THE STATUS OF RENEWABLE ENERGY IN KENYA

A study into the Status and Potential of Power Generation from Biomass Waste in Kenya

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EXECUTIVE SUMMARY

Energy has been clearly identified as the prime mover that propels the wheel of economic development. Access to modern energy affects quality of life and supports the three pillars of sustainable development: social equality, economic growth and environmental protection. Sub-Saharan Africa and countries with low per capita consumption of commercial energy continue to exhibit correspondingly low per capita gross domestic products. In a continent where both per capita income and energy consumption are both tragically low, renewable energy will be the solution to clean and sustainable energy that will fuel economic growth and spearhead the fight against poverty.

In the search for economic prosperity, too much emphasis has been placed on conventional energy, mostly powered by fossil fuels that create serious environmental and social costs. Local air pollution, regional acid deposition and global climate change are only some of these costs which we all must pay, now or in the future, regardless of our local address. Renewable energy technologies, on the other hand can provide clean, sustainable and ultimately, affordable supply in the region while providing additional social and economic benefits.

There exists, however, considerable resistance to the adoption and assimilation of renewable energy technologies, especially among the decision makers within the African Energy Sector. Lack of information and understanding in an area perceived as new, and therefore untested, has encouraged decision makers to stick to ‘business as usual’ policies, even when the facts indicate a new alternative should be explored. Policy and infrastructural barriers have also discouraged potential investors in this field. However, the situation is changing.

Power sectors all over the world, but more so in Africa, have been undergoing radical reforms over the last decade. Power companies which were vertically integrated monolithic giants are being unbundled into horizontal organisations; most are being commercialised with a view to privatisation; independent power producers are entering the scene; new regulating authorities are being empowered to act autonomously of the power companies. These reforms provide policy makers with a window of opportunity to establish policies and regulatory frameworks that are friendly to renewables. Indeed, developments in Kenya heralded by the recent announcement by the Ministry of Energy are positive signs: the field is opening up for anybody with ability and resources, to apply for licensing to generate and sell electricity to the public. Sugar companies in particular have been encouraged to invest in cogeneration plant, and the power distribution company KPLC has been ordered to buy all available power from them.

The World Summit on Sustainable Development WSSD suggested a 10% target for renewables, a challenge that was received with considerable resistance by most African countries. A close study however, reveals that a 10% renewables target is not only achievable but indeed desirable. In the case of Kenya, this target has been achieved in the electricity sector by geothermal power alone. The potential from co-generation will not only surpass the target but also confer numerous additional benefits: job creation and additional income generation in the agricultural and industrial sectors, savings in foreign exchange, strengthening and diversification of electricity generation mix, not to mention the reduction in greenhouse gasses emitted to the atmosphere.

In order to push the case for renewables, it is necessary that policy makers be provided with the facts and figures that clearly demonstrate the opportunities offered by renewables. As the power sectors are restructured, the true costs of the various options become known, the opportunities for investment in renewables will be best served by an appropriate mix of private and public partnership. However, a free market does not function according to the rules of social responsibility and therefore needs to work within boundaries that serve social and environmental as well as economic goals. Policy makers have a social responsibility to set these boundaries. Legislators and regulators have it in their control to shift the future energy portfolio if they choose to decrease demand by improving energy efficiency and to push energy generation towards renewable energy.

Social, environmental and energy security concerns, coupled with improved renewable energy technologies, add to increasing the support for renewable energy. The challenge is to introduce the right policy frameworks, and financial tools to enable renewable energy technologies to achieve real market potential. This is particularity crucial in developing countries where investment is endangered by political, economic and regulatory risks, and where lack of development financial markets and products leaves the risk resting solely on the shoulders of the investor or the lender.

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1.0 BACKGROUND

1.1 Introduction

Energy is not considered as a basic need, but it is a basic ingredient in the successful satisfaction of most basic human needs. The level and intensity of commercial energy use is a key indicator of economic growth in a country. In Kenya for example, the consumption of commercial energy has seen a decline over the last three decades due to a weak and sluggish economic performance.
Conversely, the cost and accessibility of energy has significant impacts on all economic activities. Lack of reliable energy supply discourages business activities, while high energy costs result in expensive goods, frustrating endeavours to export.

1.2 Status of Energy Sector

Figures released by the Ministry of Energy (2002) indicate that the energy sector in Kenya is dominated by biomass based fuel: fuel-wood and charcoal are the primary cooking fuel of the poor, accounting for over 68% of national consumption. Petroleum based fuels used in the transport and industrial sector account for another 22%, while electricity contributes 9%. The balance is shared between renewables such as wind power, solar amongst others.

In terms of commercial energy, fossil fuels lead the league, with some 2.5 million tonnes of petroleum fuel consumed in 2002, and projected annual growth rate of 2%. Practically all this quantity is imported and constitutes almost one quarter of the total national import bill.

The contribution from electricity amounted to some 4700 GWH of electricity energy in 2002. Of this, roughly 20% was generated from thermal plants burning petroleum products. The rest came from renewable sources, mainly hydro and geothermal. A sizeable amount of energy is also generated and consumed in-house by sugar factories burning bagasse and fuel-wood to produce process steam and electricity for own use.

1.3 Status of Electrical Power Sector

The commercial generation of power in Kenya is dominated by hydro-based supplies. Of the 1235 MW installed capacity in 2003, 707 MW was from hydro (including 30MW imported from Uganda) 121MW geothermal while 398 MW came from fossil fired thermal stations of which 173MW was from Independent Power Producers (IPPs), while the rest belong to the Government owned KenGen, the major power generating company. The effective capacity was 1123 MW, while the maximum demand was 831 MW.

Table1.1 Existing system generation installed and effective capacity 2003

	Generation source	Installed capacity KW	Effective capacity KW
1	Hydro, KenGen	677	654
2	Hydro Import	30	0
3	Geothermal, KenGen	109	109
4	Geothermal, IPP	12	12
5	Wind, KenGen	0.35	0.3
6	Thermal, KenGen	224.	166
7	Thermal IPP	173.5	173.5
8	Isolated Stations	9.6	8.8
9	Total	1235.45	1123.6
	System Peak Demand		831

1.4 Least Cost Power Development Plan: Identified Potential

The LCPD plan is a twenty-year forward plan which is the tool used by the Ministry of Energy to identify power resources and to asses their financial viability before power projects are commissioned. Initially prepared in 1986, it is updated annually, as a joint effort between the ministry and Kenya Power and Lighting Co. (KPLC), with recent input from KenGen and the Electricity

Regulating Board (ERB). The aim is to look twenty years ahead, and keep supply always ahead of demand by implementing power projects in a timely and cost effective way.

1.5 Potential for Hydro-Power Generation

Undeveloped hydroelectric power potential of economic significance is estimated to be 1558MW of which 1310 MW is for projects of 30MW or bigger. Of this, 434MW has been identified in the Lake Victoria basin, 264 MW in the Rift Valley basin 109 MW on Athi River basin, 604 on Tana River basin and 146 on Ewaso Ngiro North River basin.

Out of these, detailed resource assessments have been done for a small number. On Lake Victoria basin, Sondu-Miriu (60 MW) is under construction while an additional 21MW of viable capacity has been identified downstream. On the Tana River and Ewaso Nyiro basins, a further 420MW have also been identified. However the projected generation costs for these currently exclude them from the LCPD plan.

Small, mini and micro-hydro system (with capacities of less than 10MW each) has been estimated at 3000MW nationwide, mostly within the same basins as the large hydro considered above. The exploitability of these is limited by their projected costs, but they could be useful for off-grid rural electrification.

1.6 Geothermal

Geothermal resources within the Rift Valley have been estimated at some 2000MW that could be exploited for electricity generation for at least 20 years. Currently 121MW is being exploited, while a further 45MW is expected on stream in 2005. A further site for 70MW (Ol Karia IV) has been identified and plans for full appraisal are in progress.

1.7 Status of Cogeneration

Potential for cogeneration exists in industries and processes where steam is generated for process requirements, and either excess steam is available or excess fuel is available that will cost effectively generate electricity. This situation occurs in the sugar industry where steam is raised from bagasse, a waste product of the cane milling process. The steam is used in the sugar making process, and some of it is used to generate power for the internal requirements of the factories. A total of 36.5MW capacity is installed in the six operational sugar factories in the country. Unexploited potential also exists in the wood (sawmill) industry and paper making process.

The total amount of crop residues produced in the country has been estimated at 2,663,000 tonnes (Ministry of Energy, 2000). The more significant of these include rice husks, maize cobs, coffee residues and spent grain from brewing and other processes. Where economic quantities exist, most of these residues are already finding appropriate use.

Table1.2 Cogeneration in sugar factories

FACTORY	**WESTKENYA**	**MUHORONI**	**NZOIA**	**MUMIAS**	**CHEMELIL**	**SONY**	**TOTAL**
CANE CRUSHED (2002) TONNES	205227	413070	568098	2207120	602304	580516	4576335
SUGAR PRODUCTION TONNES	18912	36409	56948	257094	60501	59338	489202
BARGASSE TONNES	85099	180477	234046	799166	256959	205546	1761293
INSTALLED GENERATION CAPACITY MW	1.0	3.0	4.5	15	6.0	7.0	36.5
CRUSHING CAPACITY TCH	50	92	125	350	125	125	867

1.8 Bagasse in Perspective

In 2002, Kenya produced 1,760,000 tonnes of bagasse with a gross calorific value of 16800 tj, (1tj=10 ^{12}joules) equivalent to some 400,000 tonnes of oil. In conditions such as have been established in Mauritius, this cane will produce excess electricity for sale, equivalent to 360-500 GWh, depending on choice of technology. On the other hand, under normal hydrology, all the hydro power stations in the country will produce 3200-3400 GWh of electrical energy annually. Under drought conditions, this capacity reduces to 2100 GWh. The equivalent generation is 350 GWh from geothermal, 750 GWh from thermal IPPs, 300 GWh from Kengen thermal station. Other sources including the isolated power stations provide the difference to make up the total of 4800 GWh national consumption. The potential bagasse generation is therefore about 10% of the national capacity.

2.0 METHODOLOGY

Much of the data and information used in this document has been received fro the Ministry of Energy, either from their library documents, or from papers presented at various fora. Where possible the accuracy of the information has been counterchecked by alternative sources.

Information from sugar factories has been collected directly from the various sites via direct interviews with management and staff of the factories. Interviews have also been conducted with officials from various government ministries, parastatals and relevant organisations. Data has also been received from the Kenya Sugar Authority through their Annual Databook.

Information on cogeneration in Mauritius has largely been gathered from the various AFREPREN publications. Similar information has also been collected from the Internet.
Some of the information has come from the libraries of Nairobi University, and Jomo Kenyatta University.

By far the largest information has come from the internet. Various factories in India, Iran Jamaica, Cuba, Brazil, U.S.A., among others, have posted information on their websites, which have been downloaded and used for comparison. By and large, the information from Mauritius is more reliable, as their track record seems to be longer and more solid. Consequently, their figures have been used as the basis of most suggestions. Other data has been used to crosscheck

3.0 ASSESSMENT OF COGENERATION POTENTIAL

3.1 Options for Generation

Unlike other industries which only consume energy, the sugar industry can generate surplus power over and above its internal requirements. This is because the cane contains nearly 30% fibre with a significant energy content which can be usefully harnessed for energy production. Because of statutory and other limitations on the sale of electricity, the practice in most sugar plants has been to treat the bagasse as a nuisance and to burn it as a process of disposal. Sugar plants have produced process steam and power, largely as a by-process.

The recent announcement by the Kenyan Energy Minister, Hon. Ochillo Ayacko, permitting sugar companies to generate and sell energy to the grid and to the public in general, opens up new avenues for revenue creation. Various fiscal incentives for investments in regular and non conventional renewable energy projects have also been suggested for inclusion in the national energy policy document. The consequence is that, for cogeneration in sugar plants, it has become a viable proposition to raise high pressure steam in modern high efficiency boilers using bagasse and cogenerate heat and power economically to make available surplus power for export. The power and process steam in a sugar plant can be met in one of two ways: conventional cogeneration, or integrated gasification with combined cycle (IGCC).

3.2 Conventional Cogeneration

Conventional Cogeneration method deploys bagasse-fired boiler in conjunction with extraction condensing and/or back pressure steam turbine coupled to electrical generator or double extraction condensing turbine coupled to electrical generator. In this method, two alternative schemes for supply of process steam and power could be used: a back pressure turbine sized to meet the in-house electrical load and an extraction cum condensing turbine to meet balance process steam requirement and generate exportable power. This is termed as segregated mode of operation due to the fact the export power generation is made independent of the captive load during normal operation of the sugar complex. The second option is to use one double extraction, condensing turbine providing both process steam and in-house and exportable power, with proper system controls to isolate from KPLC power grid in case of abnormal disturbances or faults and to continue operation of generator at house load.The use of back pressure turbines to meet in-house electrical load is commonly used in sugar plants in Kenya today. A number of small capacity, low pressure, bagasse-fired boilers supply steam to number of small sized, back pressure turbo generators, which operate independently of the external electrical system of the national grid, and the external power system disturbances do not affect sugar plant operation. In addition the crushing mills and other drives are also powered by condensing turbines. The efficiencies achieved by these plants depend largely on maximum system pressure used and the exit temperature of the flue gases. Pressures of 20 to 25 bars as currently employed in Kenyan factories yield very poor efficiencies (less than 10%). For steam pressures of 45 to 66 bars, system efficiencies of up to 25% are achieved, permitting electricity export of up to 100KWH per tonne of cane. Plants with performances of 110KWH per TC are currently operational in Mauritius and Reunion, among other areas. The operating pressures are at 82 bars, which is the current industry boundary controlled by metallurgical limits of the boiler materials.

The process of getting more power from bagasse is essentially an efficiency upgrading exercise, and should be accompanied by a modernization and capacity improvement of sugar mills and associated cogeneration plant through the replacement of turbine mill drives with electro-hydraulic or D.C. electric drives. Efficient use of bagasse in high-pressure boilers will enable the plants to make and export/ surplus electrical power to KPLC grid. Electrical systems also need to be operated at higher voltage levels, commensurate with the capacities exported.

3.3 Integrated Gasification with Combined Cycle

Integrated Gasification Co-Generation with Combined Cycle (IGCC) technology uses an external combustor known as a gasifier, to fire the bagasse in an external combustor. The combustible gases produced are passed through a cyclone to clean the flue gases and then fired in a modified gas turbine. The hot exhaust gases from the gas turbine are passed through waste heat recovery boiler for generating steam for process requirement and for generation of power. Some of the exhaust gas is used for drying bagasse. The moisture content in the bagasse, convert into steam and is usefully employed in driving the gas turbine to generate more power. With this method, the cycle efficiency of the system in converting bio-mass fuel energy into electrical energy is much higher, and plant efficiencies of up to 37% have been achieved. However, because the IGCC system is still at experimental stage and not commercially proven, it is not prudent to adopt the technology at this stage.

3.4 Proposed Technology for Cogeneration Plant

In view of the above considerations, it is suggested that boiler pressures should range between 45-82 Bar. The lower level of 45 Bar, 475°C can be achieved with minimal outlay, and the technology is similar to current practice, but will restrict output of export power. On other hand, the upper level of 82 Bar 525°C requires heavy capital investments and training of staff in the state-of-the-art technology. In the long run, the higher pressure provides better value for money when lifetime costs are considered. It is however recommended to match the boilers with two double-extraction cum condensing turbines to provide process steam and power. The turbines will be used as straight through condensing turbine during non-crushing season, when process steam requirement is negligible, to maximise export of power.

3.5 Development of Cogeneration

Experience from other countries, including Mauritius, Reunion, India, Brazil and Cuba, among others, indicates that the practical potential for cogeneration will be limited by three main factors, namely: technology employed, financial resources and options, and legal and regulatory framework, as affected by the political and economic atmosphere.

The development of cogeneration usually evolves along some well-established stages:

a) Own generation: usually to supplement or replace grid supply. In this stage, fuel in the form of waste products (bagasse, trash) is burnt in low pressure boilers, mostly to get rid of it. Steam is generated for process, excess is used to produce electricity, to supplement or substitute or replace grid supply. This is the situation in Kenya today.

b) Intermittent Power: excess electricity is sold to the grid, only when fuel available and capacity permits. Sometimes the power is used to reinforce grid during peak periods. In Kenya, only Mumias factory has the capacity for intermittent power supply, but has been constrained by regulatory barriers. During the crisis of 2000, they were able to sell power, this time limited by the capacity of interconnecting transformers linking them to the grid.

c) Continuous Power: intermittent supply is developed and regulated to run for as long as fuel exists: i.e. power supply ceases during out-of-cane season. This situation is common in Mauritius and India where the crop season is short (around 200 days per year). Other fuels such as coal and fuel oil can be used during out-of-cane season to change the plant to firm generation.

d) Firm generation: commercial generation onto the grid on a continuous basis providing an agreed amount of energy and power. For this scenario, power supplies often use dual fuels, such as bagasse in season and coal or fuel oil off-season. Where appropriately designed, bagasse can be stored for later use.

In following the best practice, it is prudent to learn from the experience of Mauritius, avoid the intermediate steps and go straight for firm power supplies. Kenya has the advantage that the crop season lasts almost 300 days in a year. The rest of the out-of-cane season is usually during the wet season when the hydro stations have their maximum capacities. Annual maintenance can be carried out during this period. Stored bagasse can be used to provide limited power for the factories and their surroundings during this period.

4.0 KEY CONCLUSIONS

4.1 Technical Viability of the 5% Target

As indicated above, sugar factories in Kenya already generate for their own use, but only Mumias has extra capacity to be able to export to the grid, as it did during the drought crisis of 2000. However, this extra capacity is very small (5 MW) and further limited by the capacity of the link to the grid. The rest of the factories are net importers of electricity from KPLC. For the 5% target to be economically viable, factories will need to invest in firm generation, through equipment with efficiencies high enough to generate economic quantities of power for sale to the national grid. Some of the issues to be addressed are:

- High efficiency boilers to be installed in modular capacity, in a phased manner. Each unit made up of boiler/turbine generator set and controls.
- Ample storage capacity bagasse shed to cover 24 – 36 hours generation capacity to cover fortnightly maintenance stoppages. Larger storage may be required if total autonomy is necessary during out of cane season. Bagasse density is approximately 130 kg per cubic metre.
- Factory efficiency optimisation: all steam drives for process equipment to be replaced with electric motor prime movers of approved design. Where possible, high efficiency processes (such as diffusers for juice extraction) to replace conventional equipment.
- Maintenance of sugar plant to be arranged to coincide with wet season when excess KenGen hydro supply can replace bagasse power. This will reduce the need for large storage facilities for bagasse.
- Additional investment on best methods to harvest cane trash, and to process the same as boiler fuel. Additional fuel capacity of 20% is possible via this method.
- Encouragement and promotion of (local indigenous) private sector participation in the sugar factories to encourage accountability and sound corporate governance policies.

If handled correctly, cogeneration investment will enhance security of supply by diversifying fuel and source.

- Promotion of indigenous energy source; displacement of imported fuel currently used in thermal generation.
- Promotion of local capacity for IPP. Experience gained can be shared by other factories in similar circumstances.
- Import some financial benefits to cane farmers (out growers) to stimulate additional investment to cater for improved and more reliable fuel supply
- Provide appropriate entry point for private sector into sugar business currently dominated by government. Stimulate capacity building at individual and institutional level

4.2 Survey of Major Investments Required.

a) Boiler/Turbo-alternator sets and controls: these must be imported new, or if used, must be reliable equipment in good condition.

b) Electrical switchgear and metering
  - Transformer switchboard for external connection
  - Revised power distribution inside plant
  - Overheads line link to load centres

  Local expertise already exists for the supply of these items, although some equipment will be imported for local assembly

c) Civil works
  - Power house
  - Bagasse shed

  Local expertise for design and erection of civil works in available

d) Mechanical works
  - steam distribution from new power house to existing plant

  Bagasse handling equipment
  - to boiler
  - to shed
  - reclamation system for shed

  Some equipment may be imported for local assembly, but most of the mechanical works should be supplied and installed locally.

e) Plant efficiency improvement

  -replacement of steam turbine drives with electric motors

  -imported motors with their controls will be rigged and mounted locally.

Statistics from Brazil indicate that a well managed cogeneration plant will crate between 3.5 to 5.2 jobs per GWH. Most of these jobs will be created upstream, especially in the sugar plantations supplying the cane. In the case of Kenya, most of the sugar factories have over-employed (on account of past political interference), and the burden is to make current employee levels sustainable. For example, Mumias has an output ratio of 3500 tons per employee, while the world standard is 7000 tons per employee.

It is clear that the success of cogeneration in the industry will depend on how well the industry is managed.

4.3 Economic Assessment of Cogeneration Potential

Except for disparities caused by management performance, three sugar companies have identical capacities. They include Nzoia, SONY and Chemelil, all rated at 125 TCH. Muhoroni, now under receivership, used to be in the same league but is now limping along at 70% of the capacity. Miwani, also under receivership has similar capacity but has been closed for over two years now, with little signs of reopening soon. Mumias with a capacity of 350 TCH now produces half of the national production of sugar after crushing as much cane as all the other factories combined.

It is clear that the current operational performance as much as the installed capacity will be a limiting factor in the performance of the power plant. The cane crushing process is the major source of fuel for the power plant. Experience from success stories elsewhere, indicate that cogeneration projects should be managed separately from the sugar plants associates with them. The power plants should be designed for rated output of the sugar plant and both should target maximum capacity production.

A large contribution to the dismal performance of the sugar factories has been attributed to political interference with factory administration and management. Unregulated importation of cheap sugar has flooded the local market in the past, resulting in cash flow problems when the local factories were unable to sell their sugar. Over employment has also affected performance in the past. The management teams in all the factories are addressing these issues as the government has shown reluctance in providing quick bail outs as evidenced by the fate of Miwani and Muhoroni. The importation of cheaper sugar from COMESA has been kept on hold for a four years period to enable the factories to put their houses in order.

Of the total capital costs of the sugar factories, about 60% is attributable to the cost of the power plant. A number of the factories are planning some capacity expansion program, and most are in need of a large degree of reinvestment to replace obsolete plant. The power plant should therefore be designed to take expanded capacity in future. Boiler and turbines can then be installed in modular units which can be replicated, provided adequate provision has been made for their physical location. It is expected that improved efficiencies arising from better cash flows and more reliable steam and power will result in higher cane output from the farmers. Sugar farmers are currently frustrated by poor prices and late payments, will be motivated to put more land under cane. Ultimately, capacity will be limited by land available for cane, and by efficient agricultural production, account being taken of need to balance food production against commercial sugar cane plantation.

Tariffs:
A significant proportion of the electricity generated is consumed at the plant. At present, all the factories are net importers of power, either due to inadequate capacity, or in the case of Mumias, inadequate arrangements for generation when sugar plant is under maintenance. The sugar plant therefore becomes the first customer for the power plant deriving its steam power and associated services, from the power plant, in exchange for bagasse fuel. Depending on the plant efficiency, between 30-60% of the power generated will be consumed at the plant.

In order to sell their power to KPLC grid, the power plant will require an appropriate link, consisting of power transformers, electrical switchgear with metering and an adequate power line linking to the grid. At the moment, this is grey area and some negotiation with KPLC will determine how much of this cost should be borne by the power distributing company.

In terms of bulk tariffs to KPLC, case studies and experience from other countries indicate a purchase price of 5-7 US cents per KWH. These figures are higher than KenGen rates (2-3 US cents /KWH plus cost of fuel), but KPLC have indicated willingness to negotiate. The lower figures have therefore been used in calculating rates of return and payback periods for the cases considered in this document.

4.4 Investment Costs

As noted above, up to 60% of the cost of a sugar factory is the power plant. In a situation where the sugar factories are largely owned by the government, a policy decision must be taken as to possible involvement of private sector funding. Such a relationship will influence sources and costs of funds. It should be mentioned that sugar factories in Kenya are in serious need of private sector fiscal and managerial discipline.

Four government owned sugar companies, Chemelil, Nzoia, SONY, and Miwani are in the same league of 3000 TCD. All of them are planning or hoping to expand capacity to 5000 TCD. Detailed case studies have therefore been based on 5000TCD capacity and can be adjusted for other volumes.

Table 4.1 Estimate of plant capital costs

Boiler Pressure	45 Bars	60 Bars	82Bars
Recommended Plant Capacity	5000 TCD	5000 TCD	5000 TCD
Boiler Capacity	140 TPH	140 TPH	140 TPH
Bagasse feed rate	58 TPH	62 TPH	70 TPH
Turbine Capacity	25 MW	30 MW	50 MW
Daily Power Generation (Gross)	420 MWH	550 MWH	820 MWH
Equivalent Capacity	18 MW	24 MW	40 MW
Daily Export Power (Net)	260 MWH	330 MWH	550 MWH
Equivalent Export Capacity	12.5 MW	14 MW	24 MW
Total Capital Investment	US$ 18 M	US $ 25M	US$ 75M
Estimated Local Component	US$ 4 M	US $ 5 M	US$ 12M
Estimated Annual Revenue from Electricity	US$ 4 M	US $ 5 M	US$ 8.3M
Simple payback period	4.5 years	5 years	8.8 years

The investment costs as net export capacity varies from $1.44M per MW at the lower pressures, $1.8M per MW mid range to $3.1M per MW at the top end. This compares with $0.7-1M per MW for diesel powered engines for hydro power plants. It is worth noting that thermal power plants have significant fuel costs which are passed directly to the consumers under current tariffs.

4.5 Costs of 5% Capacity as Target

The 5% cogeneration target will require installation of 55MW generation plant, with a peak demand capability of 39 MW, and delivering 240 GWH per year. This corresponds to installation of 2 boilers of 120 TPH capacity each, at 82 bar pressure at Mumias, a total investment of US$120 million with a simple payback period of 8-9 years. An alternative investment would be matching installation at 60 bar pressure at four stations, namely, Mumias, Chemelil, SONY, and Nzoia. The corresponding costs would be US$ 80 million, with a simple payback period of 6-7 years. A third option would be to operate at 45 bar pressure, when it is possible to upgrade existing equipment at a reduced cost.

In principle, the higher operating pressures offer better efficiencies, and therefore better utilisation of resources. However, they also entail higher capital costs, and more sophisticated levels of technology. On the other hand, power projects tend to be designed for relatively long existence, and operating lives of 25 to 30 years are common. The more efficient units are more attractive over these periods.

Capital project costs in developing countries tend to get distorted by a number of factors external to the projects themselves. Chief among these are corrupt predators, often well politically connected persons trying to make a killing from the procurement system. Consultants specifying the projects often abet this process, either deliberately, or by sheer incompetence. Either way, loopholes in contract documents are exploited to extort money out of the project and distort project economics. Sometimes the project design is financed by donor grants, in which case the consultants invariably come from the donor country, and proceed to specify equipment from their own country, often when more cost effective equipment is available from elsewhere. Power projects, because of their financial magnitudes, often attract more than their fair share of these problems.

Like other renewable energy technologies, cogeneration lends itself to modular implementation. It is therefore possible to break down a large project into smaller units which can be implemented in phases. Apart from being easier to finance, these modules reduce the impact of the project on the system enabling planners to match demand with supply.

4.6 Impact on the National Economy

The total value of the annual bagasse production is 1,760,000 tonnes (2002), a gross equivalent of some 400,000 tonnes of petroleum oil (net 323,000 tonnes). At US$ 600 per tonne, this is worth some US$194 million. With appropriate investment, this can be used to generate steam and electricity to power our sugar factories and export up to 550 GWH of electricity to the national grid.

This will displace energy currently produced from fossil fuels. At the average specific consumption of .22 tonnes of oil per MWH, this is an annual saving of US$ 90 million of foreign exchange.

4.7 CDM and the Environmental Policy Perspective

It is important to remember the contribution of cogeneration within the sugar industry, as regards carbon sequestration. The Sugar cane plant is an efficient consumer of carbon dioxide.

Cogeneration as discussed in this paper provides an opportunity for reduction of GHG emissions, while strengthening the infrastructure base in relations to electricity supply. However, left on their own the institutions lack the ability to develop these resources into functional projects. The application of outside funds, either through direct private investment, or directed through public channels, will be essential to the realisation of the projects. In this connection a brief survey has been given to Clean Development Mechanisms and other tools related to the Kyoto Protocol, including the Prototype Carbon Fund and the Community Development Carbon Fund. While these instruments are relatively new, their use is becoming increasingly widespread. A recent study by Michaelowa, Krey and Butzengeiger indicates that the going rate for emissions purchase (around 3€ per tonne of CO2), they can improve the financing of large scale projects. However, on their own, they will not provide any great relief unless special rates can be arranged. They also note that for project developers, the lengthy CDM project cycle will generate transaction costs that make CDM projects worthwhile only above 20,000 tonnes of ‘certified’ CO2 emission a year. In addition, CDM can only be harnessed if host countries set up transparent and effective approval and promotion institutions, in addition to providing some specified incentives to private companies.

The exact impact of the application of CDM to the cogeneration projects considered in this document is currently being considered under a separate study.

4.8 Impact on the Sugar Industry

The sugar industry in Kenya today is struggling to stay afloat, battered by cheap imports from the COMESA and other sugar producers, and overwhelmed by high production costs. The local sugar factories continue to report financial losses year after year, while the sugar farmer is owed millions of shillings. The answer lies in creating alternative and additional products from sugar cane utilising waste products currently disposed of at some costs. Power generation from bagasse and other biomass waste will be the easiest to realise, while production of alcohol for medicinal and fuel use has been successfully tested in one local factory. Other possible products are paper and industrial boards from bagasse and cane leaves, and animal feeds.

Power generation from sugarcane waste offers the opportunity to achieve several goals with one effort. The power sector will benefit from additional generation of power from a stable indigenous source. The energy will replace more expensive generation from thermal sources burning imported fossil fuels. The factories will have adequate affordable electricity and steam for process purposes, while the placing of the power function in a separate and more efficient entity, leaves the sugar specialists with time to concentrate on their core function. The excess electricity sold to the national grid will improve the revenues and profitability of the sugar factories. The farmer will benefit from prompt and better pay for their cane. In addition, they will be able to sell the cane trash for power generation, further improving their rewards. It is expected that this chain of activities will result in more jobs for Kenyans, and a general reduction in poverty levels.

The combustion of sugarcane biomass is environmentally friendly as it produces less greenhouse gases than the traditional fossil fuels. The investment therefore qualifies under the Kyoto Protocol, for financing under the Clean Development Mechanism. By participating under the World Bank’s Community Development Carbon Fund, additional benefits will accrue to the farmer, and to the community, thereby supporting the poverty eradication initiative.

5.0 DISCUSSIONS

5.1 Challenges on Cogeneration

Clear Government Policy
The starting point for a successful bagasse cogeneration program is a clear government policy recognizing bagasse as an important resource, spelling out measures to facilitate development and implementation of bagasse based projects. The measures should stimulate investment in efficient generating equipment by offering tax exemptions and other incentives for investment in firm generating plant and other efficiency improvement plant.

Performance of Sugar Factories
The success of cogeneration projects within the sugar industry will depend on the performance of the factories, which may limit fuel supply and energy availability. Concern about corporate governance issues and apprehension about accountability and transparency within the public sector may hamper the flow of investment finance required to give life to the projects. Effective professional management teams with contracts linked to performance will be the way out.

Here, again, the Mauritius model provides the best option. By installing high efficiency power plants close to but not within the sugar factory, cogeneration will give the government a good opportunity to introduce private sector participation into the sugar sector, avoiding the usual pitfalls and wrangles normally associated with privatization of parastatals. The factories and private financiers, including participation from the local sugar farmers through cooperative societies, will jointly own the power plant.

Development of Human Resources
Deliberate efforts must be made to build a national pool of national competence of multi-disciplinary mix, at middle and top managerial positions to oversee the local development of the technology. They should be encouraged to identify which technologies to be adapted and adopted for local application, care being taken to keep out obsolete technologies from the Kenyan scene. Again, the Mauritian experience with its successful run of cogeneration projects, would be a good starting point.

Existing Capacity for Handling Technology and Operation of IPP
The Electric Power Act in Kenya requires an IPP operator to have resources and experience that is unlikely to be found within the indigenous community.

Sources of Funds and Their Limitations
There is a need to create awareness of existing low cost financial mechanisms and opportunities: review their appropriateness to each individual case. Develop skills in the preparation of bankable cogeneration business and project documents. Identify resource and train the stakeholders in bankable project documents.

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7.0 APPENDICES

7.1 Appendix I

Table 7.1 Operational results of sugar factories

FACTORY	WESTERN	MUHORONI	NZOIA	MUMIAS	CHEMELIL	SONY	TOTAL
CANE CRUSHED (2002) TONNES	205227	413070	568098	2207120	602304	580516	4576335
BAGASSE (BONE DRY EQ) TONNES	85099 35668	180477 78,689	234046 94304	799166 380728	256959 109920	205546 98862	1761293
ACTUAL/RATED CRUSHING CAPACITY TCH	42/ 50	85/ 92	127/ 125	325/ 350	112/ 125	124/ 125	815/ 867
PLANNED CAPACITY TCH	60	120	290	450	250	250	1420
EXISTING INSTALLED CAPACITY MW	1.0	3.0	4.5	15	6	7	36.5
POTENTIAL AT 82 BARS(MW)	5.4	12.7	16.5	62.8	18.1	18.1	133,6
POTENTIAL AT 60 BARS (MW)	4.6/ 2.8	9.5/ 5.65	14.2/ 8.3	36.3/ 21.61	12.6/ 7.44	13.8/ 8.25	91.1/ 54.2
RECOMENDED INSTALLED MW CAPACITY (	7.0	16	20	80	25	25	173
CAPACITY FOR EXPANDED PLANT MW	10	20	45	100	40	40	255
POTENTIAL WITH IGCC PLANT MW							

7.2 Appendix II

Table 7.2 Current electricity tariffs

	Power source	K sh	US cents
1	KenGen Hydro	2.36	3.0
2	KenGen (Suggested new rate)	1.76	2.0
3	Or Power IV	7.24	9.0
4	Iberafrica	9.43	11.7
5	Tsavo Power	5.6	7.0
6	Westmont	10.5	13.1
7	Or Power IV	7.24	9.0
8	KPLC Sale price to consumer	7.0 +fuel cost	8.0

7.3 Appendix II

Table 7.3 KPLC power purchased, 2003

STATION	
KENGEN	**TOTAL**
GITARU	**961,759,782.87**
KAMBURU	**479,713,354.26**
KIAMBERE	**1,009,414,333.11**
KINDARUMA	**228,794,650.25**
KIPEVU I (DIESEL)	**246,027,000.00**
KIPEVU STEAM	**71,140,034.00**
KIPEVU GT1	**4,015,000.00**
KIPEVU GT2	**11,851,000.00**
MASINGA	**207,404,051.93**
TANA	**60,562,710.18**
WANJII	**43,471,411.20**
SAGANA	**9,736,405.78**
NDULA	**7,209,883.06**
MESCO	**2,708,907.55**
OLKARIA 1	**243,879,195.83**
SOSIANI	**1,760,127.50**
TURKWEL	**215,970,900.14**
GOGO	**4,795,645.89**
FIAT	**31,654.00**
LAMU	**4,728,532.43**
GARISSA	**7,499,309.00**
NGONG	**358,696.00**
OLKARIA 2	**143,128,000.00**
Total	**3,965,960,584.98**
	-
IPPs	**-**
IBERAFRICA	**255,961,200.00**
WESTMONT	**17,783,982.00**
UETC	**189,387,524.00**
ORPOWER4	**111,348,884.00**
KIPEVU II	**300,894,300.00**
AHP	**138.00**
Total	**875,376,028.00**
IPS	**-**
MANDERA	**2,217,515.00**
LODWAR	**2,026,937.00**
WAJIR	**2,765,560.00**
MARSABIT	**1,965,803.00**

MOYALE	**1,230,178.00**
	-
Total	**10,205,993.00**
	-
TOTAL ENERGY	**4,851,542,605.98**