LOW-CARBON AFRICA: KENYA

POVERTY

Kennedy S Muzee, Practical Action Consulting

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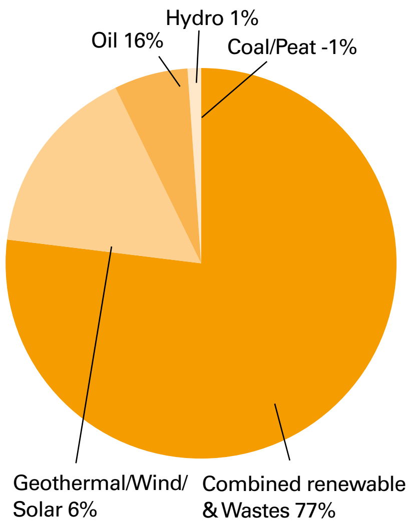
1. COUNTRY CONTEXT

1.1 Background to the Energy Sector in Kenya

Available energy resources in Kenya include biomass, petroleum, hydropower, geothermal power and renewable sources of energy: solar, wind, small hydropower and biomass residue in the agriculture industry. The Kenyan energy scene is dominated by over reliance on the ever decreasing biomass energy resource to meet most of the energy needs especially of the rural households. The recent rapid but unsustainable growth of the country has been spurred on by dependence on imported petroleum for local consumption. Petroleum products demand grew by 4.3 per cent from 3,610 thousand tonnes in 2009 to 3,760.7 thousand tonnes in 2010. During the same period, the GDP grew by 5.6 per cent with 2011 projections estimated between 3.5 per cent and 4.5 per cent (Government of Kenya, 2011). The decelerated but positive GDP growth is attributed to high international oil prices brought about by instability in Libya and the Middle East.

The reliable power supply experienced in 2010 as a result of good rainfall between March-April to May-June and October-December saw the manufacturing sector grow by 4.4 per cent compared to marginal growth of 1.3 per cent the previous year. Figure 1 illustrates the total primary energy supply (TPES).

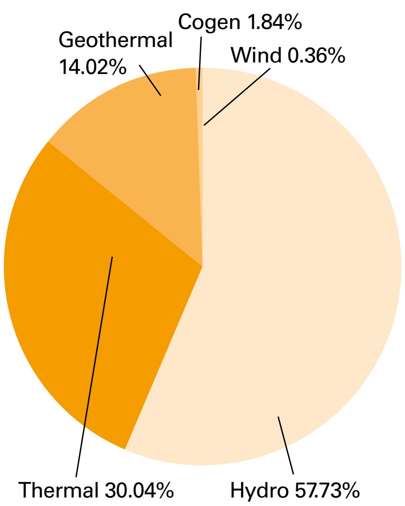
Figure 1: Share of total primary energy supply[1] in 2008



Source: IEA, 2011

The consumption of modern energy is still very low in spite of the economic growth. Kenya's per capita electricity consumption is estimated at 156 kWh per capita (IEA, 2011) compared to the global average of 2,751 kWh per capita (World Bank, 2007). The total installed capacity increased from 1,361 MW in 2009 to 1,471 MW in 2010 with the effective capacity under average hydrology increasing from 1,310 MW to 1,416 MW (Kenya Power and Lighting Company, 2011). This is approximately 16 times less than Argentina's installed capacity with a similar population size. The growth in electricity generation was mainly driven by a 49.3 per cent increase in production from hydro power sources associated with improved water levels in the seven hydro dams. Figure 2 shows electricity generation by source.

Figure 2: Kenya's electricity generation by source



Source: KPLC, 2011

The number of electrical connections has risen five-fold from a low of 265,413 customers in 1990 to a high of 1,463,639 in 2010 (KPLC, 2011) representing a 451 per cent increase. However, electricity access is still very low with rural access averaging below 5 per cent while urban access is estimated at 51 per cent. As of June 2010, the rural electrification programme had connected a total of 251,056 homes, which was a 22.3 per cent increase from the previous year (GoK, 2011). The electricity utility has a target of reaching 100,000 annual connections and the expansion of rural electrification penetration to 20 per cent by 2010 and 40 per cent by 2020 respectively. Unfortunately, the 2010 target has not been met and judging from the trend, it will take much longer unless drastic measures are instituted to, first of all, increase the country's generation capacity.

1.2 Renewable Energy Potential

Kenya is endowed with significant amounts of diverse renewable energy sources, including biomass, solar, wind, geothermal, biogas, mini/micro hydro, and bagasse cogeneration. The section below provides the specific potential for the various sources of renewable energy.

Solar: Kenya receives an estimated 4 to 6 KwH per square metre per day of solar insolation, equivalent to about 300 million tonnes of oil equivalent (toe) per day (AFREPREN, 2004). However, only a tiny fraction of this resource is harnessed for commercial and household activities including crop and animal products drying, water heating, pumping and electricity generation. There is significant potential for solar energy to be exploited particularly in the northern parts of Kenya.

Pico, mini and micro-hydro: The potential of pico, mini and micro-hydro systems is estimated at 3,000 MW nationwide with only six small, mini or micro hydro plants in operation with a total capacity of 13.64 MW (small-hydro.com). The exploitation of these resources is hampered by high capital costs. Pico, mini and micro-hydro systems can be very useful for off-grid rural electrification. To date, only one site has been able to supply 0.3 MW of electricity to the national grid – a mini hydro at the Imenti tea factory in Meru (KPLC, 2011). With only less than 1 per cent of pico, mini and micro-hydro exploited, there is still more room for the exploitation of the resource.

Wind: Kenya has one of the best wind speeds in the world averaging between 3 and 10m/s with northern parts recording speeds of up to 11m/s. Estimated installed capacity from wind generated power is 5.1 MW. Although northern Kenya is considered barren owing to a lack of or minimal precipitation, the area is pristine for setting up of wind farms. This is also the case along the Kenyan coastal line where significant wind speeds have been recorded.

Solar Thermal: approximately 5,000 square metres of collector area for solar water heating systems are installed annually in Kenya. This is based on the Ministry of Energy pre-feasibility studies done in the period 2006/7. Institutions such as schools, hospitals and prisons stand to benefit from installation of solar water heaters to reduce on cost of electricity. This is made more feasible with most areas in the country receiving more than six hours of sunshine daily. The Kenya government recently formulated the Solar Water Heating Regulation which it hopes will increase upscale of solar water heating technology. The benefits the households and institutions are expected to get include: development and utilisation of indigenous energy resources (the sun); enhanced national energy security through diversification of energy supply mix and reduction in the over-reliance on petroleum imports; reduced demand for expensive fuel fired peaking power plants resulting from grid electricity peak demand attributed to water heating; increased environmental conservation through reduction of greenhouse gases; increased employment especially in the rural areas, capacity building and income generation resulting from the expanded solar water heating industry. Large scale uptake and development of the solar water heating is foreseen to lead to reduced unit costs as a result of increased economies of scale (MoE, 2011).

Windpumps: approximately 350-400 windpumps are in operation mainly in the arid and remote parts of the country. The windpumps are applied in domestic water supply, irrigation and watering dairy cattle and ranching. Kenya has been struggling with food insecurity concerns and 80 per cent of the country is classified as either arid or semi-arid; there is great potential for adoption of windpump technology for irrigation purposes.

Geothermal: technical potential is estimated at about 7,000-10,000 MW but only 202 MW has been exploited. Currently, Geothermal Development Corporation (GDC) has harnessed about 168 MW of steam in Olkaria that will run the 280 MW Olkaria IV geothermal power plant scheduled to be operational in 2013. It also plans to drill 1,400 steam wells to provide steam for the generation of 5,000 MW of geothermal power by 2030 (gdc.co.ke). Kenya has so far exploited only 2 per cent of the total technical geothermal potential leaving a massive share to be exploited. The Kenya government has put in place a US$800m budget for development of 400 MW from geothermal resource.

Biomass: as earlier indicated, over 80 per cent of Kenyans do not have access to modern energy services and rely on biomass for their daily energy cooking needs. As the population continues to grow and the economy expands, competing demands on the existing resources will keep rising and demand on biomass in its many forms will continue to grow. The over-dependence can be explained by the undeveloped grid electricity infrastructure, high prevalence of poverty which limits the levels of economic power to afford grid power and other forms of modern energy, and poor supply chains for other fuels. Poorer households use greater quantities of traditional biomass (open fires), which are very inefficient and produce harmful emissions while higher income families tend to rely more on improved biomass cookstoves which are more efficient.

According to the most recent biomass study (2005) by the Kenyan government, close to 89 per cent of rural and 7 per cent of urban households regularly use firewood for cooking and lighting, giving a national average of 67 per cent of all households. The average annual per capita consumption is approximately 741kg and 691kg for rural and urban households, respectively. For urban areas, it is the lowest income households who depend on firewood the most. The consumption was reported to be 34.3 million tonnes of which 15.1 million tonnes was in the form of fuelwood while 16.5 million tonnes was wood for charcoal. These require annual harvesting of 240,000 and 298,000 hectares for fuelwood and charcoal respectively. From the same study, charcoal consumption was about 47 per cent at the national level representing 82 per cent and 34 per cent of urban and rural households, respectively. Per capita consumption was 156 kg in urban areas and 152 kg in rural areas.

One consequence of using biomass directly or for production of charcoal is the emission of carbon dioxide (CO_2) through burning although replacement of felled or harvested trees has zero net emissions. The emissions are estimated at 14.4 million tonnes of CO_2 per year which is equivalent to 52,000 hectares per year.

Biomass residue in the agriculture sector: There is great potential of generating electricity from agricultural residues for example bagasse and rice husks. Currently, an estimated 38 MW capacity is installed in Kenya's six operational sugar factories which use bagasse to generate electricity (Mbuthi et al, 2005). Cogeneration is the simultaneous production of

Table 1: Planned electricity generation projects

Developer	Project type	Capacity (MW)	Estimated commission date
KenGen	Geothermal well head units	70	June 2011[2]
	Eburu (geothermal)	2.5	Dec 2011
	Ngong 3 (wind)	15	July 2012
	Olkaria IV (geothermal)	140	January 2013
	Olkaria I Units IV & V (geothermal)	140	
IPPs	Lake Turkana (wind)	300	July 2013
	Osiwo Wind - Ngong&Kajiado	50	
	Aeolus – Kinangop & Ngong (wind)	160	
	OrPower 4 (Olkaria III) (geothermal)	52	July 2014
Total RE		**929.5**	

Source: KPLC, 2011

electricity and process heat from a single dynamic plant. Bagasse is the waste generated after sugar has been extracted from the sugarcane.

Over the past four years, the country has experienced significant economic growth, which has translated to vibrant industrial growth resulting in increased demand for electricity. To meet this challenge, the country was expected to inject an additional 201 MW by 2009/10 from projects it had committed. Several power generation projects are at various stages of implementation by KenGen and independent power producers (IPPs), which will increase the power capacity by 1,353 MW by 2014. To achieve this, KenGen intends to develop an additional capacity of 233 MW by end of 2011 and a total of 553 MW by 2014, while IPPs will provide more than 800 MW of additional capacity in the same period.

Table 1 shows some of the planned renewable energy projects to mitigate against climate change risks: poor hydrology and environmental degradation with other global macroeconomic factors beyond Kenya's control such as high international fuel prices.

1.3 Low-carbon Strategy

The continued unabated encroachment of agricultural and commercial activities into the water catchment areas – in Mau forest, Cherangani hills, Mt. Kenya and Mt. Elgon – appears to be making hydropower development more vulnerable to the impacts of drought and to the erratic weather patterns currently being experienced in Kenya and the horn of Africa. As a result, the country has been diversifying its energy generation sources previously dominated by hydro and thermal sources.

To mitigate and adapt to climate change, the Kenya government developed the National Climate Change Response Strategy paper (GoK, 2010) which firstly proposes to control river abstraction in the upstream so as to improve availability of water for hydro-power production. Secondly, it recommends zero rating of taxes on renewable energy technologies. This is foreseen to reduce the high upfront cost of such technologies. Thirdly, it emphasises the promotion of use of alternative renewable energy such as solar, biomass, wind, biofuels and agricultural wastes. Finally, the strategy paper identifies the role the firewood cookstoves has to play in mitigating against climate change. The paper advocates for concerted effort in promotion of efficient firewood cookstoves, solar and liquefied petroleum gas (LPG) cookers with the government taking centre stage on issues of cost through provision of subsidies and/or tax waivers to vulnerable groups in the society.

Prior to formulation of the Climate Change Response Strategy paper, the government introduced feed-in tariffs policy for electricity generated from small hydro, wind and biomass in 2008 (MoE, 2008). Ever since, there has been an influx of interest in proven renewable energy technologies such as the Lake Turkana Wind Project which is planned to inject 300 MW of green power to the national grid. A pre-determined feed-in tariff is a guarantee for securing financing for renewable energy projects and promoting market stability for investors in renewable energy electricity generation. Local companies already benefiting from these tariffs include: Mumias Sugar Company which supplies 26 MW to the national grid through bagasse-based cogeneration and Imenti tea factory which supplies 0.3 MW through a small hydro (KPLC, 2011).

To attract investors and reduce the high exploration costs and risks, the government through GDC has created numerous investment opportunities in the geothermal development sector ranging from supply of equipment and materials; development of steam fields and power plants; supply of early generation equipment and civil engineering and construction works. This is intended to reduce drastically the cost (and risks) of geothermal exploitation.

1.4 Barriers to Low-carbon Development and Energy Access

The success of renewables in the country and indeed the entire sub-Saharan region has been limited by a combination of factors that include (Beck and Martinot, 2004, GoK, 2010):

- high initial capital costs
- lack of skilled manpower
- poor policy and legal frameworks
- inadequate planning
- lack of co-ordination and linkages in renewable energy programmes
- pricing distortions that place renewable energy at a disadvantage
- weak dissemination strategies
- poor baseline information
- low maintenance capacity.

For example, according to 2007 estimates, it costs between US$1.2m and US$2.6m to install a commercial wind turbine for every MW of electricity generated (windustry.com) while the cost of establishing a cogeneration plant requires an investment in the range of US$1.5m per MW (Karekezi, et al 2008). In the case of geothermal exploitation, it costs roughly US$2.5m to drill and operate a geothermal well in the Rift Valley (Karekezi and Kithyoma, 2005). These high initial costs have somewhat been reduced by GDC through offering geothermal exploration services and hire of their equipment. Another advantage of geothermal electricity generation is that it has very low running costs as compared to thermal electricity sources. Unfortunately, this is not enough and more financing options need to be established to ensure more players are taken on board in geothermal exploitation.

There exists a high level of illiteracy especially in the rural areas owing to low levels of education and therefore getting skilled labourers to operate a wind or hydro turbine is normally very difficult, often limiting their roles to manual tasks. The National Climate Change Response Strategy paper (GoK, 2010) identifies a deficiency in research and development in renewable energy technologies and research on the production chain and sustainability of biofuels, commercialisation and widespread utilisation of renewable energy technologies, improved kilns and stoves that reduce the consumption of biomass. There is also need for research into efficient methods of conversion of wood and agricultural wastes into commercial forms of energy. In addition to this, there are no local industries or capacity in the manufacture, installation, maintenance and operation of basic renewable energy technologies such as hydro-turbines, cogenerators and bio-digesters. There is also a skills deficiency when it comes to drafting of power purchase agreements (PPA) which can take years to actualise and contain complex legal terminology and technical descriptions and mostly require numerous experts – technical, legal and financial.

Furthermore, there is lack of a decentralised coordination framework to support the promotion of renewable energy investments at the lowest level, resulting in isolated projects in rural areas lagging behind. The establishment of this framework could potentially be an important platform for promoting the participation of local communities in renewable energy technology projects such as small hydro, wind for pumping water and cogeneration.

1.5 Links between Energy and Climate Resilience and Adaptation

Judging from Kenya's experience since the 1990s, there is a direct relationship between climate change and energy security in respect to hydropower generation and flooding. Too much flooding in the catchment areas and subsequent floodplains leads to a rapid siltation in hydropower dams thus affecting the amount of water available for electricity generation. As shown in Figure 2, Kenya's reliance on hydropower can pose certain energy security challenges. Dependence on hydro-based power generation can increase vulnerability to drought-related electricity shortfalls. Drought causes shortfall in generation capacity with negative economic implications. For example, the country suffered persistent power rationing of up to eight hours per day in 2000/2001 partly because of a drought which adversely affected the hydropower plants. Consequently the country incurred losses amounting to as much as US$2m per day due to this power rationing (World Bank, 2000).

Thus, in light of the above challenges, there is a need to reduce the vulnerability of large scale hydropower generation to the impacts of climate change such as droughts. With the onset of climate change and the persistently fluctuating international oil prices, the country needs to adopt more robust, resilient and well thought out strategies for dealing with drought related power crises, especially with respect to hydropower generation. Some of the strategies that can be taken on board include adoption of decentralised renewable energy technologies such as biogas, wind power, geothermal, improved stoves and mechanical power.

To help in the adaptation of climate change, the National Climate Change Strategy paper recommends that the country should pursue an energy mix that greatly relies on carbon neutral energy sources such as geothermal. This will increase the country's energy security and help in mitigating against climate change. Accelerated development of geothermal energy, wind, solar and renewable biomass will help ease the energy demand. The paper also appreciates the significance of the energy efficiency. This is to be accomplished through mandatory energy audits by large commercial and industrial consumers and provision of subsidies and other tax incentives to promote and sustain wider adoption of energy efficient fluorescents light bulbs and the energy saving electrical gadgets used by households.

Energy can play a vital role in enhancing food security amongst the poor through technologies for water pumping and irrigation, and agricultural processing such as milling and preserving. Some of the water pumping/irrigation technologies that are suitable for low income households have significant potential of not only ensuring food supply throughout the year but also additional income. Table 2 shows the initial investment

Table 2: Initial investment cost of irrigation water

Component	Treadle Pump	Windpump	Petrol Pump	Diesel Pump
Cost + installation (US$)	110.62	1,106.19	523.23	3,429.20
Lifetime (years)	6.00	20.00	6.00	10.00
Rate of discharge (m^3/hour)	4.32	7.50	14.00	10.00
Annual fuel cost (US$)	Nil	Nil	16,040.71	17,402.65

required to buy and install various irrigation technologies.

From the table, it is clear that not all technologies are affordable for the rural poor households. However, the treadle pump appears to have the least upfront cost and is likely to be the most attractive option for the poor. The problem with treadle pumps is that they are labour intensive and therefore do not allow farmers to engage in other economic (or social) activity while operating them. Furthermore, its longevity is low compared to the windpump and diesel pump. In the case of both petrol and diesel pumps, they rely on fossil fuels which of late has seen their operation costs escalate due to high international fuel prices. They also have negative environmental impacts through their contribution to greenhouse gases. In addition, the diesel and petrol pumps have the potential to pollute the crop environment through accidental spills thus damaging flora and fauna.

The windpump is the most viable option as it has the longest lifespan. Despite its very high initial cost, one can recoup this investment depending on its application. Field data indicates that one farmer who bought the windpump for horticultural production was able to recoup his investment in six months. Moreover, the operation costs of the windpump are very minimal. It requires a single service every six months and can work for more than five years without any breakage being reported. Application of windpumps in Uasin Gishu County has improved household incomes through horticultural production, improved education as children no longer have to walk long distances to fetch water and it has also improved dairy farming as cattle are easily watered especially during the dry spells.

Wind energy is environmentally benign as it does not contribute to gaseous or liquid emissions to the environment. It especially reduces the environmental impact of generating electricity when compared to the case of thermal generation. Wind, therefore, is a clean and efficient renewable energy source. Furthermore, it is estimated that the energy used in the manufacture of a wind turbine for electricity generation can be recouped within four to five months of its operation. The energy produced by the wind generator during its lifetime is approximately 30 times the energy used in its manufacture (Martin, 2001). Another benefit of wind power is that it can be located where agricultural production is impractical eg in north eastern Kenya where the land is barren owing to very low rainfall.

1.6 National Potential Benefits for Low-Carbon Development

Renewable energy technologies offer diversification in energy generation, thus strengthening energy security especially now that climatic variation has made hydropower unpredictable. For example, geothermal energy resource is available 100 per cent of the time and it is cleaner than the unsustainable oil based electricity generation. In addition to this, renewable energies can offer considerable savings in foreign exchange as revenues that would otherwise have been used to buy fossil fuels from overseas can be kept in country for education, health or agriculture. This makes the country's balance of payment more favourable.

Small and medium scale renewable energy technologies can play an important role in poverty alleviation, particularly for small scale technologies that can be made locally and operated on the basis of solar, thermal or mechanical animate power. The growth and expansion of improved cookstoves has led to the growth of the informal sector with many people specialising in certain areas eg production of ceramic liners, making the metal cladding, marketing, etc. Thus more people stand to benefit through employment from production of second and third generation cookstoves.

- Renewable energy can also lead to enterprise creation for both the rural and urban poor in Kenya. Examples of such renewables include (Mapako and Mbewe (eds), 2004; Karekezi and Kithyoma, 2002; World Bank, 2004):
- low cost but more efficient biomass-based combustion technologies (eg improved cook stoves, efficient charcoal kilns, brick-making kilns, fish smokers, tea dryers and wood dryers)
- pico and micro hydro for shaft power that can be used to process agricultural produce and increase its value, as well as for water pumping
- low cost efficient hand tools and animal drawn implements, which would increase the agricultural productivity of rural areas
- windpump, treadle and ram pumps for irrigation, which increase agricultural outputs thus generating income for the rural farmer
- solar dryers that can lower post-harvest losses and enable the rural farmer to market his/her produce when prices are higher
- solar water pasteurisers that provide clean potable water and reduce water borne diseases, which translates to increased availability of labour and thus increases agricultural output and income.

Unlike conventional energy technologies that are mature and have evolved into large scale investment industries, most renewables can lead to independent technology development as some renewables technologies are relatively new and do not require large amounts of capital. Some technologies such as improved stoves and windpumps are also relatively less sophisticated meaning that a significant industry could be developed even where technical expertise is limited. With increased financial support, it may be possible for African countries to become significant players in the small and medium scale renewable energy and technology market. For instance, Kenya is now a global leader in geothermal energy development, with its experts offering expertise in developing geothermal power plants in other countries in the region, and even developed countries (Mariita, 2002).

Renewable energy technologies can also reduce local and regional energy-related environmental impacts. For example, cleaner and more efficient bio-stoves fitted with chimneys can reduce indoor air pollution, which is a major contributor to respiratory illness (Ezatti and Kammen, 2002). Cleaner fuels can also reduce transport-related pollution and wind, solar, hydro or geothermal energy can reduce the need for coal or other fossil fuel plants that cause significant local and regional pollution (Johansson, 2004).

Renewables that are not reliant on rainfall (eg geothermal, solar, wind) can reduce the climate related risks associated with heavy reliance on hydroelectric schemes. For instance, geothermal and bagasse-based cogeneration was used to meet the power deficits caused by drought that hit the country in 1998-2000. During this period, Kenya's two geothermal plants offered almost 100 per cent availability to cover base load regardless of prevailing weather conditions (Mbuthi, 2004).

Table 3 summarises some of the specific potential benefits from the various renewable energy technologies.

Table 3: Potential benefits for low-carbon development

Technology	Potential benefit
Biomass cogeneration	• Promotion of indigenous energy resources; • The power sector will benefit from additional generation of power from a stable indigenous source; • The energy will replace generation that is more expensive from thermal sources; • 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 may 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; • Income generation opportunities; • Links to rural development.
Geothermal	• Foreign exchange savings owing to the foregone fossil fuel that would otherwise be purchased for power generation; • An availability factor of about 100%, making it a stable and secure base-load power, which cannot be matched by other sources. It is neither susceptible to drought nor is it subject to the direct effects of the globally volatile fossil fuel prices; • Near-zero emissions (closed cycle systems that re-inject water back to the earth's crust); • Very little space requirement per unit of power generated; • Potential for local assembly and manufacture of geothermal equipment; • The heat resource can be used in horticultural farms to control night time humidity levels in order to alleviate incidence of fungal diseases.
Wind	• Wind power provides an opportunity for generating electricity at local level; • It can be used for island communities or remote areas such as Migingo, Mfangano islands or Turkana; • Wind projects can help attract new capital and foster a new approach to independent power production as the turbines are modular and can be added into supply network in relatively small increments; • Wind farms contribute no gaseous or liquid emission to the environment and thus reduce the environmental impact of producing electricity. • Windpumps are used to access water for watering animals, irrigation, domestic purposes, etc.

<table>
<tr><td>Small hydro</td><td colspan="4">• Provides a good source of clean energy generation;
• Can be applied in irrigation;
• Can be used to supply domestic water;
• Reliable technology with a solid track record suited to rural areas outside the central power grid.</td></tr>
<tr><td>Solar (PV and thermal)</td><td>Small-scale
- Lighting,
- Cooking,
- Water heaters and
- Solar architecture houses</td><td>Medium scale
- Water heating in hotels
- Irrigation</td><td>Community level
- Vaccine refrigeration,
- Water pumping and purification
- Detoxification,
- Rural electrification</td><td>Industrial level
- Pre-heating boiler water for industrial use
- Power generation,
- Municipal water heating,
- Telecommunications,
- Transportation (solar cars)</td></tr>
<tr><td>Biomass (stoves)</td><td colspan="4">• Source of employment
• Cooking
• Heating</td></tr>
<tr><td>Biogas</td><td colspan="4">• Cheap clean cooking gas
• Source of cheap fertilisers</td></tr>
</table>

2. CASE STUDIES

2.1 Bagasse Cogeneration Project

This case study is based on a power capacity expansion project involving the generation of electricity by Mumias Sugar Company (MSC) using sugarcane bagasse to generate electricity for internal consumption by the company and export to the national grid through cogeneration. Cogeneration is the simultaneous production of electricity and process heat from a single dynamic plant. A cogeneration plant heats up steam that drives a turbine to produce electricity. Various forms of biomass can be used to fuel the plant including bagasse (sugarcane waste) and wastes from paper and pulp, palm wood and rice industries. The broad goal of this project is to support the renewable energy sector in Kenya by promoting the implementation of grid-connected electricity generation from biomass residues in Kenyan agro-industrial companies. The long term objective of the MSC project is to satisfy the ever increasing demand for electricity in Kenya with a clean alternative to the more fossil-fuel based electricity component of the Kenyan national grid. The project currently generates 35 MW of electricity with 10 MW for internal consumption by the factory and 25 MW exported to the national grid.

With the country being a net importer of oil, cogeneration has the potential for replacing 503GwH of electricity generated from fossil fuels (Karekezi and Kithyoma, 2005). Studies from Mauritius, which is the regional leader in bagasse cogeneration, indicate that in the short term, bagasse projects avoid the use of 215,000 tonnes of coal, the emission of 650,000 tonnes of CO2 and generation of 35,000 tonnes of coal ash. The long-term figures are 375,000 tonnes of coal, 1,130,000 tonnes of CO2 and 60,000 tonnes of coal ash when the target of producing 110 KwH of electricity for each tonne of sugarcane is achieved (Deepchand, 2001).

Traditionally, most sugar factories in Kenya cogenerate just enough steam and electricity to meet their own requirements. This is despite the fact that the energy content of the bagasse exceeds the energy needs of the plant. Therefore, boilers and steam generators are typically run inefficiently in order to dispose of as much of the bagasse produced from crushing the cane as possible. Indeed, some older factories purchase oil or electricity, because their steam generating technologies and boilers are not efficient enough to meet the needs of the plant. With the availability of advanced cogeneration technologies, sugar factories today can potentially harness the on-site bagasse resource to go beyond meeting their own energy requirements and produce surplus electricity for sale to the national grid or directly to other electricity users.

The MSC is located in Butere-Mumias District (350 km from Nairobi) along the Kakamega Bungoma Road. Following the opening up of the Kenyan sugar market to competition from imports within countries in the Common Market for Eastern and Southern Africa (COMESA) region in 2010 and the extremely high and uncompetitive production costs, MSC set out to review its production policy and to diversify its activities. This included implementing a sizeable bagasse cogeneration project:

- to increase electricity generation in order to sell more to the national grid through Kenya's electricity utility company, Kenya Power Company (KPC)
- to diversify MSC's revenue streams
- to employ bagasse surplus currently unused
- to develop local skills and generate employment
- to increase revenue paid to farmers (sugarcane producers for the factory) from the company's savings on energy.

The technology employed for the MSC Cogeneration Project is based on conventional steam power cycle involving direct combustion of biomass (bagasse) in a boiler to raise steam, which is then expanded through a turbo alternator to generate electricity. Some of the steam generated is used in the sugar plant processes and equipment, while the power generated is used internally by the company and the excess (25 MW) is exported to the national grid.

Findings from a survey carried out in six sugar factories in western Kenya point out some technical components that need to be addressed to achieve high efficiencies. Firstly, the boiler and turbo-alternator sets, which comprise the most significant portion of the investment, should be new but some used equipment could be employed. Used sets must be reliable equipment and in good condition. Secondly, electrical switchgear and controls which comprise transformers, medium or high voltage switchboard for external connection to the grid system, including appropriate metering points for import and export power should be in place. Some investment may also be required for the overhead line link to the national grid. Existing sugar factories are already connected to the grid, but these links need strengthening to accommodate increased generation capacities.

Electrical equipment is often imported, but considerable local assembly is carried out to adapt to the specific site requirements. Local expertise already exists for carrying out this part of the project. Thirdly, civil works – structural and building works that constitute the power house, bagasse shed and other constructions – are necessary as part of the new investment. Local expertise for the design and erection of civil works is available. Fourthly, mechanical works, which entail mechanical installations – a steam distribution system from the new power-house to the existing plant, bagasse handling equipment from sugar factory to storage shed and to the boiler feed system and bagasse reclaim system from the storage shed. Some equipment may require importation for local assembly, but most of the mechanical works can be supplied and installed locally. Finally, the plant efficiency improvement (ie replacement of steam turbine drives with electric motors and general plant renovation) can improve plant steam and energy efficiency. In general, efficiency improvement equipment such as motors and their controls can be imported. Once imported, they will need to be rigged and mounted using local expertise.

Investment in cogeneration has the potential to bring in additional revenues as well as increased management focus and attention. It is estimated that revenue turnover could increase between 20-40 per cent through plant efficiency improvement and increased production to remain competitive in a liberalised sugar sector. Enhanced income from agricultural products due to the establishment of agro-processing industries attracted by the availability of electricity in rural areas. Proximity to these industries encourages growth in agricultural production, which in turn increases the incomes of the rural poor (Clancy and Redeby, 2000). Table 4 below compares the investment costs of cogeneration power plants compared with other options.

There is a lot of opportunity in bagasse-based cogeneration as all the seven sugar factories in western Kenya (Muhoroni, Chemilil, Mumias, Nzoia, South Nyanza, Kibos and West Kenya) will venture into electricity generation, significantly reducing the country's dependence on unpredictable hydro and the expensive fossil fuel based electricity sources. Currently, these companies produce an average of 1.8 million tonnes of bagasse per year, 60 per cent of which is used as boiler fuel for steam generation, with electricity being generated from surplus steam. The remaining is mostly disposed of by burning, at times at a cost. Furthermore, additional agro-based industries could embark on electricity generation through use of agricultural wastes eg rice husks, sisal, timber etc.

2.2 Davsam Windpump Project

This case study is based on energy access for agricultural purposes and domestic water access in the rural areas through use of wind energy. The broad goal of this project is to support households and communities get access to domestic water and water for irrigation purposes. The long term objective of the Davsam windpump project is to improve access to energy through supply of domestic water, irrigation and all-year-round farming through use of wind energy as an alternative to treadle and diesel pumps which were and are still common in Eastern and North Eastern parts of the country. Diesel pumps have numerous disadvantages: they require constant maintenance and a dedicated operator, who most of the time would require to be housed. Access to diesel is also another problem especially in cases where there is no adequate communication network eg poor road network (remoteness), absence or far-flung petrol stations and usually the fuel will be very expensive. Furthermore, owing to the portable nature of diesel and petrol pumps, they can easily be stolen. The biggest drawback with the diesel pump is its environmental impact. Diesel pumps emit greenhouse gases that contribute to climate change.

A windpump, on the other hand, only needs maintenance every six months with some users going as long as 12 months without experiencing any problem. Typically, a windpump reduces about 51,136 kg of CO2 and considering it has a 20 year useful lifespan, a total of 1,022,717 kg of CO2 reduction can be achieved (Appendix 1). The Davsam windpump project has so far installed approximately over 80 windpumps in typically arid and semi-arid areas in Kenya such as Mwingi, Kang'undo, Kitui, Kibwezi, Emali, Kibogo, Maralal, Kongowea, Mpeketoni and Samburu.

Davsam windpump project is located in Uasin Gishu County along the Nairobi-Eldoret Highway. Although the workshop is located in an agriculturally productive area, more of the windpumps have been installed in less productive areas ie where water access is a challenge. The project employs two individuals

Table 4: Investment costs of cogeneration power plants compared to options

Type of energy plant	Investment costs (Million US$/MW)
Cogeneration at: 45 Bar[3]	1.4
60 Bar	1.8
82 Bar	3.1
Diesel powered engines	1.0
Heavy fuel plants	1.2
Wind turbine	1.9
Geothermal	2.5
Hydro power plants	2.7

Source: Karekezi and Kithyoma, 2005; windustry.com on permanent basis with numerous casuals depending on the number of orders placed for the windpumps. The use of windpumps for water access and irrigation purposes is now on the increase owing to the frequent droughts experienced in the country brought about by climate change.

The windpump has many applications which include: supply of domestic water, watering livestock, irrigation and drainage. In Kenya, windpumps are being used for supplying domestic water, livestock watering and irrigation. The reported contributions on farming practices have been substantial. These include: increased land area under irrigation, reduced work time compared with bucket irrigation, full irrigation of fields resulting in improved crop quality, reduced frequency of irrigation to two or three times a week, less strenuous irrigation work compared to treadle and bucket irrigation, additional and new crops grown each season, increased number of growing cycles, as crops are able to grow faster with full irrigation and improve farm incomes (Karekezi and Kithyoma, 2005).

Some of the notable benefits of Davsam windpump project include:

- improved water access to households and the community. A windpump installed at Gatongora (near Ruiru town) supplied approximately 40 households with water. The windpump was installed after the community found the cost of electricity for powering a generator to pump water very prohibitive.
- reduced physical exertion especially by women and school-going children. Before installation of a windpump on his farm in Kipchumo, Mr Chumo, an employee of Moi University, used to get his domestic water approximately 20km away while his neighbours relied on a seasonal river nearby and when it dried up, they could walk for about 1.5km to the nearest well.
- improved health as a result of increased food production and nutrition. Through all-year-round irrigation, food items that were expensive (or hard to come by) to the local community such as vegetables and fruits can now be found locally which has greatly improved the diet.
- improved academic performance. School-going children can now dedicate more time to education as opposed to fetching water from distant sources.
- diversified income generating activities such as ranching, horticulture and fish farming have been taken up. Mugie Ranch which is situated north of Rumuruti Town is now able to rear 15,000 head of sheep. Another farmer in Outspan in Uasin Gishu now earns an additional KShs 1,500 per day from the sale of tomatoes, kales and onions from his five-acre plot.
- developed local skills in new agricultural activities such as horticultural production. A retired production manager from Delamere Farm in Naivasha holds clinics to create awareness on horticultural production in and around Eldoret. So far, it is estimated he has reached about 53 small scale farmers including the neighbouring Kitale County.
- offered employment to the women and the youth. Field surveys indicate that 80 per cent of the workers employed by the farms that have installed the windpump are women and youth.
- improved vegetation – the vegetation around Lerata Makutano (close to the Samburu National Park) improved as a result of watering from the windpump that was installed in the area.

Kenyan rural water access is estimated to be around 40 per cent (these include piped water, water from boreholes, streams, rivers, wells, lakes, etc) and the network expansion has been slower (or stagnant) relative to population growth and 80 per cent of the country is classified as either arid or semi-arid. In addition, most of Kenyan agricultural activities are rainfed and when the rains fail, there is massive drought. Meteorological records indicate that the country has been experiencing significant shortage of rainfall from 1997 to this year (2011) with 2010 being the only year the country had good precipitation (Table 5). The drought spells have led to rampant starvation for humans and animals, power rationing as a result of significant reduction of water levels in hydro dams and high cost of living. The windpump project provides an avenue through which these impacts of drought can be alleviated. In addition, education, rural poverty, health and water access can be improved through upscale of this technology.

With the advent of climate change in East and Horn of Africa, this windpump project stands to benefit rural poor in these regions. Furthermore, the project will build capacity of the local community who will be technicians and will lead to growth and development of other supporting industries eg scrap metal, stockists of water pumps, iron rods etc.

Risks associated with this project include lack of support from stakeholders and technological failure. These risks can be minimised through thorough consultations prior to the start of a project and drafting and follow up with letters of commitment and incorporation of long-term partners to the local communities, for example Catholic diocese, youth groups etc. The risks can further be reduced through piggy-backing on existing projects already pre-approved by the local communities.

Technological risks can be minimised through careful design of the project using locally available, tried and tested technology. This can also be overcome through procurement of windpumps from reputable manufacturers with a reasonable warranty.

Table 5: Incidence of drought in selected countries (1997-2010)

Country	'97	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10
Burundi		√	√	√						√	√			
Eritrea	√		√	√	√	√	√	√	√	√	√	√		√
Ethiopia	√		√	√	√	√	√	√	√	√	√		√	√
Kenya	√	√	√	√	√	√	√	√	√	√	√	√	√	
Tanzania	√	√	√	√		√	√	√	√				√	
Uganda	√		√	√	√	√	√				√			

√ = Significant shortage of rain   Source: World Bank, 2004; Qureshi, undated; WFP, 2008)

2.3 Upesi Stove Project

This case study is based on improving energy access and energy efficiency at household and institutional level. The broad goal of this project was to improve the quality of life of poor households in rural West Kenya by reducing their dependence on biomass fuels, increasing their access to appropriate energy saving technology options and investigating income generating opportunities.

'Upesi' is a Swahili word which means quick. The stove got this name as it cooks food fast. Upesi stove project was spearheaded in the 1980s by the Ministry of Energy, German Technical Cooperation (GTZ) and the Kenya national women's organisation, MaendeleoyaWanawake. The stove is made of a pottery cylinder built into a mud surround in the kitchen. It can be used to burn wood or other agricultural wastes eg maize and sorghum stalks and animal wastes (cow dung).

Some of the notable project achievements include:

- training on production of ceramic wood and charcoal burning stoves
- training on marketing for sustainable dissemination
- supporting the market intermediaries with promotion and production of promotion materials and promotion activities
- enabled documenting and sharing the experience of the project.

The Upesi stove project has had a number of impacts. In the initial eight groups in West Kenya, 64 women produced high quality energy saving stoves. They produced and marketed about 4,500-5,000 Upesi stoves, 11,000- 12,000 Kenya ceramic jikos and 1,500- 2,000 innovative designs of wood burning stoves. The annual production of Upesi stove is estimated at 10,000-11,000 stoves and the profit generated by the project provided artisans with a higher than average rural wage. This income has been used by the women to meet some of the family needs thus achieving economic independence. This has also boosted the women's self-esteem and social standing in the community.

Additional savings brought about by the stove include time savings of about 110 hours per year, health cost savings of Kshs 260 per year and indoor smoke reduction of 60 per cent. Family health status has also been improved through reduction of acute respiratory infections for children and mothers by 60 per cent and 65 per cent respectively and reduction of conjunctivitis in children under five and mothers by 70 per cent and 67 per cent respectively. As a whole, commercialisation of the stove has improved the living standards of West Kenya communities.

The producers have created and maintained linkages through which the stoves are marketed. Likewise, the producers have over the time mastered the skill of stove production, firing and marketing and they are able to offer quality training to interested people and/or groups. Furthermore, the project has improved the women's innovation as they are able to produce other stove models that offer acceptable efficiency and savings.

There are also some additional benefits of the project. West Kenya women have developed a package of skills which can be shared both nationally and regionally. It has also provided income generating opportunities for other non-Upesi stove producers such as collection and preparation of the clay, stove promotion and marketing and training. The producers have acquired their own assets such as land and production equipment and the project has been able to improve gender relations amongst the families.

For the success of this project to be replicated across the country, there will be the need for training on: technical aspects of Upesi stove, group organisation, project management, marketing and business skills. One potential risk of the project is community acceptance. Financial empowerment of the women may threaten male standing in the community leading to conflict which may impact negatively on the project.

3. LEAPFROG FUND POTENTIAL

Kenya is currently experiencing load shedding resulting from limited diversification in energy generation. Major industries across the country are being cut off from electricity supply for three hours (6.30-9.30pm) on Mondays, Wednesdays and Fridays beginning July 27 2011. This is scheduled to go on until electricity generating companies restore their broken-down, or perform routine maintenance on, their machines. Industry players blame this on the sector's dependence on large hydro and high international oil prices (high cost of thermal power) and the expensive nature of renewable options such as geothermal and cogeneration with solar photovoltaics (PVs) being even more expensive. This is going to result in some of the industries using alternative sources of energy such as diesel generators. Households affected may also adopt the use of kerosene lamps for lighting. Diesel and paraffin are non-renewable energy sources and contribute to climate change through release of greenhouse gases.

Financing plays a major role in the promotion of renewable options especially in rural areas where the majority of people still rely on biomass for most of their energy. The limited or total lack of financing is further complicated by competition[4] among projects for limited funds and is compounded by unfavourable macro-economic conditions in Kenya. Off-grid projects in rural areas have the potential to increase rural access to cleaner energy options such as electricity from small hydro plants which can be used for lighting and use of efficient stoves for cooking which will lead to sustainable exploitation of forest resources.

It is only recently that the national budget identified the importance of renewable energy and granted the Ministry of Energy approximately Kshs 70bn (~US$753m) in the financial year 2011/2012 with approximately 30 per cent going into geothermal and a rural electrification programme. Unfortunately, these funds are not accessible to the general public to venture into renewable energy projects such as small hydro, windpump, cogeneration and geothermal energy generation.

Regrettably for many of the potential Kenyan renewable energy investors, the private sector and financial institutions find renewable energy unconvincing. Actually, with the exception of large-scale hydro, there is limited experience in conventional banks in financing renewable energy on a commercial basis in the country. The banks do not consider renewable energy as a reliable loan product and often do not have the due diligence capacity to review renewable energy projects. Renewable energy projects are therefore perceived as 'high risk' investments. In addition, banks tend to have short repayment schedules for their loans, making renewable energy projects unsuitable candidates for these loans, as they require longer repayment periods. Project financing, where the renewable energy equipment is used as collateral, is generally not available. There is also a shortage of funds from which renewable energy projects can access concessionary financing (http://cogen.unep.org).

Other barriers limiting access to financing for renewable energy projects include:

- inadequate skills to prepare investor-quality pre-feasibility and feasibility projects
- limited technical capacity on renewable energy within financial institutions
- uncertainty in the market for renewable energy.

3.1 Co-generation

Therefore, existence of a leapfrog fund will allow more players to enter the energy generation sector, and improve energy access across different economic regions of the country. For instance, all the new and old sugar factories in the country (Muhoroni, Chemilil, Mumias, Nzoia, South Nyanza, West Kenya, Kwale International, Tana Delta) will venture into bagasse-based electricity generation. This will significantly reduce the dependence on unpredictable hydro and the expensive fossil fuel based electricity sources. Currently, only 60 per cent of the bagasse is used in electricity generation with the rest being discarded as waste.

In this case, leapfrog fund can be used to improve plant efficiency through installation of more efficient boilers and can also act as an impetus for other agro-based industries to use their wastes (eg rice husks, sisal, timber etc) to venture in electricity generation. These industries can be provided with soft loans which they can use to increase their cogeneration capabilities.

Other needs of bagasse-based cogeneration projects include capacity building for the new sugarcane industries (and other agro-based industries) that will take up cogeneration, technology transfer from the industry leaders (Mumias Sugar Company) and long term finance for the new and existing companies to reach high energy efficiencies through installation of efficient boilers.

3.2 Windpump Technology

The windpump technology uptake in the country is still very low despite the heightened development in the 1990s. This is attributed to high cost of raw materials and the majority of small scale farmers in the country not being able to afford them. Findings from a survey of windpump users indicate that they had taken loans from commercial and microfinance institutions so as to be able to buy the windpumps. Unfortunately, those that did not have employment indicated that financing was restricted to their own personal savings and well-wishers.

A leapfrog fund established to increase upscale of windpump technology can be used to subsidise the cost of raw materials used in its manufacture thus reducing the retail cost. This can be supplied through grants, soft loan or micro-credit. In addition to this, farmers can access credit through the leapfrog fund which they can repay after a suitable period.

Other additional assistance to windpump projects includes training on business management which will go a long way in keeping the costs low. It is also foreseen that more individuals and/or groups will venture into windpump manufacture thus requiring technology transfer. Creation of awareness on the benefits of windpump amongst the rural households will also be required.

3.3 Upesi Stove

Improved stoves (Upesi stoves, Kenya ceramic jiko) have been one of the few cases of successful energy interventions in Africa although there is still more to be done, as well as potential for growth through production and marketing of second and third generation stoves. Leapfrog funds can be used to do more research and development of these stoves. Additional research is also required in quantifying the degree of emissions reductions by improved stoves in actual home settings and the number and quality of jobs created in this sub-sector so that it can provide a guide for investment.

Improved stove projects will need more assistance in business management and market development to ensure the second and third generation cookstoves report equally successful results as first generation stoves. Second and third generation stoves are more efficient, economical with fuel and are more environmental friendly than the first generation stoves. Examples include ethanol and Score stoves that are currently on trial in different parts of the world. The ethanol stove uses ethanol which can be sourced from sugar factories while the Score stove uses biomass as a fuel. Score stoves will provide cooking, refrigeration and electricity. The experience of first generation stove projects can provide a good platform on which the second and third generation stoves can piggy-back. Technology transfer will also be required to train new artisans on how to make these new stoves.

3.4 Biogas

Biogas is a gaseous fuel (methane) made from anaerobic digestion of agricultural and animal wastes and can be applied in cooking, lighting and electricity generation. According to the Netherlands Development Organisation (SNV) which has been in the forefront of disseminating biogas projects in Africa and Asia, there are approximately 840 biogas systems installed in Kenya (SNV, 2011). One benefit of biogas technology is that it is simple and straightforward. The raw material is animal dung which is plentiful in many rural areas of Kenya and in cases where the animals are reared in an enclosure eg a zero-grazing system, it becomes more feasible. Another benefit of biogas technology is that it requires a relatively limited level of investment – approximately US$835 for a 6 cubic metre digester and two cows per household.

Biogas technology leads to workload reduction as children and women are saved from looking for firewood. It is also beneficial to the environment as forests remain intact as opposed to being felled for firewood or charcoal production. The biogas fuel is clean and safe for cooking and lighting ie it is smokeless. The sludge produced by the digester provides good organic fertiliser that can be used to enrich agricultural soils thus reducing the cost of farming through purchase of inorganic fertilisers. This has the potential to improve food security in the rural areas. Finally, biogas technology takes advantage of the local expertise as masons are used to construct the digesters. In cases where the animals are in a free range system, other personnel can be hired to collect the dung thus increasing employment opportunities for the locals.

The technical viability of biogas technology has been repeatedly proven in many field tests and pilot projects. To achieve greater scaling up, there is a need for partnerships and funding; a need for the leapfrog fund; knowledge development; and multi-stakeholder involvement; reinforcing local capacity and business development.

3.5 Small hydro

Small hydro has the advantage of multiple uses: it can be used in energy generation, irrigation purposes and community water supply. It is also a very reliable technology with a solid track record and well suited to rural areas outside the central power grid. Much of the unexploited potential for small hydro is in remote areas particularly in tea growing areas east and west of the Rift Valley. These places (highlands) have numerous permanent rivers and streams providing excellent hydropower development potential. However, small hydro development has been hampered by several factors: cost overruns; poor forecasting of revenues (usually too optimistic); foreign exchange rate fluctuations; interest rate risk which is inflation dependent; poor payment mechanism to contractors; poor cash inflow/outflow arrangement; increased water turbine wear rate due to silt; erratic weather patterns and other factors beyond human control ie earthquakes, fires and other unpredictable circumstances (Ogada, 2007).

The mentioned challenges can be overcome through conducting of high quality feasibility studies; reduction of the cost of the project development – eg procurement; government incentives through loans, power purchase agreement (PPA), guarantees and/or tax relief; joint developments of projects in one area to reduce costs – this can be achieved through collective planning, procurement, negotiations and funding; keeping high quality water flow and rainfall data; establishing better sources of equity funding, where the low-carbon leapfrog fund comes in handy, and procurement of insurance services against natural disasters.

3.6 Solar PVs

Solar photovoltaic projects were aggressively promoted in the country in the 1990s. Unfortunately, solar PV projects mainly benefited high-income segments of the population, due to the high cost of solar PV. Solar PV is very unaffordable to the majority of Kenyan households, which is coupled by the lack of know-how of the systems in case of breakdown.

Availability of funding to offset the high upfront cost of the solar PVs and for capacity development is bound to see an increased upscale of this technology in the rural areas. Solar PV potential is very high with most areas in Kenya receiving more than 6 hours of direct sunlight.

3.7 Conclusion

The current national energy supply in Kenya is inadequate. There is a high dependence on large hydropower and thermal electricity generation which have more than once exposed the country to energy insecurity owing to climate change and the volatility of international oil prices. A paltry 4 per cent of the rural population have access to electricity. With over 80 per cent of the population still inefficiently using biomass energy, there is a need to adopt newer and cleaner energy supplies to safeguard against climate change brought about by an increase in greenhouse gases in the atmosphere.

Small and decentralised renewable energy technologies serving different sectors have in the past helped in mitigating the impacts of climate change. Some of the technologies adopted include windpumps, which have boosted rural community development through improved domestic water supply and all-year-round irrigation, leading to improved food security in areas where the technology has been adopted. Improved cookstoves that are energy efficient ie use less fuel and direct 25-40 per cent of the fire to the cooking pot. Mumias Sugar Company has been able to sustainably sell 25 MW of electricity to Kenya Power Company which has seen its revenues surge in the midst of tough competition from the COMESA market.

Despite the impacts of these technologies, highlighted by the case studies, their uptake and upscale has been low owing to high investment costs. This is further coupled by the absence of financing mechanisms through which individuals, communities and small and medium scale enterprises can source credit. Renewable energy technologies are still not well understood and most of these projects are considered high risk. Setting up of a dedicated fund, such as a leapfrog fund, will provide an impetus for their uptake.

3.8 Recommendations

- A leapfrog fund should be established and different stakeholders ie community groups, private companies, non-governmental organisations and individuals encouraged to adopt.
- The fund should have a capacity building and business management component targeted at the rural community where education and technical skill levels are low.
- Big industry players (eg Mumias Sugar Company) should also be encouraged to work with new players(eg Kwale International Sugar Company and Tana Delta Sugar Company) to allow for technology transfer.
- Continued monitoring and evaluation of technologies adopted to their full maturity should be encouraged.

ENDNOTES

1 Share of TPES excludes electricity trade. Combined renewables and wastes include primary solid biomass, biogas, liquid biofuels, geothermal, hydro, solar PV and wind.

2 This was not commissioned owing to long procurement procedures that led to delay of the project.

3 Larger and more efficient boilers e.g. 82 Bar yield more electricity compared to smaller inefficient boilers i.e. 60 Bar and 45 Bar.

4 Government funded institutions such as KenGen, GDC and some sugar companies depend on the national budget to carry out their activities.

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Appendix 1: Estimating Baseline Emission Reduction from Diesel Water Pump

Emissions factor	= 3,140 g / kg
Density of diesel	= 840g / ltr

Therefore:

1 kg of diesel	= 0.84 ltrs
Emissions factor	= 3,738g/ltr of diesel

From the emissions factor:

3,140 g	= 0.84 ltrs
3,738 g	= 1 ltr

A typical generator:

Hourly consumption	= 4 ltrs
Emissions per hour	= 4 ltrs x 3.738 = 14.952 kg of CO2
Annual operation hours	= 3,420
Annual emissions	= 3,420 x 14.952 = 51,135.84 kg
Emissions over the project life (20yrs)	= 51,135.84 x 20 = 1,022,716.8 kg of CO2

Confirmation of calculation:

Generator annual diesel consumption	= 13,680 ltrs
Emissions from 1 ltr of diesel	= 3.738 kg
Total annual emission	= 13,680 x 3.738 kg = 51,135.84
Emissions over the project life (20yrs)	= 51,135.84 x 20 = 1,022,716.8 kg of CO2
Cost of diesel per litre (1st August 2011)	= Kshs. 115

Reference: IPCC, 2007: Emission Factor Detail (ID: 19646), ipccnggip.iges.or.jp/EFDB/ef_detail.php, Geneva, intergovernmental Panel on Climate Change (IPCC)

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