GNESD BIOENERGY STUDY THEME PAPER

Status of Bioenergy Development in Kenya: The Case of Bagasse-based Cogeneration

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Executive summary

Being relatively well endowed with biomass resources, Kenya has significant potential for bioenergy development for both liquid biofuel as well as for electricity generation. It is estimated that about 41 million litres of ethanol could be produced annually based on the existing production of molasses from the sugar production process (KSB, 2009). This is equivalent to nearly US$ 30 million per annum of oil imports (KNBS, 2009).

After the recent record high world oil prices and crippling electricity generation shortfalls, Kenya joined many other Sub-Saharan African countries in encouraging bioenergy development. In Kenya, there are three main potential sources of modern bioenergy, namely:

- Use of natural occurring biomass such as wood from trees and other plants to produce modern energy;
- Conversion of biomass waste from processes of agro-industries into modern energy; and,
- Commercially grown crops solely grown for modern energy production.

Most of the existing aforementioned biofuel initiatives are driven by non-Governmental Organizations and to a limited extent the private sector using *jatropha curcas* – a plant that is said to do well is marginal land and that can produce biodiesel as a cleaner substitute to crude oil-based diesel. However, with growing skepticism over the potential of *jatropha curcas*, greater attention is now being paid to ethanol production as a by-product of sugar processing.

The most advanced modern bioenergy sub-sector in Kenya is the conversion of biomass waste from processes of agro-industries into commercial energy. This experience is, presently, mainly found in the sugar industry where sugar factories use bagasse - the fibrous residue from sugarcane milling - to produce electricity, through cogeneration, for internal use with the excess sold to the national grid. Therefore, the focus of this paper is on the development of cogeneration in Kenya.

Kenya is well suited for sugarcane development particularly in the lowlands around Lake Victoria in the western part of the country as well as in the coastal area on the south eastern part of Kenya. The western part of the country is comprised of 3 sugarcane growing sub-regions, namely: Nyando Sugar Belt, Western Sugar Belt and South Nyanza Sugar Belt (KSB, 2010). However, the full potential for sugarcane development in the country is inhibited by over-reliance on rain-fed cultivation of sugarcane. In addition, the mismanagement of state-owned sugar factories has discouraged small holder farmers from expanding sugarcane development.

In terms of cogeneration development in Kenya, bagasse-based cogeneration is not new in the Kenyan sugar industry. By design, all sugar factories have an in-built cogeneration plant. However, historically, due to age of the equipment, poor maintenance, inefficient sugar production processes and lack of a ready market for available electricity, sugar factories in Kenya have operated relatively inefficient boilers

to limit the amount of excess bagasse in their backyards. The factories were essentially using boilers as incinerators of bagasse. However, with the demand for new investment in electricity supply, all existing and planned sugar factories in Kenya are keen to upgrade their cogeneration plants in order to more efficiently mop up all available bagasse to produce electricity for own use and sale of excess power to the national grid.

At the prevailing sugar production levels and assuming that all sugar factories had efficient high pressure boiler technology installed, sugar factories in Kenya could generate nearly 80 MW of electricity. If sugarcane farming areas were substantially expanded, the country's existing sugar factories have the potential to produce about 270 - 300 MW of electricity (Murungi, 2009).

The benefits of cogeneration development are many, chief among them being the following:

- Reduction of the cost of energy
- Additional revenue stream
- Potentially higher income for farmers
- Employment creation
- Enhancement of energy security
- Could be used to expand rural electrification
- Source of cleaner energy
- Solution to environmental hazards associated with agro-waste

While Kenya has not yet developed dedicated policies for bioenergy development or cogeneration, the existing policy, legal and regulatory framework that supports cogeneration development is embodied in the following documents:

- Sessional Paper No.4 of 2004 on Energy
- Energy Act of 2006
- Feed-in Tariff Policy for Renewable Energy

This report discusses two important case studies that provide useful lessons for cogeneration development in Kenya. The first case study is from Mauritius – the country whose cogeneration development in the sugar industry is the most advanced in Africa - providing an ideal benchmark for Kenya's cogeneration development. The second case study is on Mumias Sugar Factory in Kenya. Mumias Sugar Factory has the most advanced cogeneration development program and the most advanced cogeneration plant. Mumias provides an ideal yardstick with which other sugar factories in the country can measure up to.

Sustainable development is crucial to the success of any cogeneration development. Therefore, this report provides several considerations to be made pertaining to the extent to which prevailing economic, environmental and social issues are likely to enhance or hinder successful cogeneration develpment. In addition, the report discusses the existing barriers to cogeneration development in Kenya, which include:

- Absence of flexible Feed in tariffs

- Non-enforceable legal and regulatory instruments
- Lack of technical expertise
- Unavailable local financing
- Limited confidence among small holder sugar farmers
- Protracted sale of state-owned sugar factories

To conclude, in order to realize the full potential of cogeneration, the report provides the following policy recommendations:

- Institution of pre-determined feed-in tariffs for bioenergy power plants
- Accelerated development and transfer of high-pressure boiler technology and skills transfer (Capacity builiding)
- Innovative financing
- Innovative revenue-sharing mechanisms
- Sustainable bioenergy feedstock development

1.0 Introduction

1.1 Methodology

This study on the status of bioenergy development in Kenya was mainly a desk study complemented by computer based data collection on the sugar industry in Kenya. The methods used to achieve the study objectives involved the following:

Data and statistics compilation: This involved compiling existing data and statistics on the sugar industry in Kenya.

Literature review: This was, essentially, a review of available statistical publications on energy, the power sector, renewables and poverty, and research reports and publications on the Kenyan sugar industry.

Review of Energy Policies: This involved an analytical review of current energy policies of Kenya.

The key challenges and limitations in undertaking the study include the dynamic nature of the sugar industry which is undergoing a number of important changes thus complicating detailed analysis. The authors were fortunate to gain access to recent data and information on the sugar industry. However, the quality of the data sets was, in some cases, complicated by inconsistencies in the data provided as well as errors in aggregation. In addition, different reports often provided different and conflicting perspectives. However, efforts were made to compile the available data and estimates that aided in providing a balanced assessment of bioenergy development in Kenya.

1.2 Overview of Bioenergy Development in Kenya

Kenya is relatively well endowed with biomass resources. In summary there are three main potential sources of modern bioenergy in Kenya, namely:

- Use of natural occurring biomass such as wood from trees and other plants to produce modern energy;
- Conversion of biomass waste from processes of agro-industries into modern energy; and,
- Commercially grown crops solely grown for modern energy production.

Kenya has significant potential for bioenergy development for both liquid biofuel as well as for electricity generation. For example, it is estimated that about 41 million litres of ethanol could be produced annually based on the existing production of molasses from the sugar production process[1] (KSB, 2009). While this is equivalent to only 1% of Kenya's petroleum consumption in 2008, it can save the economy nearly US$ 30 million per annum of oil imports (KNBS, 2009). At the household level, there is a high potential

1 Estimate based on a case study in Thailand where 4.44 kg of molasses yield 1litre of ethanol (see Nguyen & Gheewala, 2008)

for biogas production. The technical potential is estimated to be 1,259,000 units but the number of installed biogas digesters is about 500 (Karekezi and Kithyoma 2005).

After the recent record high world oil prices and crippling electricity generation shortfalls, Kenya joined many other Sub-Saharan African countries in encouraging bioenergy development. Most of the existing aforementioned biofuel initiatives are driven by non-Governmental Organizations and to a limited extent the private sector. With about 80% of the country's land mass considered arid or semi-arid land, there is significant interest in the development of *jatropha curcas* – a plant that is said to do well is marginal land and that can produce biodiesel as a cleaner substitute to crude oil-based diesel. However, there is a significant degree of skepticism regarding the potential of *jatropha curcas*.

Development of bioenergy as a substitute to fossil fuel (gasohol and biodiesel) is limited. However, ethanol blending in petrol was tried in the 1980s after the second oil crisis but was discontinued after world oil prices declined. The Ministry of Energy has, however, pledged to reintroduce ethanol blending in 2012. Most sugar factories in the country have announced plans to produce ethanol. For example, Mumias Sugar Company, the largest sugar factory in Kenya has already conducted a feasibility study for ethanol production and secured debt funding for construction. At present production levels, the sugar factory has a potential of converting its molasses into 65,000 litres of ethanol per day. (Daily Nation, 2010). The following table shows the ethanol production potential of sugar factories in Kenya:

Estimated Ethanol Production Potential in Kenya

	2008		2007	
Sugar factory	**Molasses(Tonnes)**	**Ethanol(Litres)**	**Molasses(Tonnes)**	**Ethanol(Litres)**
Muhoroni	19,020	4,283,783.78	15,823	3,563,738.74
Chemilil	21,995	4,953,828.83	22,898	5,157,207.21
Mumias	75,864	17,086,486.49	80,690	18,173,423.42
Nzoia	17,865	4,023,648.65	20,663	4,653,828.83
South Nyanza	19,862	4,473,423.42	22,188	4,997,297.30
West Kenya	13,283	2,991,666.67	10,906	2,456,306.31
Soin	762	171,621.62	1,539	346,621.62
Kibos	12,667	2,852,927.93	N/A	N/A
TOTAL	**181,318**	**40,837,387.39**	**174,707**	**39,348,423.42**

Source: Adapted from KSB, 2009

The most advanced modern bioenergy sub-sector in Kenya is the conversion of biomass waste from processes of agro-industries into commercial energy. The aforementioned experience is, presently, mainly found in the sugar industry where sugar factories use bagasse - the fibrous residue from sugarcane milling - to produce electricity, through cogeneration, for internal use and sale of excess power to the national grid. Therefore, the focus of this paper is on the development of cogeneration in Kenya.

With the Kenyan sugar market increasingly becoming unpredictable due to opening up of imports within the COMESSA region, bagasse-based cogeneration (for sale of electricity to the national grid) is increasingly perceived as a crucial development for the survival of the sugar industry in Kenya. This is important because it is estimated that a substantial portion of the country's population either directly or indirectly benefits from sugar factories.

Sugar factories have also contributed to job creation by supporting about 250,000 small scale farmers within the sugar belt in Western Kenya (KSB, 2010; EPZA, 2005). The expansion of cogeneration in Kenya has important income generation implications, especially for small holder sugarcane farmers. Increased cogeneration capacity invariably increases sugarcane processing capacity hence increases the factory's sugarcane demand which, in turn, encourages small holder farmers to increase their acreage of sugarcane growing, thus increasing revenue flows to small scale farmers. In addition, under an equitable revenue sharing mechanism as found in Mauritius, farmers can benefit from a share of the revenue accrued from the sale of excess electricity to the national grid.

Furthermore, as Kenya is suffering from the adverse impact of drought-related 50 MW hydroelectric generation capacity shortfall, cogeneration can fill this important gap and enhance energy security.

1.3 Overview of the Sugar Industry in Kenya

Kenya is well suited for sugarcane development particularly in the lowlands around Lake Victoria in the western part of the country as well as in the coastal area on the south eastern part of Kenya. The western part of the country is comprised of 3 sugarcane growing sub-regions, namely: Nyando Sugar Belt, Western Sugar Belt and South Nyanza Sugar Belt (KSB, 2010). The following table provides the characteristics of the sugar belts in the western part of Kenya:

Characteristics of Sugar Belts in Western Part of Kenya

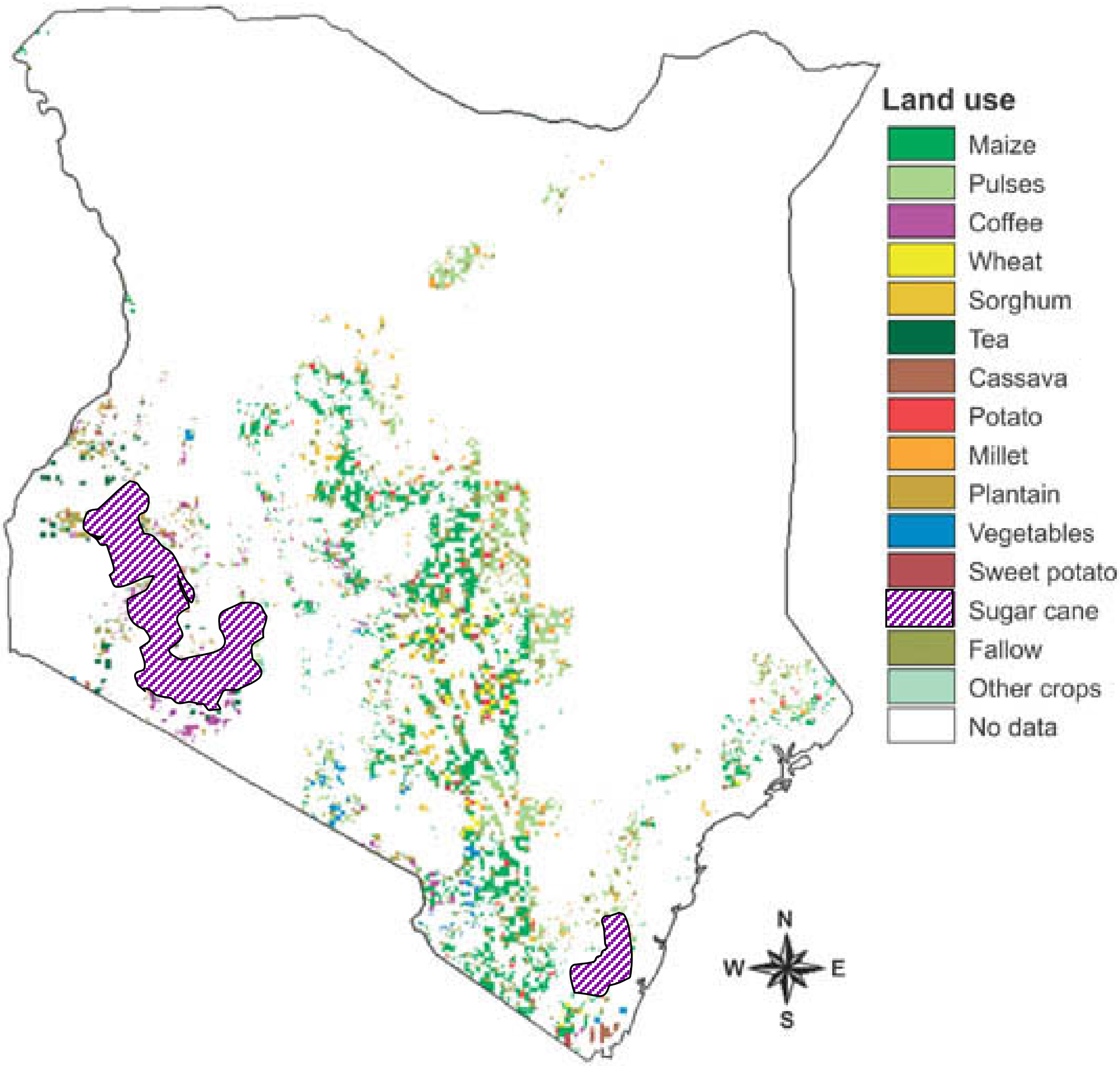
Sugar Belt	Sugar Factory in Belt	Soil Type(s)	Average Annual Rainfall (mm)
Nyando Sugar Belt	• Miwani • Muhoroni • Chemilil • Soin • Kibos	• Black cotton • Arenosols • Ferrasols • Luvisols • Cambisols • Nitosols	1,320

Sugar Belt	Sugar Factory in Belt	Soil Type(s)	Average Annual Rainfall (mm)
Western Sugar Belt	• Mumias • Busia • Nzoia • West Kenya	• Ferrasols • Nitosols • Luvisols • Acrisols	1,900
South Nyanza Sugar Belt	• Migori • Trans – Mara • Gucha • Kuria • Homa-Bay	• Red soils • Clay dark brown soils • Black soils	1,700

Source: Adapted from KSB, 2010

The following map shows the sugarcane growing areas in the country.

Map of Sugarcane Zones in Kenya[2]



Source: Adapted from FAO, 2004; EPZA, 2005

In spite of the significant potential for sugarcane development, the country is yet to realize its full potential. This is partly due to over-reliance on rain-fed cultivation of sugarcane. In addition, the mismanagement of state-owned sugar factories has discouraged small holder farmers from expanding sugarcane farming. Nevertheless, it is anticipated that the planned privatization of the state-owned sugar factories as well as the revival of a couple of formally collapsed sugar factories will boost sugarcane development and associated cogeneration promotion in the country.

2 Map is only indicative and not to scale

In a country where about 75% of the population relies on agriculture for a livelihood (Library of Congress, 2007), it is not surprising that the sugar industry and its associated bioenergy development have significant economic importance to the country. For example, it is estimated that sugar cane farming provides a source of livelihood to about 6 million people - nearly 16% of the population (KSB, 2010; EPZA, 2005; Mbendi, 2010).

Only 18% of Kenya's population has access to grid electricity (Murungi, 2009; Kiva, 2009). In the rural areas, grid electricity access levels are a paltry 5% compared to 51% in urban areas (Legros, *et al*, 2009). Cogeneration in rural-based agroindustries could potentially assist in widening rural access to electricity.

The relatively high population growth rate of Kenya coupled with increasing demand from the industrial and commercial sectors has contributed to a narrowing reserve margin in electricity supply. Bioenergy-based power generation is seen to have an important role to play in filling the aforementioned supply gap. Already, cogeneration in the sugar industry is contributing about 26 MW (from one sugar factory) with about 10 other proposals for biomass-based cogeneration development submitted to the Ministry of Energy for the development of about 270 MW - equivalent to over 20% of the current national installed capacity (Kiva, 2009).

1.4 Key Stakeholders in Kenya's Sugar Industry

There are many key players in the sugar/cogeneration industry of Kenya, notably:

1. *Ministry of Energy:*

   The Ministry of Energy is charged with the responsibility of Energy Policy and Development as well as providing energy services. The Ministry, together with other stakeholders in the energy sector, which included the sugar industry, developed the energy policy (Sessional Paper Number 4 of 2004 on Energy). The Ministry set up a steering committee on cogeneration comprising of key stake holders in both the energy sector and sugar industry which was mandated to carry out a pre-feasibility study to determine the potential and viability of bagasse based cogeneration in the country.

2. *Ministry of Agriculture:*

   The Ministry's mission is to promote sustainable and competitive agriculture through creation of enabling environment and provision of support services, to enhance food security, incomes and employment. The Ministry is a major stakeholder in the process as the sugar industry is under its jurisdiction and is responsible for formulating policies that govern the industry. The Ministry has the overall responsibility for the sugar industry development and it also has its representatives on the boards of directors of all state-owned sugar mills. Sugar cane research and advisory services to farmers also falls under the Ministry of Agriculture.

3. *Kenya Sugar Board (KSB)*

The Kenya Sugar Board is involved in policy formulation and implementation. It acts as the technical unit that advises the Ministry of Agriculture in promoting all aspects of producing, processing and marketing of sugar cane, sugar and molasses as well as also advising on pricing and necessary legislation for the industry.

The Kenya sugar board was purposely established under the Sugar Act 2001, and given the mandated to:

- Regulate, develop and promote the sugar industry
- Coordinate the activities of individuals and organizations within the industry
- Facilitate equitable access to the benefits and resources of the industry by all interested parties

4. *The Sugar Development Fund (SDF)*

This is a fund introduced by the Government and managed by the KSB. Its revenue is primarily sources from a levy, Sugar Development Levy (SDL), which is currently a consumer-based levy that is charged at the rate of 4% on the ex-factory price of sugar at the mills and 4% on the Cost Insurance & Freight (CIF) value of sugar imported into the country (KSB, 2010). This Levy was established in 1992 and is used for extending loans to the industry either for factory rehabilitation or for cane development. It also occasionally provides grants for operations of the KSB, Kenya Sugar Research Foundation (KESREF) and the development of roads infrastructure in the cane growing areas.

5. *The Kenya Sugar Research Foundation (KESREF)*

The Kenya Sugar Research Foundation (KESREF) is the scientific and research arm of the industry. Its responsibilities include breeding appropriate varieties of cane, recommending appropriate fertilizers, appraising, studying, developing and monitoring technologies, pest and diseases, agronomic packages, farm machinery, environment and safety issues in sugar. The Foundation also commissions/undertakes socio-economic studies to enhance the development of sugar as a business, as well as extension activities and collaboration with bodies that can further its mission. The foundation, established in 2001, is funded by the sugar levy and has its headquarters in Kibos, Kisumu with sub-stations in Kakamega, Mtwapa and Rongo.

6. *Cane millers (Sugar companies/factories)*

These are the sugar factories that process sugarcane to produce sugar as the main product and other by products such as bagasse (which is used for heat and power cogeneration), molasses (used for the production of alcohol) and other by-products. There are ten (10) sugar factories in Kenya, of which two (2) are defunct while three (3) are technically insolvent. Only five (5) sugar factories in the country are currently operating profitably (KSB, 2009).

7. *Kenya Sugar Manufacturers Association (KESMA)*

This is the body through which sugar millers negotiate sugar cane prices with the outgrowers and collectively advocate for favourable policies for the sugar industry. It is the same body that has been exerting pressure on the Ministry of Energy to offer a favourable feed-in tariff for cogeneration. All the sugar factories are members of KESMA.

8. *Cane Farmers (out growers)*

There are currently about 250,000 small scale cane farmers with an average holding of 0.6 to 0.8 hectares of land per farmer. Cumulatively, these farmers supply about 90% of all the cane delivered to the factories (KSB, 2009). The sugar companies support the production of cane by the small holder farmers. The remaining 10% of the sugarcane is normally sourced from the large scale farmers and nucleus estates that are owned by the respective factories.

9. *Kenya Sugarcane Growers Association (KEGSA)*

This is the body through which sugarcane farmers negotiate prices with millers. It is mainly made up of individual growers who come together to form an out-growers company or association.

10. *Kenya Society of Sugarcane Technologists (KSSCT)*

This is a non-partisan technical organization comprised of people who are involved in sugar production, manufacture, direct consumption, transportation and handling of sugar and its by-products.

11. *Kenya Power and Lighting Company*

The Kenya Power and Lighting Company (KPLC), the 51% government owned electricity supply and distribution company, has the monopsony in the purchase of electricity making it a major player in the cogeneration sector. KPLC is interested in working with sugar factories willing to sell excess electricity via a negotiated Power Purchase Agreement (PPA). To date, only Mumias Sugar Factory has entered into a PPA with KPLC.

12. *Kenya Electricity Generating Company (KenGen)*

Kenya Electricity Generating Company Limited, (KenGen) is the leading electric power generation company in Kenya, producing about 80 percent of electricity consumed in the country (KenGen, 2010). The company utilises various sources to generate electricity ranging from hydro, geothermal, thermal and wind. KenGen is currently in negotiations with some of the sugar companies to co-invest in their cogeneration installations by providing equity in exchange of part ownership of the cogeneration plants.

13. *Kenya Trasmission Company (KETRACO)*

Established in late 2008, the Kenya Transmission Company Limited (KETRACO) is the only transmission company in the country and is wholly owned by the Government. The company responsibility is to design, construct, operate and maintain new high voltage electricity transmission lines. As sugar factories invest in large scale cogeneration systems for sale of excess electricity to the national grid, KETRACO is likely to become a valuable partner in the construction and operation of the required transmission lines.

14. *Financial Institutions*

Financial institutions includes local commercial banks, regional banks e.g. East Africa Development Bank (EADB), The Africa Development Bank (AfDB), international banks such as the World Bank etc. and other financial lending institutions who have the capability to secure financial resources and are willing to lend to the sugar factories for the construction of cogeneration plants (Mbithi, 2007). Local commercial banks have limited experience in the financing of cogeneration.

15. *Non - Governmental Organizations (NGOs).*

NGOs with a keen interest in the energy sector can also be considered as key stakeholders in the cogeneration industry. An example of their participation is illustrated by the initiative dubbed **"Cogen for Africa" project,** which is implemented by AFREPREN/FWD. The "Cogen for Africa" project is an innovative and first-of-its kind regional initiative funded by the Global Environment Facility (GEF) designed to support small, medium and large-scale industries in Africa to develop their cogeneration potential. This initiative is supported by the GEF via the United Nations Environment Programme (UNEP) and the African Development Bank (AfDB). The Energy, Environment and Development Network for Africa (AFREPREN/FWD) is the Executing Agency for the project. The project's key activities include:

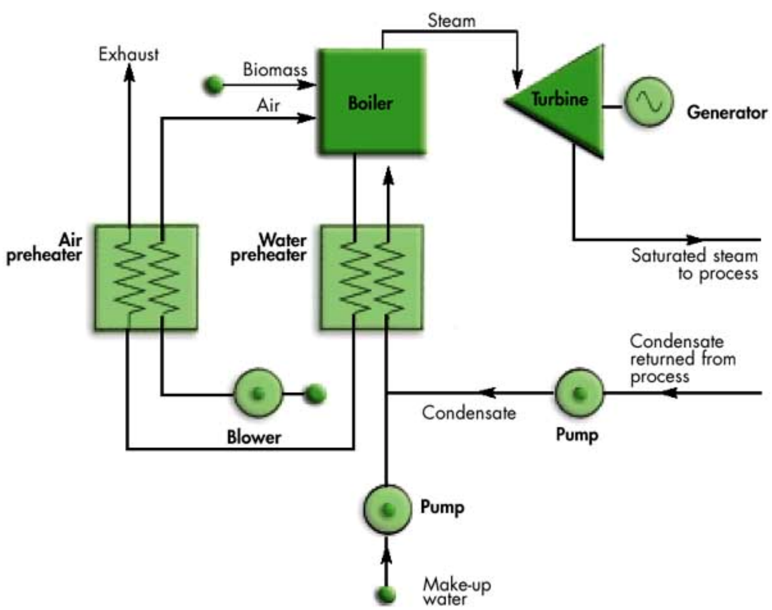
- Developing and enhancing the capacity of project developers, technical service providers and local manufacturers of modern and efficient cogeneration systems.
- Mobilizing financing for cogeneration projects based on terms and conditions that are favorable for cogeneration investments
- Demonstrating the commercial, technical, economic and environmental benefits of modern and efficient cogeneration systems through the installation of full demonstration cogen plants.
- Promoting more favorable policies and institutional arrangements that support cogeneration.

2.0 Current Situation of Cogeneration Development in Kenya

2.1 Cogeneration Technology and Energy Production

Cogeneration is the simultaneous production of electricity and process heat from a single dynamic plant. A cogeneration plant in a sugar factory burns bagasse (sugarcane waste) to generate steam for process heat and for driving a turbine to produce electricity. The following schematic diagram provides an illustration of a typical cogeneration plant found in sugar factories.

Schematic Diagram of a Typical Cogeneration Plant



Source: Mbuthi, 2006

Bagasse-based cogeneration is not a new technology in the Kenyan sugar industry. By design, all sugar factories have an in-built cogeneration plant. However, historically, due to age of the equipment, poor maintenance, inefficient sugar production processes and lack of a ready market for available electricity, sugar factories in Kenya have operated relatively inefficient boilers to limit the amount of excess bagasse in their backyards. However, with the demand for new investment in electricity supply, all existing and planned sugar factories in Kenya are planning to upgrade their cogeneration plants in order to more efficiently mop up all available bagasse to produce electricity for own use and the excess sold to the national grid.

Over the past 10 years, bagasse production in the country has increased by nearly 30% (KSB, 2009). In 2008, the sugar factories in the country crushed over 5 million tonnes of sugarcane thereby producing just above 2 million tonnes of bagasse. The following figure shows trends in bagasse production over the past 10 years:

Bagasse Production Levels in Sugar Factories in Kenya

Sugar Factory	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Chemelil	218,125	256,959	196,028	270,674	197,192	243,005	193,186	270,920	279,266	253,209
Muhoroni	157,334	67,295	6,027	180,477	171,174	142,100	144,377	161,431	177,076	190,857
Mumias	879,962	725,116	729,625	799,166	785,173	877,433	888,604	842,989	898,871	839,129
Nzoia	211,799	160,289	122,850	234,046	207,682	247,182	241,898	222,705	267,523	217,310
South Nyanza	257,415	185,297	179,945	205,546	196,321	256,318	268,533	223,445	244,406	191,865
Miwani[3]	68,583	57,803	4,229	N.A	N.A	N.A	N.A	N.A	N.A	N.A
Ramisi[4]	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A
West Kenya	77,508	45,776	55,273	85,099	85,830	86,111	114,239	156,663	119,379	201,821
Kibos[5]	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	137,104
Soin[6]	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A	N.A
Total[7]	**1,870,726**	**1,498,535**	**1,293,997**	**1,775,008**	**1,643,372**	**1,852,149**	**1,850,837**	**1,878,153**	**1,986,521**	**2,031,295**

Note: N.A = Not Applicable

Source: KSB, 2009

3Miwani Sugar Factory closed indefinitely in February 2001.

4 Ramisi Sugar Factory collapsed in 1988. It is, however, in the process of revival and anticipated to start sugar production in 2011/12.

5 Kibos Sugar Factory started operations in December 2007.

6 Soin Sugar Factory is a small sugar mill which started operations in mid-2006. However, no data is available on its bagasse production.

7 There could differences in the totals in other sources due to errors in aggregation.

With the existing production capacity, sugar factories could generate nearly 80 MW of electricity, assuming that they all had efficient high pressure boiler technology installed. The aforementioned electricity generation potential is relatively modest considering that, if sugar farming was expanded, the country's existing sugar factories have the potential to produce about 270 - 300 MW of electricity (Murungi, 2009).

2.2 Costs and Benefits of Cogeneration Development

While bagasse-based cogeneration development attracts several benefits, like most renewable energy technologies, its upfront cost is high. For example, on average, the investment cost of 1 MW of efficient bagasse-based cogeneration is about US$ 1.5 million. This implies that for Kenya's sugar industry to achieve the full potential of generating 270 - 300 MW from the existing factories, it must invest about US$ 450 million into cogeneration equipment only[8]. This is a hefty investment considering that the prevailing annual gross turnover of the sugar industry is about US$ 400 million (KSB, 2009).

The benefits of cogeneration development are many, key among them being:

> *Reduction of the cost of energy:* Sugar factories can be self reliant in terms of electricity supply, hence, incur relatively lower energy costs.
>
> *Additional revenue stream:* With investment in more efficient cogeneration, sugar factories can generate excess electricity for export to the national grid thus providing an additional revenue stream.
>
> *Potentially higher income for farmers:* If an equitable revenue sharing system is instituted, part of the aforementioned additional revenue stream to the sugar factories could be shared with small holder farmers as the suppliers of the cane from which bagasse is derived. A successful revenue sharing mechanism has been implemented in Mauritius and it is possible to have it applied in Kenya, too.

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8. With the exception of Mumias Sugar factory which operates a 87 bar boiler, most of the remaining sugar factories have old and dilapidated boilers of 45 bar or below. Hence, most require new cogeneration equipment instead of undertaking simple energy efficiency improvements.

Box 1: Revenue Sharing in Mauritius

Cogeneration in Mauritius benefits all stakeholders through a wide variety of innovative revenue sharing measures. The co-generation industry has worked closely with the Government of Mauritius to ensure that substantial benefits flow to all key stakeholders of the sugar economy, including the smallholder sugar farmer. The equitable revenue sharing policies that are in place in Mauritius provide a model for emulation in ongoing and planned modern biomass energy projects in Africa. By sharing revenue with stakeholders and the small-scale farmer, the cogeneration industry was able to convince the Government (which is very attentive to the needs of the small-scale farmers as a major source of votes) to extend supportive policies and tax incentives to cogeneration investments.

Source: Deepchand, 2002

Enhancement of energy security: As mentioned earlier, the power sector in Kenya is experiencing electricity supply challenges emanating from a drought-related shortfall in hydroelectric power generation equivalent to about 50 MW (Imitira, 2009). As a response option, the country has been forced to enlist the services of expensive Emergency Power Producers. Having a potential of about 270 - 300 MW, cogeneration in the sugar industry could address the aforementioned power generation shortfall and associated high costs.

Potential for enhancing rural electrification: Most sugar factories where cogeneration plants are installed are located in remote rural areas where the majority of the population is not connected to the utility grid. In these remote settings, the cogenerated electricity could be used to expand rural access to electricity while minimizing transmission and distribution losses.

The following section discusses further potential environmental and social impacts of cogeneration development in Kenya.

2.3 Environmental and Social Impacts of Cogeneration Development

Cogeneration development in Kenya has the following potential environmental and social impacts:

Source of clean energy: In principle, bagasse-based cogeneration is not only a clean source of energy compared to fossil fuels, it is also “carbon-neutral”. This is because the carbon dioxide emitted from the cogeneration plant is less or equal to the CO_2 absorbed by the sugarcane as it grows. In addition, as the existing or next crop of sugarcane grows, it absorbs an amount of carbon dioxide that is either equal or greater than the amount released by the cogeneration plant. Cogeneration can therefore benefit from carbon credits.

Solution to an environmental hazard: Bagasse-based cogeneration utilizes waste material which is otherwise a nuisance for sugar factories – unutilized bagasse is a fire hazard as well as an environmental concern (decomposition of bagasse releases to the atmosphere methane – a more potent greenhouse gas than carbon dioxide). Thus its use for power generation delivers significant local environmental as well as climate benefits.

Source of livelihood and employment: In Kenya, about 90% of all the sugarcane delivered to sugar factories is from small scale farmers most of whom rely on sugarcane production as their only source of income (KSB, 2009). The supply of sugarcane by small scale farmers enhances security of feedstock supply to sugar factories, not only for sugar processing, but also for cogeneration. Sugarcane production in Kenya is a very labour intensive activity lasting 18 months between planting sugarcane and when it reaches optimum maturity. Right from the onset, preparation of the cane plantation field i.e. clearing and furrowing requires some labour input. These activities in most cases, depending on the size of the land, can either be done manually or by tractors, but in most cases, a combination of both. Thereafter, weeding and harvesting is carried out by manual labourers.

Consequently, the expansion of existing cogeneration plants in the sugar industry implies that sugar factories can process larger volumes of sugarcane which, in turn, encourages the small holder farmers to produce more sugarcane – thereby increasing their income levels as well as expanding employment in sugar farming.

2.4 Business Model for Cogeneration Development

A comparison between the state owned sugar factories with privately owned sugar factories reveals that the ideal business model for cogeneration development in Kenya is the one where the private sector plays a major role. This is because, currently, virtually all state-owned sugar factories are either technically insolvent or closed. They owe a total of US$ 800 million to small holder farmers and the Government. About US$ 240 million is owed to small holder farmers in unpaid cane deliveries while US$ 560 million is owed to the Government in unpaid dividends and loans (Menya, 2008).

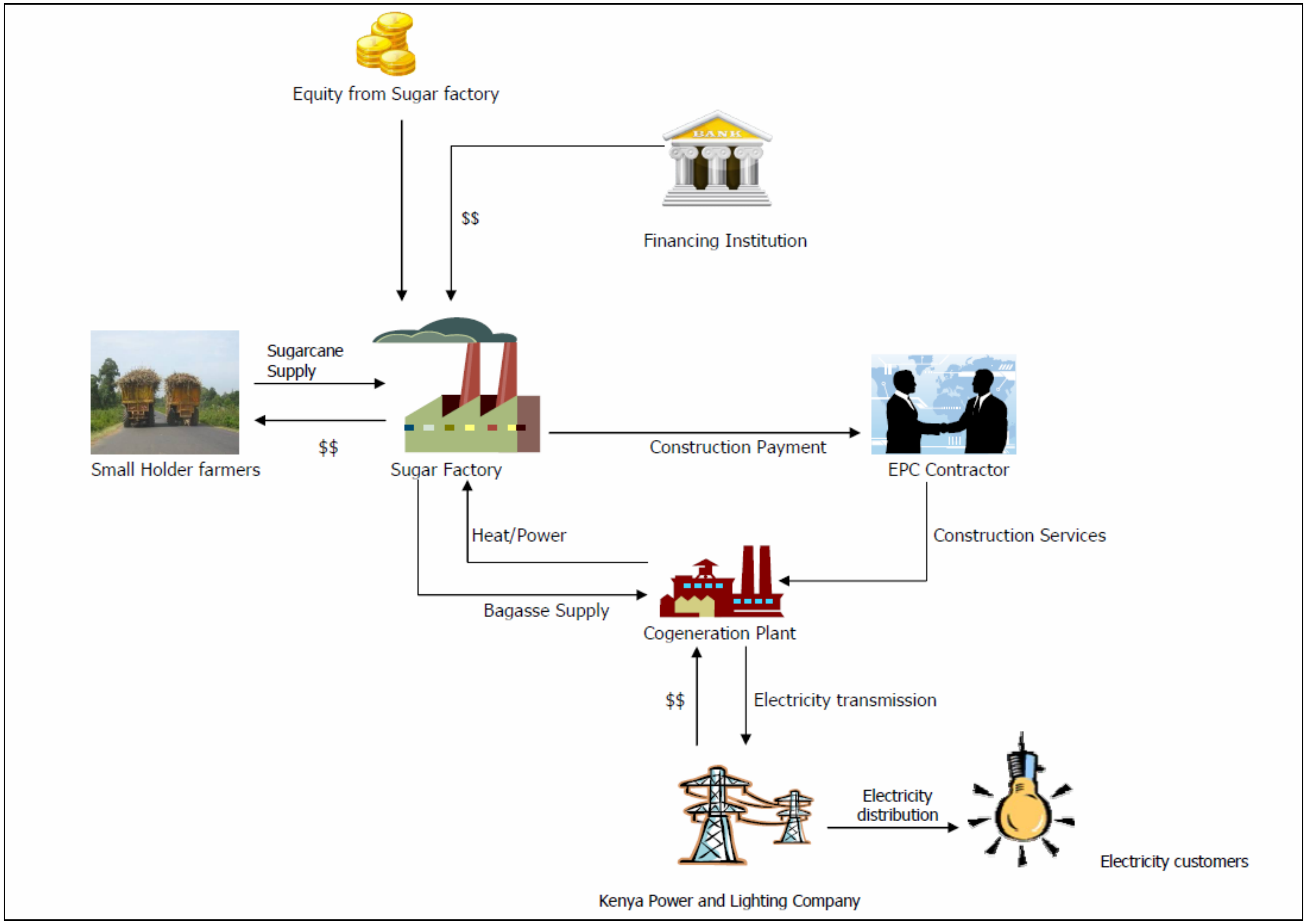
Under the proposed ideal business model, the privately owned sugar factory would invest in the more efficient cogeneration plant. Ideally, the sugar factory would contribute its own equity (usually 20-40% of the total cost of investment) while the balance would be sourced from a financing institution or a consortium of financing institutions. The sugar factory would also engage an external contractor to undertake engineering, procurement and construction (referred to as EPC) of the cogeneration plant.

The completed cogeneration plant would receive bagasse from the sugar factory as its fuel to produce heat and electricity. All the excess heat and part of the electricity produced by the cogeneration plant would be supplied to the sugar factory. In addition, subject to having a Power Purchase Agreement (PPA) with the electricity distribution utility (in this case, Kenya Power and Lighting Company - KPLC), the excess electricity would be sold to KPLC for distribution to the utility’s electricity customers.

It is worth noting that an attractive sugarcane supply agreement with small holder farmers is critical to the success of the cogeneration initiative. The ideal and most attractive cane supply agreement would the one that offers attractive prices for the cane delivered to the factory as well as provides a share of the revenue accrued from the sale of excess electricity KPLC.

The following diagram provides an illustration of the aforementioned ideal business model for cogeneration in Kenya:

Ideal Business Model for Cogeneration in Kenya



Source: *Compiled by authors*

2.5 Existing Policies for Cogeneration Development

Kenya has not yet developed dedicated policies that have important implications for bioenergy development or cogeneration. While a National Biofuels Committee was established in 2006 with the objective of coordinating stakeholders, the Committee has been focusing on developing a biodiesel strategy using *jatropha curcas*.

Therefore, the existing policy, legal and regulatory framework that supports cogeneration development is embodied in the following documents:

- Sessional Paper No.4 of 2004 on Energy
- Energy Act of 2006
- Feed-in Tariff Policy for Renewable Energy

The above documents are discussed in further detail below:

Sessional Paper No.4 of 2004 on Energy

This document was prepared in 2003 and tabled to the Cabinet for approval in 2004 (MoE, 2004). The document is perhaps the most comprehensive official document clearly stipulating the mandate and priorities of the Minisitry of Energy for cogeneration development. It is relatively supportive of cogeneration development and articulates the following actions relating to cogeneration promotion in its implementation plan:

- Assess bagasse based cogeneration potential and implement identified projects based on least cost criteria;
- Draw appropriate plans for biomass energy development including biomass resource assessments and surveys;
- Establish a pilot cogeneration investment programme;
- Launch medium term bagasse based cogeneration investment programme with a target of 150 MW by 2010;
- Formulate strategies for attaining the target of 300 MW of co-generation capacity by 2015 and incorporate the same in the least cost power development plan;
- Review and update biomass energy development plans;
- Establish biomass energy technology databases; and,
- Revitalize the existing energy centres to make them effective outreaches for promoting agro-forestry and other renewable energy technologies.

Energy Act of 2006

The Energy Act of 2006 does provide strong support for cogeneration development. The Act provides for both the Minister and the Authority to promote the use of renewable energy (including biomass). Another important provision of the Energy Act that is useful for cogeneration development is its stipulation of relatively open licensing to entities interested in electricity generation.

Feed-in Tariff Policy for Renewable Energy

Kenya is one of the few sub-Saharan African countries that has stipulated feed-in tariffs for renewable energy (including bagasse-based cogeneration). The Feed-in Tariff Policy was first introduced by the Ministry of Energy in 2008.

The 2008 Feed-in Tariffs for cogeneration provided for US¢ 7.0/kWh for firm electricity generation and US¢ 4.5/kWh for non-firm electricity generation (MoE, 2008). This offer was considered to be much more attractive than what KPLC previously offered to sugar factories. However, the most attractive part of the policy was its provision for a long term PPA (i.e. 15 years). The first beneficiary of the Feed-in Tariff Policy was one of the leading sugar millers – Mumias Sugar Company.

In January 2010, the Ministry of Energy in conjunction with the Energy Regulatory Commission reviewed the Feed-in Tariff Policy in order to offer much more attractive feed-in tariffs as well as to include other renewable energy technologies, namely: Geothermal, solar and biogas. The implications for bagasse-based cogeneration of the revised Feed-in Tariff Policy included the following (MoE, 2010):

- An increase of feed-in tariffs for firm and non-firm cogeneration to a maximum of US¢ 8.0/kWh and US¢ 6.0/kWh, respectively.
- Longer term PPAs i.e 20 years as opposed to 15 years.

The Feed-in Tariff Policy has been received by the sugar industry with great interest. As in the case of Mauritius, the pre-determined feed-in-tariff for cogeneration is key to success of the cogeneration development in Kenya.

3.0 Case Studies of Cogeneration Development

This section discusses two important case studies for cogeneration development in Kenya. The case studies highlight key issues and challenges that provide useful lessons for future cogeneration development in Kenya. The first case study is from Mauritius – the country whose cogeneration development in the sugar industry is the most advanced in Africa - providing an ideal benchmark for Kenya's cogeneration development. The second case study is on Mumias Sugar Factory in Kenya. Mumias Sugar Factory has the most advanced cogeneration development program and also has the most advanced cogeneration equipment. Mumias provides an ideal yardstick with which other sugar factories in the country can measure up to.

3.1 Case Study of Cogeneration Development in the Mauritian Sugar Industry

Perhaps the single most important driver for the successful implementation of the cogeneration programme in Mauritius is a clearly defined government policy on the use of bagasse for electricity generation. Plans and policies have constantly been worked out over the last more than two decades for the sugar industry in general. First, in 1985, the Sugar Sector Package Deal Act (1985) was enacted to encourage the production of bagasse for the generation of electricity. The Sugar Industry Efficiency Act (1988) provided tax incentives for investments in the generation of electricity and encouraged small planters to provide bagasse for electricity generation. Three years later, the Bagasse Energy Development Programme (BEDP) for the sugar industry was initiated. In 1994, the Mauritian Government abolished the sugar export duty, an additional incentive to the industry. A year later, foreign exchange controls were removed and the centralization of the sugar industry was accelerated. These and other measures are summarised in the following table:

Policy Measures for Bagasse Cogeneration Development in Mauritius

Year	Policy initiatives	Key objectives/Areas of focus
1985	Sugar Sector Action Plan	- Bagasse energy policy evoked
1988	Sugar Industry Efficiency Act	- Tax free revenue from sales of bagasse and electricity - Export duty rebate on bagasse savings for firm power production - Capital allowance on investment in bagasse energy
1991	Bagasse Energy Development Programme	- Diversification of energy base - Reduction of reliance on imported fuel - Modernisation of sugar factories - Enhanced environmental benefits
1997	Blue Print on the Centralisation of Cane Milling Activities	- Facilitated closure of small mills with concurrent increase in capacities and investment in bagasse energy

Year	Policy initiatives	Key objectives/Areas of focus
2001	Sugar Sector Strategic Plan	- Enhanced energy efficiency in milling - Decreased number and increased capacity of mills - Favoured investment in cogeneration units
2005	Roadmap for the Mauritius Sugarcane Industry for the 21st Century	- Reduction in the number of mills to 6 with a cogeneration plant annexed to each plant
2007	Multi-annual Adaptation Strategy	- Reduction from 11 factories to 4 major milling factories with coal/bagasse cogeneration plants (Belle Vue, FUEL, Medine and Savannah) - Bio-ethanol production for the transport fuel markets. Spirits/rum and pharmaceutical products e.g. aspirin - Commissioning of four 42MW and one 35MW plants operating at 82bars - Promotion of the use of cane field residues as combustibles in bagasse/coal power plants to replace coal

Source: Deepchand, 2002

As a result of consistent policy development and commitment to bagasse energy development in Mauritius, the installed capacity of cogeneration power has increased over the years. In 1998, close to 25% of the country's electricity was generated from the sugar industry, largely using bagasse, a by-product of the sugar industry. By 2001, electricity generation from sugar estates stood at 40% (half of it from bagasse) of the total electricity supply in country (Veragoo, 2003). Presently, electricity from cogeneration in the Mauritian sugar industry accounts for about 60% of the electricity generated on the island (CEB, 2009). The aforementioned growth in electricity supply from cogeneration in Mauritius is a result of modest capital investments combined with judicious equipment selection, modifications of sugar manufacturing processes (to reduce energy use in manufactured sugar) and proper planning.

Bagasse cogeneration has delivered a number of benefits to Mauritius including reduced dependence on imported oil, diversification in electricity generation and improved efficiency in the power sector in general. It is available 100% of the time as long as bagasse production is in place thus enhancing Mauritius' energy security.

Cogeneration in Mauritius benefits all stakeholders through a wide variety of innovative revenue sharing measures. The cogeneration industry has worked closely with the Government of Mauritius to ensure that substantial benefits flow to all key stakeholders of the sugar economy, including the smallholder sugar farmer. The equitable revenue sharing policies that are in place in Mauritius provide a model for emulation in ongoing and planned cogeneration development in Kenya. By sharing revenue with stakeholders and the small-scale farmer, the cogeneration industry was able to convince the Government (which is very attentive to the needs of the small-scale farmers as a major source of votes) to extend supportive policies and tax incentives to cogeneration investments (Deepchand, 2002).

3.2 Case Study of Mumias Sugar Factory

Mumias Sugar Company (MSC) is the largest sugar factory in Kenya and has the most advanced cogeneration development experience in the sugar industry. The company started operations in 1973 with the Government as the majority shareholder (MSC, 2010). However, in 2001, the Government sold 40% of its 78%-shareholding to sugarcane farmers. In 2007, the Government reduced its shares to 20% through a successful Initial Public Offering at the Nairobi Stock Exchange. The IPO was over-subscribed with the main driver being the high level of interest in its planned cogeneration development.

Like most other sugar factories in Kenya, the original cogeneration plant at Mumias sugar factory was deliberately designed to be inefficient by burning as much bagasse as possible to avoid accumulating an excess of the by-product. However, MSC's interest in exporting excess cogenerated electricity dates back in the 1990s. The national electricity utility, however, was not interested in offering attractive tariffs to the sugar factory. In addition, the national utility – KPLC - was skeptical of the ability of any sugar factory to supply firm power to the national grid. Therefore, for several years, in spite of having the potential to export 5.5 MW to the national grid, Mumias supplied only about 2 MW on an intermittent basis (Mumias, 2010) for paltry tariff of less than USc 5.0 per kWh. It was not until the year 2000 when the country faced a drought that the value and reliability of MSC's cogeneration plant was noted by KPLC. Since then, Mumias worked towards investing in a largescale cogeneration plant.

In May 2009, Mumias Sugar Company commissioned its 38 MW cogeneration plant – making it the sugar factory with the largest and most efficient cogeneration plant. With the new cogeneration plant, Mumias increased its electricity generation capacity nearly three-fold. Currently, the sugar factory exports about 26 megawatts to the national grid. In March 2008, the Energy Regulatory Commission (ERC) approved the Power Purchase Agreement (PPA) between Mumias and KPLC for sale of electricity to the national grid at a price of about USc 6.0 per kWh (Mugambi, 2010). In January 2010, the PPA for Mumias was revised upwards to USc 8.0 following the Ministry of Energy and ERC's review of the Feed-in Tariff Policy for renewable energy which was first introduced in 2008 (Odhiambo, 2010). This was an unusual move in a bid to encourage other potential investors in cogeneration development.

While the company has successfully developed an advanced cogeneration plant, its implementation has met a several challenges including about a 6 months' delay in commissioning of the plant (MSC, 2009). However, the most significant challenge has been KPLC's failure to provide the cogeneration plant at Mumias Sugar Factory priority dispatch as stipulated in the Feed-in Tariff Policy. The resolution of this issue is critical to the future development of cogeneration in Kenya as all other sugar are looking up to Mumias Sugar Factory as the benchmark on which to develop their own cogeneration plants.

4.0 Sustainability of Cogeneration Development in Kenya

Sustainable development is crucial to the success of any cogeneration development. In Kenya, there are several considerations to be made pertaining to the extent to which prevailing economic, environmental and social issues are likely to enhance or hinder successful cogeneration develpment. These issues are discussed in detail in the following sections:

4.1 Economic Considerations of Sustainable Cogeneration Development in Kenya

One of the most important economic considerations for sustainable cogeneration development is the availability of a market. In the case of Kenya, the market for cogenerated electricity is significant as the country is facing a persistent power supply shorfall. The business community and some policy makers in the country have clamoured for the target reserve margin in the country to be revised to 30% (up from the global norm of 15%) in order to be secure from the vagaries of what is thought to be climate change-related hydroelectric generation shortfalls. A more stable power supply translates into significant macro-economic benefits for the country. If a 30% reserve margin on the existing national installed capacity were to be fulfilled, this would translate into 360 MW - implying that full scale development of cogeneration in the sugar industry could meet over 80% of the targeted reserve margin.

Another important economic consideration for sustainable cogeneration development is its impact on end-user electricity costs. Cogeneration development is likely to contribute to a reduction in the end-user electricity costs due to two factors: Firstly, with the maximum selling price of cogenerated electricity being set at US¢ 8.0 per kWh, this is very competitive compared to the selling price awarded to the oil-based Independent Power Producers and Emergency Power Producers whose tariffs are two and a half times higher at US¢ 20 per kWh (Odhiambo, 2010). Secondly, oil-based electricity generation burdens the end-user electricity bill with separate costs associated with the fuel consumed to generate electricity as well as the costs associated with fuel related foreign exchange losses. Electricity from cogeneration plants in the sugar factories does attract the aforementioned costs, therefore making it cheaper for electricity consumers in the long run which could result in significant positive macro-economic impact.

Perhaps the most important economic consideration for cogeneration development is the fact that the sugar business on its own cannot sustain the sugar factories in Kenya after 2012 when the sugar market in the COMESA region will be liberalized. The survival of sugar factories in Kenya post-2012 depends, to a large extent, on cogeneration development. This was also the case in Mauritius where it was reported that income from the sale of electricity became more profitable than that from sugar thereby enabling the factories survive periods when the price of sugar was low.

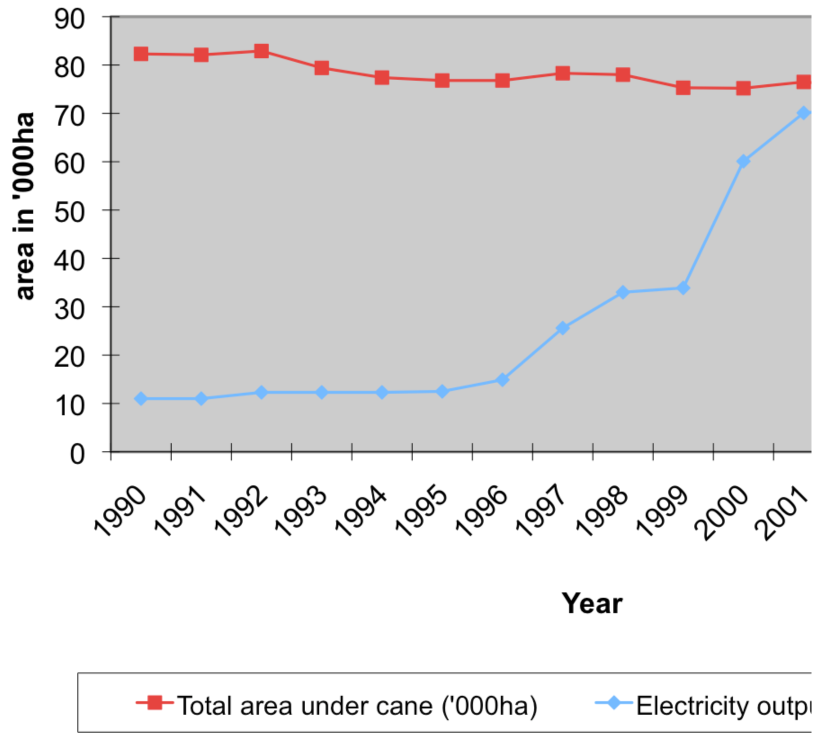
4.2 Environmental Considerations of Sustainable Cogeneration Development in Kenya

As mentioned earlier, bagasse-based cogeneration is a clean source of energy compared to fossil fuels and, it is “carbon-neutral”. In addition, bagasse-based cogeneration utilizes waste material which, if not well disposed off, becomes a fire hazard as well as an environmental concern - decomposition of bagasse releases to the atmosphere methane which is a more potent greenhouse gas than carbon dioxide. Thus its use for power generation delivers significant local environmental as well as climate benefits. Nevertheless, all cogeneration plants in Kenya undergo an Environmental Impact Assessment for approval by the National Environment Management Authority (NEMA).

NEMA has instituted ways for continuous monitoring environmental issues associated with sugar factories in which cogeneration plants reside. However, while NEMA has published standards for treatment and disposal of waste (including air quality emission standards), these are not specific regulations for cogeneration plants. Furthermore, the Environment Impact Assessment specialists in the country do not have much exposure to cogeneration - this is an area that could benefit from capacity strengthening.

Another important consideration for bioenergy development is the potential conflict between food production and energy generation. Bioenergy development has been criticized for impacting negatively on food production due to changes in land use. Based on lessons learn from cogeneration development in Mauritius, it appears that, at the peak of the country’s cogeneration development, there was neither an increased competition for land, neither did it lead to the increase in food prices – the two most notable negative impacts of large scale bioenergy development. In fact, in the case of Mauritius, over time, while increased cogeneration development has led to additional electricity supply, the land area on which sugarcane was cultivated has been declining (MSIRI, 2006) – implying that efficient cogeneration development partly led to freeing up land for other uses, including food production. The following figure shows electricity generation from cogeneration compared with land area under sugarcane production in Mauritius:

Land Area Under Cane in Mauritius vs. Electricity Output from Sugar Industry



Source: MSIRI, 2006

4.3 Social Considerations of Sustainable Cogeneration Development in Kenya

Minimizing negative impacts of cogeneration development on society is an important part of sustainable development. Cogeneration development has several positive impacts on rural communities where sugarcane is grown. For example, cogeneration development does not impact on existing settlements and therefore does not lead to displacement of communities.

Cogeneration development enhances job creation opportunities in sugarcane growing zones. At the minimum, by ensuring the survival of Kenya's sugar industry post-2012, cogeneration assures the security of existing jobs. Expansion of cogeneration development invariably leads to increased sugarcane production which, in turn, requires additional labour – thereby increasing job opportunities.

Furthermore, as mentioned earlier, about 90% of all the sugarcane delivered to sugar factories in Kenya is supplied by small scale farmers (KSB, 2009). Most of these farmers rely on sugarcane production as their only source of income. Consequently, by increasing sugarcane production, to meet the increased demand by sugar factories leads to an increase in the small holder farmers' income levels.

Aided by cogeneration development, the survival of sugar factories in Kenya is crucial for the social welfare of rural communities residing in the sugar belt of Kenya. This is because all sugar factories provide important social amenities such as hospitals, schools and clean water. In addition, sugar factories are heavily involved in roads maintenance, therefore improving road networks in the rural areas.

5.0 Existing Barriers to Cogeneration Development in Kenya

As mentioned earlier, Kenya's potential for bioenergy by using cogeneration is significant. However, several barriers appear to be in the way of the country to fully realize its cogeneration potential. These barriers are discussed below:

Flexible Feed in tariff: As previously noted, Feed-in Tariff Policy has spurred interest in cogeneration development in the country. For example, by mid-2009, the Ministry of Energy had received proposals for cogeneration development amounting to nearly 270 MW (Kiva, 2009). However, the lack of a "fixed" feed-in tariff implies that an investor in cogeneration has to negotiate with the distribution utility. However, institution of firmly fixed tariff levels eliminates the notion of negotiation with the utility – which, from past experience, has been a lengthy and difficult process.

Non-enforceable legal and regulatory instruments: Since cogeneration investments are long term in nature, it is imperative that the existing and future legal and regulatory instruments are enforceable by a court of law. The recent experience of Mumias Sugar where the distribution utility has not been providing priority dispatch as required by the Feed-in Tariff Policy could discourage cogeneration development in the country.

Lack of technical expertise: Due to the country's limited experience in cogeneration development, there is limited expertise available on cogeneration development. The skills gap ranges from lack of experts to carry out comprehensive and bankable feasibility studies and engineering studies to the expertise required for the construction, installation, commissioning and maintenance of advanced cogeneration equipment such as steam turbines and high pressure boilers.

Unavailable local financing: While nearly all sugar factories bank with local commercial banks and, in some cases, enjoy healthy business ties, unfortunately, local commercial banks do not have the experience or technical capacity to conduct the requisite due dilligence for financing of cogeneration plants. Consequently, sugar factories have to seek investment financing from the regional and international development financing institutions which are not as familiar with the operations of Kenya sugar factories thus complication the process of raising investment finance for cogeneration.

Confidence among small holder farmers: Perhaps the least problematic barrier yet the most crucial component for successful cogeneration development is the confidence among sugarcane small holder farmers. Having experienced nearly two decades of systematic degradation of the publicly-owned sugar industry in the country, it is not surprising that a significant number of small holder farmers are likely to adopt a wait-and-see attitude before committing addtional investment in increasing sugarcane acreage to meet the foreseeable increased demand in sugarcane by sugar factories arising from increased investment in cogeneration.

Protracted sale of State – owned sugar Factories: State-owned sugar factories form the bulk of sugar factories in Kenya. The fact that all of them are either defuct or technically insolvent implies that they cannot embark on the much needed cogeneration investment. Their planned privitasation has been ongoing for about a decade therefore denying the small holder farmers of reliable revenue stream from sale of sugarcane to the factories.

6.0 Policy Recommendations and Conclusions

This report demonstrates that Kenya has a significant bioenergy development potential, especially with regard to cogeneration. In order to realize the full potential of cogeneration, the following policy recommendations are proposed:

Institution of pre-determined feed-in tariffs for bioenergy power plants: A pre-determined feed-in tariff can limit market uncertainty, which stands in the way of substantial investment in cogeneration development in the region. In addition, a Power Puchase Agreement, linked to a pre-determined standard-offer or feed-in tariff, from the national utility to purchase all energy produced by cogeneration plants can be instrumental in the successful scaling up bioenergy investments the Kenyan power sector (AFREPREN/FWD, 2006).

In India and Brazil, development of feed-in-tariffs has directly increased electricity generation. In India, it has promoted the operation of over 500 sugar mills, with a significant number of mills in the pipeline, that produce and sell electricity to the grid (WADE, 2004).

High-Pressure Technology and Skills Transfer (Capacity Builiding): Another lesson learnt from Mauritius as well as the Mumias case studies is that emphasis should be on encouraging existing agro-industries to adopt high-efficiency bioenergy technologies e.g. cogeneration power plants that can efficiently utilize existing solid biomass wastes to generate electricity for own consumption and sale of excess to the national grid. This can be achieved through the introduction and dissemination of high-pressure advanced cogeneration systems with capacity and skills development support from the Government and other initiatives such as the Cogen for Africa project (Http://cogen.unep.org). In addition, technology transfer could be attained through technical cooperation with other developing countries with good experiences in cogeneration development such as Mauritius, India and Brazil.

Innovative Financing: Innovative financing schemes should be developed by financial institutions (especially local commercial banks) in collaboration with project developers. Interaction between financiers and project developers could help bridge the knowledge gap on both sides – financiers would gain a better understanding of cogeneration technologies while project developers would have a better appreciation of pre-requisites for raising financing for cogeneration investments.

Kenya can tap into the various international and regional initiatives that can provide funding for bioenergy projects. These initiatives include: the Global Environment Facility (GEF) and the Kyoto Protocol's Clean Development Mechanism (CDM). One drawback of the CDM, however, is its high transaction costs and specialized skills requirements that have tended to limit the participation of African countries, such as Kenya. There are useful lessons to be learnt by Kenya and other African countries from the experience India, China, Brazil and Mexico, on how to expedite CDM cogeneration projects.

Innovative Revenue-Sharing Mechanisms: Perhaps the most useful lesson learnt from Mauritius is that the benefits of bioenergy development should trickle down to the small-scale farmer involved in growing the feedstock. One way of ensuring support for the development of cogeneration is by instituting a revenue-sharing mechanism where proceeds from the sale of cogenerated electricity are shared equitably among the key stakeholders - including the small-scale farmers who provide sugarcane. Revenue sharing mechanisms similar to the one implemented in Mauritius can work in the Kenyan sugar industry.

Sustainable Bioenergy Feedstock Development: One of the lessons learnt from the case study of Mauritius is that, bioenergy projects in Kenya should primarily focus on more efficient exploitation of existing agricultural wastes. This is crucial as it presents significant bioenergy potential without unduly disrupting existing agricultural practices and food production or requiring new land to come into production. For example, unlike many other agricultural sectors, biomass cogeneration-related waste products (e.g. bagasse) are generated during agro-processing and are rarely returned to the field. Consequently, use of such agricultural wastes for energy generation is unlikely to have a detrimental impact on soil management and food production and could potentially constitute an important additional source of revenue for the poor.

At a later stage, and with sustainability guidelines in place, the development of bioenergy dependent on energy plantations on new land can be assessed. Although useful long-term scenarios of potential conflict between food and bioenergy plantations have been undertaken, available data is still not fully conclusive. With agricultural practices in Africa being very inefficient, there is substantial bioenergy production potential to be tapped simply through increased productivity on existing lands. Additional research is required to provide a more nuanced and disaggregated understanding of the biomass energy production potential as well as the potential role of bioenergy technologies such as cogeneration.

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