the Charcoal in Kenya is unsustainably produced which contributes to forest degradation. Industries such as tea factories and institutions (schools, prisons, hospital etc.) form a category of large-scale consumers of wood fuel. For instance, in 2018, the tea factories in operation consumed around 904,000 tons of firewood[13]. Other industries with significant consumption of firewood and charcoal include brick making, tobacco processing, milk processing, fishing and fish smoking, bakeries and restaurants and kiosks. Consumption of firewood and charcoal at a rate that does not allow for regeneration of forests results to land cover change and impacts on an important global carbon sink (forests). Sustainable production and large-scale uptake of briquette will contribute to curbing deforestation and forest degradation and contribute to climate change mitigation by having more trees to absorb carbon.

Briquette production is viewed as one of the pathways that can be used for waste management resulting to cleaner environments and healthy societies. Increase in population especially in urban areas has resulted in the increase in the quantities of waste generated. This is especially the case in countries where waste collection and management systems are not fully developed. Consequently, open dumpsites are common in these cities and they form breeding grounds for disease causing pests and parasites such as rats that pose a significant risk to public health. Utilization of this waste for briquette production will aid in addressing the health concerns and environmental issues associated with waste generation.

Development and growth of the briquette sector will also contribute to creation of jobs. Different job opportunities exists across the briquette production value chain including; raw material suppliers, brokers of both raw materials and briquettes, workers in the briquette production sites, distribution points and salesmen. This is viewed as an opportunity to grow the household income contributing to better lives. Quality briquettes also increases the cooking options at the household level.

[12] Ministry of Energy (2019). *Kenya Household Cooking Sector Study*
[13] UNEP (2019). *Sustainability of sugarcane bagasse briquettes and charcoal value chains in Kenya*

3 Identification of viable business models

The aim of this chapter is to enable a briquette business start-up to evaluate their business model and guide already existing briquette businesses to resources that can help improve their business models. The business model addresses the technical aspects of the briquettes production chain from a business lens. The aim is to build sustainable, scalable and economically viable businesses that will be able to compete in the competitive market. This can be realised using two proven approaches on business model development namely: The Lean Canvas Model (designed for start-ups) and Business Model Canvas (designed for already existing businesses).

3.1 Lean Canvas Business Model

The Lean Canvas Model (LCM) is designed for start-ups. Before embarking on a briquette production, a producer needs to determine if there exists a business opportunity, the risks and the uncertainties involved in the business. The tool focuses on the problems-solutions approach. It has 9 core components as discussed below.

Problem

Define the problem that you want to solve for your customer segment. Without a problem to solve then the product has no market. The producer can conduct market intelligence studies or through literature, review to identify some of the prevailing challenges in the general fuel sector and whether the briquettes have an upper hand of addressing the challenge. Some of the key issue identified in the fuel sector include cost, high carbon emission from fossil fuels, emerging investment trend among others and in briquetting sector; the challenges include poor quality briquettes for households, lack of developed supply chains and inconsistent availability of the product in the market among others. A business idea can be based on how to address these problems by researching on possible ways to tackle these barriers.

Solution

The next step after identifying the problem is to formulate possible solutions to the problem. The issue on poor quality can be addressed by using the briquettes standards, which are currently in use, understanding what people, are using as an alternate and working on your briquettes to be comparable and or better. To be able to achieve these standards the producer can identify the suitable briquetting machines and raw materials (as discussed in chapter 2 of this manual). Training is also important on how to produce suitable briquettes. This can be obtained from briquette technology experts or being part of the United Briquette Producer Association.

Unique Value Proposition

This step explains what value you are adding to your customers. Why would a customer buy your product and not the already existing solutions in the market or from other existing businesses? How will the briquettes compare with existing solutions such as charcoal in terms of cost, quality and availability? How do the briquettes produced compare with briquettes from other producers? If the briquettes you aim to produce will not add value to the end-users, uptake and continued use will be low and sustainability of the business may not be realized.

Unfair Advantage

This is hard to develop but very important when looking for investors and partners. The question to answer is what is unique to your briquettes and cannot be easily replicated by other briquette

producers or other alternative solutions in the market? The aim of that gives you a competing edge over the other competing solutions in the market.

Customer Segment

This step answers who your target market is. Households, poultry farmers, and space heating in hotels, institutions and small eateries on the roadside (kiosks) consume carbonized briquettes. Non-carbonized briquettes are for institutions and thermal intense industries. Depending on the market intelligence, you have gathered you can decide on which type of end-users to target. Key information to gather is where demand is high among the different groups of end-users.

Key Metrics

Identify the key metrics that you will track as indicators for the success of your business. Quantities sold monthly can be used as a measure of business expansion. If you are selling the briquettes to large-scale users, you can track the repeat customers and the new ones that are added over time.

Channels

Identify how the products will reach the end-users. These will be determined by the location of the end-users and cost associated with the various distribution channels. Direct sales from the producers reduces the cost associated with transporting the briquettes to the consumers but also is limited to the consumers near the production site. Introducing distribution points along the supply chain for household's briquettes introduces a mark-up on the cost of the briquettes, which turn out to be more costly than if bought at the producer's site. The briquette producers can compare the merits and demerits of each possible distribution channel and decide on the most effective distribution channel to employ. Another key component under this is to determine how to create awareness of the products to the consumers. Possible options of creating consumer awareness campaigns include road shows, advertising, and one on one engagement with potential consumers (e.g. schools and industries) demonstrations and providing trial briquettes to the target market.

Cost structure

Estimate the cost associated with setting up the business and daily operations. Cost of fixed assets such as machinery, premises, acquiring permits and variable costs such as cost of feedstock, cost of labour etc. The estimates of the cost of machinery is provided in chapter 2. This is useful in determining how long it will take the business to break even and to calculate the profit margins.

Revenue streams

Determine the pricing of briquettes. This is informed by the cost of production. The producer must ensure that the price of briquettes reflects the cost of production but at the same time ensure that the briquettes are competitive compared to the price of the alternative solutions. If the cost is higher than the cost of alternative solutions e.g. charcoal then the value add of the briquettes must be higher than what charcoal has to offer. This will be important in convincing the customers why the cost is higher than charcoal by explaining the advantages of briquettes to charcoal.

The table below provides an example of a filled-out template for a carbonized briquette start-up business. The cost of component is not calculated as it would be highly determined by the scale of production per producers but the main items to be calculated have been outlined.

Table 12: An example of a filled out LCMP template

<table>
<tr>
<td rowspan="2">PROBLEM
<u>List your top 1-3</u>
- Sub-standard briquettes
- Low supply of briquettes (quantities and consistency)
- Lack of consumers awareness
EXISTING ALTERNATIVES
<u>List how these problems are solved today</u>
- Use of alternative cooking solutions e.g charcoal</td>
<td>SOLUTION
<u>Outline a possible solution for each problem</u>
- Use stipulate procedures/standards to produce quality briquettes that meet consumer specifications. This will be influenced by suitable raw materials and technologies
- Ensure that production of briquettes is consistent by having sufficient raw materials and the suitable briquetting machines
- Create consumer awareness campaigns (road shows, demonstrations and providing trial briquettes to the target market)</td>
<td rowspan="2">UNIQUE VALUE PROPOSITION
<u>Single clear, competing message that states why you are different and worth paying attention</u>
- Provide quality briquettes (smokeless, low ash content, high calorific value etc)
HIGH-LEVEL CONCEPT
<u>List your X for Y analogy e.g YouTube-Flicker for videos</u></td>
<td>UNFAIR ADVANTAGE
<u>Something that cannot easily be bought copied</u>
Large energy out-put over a period time. Thus, ideal for cooking foods that take long to cook, space heating and cooking of large quantities of food as experienced in hotels or institutions</td>
<td rowspan="2">CUSTOMER SEGMENTS
<u>List your target customers and users</u>
- Households
- Poultry farmers
- Space heating for hotels
- Small eateries such as Kiosks
- Institutions</td>
</tr>
<tr>
<td>KEY METRICS
<u>List the key numbers that tell you how your business is doing</u>
- Quantities sold
- Repeat consumers
- New consumers</td>
<td>CHANNELS
<u>List your path to customers (unbound or outbound)</u>
- Direct sales-from the production site (consumer going to the producer) and consumer delivering to the consumer at a cost
- Business to Business</td>
</tr>
<tr>
<td colspan="3">COST STRUCTURE
<u>List your fixed and variable costs</u>

Fixed cost
- Cost of machinery (this will be guided by discussions in
- chapter 2)
- Cost of premises Protective clothes
- Business permit
- Cost of testing of briquettes
Variable costs
- Cost of labour
- Cost of feedstock
- Renewal of business permit</td>
<td colspan="3">REVENUE STREAMS
<u>List your streams of revenue</u>
- Sale of briquettes</td>
</tr>
</table>

3.2 Business Model Canvas

The Business Model Canvas (BMC) is designed for already existing businesses with the aim of visualizing and testing your business model to identify areas of improvement. The LCBM discussed above was developed from the BMC. All the components of LCMB discussed above apply to the BCM. However, BCM has 3 additional components that are not covered under LCBM. These components are discussed below.

Key partners

The existing briquette production businesses have to answer these three questions;

(i) Who are your most important partners?
(ii) Which key resources do you acquire from partners? And;
(iii) Which key activities do your partners perform?

Key partners in the briquette sector could range from financing institutions (EEP Africa, KawiSafi, Acumen etc.), briquette program implementers (Practical Action, Energy for impact, Netherlands Development Organization etc), the United Briquette Production Association (UBPA). The financing organization would provide financing to viable business models through grants or loans that the business can use to expand the work. Organizations that have implemented briquette programs in the past or have on-going programs would provide information on lessons learnt, direct the briquette producers to useful actors in the sector such as briquetting machines fabricators and importers and inform them of programs that are on the pipeline that could potentially benefit the briquette businesses. Being part of an association with other briquette producers such as UBPA is useful in activities such as capacity building and you get access to current information on the prevailing trends in the sector.

Key activities

What are the activities you perform every day to create & deliver your value proposition?

- Sourcing of raw materials
- Production of quality briquettes
- Marketing of the briquettes

Customer relationships

What relationship does each customer segment expect you to establish and maintain, for example, dedicated personal assistance, self-service, automated service etc.

ANNEXES

ANNEX 1: LIST OF BRIQUETTE MANUFACTURERS INTERVIEWED

#	Name of Business	Location	Name of Respondent	Gender
1.	Imarisha Kenya	Nyeri	David Nderitu	Male
2.	Mwaki Mutheu	Kitui	Patrick Vaati	Male
3.	Kiangure Springs environment innitiative	Tetu-Wamagana-Nyeri-Gathuthi	Joram Mathenge	Male
4.	Biomass Energy East Africa Limited	Kisumu	Rose Maiyo	Female
5.	Loyce Auma	Nairobi	Loyce Auma	Female
6.	African Solutions	Kisii Town	Elias	Female
7.	Eco charge	Nakuru	Mary Nyambura	Female
8.	Nerea Akinyi	Kisumu ndogo Nairobi, Kibera	Nereah Akinyi	Female
9.	Kings Biofuels	Kenol-Thika	Francis Akamu	Male
10.	Wood Heat Energy Limited	Fly- over along the Nakuru highway	Isaiah Maobe	Male
11.	Janet Adhiambo	Kibra	Janet Adhiambo	Female
12.	Eversafe briquette Limited	Mai Mahiu Naivasha	Lydia Waithera	Female
13.	Titus Kinoti	Njiru Nairobi	Titus kinoti	Male
14.	Kencoco	Kikambala Kilifi	Said Twahir	Male
15.	Sanivation	Naivasha	Dickson Ochieng	Male
16.	Roda Auma	Kibira	Rodha Auma	Female
17.	Nyalore Impact	Homa Bay Town	Dorothy Otieno	Female
18.	Bioafriqenergy Limited	Machakos	Doreen Achieng	Female
19.	White coal industries ltd	Kisumu kibos road	Anonymous	Anonymous
20.	Acacia Innovations	Bungoma	Elana Laichena	Female

ANNEX 2: LOCAL FABRICATORS AND IMPORTERS OF BRIQUETTE MACHINES

#	Name of company	Type of Business	Name of respondent	Contacts
1.	Kejofra Engineering	Local Fabricators	Martin Maina	0741 077384
2.	Benmah Product Company	Local Fabricators	Benson Mahogo	0722 237869
3.	Kendubay Machinery Service	Local Fabricators	Mr. Victor	0798 990468
4.	Camco Machinery	Importer/distributor	Mr.Osiemo	0714 255499
5.	CF Neilsen	Manufacturer/distributor	Thomas Nyabera	020 4440293
6.	Individual consultant/fabricator	Briquette technology expert	Isaiah Maobe	0720 280 528