CASE

Power from slaughterhouse waste (Nyongara Slaughter House, Dagorretti, Kenya)

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Supporting case for Business Model 8	
Location:	Dagorretti, Kenya
Waste input type:	Slaughterhouse waste (solid and liquid) form
Value offer:	Biogas, power and bio-fertilizer
Organization type:	Private
Status of organization:	Operational since 2011
Scale of businesses:	Small
Major partners:	United Nations Industrial Development Organization (UNIDO), Kenya Industrial Research and Development Institute (KIRIDI) and United Nations Environment Programme (UNEP)

Executive summary

The Nyongara Slaughter House is located in Dagorretti on the outskirts of Nairobi. Dagorretti is an area famous with the presence of slaughterhouses that supply meat to different regions in Nairobi and its environs. The waste generated by the slaughterhouse was polluting Nairobi River and the National Environmental Management Authority (NEMA), an environment regulatory body, was closing slaughter-house units that were not meeting the regulatory norms of treating their waste. This catalysed partnership between Nyongara Slaughter House and UNEP, UNIDO and KIRIDI through the Ministry of Environment to develop and demonstrate a solution to not only treat the waste to produce biogas but also provide monetary benefits to the slaughterhouse units. The biogas operations began in 2011 with biogas used for heating and to generate electricity primarily for refrigeration and lighting purpose. The slurry output from the plant is high in nutrients and is used in cultivation of tomatoes within the slaughterhouse. Based on the success of Nyongara biogas plant, the proprietor of Nyongara Slaughter House wants to set up a business of treating waste from other slaughterhouse units in Dagorretti, Kenya to generate biogas and sell the electricity to slaughterhouse units.

KEY PERFORMANCE INDICATORS (AS OF 2012)						
Water requirement:	4,000 L/day wastewater input from the slaughterhouse					
Capital investment:	USD 35,000 to 60,000					
Labor:	1 full-time for composting; 2 part-time for biogas plant operations					
O&M cost:	NA					
Output:	25 cubic meter per day of biogas generating 10 kVA electricity and bio- fertilizer					
Potential social and/or environmental impact:	1 full-time and 2 part-time jobs, a cleaner environment through reduced water pollution and CO_2 emissions, reduction of GHG emissions					
Financial viability indicators	Payback period:	3–5 years	Post-tax IRR:	N.A.	Gross margin:	N.A.

Context and background

Dagorretti is a suburb of Nairobi well known for its slaughterhouses, employing over 5,000 people, which were almost shut down in 2009 due to untreated slaughterhouse waste polluting the Nairobi River. The surroundings were stinking, emitting large quantities of methane, and the blood and wash water were seeping into the groundwater. Unreliable grid electricity forced the slaughterhouses to depend on diesel generators, increasing their high-energy bill, accounting for up to 40% of their total cost of production.

Based on the request of the Ministry of Environment, Government of Kenya and as a part of cleaning of the Nairobi River Initiative, UNEP requested UNIDO to develop solutions to manage slaughter-house waste. At the same time, the proprietor of Nyongara Slaughter House was looking out for a solution to manage its waste and comply with NEMA regulations. This led to the collaboration between Nyongara Slaughter House, UNIDO, UNEP, KIRDI under a public-private partnership for this pilot project.

A 15-kW biogas plant was installed at the Nyongara slaughterhouse, with a high-performance temperature-controlled digester (using solar heating), replacing the diesel generator and recovering waste heat to replace wood and charcoal for hot water to clean the slaughterhouse. The generated electricity is consumed for lighting and powering water pumps and compressors for cold storage and processing of hides and skins while mitigating the pollution of Nairobi River. At the time of the interview, the proprietor of Nyongara Slaughter House was planning to initiate conversation with the owners of other slaughter-house units to process their waste and sell electricity to those units and neighbouring households and enterprises.

Market environment

At the time of the assessment, Nyongara biogas plant processed about 300 kg of solid waste per day and generated electricity for four hours in a day. Dagorretti recorded more than 15 slaughter-house units, and on an average, each unit produces about four tons of solid waste and 4,000 L of wastewater per day. Based on the total quantity of waste (60 tons of solid waste + 60,000 L of wastewater) generated from all the slaughter-house units in Dagoretti, it has the potential to meet the electricity demand of all the units and generate surplus electricity. A typical slaughterhouse requires electricity for refrigerating units, water pumping, heating, slaughtering appliances, office equipment and lighting. At the time of the interview, majority of the slaughter-house units were shut down by NEMA, and these slaughter-house units were looking at Nyongara to provide them with a solution

to meet the environment regulations and reopen their business. Key competitor for Nyongara biogas plant is from a local electricity authority in Dagoretti. However, the electricity authority is struggling to meet public and private demand. Dagoretti area suffers from severe electricity shortage and majority of the slaughterhouses invest in diesel generators from backup power supply.

Macro-economic environment

Only 25% of the population in Kenya has access to electricity with less than 5% in rural areas. Installed capacity in 2011 was only 1,590 MW, which is very low for a country of 40 million people (40 W per capita – South Africa's figures are roughly 40,000 MW for 50 million people or 800 W per capita). The main problems in the sector are that existing capacity is barely able to meet demand, especially when hydrological conditions dip. There are independent power producers (IPPs) providing around 27% of the generated energy. Small-scale renewables contribute about 3% of installed capacity and is expected to grow to 6% by 2018.

Kenya's Vision 2030 ambition is to be a middle-income country in 18 years' time. This will require system capacity to grow to 15,000 MW by 2030. Rapid growth in capacity is required both to underpin the GDP growth targets and to allow universal access to electricity to be achieved. However, the present situation remains dogged by problems. Severe power shortage and electricity blackouts are putting pressure on the economic growth. While government plans to significantly add new generation capacity, initiatives such as the biogas plant at Nyongara Slaughter House, is a drop in the ocean that is still an urgent need not just from electricity access but also from environment perspective.

Business model

The Nyongara biogas plant exhibits three value propositions (Figure 92): treating waste from slaughter-house units to enable them to meet environmental regulations, generating electricity from the waste and producing bio-fertilizer. The electricity generated is consumed by the unit and surplus is sold to adjacent slaughter-house units and neighbouring households. The outlet slurry from the biogas plant is rich in nutrients and has the potential to be sold as bio-fertilizer.

Value chain and position

Nyongara biogas plant accepts 300 kg of waste per day, generating 9 kWh of electricity at the Nyongara Slaughter House. However, the proprietor plans to treat waste from other slaughter-house units to generate and provide electricity and thermal energy (Hot water for cleaning). The value chain analysis (Figure 93) is based on future plans. The value chain consists of procuring waste from other slaughter-house units and supplying electricity to slaughter-house units and neighbouring households and enterprise. The project will reduce dumping of slaughterhouse waste, and hence lower methane emissions to the atmosphere.

Since other slaughter-house units are looking for a solution to treat their respective waste, the supplier power is low. The slaughter-house units have existing investments in diesel generator, so unless the Nyongara biogas plant can provide electricity at lower costs, buyer power is prominent. In addition, the enterprise has threat from new entrants. The enterprise has potential to add another revenue source through production and sales of nutrient-rich bio-fertilizer from the slurry output of the biogas plant. The slurry is in the meantime used to irrigate the compound, thus providing the hundreds of workers with a cleaner and greener working environment.

FIGURE 92. NYONGARA BIOGAS PLANT BUSINESS MODEL CANVAS

KEY PARTNERS

- UNIDO, UNEP, KIRDI for providing know-how

KEY ACTIVITIES

- Procuring and treating waste from slaughterhouses
- Biogas to electricity conversion
- Organic fertilizer production from biogas outlet slurry
- Sales

KEY RESOURCES

- Financial resources
- Land, building, equipment, labor
- Agreement with slaughterhouse units
- Slaughter-house waste

VALUE PROPOSITIONS

- Treating waste produced by slaughter-house units to enable them to meet local environmental regulations
- Electricity for slaughterhouse operations and cooking for household
- Organic fertilizer for crop cultivation (potential)

CUSTOMER RELATIONSHIPS

- Direct

CHANNELS

- Direct sales

CUSTOMER SEGMENTS

- Slaughter-house units
- Slaughter-house units, neighbouring households and enterprise for energy service
- Farmers

COST STRUCTURE

- Investment cost (land, building, briquetting machines)
- Operational cost (labor, maintenance cost)
- Energy savings

REVENUE STREAMS

- Sale of electricity
- Sale of organic fertilizer

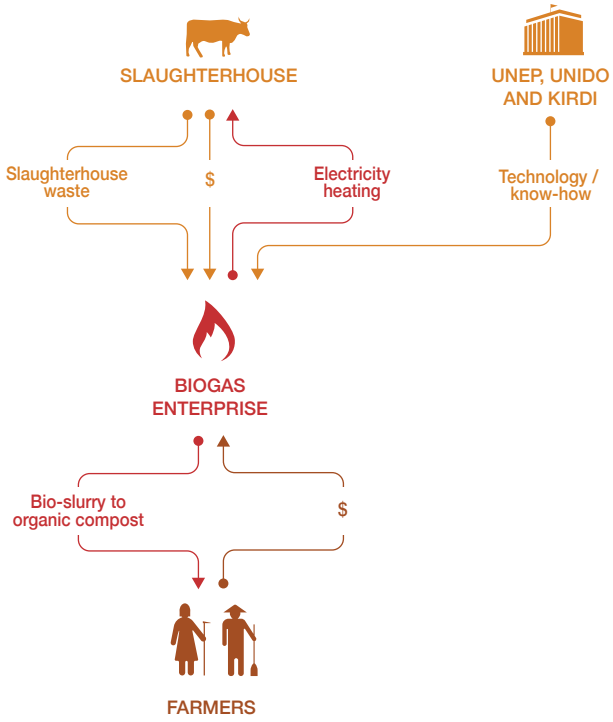
SOCIAL & ENVIRONMENTAL COSTS

- Possible human health hazard from direct contact to pathogens that may still exist from the organic fertilizer
- Laborers' health risk due to contact with slaughterhouse waste
- Environmental risks from biogas leakage to the atmosphere

SOCIAL & ENVIRONMENTAL BENEFITS

- Waste from slaughterhouses treated reduces pollution of Nairobi River
- Reduction of human health problems (and related costs) in the locality due to reduction of pollution of water bodies
- Creation of jobs

FIGURE 93. NYONGARA BIOGAS PLANT VALUE CHAIN



Institutional environment

The project was developed to address NEMA, a national environmental agency regulation that mandates appropriate treating of the waste generated by slaughterhouses. The project plans an expansion phase to treat waste from other slaughter-house units, and it has buy-in from the Ministry of Energy and Petroleum (MEP), thus showing an acceptance from the government for such operations. The 2006 Energy Act sets up the Energy Regulatory Commission (ERC), an independent regulator meant to formulate licensing procedures, issue permits, make recommendations for further energy regulations, set and adjust tariffs, approve power purchase agreements (PPAs) and prepare national energy plans.

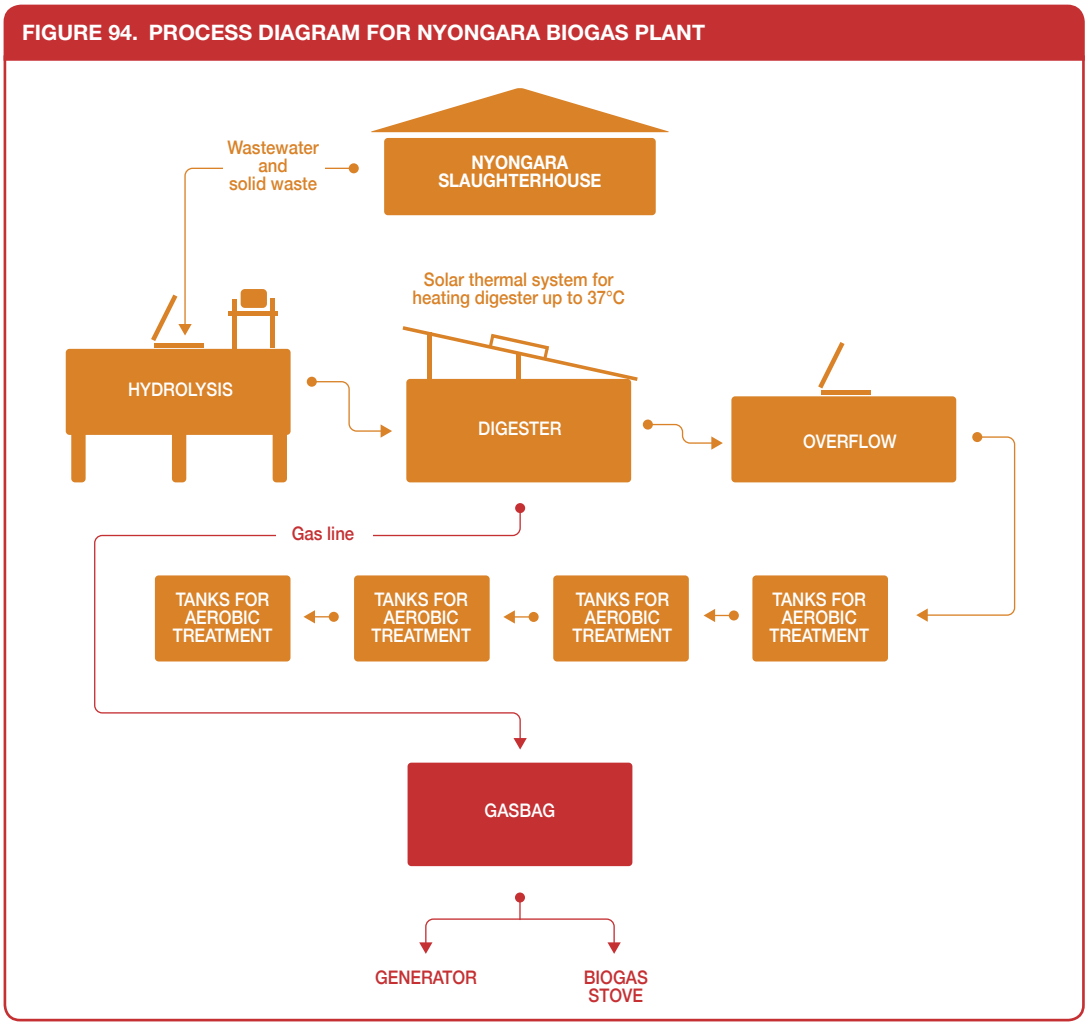
The Energy Act entrusts the MEP to elaborate sustainable renewable energy production, distribution and commercialization frameworks with emphasis on the expansion of local manufacturing sectors and provide specific incentives to existing renewable markets such as bio-digesters, solar systems and hydro-turbines. Renewable energy frameworks will also encourage biomass co-generation – heat and power – and alternative fuel production from sugar mills. The MEP shall also improve levels of international cooperation in the field of technology transfer and financial support. The broad objective of the directorate of renewable energy, one of the four technical directorates of the MEP, is to promote the development and use of renewable energy technologies. Renewable energy support tools included in the Energy Act are income tax holidays for relevant generation and transmission projects; full custom and import duties exemption for exclusive renewable energy equipment. In May 2008, a feed-in tariffs policy on wind, biomass and small hydro-resource-generated electricity was implemented by the MEP.

The feed-in tariff for biomass derived electricity up to 40 MW is USD 0.07 for firm power and USD 0.045 for non-firm power per kWh at interconnection point.

Technology and processes

UNIDO identified, based on the previous implementations at the Bungoma municipal slaughterhouse and the Homa Bay municipal slaughterhouse, the high-performance temperature-controlled (HPTC) biogas digester model marketed by Rottaler as most suitable to process the waste from slaughterhouse (Figure 94). Wastewater and solid waste from Nyongara Slaughter House is transferred daily to the hydrolysis tanks of the biogas plant where complex carbon chains (carbohydrates, proteins and fats) in the organic materials are decomposed into lower organic compounds (amino acid, sugar and fatty acids), which is the main substrate for the methane producing bacteria. These lower compounds are then released into the digester. The digester is an anaerobic (airtight) system in which the methanogens have the best living conditions (37°C) to produce methane out of organic material. Biogas produced in the digester is collected in a balloon (gas holder) from which it is fed either into the generator for

FIGURE 94. PROCESS DIAGRAM FOR NYONGARA BIOGAS PLANT



Source: http://www.kirdi.go.ke

electricity or into the gas compressor to send pressurized gas to the burners. Along with newly-installed solar panels, enough biogas-electricity is being generated to power the slaughterhouse including its cold-storage facilities. The biogas yield of a plant depends not only on the type of feedstock, but also on the plant design, fermentation temperature and retention time. One cubic meter of biogas can be converted only to around 1.7 kWh.

The output slurry from the digester can be further sterilized after the aerobic treatment and used for surface irrigation. Through adding oxygen into the system the BOD and the bacteria can be reduced to an amount which is not effecting the environment and groundwater. Generator operated with 100% biogas supplies the slaughterhouse as well as biogas plant with electricity. Whereas using the gas for direct combustion in household stoves or gas lamps is common, producing electricity from biogas is still relatively rare in most developing countries.

Funding and financial outlook

The capital cost for the Nyongara biogas plant was financed by UNDP, UNIDO, KIRDI and the proprietor of the slaughterhouse. Information on the total investment cost was not provided by the entity. However, it was estimated to be about USD 40,000. Based on limited data provided by the enterprise and from the literature, approximate savings from biogas was calculated. The opportunity cost of using biogas instead of electricity was taken into consideration. In Kenya, 1 kWh of electricity is priced at approximately 16 Kshs (0.2 USD, at an exchange rate of 1 USD = 80 Kshs). Therefore, the 72.6 kWh electricity generated from the biogas will result in daily cost savings of 1,161 Kshs (15 USD) and 34,848 Kshs (436 USD) per month or 5,227 USD per year, with payback period of less than eight years. If the value of heat energy used and revenue by sale of bio-fertilizer is added, the payback period is expected to be in the range of 4–5 years.

Socio-economic, health and environmental impact

The wastes arising from blood and ingesta combined with the large volume of water used to wash off these wastes constituted the greatest proportion of environmental hazards associated with day-to-day slaughterhouse activities. Slaughterhouse wastes pose a serious threat to the environment and the general population at large because of poor waste-management practices which results into adverse impacts on water, land and air (water being the most affected). The adjacent land of most slaughterhouses is often marshy due to improper drainage of wastewater arising from washings in the slaughterhouses. Land pollution occurs when solid wastes such as hides, hooves, horns and ingesta/dung are left unattended on open land. When the rain falls, these wastes are washed into nearby sewerage channels or streams. The project was initiated to assist slaughter-house units to meet the environmental regulations, and thus reduce pollution of Nairobi River. NEMA had closed down all the slaughter-house units in Dagorretti for flaunting environmental regulations. The biogas plant now provides solutions for the closed down units to treat their waste and meet NEMA's requirements.

The economic benefits include reducing the cost of energy from USD 0.20 to USD 0.09 per kW. The biogas produced is used for electricity generation of about 30 KW resulting in reduction in GHG emissions and improving the energy security for the region. The project has cut CO_2 emissions by 108 tons per year. This will not only help to stop deforestation as people look to cleaner, greener sources of fuel but will also assist the country to cut GHG gases and hence their devastating effects.

The biogas plant provides employment in operation and maintenance. Reopening of these closed units will result in restoration of lost jobs. Additionally, if the enterprise gets into production of organic fertilizer from the slurry output, it provides additional benefits to the environment by improving soil quality and carbon offset in comparison to chemical fertilizers.

Scalability and replicability considerations

The key drivers for the success of this business are:

- Strict implementation of environmental regulations from NEMA and closure of slaughter-house units.
- Technology transfer from Germany by UNIDO and financial assistance from UNEP and KIRDI.
- Electricity shortage in Kenya.
- Government promotes renewable energy.

The project could be a blueprint for slaughterhouses across the continent and an important example of how to reduce water pollution from industrial sector. As mentioned earlier, the proprietor of Nyongara biogas plant is planning to scale up the biogas plant and its operations to process waste from all the slaughter-house units. The initial pilot unit is realizing savings from reduced electricity usage and achieving cost recovery. This solution has high replication potential where all slaughter-house units can have an individual retrofit unit within their respective premises. This solution is applicable not only for waste from slaughter-house units but also other organic solid waste. The company is now looking to other products and employment opportunities including poultry feed and pet food as it seeks to be a zero-waste operation. Scientists and engineers from the KIRDI were involved in the implementation from the very beginning of the activity, which enabled UNIDO to transfer the know-how and skills to local technicians, so that the maintenance, replication and up-scaling process would be very smooth.

The two-stage biogas digester technology is widely used for commercial power generation in Europe and the USA. The design was adapted by UNIDO to meet local African requirements (ease of replication, up-scaling and maintenance) and can be implemented in any place where organic waste (food waste, market waste, fish waste, slaughter-house waste, agro-waste, chicken or animal manure) is available. This is the third HPTC biogas project UNIDO is completing in Kenya and, with the support of Government of Kenya through the Ministry of Industrialization, UNIDO would like to implement this model of biogas digesters as a standard in all mid-size slaughterhouses in Kenya. UNIDO will also look into establishing mini tanneries to process raw hides and skin to wet blue, which would further facilitate effective waste treatment as well as energy and employment generation in and around the slaughterhouses. Almost all well-known biogas power plants in developing countries depend on financial support from a third international party. Many new studies come to the conclusion that biogas power plants are not commercially viable without subsidies or guaranteed high prices (approx. 0.20 USD) for the produced outputs.

Summary assessment – SWOT analysis

The key strength Nyongara biogas plant is the reliable technology that can treat the waste to required local environmental norms. In addition, demand for electricity generated is high (Figure 95). The weakness is the investment required is high and financial assistance is needed for small enterprise. The business has the opportunity to both scale up and scale out, and scaling would require increased effort in building sound partnerships. The biggest threat for the business is from competition. The competition is not only from local electricity authority, but also once other slaughterhouse units have access to the technology, they can plan for a similar business approach and eat into Nyongara's market.

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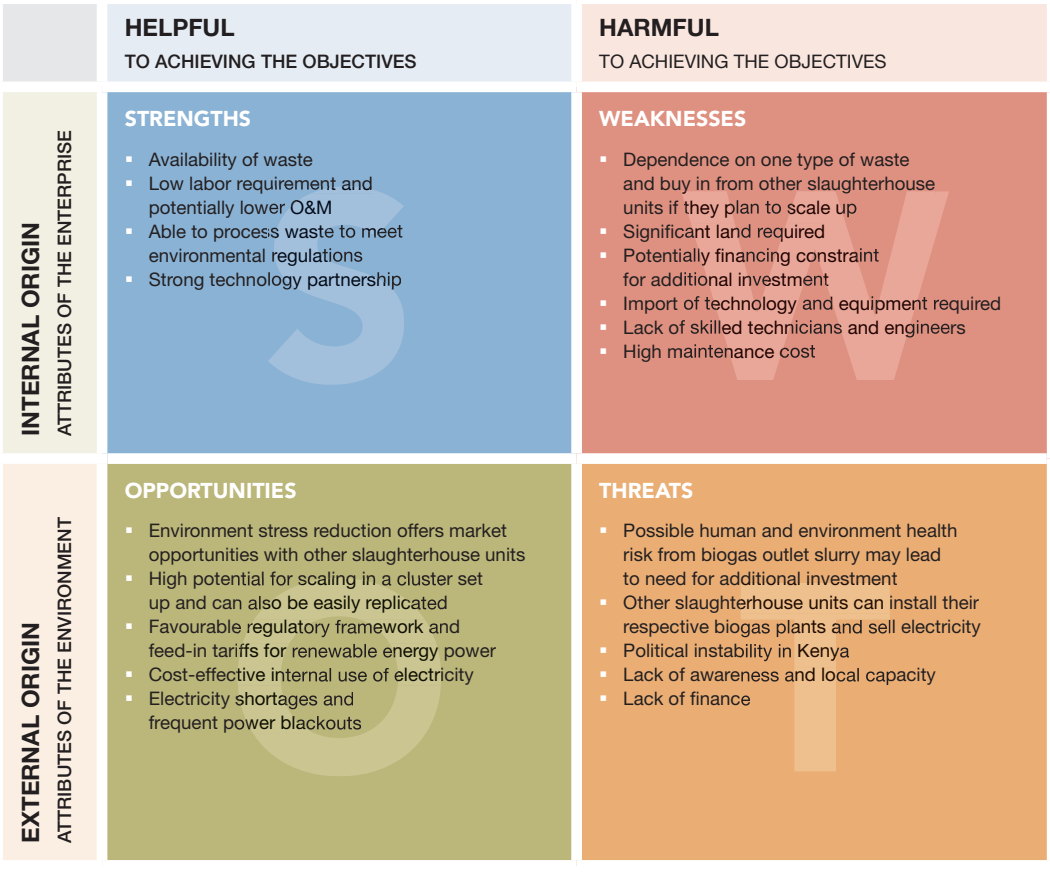
FIGURE 95. NYONGARA BIOGAS PLANT SWOT ANALYSIS



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Case descriptions are based on primary and secondary data provided by case operators, insiders, or other stakeholders, and reflects our best knowledge at the time of the assessments 2013/2014. As business operations are dynamic, data can be subject to change.