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CENTRE FOR RESEARCH IN ENERGY AND ENERGY CONSERVATION

Sludge to Energy Enterprises in Kampala (SEEK)

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Market assessment of pelletizing and gasification technologies and associated end products in Kampala, Uganda

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Executive summary

The goal of the Sludge to Energy Enterprises in Kampala (SEEK) project is to work towards resource recovery based solutions for waste management become a reality and thereby:

- providing new business opportunities and increasing access to renewable energy
- improving public and environmental health in urban areas through the provision of sustainable sanitation service chains

The objective of this study was to assess the market potential for faecal sludge (FS) treatment end products and resource recovery technologies in Uganda. The products and technologies assessed are:

(a) FS treatment end products
- fuel pellets
- electricity
- char

(b) resource recovery technologies
- pelletizers
- gasifiers

Each of these products and technologies was studied in detail because they are very different from each other and have different specific customer segments. In general, the Ugandan market shows demand for the FS end products and technologies. However, to meet the demand of certain customers, adjustments need to be made. Most of the adjustments are required on the FS treatment end products. The findings from the research are summarized below.

Fuel pellets

The focus should be on industries which are currently using biomass fuels for heating of non-edible products. A good example is clay companies which could use the FS fuel for curing of clay products that are mainly used for construction. Therefore, health concerns are not a major issue. However, the fuel might need to be adjusted to meet the requirements and conversion technologies of these factories, e.g. it has to be supplied in powdered/crushed form to suit the technologies used. Although teaching institutions are interested in the FS fuels pellets as a fuel, they have much greater concerns regarding FS fuel pellets for cooking purposes due to the FS origin and emission from combustion.

The estimated theoretical market size for FS fuel pellets is about USD 2.8 million with firewood savings of almost 80 ton per year. However, if schools are not included, the theoretical market size drops significantly to roughly USD 450,000 with firewood savings of 12.5 ton per year.

Electricity

Although many factories, companies and industries (mainly located in (peri-)urban areas) are connected to the national grid, they can benefit from electricity, produced with gasification technology using FS fuel pellets to run their machinery, operations and activities. SEEK has to demonstrate a high-quality and user friendly system which provides clean, reliable and affordable electricity as an alternative or back-up to the non-reliable electricity supply from the national grid.

Rural off-grid communities on the other hand require electricity for lighting, televisions, radios and phone charging for households and machines and equipment for micro, small and medium enterprises (MSMEs). Electricity produced from FS fuel pellets can provide this electricity and thus satisfy a demand. Again reliability, availability and affordability are important factors.

Although potential for seven gasifiers, totalling to 200 kW, seems likely from community visits, it is rather difficult to provide a market estimate due to lack of data on other communities.

Char

Certain gasification technologies produce char as a by-product. To build a business case for this char, firstly, there needs to be a guarantee that gasification of FS fuel pellets is actually possible. Continuous production of char has to be ensured because most of the interested companies require a steady char supply. Secondly, char properties need to be accessed and communicated clearly. The main focus should be on companies producing briquettes for the industrial non-food market. The market segments for households, food industries and cooking purposes need a lot of sensitization and quality assurances due to the FS origin.

Support organisations in the char segment have embarked on a system of giving capital to entrepreneurs and later empowering them to be able to run their companies successfully. SEEK should consider working in partnership with these support organisations, like Living Earth which supplies char to its groups.

Based on the current needs, there is a potential for char of close to 500 ton/yr. If an average of USD 25 per ton is used, this has a financial equivalent of USD 12,500 per year. All organisations visited have potential to grow further and thus increase these numbers.

Pelletizers

Although there is potential for Bioburn, the market size seems rather limited due to various issues, described in more detail below.

The assessment of the pelletizer technology revealed four types of organizations of interest for the SEEK project:

- *pelletizers for manufacturing of pellets:*

The Bioburn pelletizer needs certain modifications to better suit the needs of potential customers. It could be matching the production techniques required for animal feeds or permitting the extrusion of both damp and dry organic matter, since the majority of companies in this segment produce animal feeds. There could also be efforts to sensitise the public about pellets to promote their use as fuel thus increasing demand for pelletizers.

- *pelletizers for manufacturing briquettes:*

The Bioburn pelletizer can be adjusted to allow for larger diameters from the extruder hence producing briquettes. Briquetting companies have a much higher potential for taking up the machines since the briquette market is much more developed compared to the pellet market in Uganda. However, when compared to locally produced briquette machines, the Bioburn pelletizer is rather pricey (USD 20,000 versus USD 1,700). On the other hand, it offers an advantage of less time required for drying since it can pelletize biomass at 60% dryness which cannot be achieved with the local machines in Uganda.

- *support organisations:*

Through support organisations, entrepreneurs attain soft loans from financial institutions for machinery, among other benefits. However, the support organisations have limited influence on the kind of machinery the entrepreneurs purchase. The support organisations mainly focus on briquette producers with less attention to pellet producers. Nevertheless, Bioburn pelletizers can be sold on credit, rented or leased to trustworthy customers endorsed by the support organisations since they have records on the different producers and can easily monitor their performance. This may enhance sales of pelletizers.

- *local machine manufacturers:*

The majority of machines is produced on demand. Manufacturers hold no stock and payments for these machines is usually made in instalments. During machine production, sophisticated machine parts are imported and imbedded into their fabricated designs to reduce production costs. Imported parts normally include motors, generators and shafts. This has made machine customization, modifications and maintenance easy. There is potential for Bioburn to cooperate with Ugandan companies in fabrication of pelletizers where the more simple parts can be produced locally and the more sophisticated parts are produced by Bioburn.

Gasifiers

Although gasification technologies are not yet widely known in Uganda, thus currently limiting the possibilities for this technology, the market assessment showed that there are several customer segments that can use gasifiers in order to meet their energy needs: rural off-grid communities and urban/peri-urban companies.

The first market has already been discussed under the section “Electricity” above. The latter segment has potential for gasifiers, but requires sensitization about the technology. This however is outside the scope of the SEEK project.

Just as with the communities, it is difficult to provide a market estimate due to lack of data on the other categories.

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List of Abbreviations

APL	All Power Labs
CBO	Community Based Organisation
CREEC	Centre for Research in Energy and Energy Conservation
Eawag	Swiss Federal Institute of Aquatic Sciences and Technology
FaME	Faecal Management Enterprises Project
FS	Faecal Sludge
GVEP	Global Village Energy Partnership
HPS	Husk Power Systems
Kg	Kilogram
kW	Kilo Watt
MW	Mega Watt
NDF	Norwegian Development Fund
NWSC	National Water and Sewerage Corporation
REA	Rural Electrification Agency
Sandec	Department of Water, Sanitation and Solid Waste for Development
SEEK	Sludge to Energy Enterprises in Kampala Project
MSME	Micro, Small and Medium Enterprises
UBOS	Uganda Bureau of Statistics
UGX	Uganda Shillings
USD	United States Dollar

1. Introduction

In Uganda, the demand for electricity greatly outstrips production rates (REA, 2013). Industries have to rely on fuel imports, and the majority of the population relies on unsustainably produced charcoal. Concurrently, urban wastes (e.g. faecal sludge from onsite sanitation technologies) are discharged directly to the environment jeopardizing public and environmental health, and large amounts of wastewater and faecal sludge (FS) end up in landfills (Strande et al., 2015). The Faecal Management Enterprises project (FaME, www.sandec.ch/fame) demonstrated that the calorific value of FS is on average 17.3 MJ/kg total solids, which is comparable to other currently used biofuels (Murray Muspratt et al., 2014). FaME has also identified a high demand for solid fuels and acceptance towards using FS as a fuel in Kampala. Pilot-scale kilns using dried FS as an industrial solid fuel were implemented to illustrate the technical viability to industries (Gold et al., submitted). FaME showed that sludge as fuel also has the potential to generate revenues four times higher than if used as a soil conditioner in agriculture (Gold et al., 2014).

Building on this knowledge, the Sludge to Energy Enterprises in Kampala project (SEEK, www.sandec.ch/seek) aims to increase the revenue potential from resource recovery of FS by processing FS together with other urban waste streams into fuel pellets and electricity through gasification. The Bioburn pelletizer (www.bioburn.ch) and the All Power Labs Power Pallet gasifier (www.allpowerlabs.com) are proven technologies in Switzerland and the United States. SEEK will apply these technologies to a developing country context in Uganda. This will entail making required adaptions to ensure technical viability and optimizing marketable commodities (i.e. pellets, electricity and char).

The development of energy supply infrastructures requires long-term decisions and large upfront investments. By implementing a drying, pelletizing and gasification system at the National Water and Sewerage Company (NWSC) Lubigi wastewater and faecal sludge treatment plant in Kampala, SEEK will provide reliable operating and financial parameters to allow informed decision-making. Through participation with potential customers and other stakeholders, SEEK will develop business models to ensure feedstock supply, financially sustainable operation and electricity allocation, creating a package that is attractive to investors for replication in Kampala and other urban areas of developing countries.

SEEK supports Uganda's efforts for increased private sector engagement in energy provision, increased provision of modern renewable energy, and climate change mitigation. SEEK will increase the potential for reduced use of fossil fuels and overharvesting of forests; in addition to reducing the pervasive dumping of sludge into the urban environment. Revenue generated from resource recovery of sludge could partially or fully offset FS treatment costs, provide an incentive to increase FS collection, reduce sanitation costs and in the long-term increase overall sanitation and quality of life in urban areas of developing countries.

Although sewage sludge has been widely used as a fertilizer in many regions all over the world, it can also contribute to provide renewable energy. In order to tap this energy potential, suitable technologies need to be adapted or developed for FS considering environmental implications and FS treatment costs. Pelletizing to produce a marketable pellet is one attractive technology. FS fuel pellets can be used as a fuel to meet heat requirements for several industries in Uganda. In addition, gasification technologies can be applied to convert FS fuel pellets into an energy source: gas produced can be used to power generators for electricity production and/or for producing heat. Char, an additional product from gasification with certain types of gasifiers, can be used as solid fuel (i.e. as substitute for charcoal) or as soil conditioner.

2. Scope

The study area was mainly Kampala, the capital city of Uganda, but for off-grid electricity, also areas out of Kampala were considered.

The products and technologies assessed are:

(a) FS treatment end products
- fuel pellets
- electricity
- char

(b) resource recovery technologies
- pelletizers
- gasifiers

During consultations, customer target groups included: industries, training institutions, agricultural enterprises and off-grid communities. Table 1 gives an overview of the various customer target groups for the different FS treatment products and resource recovery technologies.

Table 1: Customer target groups for the different products and technologies

Product / technology	Customer target group
Pellets	Industries and training institutions
Electricity	Off-grid communities outside of Kampala with demand for productive use of energy
Char	Briquetting and fish farming companies
Gasifier	Agricultural farms, industries and companies with high electricity demands as well as combustible feedstock for feeding the gasifier
Pelletizer	Pelletizing and briquetting companies

3. Methodology

The research was conducted mainly through interviews (mostly face-to-face) with potential customers of each of the FS treatment end products (fuel pellets, electricity and char) or resource recovery technologies (pelletizers and gasifiers).

Potential customers were companies or organisations or communities which were either:

- already using a product or technology similar to the FS treatment end products or resource recovery technologies being assessed in this study (e.g. briquette companies were consulted on the pelletizer assessment since these companies were already using pelletizers for production of char briquettes) or
- have processes or activities which require services that can be delivered by the FS treatment end products or resource recovery technologies being assessed in this study (e.g. communities without connection the electricity grid (i.e. off-grid) were consulted on electricity since they need electricity for lighting and productive use).

The indicators for assessment of potential demand and supply were adopted from the CREEC solar market study conducted in 2013 as seen in Table 2 below. In addition, since all the FS treatment end products and resource recovery technologies are very different and meet different customer segments, different indicators and questionnaires were used for each FS treatment end products and technologies (see annexes). Since most of the FS treatment end products and resource recovery technologies assessed were relatively new in the Ugandan market, the research focused more on the demand side to assess what quantities potential customers are willing to take and their other preferences on products and service delivery.

Table 2: Indicators used for assessing potential demand and supply

Observation level	Supply Side	Demand Side	Support Functions	Market Rules
Indicators	1) Distribution 2) Products and price 3) Warranty	1) Consumer awareness 2) Number of sales 3) Energy access rate	1) Financing 2) Labour market 3) Professional education	1) Incentive schemes 2) Quality regulations 3) Exogenous factors

Criteria for selection of indicators and potential customers to visit

Fuel pellets

Selection of potential customers to be consulted was based on the following criteria:

- Client location - focus was on clients in and around Kampala due to ease of transportation and logistics
- Quantities of biomass fuel being used - potential customers with high quantities of biomass usage were taken as first priority; however, especially for factories, some of the large ones were not visited due to too much bureaucracy in these organisations (i.e. it was very difficult to arrange a visit)
- The size of the client - whether it is a bigger, established organisation or a start-up; the latter ones were more open to consultations than the former ones which usually already have long term agreements with their current energy service providers

Electricity

Potential customers visited were mainly off-grid communities, where the national electricity grid will take longer to reach, and who have demand for productive use of electricity.

Char

Potential customers to be visited were chosen on the following criteria:

- the customer can apply char in their processes, i.e. can char actually be used?
- the customer has a need for char, i.e. how critical is their need?
- the customer has a commercial use for char, i.e. can it be used in a commercial way?

Table 3: Criteria and rankings for selecting potential customers of char to visit

Organizations / Criteria	Farmers	Briquetting companies	Construction companies	Fish rearing companies
Applications for char	10 In nursery beds and/or animal farming	10 As ingredient for making briquettes	10 Used for concrete, bricks	10 In fish feeds
Need for char in their production process	5 Could have substitutes	10 No substitute, char is required	2 Could have substitutes	3 Could have substitutes
Commercial use for char	4 Supplementary use only	10 Core of production resources	2 Supplementary use	2 Supplementary use
Overall rank	**19/30**	**30/30**	**14/30**	**15/30**

Ranking of the organisations was done on a scale from one to ten, with ten being the most positive and showing the highest potential. As can be seen from Table 3, briquetting companies had the highest rank and thus were mainly visited during the consultations.

Pelletizers

Potential customers to be visited were chosen on the following criteria:

- the customer has a commercial applications for pellets
- the customer produces pellets
- the customer is manufacturing pelletizers

Gasifiers

Potential customers to be visited were chosen on the following criteria:

- the customer is/or has been operating gasifiers
- the customer has high energy costs with heavy dependence on expensive back-up systems like diesel generators
- the customer has a reliable source of feedstock (especially in cases outside Kampala where transportation of pellets might become expensive)

4. Results and discussions

4.1 Fuel pellets

Table 4 summarizes the potential demand for FS fuel pellets at the visited organizations.

Table 4: Potential demand for biomass fuels in the visited organizations

Organisation	Fuel type	Daily use of fire-wood (ton)	Cost of fuel (USD/ton)	Number of processes per day (cooking or heating)	Potential demand (USD/yr)	Remarks
Teaching Institutions						
Namilyango College	firewood gas charcoal	0.069	34.4	3	700	These organizations responded that they are willing to test FS fuel pellets in their current technologies.
Kyambogo College	firewood charcoal	0.013	34.4	1	100	
Kyambogo University	firewood gas electricity	0.038	34.4	3	400	
Industries						
Mukono Bakery	diesel firewood	0.5	34.4	>10	6,300	The bread oven only uses diesel. Firewood is only used for deep fried products (e.g. pancakes and doughnuts).
Zoo Clays	sawdust	0.768	8.8	3-4	2,500	Sawdust is used in a powered/crushed form. Special wood is only used to start the fire.
	special wood	0.023	34.4	Monthly	300	
Katale Clays	Sawdust	4.80	36.6	2	64,100	Sawdust is used in powder/crushed form. They are willing to use FS fuel pellets for faster drying of their products as they currently use sun-drying.

Note 1: Due to their seasonal character, teaching institutions only require fuel for nine months in a year and not throughout the year as for example industries do.

Note 2: The yearly potential demand is calculated by multiplying the daily use by 365 days/year and the cost of the fuel, rounded off to the nearest USD 100

The results summarized in Table 4 indicate that the biomass fuel consumption for the visited clay factories is higher than that of the visited teaching institutions or bakery. However, the combustion technologies used by most clay industries require a powdered/crushed fuel, making FS fuel pellets unsuitable for use. FS fuel pellets could therefore apply more to teaching institutions and other factories that use fuel in solid form. Zoo Clays, however, has the potential to use FS fuel pellets to substitute the special wood used for starting the fire.

Currently, FS fuel pellets may not a suitable for teaching institutions who cannot control emissions from combustion. Emissions also need to be considered for clay companies. However, it is expected that large industries have to comply with emission standards. This should be confirmed before implementation.

To provide a conservative rough market size estimate of the biomass industry for productive use, the following assumptions are made based on CREEC's experience and knowledge of the market:

- the visited school constitute about 0.05% of the market share (there are about 2,000 secondary and 22,500 primary schools but of varying size).
- it is estimated that there are about 50 times as many bakeries comparable to the one visited.
- Katale Clays is one of four or five major clay manufacturers, but only two out of them may be able to use the FS fuel pellets.

This means that there is an estimated theoretical market size for FS fuel pellets of about USD 2.8 million (2,000 x USD 1,200 + 50 x USD 6,300 + 2 x USD 64,100) with firewood savings of almost 80 ton per year. However, if schools are not included, the theoretical market size drops significantly to roughly USD 450,000 with firewood savings of 12.5 ton per year.

All the consulted companies above showed a willingness to try out the FS fuel pellets. However, when contacted to commit with a letter, none of them was willing immediately. This indicated that companies need a lot more convincing to adjust from their current fuel.

Note: Even though the demand for biomass fuels for productive use keeps increasing, biomass or char fuel pellets have not yet had wide application in Uganda.

4.2 Electricity

Table 5 summarizes the potential demand for electricity from the visited communities. As can be seen all have the need for electricity (in total 200 kW), mainly for processing of agricultural produce. This means there is a potential for six gasifiers of 32 kW and one gasifier of 8 kW from just these seven. It is however very difficult to provide a market estimate due to lack of data on other communities.

Table 5: Potential electricity demand of visited communities

Community	Current Activity	Potential demand (kW)	Level of urgency	Remarks
Buvuma Island	Rice farming fishing, business	8	high	Electricity needed to process rice and run businesses
Kanakilak Soroti district	Farming	32	high	Electricity needed to power farming technologies
Agoro Lamwo district	Rice farming	32	high	Electricity needed to process rice
Aukot Soroti district	Farming (rice, groundnuts and maize)	32	high	Electricity needed to process rice and groundnuts
Buwalagoma Bugiri district	Farming (rice, groundnuts and maize)	32	low	Electricity needed to process rice, groundnuts and maize
Kashari Mbarara district	Farming	32	low	Electricity needed to power farming technologies
Amour Soroti district	Farming (rice and groundnuts)	32	high	Electricity needed to process rice and groundnuts

From the observations it can be concluded that there are more potential investment opportunities in electricity in off-grid communities compared to on-grid. This is because most of the off-grid communities lack access to electricity. In some areas the national grid will take long to reach, if ever.

Therefore, business opportunities exist through simply purchasing, installing and operating gasifier systems to generate electricity that is sold to the community. The latter require electricity for lighting, televisions, radios and phone charging for households and machines and equipment for micro, small and medium enterprises (MSMEs).

Although many factories, companies and industries (mainly located in (peri-)urban areas) are connected to the national grid, they can benefit from electricity, produced with gasification technologies using FS fuel pellets to run their machinery, operations and activities. To penetrate this market, a high-quality and user-friendly system which provides clean, reliable and affordable electricity as an alternative or back-up to the non-reliable electricity supply from the national grid needs to be demonstrated.

4.3 Char

Table 6 and Table 7 summarize the potential demand for char. The study identified two market segments: start-up briquetting companies (see Table 6) and established briquetting companies (see Table 7). Based on the current needs, there is a potential of close to 500 ton/yr. If an average of USD 25 per ton is used, this has a financial equivalent of USD 12,500 per year. All organisations have potential to grow further and thus increase these numbers.

Table 6: Potential demand of char at start-up companies

Organisation	Fuel type manufactured	Amount needed (ton/yr)	Cost of char (USD/ton)	Potential demand (USD/yr)	Remarks
King Fire Energy Solutions	Hollow briquettes	72	20.4	1,500	Interested but concerned about using FS char briquettes for barbecues.
Kyebando Energy and Environment Project	Hollow and honey comb briquettes	17	0 No cost incurred	0	Need for training to change consumers perceptions.
LULUNA CBO	Hollow and honey comb briquettes	48	21	1,000	
MASUPA Enterprises	Hollow and honey comb briquettes	10.8	20.4	200	FS char briquette production should focus on industries and should not have a foul smell. Workers have to wear protective gear.

Note: The yearly potential demand is rounded off to the nearest USD 100

Another start-up organisation, Water for People, was visited since they are involved in research and development regarding briquettes made from faecal sludge. They are not operational yet and only have some briquette samples from their experiments. They commented that briquettes from faecal sludge should be tested to ensure that they meet the needs and expectations of users.

Table 7: Potential demand of established companies

Organisation	Fuel type manufactured	Amount needed (ton/yr)	Cost of char (USD/ton)	Potential demand (USD/yr)	Remarks
Green Heat Uganda	Pillow shaped briquettes	120	Not provided	Unknown	Would require experimentation in the field for minimum about one month. Need to change attitudes. Training of end users is a must for adoption.
Green Bio Energy	Hollow and honey comb briquettes	220	30	6,600	Requires generating further information on use in production process

Note: The yearly potential demand is rounded off to the nearest USD 100

Furthermore, several support organisations were visited:

- AfriBanana Products which provides raw materials (banana peels) and machines. The Banana peels are given to Green Heat Uganda (see table above) to produce char for their briquettes. AfriBanana operations are carried out in rural areas, away from Kampala, so transportation of the peels to Green Heat premises is challenging.
- GVEP International which provides training. Their support many briquette producers producing between 200 kg/h to 56 t/d. Among their top 20, 90% produces carbonized briquettes. While venturing into use of char from gasification, GVEP advised to consider the following:
  - Behavioural aspect of the users
  - Consumers require more information
  - Requires testing the product to establish facts about; time spent cooking, starting time, burning rate, ash content, moisture content, environmental factors and also address concerns about the smoke and smell
- Living Earth Uganda which provides raw materials, training and briquette making machines, while currently supporting 70 MSMEs. They have a potential demand of almost 275,000 tons per month. They are very interested in char from FS gasification because of this high demand.

Five out of ten visited companies were willing to use the char from FS. Three of these willing companies had some concerns that could be addressed with further training. Only two companies were not open to the idea of using char from FS.

In Uganda, the briquette sector heavily relies on charcoal production for feedstock supply. Charcoal vendors are the main suppliers of char (charcoal dust). The char is collected from several charcoal wholesale yards and costs between USD 1.6-3.2 per bag and from middle men who hike the price as high as USD 4 per bag, each bag weighing approximately 100 kg.

Briquette producers usually supplement the char quantity with agricultural waste they acquire from markets and farmers on a contractual basis.

Some briquette producers have adopted the method of leasing out small carbonisation kilns to farmers so that they can buy ready/processed char and also forego the tedious process of carbonisation.

Living Earth have come up with an efficient supply chain that involves centralised collection of waste for char and actual char from city waste collectors which is then distributed among the MSMEs they support at a subsidized fee.

Other companies, such as Green Heat, have entered into partnerships with companies, e.g. AfriBanana Products, whose production residues -banana peels- become feedstock for briquette production. Such partnerships ensure steady supply throughout the year.

Lastly, there is competition for char from another organisation: Umeme, the national electricity distribution company. Umeme requires char in large quantities, but does not have serious concerns over health issues.

4.4 Pelletizers

Several categories of potential customers for pelletizers were visited. The information gathered, however, is of a more qualitative nature, i.e. comparing the Bioburn pelletizer to available alternatives on the market. It is therefore not possible to make supported estimates of the market size for the pelletizer. Although there is potential for Bioburn, the market size seems rather limited due to various issues, described in more detail below.

- *Pelletizers for manufacturing pellets:*

Pellets can be produced from various commodities depending on the intended use. In Uganda, whereas some companies produce them as animal feeds, others utilise them as fuels.

Table 8: Pellet producing companies visited

Organization	Activity	Feedstock	Technique	Capacity	Price (USD)
Ugachick Poultry Breeders	Chicken & fish farmers Producers of pelleted poultry & Fish feeds	Maize bran and soya beans	Extrusion	4 t/hr	
			Compression	5 t/hr	
Biyinzika Poultry International	Chicken farmers and produce pelleted poultry feeds from	Maize bran and soya beans	Extrusion	4 t/hr	
Eco Home Solutions	Sale of fuel efficient stoves and pellets	Import wood pellets			
MusaBody	Pellet feed machine manufacturers	Maize bran and cereals	Extrusion	10 t/d	8,334

All feeds companies produce pellets in sizes ranging from 1 to 8 mm to cater for the different feeding habits of animals. Eco Home Solution used to import wooden pellets of 8 mm for the cookstoves they used to sell.

The animal feed companies have large production machines to enable them to supply feeds to their farms and customers. The machines heat the maize bran, crushed soya beans and other nutrients before wetting them. They are then extruded to the required size and dried for packaging.

- *Pelletizers for manufacturing briquettes:*

Briquettes are either carbonised or non-carbonised. Most producers deal in carbonised briquettes using basic manual pelletizer machines. Therefore, they are majorly small-scale producers supplying households and a few institutional consumers. The few producers of non-carbonised briquettes supply mainly institutions (e.g. schools).

Table 9: Briquette producers visited

Organization	Type of briquette	Production technique	Power source	Production capacity	Price (USD)
Kingfire Energy Solutions Ltd	Carbonised	Semi-automated extrusion machine	Petrol engine	1 t/d	1,500
Masupa Enterprises Ltd	Carbonised	Manual press machines			150
Kyebando Energy and Environmental Project	Carbonised	Manual press			200
	Carbonised	Semi-automated extrusion machine	Electric motor	1 t/d	1,667
Luluna CBO	Carbonised	Semi-automated extrusion machine	Petrol engine	1 t/d	1,500
Kampala Jellitone Suppliers	Non-carbonised	Extrusion machine	Electric motor	560-700 kg/hr	

The process of non-carbonised briquette production requires grinding the various organic matters before drying and compressing. For carbonised briquettes, the dried biomass is heated with limited oxygen supply to produce char which is mixed with binders (e.g. starch to prevent the briquette from disintegrating) before it is compressed.

Most of the extrusion machines available in the visited companies use the same drive with the grinder and this greatly lowers the cost of the machines. This however, reduces productivity since the machines cannot be operated simultaneously. Nevertheless, the limited markets for briquettes do not require running machines to full capacity.

The Bioburn pelletizer can be adjusted to allow for larger diameters from the extruder hence producing briquettes. Briquetting companies have higher potential for taking up the machines since the briquette market is much more developed compared to the pellets' one in Uganda.

However, when compared to locally produced briquette machines, the Bioburn pelletizer is rather pricey (USD 20,000 versus USD 1,700). On the other hand, it offers an advantage of less time required for drying since it can pelletize biomass at 60% dryness which the local machines can't manage.

- *Support organisations:*

There are various support organisations that promote briquette producers in Uganda. The support given includes: briquette production techniques, machine manufacturing techniques, market for the briquettes and support in acquisition of soft loans which are used to purchase machinery. Table 6 shows the support organisations which were consulted for this assessment.

Table 10: Support organisations visited

Organization	Support group
Living Earth Uganda	Environmental conservation projects like briquette production through CBOs
GVEP International	Energy MSMEs enterprises like briquette manufactures
Renewable Energy Incubator	Start-up businesses related to renewable energy technologies

Through the support organisations, many entrepreneurs attain soft loans from financial institutions for machinery among other benefits. However, they have limited influence on the kind of machinery the entrepreneur purchases. They normally focus more on briquette- than on pellet producers.

The Bioburn pelletiser can be sold on credit, rented or leased to trustworthy entrepreneurs endorsed by the support organisations. The latter have good records on the various companies and can easily monitor their performance. This may help in sales of the pelletisers since they are rather expensive to be purchased at once for the majority of entrepreneurs.

Most of the enterprising briquette producers, often with support from various non-government organisations have purchased manual machines to enable them to produce up to 20 tonnes per year (Ferguson, 2012). Since rural areas were the main targets, these machines do not require electricity for operation.

- *Machine manufacturers:*

The motorized machines fabricated by skilled artisans are capable of producing up to 200 tonnes of briquettes per year (Ferguson, 2012). The different machine manufacturers usually make customized machines based on the customers' requirements. This has promoted the idea of designing machines utilised in rural areas with no grid electricity.

Table 11: Machine manufacturers visited

Organization	Specialty
Central Engineering	Agro processing and food processing machines
MusaBody	Food processing, packaging, animal feeds, agro-processing, carpentry, construction and fabrication machines
Davidston Hatchery and Invent Technology Partners Ltd	Food processing machines

The majority of machines is produced on demand. Manufacturers hold no stock and payments for these machines is usually made in instalments.

During machine production, sophisticated machine parts are imported and imbedded into their fabricated designs to reduce production costs. Imported parts normally include motors, generators and shafts. This has made machine customization, modifications and maintenance easy.

4.5 Gasifiers

In Uganda, the gasification technology is growing and several new players are coming into the market to supply and operate the gasifiers. Potential customers of gasifiers can be grouped into three main categories: (i) organizations already operating gasifiers, but not necessarily owning the gasifiers, (ii) individual users like industries and farms, and (iii) communities with demand for productive use of electricity. The latter has been discussed under the FS treatment end-product electricity in section 4.3 and will therefore not be repeated here. Just as with the communities, it is difficult to provide a market estimate due to lack of data on the other categories.

- *Operators of gasification sites:*

The table below displays the sites visited. Most gasifiers are in the Central and Northern regions of the country. The major feedstock is agricultural waste streams. All current gasifiers are off-grid, covering rather small rural villages up to 100 households.

Table 12: Gasifier operators visited

Operator	Number of gasifiers	Size of gasifiers (kW)	Manufacturer
Mandulis Energy Ltd	1	32	HPS
Pamoja Energy Ltd	3	32 and 10	HPS
GRS Commodities	1	32	HPS
CREEC	2	10	All Power labs
Simba group	1	32	HPS

Installation of the gasifiers is done by the manufacturers as well as the team from the local operating company. Operators are trained by manufacturers to maintain the gasification system. The gasifiers currently in Uganda are mainly from India and USA. Gasifier operators in Uganda have support from various partners including the Renewable Energy Business Incubator, CREEC, Husk Power Systems, NORGESVEL and the Nordic Development Fund (NDF).

Table 13: Typical cost example of a gasifier

Item	Amounts (USD)
Gasifier purchase price from the manufacturer	40,000
Logistics	20,000
Taxes	15,000
Installation	20,000
Land for the gasification plant	5,000
Other costs	20,000
Total	**120,000**

Source: Mandulis Energy Ltd, 2015 for a 40 kVA gasifier from HPS in Northern Uganda

- *Individual users:*

Two large industries, Parambot Breweries Ltd and SAB Miller Nile Breweries Ltd, and one large farm, Sunshine Agro Product Ltd, were visited. The breweries get their energy mainly from the electricity grid, while the farm relies on a diesel generator for its energy needs.

Table 14: Daily demand for the visited potential users

Organization	Current energy source	Daily energy consumption	Daily cost (USD)	Comment
Parambot Breweries Ltd	Grid - 90%	6,912 kWh	2,212 (1)	Gasifier needed
	Diesel generator - 10%	288 litres (2)	403 (3)	
SAB Miller Nile Breweries Ltd	Grid - 97%	-	3,100,896	Gasifier needed to substitute diesel engine
	Diesel generator - 3%	-	2,034.45	
Sunshine Agro Product Ltd	500 kVA diesel generator (20 hours daily) - 100%	6,000 kWh	4,334	

(1) Electricity from the grid is taken at USD 0.32/kWh
(2) The factory is assumed to run 24 hour/day and the diesel generator consumption is 120 litres/hour
(3) Diesel price is taken at USD 1.40/litre
(4) Generator is assumed to run at 75% load and a power factor of 0.8

5. Conclusions and recommendations

Pellets

Even though teaching institutions are willing to try pellets, they are concerned using them for cooking purposes as they are produced from faecal sludge. The focus should thus be on industries which are currently using biomass fuels for heating non-edible products, such as clay companies whose products are used for example in roofing and health concerns are not a major issue. However, for a solid uptake of FS fuel pellets, their form needs to be adjusted from pellets to powder to meet the requirements and conversion technologies of these factories. There are nevertheless companies who see potential for pellets in specific processes; these opportunities should be explored in further detail.

Electricity

Many off-grid communities lack access to electricity and thus provide excellent opportunities for installing and operating gasifier systems. The electricity produced can satisfy the demand for productive use (running of tools, machinery and equipment) and domestic use (such as televisions, radios, fridges and lights).

Though connected in urban and peri-urban areas, several companies struggle with their electricity supply due to the non-reliability of the national grid. Electricity from gasifier being fed with FS fuel pellets can work as an alternative or back-up to the grid supply.

SEEK can focus on implementing and demonstrating that clean reliable and affordable electricity from a high-quality and user friendly system can be provided. The decision to go along this road will highly depend on gasification trials determining if FS fuel pellets are a good fuel source.

Char

Selling char to briquette making companies seems a good avenue. It however still requires further research and development on the technical side. First of all, a steady supply needs to be ensured, which requires continuous and stable gasification. Secondly, providing the required quantities is a challenge, unless several gasifiers are operating at the same time. As mentioned before for electricity, the decision to focus on this product depends on the results of the gasification trials.

The assessments show that there is demand for char already; ensuring a constant supply is the challenge faced.

Gupta & Kolin (2006) state that factors influencing the choice of feedstock include: availability, proximity, cost, energy content (heat output, smoke levels and ash content), conversion potential (physical and chemical) and attributes that determine ease of drying, need for binding, moisture content and size of raw materials. Hence, conducting further detailed research should be done with regard to these factors.

Since several support organisations embarked on systems of providing capital to entrepreneurs and later empowering them to run their companies successfully, it should be considered to work in partnership with these organisations.

Lastly, supplying the electricity distribution company Umeme with char requires further investigation in their specification concerning char.

Pelletizers

There are four segments for pelletizers: manufacturers of pellets, producers of briquettes, support organizations and machine manufacturers.

There are few pellet producers in Uganda and the majority deals in animal feeds. These are large scale organisation using machines with a far higher capacity than the Bioburn pelletiser. In addition, they use a slightly different production technique with feedstock heating, requiring certain modifications to the Bioburn pelletiser. Similar considerations are valid for briquette producers.

Furthermore, companies found the Bioburn pelletizer rather expensive compared to locally manufacture machinery. However, there is potential for Bioburn to cooperate with Ugandan companies in fabrication of pelletizers where the more simple parts can be produced locally and the more sophisticated parts are produced by Bioburn. This should be investigated further.

Support organisation play a significant role in providing entrepreneurs (access to) loans from financial institutions for the purchase of equipment among other benefits. They also can support sales of Bioburn pelletizers on credit or through rent/lease constructions to entrepreneurs they endorse. On the other hand, they have only limited influence on the kind of machinery being purchased. Potential cooperation with these support organisations should be assessed in more detail to enhance market opportunities.

Gasifiers

Although gasification technology is not yet widely known in Uganda, thus currently limiting the possibilities for this technology, the market assessment show that there are several customer segments that can use gasifiers to solve their energy problems: rural off-grid communities and urban / peri-urban companies.

The first one is already discussed under the section “Electricity” above. The latter segment has potential for gasifiers, but requires sensitization about the technology. This however is outside the scope of the SEEK project.

References

Gold, M., Niang, S., Niwagaba, C. B., Eder, G., Murray Muspratt, A., Diop, P. S. & Strande, L. 2014. Results from FaME (Faecal Management Enterprised) - can dried faecal sludge fuel the sanitation service chain? *37th WEDC International Conferecnce.* Hanoi, Vietnam.

Ferguson, H. 2012. Briquette business in Uganda. GVEP International.

Murray Muspratt, A., Nakato, T., Niwagaba, C. B., Dione, H., Kang, J., Stupin, L., Regulinski, J., Mnéguéré, M. & Strande, L. 2013. Fuel potential of faecal sludge: calorific value results from Uganda, Ghana and Senegal. *Journal of Water, Sanitation and Hygiene for Development,* 4**,** 223-230.

Rural Electrification Agency Uganda (REA), 2013, Overview of the performance of Uganda's electricity sector. Parliamentary Stakeholder Symposium, 19-20 July 2013.

Strande, L. 2014. The global situation. *In:* Strande, L., Ronteltap, M. & Brdjanovic, D. (eds.) *Faecal sludge management: Systems approach for implementation and operation.* London: IWA Publishing.