Circular bioeconomy business models – Energy recovery from agricultural waste: Cases from Kenya and Burkina Faso

Solomie Gebrezgabher, Avinandan Taron, Jack Odero, Safietou Sanfo, Ramata Ouedraogo, Seyni Salack, Karim Diarra, Soumaila Ouedraogo, Kehinde Ojungobi

December 2022

The Authors

Solomie Gebrezgabher, International Water Management (IWMI), Accra, Ghana

Avinandan Taron, International Water Management (IWMI), Colombia, Ghana

Jack Odero, Revolve, Research and Consulting Group (RRCG), Nairobi, Kenya

Safietou Sanfo, West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL), Ouagadougou, Burkina Faso.

Ramata Ouedraogo, International Water Management (IWMI), Accra, Ghana

Seyni Salack, West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL), Ouagadougou, Burkina Faso.

Karim Diarra, West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL), Ouagadougou, Burkina Faso.

Soumaila Ouedraogo, West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL), Ouagadougou, Burkina Faso.

Ogunjobi O. Kehinde, West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL), Ouagadougou, Burkina Faso.

Kehinde Ojungobi, West African Science Service Centre on Climate Change and Adapted Land Use (WASCAL), Ouagadougou, Burkina Faso.

Gebrezgabher, S.; Taron, A.; Odero, J.; Sanfo, S.; Ouedraogo, R.; Salack, S.; Diarra, K.; Ouedraogo, S.; Ojungobi, K. 2022. *Circular bioeconomy business models - energy recovery from agricultural waste: cases from Kenya and Burkina Faso*. Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Initiative on Nature-Positive Solutions. 37p.

About Nature-Positive-Solutions

Nature-Positive-Solutions is a One CGIAR initiative that aims to re-imagine, co-create, and implement nature-positive solutions-based agrifood systems that equitably support local food and livelihoods, while simultaneously ensuring that agriculture is a net positive contributor to nature. For more details about the initiative https://on.cgiar.org/3rHjbRO

Acknowledgments

This work was carried out under the CGIAR Initiative on Nature-Positive Solutions, which is grateful for the support of CGIAR Trust Fund contributors (www.cgiar.org/funders).

***Disclaimer**: This publication has been prepared as an output of the CGIAR Initiative on Nature-Positive-Solutions and has not been independently peer reviewed. Responsibility for editing, proofreading, and layout, opinions expressed and any possible errors lies with the authors and not the institutions involved.*

Summary

Agricultural waste can be widely adopted to manufacture biogas or biofuel, which is obtained from biomass or agricultural wastes like molasses, bagasse slurries manure etc. Agricultural waste is mostly burned or left decomposing on the fields, where it has potential for polluting the environment and release greenhouse gases. Recovering energy helps to (i) reduce greenhouse emissions by reducing environmental pollution from unwanted biomasses otherwise being burnt in the field; (ii) improve energy efficiency in heating systems from renewable energy sources; (iii) introduce renewable energy by substituting carbon neutral biomass for hydro-carbons (coal, heavy oil and gas); and (iv) Recycle ash residues or slurry as a fertilizer.

The present report covers four case studies from Kenya and Burkina Faso related to recovering energy from agrowaste. **Biogas International Limited (BIL)** is a public private venture in Kenya involved in collection of market waste and recovering biogas, compost, liquid bio fertilizer. The **Dunga Beach biogas plant** in Kenya turns the invasive water hyacinth (Eichhornia crassipes) on the shores of Lake Victoria to biogas energy, an alternative to charcoal burning for fish vendors at the beach. **Keveye Girls** is a boarding high school located in Vihiga County. Through consultations and interventions by the Department of Agriculture and Livestock at Vihiga County, Keveye Girls now converts cow dung into biogas, which is then used to power the school's science laboratories and kitchen as an alternative to LPG gas and wood energy. Similar case studies exist in Burkina Faso. **FasoBiogaz**, an SME was founded by two Dutch entrepreneurs and supported by the Dutch government and is fully operated by a local team. FasoBiogaz operates the first industrial biogas plant connected to the SONABEL power grid and provides innovative resource recovery solutions producing 550 KW of power.

Business case: Kenya

Biogas International Limited (BIL)

Business case at a glance

Location:	Ngong' town, Kajiado County	
Waste input type:	Market Waste	
Value offer:	Biogas, compost, liquid bio fertilizer, flexi biogas tech and bricks	
Organization type:	Public Private Partnership	
Status of organization:	Operational since 2011	
Scale of businesses:	Medium scale	
Major partners:	• Kajiado County government • Kisumu County government • Kenya Biogas Program • Egerton University • Kenya Association of Manufacturers • Ngare Ndare Forest Trust • UNDP	• UNICEF • UNHCR • Africa Action Help International • SNV • IFAD • Moi University • Pumwani University

Executive summary

Biogas International Limited or BIL, is a limited liability company founded in Kenya in the year 2011 and operates from Karen in Nairobi. Its product portfolio includes flexi-biogas digesters, bio-sanitation waste management systems, evapo-coolers, chick incubators and brooders, biogas and solar combo fruit and vegetable dryers and vertical gardens. While the company's focus is on designing simple appropriate technology tools such as flexi biogas digesters to alleviate daily challenges on rural farms, it also involves in recycling agro-food residues. The focus of this business profile will be on its activities at the ngong market, which is located south of Nairobi, at the edge of the Great Rift Valley within Kajiado County. BIL's Recycling process at the Ngong market includes the following:

- Collection of all market waste
- Sorting wastes into biodegradables (80% of all waste) and 'other' waste
- Further sorting of biodegradables into fibrous vs easily digestible waste
- Crushing the easily digestible biomass and feeding them into biogas digesters
- Production of biogas and liquid bio slurry
- Composting of the more fibrous portion for organic fertilizer and
- Incinerating the 'other' waste to produce ash used to make bricks for construction.

Key performance indicators						
Land use	0.25 Ha					
Capital investment:	USD 120,000					
Labor requirements:	5 full-time workers and 50 -60 part-time workers					
O&M cost:	USD 1500 per 3.5 tons of waste processed					
Output:	40,000 to 50,000 liters of gas/day. 1500 liters of liquid fertilizer and insect repellant/day. 600 kgs of compost/day					
Potential social and/or environmental impact:	Job creation; enhanced public health via improved sanitation; environmental conservation					
Viability indicators	Payback period:	6-8 years	Gross margin:	40%	Net profit (after tax)	25%

At the market, BIL's biogas plant has seven multistage digesters of 50m^3 each with a daily gas production capacity of between 40,000 and 50,000 liters of gas. The resulting bio fertilizer from biogas production flows by gravity to a holding tank, where it is packaged into 5-liter cans and sold to farmers as a liquid fertilizer and an insect repellant (for Ksh. 50 per

liter). Compost mostly from banana leaves and other fibrous biomass is sold to nearby peri-urban farmers. BIL's intervention at the Ngong market has contributed to income opportunities for the youth, improved waste management and sanitation at the market and its surrounding.

Key success drivers for BIL in recycling at the ngong market

- Strategic partnership with Kajiado County to lead sanitation efforts at the market
- Partnership with traders for a guaranteed and easy collection of market waste
- Availability of sufficient waste stock to feed the digesters and drive the composting processes
- Partnership with multiple agencies and universities for funding and technical backstopping

Context and background

Ngong areas is predominantly peri urban with a population largely dependent on trade and agriculture. The market in Ngong town is the largest trading center in the area. Waste management around the market is therefore a concern for the county government and the public at large. BIL's partnership with the county government contributed towards enhanced waste management around the market through collection and processing of market waste. In addition, the collaboration with county government also ensured a ready market (at the beginning of operations) for the produced biogas as traders would use the gas in communal kitchen set up at the market. A new market has since been built and traders moved further away from BIL's biogas plant. Most of the gas produced currently is not sold/used but plans are underway to pipe it to nearby kiosks and restaurants. Peri- urban farmers within the outskirts of Ngong town make up the key customer segment for both the compost and liquid fertilizer.

Market environment

Prior to BIL partnership with the county government, market waste management involved collection and dumping in landfills within the peripheries of Ngong town. The result was an overburdened dumping site, bad smell, pollution and dumping on roadsides, rivers, and forests. BIL contributed to providing solution to the waste build up problem by partnering with the county government to manage market waste. Processing market waste to biogas, compost and liquid fertilizer has not only reduced dumping by the roadside but has also produced value marketable products to farmers (compost and liquid fertilizer). Peri- urban farmers within the outskirts of Ngong town make up a key customer segment for both the

compost and liquid fertilizer. However, the market segments for bricks made from the incinerator are not clear. The partnership ensures free access to market waste input while processes at the plant contributes to public health through improved market waste management.

Business Model

In collaboration with the county government, BIL ensures improved market waste management through waste collection, sorting, composting and biogas production. Biogas is marketed or sold back to the market fraternity. Compost and liquid fertilizer are sold to per-urban farmers from around the market vicinity (Figure 1).

<table>
<tr>
<td rowspan="2">Key Partners
• Kajiado and Kisumu County government
• Kenya Biogas Program
• Egerton University
• Kenya Association of Manufactures
• Ngare Ndare Forest Trust
• UNDP, UNICEF, UNHCR,
• SNV,
• IFAD
• Africa Action Help International
• Moi University
• Pumwani University</td>
<td>Key Activities
• Waste collection, sorting
• Compost, biogas and brick production
• Sales and marketing</td>
<td rowspan="2">Value Propositions
• Low cost and efficient biogas for cooking
• Compost, bio slurry for urban agriculture
• Improved market waste management environment</td>
<td>Customer Relationships
• Direct and Indirect</td>
<td rowspan="2">Customer Segments
• Market Traders
• Farmers</td>
</tr>
<tr>
<td>Key Resources
• Commercial biogas machines
• Land
• Skilled workforce</td>
<td>Channels
• Direct sales</td>
</tr>
<tr>
<td colspan="3">Cost Structure
• Investment cost – land, building, plant
• Operational cost – labour, utilities (water and fuel) and maintenance
• Land – free lease by the County</td>
<td colspan="2">Revenue Streams
• Sale of Biogas
• Sale of compost and liquid fertilizer
• Advisory services (installation of biogas digesters)</td>
</tr>
<tr>
<td colspan="3">Social & environmental costs
• Possibility of work-related hazards and risks, for example, risk to injury and exposure to pathogens.
• Foul smell at the sorting site
• Environmental risk from plant discharges and waste</td>
<td colspan="2">Social & environmental benefits
• Generation of employment opportunities
• Contribute to improved management of market waste
• Contribute to soil conservation among farmers using compost
• Overall generation of value from waste and conservation of the environment</td>
</tr>
</table>

Figure 1 Bio-Corn business model canvas

Value chain and position

BIL's value chain actors at ngong market consists of the following:

- Market waste (both biodegradable and inorganic waste)
- Farmers/Market suppliers of products
- Traders at the market
- County government (licensing, sanitation and public health services)
- Waste collection entrepreneurs (collection and dumping)
- Street urchins sorting waste for valuables
- Farmers –compost and liquid fertilizer customers

BIL contributes to managing or transforming market waste to value. The waste is generated from farm and industrial supplies, market traders in the process of selling, buying and consumption at the marketplace. The value chain includes county government (licensing, sanitation and public health services), Waste collection entrepreneurs (collection and dumping) and street urchins who scavenge and sort through waste heaps for valuables. BIL situates in the middle of the chain/at the point of waste generation but before it is collected by waste collection and dumping entrepreneurs. BIL works with both traders and county government and collects, sorts and produces biogas, compost, and bricks from incinerated inorganic waste.

Institutional environment

By collaborating with the county government of Kajiado, BIL was licensed (by the county government) to manage waste generated in all the markets within the county of Kajiado. The county also provided BIL with free lease on land it operates on at the ngong market. These supports have reportedly made it easy to do business. Nevertheless, BIL has faced various challenges in the course of doing business, for example, there has been resistance by waste collectors in allowing BIL to collect market waste, and sometimes officials from the ministry of environment have claimed direct responsibility for market sanitation regardless of BIL's contract with the county government and lack of funding (sanitation cost savings for government was to aid BIL activities) support from the county.

Technology and processes

Waste to compost: BIL works on a collaborative basis where traders collect and heap their market waste at points accessible to BIL's collection team. The collection team walks through the market with trolleys collecting and transporting waste to BIL's composting site located

behind the market. At the operations site, market waste is sorted into three levels. One, the easily digestible organics such as fruits and vegetables, secondly, the more fibrous organics such as banana leaves used in packaging and finally inorganic waste. The first level is used in biogas production, while the fibrous organics are composted. The inorganic waste is incinerated and resulting ash is used to make bricks. Windrow composting is the technology used. This technology, although labor-intensive, requires low capital investment and has high rates of resource recovery. The technology however requires significant amounts of space, which can be a challenge for replicability. BIL's fully matured compost samples have been tested, approved and registered with Kenya Bureau of Standards (KeBS). Plans to package and formally sell at the market were underway as at the time of data collection. BIL implements strong internal regulations, ensuring that all persons involved in the compost production process wear protective gear at all times.

Waste to biogas: BIL uses s the anaerobic digestion process to produce biogas from the portion of market waste that is easily digestible (fruits and vegetables). However, its technology includes a grinding machine that cuts down waste into smaller pieces to fast-track digester processes. BIL's digesters are multistage or multi chambered 50m^3 in volume each. Multiple layers ensure efficiency in biomass breakdown and gas production as feed is pushed forward (by new batch of waste/feed) to the next chamber, allowing continued gas production from batches of waste fed to the digester. The gas produced is collected in gas canvas placed above the digesters while resulting liquid fertilizer is collected at the last chamber. Both the grinding machine and biogas digesters are locally fabricated. Gas canvas is also available and bought locally. The technology is registered under the company's intellectual property.

Financial analysis

The total investment for BIL's operation at the ngong market is estimated at USD 120,000 over the last two-three years. This is barely sufficient since full operation requires approximately between USD 250,000 and 300,000 per year. There has been support from the donor community for purchase/fabrication of digesters and grinding machines as well as compost testing and approvals. Operation and maintenance cost is estimated at USD 1,500/3.5 tons of waste processed and includes costs of labor (5 full-time), electricity, water and other associated repairs and maintenance costs.

The revenue streams of BIL are sales of compost (50%), fees for use of the biogas at communal kitchens in old ngong market (10%) and sale of liquid fertilizer (40%) at 0.83 USD/litre (USD 1= Ksh 120). BIL sells between 400–500 kgs of compost daily, retailing at

0.42 USD/kg. Demand for compost is seasonal and is mostly sold in two seasons in any year. This translates into approximate gross revenue of USD 50,000 per year. About 800 liters of liquid fertilizer is produced daily and about 500 liters is sold amounting to USD 49,800. BIL is yet to breakeven but with plans to package the compost, profits are estimated within the next two years (2025). It is plausible that with production at capacity and increased demand, there is opportunity for BIL to earn higher profits.

Business case summary assessment -SWOT analysis

STRENGTH	WEAKNESS
• Ready supply of market waste • Partnership with county government has reduced cost of doing business • Strong partnership with academic and donor institutions • Tested and approved organic fertilizer • Low operating and maintenance costs • High upscaling potential	• Lacking market for biogas • No good retail price for biogas • Financial instability – low cash flow
OPPORTUNITY	**THREAT**
• Expansion of activities to other counties • Ongoing plans to automate production • Potential to produce granulated compost to access new market • Certification of high nutrient liquid fertilizer • Potential for increased scope of market and revenue from certification of liquid fertilizer	• Government subsidies on inorganic fertilizer • Limited funding, especially from mainstream financial institutions • Long pay back periods (6-8 years at full capacity) • Push back/negative competition for market waste from waste collectors • Low promotion of both compost and liquid fertilizers • Low goodwill from county government – land allocated for BIL operations continues to shrink by the day

Socio-economic, health and environmental impact

BIL's economic gains include environmental, social, and human health benefits. BIL has created jobs to five permanently employed youths, about 50-60 temporary employees and an estimated 300 people employed indirectly. Waste is prevented from ending up in rivers and methane gas voided from ending up in the atmosphere. While no absolute figures were provided, reduction of pollution due to reduced human exposure to untreated waste and contamination of water bodies (from open dumping) can be used as a proxy for

environmental benefits. BIL's activities have had a positive impact on the county government budgets as waste collection is done free of charge and the cost saving for the county government can be re-prioritized to other social expenditures. Nevertheless, manual sorting, sieving and packaging of the compost and liquid fertilizer, may represent a source of occupational health risk if mitigation measures such as wearing of nose mask and gloves are not adhered to.

Scalability and replicability considerations

Key drivers for the success of this business case are:

- Availability of cheap and locally available waste resource – market waste.
- Farmers have observed declining soil health and decreased crop yields over time and recognize the need to adopt environmentally sustainable agricultural practice. In this regard, demand for the liquid fertilizer has been growing.
- Strong partnerships with the county government, leading universities, research institutions and non-government organizations.
- Sponsorship in terms of grants from various institutions.
- Assured high quality product sold at a competitive market price

References

- https://biogas.co.ke/
- https://www.youtube.com/watch?v=QtZl2Ie8SiY

Business case: Kenya

Dunga Beach Biogas Plant: Biogas and bio-slurry from water hyacinth

Business case at a glace

Location:	Dunga Beach Kisumu
Waste input type:	Water hyacinth, market refuse, food waste
Value offer:	Biogas, bio-slurry and compost
Organization type:	Private
Status of organization:	Operational since 2017
Scale of business:	Medium scale
Major partners:	Biogas International, Cambridge University and Astra Zeneca

Executive summary

The Dunga Beach biogas plant turns the invasive water hyacinth (*Eichhornia crassipes*) on the shores of Lake Victoria to biogas energy, an alternative to charcoal burning for fish vendors at the beach. The biogas facility is reliant on fish ofal wastes (300kgs/day), food market refuse (150 kgs/day) and water hyacinth (600 to 800 kgs/day) to meet the production demand necessary to sustain its operation. Gas produced is 1300 m^3 a month through a commercial-sized biodigester which has special capabilities and design to break down tough hyacinth weeds.

The plant offers bioenergy as a sustainable clean alternative to wood fuel that was previously common and preferable by the surrounding community. Not only is the plant producing clean efficient energy from waste, but also positively impacts conservation of the environment by extending the linear end of life for agricultural wastes produced at the market. Previously, fish vendors burned KES 600 per day worth of wood to prepare fish but with the biogas, the costs have significantly reduced to KES 50 per cubic metre per hour. Surplus gas is commercially sold to the surrounding community for both domestic and commercial use. In addition to biogas, Dunga Beach plant generates up to 500 litres of bio-slurry daily. This by-product from the biogas facility is channelled to a vegetable farm as organic fertilizer and/or sold to farmers as safe, organic and less costly alternative to chemical fertilizers.

The plant employs four full time workers including the manager of the facility to oversee the operations as well as tend to clients. During the plant's inception, fifty households were sponsored with domestic biogas digesters as part of an effort to promote the use of sustainable biofuel to reduce overreliance on wood energy and curb ailments associated with prolonged exposure to smoke. The plant through its Astra Zeneca link tracked and monitored Malaria cases in the community especially with the disruptions of water hyacinths as mosquito breeding grounds.

Key performance indicators					
Land use	0.046 ha				
Capital investment:	20,000 USD (Exchange rate 1USD = KES 120)				
Labor requirements:	4 full time employees				
O&M cost:					
Output:	1300 M3 / Monthly ; 500 litres of slurry daily				
Potential social and/or environmental impact:	Job creation, reduced malaria incidences, lowered cost of energy, saving trees and forests through firewood -biogas substitution				
Viability indicators	Payback period:	NA	Gross margin:	NA	Net profit (after tax)	NA

Context and background

Dunga Beach biogas plant is located in Kisumu which is a lakeside city endowed with massive beaches attracting tourists and spurring economic growth through trade in the region. Lake Victoria's waters is invaded with water hyacinth to unprecedented levels disrupting the economic lifelines which are tourism and fishing in the region, as well as negatively impacting the ecosystem. The Dunga Beach biogas plant was therefore conceived to address the challenge posed by the multiplying mass growth of hyacinth and partly the unmanaged wastes from the local fish market. Cambridge University and Astra Zeneca while partnering with local biogas digester manufacturer, Biogas International, set up the facility as an experiment to assess the use of hyacinth as a potential biogas feedstock, track malaria transmission in the community as a result of water hyacinth which provides a good breeding grounds for mosquitoes and mitigate the environmental degradation resulting from poor waste management in the fishing community.[1]

Market environment

Lake Victoria has for a long time grappled with the negative effects of water hyacinth, an invasive weed species endemic to the region that not only has negative impact on the local ecosystem, but also stifled economic growth for the majority fisherfolk. Dunga Beach community comprises of households, fish traders and a couple of restaurants all of which generate massive waste from the market and have had to rely mostly on wood fuel for their energy needs. With the community choking up on wastes and the population exposed to health hazards from burning smoke, production of biogas as alternative fuel from the readily available wastes and hyacinth was fronted as a sustainable and non-risky solution.

Business Model

Dunga Biogas was initially fronted as a project to assess the viability of clean energy, and health benefits associated with consumption of green energy in the community while mitigating environmental degradation. Cambridge University Centre of Development Studies conducted an assessment in Dunga with the aim of converting water hyacinth along with market refuse to sustainable source of biofuel in a community that mostly relied on burning fuel wood. This assessment opened an opportunity to further interrogate the health implications of using biogas as a primary source of energy where the risk of respiratory

[1] https://biogas.co.ke/2018/11/21/water-hyacinth-to-biogas-at-dunga-beach-lake-victoria/ accessed 29 Oct. 2022

ailments is compounded by inhalation of smoke from burning wood. For this reason, Cambridge University and Astra Zeneca funded the initial set up of a commercial biogas facility as well as donating 50 household-sized biodigesters for domestic production of biogas. The project yielded excellent result, producing clean biofuel in the form of biogas as well as bio-slurry, which is used as organic fertilizer. This means that the surrounding communities now have access to clean, efficient, cost-effective source of energy, with the risk respiratory ailments arising from inhalation of smoke greatly reduced (Figure 2).

<table>
<tr>
<td rowspan="2">Key Partners
• AstraZeneca/ Cambridge University
• Biogas International
• Kisumu County</td>
<td>Key Activities
• Collection of input
• Production of biogas and slurry
• Selling of products</td>
<td rowspan="2">Value Propositions
• Clean and low cost biogas for cooking fish
• Bioslurry for farming
• Electricity from biogas (Prospects)</td>
<td>Customer Relationships
• Direct</td>
<td rowspan="2">Customer Segments
• Fish sellers at the beach
• Surrounding households
• Farmers</td>
</tr>
<tr>
<td>Key Resources
• Commercial biogas machines
• Land
• Skilled workforce</td>
<td>Channels
• Direct</td>
</tr>
<tr>
<td colspan="2">Cost Structure
• Capital investment - financed by Cambridge University
• Operational Costs - employee wages</td>
<td colspan="3">Revenue Streams
• Biogas sales
• Organic fertilizer
• Electricity (prospect)</td>
</tr>
<tr>
<td colspan="2">Social & environmental costs
• Exposure to health risks by employees when handling contaminated wastes</td>
<td colspan="3">Social & environmental benefits
• Source of livelihood for direct and indirect employees
• Healthy communities due to reduced exposure to smoke inhaled through burning of wood
• Minimal stress on the environment through proper waste management</td>
</tr>
</table>

Figure 2: Dunga Beach biogas plant Business model canvas

Plant operations are managed by employees of Biogas International who also come across as the focal points for these businesses. Biogas produced is directly sold to fishmongers and local restaurants at the rate of 0.34 USD per m^3, whereas slurry from the biogas plant is channelled to a model organic garden or sold to farmers. Beyond production of biogas, Dunga Beach biogas plant sees a gap in electricity production from biogas as an alternative energy. The model adopted by this plant offers a sustainable solution to waste reuse because of the abundance of market refuse, as well as the readily available water hyacinth which is a key component of nature positive energy production.

Value chain and position

The biogas facility manages up to 500 kgs of fisherfolk market waste which is shredded and directly used as feedstock for the biogas digester. The county Government of Kisumu has also partnered with Biogas International, the company managing the biogas facility to also handle non-degradable waste at the county. This partnership is set to further enhance Dunga Beach plant's capacity as it will handle food refuse from other municipal markets in Kisumu town and eliminate dumpsites. Waste segregation will happen at the market with both biodegradable and non-biodegradable wastes will be aqcuired and sent to the facility at a fee (Figure 3). Food refuse is shredded and fed into the biodigester to produce approximately 1300 m^3 of gas which is sold to fish mongers and restaurants for meal preparation. The plant owner has prospects for a biogas to electricity conversion with the advent of the partnership with the local government of Kisumu.

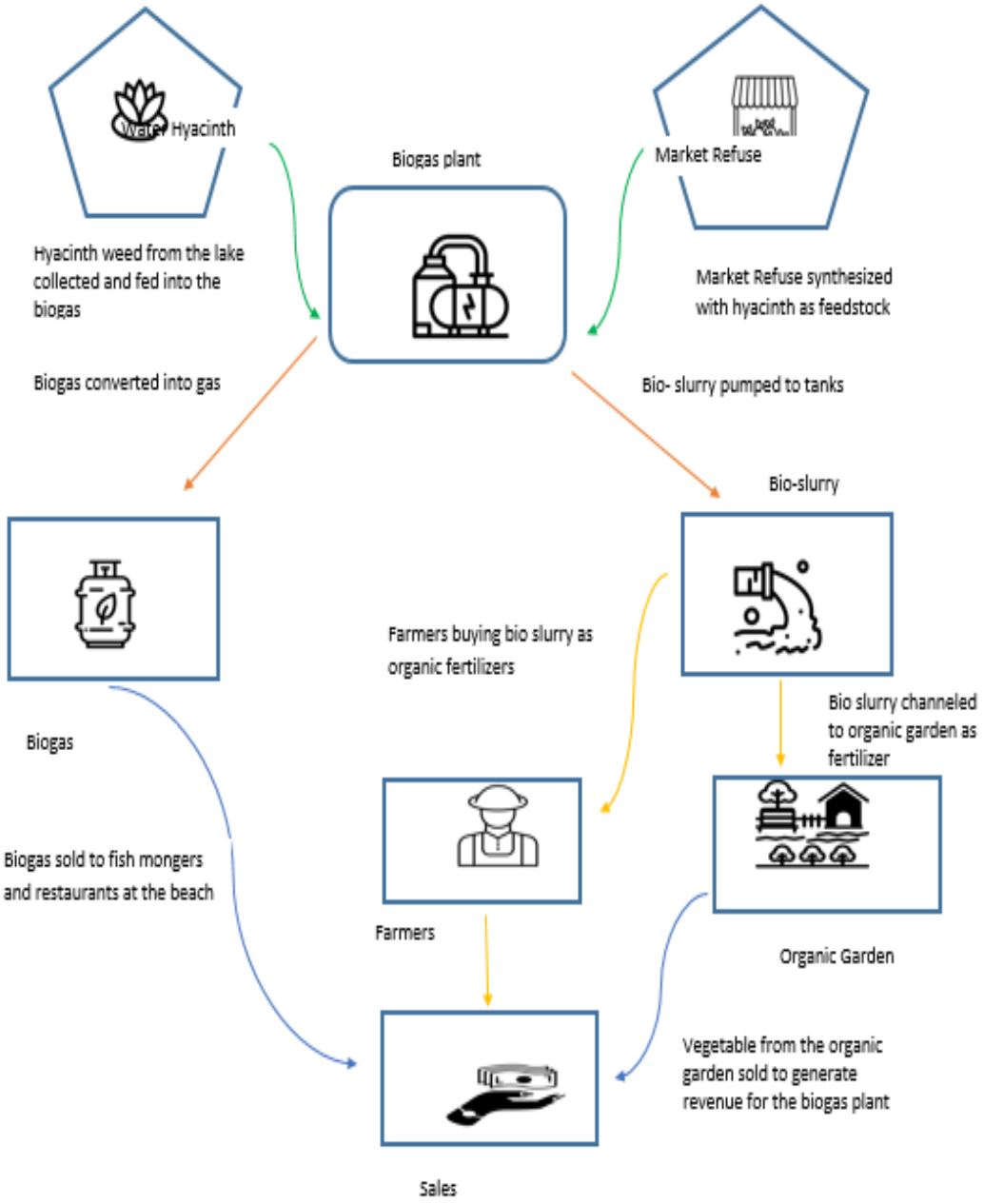


Figure 3: Dunga Beach Biogas Plant value chain

Institutional environment

Dunga Beach is classified as a Key Biodiversity Area (KBA) for the role it plays on the ecosystem. It is also formally recognized as a wetland under the Environmental Management and Coordination Act (EMCA) overseen by National Environment Management Authority

(NEMA).[2] In so far as regulations is concerned, The County Governemnt of Kisumu through its county regulatory framework has undertaken to issue necessary permits and approvals as well as undertake environmental impact measurement assessments on Dunga Biogas operations.

Technology and processes

The installed biogas plant at Dunga Beach is a modular anaerobic plant named the TREX with the capacity to produce up to 50 m^3 of biogas daily. Dunga biogas plant utilises biomass from agricultural waste and hyacinth as feedstock for the anaerobic digester (AD) (Figure 4). The biomass input is first shredded into a semi-liquid combination of wastes and added to the plant as feedstock where microbes begin the process to further break it down. The feedstock is broken down into amino acids, fatty acids and methane (CH_4) and Carbon dioxide (CO_2). The anaerobic digestion of biomass equally produces a semi-solid nutrient filled component called digestate or bio-slurry, which after extraction is used as organic fertiliser.[3]

The technology and human resource to develop the Dunga biogas plant is sourced locally with the proof of concept a success in other countries such as Uganda. Dunga biogas project has expanded its business horizons beyond gas production and now does fruit drying through controlled low emitted biogas burning. The applications for biogas in the Dunga community are are sustainable and environment friendly. Plans to install electricity generators at the facility are rife, with the intention to convert surplus biogas into electricity to be used onsite and to run other machines.

[2] https://swara.co.ke/kisumus-beautiful-dunga-swamp-burns/

[3] https://www.researchgate.net/publication/277982043_Biogas_Production_Using_Water_Hyacinth_Eicchornia_crassipes_for_Electricity_Generation_in_Kenya

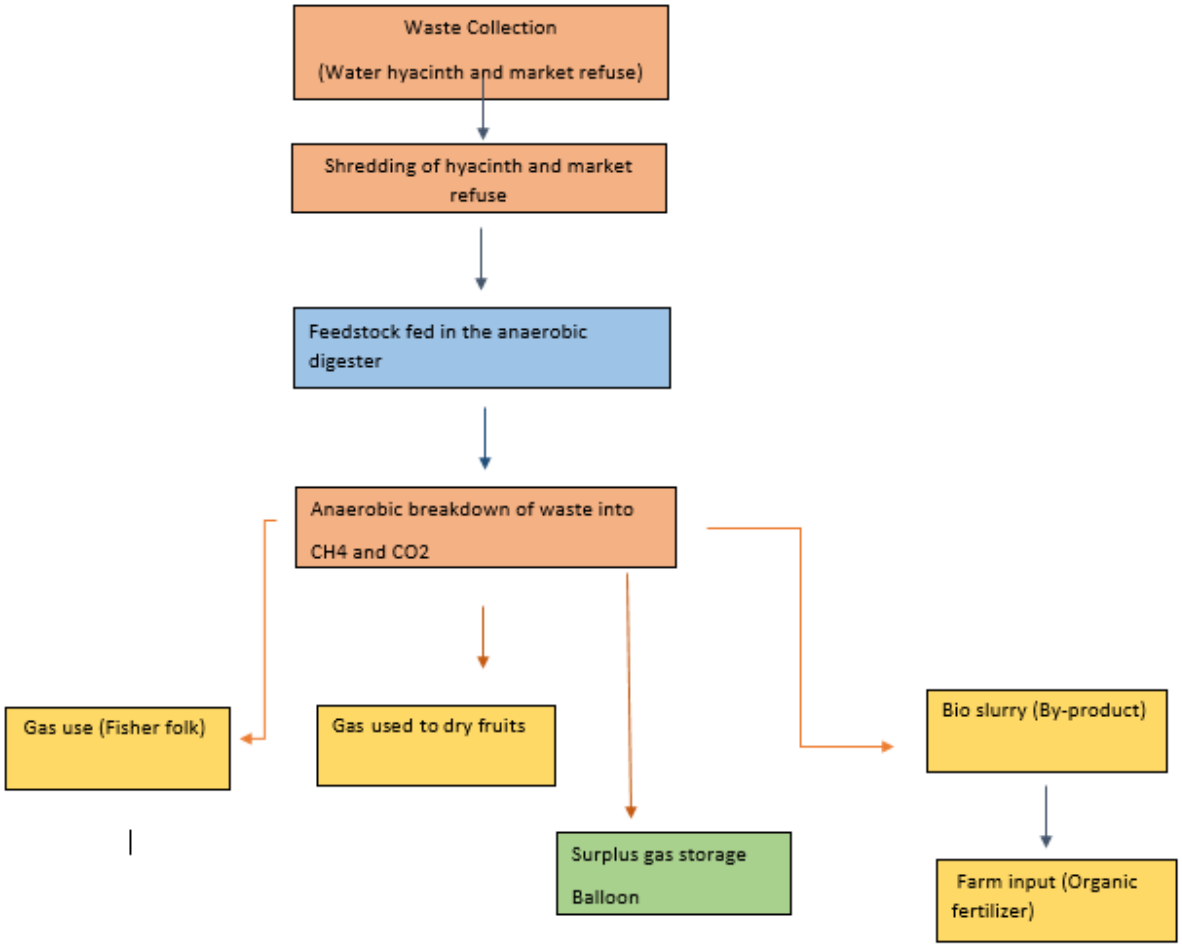


Figure 4: Process diagram of Dunga Beach Biogas Plant

Financial analysis

Funding capital for the Dunga Beach biogas plant was secured through a partnership between Astrazeneca and Biogas International with up to 24,000 USD as part seed capital. Information on the exact capital investment is unclear as it could not be provided by the plant's focal point or sourced from available secondary data. However, it is established that because of the plant's business diversification, there are two more revenue streams beyond the primary production of biogas supporting its operations.

Firstly, biogas is produced at a rate of 45m^3 daily and sold at an average cost of KES 50 per cubic metre/hour, which translates to 0.42 USD per cubic metre at the current exchange rate

(1USD= 120 KES). The firm doesn't sell all their biogas and are forced to often freely give out the gas as part of a green energy sensitization program. This significantly reduces their monthly income from biogas sales to just about 133 USD. Secondly, the bio slurry from the plant is channelled to a nearby organic vegetable vertical garden owned by the facility. The excess surplus is sold to farmers or households in the surrounding communities, generating upto 50 USD from this venture.

The last stream of income of Dunga Beach biogas is the production of dried fruits. The fruits get dried through an elaborate dehydration process that involves slow but controlled burning of biogas inside insulated booths. This venture guarantees the business up to 100 USD monthly. It is noteworthy to state that whereas the business is fronted as biogas digester facility, the main business is actually the sales of biodigesters and the Dunga Beach projects is only used as model.

Business case summary assessment -SWOT analysis

STRENGTH	WEAKNESS
• Abundance of wastes at the location • Environmentally friendly products • Local buy-in • Strong partnership	• Low biogas uptake rate • Over reliance on traditional energy such as charcoal burning • Limited opportunity for upscaling because of initial set up costs.
OPPORTUNITY	**THREAT**
• Reduction of hyacinth from the lake improves ecosystem. • Biogas use economically viable for Dunga communities. • Reduced exposure to smoke inhalation through use of clean energy	• Swelling water level may destroy the facility • Possible health hazards for employees handling waste in unsanitary conditions • Risk of feedstock and slurry spillover and contamination of the lake due to the technology used and proximity to the lake

Socio-economic, health and environmental impact

The Dunga beach biogas plant offers a number of health and environmental benefits in its locality. Decomposing market refuse which would otherwise have been disposed hazardously now find better use as raw materials for bioenergy. This means that the propensity of the population to contracting diseases from exposure to contaminated sites

has greatly reduced. Additionally, water hyacinth which poses a great deal of stress in Dunga's ecosystem is now sustainably harvested, managed and disposed providing both energy and a source of livelihood.

The fisherfolk community that relies mostly on wood energy is now tapping into clean green energy, significantly reducing the risk of respiratory ailments from inhaling smoke. The project was initiated to introduce the community to alternative clean energy and has now gone beyond that to offering employment and creating a value chain through which sustenance is earned.

Scalability and replicability potential

There exist numerous opportunities to expand the business beyond its current state and replicate it across sites with similar challenges. Currently, water hyacinth which is endemic in lake victoria has infested most beaches in Kisumu, Siaya and Homabay counties stifling economic growth and negatively impacting the ecosystem in the affected areas. Evidence from the success of market waste and water hyacinth synthesis to produce biogas at Dunga Beach can be replicated in Siaya and Homabay. Additionally, following success of the biogas plant in Dunga, Kisumu, a similar project has been launched in Ahero, Kisumu to tackle the menace that is poor disposal of market refuse and production of commercial biogas.

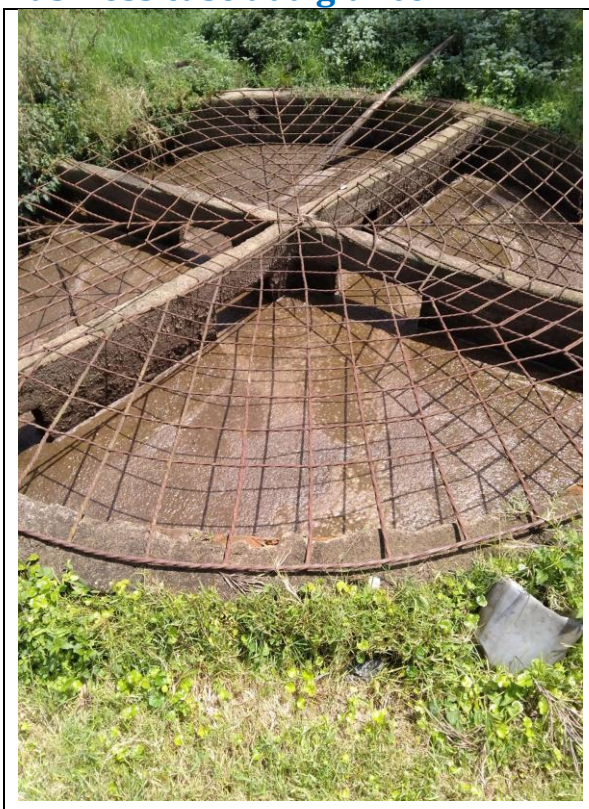
References

- Water Hyacinth "Menace" to clean energy (biogas) and rich organic fertilizer. (2018, November 21). Flexi Biogas. Retrieved October 29, 2022, from https://biogas.co.ke/2018/11/21/water-hyacinth-to-biogas-at-dunga-beach-lake-victoria/
- https://www.researchgate.net/publication/277982043_Biogas_Production_Using_Water_Hyacinth_Eicchornia_crassipes_for_Electricity_Generation_in_Kenya
- Water Hyacinth "Menace" to clean energy (biogas) and rich organic fertilizer. (2018, November 21). Flexi Biogas. Retrieved October 29, 2022, from https://biogas.co.ke/2018/11/21/water-hyacinth-to-biogas-at-dunga-beach-lake-victoria/
- Nyaga, J. (2022, January 18). *Kisumu's Beautiful Dunga Swamp Burns*. SWARA Magazine. Retrieved October 29, 2022, from https://swara.co.ke/kisumus-beautiful-dunga-swamp-burns/

Business case: Kenya

Keveye Girls High School - Livestock waste to biogas

Business case at a glance



Location:	Sabatia, Vihiga
Waste input type:	Animal waste
Value offer:	Biogas, bio fertilizer
Organization type:	Private
Status of organization:	Operational since 2015
Scale of businesses:	Medium scale
Major partners:	Vihiga County; Livestock Department

Executive summary

Keveye Girls is a boarding high school located in Mbale, Vihiga County. The school which has an estimated population of around 2500 students, rears 8 heads of cattle to cater for the school's milk demand. Wastes generated by the cattle, on average 240 Kgs daily, was initially a problem for the school as it had limited safe disposal options, posing a huge health risk to occupants of the school as well as polluting the environment. Through consultations and interventions by the Department of Agriculture and Livestock at Vihiga County, Keveye Girls now converts cow dung into biogas, which is then used to power the school's science laboratories and kitchen as an alternative to LPG gas and wood energy.

The school utilizes an excavated bio-digester facility that anaerobically breakdown animal waste, to yield methane gas (CH_4) and slurry, which is used as bio fertilizer. Keveye Girls

through this initiative, is able to sustainably meet its energy needs while generating organic fertilizer for the school's napier farm to feed its cattle. The school has plans to set up biogas refill station for commercial sales to the community as the gas is produced in surplus. Additionally, plans are rife in the school to connect teachers living within the school compound to its biogas reserves to help bring down the high cost of living.

Key performance indicators			
Land use			
Capital investment:	Estimated USD 6,250		
Labor requirements:	1 full time technician		
O&M cost:			
Output:	1000 m^3 of biogas monthly		
Potential social and/or enviornmental impact:	Improved sanitation and health of students; reduced GHG emissions; renewable energy for cooking; reduced deforestation		
Viability indicators	Payback period:	Gross margin:	Net profit (after tax)

Context and background

In 2008, the Government of Kenya introduced Free Day Secondary Education (FDSE) in the country while simultaneously subsidizing the cost of public boarding school. The government's set capitation per student at inception of the program was set at KES 10,000 (83 USD) per year but gradually reviewed upwards to KES 22,244 (185 USD) due to inflation and the rising cost of living[4]. Macroeconomic shocks such as inflation and changes in Kenya's fiscal policy meant that schools like Keveye needed to find alternative income generating activities to supplement capitation funds from Ministry of Education (MoE), and to manage the school's liabilities in the face of a ballooning school population. Using wastes from livestock, the school established a biogas unit to meet its energy demands both in the kitchen and science laboratories. The school, which is located in Sabatia town, Vihiga County is under the guidance of the Livestock Department to enhance its nature- positive biogas initiative.

Market environment

[4] https://kippra.or.ke/achieving-100-per-cent-transition-from-primary-to-secondary-school-status-challenges-and-opportunities-for-sustainability/

The market environment for this venture was largely dictated by the school's need to cut and save on energy costs. Two sets of problems presented at Keveye Girls necessitating adoption of waste to biogas conversion.

- The school rears 8 livestock to support the school's dietary needs (for apprx.2500). Cattle reared generate a lot of animal waste stressing and polluting the environment.
- High costs of energy for cooking and learning purposes.

Production of biogas stood at the nexus of both challenges facing the school, providing a safe and sustainable solution for the school by eliminating agents polluting the environment, meeting energy demands and cutting costs for the school.

Business model

This institutional biogas business model at the school provides improved sanitation service to the school by processing and treating animal waste generated at the school. The biogas plant provides biogas as cooking fuel in the school kitchens as well as providing energy to the school's laboratories (Figure 5). Furthermore, the bio fertilizer from the digestion process is used for cultivation of fodder crops which feed the school's cattle and thus creating a closed loop system.

<table>
<tr>
<td rowspan="2">Key Partners
• Livestock and Agriculture department of Vihiga
• County for providing technical guidance</td>
<td>Key Activities
• Biogas plant construction
• Conversion of animal waste to biogas and bio slurry
• Use of bio slurry for fodder production</td>
<td rowspan="2">Value Propositions
• Improved sanitation for school
• Biogas as cooking fuel and powering the school's science laboratories
• Bio fertilizer used for cultivation of fodder which feed the school's cattle</td>
<td>Customer Relationships
• Direct onsite use</td>
<td rowspan="2">Customer Segments
• School</td>
</tr>
<tr>
<td>Key Resources
• Land, digester facility
• Manpower to run operations
• Guidance and Know-how from county
• Animal waste</td>
<td>Channels
• Onsite use</td>
</tr>
<tr>
<td colspan="3">Cost Structure
• Capital investment cost (digester facility, biogas storage balloon)
• O&M costs (labor cost)
• Saving on energy cost</td>
<td colspan="2">Revenue Streams
• Cost savings on energy bills for the school
• Commercial packaging and sales of biogas (Prospects)</td>
</tr>
<tr>
<td colspan="3">Social & environmental costs
• Risk of disease spreading to waste handlers from possibly existing pathogens.
• Environment pollution from possible leakages</td>
<td colspan="2">Social & environmental benefits
• The facility has created a direct line of income for technicians working on the digester.
• Treatment of animal waste reduces the risk of pollution on the environment.
• Improved health at the school and surrounding communities through proper handling of possible contaminants.</td>
</tr>
</table>

Figure 5: Keveye Girls biogas business model canvas

Value chain and position

Keveye Girls secondary School generates up to 3 tons of animal waste monthly, enough capacity to produce about a 1000 m^3 of biogas monthly. At the time of this assessment, the biogas was solely used to facilitate cooking and learning activities, in what is seen as a major cost savings strategy for the school. The school's partnership with the Livestock and Agriculture department of Vihiga county ensures continued support in the technical areas, innovations and material support to further reinforce the initiative (Figure 6). Whereas the biogas is only beneficial to the school currently, there are proposals to compress, package and sell the low cost gas to residents in the area as an income diversification strategy for the school.

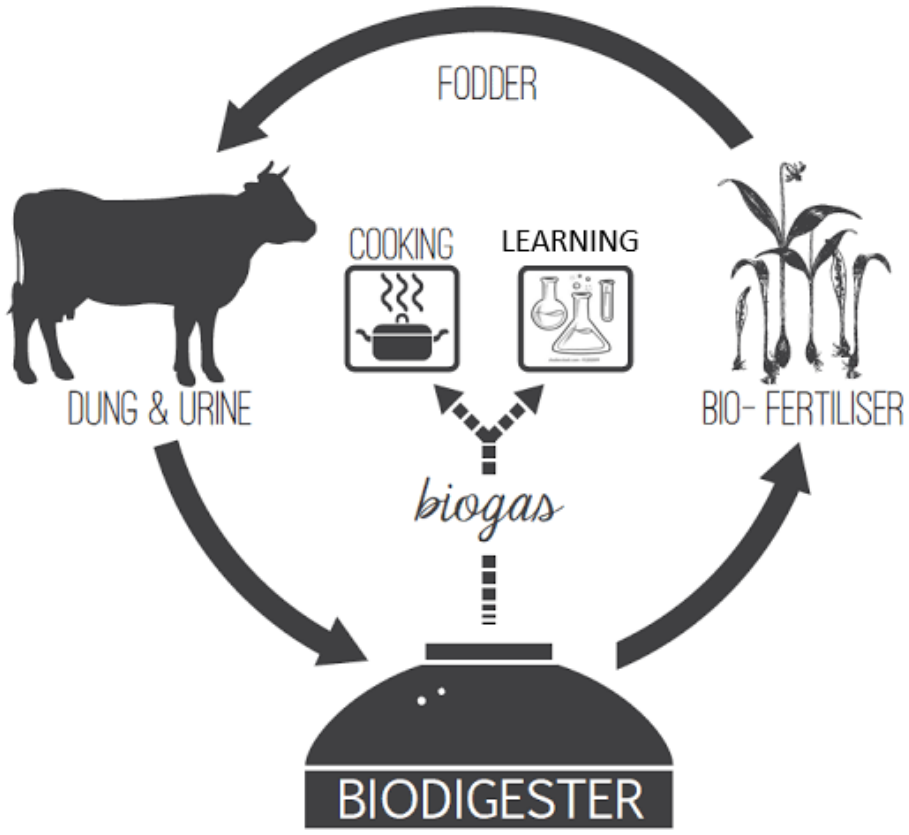


Figure 6: Keveye Girls biogas model value chain

Institutional enviroment

The Constitution of Kenya (2010) envisages a clean and healthy environment for every citizen and goes further to guarantee Kenyans' rights to legislatively work towards zero tolerant environments.[5] At the county level, the Vihiga County Environment policy of 2019 spells out challenges it faces with inadequate dumping sites, landfills and sewerage system. The policy further encourages businesses, individuals, and institutions to adopt waste recovery, recycling and reuse mechanisms to mitigate solid and liquid waste management challenges. Backed by the COK 2010 and Vihiga county relevant policies and regulations, the school's biogas generation from livestock waste is within regulatory and legal provisions. Collaborative engagements between the school and the department of Livestock and

[5] https://www.klrc.go.ke/index.php/constitution-of-kenya/112-chapter-four-the-bill-of-rights/part-2-rights-and-fundamental-freedoms/208-42-environment

Agriculture on enhancing capacity of the facility and its general health is an indication that the school is issued all necessary approvals and licenses.

Technology and processes

Keveye Girls employs the use of an underground anaerobic digestor (AD) to treat animal waste while recovering biogas. The facility comprises of an open effluent holding tank, double-membrane biogas storage balloon, the AD and an inlet feeding mechanism. Waste from the cow shed is collected twice a day, approximately 0.24 tons is collected daily translating to averagely 7.2 tons in a month. This waste is used as feedstock for the AD and is mixed in the ratio 2:1 with water to yield optimum methane (CH_4)[6]. Although the facility has two main outlets to facilitate the overflow of concomitant bio slurry, the open effluent tank allows for the physical removal of slurry by a biogas technician working at the site. An inflatable 3 m^3 storage balloon connected to the AD through a network of elaborate gas conduits stores surplus gas for the school. Further away from production, this particular system poses a possible health risk due to the openness of the effluent holding tank and the need to have the slurry physically collected from the system. The risk of existing contaminants in the slurry could be pathogenic and inimic to the system's handler. The technology used to set up the biogas facility at Keveye Girls is sourced locally and does not require advanced technical expertise to operate (Figure 7).

[6] https://www.sciencedirect.com/science/article/pii/B9780123847317000738

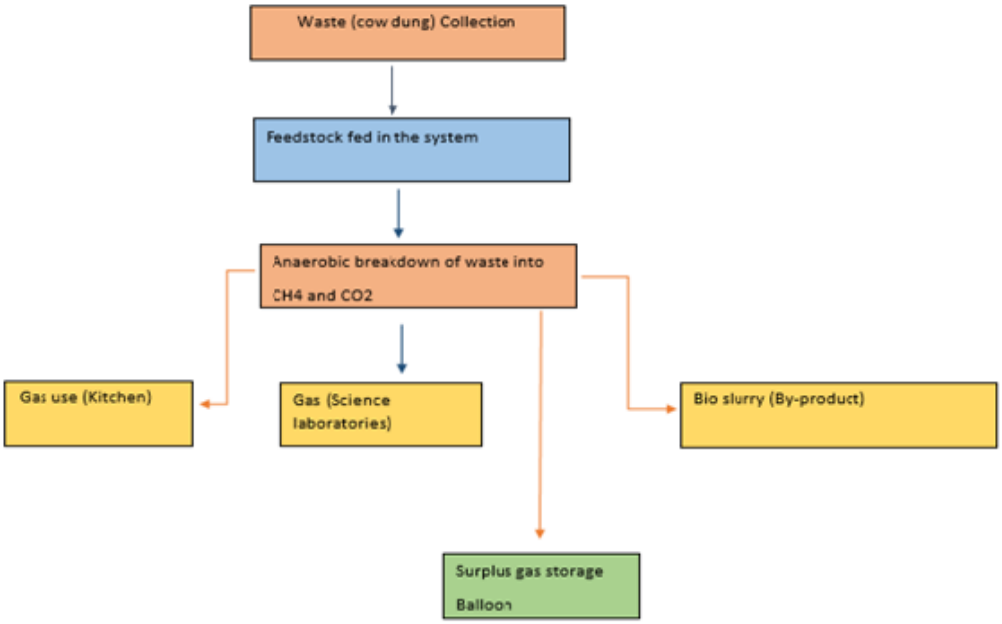


Figure 7: Process diagram for Keveye Girls biogas

Financial analysis

Keveye Girls biogas initiative was funded by the school's administration. The school did not provide initial capital investment costs of the facility, however, it is estimated at 6250 USD. Given that the school has proprietary rights to the system, O&M costs are absorbed by the school's administration, hence it is difficult to classify associated O&M costs appropriately. In terms of cost recovery, the school is able to save a gross of KES 50,000 monthly, equivalent to 416 USD from biogas use in its science laboratories and kitchen areas. Compounded to annual savings, the school recovers 5,000 USD gross savings from the biogas setup annually. Given that the facility is said to have been installed four years ago and its gross savings amounting to 5,000 USD, it can then be assumed that the payback period for the investment was achieved one year three months after it became operational.

Business case summary assessment -SWOT analysis

STRENGTH	WEAKNESS
• Continuous supply of animal waste • Strong partnership with county • Low O&M cost • Mandate allows replication	• No disinfection • No market for organic slurry • Over reliance on animal waste only
OPPORTUNITY	**THREAT**
• High cost of energy offers opportunity to commercialize end product • Positive image through environmental impact • Out-scaling & up-scaling combination opportunity in institutions with abundance of animal waste	• Possible human health risk due to handling of waste • Risk of gas leak • Open slurry pit could be an occupational hazard

Socio-economic, health and environmental impact

Setting up of the biogas system at Keveye Girls has positively impacted the socio-economic, health and environmental outlook of the school. Existence and operationalization of the biogas facility guarantees the school to save on energy costs. The plant has also mitigated the effect of livestock wastes pollution on the environment. This means that the school at large is safe from sanitary diseases, which would otherwise thrive as a result of poor disposal options. Although the greater risk of contamination is reduced, the system which is open and relies on human labour to be operational is an occupational hazard to the biogas technician.

Scalability and replicability potential

Opportunities for scalability and replicability of Keveye's biogas model are dependent on;

- Technical support from relevant administrative bodies i.e county, national key ministries and departments.
- High energy costs (LPG and wood) for school use
- School administration's need to diversify income portfolio

Data from the Ministry of Education in Kenya indicates that the country has more than 4000 public secondary boarding schools, most of which are grappling with financial challenges.[7] MOE, since adoption of the 2018 capitation standards for all registered students in public schools now encourages schools to venture out into income generation via special projects. Biogas generation by Keveye offers a blueprint that schools can adopt. Materials and technical expertise to set up and maintain the system exist locally and therefore schools and similar institutions plagued with the challenge of solid waste disposal can explore biogas possibilities. More schools and institutions could adopt this technology with the help of government programmes and a robust framework of waste management supported by both the national government and local government.

[7] https://www.standardmedia.co.ke/article/2001241457/boarding-schools-to-be-audited-and-why-many-may-be-closed

Business case: Burkina Faso

FasoBiogaz: Power and bio fertilizer from agri-food-resides, manure and slaughterhouse waste

Business case at a glance

Location:	Ouagadougou
Waste input type:	Animal manure, paunch, biomass agriculture waste, water hyacinth, yeast
Value offer:	Power and biofertilizer (Solid and liquid)
Organization type:	Private
Status of organization:	Operational since 2015
Scale of businesses:	Medium
Major partners:	Nijhuis, ECREEE, SONABEL, BRAKINA, SOGEAO, PFAN, Thecogas Senegal, Ministry of Environment, Energy, Water and Sanitation, The company house; Ministry of Mines and Energy, Embasy of Denmark, Netherlands Enterprise Agency

Executive Summary

FasoBiogaz, an SME was founded by two Dutch entrepreneurs and supported by the Dutch government and is fully operated by a local team. FasoBiogaz operates the first industrial biogas plant connected to the SONABEL power grid and provides innovative resource recovery solutions. FasoBiogaz is located in the industrial zone of Kossodo in Ouagadougou between the municipal slaughterhouse and the country's leading brewery. Using methanization technology, FasoBiogaz uses waste streams from these companies and other

agro-food companies and water hyacinth to generate biogas (CH_4) and valuable organic fertilizer. The biogas is repurposed into electricity and injected into the national power grid, and the digestate is commercialized as a biofertilizer. The first plant, with an installed electrical power capacity of 275 kW, was completed in 2015. Production capaciy was subsequently increased to 550 KW in 2016. FasoBiogaz provides low-cost, clean and reliable electricity to the country which has one of the lowest electrification rates in West Africa. Operating revenues are generated through the sale of electricity and digestate as bio fertilizer. With its expanssion over the years, FasoBiogaz ensures a constant supply, in quality and quantity, and provides twenty permanent jobs.

Key Performance Indicators						
Land Use	0.84 ha					
Capital investment:	USD 1,484,415 (for 550 kW)					
Labor requirements:	20 full-time workers and 2 part-time workers					
O&M cost:	NA					
Output:	1.3 GWh of power and 80% of the input as bio fertilizer					
Potential social and/or environmental impact:	22 jobs, carbon mitigation by reducing GHG emissions, reducing fossil fuel dependence, expanding access to electricity for rural areas					
Viability indicators	Payback period:	5 to 7 years	Gross margin:	NA	Net profit (after tax)	NA

Context and background

Ouagadougou faces challenges such as water and air pollution and associated risks such as flooding and water scarcity due to inadequate waste management. In addition, rapid urbanization leads to an increase in the demand for energy and a decrease in soil fertility. Furthermore, the water bodies of the city are invaded by water hyacinths, leading to shortages of drinking water supplies. To help manage waste, reduce electricity outages, and recover degraded soils, Dutch entrepreneurs created FasoBiogaz and started operating in 2015. In 2016, FasoBiogaz generated additional revenue streams from electricity generation through an increase in the company's production capacity to 550 kW.

Market environment

Burkina Faso's demand for electricity exceeds supply despite imports. With projected electricity demand set to grow, the government is encouraging green power initiatives such

as biogas units. The FasoBiogaz solution is particularly relevant in the context of population growth, electricity supply shortages and agricultural soil depletion.

Business Model

FasoBiogaz offers two value propositions. The company provides green and low-cost electricity to SONABEL and high-quality bio fertilizer to farmers (Figure 8). It also provides pretreated industrial wastewater to ONEA, the National Office of Water and Sanitation, which has a wastewater treatment plant located in the industrial zone, in Kossodo.

<table>
<tr>
<td rowspan="2">Key Partners
• NIJHUIS
• ECREEE
• BRAKINA
• Ministry of Environment, Energy, Water and Sanitation,
• Ministry of Mines and Energy
• Embasy of Denmark
• Netherlands, Enterprise Agency</td>
<td>Key Activities
• Contact with input suppliers
• operate cogeneration plant
• Production and sales of power and bio-fertilizer
• Wastewater pretreatment</td>
<td rowspan="2">Value Propositions
• Low cost, environmentally friendly and green energy-based electricity
• Organic fertilizer
• Pretreated wastewater</td>
<td>Customer Relationships
• Short-term contract with National Electricity Company (SONABEL)</td>
<td rowspan="2">Customer Segments
• National Electricity Company (SONABEL)
• Farmers
• ONEA</td>
</tr>
<tr>
<td>Key Resources
• Technical and operational competencies
• Partnerships
• Equipment</td>
<td>Channels
• Direct with distributors and export companies
• Directly through own shop</td>
</tr>
<tr>
<td colspan="3">Cost Structure
• Investment cost - Land, infrastructures, and machinery
• Environmental Impact Assessment Cost
• Operational cost - Transportation, labor, utilities, maintenance, marketing, and packaging cost</td>
<td colspan="2">Revenue Streams
• Sale of electricity (major revenue stream)
• Sale of bio fertilizers (minor revenue stream)</td>
</tr>
<tr>
<td colspan="3">Social & environmental costs
• Possible human health hazards from direct contact with pathogens that may still exist in organic fertilizer
• Possible human health hazards or human loss from direct contact to high tension
• Environmental risks of biogas leakage</td>
<td colspan="2">Social & environmental benefits
• Provides employment
• Reduces deforestation
• Reduce GHG emissions
• Increase agricultural production</td>
</tr>
</table>

Figure 8: Business model canvas for FASOBIOGAZ

Value chain and position

FasoBiogaz is a flagship project for Burkina Faso in the recycling and repurposing of solid organic waste and agricultural residues into clean and green electricity and bio fertilizers on a large scale. The company benefits from favorable operational conditions because it is located in the industrial area and has an agreement with industries for the input waste

supply. FasoBiogaz also benefits from the abundance of water hyacinths and low-cost transportation. Large-scale biogas technology remains unique in the city. To strengthen the sector, reduce operating costs, and avoid dependence on international experts, in-depth professional and customized training have been organized. The electrical autonomy of farms is also an important development axis for the future. The value chain is explained in Figure 9.

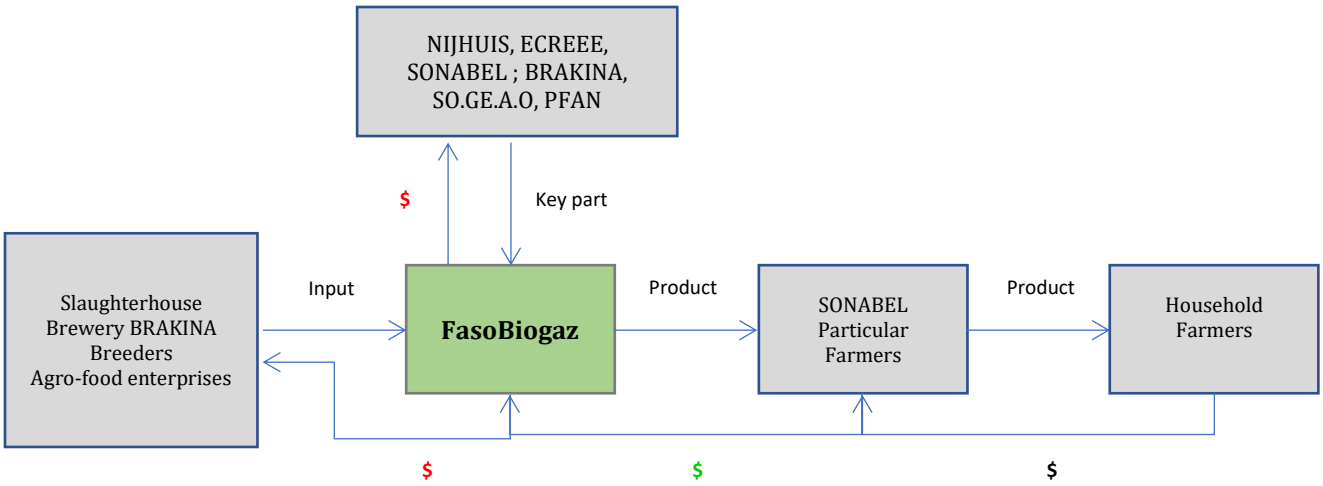


Figure 9: FASOBIOGAZ value chain

Institutional Environment

The main policy objective of the Burkina Faso government for biogas production is that an environmental and social impact study must be carried out beforehand and a plan of how compliance can be achieved. However, taxes remain relatively high for the importation of equipment.

Technology and processes

Figure 3 shows the FasoBiogaz power generation system. It uses two digesters with a volume of 2,500 m^3 each with a crusher to grind the waste. The receiving pond is an underground concrete structure, leveled at the bottom with an open top. The structure is equipped with four stainless steel heating coils and a sieve on top to remove impurities. Inside the pond, a mixing pump is installed and is also used to transport the substrate to the digester. The lagoon digester has a concrete enclosure and a double membrane roof. The 2,500 m^3 structure is equipped with two inclined submersible mixers, an underfloor heating system, as well as an over and under pressure device. The double membrane is further stabilized by

a compressor. Biogas is transformed into electricity and heat by a cogeneration unit. After fermentation in the lagoon digester, the digestate is sent to the mechanical screw solid-liquid separator. As liquid digestate storage is more complex, a storage tank is placed next to the separator. The electricity produced is injected into the electricity grid through a 15 kV substation located on the site. In the event of an increase in installed capacity (above 550 kW), the electricity is routed to the nearest SONABEL power station. The technology and process flow is shown in Figure 10.

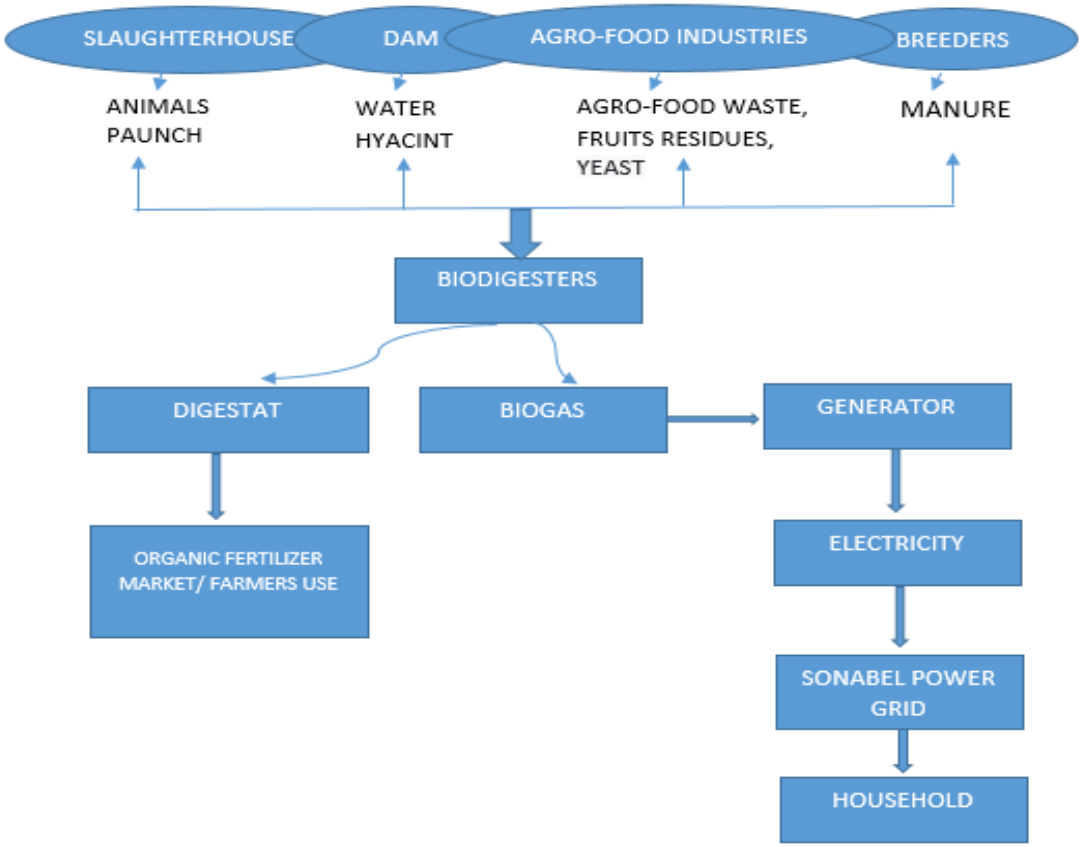


Figure 10: process diagram of FASOBIOGAZ power project

Financial analysis

The initial investment of the FasoBiogaz plant with an installed capacity of 500 kW amounts to 1,500,000 Euros. The plant injects between 4,200 and 4,300 kWh daily into the SONABEL grid. With the planned extension, the income generated by electricity production could be doubled. Strong demand for solid fertilizers can be observed, higher than current supply. In order to meet the demand for bio fertilizers, the biogas plant must ensure a constant supply.

Business case summary assessment -SWOT analysis

STRENGTH	WEAKNESS
• Good relationship with actors along the value chain • Geographical location of the company • Able to process waste to meet environmental regulations • Use of abundant waste source to generate green power • Direct connection to SONABEL • Limited/low operational and maintenance requirements	• High-cost technology equipment • Lack of local technical and institutional capacity and finance to improve technology • Requirement of import of technology and equipment • High taxes for equipment importation
OPPORTUNITY	**THREAT**
• Low energy supply in the country • Electricity shortages and frequent power blackouts • Environmental stress reduction offers image and Carbon credit market opportunities • Positive environmental impact	• Possible risk from leakage of gas may force O&M costs higher • Political instability in Burkina Faso • The slaughterhouse units can install their own biogas plant

Socioeconomic, health and environmental impact

The current plant provides 22 jobs and supplies more than 22,000 households with electricity. Biogas systems reduce the waste disposal problem that confronts the city and local industries and provide the city with green, reliable, and affordable energy. The supply of bio-financiers for agriculture reduces numerous consumer health issues caused by chemical fertilizers. The environmental benefits of the project are: i) reduction of greenhouse gas (GHG) emissions (including methane); ii) mitigation of various pollutions, such as air/atmospheric pollution, iii) reduction of soil or groundwater pollution and surface water degradation due to water hyacinth proliferation, and iv) production of renewable energy.

Scalability and replicability potential

The key drivers for the success of this business are the partnerships, localization, and the technology transfer from the Netherlands. A large amount of organic waste available in Ouagadougou allows this project to be extended and/or repeated. Competition is almost nonexistent, and demand remains greater than the actual supply, but investment costs for large biogas plants are relatively high and require subsidies. Ideally, projects should be

implemented in partnership with the state or communities to obtain land taking into consideration the geographical situation of the new scaling site, and thus reduce expenses.

Reference

- https://ppp.worldbank.org/public-private-partnership/library/fasobiogaz
  Updated: November 1, 2022
- https://www.fmo.nl/project-detail/57997
- Développement durable : Le Burkina dispose désormais d'une centrale électrique à biogaz – Burkina24.com – L'Actualité du Burkina Faso 24h/24
- http://www.ecreee.org/sites/default/files/documents/projects/documentation_fasobiogaz_en.pdf
- https://www.agenceecofin.com/biomasse/0111-33541-burkina-faso-le-prive-fasobiogaz-exploite-la-premiere-centrale-a-biogaz

Case descriptions are based on primary and secondary data provided by case operators, insiders, or other stakeholders, and reflect our best knowledge at the time of the assessments Dec 2022. As business operations are dynamic, data can be subject to change