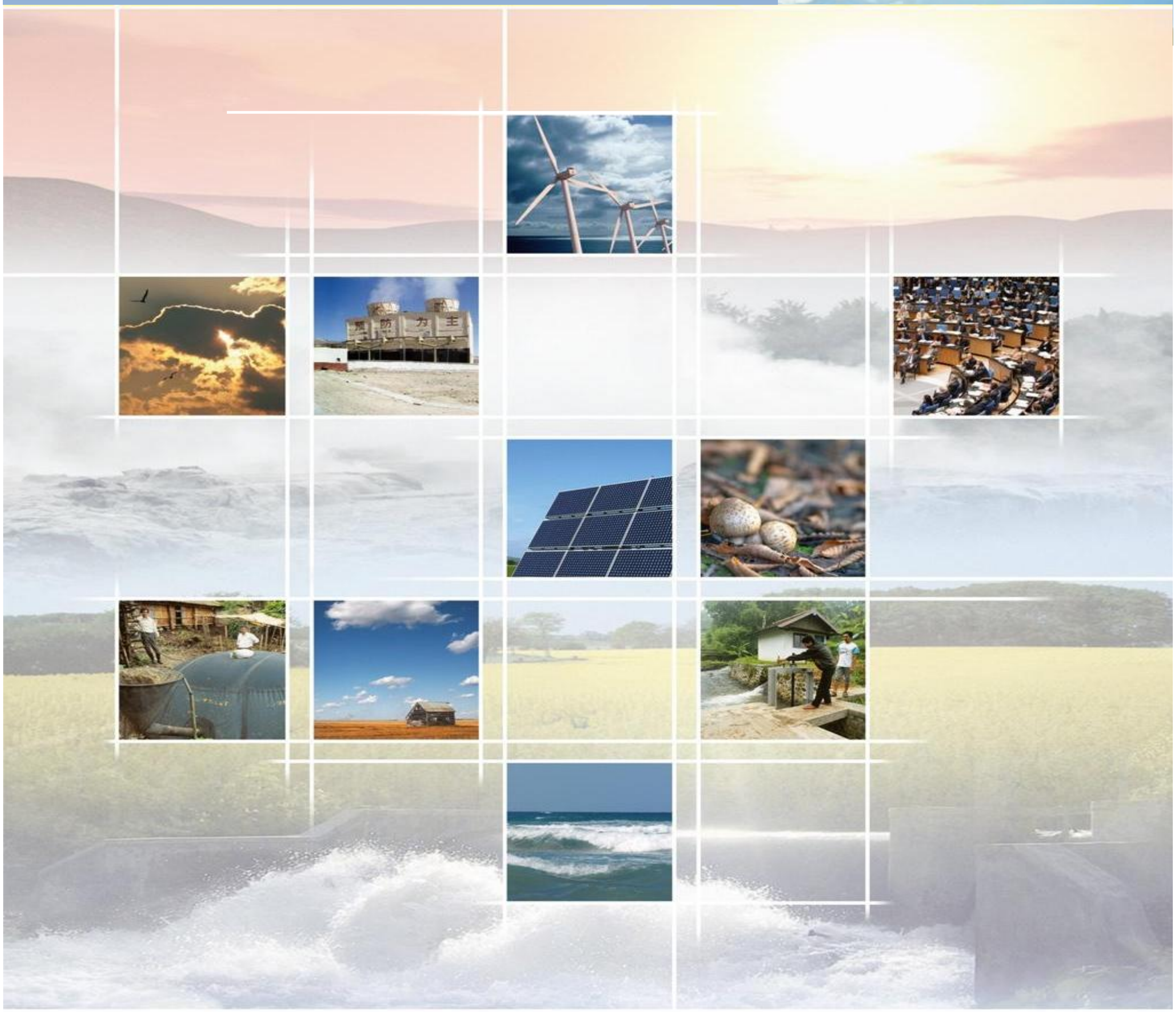
RENEWABLE ENERGIES FOR AFRICA

Potential, Markets and Strategies

January, 2010



REN21 Renewable Energy Policy Network for the 21st Century

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Table of Contents

List of Tables

List of Figures

List of Boxes

Introduction

Recent interest in renewable energy in Africa is driven by, among others, the following important developments. The first key driver is the economic growth experienced in the continent in the last few years which is, in turn, increasing demand for energy services. Africa has recorded steady economic growth in last 3 years, and is estimated to have grown by an average of 5.8% in 2007. The global financial crisis is likely to slow Africa's economic growth and weaken the African population's ability to pay for high energy cost services. Analysts predict that Africa will return to its growth path in the latter part of 2010. However, the overall demand for low-cost and affordable energy services appears to have remained strong. According to the Economic Report on Africa (ERA 2007), the annual flagship publication of the United Nations Economic Commission for Africa (ECA). Many experts believe that renewable energy can help to meet the rising demand for energy.

The second driver is the 2007 and 2008 rapid increase in oil prices, which in July 2008 peaked at almost USD 150 per barrel (Oil-Price.net, 2008). It is estimated that for non-oil producing African countries, petroleum imports as a percentage of export merchandise earnings has doubled over the past decade (AFREPREN, 2007). For example in Guinea, oil prices shot up by 61% in April 2008 grinding public transport to halt[1]. Although the price of oil has fallen dramatically over the last few months, the impact of the high oil priced on African countries continues to be felt, as the prices of the primary exports have experienced equally steep declines. In addition, experts cannot predict with certainty whether a similar or sudden oil price increase will not occur in the future. Renewables are often floated as important options for mitigating the impacts of unpredictable oil price increases.

The third important development that has increased interest in renewables in the region is the recurrent crises faced by most power utilities in the region. For example, in 2006-2007, Ethiopia, Rwanda, Burundi, Uganda, Ghana, Zimbabwe and Tanzania faced unprecedented power rationing which adversely affected their economies (Karekezi and Kithyoma, 2007). Most countries are unable to meet the demand for electricity with their current installed capacities. For example South Africa recently experienced serious power shortage resulting in frequent incidences of load shedding[2]. In Kenya, it was recently revealed that the demand for electricity is growing faster than the supply. According to the national utility, KPLC, a three-year economic boom in the country has resulted in depletion of the country's power reserve margin to about 3%. The peak demand was projected to increase to 1,153 MW in 2007/2008 against an effective generation capacity of 1,185MW (KPLC, 2008, NMG, 2008). The rapid development of renewables is often mentioned as an important response option for addressing inadequate power generation capacity.

A fourth important driver is the growing number of important global environment initiatives that have also stimulated greater interest in renewables in Africa. Renewables featured in Agenda 21 and Climate Change Convention (United Nations, 1992), and the World Summit for Sustainable Development (WSSD) in 2002. Because of the important role of fossil fuels in the build-up of greenhouse gases in the atmosphere (it is estimated that the energy sector accounts for more than half the global emissions of green-house gases) and concomitant climate change concerns, renewables are perceived as an important option for mitigating the emissions of greenhouse gases (Socolow, 1992). In the recent past, renewable energy has received more attention at

[1] In addition, the high oil prices have contributed to escalated food prices. In Sierra Leone, the cost of rice rose to over 300% (Grosbois, 2008) between October 2007 and July 2008. This increase in food prices has resulted in violent protests in some countries e.g. Cameroon, Guinea, Guinea-Bissau and Senegal. High fuel prices are likely to have contributed to high food prices.

[2] Demand for power in South Africa has increased by 50% since 1994.

international level, with the organization of the International Conference on Renewable Energy in Bonn, Germany in 2004.

The Bonn conference brought together ministers and government representatives from 154 countries. Participants acknowledged that renewable energy combined with enhanced energy efficiency, can significantly contribute to sustainable development, to providing access to energy, especially for the poor, to mitigating greenhouse gas emissions, reducing harmful air pollutants, thereby creating new economic opportunities, and enhancing energy security through cooperation and collaboration. The conference reaffirmed the participating countries' commitment to substantially increase with, a sense of urgency, the global share of renewable energy in the total energy supply. Subsequent global conferences have been organized, giving renewables higher profile at political level (http://www.renewables2004.de/pdf/conference_report.pdf). The idea of a global policy network was born at the "Renewables 2004" Bonn conference, as part of the political declaration of the conference, and at a key follow-up, REN21 (Renewable Energy Policy Network for the 21st Century), was launched in June 2005 (www.ren21.net/).

During the most recent International Conference on Renewable Energy in Africa held in Dakar in April 2008, participants recognized the potential contribution of renewable energy to increasing access to modern energy services and ensuring energy security for poverty reduction and economic growth. In a joint declaration, they highlighted the role that renewable energy can play in reducing the impact of the high cost of oil in 2007 and 2008 and in overcoming the power crises experienced in most African countries (http://www.unido.org/index.php?id=o76539).

The above support for renewables, however, was not initially shared by many energy analysts in Africa. In contrast to the industrialized world, which is worried by the long-term global environmental impact of current patterns of energy production and use, African countries are largely pre-occupied with the immediate problems of reversing the poor performance of their centralized power systems, as well as meeting the long-standing and pressing demands for a minimum level of modern energy services for the majority of their poor - many of whom have no electricity and continue to rely on inefficient and environmentally hazardous unprocessed biomass fuels. Recent experiences combined with the rapid decrease in the cost of renewables has begun to generate interest in renewables within African Governments, who increasingly perceive renewables as an option for increasing the robustness of national power systems and contributing to increased access to modern energy in rural Africa.

The above-mentioned developments demonstrate that renewables are increasingly recognised for their potential contribution to meeting the modern energy needs of a rapidly growing African population. What is not yet clear are the prospects for renewables in Africa and the instruments and strategies that are needed to scale-up renewable energy development in the continent - the subject of this study.

1.1. Objectives of the Study

This study demonstrates that Africa has vast renewable energy (RE) potential, which can be cost-effectively exploited where the right policies and supportive measures are in place. Based on success stories and case examples that point out existing barriers that impede RE deployment, it advocates the establishment of suitable regulatory frameworks and planning processes, technology development and deployment schemes, capacity development measures, and appropriate financing instruments. This report mainly targets policy makers, donors and practitioners in the field of renewable energy and aims to provide them with proven policy options and share best practices and lessons learnt from projects implemented in different countries. The report therefore intends to assist in mobilizing high-level policy support for scaling up renewable energy in Africa and contribute to setting the basis for different stakeholders to guide the implementation of Renewable Energy initiatives based on empirical evidence of what has worked in Africa.

1.2. Context

Compiled by AFREPREN/FWD and published by REN21, this study adds an Africa-focussed publication to REN21's work on renewable energy potential analysis. It will serve REN21 participants from governments, international institutions, non-governmental organisations, industry associations, and other partnerships and initiatives in 'catalysing' RE, e.g. by making recommendations in the area of finance and 'good practices' for donors and project developers, which may be used to initiate new or modify existing renewables programmes and policies in Africa. Building on empirical data from African countries and regions, the study will also meet the objective of REN21 of compiling selected country briefs. The findings of the study are expected to feed into ongoing energy initiatives and events of relevant Africa-wide agencies, such as African Union (AU), African Regional Energy Commission (AFREC), the Forum for Energy Ministers in Africa (FEMA), African Development Bank, selected sub-regional agencies and initiatives such as the AFREPREN/FWD Cogeneration for Africa Project (http://cogen.unep.org), as well as international initiatives, such as the Africa-EU-Energy Partnership.

1.3. Content and Methodology

The study provides a brief overview of technically and economically feasible potential for increased use of renewable energy in Africa. Commissioned sub-regional assessments analysed, in detail, the current status of renewables in each of the sub-regions, and potential for renewable energy development (based on existing plans). In addition, the sub-regional assessments included case studies of renewable energy initiatives that have been successfully implemented, as well as those that were less successful, to provide lessons learnt for future initiatives. Case studies were limited to Africa, although relevant experiences in other developing regions were considered. The findings of the sub-regional studies as well as case studies of successful and unsuccessful examples of renewables dissemination provide selected plausible scenarios that could constitute the basis for action.

The study addressed the following key questions:

a) What contribution can renewable energies make to Africa's development? This analysis includes centralised and decentralised electricity generation, RE for cooking/heating, and biofuels.

b) How can opportunities be turned into benefits? This analysis includes policy, regulatory, capacity, and financial constraints.

The study primarily relied on desk studies, which were conducted by several recognised African researchers on potentials and markets of renewable energies in Africa as well as appropriate policies and strategies for promoting them. Limited consultations with key stakeholders were undertaken. Expert reviewers from various disciplines were invited to review the initial draft report. The reviewers, who included stakeholders from ministries of energy, renewable energy experts, private sector renewable energy practitioners and professionals from academic circles, provided valuable insights which were incorporated in the first draft report.

The study integrated findings of relevant studies already prepared for REN21 such as the Global Status Report (www.ren21.net) and other relevant papers and publications of AFREPREN/FWD (www.afrepren.org). Key arguments for promoting renewables in Africa were also sourced from the Bonn renewables 2004 conference issue paper. The relevance of renewables for meeting the MDGs was sourced from the REN21 issue paper "Energy for Development: the Potential of Renewable Energy in Meeting the MDGs".

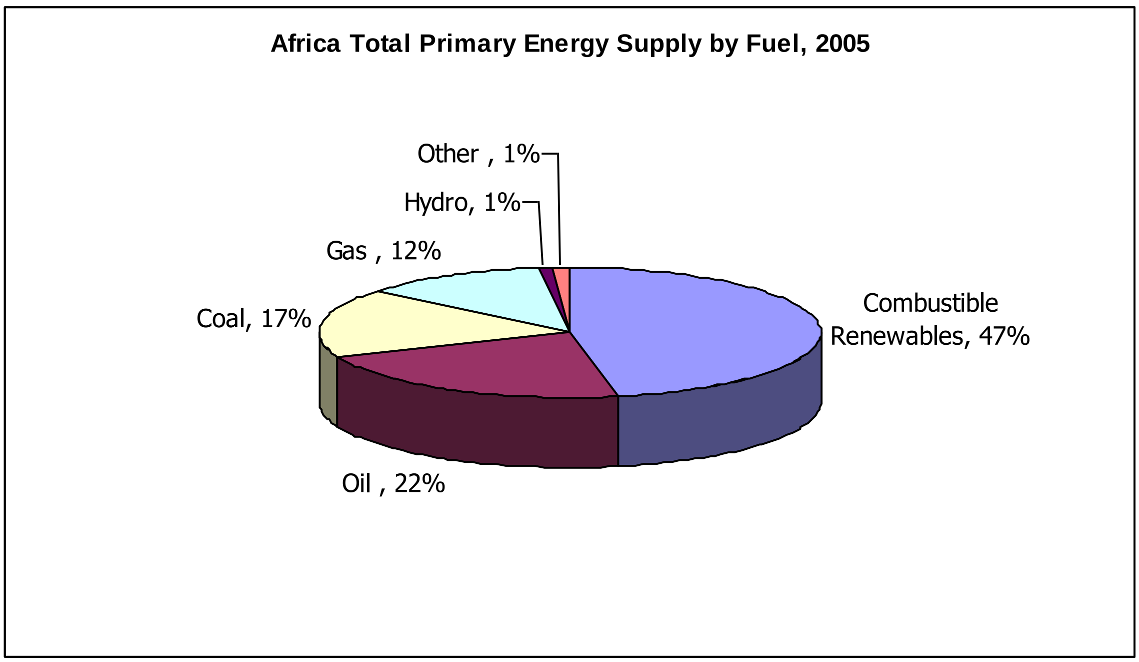
1.4. Report Structure

The report begins by presenting a short overview of the energy sector in Africa. Comparisons between the various regions on the continent are provided. The report then goes on to discuss the potential, current utilization, future projections and rationale for renewable energy in Africa. The renewable energy technologies discussed include bio-energy, hydro, solar, wind, and geothermal. The report then assesses barriers to and opportunities of renewable energy development in Africa. The barriers include policy, skills, institutional, financial and capacity building barriers. The assessment of barriers to renewable energy development is based on various successful and unsuccessful renewable energy case examples. Key lessons from the case examples are provided. The final chapter summarizes the key lessons learnt, and provides recommendations for the development of renewable energy in Africa.

2. Energy Sector in Africa – Brief Background Review

Africa's primary energy sector can be classified into three distinct geographical areas: North Africa, which is heavily dependent on oil; South Africa, which depends on coal; and the rest of Sub-Saharan Africa, largely reliant on traditional biomass – (Figure 1). Biomass accounts for 70-90% of primary energy supply in some sub-Saharan countries (UNDP, 2003; Karekezi, et al, 2002), and 86% of energy consumption (IPCC, 2003). Based on this distinction, the enormous energy challenges facing Sub-Saharan Africa (excluding South Africa), differ from those of North Africa, and South Africa. Although this report covers the whole of Africa, the bulk of the findings and recommendations focus on sub-Saharan Africa as the region with the greatest energy challenges.

Figure 1: Total Primary Energy Supply (2005)



Note: Combustible renewables – primarily biomass.
Source: IEA, 2007

Some of the key challenges facing the energy sector in Africa include:

- Heavy reliance on solid biomass (included in combustible renewables category in Figure 1) is notably prominent in sub-Saharan Africa, with the bulk of biomass energy used in sub-Saharan Africa being traditional biomass which, in turn, contributes to problems of indoor air pollution, land degradation and deforestation (primarily linked to charcoal).
- Declining or stagnant modern energy[3] consumption on a per capita basis
- Low electrification level and slow increase in number of connections – lower than population growth in most sub-Saharan African countries implying that the unelectrified proportion of the population is increasing

[3] This refers to energy sources that are cleaner than traditional biomass.

- Unreliable electricity supply. In 2007 alone, nearly two-thirds of African countries experienced frequent and extended electricity outages. Although conflict and drought triggered several of these crises, in most cases the cause was electricity supplies failing to keep pace with growth in demand (IMF, 2008).
- For oil-importing African countries, high and volatile oil prices experienced in 2007 and early 2008 have had significant adverse impact on the balance of payments.

The next sub-sections review the status of electricity, oil and gas and renewable energy in Africa.

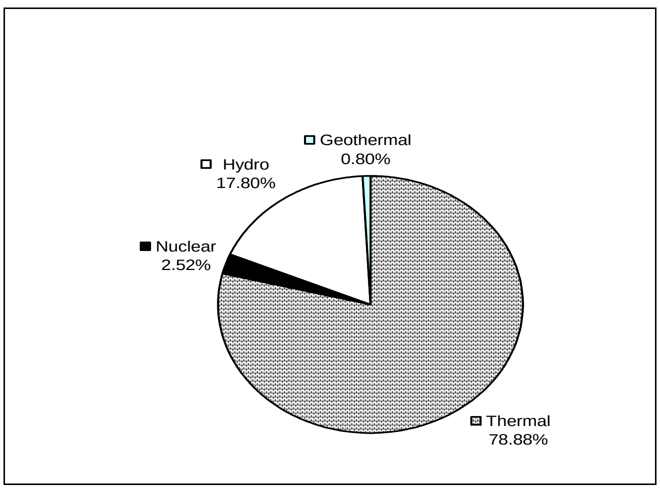
2.1. Electricity

Although Africa accounts for close to 14% of the world's population, its share of global electricity generation is less than 4%. The total electricity production for Africa in 2006 was approximately 3% of the total global electricity production (BP Energy Statistical Review, 2007).

The bulk of the electricity produced in Africa is from thermal stations, because of large coal plants in South Africa and oil fired generation units in Nigeria and North Africa, as well as growing use of emergency oil-fired power stations in many sub-Saharan African countries.

Electricity generation in the North African region is largely dependent on thermal power plants. In Egypt, about 14.1% of the electricity is generated from renewables primarily large scale hydro but with growing proportion of wind power. The balance is mainly from thermal plants. Libya's peak load of 4,012 MW is almost completely met by thermal power plants while in Morocco, 65.6% of power is from the thermal plants (El-Khayat, 2008; OAPEC, 2007).

Figure 2: Electricity Production in Africa by Source (2004)



Note: Thermal generation includes electricity produced from burning fossil fuels (coal, diesel, heavy fuel oil, industrial fuel oil, natural gas, kerosene, etc); Source: IEA, 2007

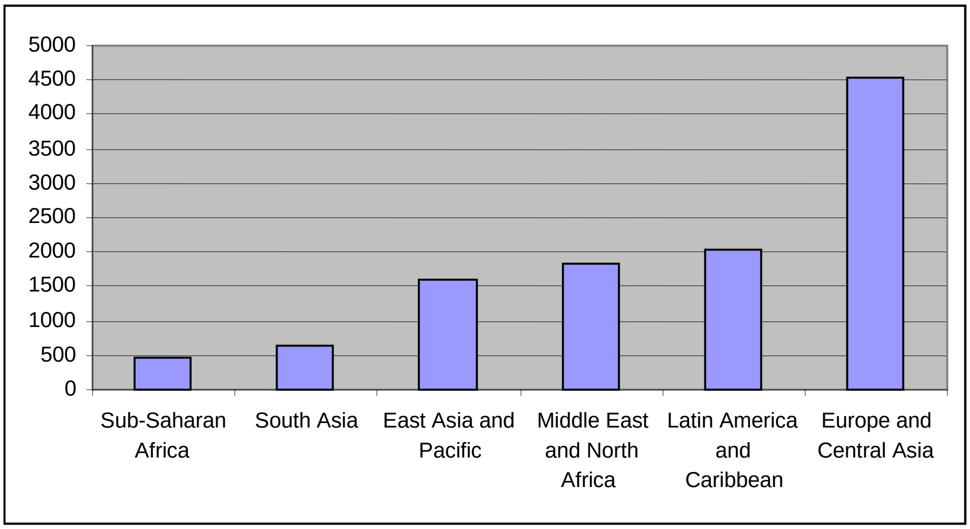
In spite of the massive exploitable hydropower capacity in Africa, its contribution to total power generation is relatively low. Hydropower contributes about 18% of the total power generation in Africa (Figure 2) but it is an important source of power generation in many small sub-Saharan African countries. In 23 African countries, 50% of the total power supply is provided by hydropower[4].

[4] It is important that large-scale hydropower projects identify all the risks, and ensure they are reduced to acceptable levels through long-lasting and environmentally sound, economically viable, and socially acceptable approaches.

The major electricity demand sectors are industry, commerce and households. Use of electricity for transport is largely limited to electric trains in parts of southern and northern Africa. In agriculture, some electricity is used in large-scale farms as well as in agro-industries (UNECA, 2007).

Sub-Saharan Africa is the region with the lowest level of per capita electricity consumption in the world (Figure 3). Per capita electricity consumption increased by only 10% from 1980 to 2004/05 (from 434 kWh to 495 kWh). Excluding South Africa, per capita consumption of electricity in sub-Saharan Africa stands at 228 kWh. This is equivalent to 2.4% of per capita electricity consumption of industrialized countries (World Bank, 2007).

Figure 3: Annual Electricity Consumption per Capita (kWh/Capita) by Regions of the World (2004)



Source: UNDP, 2007

North Africa and South Africa have higher per capita electricity consumption. The two sub-regions account for about 80% of power generated in Africa. This implies that about 47 nations in Sub-Saharan Africa, including Nigeria, Africa's most populous country, consume about 20% of power generated in Africa (IEA, 2006). Table 1 presents electricity consumption in selected African countries.

Table 1: Electricity Consumption in Selected African Countries

Countries	**Annual Electric Power Consumption per Capita – kWh (2004/2005)**	**Rate of electrification**
Chad	11	4.3
Burundi	22	2.0
Sierra Leone	24	5.0
Rwanda	31	10.0
Comoros	31	NA
Burkina Faso	31	4.5
Ethiopia	36	17.0
Niger	40	NA
Mali	41	13.0
Guinea Bissau	44	NA
Equatorial Guinea	52	NA
Eritrea	67	21.0
Benin	69	22.0

Tanzania	69	12.0
Guinea	87	21.0
Democratic Republic of Congo	91	5.8
Togo	102	17.0
Sudan	116	30.0
Nigeria	157	46.0
Kenya	169	16.0
Senegal	206	46.0
Angola	220	15.0
Cote d'Ivoire	224	NA
Cameroon	256	47.0
Ghana	289	54.0
Mozambique	545	11.0
Morocco	652	85.1
Zambia	721	22.0
Zimbabwe	924	34.0
Gabon	999	49.7
Tunisia	1,313	98.9
Botswana	1,406	38.5
Egypt	1,465	98.0
Mauritius	1,775	100.0
Algeria	2,678	98.1
Seychelles	2,716	NA
South Africa	4,848	70.0
Sub-Saharan Africa	**495**	
Sub-Saharan Africa (Excl. South Africa)	**228**	
South Asia	**628**	
Industrialized Countries*	**9,760**	

*Source: Human Development Report, 2008, IEA, 2007, World Bank, 2008; *2005 data*

Sub-Saharan Africa (excluding a few countries such as Mauritius and Seychelles) is characterized by low levels of access to electricity[5] (Figure 4). It is estimated that 64% of Africa's population – equivalent to more than 554 million people have no access to electricity with rural access levels estimated at 8% – Table 2. These figures mask huge differences between the various African countries.

Table 2: Access to Electricity in 2005

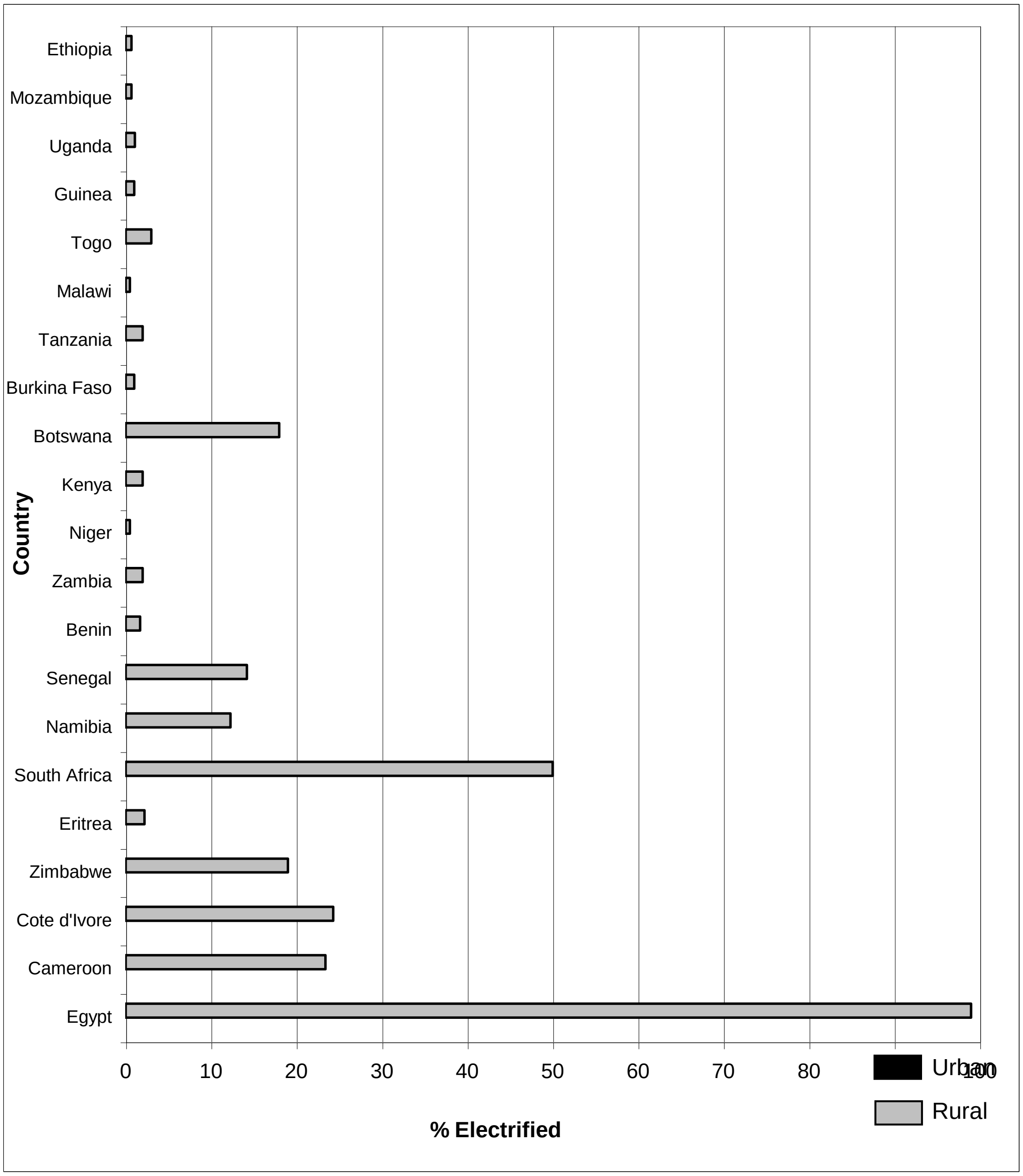
Country or region	Population without electricity (million)	Population with electricity (million)	Urban electrification rate (%)	Rural electrification rate (%)
North Africa	**7**	**146**	**99**	**92**
Sub-Saharan Africa (SSA)	**547**	**191**	**58**	**8**
Africa	**554**	**337**	**68**	**19**
South Asia	706	760	70	45
Latin America	45	404	98	66
China and East Asia	224	1728	95	84
Middle East	41	145	87	62
Developing economies	**1,569**	**3374**	**85**	**56**

Sources: IEA, 2007, WEC, 2006, Mangwengwende & Wamukonya, 2007

[5] Access is sometimes defined as being connected to the electricity grid, and/or having grid extension within the village. (Wamukonya, N. 2003). Information about electrification rates is generally poor while there is a general concordance of magnitudes; there are cases of widely diverging figures.

Most North-African countries have high levels of access to electricity, often registering over 90% electricity access levels. In both Egypt and Tunisia, 99% of the population has access to electricity (El-Khayat, 2008). South Africa's access to electricity is estimated at 70% (Prasad, 2008). The sub-Saharan region has very low access to electricity as shown in the figure below (figure 4).

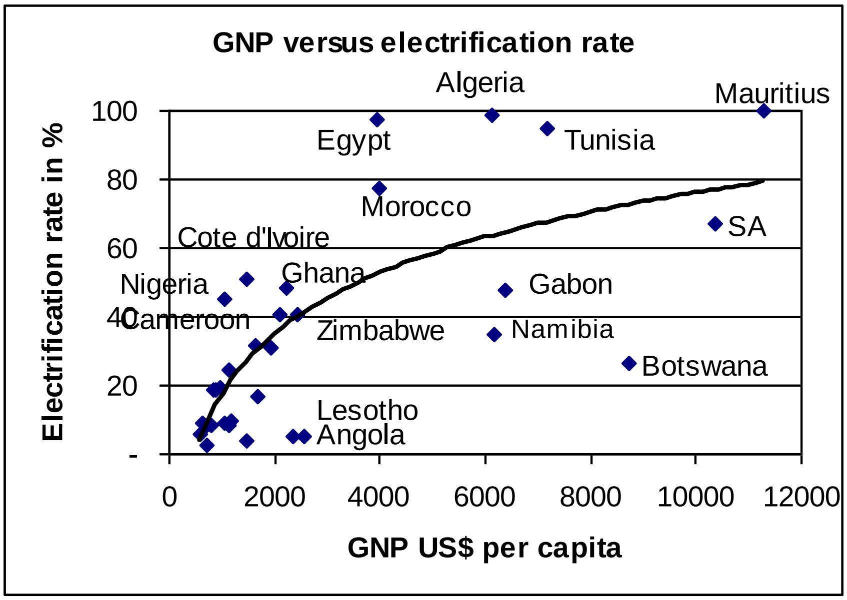
Figure 4: Rural Electrification Levels in Selected African Countries (2003/2004)



Source: GTZ, 2007, UEMOA, 2008; AFREPREN/FWD, 2006

Figure 5 shows that higher rates of electrification are to, some extent, correlated to higher economic development, (measured in GNP per capita). Although attempts have been made to establish a firm causal relationship between access to electricity and GNP, such correlation has so far been inconclusive. There is, however, a growing consensus that access to electricity is a necessary but not sufficient condition for economic development. On the other hand, some level of economic development is also necessary to establish high rates of electrification. This means that experiences with successful programmes in higher income countries should not be used as blue-print models for poorer sub-Saharan African countries.

Figure 5: National Electrification Rate versus GNP (PPP)



Source: IEA, 2004, UNDP, 2005[6]

According to Wamukonya and Magwengwende (2007), the African power sector is facing the following challenges:

- Inadequate generating capacity to provide adequate reliability and security at least-cost to existing consumers and also to meet increasing demand. Since the early 1990's almost every country in Africa has been undertaking reforms in the power sector designed to improve operational and financial performance as well as attract investment from the private sector into a sector that has been dominated by state-owned monopolies. Power sector reforms were primarily designed to bridge short-term generation shortfalls and enhance the financial health of state-owned power utilities. Most of the generation projects by IPPs have been fossil-fuel based and very few sustainable energy IPPs have been constructed (small hydro, solar, wind, geothermal or bagasse). According to many energy analysts, there is little to show in terms of positive results arising from power sector reforms. Rural electrification levels continue to be low and power crises continue to occur frequently. It is interesting to note that the impressive electricity access rates in North Africa were achieved before the initiation of power sector reforms. In both South Africa and Mauritius, impressive electrification levels were realized by state-owned utilities without any reforms (Karekezi and Sihag, 2004).

- Absence of robust regional transmission networks that can provide emergency support and take advantage of savings from regional cooperation. Through regional cooperation countries can develop bankable projects based on the benefits of deferring more costly domestic projects. Several countries in the region that have benefited through regional

[6] http://hdr.undp.org/statistics/data/indicators.cfm?x=9&y=1&z=1

interconnection (SAPP) include Botswana, Lesotho, Namibia, Swaziland and Zimbabwe. These are countries whose maximum demand exceeds the capacity available from their domestic sources. These countries have been able to use long-term power import contracts and the short-term energy market (STEM) to meet demand while deferring the development of higher cost domestic options.

Many of the problems facing the power sector in Africa mentioned by Wamukonya and Magwengwende have their roots in the poor and often deteriorating performance of African countries' electricity distribution system. Losses of over 20% are routinely recorded in many sub-Saharan countries with some countries losing more than 40% of the power generated due to technical and non technical losses[7].

2.2. Renewable Energy

Africa is endowed with substantial renewable energy resources. The region has an estimated 1750 TWh/year[8] of hydropower capacity, 9,000 megawatts of geothermal potential (hot water and steam based), abundant biomass, and significant solar and wind potential (Karekezi and Ranja, 1997; IHA, et al, 2000; BCSE, 2003; Hydro4africa, 2008; Nepad, 2003; Bartle, 2008).

If successfully exploited, renewables can contribute to addressing two key challenges of the energy sector in Africa, which are at the forefront of policy makers list of priorities: provision of improved and modern energy services to the majority of the population, who are poor; and power unreliability and risks associated with over-reliance on imported oil and hydro power.

Renewables can contribute to poverty alleviation and assist in addressing the Millennium Development Goals (MDGs), while providing modern improved energy services to the poor. This is particularly true of small-scale renewable energy technologies that are made locally and operate on the basis of small scale solar, thermal, wind or animate power options. Such systems can not only provide energy that is affordable to the poor but can also be a source of employment and enterprise creation for both the rural and urban poor in the east and horn of Africa[9]. Examples of such renewables include (Mapako and Mbewe (eds), 2004; Karekezi and Kithyoma, 2002; UNDP, 2004; World Bank, 2004):

- Low cost but more efficient biomass-based combustion technologies (e.g. improved cook stoves, efficient charcoal kilns, brick-making kilns, fish smokers, tea dryers and wood dryers).
- Pico and micro hydro solar and wind pumps 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 of Africa through better use of animate power options.
- Treadle, ram, solar powered and wind pumps for irrigation, which increase agricultural outputs thus generating income for the rural farmer.
- Solar dryers[10] that can lower post-harvest losses enabling the rural farmer to store surplus produce and market his/her produce when prices are higher.

[7] Non technical losses include electricity theft, non-payment by customers, errors in technical losses computation and errors in accounting and record keeping that distort technical information

[8] According to a study involving International Hydropower Association; International Commission on Large Dams; International Energy Agency; and, the Canadian Hydropower Association; Africa's technical potential for hydropower is 1,750 TWh/year while the economic potential is 1,000 TWh/year (see IHA, et al, 2000).

[9] Sub-Sahara Africa countries already use renewable energy for cooking and powering rural industries although the effectiveness and efficiency of these renewable resources needs to be improved.

[10] Solar dryers also ensure that the farm produce is dried to the recommended moisture content thus ensuring longevity against pest attack and rotting.

- Solar water pasteurizers that provide clean potable water and reduce water borne diseases, which translates to increased availability of labour and thus increases agricultural output and income.
- Forestry and agricultural residues for electricity generation, cogeneration of heat and power, motive power and biogas production

The potential contribution of renewable energy to the MDGs is summarized in table 3.

Table 3: Importance of Renewable Energy to Achieving Specific Millennium Development Goals

MDG	Renewable Energy Contributes by
1 Cutting Extreme Poverty and Hunger	• Reducing share of household income spent on cooking, lighting, and space heating by eliminating the purchase of kerosene through wider use of renewable options such as biogas. • Improving ability to cook staple foods. • Reducing post-harvest losses through use of solar dryers as opposed to diesel run generators for better preservation. • Use of treadle and ram pumps, and electricity from renewable energy sources for irrigation to increase food production and access to nutrition. • Enabling enterprise development, utilizing locally available resources such as agricultural residues, biogas etc and creating jobs. • Use of renewables-based lighting to allow permit income generating activities during the night. •
2 Universal Primary Education	• Renewables based lighting for reading or studying beyond daylight. • Creating a more child-friendly environment (access to clean water, sanitation, lighting, and space heating/cooling, less time needed for firewood collection, school feeding), which can improve attendance in school and reduce dropout rates. • Provision of renewables based electricity to rural schools can assist in retaining teachers. • Electricity from renewables can power equipment enabling access to media and communications that increase educational opportunities.
3 Gender Equality and Women's Empowerment	• Freeing women's time from survival activities, allowing opportunities for income generation. • Clean energy options such improved biomass cookstoves and biogas units can reduce exposure to indoor air pollution which adversely affects women in Africa and improve health (through use of improved stoves). • Lighting streets using electricity from renewables can improve women's safety. • Providing lighting for home study and the possibility of holding evening classes for women.
4, 5, 6. Health	• Reducing exposure to indoor air pollution thus reducing respiratory and eye diseases, less burns, and improving health through improved and more efficient biofuel cookstoves. • Providing access to better medical facilities for maternal care through PV-powered clinics and medical equipment. • Allowing for medicine refrigeration, equipment sterilization, and safe disposal by incineration. • Facilitating development, testing, and distribution of drugs through PV-powered rural clinics. • Enabling access to the latest medicines/expertise through renewable-energy based telemedicine systems. • Providing access to health education media.
7 Environmental Sustainability	• Boosting agricultural productivity, increasing quality instead of quantity of cultivated land. • Reducing deforestation for traditional fuels, reducing erosion and desertification. • Reducing greenhouse gas emissions. • Restoring ecosystem integrity through land management.

Source: REN21 Renewable Energy Policy Network, 2005

Chapter 3 of this report assesses the potential for renewables in Africa and provides a brief on status or current utilization of each of the renewable energy and provides notable case studies which provide useful lessons for future development of renewable energy projects in Africa[11].

Renewable energy options can help to diversify the sources of electricity for African countries, thereby enhancing energy supply security. Due to the recent droughts experienced in the region, many hydro dams have been operating under capacity due to low water levels. Renewable

[11] Some of notable case studies include: Biomass cogeneration in Mauritius; Geothermal in Kenya; Solar PVMTI in Kenya; and Wind power generation in Egypt and Morocco. These are discussed in detail in Chapter 4 of this report.

energy can play a critical role in ensuring security of generation. For instance, in the case of Kenya, geothermal was available 100% of the time during its episodes of drought and significantly reduced the shortfall in capacity.

The dispersed character of rural settlements in east and southern Africa provides an ideal setting for renewables that are more cost competitive in remote and dispersed communities, and can help to reduce power losses which occur due to transmission over long distances[12].

2.3. Oil and Gas

The oil and gas sector in Africa is characterized by rising levels of proven oil and gas reserves[13] in the continent over the past 10 years, the emergence of new players in the production scene triggered by successes in exploration activities, and the exportation of more than two thirds of the oil and gas produced in the African continent (UCT, 2003). The following table (Table 4) shows the proven oil reserves and production for the year 1987-2007 in Africa.

Table 4: Africa proven oil reserves and production for the year 1987-2007

Africa Proven oil Reserves (billion barrels)					**Oil Production (Thousand Barrels per Day)**				**Reserves/Production Ratio**			
Country	1987	1997	2006	2007	1987	1997	2006	2007	1987	1997	2006	2007
Algeria	8.6	11.2	12.3	12.3	1,048.0	1,276.7	1,814.1	1,833.6	22.5	24.0	18.6	18.4
Angola	2.0	3.9	9.0	9.0	360.0	714.0	1,413.0	1,744.5	15.2	15.0	17.5	14.1
Chad	0.0	0.0	0.9	0.9	0	0	157.9	144.2	0.0	0.0	15.6	17.1
Brazzaville	0.7	1.6	1.9	1.9	123.0	253.0	241.6	242.2	15.6	17.3	21.5	21.5
Egypt	4.7	3.7	3.7	4.1	896.0	856.4	639.2	637.0	14.4	11.8	15.9	17.6
E. Guinea	0.0	0.6	1.8	1.8	0	52.4	366.0	377.3	0.0	31.4	13.5	13.1
Gabon	1.0	2.7	2.0	2.0	155.0	370.4	237.2	244.2	17.7	20.0	23.1	22.4
Libya	22.8	29.5	41.5	41.5	972.0	1,445.9	1,681.0	1,701.8	64.3	55.9	67.6	66.8
Nigeria	16.0	20.8	36.2	36.2	1,341.0	2,132.5	2,439.9	2,349.6	32.7	26.7	40.6	42.2
Sudan	0.3	0.3	6.6	6.6	0	5.0	378.1	463.8	0.0	164.4	47.8	39.0
Tunisia	1.7	0.3	0.6	0.6	106.0	84.0	76.4	95.0	43.9	9.8	21.5	17.3
Other Africa	1.0	0.7	0.6	0.6	231.4	197.5	252.4	252.0	11.8	9.7	6.5	6.5
Total Africa	58.8	75.3	117.1	117.5	5,232.4	7,387.8	9,696.8	10,085.2	30.8	27.9	33.1	31.9

P-Preliminary data; Source: EIA, 2008; BP Statistics, 2008

The oil and gas sector plays a pivotal role in the continent's development agenda by fulfilling three functions: it is a major source of foreign exchange earnings for oil exporting countries; a significant contributor to government revenues; and a source of liquidity to the banking sector. The oil and gas industry in Africa has over the years attracted the highest foreign direct investment (FDI) but due to its capital-intensive and advanced technology requirement, exceptionally high associated risks, poor access to funds by indigenous oil companies, the major players in both oil and gas upstream and downstream sub-sectors are owned and run by international oil companies in cooperation with some African national companies.

[12] See Annex 6 for the average cost of grid extension in rural Kenya.

[13] Proved reserves of oil– Generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions.

2.3.1. Oil in Africa

Africa's proven oil reserves account for about 9.6% of the world's total. The continent's major oil producers are Nigeria, Libya, Algeria and Angola. Over 83% of oil reserves in Africa are estimated to be in 4 countries, Algeria, Libya, Nigeria and Angola, the remaining oil producers account for under 17% of the reserves (EIA, 2009).

Partly due to high international interests as well as the challenges of managing oil reserves, many of the oil producing countries in sub-Saharan Africa have experienced social, political and economic instability. Some sub-Saharan African oil producers such as Nigeria, which has experienced massive and persistent oil product shortages, in spite of being one of the world's largest oil exporters – a demonstration of the disorganization oil revenues can engender. Another example of a country with contrasts when it comes to oil is Angola, a significant crude oil exporter. The country is the seventh largest contributor of crude oil imports to the United States. However, the country still imports a large portion of its refined oil (EIA, 2008).

Future consumption of oil and gas in Africa is set to increase (Table 5) at rates higher than production because of the recent strong economic growth being experienced by most African countries. Table 5 presents oil consumption in various African regions.

Table 5: Oil Consumption in Selected African Countries

Oil consumption (Thousand barrels per day)	2002	2003	2004	2005	2006
North Africa					
Algeria	224.6	228.8	238.4	250.0	279.8
Egypt	564.7	561.1	603.9	635.0	652.7
Libya	233.3	244.1	254.4	266.0	278.7
Sub-Saharan Africa (excl South Africa)					
Nigeria	303.9	288.5	277.1	300.0	302.0
Senegal	30.1	30.3	33.8	35.0	36.2
Mali	4.2	4.2	4.4	4.5	4.6
Sudan	58.3	65.4	71.2	72.0	79.8
Kenya	51.2	54.2	59.2	64.0	65.5
Ethiopia	30.4	29.0	28.6	27.6	25.6
Cote d'Ivore	23.2	22.9	26.9	27.0	26.0
Benin	12.1	14.1	16.8	16.0	17.1
Ghana	38. 7	41.5	45.3	47.0	49.3
Angola	44.9	47.5	48.3	50.0	55.6
Burkina Faso	7. 8	8.1	8.2	8.3	8.5
Gambia	1097	2.0	2.0	2.0	2.1
Guinea	8.4	8.4	8.5	8.5	8. 6
Malawi	5.4	5.4	6.3	6.0	6.2
South Africa	475.4	490.2	503.9	497.0	504.9

Source: EIA, 2008 (http://tonto.eia.doe.gov/country); BP Statistics, 2008

In the recent past, global oil prices have hit record high price levels, with prices reaching a high of more than $140 per barrel (Oil-Price.net, 2008). With the countries in the region mostly classified as low-income oil importing economies, the reliance on the highly priced fossil fuels as a source of energy impacts negatively on their balance of payments and GDP growth rates. For example, the debt relief that the G8 countries agreed to, is set to save sub-Saharan African countries around $1 billion a year; however, available estimates indicate that the rise in crude oil prices cost these countries an additional $10.5 billion in oil imports, ten times more than the gain in debt relief (IEA, 2005).

A renewable energy option that could directly substitute for fossil fuels is bio-fuels. Bio-fuels have grown in importance in the recent past due to their potential to provide a reliable and sustainable source of energy in most parts of the world. Bio-fuels have the potential to reduce dependence on imported fossil fuels and increase energy security. Furthermore, bio fuels can play a key role in reducing the rate of global climate change by replacing the burning of fossil fuels. Other key benefits of bio-fuels includes the potential to provide communities in Africa with energy services for essential uses like lighting, income generating activities, pumping water, transportation, and for educational activities (UNDESA, 2007). Some oil producing countries such as Nigeria and Angola are interested in biofuels primarily as a mechanism for reducing national oil consumption and extending the lifespan of their oil reserves. There are, however, a number of important drawbacks associated with biofuels – ranging from possible diversion of land for food to fuel production, to the problem of equity and adverse environmental impacts. Biofuels are discussed in greater detail in chapter 3 of this report.

2.3.2. Gas in Africa

Africa holds about 8% of the world's natural gas resources with about 500 trillion cubic feet of proven gas reserves, (EIA, 2009). Most of the natural gas reserves are found in North Africa and West Africa, out of which about 70% are found in Algeria and Nigeria (EIA, 2009). Other countries with relatively significant proven natural gas reserves are Egypt, Libya, Angola, Mozambique and Namibia (Table 6). Gas exports are largely from North Africa which has the requisite infrastructure. Most of the associated gas from the continent's Western coastline is flared due to limited infrastructure. Several major gas development projects that are either ongoing or planned are expected to result in a major increase in the use of associated gas for power generation in a number of West African countries.

Table 6: Proven Natural Gas Reserves in Africa

Natural Gas: Proved Reserves (Trillion cubic feet)	**2008**
North Africa	
Algeria	159.00
Egypt	58.50
Libya	54.38
Morocco	0.05
Tunisia	2.30
Sub-Saharan Africa (excl. South Africa)	
Nigeria	184.16
Equatorial Guinea	1.30
Mauritania	1.00
Rwanda	2.00
Somalia	0.20
Sudan	3.00
Mozambique	4.50
Cameroon	4.77
Congo Brazzaville	3.20
Namibia	2.20
Angola	9.53
Gabon	1.00
Cote d'Ivoire	1.00
Ghana	0.80
Ethiopia	0.88
Tanzania	0.81
Congo Kinshasa	0.04
Benin	0.04
South Africa	0.318

Source: BP Statistics, 2008 ; EIA, 2009, EWURA, 2008

Table 7: Natural Gas Production in Africa

Natural Gas production (trillion cubic feet)	2000	2001	2002	2003	2004	2005	*P2006	*P2007
North Africa								
Algeria	2.940	2.787	2.799	2.850	2.830	3.108	3.079	3.026
Egypt	0.646	0.867	0.883	1.058	1.150	1.501	1.596	1.677
Morocco	0.002	0.002	0.002	0.002	0.002	0.002	0.002	NA
Libya	0.212	0.218	0.219	0.194	0.285	0.399	0.523	NA
Sub-Saharan Africa (Excl South Africa)								
Nigeria	0.440	0.526	0.501	0.717	0.770	0.791	1.006	1.200
Tanzania	0	0	0	0	0	0	0.005	NA
Angola	0.02	0.019	0.022	0.023	0.026	0.028	0.024	NA
Mozambique	0.002	0.002	0.002	0.003	0.003	0.007	0.058	NA
Senegal	0.002	0.002	0.002	0.002	0.002	0.002	0.002	NA
Cote d'Ivore	0.048	0.048	0.047	0.047	0.046	0.046	0.046	NA
Gabon	0.003	0.003	0.003	0.003	0.004	0.004	0.004	NA
Equatorial Guinea	0.001	0.001	0.045	0.046	0.004	0.046	0.046	NA
South Africa	0.058	0.074	0.081	0.081	0.079	0.078	0.102	NA

Source: EIA, 2008; BP Statistics, 2008

*P – preliminary data

In the past, gas has been substantially under utilized or wasted in many African countries. Substantial quantities of associated gas have been flared[14], thereby wasting the resource and causing significant environmental damage[15]. Sub-Saharan Africa is often mentioned as being the largest source of flared associated gas, which is produced as part of oil production. Although gas markets are being established on a country-by-country basis, regional development is considered an equally attractive medium and long-term goal. There has also been activity in the development and utilization of natural gas, previously limited to North Africa (i.e., through the Algeria-Tunisia-Italy Gas Pipeline).

In West Africa, a pipeline project (the West Africa Gas Pipeline, WAGP) to supply Benin, Ghana and Togo with Nigerian gas is under way, while in southern Africa, the Mozambique-South Africa gas pipeline has been developed (Davidson and Sokona, 2002). In addition to the two projects, South Africa has taken two steps towards further utilization of regional natural gas resources: (a) pre-feasibility studies on use of gas from the Kudu gas field off the coast of Namibia to power a combined cycle gas turbine power station to be located in the Western Cape, as well as to establish new industries along the pipeline, (b) a comprehensive gas bill/law that sets conditions for licensing the construction, operation and trading for transmission, distribution and storage of piped natural gas. Tanzania also has significant gas resources that it has started to exploit and Rwanda has started exploiting natural gas from its Lake Kivu for power production. One of the advantages of natural gas development is that it can lead to the establishment of natural gas

[14] If not flared, associated gas may be used at the installation as fuel for generators, may be transported via pipelines and sold elsewhere, or may be injected into the ground (World Bank, 2006). But in areas of the world, such as sub-Saharan Africa, lacking gas infrastructure and markets, this associated gas is usually released into the atmosphere, ignited (flared or burned) or un-ignited (vented)" (World Bank, 2006).

[15] Gas flaring and venting is a major issue in Africa because most of her gas resources are flared. Of the world total amount of flared or vented gas, Africa's contribution is in excess of 35%, of which North Africa accounts for 24% and sub-Saharan Africa the remaining 76%. On average, oil operators in sub-Saharan Africa flare over 70% of overall regional production compared with the worldwide average of 4%. In only a few cases does small-scale gas development occur. Gas flaring represents an economic cost of US$3 billion annually in sub-Saharan Africa (AGI 2001). Furthermore, gas flaring and venting represents an environmental problem because of its release into the atmosphere of greenhouse gases.

pipeline systems that can stimulate decentralized combined heat and power investments – an energy efficient option that is often an important component of sustainable energy plans.

2.4 Other Energy Sources in Africa

Coal production is also on the increase in Africa though available mostly in Southern Africa. South Africa accounts for around 90% of Africa's coal production (coal liquefaction), and it is estimated that 90% of the continent's proven and economically attractive coal reserves and a substantial portion of its uranium deposits are located in South Africa, Zimbabwe and Namibia. In East Africa, Tanzania is estimated to have 200 million metric tons of coal reserves. In North and West Africa, Egypt, Algeria, Niger and Nigeria have 21, 40, 70 and 190 million metric tons of coal reserves, respectively (IEA, 2007). Increased use of coal is beginning to generate the common environment problems associated with coal use throughout the world. Examples include indoor air pollution, local and regional air pollution, greenhouse gases emissions and land degradation in the case of open cast coal mines (Asamoah, 2001). Growing coal consumption in China and India is also ramping up coal prices.

Nuclear energy in Africa is still at its embryonic stage with the most significant installations constructed in South Africa. Interest in nuclear power is growing in North African countries such as Egypt, and Libya (France recently announced willingness to construct nuclear power stations in Libya) and Nigeria (MoST[16], 2008). Out of the 440 nuclear power plants operating around the world today (ATDF, 2005), Africa has 2 which are Koeberg 1 and Koeberg 2 both in South Africa with a total installed capacity of 1,840 MW (ESKOM, 2006). Just as with other regions of the world, the embryonic nuclear power industry is bedeviled by problems of cost overruns[17], operational safety/reliability issues, and proliferation concerns and has also not been able to find permanent solutions for nuclear waste disposal. The other significant energy resource available is peat mainly found in Rwanda and Burundi.

Chapter 3 delves into renewable energy in Africa in greater detail.

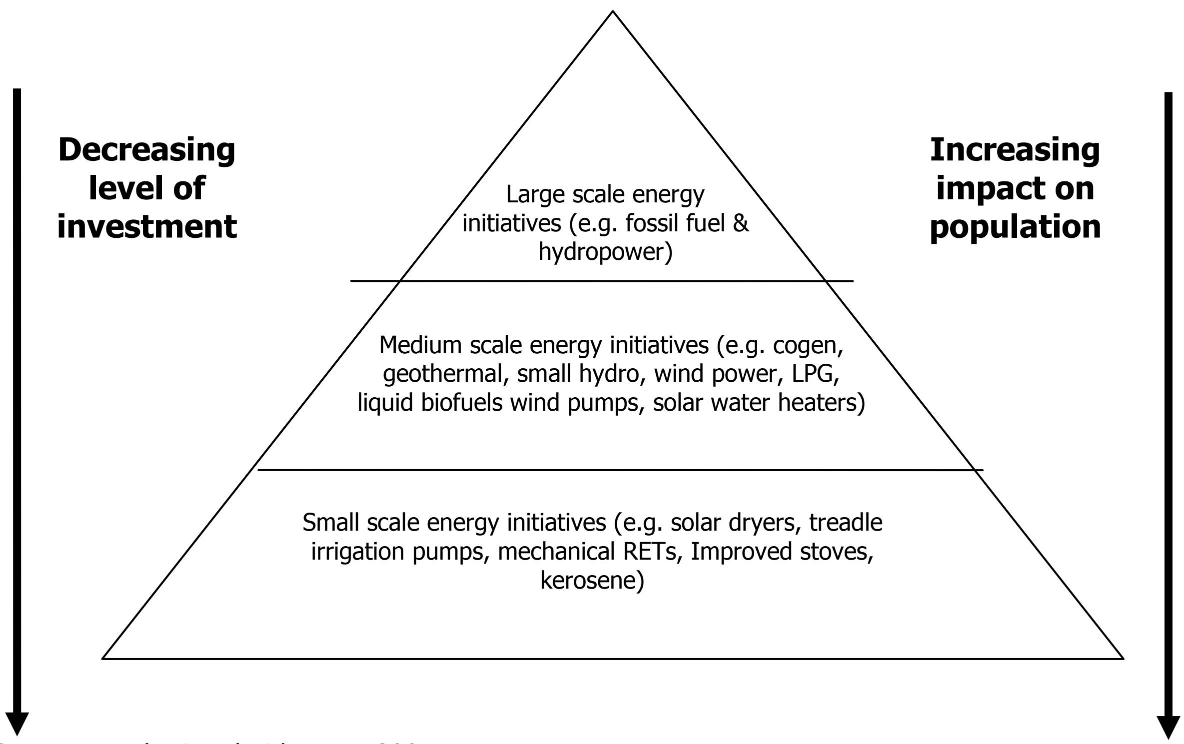
[16] Nigerian Ministry of Science and Technology

[17] Recent report from the South African power utility, Eskom, states that it was not in a position to invest in nuclear, and has terminated the talks it was holding with Global Nuclear Technology providers Westinghouse and Areva. The utility said it has decided not to proceed with the proposed investment in the Nuclear 1 project due to the magnitude of the investment required (Mail & Guardian, 2008).

3. Potential, Status and Prospects for Renewable Energy in Africa

Power utilities in Africa have, by and large, failed to provide adequate electricity services to the majority of the region's population, especially to rural communities and to the urban poor (Karekezi and Kimani, 2002; Karekezi et al, 2004). In spite of the fact that the large-scale conventional energy sector (electricity and petroleum) receives the bulk of energy investment in most African countries (Wolde-Ghiorgis, 2002), it serves only a small proportion of the population, with provision of electricity being largely confined to urban middle and upper income groups and to the formal commercial and industrial sectors. Figure 6 illustrates this somewhat paradoxical situation clearly.

Figure 6: Energy Pyramid in Africa



Source: Karekezi and Kithyoma, 2005

In spite of substantial investment, the conventional sector (mainly electricity) in sub-Saharan Africa is characterised by unreliability of supply, low access levels, low capacity utilisation and availability factor, deficient maintenance, poor procurement of spare parts and high transmission and distribution losses. In addition, the financial performance of many power utilities throughout Africa is unsatisfactory (Karekezi and Kimani, 2002, AFREPREN/FWD, 2001b; Teferra, 2001a, b & c; Mapako, 2000; Kayo, 2001; Dube, 2001; NER, 2001).

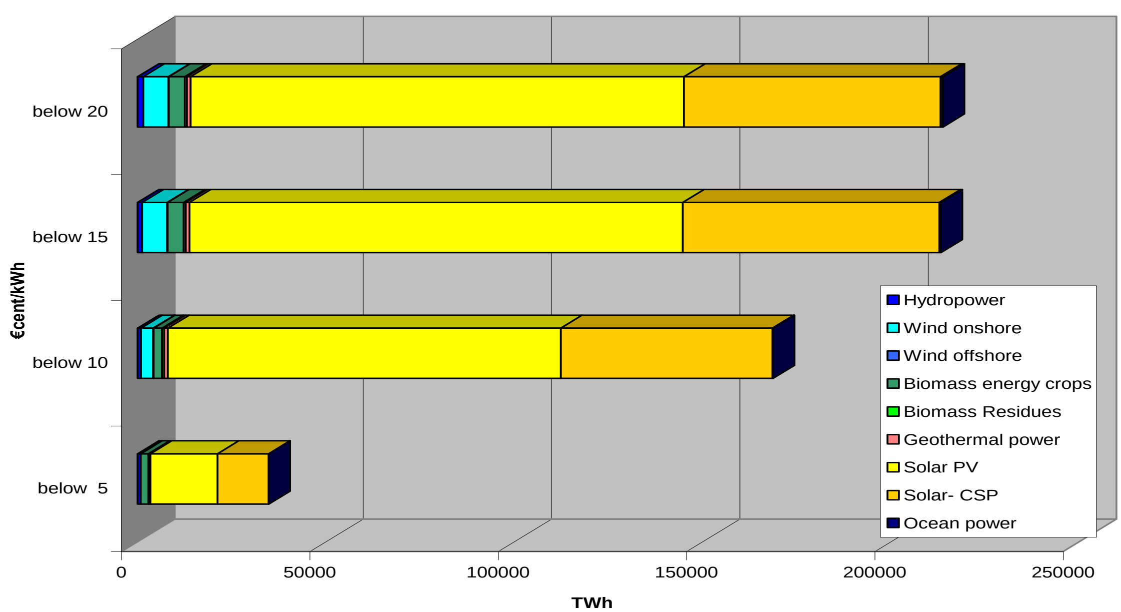
There is growing evidence that investment in small and medium scale renewable energy technologies options may have more impact in improving energy services for the majority of sub-Saharan Africa's population especially the poor (Mapako and Mbewe (eds), 2004; Karekezi and Kithyoma, 2005; UNDP, 2004; World Bank, 2004). Therefore, equal emphasis on small and medium scale renewables should be promoted.

A number of analysts argue that African countries that still have embryonic energy infrastructure can leapfrog to new, cleaner and more efficient energy technologies and systems thus avoiding the adverse impacts associated with conventional fossil-fuel centralized energy systems. There are a number of renewable energy technologies that are already cost-competitive, available in the public domain and are not protected by costly patent barriers. Adoption of these technologies by African countries could deliver significant environmental as well as economic benefits. Mauritius provides an interesting example of such a possibility.

With the initiation of major bagasse-based co-generation investments (discussed in greater detail later in this report), Mauritius relies on relatively clean biomass fuels to supply about 20% of its electricity needs (Deepchand, 2002; Veragoo, 2003). AFREPREN research results indicate that over 50% of the electricity needs of selected eastern and southern African countries could be met by bagasse fuelled co-generation plants (Karekezi and Kithyoma, 2005). Another example is Kenya which meets over 10% of its electricity needs from geothermal – a local resource that reduces the need for oil imports and, in contrast to oil fired power stations is not adversely affected by high oil price. These and more examples of the renewables contribution to energy sector in Africa are discussed in more detail later in this chapter.

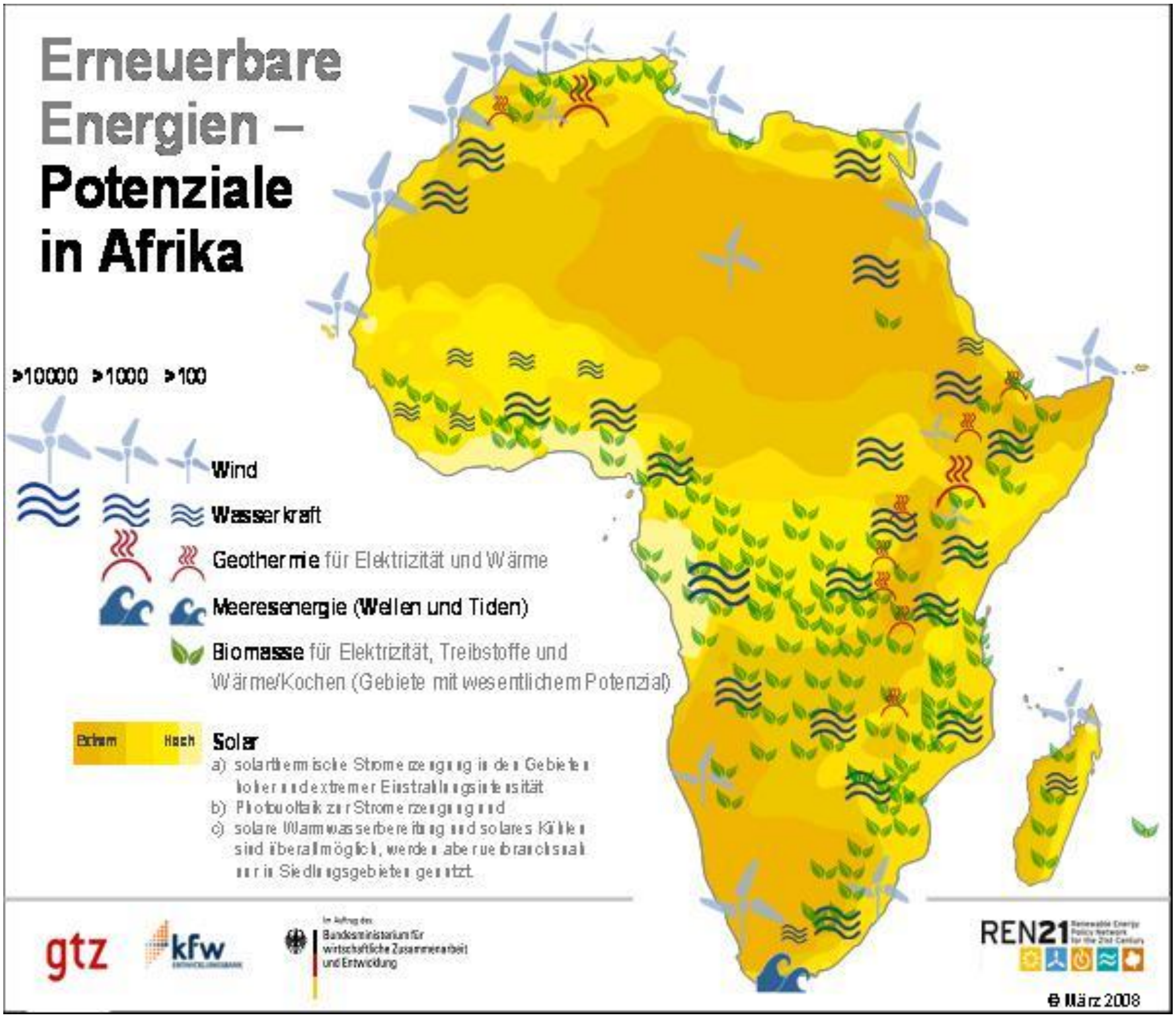
Africa is a continent with an abundance of energy resources. Its annual output of finite resources in the form of petroleum, natural gas and coal totals some 700 million tonnes of oil equivalent (Mtoe). Africa could, however, extract many times that amount from renewable energy resources. The continent's future economic potential for power generation from water, wind, solar, geothermal and biomass resources adds up to several 10,000 TWh/year, while the potential amount of electricity that could be produced from fossil energy sources is less than 5,000 TWh/year. The following figures (Figures 7 and 8) shows that estimated technical RE potentials extend beyond 200,000 TWh/year, including more than 30,000 TWh/year rated as competitive in the future (Krewitt, et al, 2008).

Figure 7: Renewable Energies in Africa



Source: GTZ, 2008

Figure 8: Africa Renewable Energy Potential



Source: GTZ, 2008

3.1. Bio-energy

Biomass energy forms the bulk of Africa's energy supply as most of the population relies on traditional uses of biomass, which are used inefficiently. In 2001, biomass accounted for 49% of total primary energy supply (IEA, 2003). Although there was a decrease in the share of biomass in total primary energy supply (from 60% in 1995 to 49% in 2001), (IEA, 2003), biomass still plays a dominant role in Africa's energy sector (IEA, 2003a). More recent estimates indicate that biomass and waste and other renewables account for nearly 40% of incremental energy demand in Africa, consumed mostly as fuelwood, crop residues and charcoal for cooking and heating WEO, 2008; IEA, 2005). It is, however, important to note that data on biomass in Africa is particularly problematic. Most countries do not have reliable and up-to-date databases on energy, and especially biomass energy[18].

[18] The IEA rates the quality of data on Africa's biomass energy sector as low quality (IEA, 2003). There is need for urgent capacity building in order to improve biomass energy databases in this region.

The heavy reliance on biomass is notably prominent in sub-Saharan Africa, where biomass accounts for 70-90% of primary energy supply in some countries (UNDP, 2003; Karekezi, et al, 2002), and up to 86% of energy consumption in some countries (IPCC, 2003; IEA, 2005). Major variations within Africa exist, with biomass accounting for only 5% of energy consumption in North Africa and 15% in South Africa (IPCC, 2003). The bulk of biomass in sub-Saharan Africa is converted using traditional and inefficient technologies hence the use of the term 'traditional biomass (UNDP, 2003)

Given the stagnant (or sometimes declining) per capita modern energy use, the heavy reliance on biomass energy in Africa (especially in sub-Saharan Africa) is unlikely to change in the near future (Karekezi, Lata and Coelho, 2004).

Available estimates indicate that by 2020, Africa's biomass energy use is expected to increase roughly at the same rate as population growth rates (IEA, 2003), resulting in insignificant changes in the share of biomass in total final energy supply. Table 8 shows the number of people relying on biomass for cooking and heating in developing countries.

Table 8: Number of People Relying on Biomass for Cooking and Heating in Developing Countries (million)

Country/Region	**2000**	**2030[19]**	**2000-2030 (%)**
China	706	645	-9
Indonesia	155	124	-25
Rest of Asia	137	145	6
India	585	632	7
Rest of South Asia	128	187	32
Latin America	96	72	-33
Africa	**583**	**823**	**27**
Developing Countries Total	2,390	2,628	10

Source: IEA, 2002a

3.1.1. Traditional Biomass[20]

Although inefficient, traditional biomass energy is a local energy source, which is readily available to meet the energy needs of a significant proportion of the population – particularly the poor in rural areas of the developing world. Traditional biomass energy is low priced[21] and does not require processing before use (Hall and Mao, 1994).

Traditional biomass use, however, has significant drawbacks. The indoor air pollution from unvented bio-fuel cooking stoves is linked to respiratory diseases in many highland areas of Africa[22] (Karekezi and Ranja, 1997; Karekezi and Kithyoma, 2002; Kammen and Ezatti, 2002; Smith 1991; Smith, 1994; (WHO, 2006).). Rural and poor women and children in many developing countries spend a significant portion of their time gathering and collecting woodfuel,

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[19] Assuming that biomass use per capita is constant, at 0.3toe per capita over the projected period. This figure is an average across all regions and countries. Analysis indicates that average per capita biomass use varies between 0.24toe in South Asia to nearly 0.40toe in many countries in East Asia (IEA, 2002)

[20] The phrase *"traditional biomass energy use"* as used in this paper refers to the direct inefficient combustion/conversion of unprocessed wood, charcoal, leaves, agricultural residue, animal/human waste urban waste for cooking, drying.

[21] Biomass is mostly collected as a 'free' resource, with no regard to the cost of its unsustainable use on the environment.

[22] In many rural highland areas of Africa, biomass is used for both cooking and space heating in poorly ventilated homes that aggravate indoor air pollution. The need for space heating is less acute in low-lying areas thus reducing exposure to indoor air pollution from biomass-fuelled cookstoves.

crop residues and animal dung for use as cooking and space heating fuels (Energia, 2001; Energia 2002). Indoor air pollution disproportionately affects women and children who spend the most time near the domestic hearth. According to the World Health Organization (WHO), globally, 1.5 million people died from diseases caused by indoor air pollution in the year 2002, with 396,000 deaths (about 26%) from sub-Saharan Africa (WHO, 2006).

Reliance on traditional biomass (especially in the form of charcoal) contributes to land degradation (Scully, 2002) and deforestation in countries where charcoal[23] (sourced from natural forests and not planted forests) is widely used. The dominant use of wood in Africa is for fuel, and a large part of the demand is met from other wooded land and trees outside forests. Almost 90 percent of the wood removals in Africa are used for fuel, compared with less than 40 percent in the world at large[24] (State of the World's Forests, FAO 2007).

The ownership of traditional biomass resources presents an additional problem. Forests are often public property (communal) and the entire community harvests products from the forest (e.g. wood and timber). However, few people are willing to pay for the resource recovery through protection and reforestation (Scully, 2002). Often termed the "crisis of the commons", the question of ownership of traditional biomass resources bedevils both researchers and policy makers and has yet to be satisfactorily resolved. This is often compounded by the intricate relationship between control over biomass energy resources and prevailing land tenure practices, policies and regulatory frameworks (FAO/ADB, 1995; Scully, 2002).

Some of the key challenges facing many countries that rely heavily on traditional use of biomass include: firstly, ensuring the biomass used is sourced from sustainable biomass resources (e.g. wood plantation, sustainable management of native forests); secondly, how to widely disseminate improved biomass energy technologies (IBTs); and finally, how to promote modern biomass energy technologies (MBTs) that use a wide range of biomass resources (woodfuel, agro industrial residues, rural and urban residues) to generate high quality fuels, gases and electricity (Hall and Rosillo-Calle, 1998; Masera et al, 2000).

3.1.2. Improved Technologies for Traditional Biomass Resources[25]

Since the bulk of biomass energy in use in the region is traditional biomass, there are opportunities for efficient use of biomass energy. Improved biomass technologies (IBTs) such as institutional cookstoves, efficient kilns for charcoal and brick-making, efficient fish dryers, efficient tobacco curing kilns and efficient tea dryers can contribute to more efficient and environmentally sound use of biomass energy. Improved cookstoves, for instance, are designed to reduce heat loss, decrease indoor air pollution, increase combustion efficiency and attain a higher heat transfer (Karekezi and Ranja, 1997; Masera et al, 2000).

There are several advantages of using improved biomass technologies such as more efficient cookstoves, charcoal kilns and dryers. According to the World Health Organization (WHO), and as mentioned earlier, globally, 1.5 million people died from diseases caused by indoor air pollution in the year 2002, with 396,000 deaths (about 26%) from sub-Saharan Africa (WHO, 2006). The provision of more efficient stoves can reduce respiratory health problems associated with smoke emission from biofuel stoves (Khennas et al, 1999; Karekezi and Kithyoma, 2002). These

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[23] The sustainability of wood and charcoal fuel needs to be addressed by suitable regulation and market improvements. End use appliances need to have better efficiency (there is considerable experience in both these supply and demand aspects).
[24] The sustainability of wood and charcoal fuel needs to be addressed by suitable regulation and market improvements. End use appliances need to have better efficiency.
[25] "*Improved biomass energy technologies (IBTs)"* refers to improved and efficient technologies for direct combustion of biomass e.g. improved cookstoves, improved kilns, etc.

advantages are not limited to the reduction of local (mainly indoor) pollution[26], but also because more efficient biomass conversion technologies can reduce the negative deforestation impact of, for example, traditional charcoal production. Improved use of biomass in households, institutions and industries leads to reduced fuel consumption (biomass), faster processing, improved product quality and products with better shelf life (Schirnding, 2001; Karekezi and Ranja, 1997; Karekezi et al, 2002).

Other benefits that accrue from increased use of improved biomass technologies (IBTs) include the alleviation of the burden placed on women and children in fuel collection, freeing up more time for women to engage in other activities, especially income generating activities. Reduced fuel collection times can also translate to increased time for education of rural children especially the girl-child (Karekezi et al, 2002b). The production and dissemination of improved biomass energy technologies provides employment and job opportunities for a significant proportion of the population, particularly women (Energia, 2002).

Improved biomass energy technologies (IBTs) provide an attractive option for small and medium scale enterprises. IBTs improve the efficiency of biomass use in traditional energy-intensive rural productive activities such as charcoal production, crop drying, fish drying and beer brewing (Reddy et al, 1997; Karekezi and Kithyoma, 2002).

Initiatives to disseminate IBTs such as improved cookstoves have delivered significant benefits to both the urban and rural poor in Africa. First, in terms of jobs created in improved stoves programs and second, in terms of reduced charcoal consumption through the use of improved charcoal stoves (Khennas et al, 1999; Karekezi and Kithyoma, 2002). The informal sector[27], which provides employment to the urban poor, is the principal source of improved stoves. Box 1 summarises the case examples of the Kenya ceramic jiko, an improved biomass stove widely disseminated in Africa.

[26] Studies have shown that women and children are most likely to be adversely affected by particle emissions from biofuels smoke because they spend a significant proportion of their time near biomass based cooking fires (Schirnding, 2001; Karekezi et al, 1995; Energia, 2001; Kammen et al, 2001).

[27] Informal sector refers to all economic activities that fall outside the formal economy regulated by the state (Wikipedia, 2008).

Box 1: Case Study of Kenya Ceramic Jiko (KCJ) Improved Charcoal Cookstove

The Kenya Ceramic Jiko (KCJ) is one of the most successful stove projects in Africa (KENGO, 1991; Karekezi and Kithyoma, 2002; Houck and Tiegs, 2005; ITDG, 2005; Kammen, 1995b). The development of the KCJ was a combination of local input and international agency involvement. It was the result of research on stove design, efficiency and patterns of usage initiated in the 1970's and actively continued through the 1980's (Kinyanjui and Minae, 1982; Openshaw, 1982; Barnes et al., 1994; Kammen, 1995a,b). Feedback from groups of users including women's cooperatives contributed to the development of the KCJ.

The KCJ is made of a metal cladding with a wide base and a ceramic liner. At least 25 per cent of the liner base is perforated with holes of 1.5 cm diameter to form the grate. The stove has three pot rests, two handles, three legs and a door. The door is used to control the airflow. The standard model weighs about 6kg, which means it can be carried around easily (KENGO, 1991; Karekezi and Kithyoma, 2002).

The stove is suitable for cooking and space heating. The KCJ helps to direct 25-40 percent of the heat from the fire to the cooking pot. The traditional metal stove that the ceramic Jiko replaces delivers only 15-20 percent of the heat to the pot, whereas an open cooking fire yields efficiencies as low as 10 percent (Kammen, 1995a). Reductions in fuel use associated with the KCJ have been examined in a number of countries. If used and maintained properly, the KCJ can reduce fuel use by 30 – 50%. For instance, in Kenya, charcoal use among a sample of families using the KCJ fell from 0.67 to 0.39 kg/charcoal/day. This totals over 600 kg of charcoal/year for an average family, and a savings of over $US 60/year (Karekezi and Ranja, 1997, World Bank, 2006).

Under proper use and maintenance, the KCJ reduces emissions of products of incomplete combustion (carbon monoxide, nitrogen and sulphur oxides and other organic compounds) as well as particulate matters, which happens to be one of the leading factors contributing to development of acute respiratory infection. Quantifying the degree of emissions reductions in actual home conditions is an ongoing area of study. The KCJ also provides greater safety for children, as the ceramic lined stove is less of a threat to burn on accidental contact, and its bell bottom shape ensures stability as it is unlikely to tip over – a major risk in other stoves, which can lead to cooking related burns.

The process of research, development, demonstration and then commercialization that led first to the KCJ and then to other stove models in Kenya was seeded by international and local development funds. After extensive analysis a decision was made not to directly subsidize commercial stove production and dissemination. The Government through micro-level de-regulation allowed the informal sector freedom and did not attempt to over-regulate. In addition, it eased up on taxes and licenses required for the manufacture and assembly of the stoves. Initially stoves were expensive (~ US$ 15/stove), sales were slow, and the quality was variable. Continued research and refinement, and expanded numbers and types of manufacturers and vendors increased competition, and spurred innovations in materials used and in production methods. The wholesale and retail network for stoves is now extensive. The KCJ can be purchased in a variety of sizes. Prices for KCJ models have decreased to roughly US$ 2 (this cost does not include fuel costs - charcoal) depending on stove size, design and quality (Kammen, 1995a; Walubengo, 1995). This makes it accessible to the majority of the urban population in Kenya.

The manufacture of the KCJ is now a relatively mature cottage industry in Kenya and other countries in the region. As expected, the level of specialization in the manufacture of the stove has increased, as has the level of mechanization. There is now a discernible labour division. There are two types of stove producers in Nairobi: mechanized manufacturers and semi mechanized producers. Shauri Moyo (a major informal manufacturing centre in Nairobi, Kenya) is the principal artisan production centre in Kenya, where there are artisans whose occupation is to purchase clay liners and metal claddings and to assemble and retail complete stoves to customers. The KCJ has also increased employment in the stove and informal ceramic industry, which involves both men and women. There are now more than 200 businesses, artisans and micro-enterprises involved in the KCJ industry in Kenya alone (Karekezi and Kithyoma, 2002).

A recent survey undertaken by AFREPREN/FWD on the dissemination of improved cook stoves in Kenya's two main towns (Nairobi and Mombasa) indicated that the use of the stove in urban areas is very high, at over 80%. KCJ-type improved stoves are widely used in Sub-Saharan Africa and can now be found in Uganda, Tanzania, Rwanda, Burundi, Sudan, Ethiopia, Senegal, Mali, Burkina Faso and Ghana. The KCJ can presently be declared a success story.

The success story of the KCJ can be attributed to the long-term commitment by both the private and public sector in its development, and specialized focus on the KCJ and sustained support from local champions. In addition, through innovative use of the piggy back principle, the KCJ developed around the existing artisanal industry which reduced the costs of setting up a whole new network. Another key feature of the KCJ initiative is the opportunity for income generation, from the manufacture of the stoves. This initiative has led to increased income generation to all the parties involved in its production.

Given the relatively low levels of dissemination of improved biomass energy technologies (IBTs) in Africa (Table 9), and the projected increase in the number of people relying on biomass, the potential for IBTs is significant.

Table 9: Dissemination of Improved Biomass Cookstoves[28]

Country	No. Disseminated
Sub-Saharan Africa	
Kenya	3,136,739
Uganda	170,000
Tanzania	54,000
Ethiopia	3,010,000
Botswana	1,500
Zambia	4,082
Zimbabwe	20,880
Malawi	3,700
Sudan	100,000
Ghana	150,000
Niger	200,000
Burkina Faso	200,000
Senegal	250,000
Eritrea	50,000
South Africa	*1,250,000*

Source: AFREPREN/FWD 2007; Martinot, 2007; Vita 2006

3.1.3. Improved kilns

Improved charcoal production and tree growing are often touted as effective options for reducing deforestation in Africa. Field experiences have shown that dissemination of knowledge on proper tree harvesting techniques, use of efficient charcoal production kiln and tree planting to charcoal producers can contribute to reducing deforestation (TaTEDO, 2007). There is ongoing research to develop more efficient charcoal production methods using improved kilns in a number of countries in Eastern and Southern Africa (UNEP and Zaikowski, 2007).

3.1.4. Modern Biomass Technologies[29]

Modern biomass technologies can provide improved energy services based on available biomass resources and agricultural residues[30]. Widespread use of combined heat and power generation (cogeneration) biomass options in rural areas can address multiple social, economic and environmental issues that now constrain local development.

[28] The data is based on estimates from AFREPREN/FWD contacts and from African ministries of energy.

29 "Modern biomass energy use" refers to the conversion of biomass energy to advanced fuels namely liquid fuels, gas and electricity (AFREPREN, 2002).

30 Another way of modernizing biomass energy use is through the use of ethanol gel, although its use is not widespread. This is a liquid fuel that is composed of ethanol, water, thickening agent, colouring and flavouring agent. It has a heat value of 22.3MJ/kg. Ethanol gel is packed in bottles and sachets for easy transportation. The fuel can suitably substitute wood, charcoal, gas and kerosene for domestic cooking in developing countries with ethanol production potential. In Zimbabwe, ethanol gel is used for camping, starting barbeque fires and in the army (BTG, 2003).

Biomass Cogeneration:
Estimates show that a number of African countries can meet significant proportions of their current electricity consumption from bagasse-based cogeneration in the sugar industry (see Table 10). Mauritius is an excellent example and meets 56% of its electricity demand from cogeneration (a significant portion of cogeneration electricity – 20% - is from bagasse – a renewable biomass fuel).

Table 10: Cogeneration (Bagasse) Potential for Eastern and Southern Africa

Countries	Installed National Power Generation capacity from all sources (MW), 2007	Cogen Potential, 82 Bar* (MW)	Cogen potential as % of total installed national power generation capacity from all sources
Sub-Saharan Africa			
Ethiopia	814	30.9	3.8%
Kenya	1197	190	15.9%
Tanzania	1080	97.8	9.1%
Uganda	380	46.0	12.1%
Malawi	300	56.5	18.8%
Swaziland	128	185.0	144.5%
Sudan	1023	156.9	15.3%

* Refers to the operating pressure of the cogeneration system; 82 bar cogen systems are still not widespread in Africa, but are now in use in Mauritius.

Source: Deepchand, 2002; Karekezi and Kimani, 2002; EIA, 2006; Kiva, 2008

In a bid to facilitate the realization of the aforementioned significant potential of cogeneration in sub-Saharan Africa, the Cogen for Africa project – an innovative and first-of-its-kind regional initiative – was recently launched by the African Development Bank (AfDB) and UNEP/GEF and executed by AFREPREN/FWD (see http://cogen.unep.org). This initiative seeks to significantly scale up the use of efficient cogeneration technology options in seven eastern and southern African countries, namely: Kenya, Uganda, Tanzania, Ethiopia, Malawi, Swaziland and Sudan.

The Cogen for Africa project builds on the success of cogeneration in Mauritius and plans to replicate this technological success in other countries of the region as well as in other key agro-processing sectors found in eastern and southern Africa. The initiative also takes on board relevant elements of the European Commission-supported regional cogeneration programme in South-east Asia, which has been successful in promoting numerous efficient cogeneration installations.

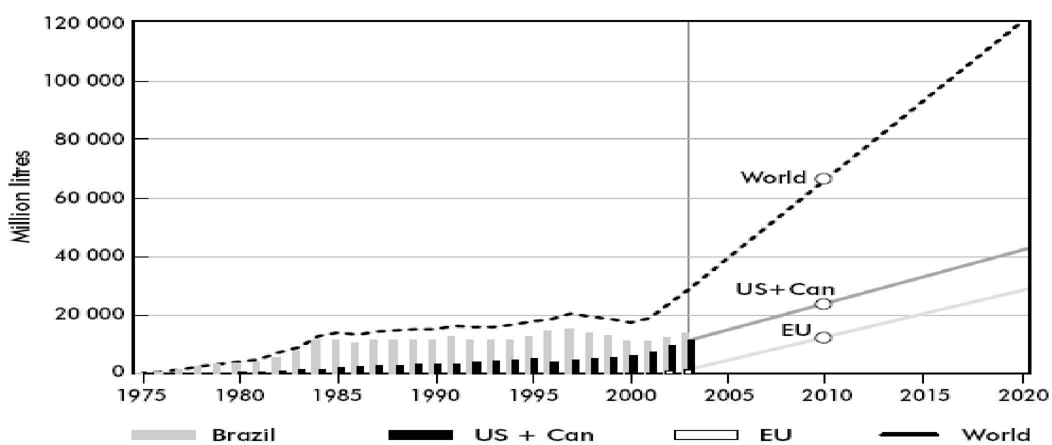
Bio-fuels:
Bio-fuels have grown in importance lately due to their potential in providing a reliable and sustainable alternative to fossil based oil in most parts of the world. They have significant political appeal because of their contribution to reducing dependence on imported fossil fuels and to, a much lesser extent, because of their ability to attract grant finance and climate credits arising from the reduction of greenhouse gases. Africa is one of the lowest emitters of greenhouse gases, thus decreasing the relevance of the climate rationale in promoting renewables in the continent. However, there is a growing realization within the African region that dependency on imported fuel is having a negative impact on regional economic development and biofuels constitute an important response option.

Out of 47 of the world's poorest countries, 38 are net oil importers (majority of them are from Africa). It is estimated that the negative impact of the increases in oil prices in 2007 and early 2008 on oil importing economies of sub-Saharan Africa far outstrip the benefits of debt relief extended to the region. According to the African Development Bank (AfDB), high oil prices will not only increase commuting costs, especially the cost of transporting agricultural produce to the market, but will also adversely affect the standard of living of the poor who largely rely on kerosene for cooking and lighting. High prices of fossil fuels enhance the attractiveness of biofuels as alternative sources of fuels for transportation and stationary applications. The development of biofuels in oil producing African countries can also be justified by their dwindling oil reserves and rapidly growing local oil consumption.

Energy crops for bio-fuels production can create job opportunities for rural communities in Africa due to the high labour-intensive operations involved in the cultivation stages. According to a study conducted by Earth life Africa in 2003, there is substantial potential for the biofuels industry to create more jobs than conventional fossil fuel based technologies. It is estimated that if 15% of all diesel and petroleum used in South Africa is replaced with biofuels, it would create 180,000 direct jobs (Earthlife Africa/SECCP Report 2003). Biofuels crops also provide the opportunity for the region to strengthen its local agriculture and its non-food markets. It is worth noting, however, that concerns have been raised regarding the development of biofuels. One of the key issues of concern is the competition for land for fuel and food.

With policy initiatives and changes towards preference of biofuels, global ethanol production is expected to quadruple to over 120 billion litres by 2020 (IEA, 2004). Figures 9 and 10 show the projection to 2020 for two important biofuels i.e. fuel ethanol and biodiesel. Production of biofuels in Africa is likely to increase, in order to meet the demand for biofuels in advanced economies in the EU and the Far East (European Commission, 2007).

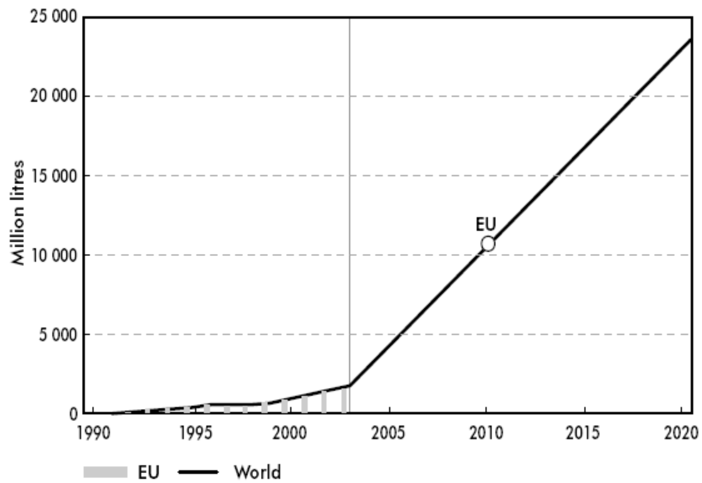
Figure 9: Fuel Ethanol Production, Projections to 2020



Source: IEA, 2004

Similarly, global biodiesel production is projected to increase to more than 20 billion liters by 2020 (IEA, 2004), mainly in the European Union. This growing biodiesel market presents export opportunities for Africa which could produce the biodiesel at prices that are competitive world-wide.

Figure 10: Biodiesel Production Projections to 2020



Source: IEA, 2004

One of the key issues of concern with regard to biofuel development is the competition for land for food and fuel. Recent studies have indicated that certain biofuel options may lead to more emissions, and do not reduce climate change related emissions, as earlier thought, according to a study by the Joint Research Centre, the European Commission's in-house scientific institute (Edwards et al, 2008). The process of producing biofuels is very energy intensive when all sectors involved are considered (fertilizer, agricultural machinery and transportation of biofuel feedstocks, among others) therefore resulting in higher emissions as compared to natural biofuel production.

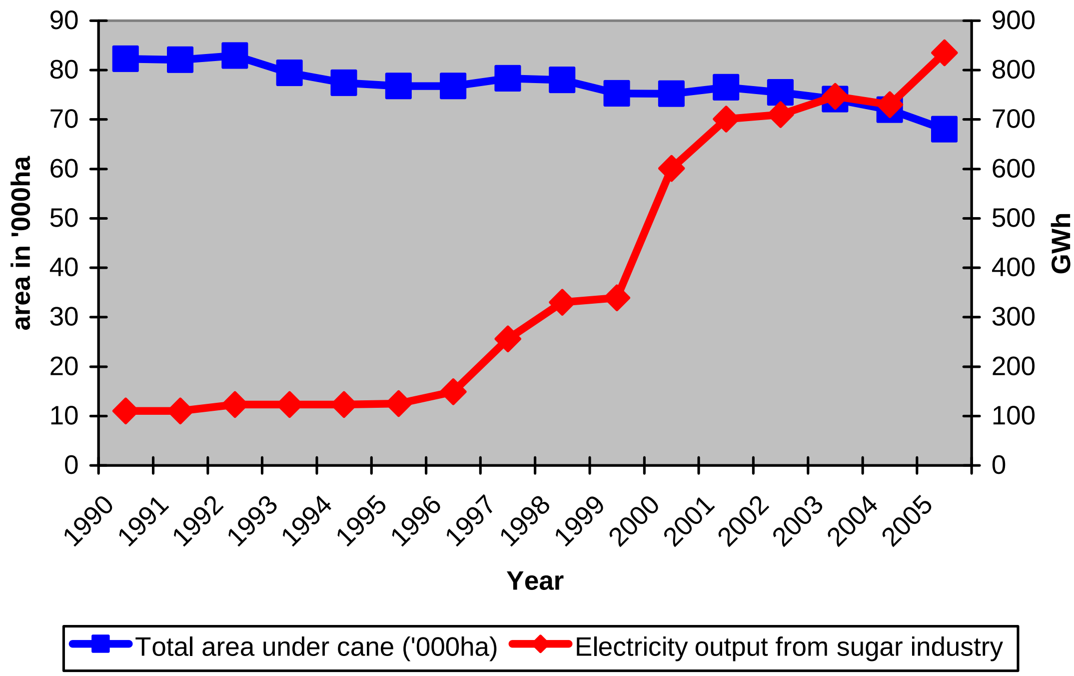
The EU target of 10% renewable energy in transport (including biofuels) in particular the 1st generation biofuels, has been under discussion recently, due to uncertainty over the potential for biofuels to reduce emissions. During the recent G8 summit, a call for the EU and USA to "Commit to re-examine policies towards bio-fuels in the G8 countries" was floated. A World Bank background paper for the G8 summit on food and fuel, one of the key action item proposed for consideration by the G8 countries is "Agree on action in the US and Europe to ease subsidies, mandates and tariffs on bio-fuels that are derived from maize and oilseeds; accelerate the development of second generation cellulosic bioenergy products" (World Bank, 2008).

Linked to the above issue, another concern is the fear that history might repeat itself again in Africa with regard to natural resources extraction and export to Europe. That is, historically, the continent has been perceived primarily as a source of abundant natural resources to be extracted and exported. The consequences are well known – resource exhaustion and environmental degradation (the case of timber comes to mind). Consequently, an important question is whether history may be repeated when it comes to the exploitation of Africa's biomass for bio-fuels - mainly for consumption in Europe - while bringing minimum developmental benefits to Africa (Agbemabiese, 2009).

To address the aforementioned concerns, some of the options for limiting the competition for land between food and fuel include: (i) greater use of bio-wastes and agricultural residues to produce biofuels (ii) increasing food production on current agricultural lands; (iii) establishment of large tree plantations on low potential areas and degraded lands that are not currently used for food (Azar and Larson 2000).

There are however a number of bio-energy options that can increase land available for food[31]. One example of increasing food production on current agricultural lands is the case of Mauritius, where the acreage of sugarcane fields has been decreasing over time (from 82,000 ha in 1990 to about 68,000ha in 2005) – see Figure 11. However, sugar production has remained roughly the same, and electricity from bagasse has been on the increase. This is a result of constant research and development on new sugarcane varieties that are better yielding and the introduction of more efficient cogeneration technologies (Mauritius Sugar Industry Research Institute, 2006).

Figure 11: Land area under cane in Mauritius vs. Electricity Output from Sugar Industry



Source: MSIRI, 2006

The trade-offs of dedicated energy plantations have to be carefully evaluated to ensure optimum use of existing land resources without endangering food supplies and increasing food prices as highlighted by growing number of alarming press reports on the adverse impact of biofuels on food prices. However, a study by the Energy Sector Management Assistance Programme (ESMAP) appears to indicate that higher food prices could benefit producers, especially smallholders who constitute the majority of the rural poor. This development is likely to be detrimental to the consumers who are net buyers, particularly urban workers (largely the urban poor) whose welfare would therefore decline (Kojima, et al 2007).

Therefore, additional research is needed to better predict the net impacts which are likely to vary by type of region as well as household and the extent to which one is successful in establishing a viable and competitive bio-energy sub-sector. Existing data and studies on the impact of

[31] Although the potential to use under-exploited land for biofuels production to generate income varies widely from one country to another, in Africa there is a huge potential to grow biofuels as a valuable market crop, without displacing current food production.

dedicated energy plantations on the poor and on food security are largely speculative and more detailed research and monitoring work is still required (Karekezi and Kithyoma, 2007).

The theoretical potential for biofuels in Africa is high, based on the estimated potential feedstock yield depending on assumptions concerning key factors such as production technology used, kind of water supply assumed, among other factors. Smeets and Faaij (2006) calculate a potential of 109 Mtoe to 835 Mtoe per year – a huge margin that is indicative of the uncertainties associated with biofuels. This would be the equivalent of 19% to 143% of the current total primary energy supply of the continent (Lindlein, 2007). The potential of the various biofuels is discussed in detail in the subsequent subsections. The next sub sections briefly review the status of key biofuels in Africa.

Bioethanol:
In Africa, ethanol has been produced in several countries, which include Zimbabwe, South Africa, Mauritius, Malawi, Zambia and Swaziland (Table 11). South Africa accounts for about 70% of Africa's ethanol production, although the bulk of it is high-purity ethanol destined for industrial and pharmaceutical markets (IEA, 2004). Fuel ethanol production and use has a number of advantages. It makes use of molasses that might otherwise go to waste; it also provides additional revenue for the agricultural sector-the bedrock of most African economies. Ethanol can enhance the security of liquid fuel supplies. In contrast to imported liquid fossil fuels, ethanol is sourced from locally available feedstock.

Table 11: Africa Ethanol Production by Country, 2005 (Millions of gallons, all grades)

Country	2005	2006
Sub Saharan Africa		
Zimbabwe	5	7
Swaziland	5	5
Mauritius	3	2
Kenya	4	5
Egypt	30	NA
Nigeria	30	NA
Others	92	NA
South Africa	**103**	**102**
Total	**272**	**N/A**

Source: RFA, 2005, Bioeneergy Wiki, 2008; NA – data not available

Ethanol programmes that produce a blend of ethanol and gasoline (gasohol) for use in existing fleets of motor vehicles have been implemented in Malawi, Zimbabwe and Kenya. Available evidence indicates that these programmes have registered important economic benefits. Since 1983, Zimbabwe's production capacity has exceeded 10 million gallons, though actual production stood at only 5 million gallons in 2005 as shown in Table 11 (RFA, 2005). The recent economic problems facing Zimbabwe are likely to have had adverse impacts on the country's ethanol program. Table 12 presents the ethanol production potential of existing sugar factories in selected eastern and southern African countries. As shown in the table, the large number of cane processing industries in Africa indicates significant potential for expanded ethanol production and co-generation (Dutkiewicz and Gielink, 1991, 1992; Eberhard and Williams, 1988; Scurlock and Hall, 1991; Baraka, 1991; Karekezi and Ranja, 1997).

Table 12: Ethanol Potential from Cane in Selected sub-Saharan Africa Countries

Country	Cane crushed (2002) Tons	Ethanol production potential, 000 Liters (2002)
Kenya	5,904,108	413,288
Sudan	5,821,000	407,470
Tanzania	3,628,800	254,016
Malawi	2,095,065	146,655
Ethiopia	1,147,283	80,310
Uganda	1,707,000	119,490
Swaziland	6,861,600	480,312

* Estimated ethanol potential assuming an average of 70 litres of Ethanol produced per tonne of cane crushed and that all cane is used for ethanol production (SEI, 2003; TaTEDO, 2006).

Sources: Karekezi & Kithyoma, 2005; SEI, 2003; TaTEDO, 2006

Table 13 briefly summarizes ethanol development in selected countries.

Table 13: Ethanol development in selected countries

Country	Ethanol Development
Kenya	The Kisumu Ethanol Plant was privatized and Energem, a Canadian energy firm bought 55 per cent of the plant. The plant is one of the largest manufacturing concerns in the country employing hundreds of people and producing at least 60,000 litres of industrial ethanol, beverage-grade and industrial alcohols for local consumption. The ethanol produced is used as a fuel additive and is exported to East and Central Africa. Other by products of the plant include yeast, carbon dioxide, alcohol and related industrial products (Energem Resources Inc, 2007). Production at the Kenya Ethanol Plant has been increasing. In early March 2005, the KEP was producing 30,000 litres per day (lpd) and production has been increasing over time. Future projections indicate an estimated production output of 250,000 lpd (Energem Resources Inc, 2007). In late 2009, the Government of Kenya announced its intention to introduce a mandatory ten percent ethanol blending (E10) to commence in 2012/13.
Uganda	The Sugar Corporation of Uganda (SCOUL) sugar factory produces ethanol. (The Republic of Uganda, 2007). Kakira Sugar Works Ltd could also produce up to 20 million litres of ethanol per year, which can be added to petrol, at a ratio of about 15 per cent without any need to modify vehicle engines.
Tanzania	Swedish biofuels firm Sekab plans to start producing 100 million litres of ethanol a year in Tanzania by 2012 at a cost of between $200 million and $300 million (http://uk.reuters.com/article/oilRpt/idUKLH54668720080917) A United States company, CAMS Group, has acquired 45,000 hectares of land in two districts in Tanzania to set up an ethanol plant (http://www.planetark.com/dailynewsstory.cfm/newsid/50310/story.htm)
Ethiopia	The Finchaa Sugar Factory (FSF) of Ethiopia has an ethanol plant with a maximum production capacity of 45,000 litres of ethanol per day (Karekezi et al, 2007) Ethiopia has announced plans to produce 130 million litres of ethanol annually http://africanpress.wordpress.com/2008/08/03/ethiopia-reveals-plans-to-produce-130-million-litres-of-ethanol-annually/(The East African, June 20, 2006)
Nigeria	Nigeria is planning to launch the first fuel ethanol project in Africa, worth N14.4billion (€ 86.7 million) in Ekiti State which will produce 180,000 litres of ethanol and 100 tonnes of starch a day, which would require 1,500 tonnes of Cassava daily - http://www.biomass4africa.net/news/viewnews.php?ID=387
Ghana	Caltech Ventures Ghana Limited, is planning to begin the production of ethanol from cassava at Hodzo, near the city of Ho at the tune of $6.5 million - http://www.modernghana.com/GhanaHome/NewsArchive/news_details.asp?menu_id=1&id=VFZSUk1FMXFVVFU9 Northern Sugar Resources Ltd intends to grow sugar cane on 30,000 hectares of currently unused

	land in the centre of the country and turn it into ethanol plant. http://www.energy-daily.com/reports/Ghana_to_produce_ethanol_for_export_to_Sweden_999.html
Zimbabwe	Zimbabwe to revive sugar ethanol industry in emergency move to offset energy price increases. Biofuels digest. 3rd March 2008. http://www.biofuelsdigest.com/blog2/2008/03/03/zimbabwe-to-revive-sugar-ethanol-industry-in-emergency-move-to-offset-energy-price-increases/
South Africa	South Africa plans to set up 8 ethanol plants from maize plants with capacity to produce 470 litres/day in 2007 (IMCSA, 2005).
Sudan	In Sudan, there are already ongoing projects and assessments of ethanol production, mostly undertaken by the country's largest sugar factory Kenana which intends to start commercial production of ethanol within the next few years (ANBA, 2007).
Zambia	The Ministry of Energy & Water Development commissioned a study to assess options for using the potential sugarcane resource in Luena as a tool for sustainable development. Unlike previous studies which emphasised sugar production only, the Luena sugarcane estate study also examined the combined production of ethanol from molasses with electricity from bagasse (Kalumiana, 2007).

Biodiesel:

Bio-diesel production in Africa is still not well developed, although there is significant potential. Production of biodiesel from *Jatropha carcus* seeds is the most commonly cited option in Africa. One of the main reasons for growing interest in *Jatropha carcus* is that it can grow in infertile soil, even in drought prone areas and animals don't graze on it. It therefore has high potential for adoption in parts of Africa with degraded or marginal land not suitable for food production. The cost of producing bio-diesel from *Jatropha* appears to be cost-competitive although there are few large scale initiatives that can provide reliable estimates (Hazell and Pachauri, 2006).

Production of bio-diesel could be undertaken in rural based industries, which will enable the poor to access this fuel easily. In addition to using locally available resources, with appropriate processing, its lubricating characteristics are 50% superior to that of conventional fossil diesel (Bio Diesel S.A., 2003). Current estimated bio-diesel production costs range between USD$ 0.70 and USD$ 1.2 per litre of diesel equivalent (IEA, 2006). Although these prices have been above those of petroleum and diesel, there is high potential for growth through research and development as well as tax concessions. The high prices of oil experienced in 2007 and early 2008 improved the competitiveness of bio-diesel (the recent collapse of oil prices is likely to slow investment in biodiesel). Experiences of selected African countries that have registered some progress in bio-diesel development are summarized in table 14.

Table 13: Selected Briefs on Biodiesel Development in Africa

Southern Africa	Zimbabwe has probably one of the most ambitious Jatropha bio-diesel programmes. It plans to substitute 10% of petroleum diesel over a 5 year period. About 360,000 tonnes of Jatropha seeds are to be produced annually and processed into 110 million litres of bio-diesel by 2010 in a programme which will involve contracting small scale outgrowers and at least 60,000 ha of plantations (MOEPD, 2007). Elsewhere C3, a private South African company has jatropha oil initiatives in Malawi, Zambia and Madagascar[32]. In Malawi, C3 works with the Jatropha Bio-diesel Association, which owns a factory for processing of Jatropha seed (Takavarasha, et al, 2006). Individual farmers in South Africa are running bio-diesel plants. For example in the Klerksdorp area, a bio-diesel plant produces 80 000 litres of diesel annually, as well as oil-seed cake for cattle feed from sunflower and soya [du Preez, 2005] Bio-diesel production from algae is another technology that has been experimented on in South Africa. It is considered the most efficient way to produce bio-diesel fuel. Studies indicate that one hectare of algae can produce up to 227,000 litres of bio-fuels a year, while

[32] C3 enters into management contracts with local NGOs which identify out growers, plant nurseries, train farmers, supervise trees, collect seed and crush into oil. C3 buys the crude oil to make biodiesel.

	over the same period of time; one hectare of sunflowers produces 450-600 litres of bio-diesel. In addition, algae bio-fuel is non-toxic and highly biodegradable (Reuters, 2006). In Mozambique, a project by the name "Fuel Fences and Biodiesel" has Jatropha trees in three districts: Gorongoso, Chimoio and Nhamatanda. The project aim at providing a sustainable source of fuel for rural communities as well as building capacity among locals on the use of biofuels to combat deforestation (UNDESA, 2007). In Zambia, biodiesel trials have been conducted on a small scale using Jatropha while awaiting Government policy guidance before a major nation-wide initiative is launched. A private organization, Marli Investments, grows Jatropha and contracts about 4000 out growers in Zambia[33]. It plans to plant 200,000 trees.
Eastern Africa	Bio-diesel has not recorded widespread implementation in Eastern Africa - most of the existing projects are pilot projects at trial stages. Tanzania has, perhaps, advanced the furthest in promoting bio-diesel production and especially from jatropha. Even though most of the biodiesel projects in Tanzania are in the embryonic stages, the potentials for expansion are high. A local company - KAKUTE Ltd has been working with women's groups where it has trained over 1500 people in jatropha management techniques. They have also been involved in planting more than 400 hectares of jatropha on marginal lands. The same company has also provided 10 stoves and 100 hurricane lamps to operate on Jatropha oil (UNDESA, 2007). Another local organization – TaTEDO has been involved in developing multi functional platforms in the country. There are plans to implement multi-functional platforms (MFPs) projects that will run on diesel and jatropha oil in Monduli/ Arumeru Districts. This will provide electricity for lighting, powering grain-milling machines and battery charging (TaTEDO, 2007). In Kenya, bio-diesel production has received some attention in the recent past, primarily linked to the development of j*atropha carcus.* The Vanilla/Jatropha Development Foundation based in Nairobi, Kenya, is promoting a pilot project on the cultivation of jatropha for bio diesel production in several districts in the country. Although the project is still a pilot initiative, there is significant potential for scale up, especially in the vast arid and semi arid areas. Another local Kenyan company, Energy Africa Ltd has initiated jatropha plantations among rural farmers in Kenya, with the aim of producing the oil seeds for biodiesel production. The overall aim of this initiative is to alleviate poverty among the farmers involved. To date, Energy Africa Ltd has worked together with more than 600 farms, and planted approximately 350,000 jatropha plants. The number of farms is expected to rise to 800, with a total of 500,000 plants by end of 2007. There are also plans to install oil expeller and filter unit for the processing (Energy Africa Ltd, 2007) Although biodiesel may be new to Uganda, rural farmers in the country have grown the Jatropha plants for many years. The plant grows well in most parts of the country and if well managed and exploited, Jatropha can contribute to reduction of fossil fuel' dependence in the country (The Republic of Uganda, 2007).
West Africa	The most significant experience of Mali in the field of biofuels is with Jatropha oil. Many initiatives aimed at promoting use of Jatropha biofuels have been implemented by various actors with some level of success. However, these initiatives have been limited to the cultivation of the jatropha plant, extraction of oil from the jatropha seed, and small scale production and utilisation of the pure jatropha oil as fuel for transport, rural energy service provision and soap production. Organised commercial large-scale production of pure jatropha oil and its refining into biodiesel has not yet been realized in Mali.

Source: Karekezi et al, 2007

[33] Marli Investments provides seed and training in tree management and enters into contracts with each grower (Takavarasha, etal, 2006).

Biogas:
Biogas, a clean and renewable form of energy can be a competitive substitute to conventional sources of energy, especially in the rural sector. Compared to other fossil fuels, biogas produces considerably reduced exhaust noise levels, few atmospheric pollutants (lower emissions of nitrogen oxides and almost zero emissions of particles or dust) and generates less carbon dioxide per unit energy; Biogas consists mainly of methane (CH_4) and carbon dioxide (CO_2) which is absorbed during the plants' (principal food of livestock thus the ultimate source of manure feedstock for biogas plants) growth cycle, making it sustainable.

Biogas technology has received considerable attention over the last three decades in the region, mainly in the promotion of domestic and institutional biogas digesters. Industrial size biogas plants are not common in Africa. Conceptually, biogas technology appears deceptively simple and straightforward. The raw material is primarily animal dung, which is plentiful in many rural areas of sub-Saharan Africa. The technical viability of biogas has been repeatedly proven in many field tests and pilot projects in the region as shown in Table 15.

Findings from a study on biogas in Africa undertaken by the Netherlands Development Organisation (SNV[34]) indicate that the technical potential of domestic biogas installations in Africa is estimated to be 18.5million domestic biogas installations (Heedge & Sonder, 2007). Table 15 presents the estimated technical potential of biogas digesters in selected African countries.

Table 14: Technical Potential of Biogas Digesters in Africa

Country	Technical potential (000 Units)
North Africa	
Algeria	278
Egypt	980
Sub Sahara Africa	
Benin	254
Burkina Faso	876
Senegal	439
Mauritania	100
Niger	264
Nigeria	2,241
Guinea	255
Ghana	278
Cameroon	488
Chad	213
Kenya	1,259
Madagascar	678
Tanzania	1,781
Uganda	1,314
Rwanda	140
Sudan	1,784
Angola	322
Zambia	341
Zimbabwe	400
Mali	839
South Africa	579

Source: Winrock, 2007; Dube, 2008

[34]The SNV study is part of an existing biogas initiative called "Biogas for better life: An African initiative". This initiative aims to provide 2 million households with biogas digesters by 2020 at a cost of 600-800 Euros per installation.

In Rwanda, dissemination of biogas digesters to prisons has registered significant success. The initiative by the Kigali Institute of Science, Technology and Management (KIST) won the Ashden Award for Sustainable Energy in 2005 for the development and installation of large-scale biogas digesters in prisons across the country to treat toilet wastes and generate biogas for cooking. The first prison biogas digester became operational in 2001 and currently KIST has installed biogas digesters in almost half of the 30 prisons in the country. The Ministry of Internal Security purchases the biogas plants for the prisons at a cost of about £50,000 for a 500m^3 plant. Due to its success, the initiative is receiving support from donor organizations like UNDP and the Red Cross. An important factor for success of the initiative is that locals (including prisoners) have received technical and business training. To date over 30 civilians and 250 prisoners have been trained (Ashden Awards, 2005).

Biogas technology was introduced in Southern Sudan during the year 2001 through a UNICEF/OLS-supported Biogas Pilot Project at a Secondary School in Rumbek (Kuria, 2002). As shown in Table 16, about 1000 units of biogas digesters had been disseminated in Ethiopia and Tanzania (Winrock International, 2007).

Table 15: Number of Installed Biogas Digesters in Selected Countries of Africa

Country	Units
Eritrea	5
Ethiopia	1,000
Kenya	500
Tanzania	> 1,000
Burkina Faso	20
Botswana	215
Burundi	279
Lesotho	40
Uganda	600
Zimbabwe	200

Sources: Karekezi and Kithyoma, 2005; Winrock International, 2007

There has been limited implementation of municipal waste-to-energy projects in Africa, despite the large potential. Waste-to-energy projects could help many African cities solve their waste management problems in an efficient fashion. A limited number of projects have been implemented in Africa. Madagascar has also initiated a UNDP supported project to sort, collect and recycle waste including generating energy from waste (Karekezi et al, 2007).

Landfilling technology, which uses biogas technology principles with urban waste being the primary feedstock, has significant potential in the region. Waste in Africa is largely organic in nature and has a high moisture content (45-85%). In addition, it has a low energy content of about 900-1,200 kcal/kg (AFREPREN/FWD, 2005). South Africa has a Landfill-gas-to-electricity CDM project in Durban, with a total electricity generation capacity of 10 MW. The electricity will be delivered to the South African grid, based on a power purchase agreement for 10 years with options for two additional 5-year extensions (http://www.jiqweb.org/durban.htm; www.unfccc.int). In Egypt, the Onyx Alexandria Landfill Gas Capture and Flaring project, which includes 2 municipal waste landfills, was awaiting CDM registration in 2006 (UNEP Risoe, 2006; www.cdmegypt.org).,

Biomass Gasification:
Biomass gasification technology has recorded some success at global level but its record in Africa is, at best, patchy. Encouraging technical results have been realized in pilot testing of biomass

gasifiers but large-scale commercial replication is yet to be fully realized (Kwant, 2004). However some countries outside Africa have recorded encouraging success in gasification such as India[35] gearing to increase biomass gasification by 88 folds in another 7 to 8 years.

A few donor funded demonstration projects have been implemented in Southern Africa. In addition, experimental systems have also been reported at universities in South Africa. Two pilot gasification projects were initiated by the Department of Energy in Zimbabwe in 1989. An Indian Ankur dual fuel gasifier (40kW) and an Italian Soft Energy system (35-40kW) were installed, tested and evaluated at Kushinga Phikelela College and Nijo Estates near Harare[36], Zimbabwe. The electricity generated was used for water pumping and running a small workshop. Both gasifiers have not been operating since 1991 (SADC TAU, 1997; ProBEC, 2006). The University of Fort Hare (South Africa) is installing a biomass gasifier in Eastern Cape using sawmill waste as feedstock as part of its research efforts to assess the performance of the system, costs and sustainability of the project (UFH, 2007). A gasifier has been successfully tested by the Council for Scientific and Industrial Research (CSIR) in Pretoria proving that the technology can provide a reliable alternative energy source.

There are very few documented bio-gasification projects in Eastern Africa. A plant to introduce, test and develop producer gas techniques for applications such as saw milling; small-scale generation and vehicle usage was established by the Tanzanian Wood industry Corporation (TWICO). Funding was provided by both the Tanzanian Government and the Swedish International Development Cooperation Agency (SIDA). The plant proved practical and economically feasible (Karekezi and Ranja, 1997). In the 1980s TWICO also tested operations of a sawmill run on charcoal gas with charcoal produced from sawmill residue in Kilimanjaro and Meru regions of Tanzania. The Small Industries Development Organization (SIDO) has also run thermo-gasification technology demonstration plants in Tanzania.

In 1987, a gasifier system was installed in Ethiopia, but this system is no longer operational (Karekezi and Ranja, 1997). Gasifier systems were also installed in Sudan for saw milling operations and in Uganda to generate electricity for briquetting plants. Operation has been intermittent, however, and leading to the briquetting plants relying mainly on the national grid for electricity. The James Finlays Tea Estate has a gasification plant with a capacity of 0.5MW in their tea factory in Muzizi, Western Uganda, which faced some initial operational challenges but is now reported to be working well.

In Uganda, Sesam Energetics 1 Limited, a private company is working with Taylor Biomass Energy USA, on a project that intends to generate 33 megawatts (MW) of electricity for sale to the Ugandan electricity grid from urban waste to energy cogeneration plant. The company is at an advanced stage in securing a power purchase agreement with the electricity utility and negotiating a 30 year waste management contract with relevant authorities in Uganda (ERA, 2008; ESI-Africa, 2008).

[35] Use of Biomass Gasifier in India has increased tremendously and the Government through the Ministry of Agriculture and the Ministry of Non Conventional Energy Sources, have geared up to boost the power generation from Biomass to 19000 MW (Mega Watt) from the present level of just 220 MW.

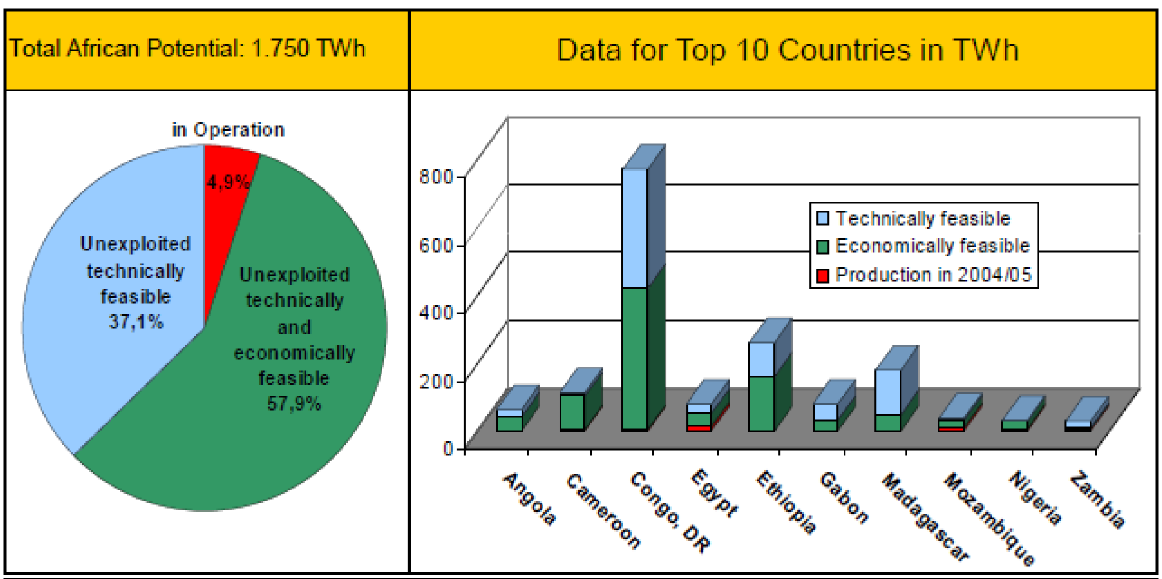
[36] A number of reactor designs are possible, at small scale; the down-draught type is the most successful since it does not require sophisticated skills.

3.2. Hydropower[37]

3.2.1. Large Scale Hydropower

Africa accounts for 12% of global hydropower potential. Hydropower has an enormous potential to contribute to the growing energy needs of the African continent but its exploitation continues to be limited. Although Africa has one of the biggest hydropower potentials in the world, it currently uses only 7% of its rich potential – see Figure 12 (International Hydropower Association, 2003). For example, Ethiopia, which has a large hydropower potential of about 30,000 MW, has only exploited about 3% of its potential (Karekezi and Kithyoma, 2005). The total installed capacity of hydropower in Africa, over 21,000 MW (Table 17), is the equivalent of the total installed power plant capacity in the Netherlands. More than half of the installed hydropower capacity of Africa is concentrated in the Democratic Republic of Congo, Ethiopia, Egypt, Mozambique, Nigeria and Zambia. Another 7,489 MW were under construction at the end of 2008 (Seeger, 2009). One reason for the limited exploitation of hydropower is the capital intensive nature of large-scale hydropower plants. Access to the significant amount of investment financing required for large scale hydropower development is increasingly becoming difficult to come by due to the continent's high investment risk ratings and a history of high external debts.

Figure 12: African Hydropower Potential



Source: Federal Ministry for Economic Cooperation and Development, undated

[37] Hydropower plants can be classified as large, medium and small, depending on the capacity of energy that can potentially be generated. Broadly plants above 500 MW are generally considered large. Plants between 500MW and 10MW are considered medium sized. Below 10 MW they are considered small sized hydro plants. Small hydro plants are further classified as mini (500 kW to 10 MW) micro (10 kW to 500 kW) and pico (less than 10 kW). The ranges are however not universal. In this paper, large scale hydro refers to both large and medium sized hydro plants, while small hydro refers to mini, micro and pico hydro plants. It is important that hydropower projects identify all the risks, and ensure they are reduced to acceptable levels through long-lasting and environmentally sound, economically viable, and socially acceptable approaches (Asian Development Bank, 2005).

Table 16: Hydropower: Status of Development at End – 2006 (all schemes)

Country	In Operation		Under construction	planned
	Capacity (MW)	Actual Generation in 2006/2007 (GWh)	Capacity (MW)	Capacity (MW)
Sub Saharan Africa				
Algeria	280	560	0	n/a
Egypt	2793	12926	64	74.5
Tunisia	62	143	n/a	28.8
Morocco	1500	1400	40	84-384
North Africa				
Benin	<1	172	0	250
Burkina Faso	32	111	2.5	>60
Cote d'Ivoire	606	1797	n/a	276.5
Mali	155	>500	140	>81
Mauritania	30	120	0	n/a
Ghana	1198	5619	400	n/a
Niger	0	0	0	125
Nigeria	2000	8200	3300	950-1150
Guinea	129	519	n/a	160-918.5
Senegal	66	293	0	325
Sierra Leone	<5	~18	135	n/a
Togo	>66	200	n/a	n/a
Cameroon	721	3772	0	717
Central African Republic	18.7	130	0	35-136.6
Chad	0	0	0	6
Comoros	1	2	n/a	n/a
Congo (Brazzaville)	89	394	120	1651
Congo (Democratic Rep)	2409.7	7220	>162	3600-43000
Equatorial Guinea	1	2	0	n/a
Gabon	170	893	0	n/a
Reunion	125	500	n/a	n/a
Sao Tome & Principe	6	10	4	26
Burundi	32	150	n/a	42.9-225
Ethiopia	669	2700	1277	7280
Kenya	677.2	2869	n/a	140-375
Tanzania	579	1800	n/a	1680
Uganda	318	1650	330	927-977
Sudan	323	1000	1300	300-1542
Rwanda	54.5	130	0	110.5
Angola	790	>2000	n/a	>26-600
Lesotho	75.7	200	0	26
Malawi	285	1100	n/a	365
Zambia	1120	9729	210	960-2885
Zimbabwe	754	5521	0	910-2384
Swaziland	60	124	0	20
Mauritius	59.4	84	0.4	0.35
Mozambique	2179	14710	0	2000
Namibia	249	1600	0	620
Madagascar	105	540	n/a	158
Somalia	5	n/a	n/a	n/a
South Africa	687	2734	3	120
Total	**~21,486.2**	**>94,142**	**>7487.9**	**24,135.55 - 70,577.75**

Source: WEC, 2007; Dube, 2008, Bartle, 2008

The reliance on hydro power can pose certain energy security challenges. Over-reliance on hydro-based power generation can increase vulnerability to drought-related electricity shortfalls. For example, Kenya and Senegal suffered persistent power rationing of up to 8 hours per day in 2000-1 partly because of drought which adversely affects their hydropower plants. Kenya incurred losses amounting to as much as US$2 million per day due to this power rationing (World Bank, 2000). In 2003, Ethiopia suffered daily power rationing of up to 14 hours for similar reasons. Between 1994 and 2000, Tanzania suffered three major electricity shortages due to drought and sub-optimal operations of the hydro/thermal system (World Bank, 2000). Between 1997 and 1999, the National Electricity Corporation of Cameroon constantly resorted to load-shedding in many parts of the country due to low water levels in the country's hydro power dams (Zekeyo, 2001).

In 2006/2007, Kenya, Tanzania, Uganda and Rwanda were all facing massive power disruptions due to drought, dramatically demonstrated by an unprecedented 1metre plus drop in the level of Lake Victoria – Africa's largest lake and main source of hydropower for Uganda. This has contributed to the shut-down of more than a third of Uganda's hydropower installed capacity and initiation of 12-hour load shedding programmes. Tanzania initiated a 12-hour load shedding programme due to a drought-related hydro power crisis. Ethiopia recently experienced outages for up to five days due to reduced hydro power capacity (Tafere, 2008). Such rationing has very high economic costs and underlines the need for a diversified electricity generation resource development that in addition to large-scale hydro includes geothermal, cogeneration, coal and natural gas. In addition, better management of water resources and river/catchment basins (including on a transboundary level) is required in the region, to monitor river flows, collect and analyse data on hydrological flows and ensure reservoirs/basins and catchments are better managed.

Large-scale hydro development is often associated with negative environmental and socio-economic impacts. These include: displacement of local communities, environmental degradation, and diversion of river water for irrigation purposes – especially where irrigation was not accounted for during the design of hydropower development. Local communities should be better compensated to create buy-in and ensure they support the hydro projects. Most compensation schemes for communities displaced by hydropower plants are often in the form of one off payment. Instead of one off compensation for communities displaced by hydropower plants, a better option might be to work out land-for-land compensation in combination with schemes that ensure regular, permanent and probably more modest payments to surrounding communities. If such a scheme is in place, it should prove easier to convince local communities to support large scale hydropower development as well as protect upstream river flows.

The World Commission on Dams provides valuable guidance on how environmental and social related problems of large scale dams can be addressed. In spite of drought related insecurity, some adverse environmental and socio-economic impacts, it is important that development of hydropower in Africa is not restricted. With appropriate mitigation measures in place and within the context of a diversified development strategy, hydropower can be a long term and reliable source of low cost electricity and is deserving of substantial investment flows and continued policy support.

In spite of the drought-related insecurity, it is important to note that in nearly all the aforementioned countries, a large share of the hydro potential remains unexploited while the per capita consumption is quite low and many people remain un-served. The exploitation of hydropower, however, does not automatically translate to wide access to electricity, as it required significant transmission and distribution investment. It is therefore important to balance between investment in the development of hydropower and transmission and distribution to facilitate increased access by the populace.

3.2.2. Small Hydropower

Small hydropower is often categorised into mini, micro and pico hydro, referring to the harnessing of power from water at a small-scale (capacity of less than 10MW). Small hydro has the advantage of multiple uses: energy generation, irrigation and water supply. It is also a very reliable technology with a solid track record, well suited to rural areas outside the central power grid (Pandey, 2002).

Much of the unexploited potential for small hydro is in remote areas of Africa (Hydronet 3, 1994). Eastern and southern Africa has many permanent rivers and streams providing excellent hydropower development potential. However, as shown in Table 18, small hydro utilisation in Africa is still very low.

Table 17: Small Hydropower Utilisation in the Region

Country	Small Hydro Installed (MW)
North Africa	
Algeria	54.0
Morocco	30.0
Tunisia	15.0
Egypt	10.0
Sub-Saharan Africa	
Kenya	44.7
Tanzania	10.8
Uganda	17.0
Somalia	4.6
Mali	5.8
Ghana	10.0
Nigeria	33.0
Malawi	4.5
Rwanda	1.1
Zambia	12.5
Mozambique	10.7
Mauritius	6.7
Cote d'ivoire	5.0
Ethiopia	7.0
Gabon	6.0
Guinea	11.0
Lesotho	8.7
Swaziland	0.3
Botswana	1.0
Burundi	2.9

Sources: AFREPREN/FWD; Scoping Reports, Innovation Energies Development (IED); Presentation Unilever Kenya; Karekezi and Ranja, 1997; www.small-hydro.com; http://greeningtea.unep.org; World Energy Council, 2007; El-Khayat, 2008; Ministry of Energy and Mineral Development, 2007

Some of the key barriers to the development and implementation of small hydropower are summarized in Box 2, which is extracted from a GEF project 'Greening the Tea Industry in East Africa, which seeks to develop small hydro power in the tea industry in East and Southern Africa.

Box 2: Barriers to the Development and Implementation of Small Hydro power Projects

Policy and regulatory barriers: Although most countries are supportive of small hydropower development, the absence of targeted incentives for private development of small hydro power is a major barrier. Lack of clear rules (such as predetermined feed-in tariffs and standard power purchase agreements (PPAs) to allow sale of power produced from small hydropower projects is also a limiting factor.

Financing barriers: Most small hydro plants are starved of funding, as conventional financiers prefer to fund large scale hydro projects. Sourcing of financing from commercial banks is an uphill task, as these banks do not traditionally consider energy as a loan product and currently do not have the due diligence capacity to review hydropower projects.

Technical/Capacity barriers: Engineering and construction firms do not have sufficient experience in carrying out detailed feasibility studies, designing or constructing small hydropower. The lack of local expertise contributes to high costs of procuring the services and delays in developing hydropower projects.

Source: GTIEA, 2008 (http://greeningtea.unep.org)

3.3. Solar Energy

Solar energy is the best-known renewable energy resources in Africa, which has very attractive solar insolation (see table 19). It has been in use for a long time for drying animal skins and clothes, preserving meat, drying crops and evaporating seawater to extract salt (Karekezi and Ranja, 1997).

Table 18: Average Daily Solar Insolation for Selected African Countries

Country	**Average Solar Insolation (kWh/m^2)**
North Africa	
Egypt	5.5-6.0
Algeria	5.0-6.0
Morocco	5.0-6.0
Sub Saharan Africa	
Eritrea	4.0-7.0
Ethiopia	5.0-6.0
Kenya	4.0-6.0
Uganda	4.0-5.0
Sudan	6.1
Botswana	6.1
Swaziland	5.0
South Africa	4.5-6.5
Zambia	5.6
Mozambique	5.0
Zimbabwe	5.7
Tanzania	4.5-6.5
South Africa	**5.5**

Source: Karekezi and Kithyoma, 2005; El-Khayat, 2008

Substantial research has also been undertaken over the years into exploiting Africa's huge solar energy resource. Today, solar energy is utilised at various levels. It is used at the household level for lighting, cooking, water heaters and in passive solar architecture houses. Medium-scale appliances include water heating in hotels and water pumping for irrigation. At the community level, it is used for vaccine refrigeration, water pumping, purification and rural electrification. On the larger scale, it can be used for telecommunications and for pre-heating boiler water for industrial use (Karekezi and Ranja, 1997; Ecosystems, 2002) as well as power generation.

3.3.1. Solar PV

Solar photovoltaic have been widely promoted in the region, with almost every African country having had a major PV project (see Table 20 for data on dissemination).

Table 20: PV Dissemination in Selected sub-Saharan African Countries

Country	Estimated number of systems	Estimated kWp
North Africa		
Tunisia	11,000	-
Egypt	-	5,000
Sub Saharan Africa		
Uganda	3,000	152
Tanzania	2,000	300
Eritrea	2,000	-
Ethiopia	5,000	-
Lesotho	1,100	-
Mozambique		100
Malawi	900	40
Swaziland	1,000	50
Botswana	5,724	286
Zambia	5,000	400
Zimbabwe	85,000	1,689
Kenya	200,000	3,600
South Africa	150,000	11,000

Source: AFREPREN/FWD 2004; Martinot, 2007; El-Khayat, 2008

Reports indicate that 25 MWp of PVs installed in Africa in 2007 were off-grid. Rural demand through use of TVs, radios, and cell phones has spurred healthy, but small markets for PV in East and Southern Africa. There are currently over half a million rural African households using solar systems. Innovative marketing, as well as subsidies, donor projects and loan programmes, are growing demand in Kenya, Tanzania, Uganda, South Africa, Zimbabwe, Namibia and elsewhere.

Tunisia started introducing PV systems for the electrification of scattered and isolated villages in the late 1970s. The dissemination of PV led to an increase of the rural electrification level to 95% by 2006. In total, 11,000 PV systems have been installed for the electrification of rural households and water pumping. The remaining number of households to be electrified by the year 2010 is estimated at about 6,000, mostly located in the north-east and south-east of the country[38] (El-Khayat, 2008).

In Egypt the main applications for PV are water pumping, desalination, rural clinic, telecommunication, rural village electrification and ice making. The PV applications for telecommunication systems and billboards are already commercialized. In 2005, the overall output was distributed as follows: communications 40%, lighting 33%, seawater desalination 12%, advertising 10 %, cathodic protection 3% and water pumps 2% (GTZ 2007).

[38] MED 2010 Research Program, "Final Publishable Report"

The following table (Table 21) shows the dissemination of solar systems in the Sahel region through a Comité Inter-États de Lutte contre la Sécheresse au Sahel (CILSS) project funded by the European Commission. This was carried out between 1990 and 1998, the programme installed in the nine member countries, 610 water pumping systems, 16 water pumping systems for irrigation and 649 community systems for lighting and refrigeration.

Table 19: Quantitative achievements of the solar regional programme in the Sahel

	Water pumping home use	Water pumping for irrigation	Solar community systems
Burkina Faso	80		287
Cape Verde	31		36
Gambia	50		57
Guinea Bissau	31		31
Mali	151		33
Mauritania	63		31
Niger	66		29
Senegal	68	16	121
Chad	70		24
Total	**610**	**16**	**649**

Source: Togola, 2008

There is growing evidence, however, that solar PV projects in the region have mainly benefited high-income segments of the population, due to the high cost of solar PV (Karekezi and Kithyoma, 2002; Mulugetta, et al 2000, Mapako, 2001; Cloin, 1998). Community applications of PV have, however, proven to be more successful with encouraging results registered in the use of PVs in the rural dispensaries and missionary establishments (AFREPREN, 2004; AFREPREN, 2003; Mapako and Mbewe, 2004; MPWE, 1994; Kgathi et al, 1997; Karekezi and Ranja, 1997; Karekezi et al, 2004).

3.3.2. Solar Thermal

Solar thermal technologies that have been disseminated in Africa include solar water heaters, solar cookers (Kammen 1991; 1992), solar stills and solar dryers. With increased efficiency and reduced cost of solar water heaters, small-scale solar water heaters have a payback period of 3 - 5 years (Karekezi and Karottki, 1989; Karekezi and Ranja, 1997). However, the diffusion of these systems has been slower than anticipated (Vanderhulst et al 1990).

Significant numbers of solar water heaters have been disseminated in North Africa and South Africa. Not much aggregate data on dissemination of solar water heaters has been gathered in sub-Saharan Africa (Ward et al, 1984; Karekezi and Ranja, 1997). The data available is from a few country studies. For example, in Botswana, about 15,000 domestic solar water heaters were estimated to have been installed in 2001(Fagbenle, 2001). In Zimbabwe, about 4,000 solar water heaters are in use (AFREPREN, 2001). Additional estimates on solar water heater installed capacity are provided in Table 22. The bulk of the solar water heaters in use are bought by high-income households, institutions and large and medium scale commercial establishments such as hotels and game lodges.

In Tunisia, solar water-heaters are widely used. The Tunisian experiment in spreading SWHs started at the beginning of the eighties, with the establishment of a national manufacturing company and a system of credit to the consumer over a period of 7 years. The credit was recovered through the electricity bill. Due to a number of reasons, including lack of quality control, the market faced problems which decreased the number of solar heaters commercialized from approximately 5000 m²/year at the end of the eighties to a few hundred square meters in the middle of the nineties. In order to revive the SWH market, the Tunisian Government launched in 1995, with assistance of GEF and Belgium Kingdom Government, an ambitious program aimed at installing around 50,000 m²/year. The program resulted in significant growth of SWHs in Tunisia, and currently about 110,000 square metres of solar water heaters are in use (El Khayat, 2008). In addition, Tunisia submitted a CDM project in 2008, "small-scale programme of activities" which seeks to intall domestic solar water heaters in households throughout Tunisia. The project is to be undertaken in conjunction with a nation-wide loan support solar programme known as "Prosol 2 – Residential" and its goal is to install 30,000 SWH per year in households, to displace carbon intensive electricity from the grid and fossil fuels currently used to provide hot water in the households (http://cdm.unfccc.int/).

Table 20: Domestic Solar Water Heater Installed Capacity

Country	**Installed Capacity (m2)**
North Africa	
Morocco	118,000
Egypt	500,000
Tunisia	110,000
Libya	17,300
Sub Saharan Africa	
Seychelles	2,400
Kenya[39]	40,000
Mauritius	40,000
Namibia	24,000
Niger	620
Botswana	50,000
Zimbabwe	10,000
Malawi	4,800
Zambia	4,000
Algeria	1,000
South Africa	500,000

Source: Karekezi and Kithyoma, 2005; World Energy Council, 2005; GEF, 2001, 2004; El-Khayat, 2008

3.3.3. Concentrated Solar Power (CSP)

North African region has significant potential for production of electricity from CSP due to higher solar irradiance levels. Morocco, Algeria, Tunisia, Libya and Egypt are well positioned for exploring the power generation potential from CSP (Salazar, 2008). Algeria has the highest potential for CSP (Table 23).

The CSP market in North Africa is in its nascent stages with planned developments announced in Algeria, Egypt and Morocco. Currently, Abengoa is building Integrated Solar Combined Cycle

39 A pre-feasibility study carried out by the Ministry of Energy in 2006/2007 indicated that a total of 5000square meters of collector area for solar water heating is installed annually in Kenya (Kiva, 2008)

plants in Algeria and Morocco and Solar Millennium is building the first CSP plant in Egypt (Salazer, 2008)

The opportunity for exporting CSP electricity to Europe is one of the major drivers for growing interest in CSP in North Africa. This would open up new opportunities for economic and technical co-operation between the two regions and in turn help Europe in its long-term CO2 reduction targets (Salazar, 2008). Table 23 shows North Africa's CSP potential and development status.

Table 21: North African countries CSP development and potential summary

Location	Planned capacity (MW)*	Economic Potential (TWh)	Technical Potential (TWh)
Algeria	255	168,972	169,440
Egypt	150	73,656	73,656
Morocco	230	20,146	20,151

** Based on projects announced; Source: Salazar, 2008*

CSP development in Africa has met several challenges. Cost competitiveness is a key barrier as the cost of producing electricity from CSP is approximately twice as high as electricity produced from fossil fuels in 2007. In addition, CSP plants in distant places would require construction of dedicated high-voltage (HV) transmission lines, which would in turn increase costs and may result in greater transmission losses. Availability of water is another critical issue that needs to be addressed for CSP development as the plants require continual water supply for steam generation, cooling and cleaning solar mirrors. This poses a great challenge for African countries which are still grappling with meeting the population's need for drinking water.

Another significant challenge to CSP development is its maturity for commercialization, especially within developing countries. This challenge is clearly attested by the slower than anticipated development of CSP projects supported by the Global Environment Facility (GEF) in Morocco, South Africa and Egypt. GEF reports that its experience in the aforementioned CSP projects revealed a very important lesson for developing countries - that it is difficult to adopt technologies from developed countries that have not reached commercial maturity in developed countries (GEF, 2008).

However, in spite of the foregoing drawbacks, Egypt plans to install a 150 MW Integrated Solar Combined Cycle (ISCCS) plant of which 30 MW would be from solar; while, in Morocco, a 230 MW CSP plant is under construction with solar contributing about 30 MW (Salazer, 2008). These developments come in the wake of very few successful CSP plants reported in the world that could provide lessons for Africa. For example, modest positive results have been reported in California's Mojave Desert which has been operational for 20 years and another newer plant in Southern Spain (e-Parliament, 2008).

More recently, there are twenty (20) blue chip companies from Germany that are have shown strong interest in investing about €400bn to generate electric power from solar energy from the deserts in North Africa (i.e. Libya, Algeria and Morocco) for end-use in Europe. If the aforementioned investors fulfil their ambition, it would make their investment - known as Desertec - the largest ever solar energy initiative (Connolly, 2009).

3.4. Geothermal

Using today's technology and excluding heat applications and ground source heat pumps, Africa has the potential to provide 9,000 MW of power generation capacity from hot water/steam based geothermal resources (BCSE, 2003).

Of this geothermal power potential, only 128 MW has been tapped in Kenya, and less than 7 MW in Ethiopia which is not operational (KENGEN, 2003). In Zambia, a small 0.2 MW plant was built in the 1980s. Due to the fact that there was no connection to the grid, though, the plant was never taken into use. Zambia is currently considering construction of a 2MW plant at the same site. The geothermal potential for selected African countries is provided in Table 24. These estimates of existing geothermal power generating capacity do not include direct thermal use of geothermal energy, which is widely practiced in North Africa and parts of eastern Africa nor does it include the potential of geothermal technologies such as ground source heat pumps.

Table 22: Geothermal Potential for Selected African Countries

Country	Potential Generation in MW
North Africa	
Algeria	700
Sub Saharan Africa	
Kenya	3,000
Ethiopia	>1,000
Djibouti	230-860
Uganda	450
Tanzania	150

Source: Karekezi and Kithyoma, 2005; GEF, 2007

Varying levels of geothermal exploration and research have been undertaken in Djibouti, Eritrea, Uganda, Tanzania, Zambia, Malawi and Madagascar, but the potential for grid connected geothermal exploitation is highest in Ethiopia, Kenya, Uganda and Tanzania, which are all part of the Great Rift Valley. Government representatives from Ethiopia, Uganda, Tanzania and Eritrea are considering the use of small-scale geothermal plants for rural electrification mini-grid systems, although this has not yet been attempted. Based on its extensive expertise in geothermal power, Kenya's principal power generation company, KenGen has assisted neighbouring countries, e.g. Rwanda, Eritrea and Zambia in developing know-how and expertise.

Geothermal energy has also been successfully exploited in northern African countries, using geothermal fluid for irrigation of oases as well as heating and irrigation of greenhouses (Table 25). In Kenya, a flower company is exploiting geothermal heat for use in the greenhouses, with good results[40].

Table 23: Geothermal Energy: Electricity Generation and Direct Use at end-2005

	Electricity Generation			[1]Direct Use		
	Installed Capacity (Mwe)	**Annual Output (GWh)**	**Annual Capacity Factor**	**Installed Capacity (MWt)**	**Annual Output (TJ)**	**Annual Capacity Factor**
North Africa						
Algeria				152	2417	0.50

40 Geothermal steam is used to provide Oserian Flower Company with the opportunity of controlling relative humidity and temperature in the greenhouses. In addition to the steam from the well, carbon dioxide from the same well is used to drive productivity to higher levels. As a result of the geothermal investment programme, Oserian, is today one of the most technologically advanced flower farms in Kenya. The new 50 ha Rose Flower project employing geothermal heating and carbon dioxide makes it the largest Geothermal Greenhouse Heating Project in the world. The value added from using waste steam in greenhouses could be useful in marketing the flowers as carbon neutral (Oserian, 2008).

Egypt (Arab Rep.)				1	15	0.48
Tunisia				25	219	0.28
Sub Saharan Africa						
Ethiopia	7			1	15	0.48
Kenya	115	886	0.88	10	79	0.25
Total	**122**	**886**	**0.88**	**189**	**2745**	**0.73**

Notes: [1]Where possible, direct use includes the capacity and output of geothermal (ground source) heat pumps; Source: WEC, 2007

3.5. Wind

Africa has significant wind energy resources, estimated at 200,000 GW, which accounts to about 20% of the world's wind energy resources (AfDB, 2002). Much of Africa straddles the tropical equatorial zones of the globe and only the southern and northern regions overlap with the wind regime of the temperate westerlies, which explains the high wind regimes found in North and Southern Africa. In other parts of sub-Saharan Africa, low wind speeds prevail, particularly in land-locked countries. Islands such as Cape Verde, coastal areas of South Africa, North Africa and the Red Sea coast (and surprisingly parts of Chad and Northern Kenya, which owes its wind power potential to its topographical features), and Northern Kenya have some of the highest wind potential in the region.

Elsewhere, average wind speeds of 7.2–9.7m/s have been recorded around Cape Point and Cape Alguhas in South Africa, Kenya, Morocco and Egypt. Table 26 presents the average wind speeds in selected African countries.

Table 24: Estimated Average Wind Speeds in Selected African Countries

Country	**Average Wind Speed (m/s)**
North Africa	
Morocco	10
Egypt	10
Sub-Saharan Africa	
Botswana	3
Burundi	6
Djibouti	4
Sudan	3
Tanzania	3
Uganda	3
Kenya*	3 - 9
Eritrea	6 - 9
Mozambique	3
Mauritius	8
Zimbabwe	4
Burkina Faso	4
Mali	1 - 6
Niger	3 - 5
Senegal	5 – 6
Chad**	2 - 5
Mauritania	5 - 8
Ethiopia	4 - 6
Guinea	2 -4
Cape Verde	8
Namibia	8
Zambia	3
Mauritius	8
South Africa	9

Source: Enda, 1994; Karekezi, 2002b; Karekezi and Ranja, 1997; Togola, 2008 AFREPREN, 2004; World Bank, 1986

* - Part of Northern Kenyan region has registered high levels of wind speeds of up to 9 m/s.
** - Parts of Chad are said to have very high wind speeds.

3.5.1. Wind Generators

The North African coast is an attractive wind speed region and large-scale wind power generation projects to exploit this abundant energy source are now under way in Morocco and Egypt (Knecht, 2004). The estimated potential for wind energy in Egypt is about 3000 MW. Currently, the New and Renewable Energy Authority (NREA) is implementing a feasibility study to implement large wind farms in co-operation with KfW Bank, JBIC and private sector. A long-term target has been announced by the Egyptian Supreme Council of Energy (SCE) to increase the share of wind energy to 12% of the total generated electric energy in the fiscal year 2020/2021 (El Khayat, 2008). By the end of 2007, the installed capacity of wind farms operated by New and Renewable Energy Authority was 305MW. Another 240 MW are in construction phase (El Khayat, 2008).

In the case of Morocco, a 3.5 MW wind farm was erected at Al Koudia Al Baida site in late 2000 at a cost of approximately € 6.0 million. KfW Bank provided a low-interest loan of € 4.35 million for this scheme. In August 2000, another wind farm at the same location with a rating power of 50 MW had entered service with the help of a € 24.4 million loan from the European Investment Bank. Other wind farms with capacity totalling 200 MW are planned, and Morocco intends to exploit wind potentials in the greater Tangier area in the north of Morocco and in an Atlantic coast region (El Khayat, 2008).

Table 27 shows the share of wind in the electric system in North Africa, and Table 28 presents wind energy installed capacity in Africa. Kenya has a few wind generators that are connected to the grid (KPLC, 2003; KENGEN, 2003) and large-scale wind power projects have been initiated in the country. It is worth noting that African countries with a coastline have great potential in developing off-shore wind potential. However, the development of this technology is still ongoing.

Table 25: Share of Wind in the Electric System in North Africa

Country	Wind Energy (%)
Algeria	**0.5**
Egypt	**1.0**
Libya	**0.0**
Morocco	**2.3**
Tunisia	**1.0**

Source: El-Khayat, 2008

Table 26: Wind Energy Installed Generating Capacity and Annual Electricity Output at end - 2005

	Installed Capacity (MWe)	Annual Outputs* (GWh)
North Africa		
Algeria	1	2
Egypt (Arab Rep.)	305**	-
Tunisia	20	42
Morocco	123.5**	220
Sub Saharan Africa		
Kenya	<1	
Eritrea	1	2
Nigeria	2	4
Cape Verde Islands	3	6
Namibia	<1	<1
South Africa	**8.4**	**6**
Total	**459.5**	**535**
Total Africa potential (est)	**200,000 MW**	

**Where data on wind energy output are not available, estimates have been calculated by applying a 22% capacity factor to the end-2005 installed capacity*
***2007 data*
Source: WEC, 2007, El-Khayat, 2008; KPLC, 2008, AfDB, 2002; Cole, 1992

Large wind power projects are now underway in Morocco, Egypt, Ethiopia, Kenya and South Africa. Currently, there are at least three projects with a total combined capacity of over 300 MW in various stages of planning in Kenya. These include wind farms that will take advantage of resources along the Ngong Hills, the Rift Valley (Kinangop), and in the north (Marsabit). The government has also instituted a feed-in tariff of 9 US cents/kWh for the first 150 MW in the country (MoE, 2008).

South Africa inaugurated its first commercial wind farm of 5 MW - the Darling project in the Western Cape Province in 2008. There are plans for a second phase of Darling, and the national utility, Eskom, is studying a project of over 100 MW along the west coast. Ethiopia has also shown interest in developing a three phase 120 MW wind farm. Wind East Africa is managing a $113 million effort to install 100 MW in two 50 MW phases in Singida along the Rift Valley in Tanzania. The company is finalizing a power purchase agreement and expects the first phase to be installed by December 2009 (Barker, 2008).

The cost of integrating wind power is a major issue. Estimates average at $10/MWh, dependent on availability of hydropower for energy storage and levels of wind power penetration (Business Insights, 2008).

3.5.2. Wind pumps

Wind pumping can supply water for household use, irrigation and for livestock (Harries, 2002). The wind speeds in most countries in Africa are suitable for wind pumping. However, there has been limited use of wind pumps in the region (Table 29) but South Africa and Namibia possess large numbers of wind pumps.

Bobs Harries Engineering Ltd. (BHEL), a local company in Kenya, is involved in the manufacture of *Kijito* wind pumps. With over 20 years experience in the manufacture and installation of over 300 wind pumps (both in Kenya and abroad), BHEL has developed a range of reliable and sturdy machines capable of withstanding storms and pumping water for years, with only minimal maintenance and attention. The manufacture of windpumps is now an established industry in Kenya. Kijito windpumps have been disseminated in the following countries: Rwanda, Niger, Botswana, Comoros, Nigeria, Sudan, Uganda, Somalia, Tanzania and Kenya (BHEL, 2005).

Table 27: Number of Wind Pumps for Selected Countries

Country	Number of Wind Pumps
Botswana	200-300
Djibouti	7
Eritrea	8
Kenya	300-350
Mozambique	50
Namibia	30,000
Sudan	12
Tanzania	58
Uganda	7
Zambia	100
Zimbabwe	650
South Africa	400,000

Source: Karekezi and Ranja, 1997; Karekezi and Kithyoma, 2005; SEI, 1995; DFIC, 2007; BDA, 2008

3.6. Tidal and wave energy

Tidal and wave energy are not well developed in Africa and are not likely to develop rapidly in the near future, except in South Africa and Northern Africa partly due to limitations in expertise. In South Africa, there are plans to exploit wave energy resource off the Western Cape, with negotiations underway to develop a 30 MW wave farm in Mossel Bay, with the possibility of expansion to 700 MW.

This chapter has demonstrated the vast potential of renewable energy in Africa, and the limited exploitation in most African countries. The next chapter assesses the barriers to development of renewable energy in Africa, and provides case examples of RE development in the region. Based on case studies, the chapter provides lessons learnt in overcoming the barriers to RE development.

4. Opportunities and Barriers to Renewable Energy Development - Case Studies

Africa has a great potential for renewable energy technologies development and their increased share can make a significant contribution to security of energy supply and as well as access to energy, especially electricity in remote locations of Africa. However, one of the greatest challenges is how quickly the already existing and viable technologies can be deployed and at what cost (Jarvilehto, 2009).

The success of renewables in the region has been limited by a combination of factors that include: 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; high initial capital costs; weak dissemination strategies; lack of skilled manpower; poor baseline information; and, low maintenance capacity (Martinot, 2004) *(see annex 4 and 5)*. In this report, the following three key main barriers to the adoption of renewables in Africa are briefly explored:

i) Policy and legal framework barriers
ii) Financial barriers
iii) Skills barriers

4.1. Policy and Legal Framework Barriers

Most African governments do not have long-term and clearly articulated policies on renewables. As a result, renewables development follows an ad hoc path, with little recourse to national energy plans, which are rarely available or out of date and inadequate (Karekezi, 2002a).

Experience in Africa shows that the introduction and success of any renewable energy option is to some extent dependent on the existing policy framework. Government policies are important because of their ability to create an enabling environment for mobilising resources and encouraging private sector investment. Most of the early policy initiatives on renewables in the region were a response to the oil crises of the 1970s and early 1980s. In response, governments established either an autonomous Ministry of Energy or a department dedicated to the promotion of sound energy policies, including the development of renewables. For example, in its Third National Development Plan (1979-83), Zambia proposed to develop alternative forms of energy as partial substitutes for conventional energy resources. Unfortunately, once the oil crisis subsided, government support for renewables diminished.

Some key policy statements supportive of renewables in national energy policy documents of selected countries are summarized in Box 2. These policy statements sometimes remain at the level of noble intentions with limited follow through investment, partly due to lack of a clear strategy for implementation.

Box 3: Policy Statements in Support of Renewable Energy

Djibouti – "The replacement of oil by the development of new and renewable sources of energy answering to the objectives of the economic and social orientated law, which are to combat energy dependency and poverty in rural and urban areas"
Rwanda – "Build capacity for policy development and investment planning in key sub-sectors such as gas, hydropower, petroleum products, rural electrification, and renewable energy"
Kenya - "Promote development and use of new and renewable energy forms"
Ethiopia – "To provide alternative energy sources for the household, industry, agriculture, transport and other sectors"
Sudan – "To develop and promote local and/or adapted energy technologies, particularly in the field of renewables (RETs)"
Eritrea – "To exploit the potential of renewable energy sources when the development is economic or when it complements the Government's social policy"
Uganda – "Support the dissemination of biomass and other renewable energy technologies (RETs) to increase their positive impact on the energy balance and the environment"
Tanzania – "Enhance the development and utilization of indigenous and renewable energy sources and technologies"

Source : MoI, 2004 ; MoE, 2004 ; MME, 1998 ; GoS, 2005 ; MEM-Eritrea, 1997 ; MEMD, 2002 ; MEM-Tanzania , 2003

Even at regional level energy strategies have not prioritized renewables, in spite of their potential in contributing to the energy sector and their widespread availability. In some cases, however, some effort has been made to identify objectives for renewable energy development. For instance, the Southern Africa Development Corporation (SADC) has developed the SADC energy protocol, which highlights the priorities for energy for 12 member countries. The document highlights priorities for woodfuel and renewable energy (See Box 3).

Box 4: Extract from the SADC Energy Protocol

4. Woodfuel

Woodfuel is recognized as a predominant source of energy throughout the Region, presently and in the future. Accordingly, the goal of the Commission should be to develop, enhance and facilitate co-operation at a regional level relative to the provision and use of wood fuel in a sustainable, rational and environmentally benign manner. In doing so, it should be recognized that biomass has several end-uses, such as the provision of fuel, fodder, food, farming, construction and forestry products. Moreover, most problems in the wood fuel sector are local and site-specific in character and therefore, solutions to the biomass problems would emanate largely from local communities. In light of this, the following sets forth guidelines for regional co-operation:

a) Promote local community participation in policy formulation and implementation with special attention on the gender dimension.
b) Strengthen institutional capacity in the wood fuel sub-sector, particularly with respect to training, data collection and information dissemination.
c) Encourage applied research.
d) Improve woodfuel end-use efficiency and seek acceptable alternatives to wood fuel.

5 New and Renewable Sources of Energy

Like woodfuel and coal, new and renewable sources of energy (hereinafter "NRSE") are generally site-specific. Applications often take the form of biogas, windmills, mini hydro plants, passive solar design of buildings, photovoltaic, solar thermal, and solar stoves and water heaters. The potential is great for use of renewables in the Region. The following lists the guidelines of strategy to promote increased production and use of renewables in an economically and socially acceptable manner:

a) The Commission shall develop appropriate financing mechanisms suitable for the development of NRSE.
b) Member States shall consider the implementation of suitable tax regimes that promote the development and use of NRSE.
c) Member States shall strive to create an enabling environment for private sector involvement in NRSE.
d) The Commission shall provide, upon request and to the extent possible, technical support to governments and non-governmental organisations involved in the NRSE sub-sector.
e) Member states shall include cost-effective NRSE applications in their public investment programmes.

One limitation of the SADC energy protocol is that it does not mention the source of funding for the proposed activities.

The Economic Commission for West African States (ECOWAS) has also developed a white paper on energy. The paper mentions the limited policy support to renewables in the West African region, as the reason for the very few renewables initiatives and programs found in the region (see Box 4). The paper estimates the financial resources required to undertake the various activities, although it does not indicate the source of funding, but mentions that financing is expected to be on an ad-hoc basis (ECOWAS, 2005).

Box 5: Extract from ECOWAS White Paper on Energy

The Regional Agency for Access to Energy Services which is proposed under the strategy, will perform more specific project-related activities, for which financing will be found on an ad hoc basis. Examples of such activities include: (1) Helping Member States incorporate an energy component into their PRSPs; (2) Conducting case studies and impact studies to document good practices. This should be done with reference to the international schedule, so that the work can help inform and bolster the region's – and Africa's participation in major international conferences and global political processes; (3) Carrying out feasibility studies and reviews of various productive services likely to meet expressed needs, especially in rural areas; (4) Conducting a regional study on the technical and economic conditions for viably harnessing the full potential of renewable energy sectors (biomass energy), hydro-electricity, solar heating and PV pumping; (5) Investigating the market potential for bio-fuels and the conditions for developing industrial crops on an ad hoc basis; (6) conducting a feasibility study on a regional plant for manufacturing components of renewable energy equipment such as solar water heaters and a biomass plant for steam/electricity co-generation, at local level; (7) carrying out a prospective study of some local economic zones, featuring a central town and its hinterlands, in order to determine how they could develop, economically and socially, if regional integration opened their subsistence economies to a wider market: this study should produce models of technical options and more or less decentralized methods for supplying energy and harnessing any local energy potential, as well as sharing the best way possible, energy resources between Member States.

The following renewable energy options continued to receive significant policy support and financing: large scale hydro[41] in most African countries, cogeneration in Mauritius; wind in North Africa and geothermal in Kenya. Detailed review of these options can demonstrate how to overcome barriers to renewables development, and policy measures that have worked well.

A number of African countries have been proactive in setting targets for RE, as part of their renewable energy policy strategies. As shown in Table 30, a number of countries have set renewable energy targets (see Box 6 and Box 7 for case studies on renewable energy targets). In addition, a number of countries set targets at the Washington International Renewable Energy Conference (WIREC). The due dates for most of the targets agreed on are yet to pass; therefore, it is not possible to gauge the success of the targets at this stage. However, renewable energy targets are likely to result in development and growth of renewable energy, especially if a clear strategy for implementation and requisite follow-up is put in place. Notably, successful application of renewables targets has been realised in Morocco and Egypt as shown in Box 7.

Table 30: Renewable Energy Targets in Africa

Country	Target for Renewable Energy
Kenya	Promote cogeneration to generate 200MW by 2020 in the sugar industry and other commercial establishments; promote wind energy to generate 150 MW by 2020 through favourable policy and regulatory interventions.
Ghana	- Reduce the wood intensity of charcoal production (ratio of wood input to charcoal) from existing 4:1 to 3:1 in the Savannah zone and from 5-6:1 to 4:1 in the Forest zone by 2015. - Ensure that the energy share of traditional biomass (woodfuels) in the national final energy mix is reduced from about 60 percent at present to at least 50 percent by 2015 and subsequently to 40 percent by 2020. - Increase the supply of renewable energy and modern biomass in the Ghanaian final energy supply to achieve at least 10 percent penetration by 2020.

[41] Despite the significant support by policy makers for large hydro, Africa's hydro potential that is untapped is still enormous.

Morocco	A new renewable energy law is being drafted that would target 10% share of primary energy and 20% share of electricity by 2012, equivalent to 1GW of new renewables capacity and 400,000 square meters of solar hot water until 2015
Egypt	20 percent share of electricity by 2020, which includes 12 percent for wind power
South Africa	10,000 GWh renewable energy contribution by 2013
Senegal	15% of primary energy by 2025
Mali	15% of primary energy by 2020
Nigeria	Increase the share of electricity from renewables to 7% by 2025
Rwanda	Ensure that by 2012, 90% of the electricity in produced will be by renewable energy sources compared to 45% in 2008. In addition, solar hot water will be obligatory for all new constructions by 2010.
Cape Verde	50% renewables in nationwide power production by 2020, 100% on one island
Uganda	Making modern renewable energy a substantial part of Uganda's national energy consumption, up from 4% to 61%
Madagascar	National policies to achieve 54% renewable energy share by 2020
Tunisia	Promotion of renewable energy to reach 10% in national energy demand by 2011 and reduction of total demand

Source: REN21, 2007 (www.ren21.net/wiap)

Box 6: Case Example: Renewable Energy Targets in South Africa

In the case of South Africa, in order to meet the long-term goal of a sustainable renewable energy industry, the Government has set the following 10-year target for renewable energy:

- 10 000 GWh (0.8 Mtoe) renewable energy contribution to final energy consumption by 2013, to be produced mainly from biomass, wind, solar and small-scale hydro.
- Renewable energy to be utilised for power generation and non-electric technologies such as solar water heating and bio-fuels. This is expected to account for approximately 4% (1667 MW) of the estimated electricity demand (41539 MW) by 2013. This is equivalent to replacing two (2x 660 MW) units of Eskom's combined coal fired power stations.
- This is in addition to the estimated existing (in 2000) renewable energy contribution of 115,278 GWh/annum (mainly fuelwood and waste) (Hughes et al, 2000). More efficient conversion of wood and waste for power generation will contribute to the target.

The progress achieved so far with regard to the target cannot be fully ascertained. However, a number of measures are in place to ensure that the target is met. One notable aspect of the RE programme in South Africa is that it has identified a team – the DME Renewable section- to act as think tank and strategic team for RE development. As of 2007, the following was reported as the current status of the project:

- Providing capital subsidy to renewable energy producers (2 projects subsidized to date)
- Investigating the implementation of Renewable Energy Certificates (TRECs) to provide additional revenue
- Investigating feed in tariff mechanism with NERSA
- Implementing Renewable Energy Market Transformation (REMT) project – will provide technical support
- Implementing South African Wind Energy Programme (SAWEP)
- Supporting the development of the Electricity Regulation Act (Act No. 4 of 2006) regulations regarding new generation capacity to examine the case for pro-renewables regulatory measures. Providing inputs to the Energy Bill pertaining to renewable energy concerns
- Supporting ongoing non-grid R&D (e.g. hybrid mini-grid systems for activation of rural economies)

Box 7: Case Example: Renewable Energy Targets in North Africa

Targets for wind energy contribution to electricity supply have led to vibrant wind energy sectors in Egypt and Morocco.

In Egypt, a comprehensive plan to increase share of wind energy to 12% of the total generated electric energy in the fiscal year 2020/2021 is the key factor that led to the focus on wind by the National Renewable Energy Agency (NREA). The program started in 1986. An assessment of wind resources showed that the Red Sea Coast, especially the Gulf of Suez had some of the highest wind speeds in the world. A wind atlas covering both banks of the Gulf of Suez and Egypt was prepared. The estimated potential for wind energy is about 3000 MW.

The first pioneer wind farm was installed in Ras Ghareb in the Red Sea region with a total capacity of 400 kW, followed by a 5.4 MW wind farm, encompassing 42 turbines from various manufacturers with ratings between 100 and 300 kW with different technologies and capacities. This wind farm has been connected to the local grid of Hurghada since 1993. Over the past decade, and after gaining experience and confidence in the field of wind energy, Egypt has moved from demonstration and pilot scale projects to large-scale wind farms.

By the end of 2007, the installed capacity of wind farms operated by NREA was 305 MW, and another 240 MW are in the construction phase. The current installed wind power capacity in Egypt is equivalent to 1% of the total installed electricity capacity. NREA is also investigating the potential for a wind power plant in the Gabal El-Zayt region which, according to the results of the wind atlas measurements records speeds of 11 m/s. Currently, NREA is implementing a feasibility study for large wind farms for this area, in co-operation with the KfW Bank.

In November 2006, the Moroccan government launched a national debate on energy in the country following which a National Plan for the Development of Renewable Energy and Energy Efficiency (NPDREEE), was adopted for the period 2007-2012. The target set by the NPDREEE is to reach a contribution of RE of 10% of the total primary energy supply and 20% of the electricity generation by 2012. Consequently, the Moroccan Government with the help of GTZ started evaluating the wind potential of Morocco in early 1990.

Between 1991 and 1994, in the course of a wind energy evaluation program, measurements to determine the wind potential along the Atlantic coast and in the northeast of Morocco were conducted, with financial assistance from GTZ. In the second phase from 1997 to 2000, the wind potential of selected sites along the Atlantic coast was investigated. The third phase – from 2001 to 2010 – is geared to evaluate new regions. The data gathered to date confirms that Morocco has several areas with excellent potential for exploiting wind energy, particularly in the greater Tangier, Ksar Sghir and Tétouan areas (where average annual wind speeds at a height of 10 m range from 8 m/s to 11 m/s) and in the Dakhla, Laâyoune, Tarfaya and Essaouira areas (with average annual wind speeds ranging from 8 m/s to 10 m/s) (*GTZ, 2007)*.

A 3.5 MW wind farm was installed at Al Koudia Al Baida site. Another wind farm with a rating power of 50 MW was constructed at the same location. Two additional wind farms 10 MW and 60 MW were also put up at both Lafarge and Essouira, respectively. Other wind farms with capacity totaling 200 MW are planned, and there are plans to exploit wind potentials in the greater Tangier area in the north of Morocco and in an Atlantic coast region. Wind energy currently contributes to 2.3% of Morocco's electricity supply.

Source: El-Khayat, 2008

In a few selected cases (in addition to large scale hydropower), renewable energy policies have been implemented with some level of success, demonstrated by a steady increase in the development and use of renewable energy technologies, and their contribution to the national energy. A number of countries in North Africa (Tunisia, Morocco and Egypt) have instituted policies for solar water heaters, coupled with a number of measures including supportive building codes and promotion programmes. This has led to a steady growth of solar water heater use in these countries. Countries that have RE policies that are beginning to show signs of success are summarized in the Table 31.

Table 28: Successful RE Policies

RE Sub-sector	Countries with supportive policy measures
Solar Water Heaters – Developing solar hot water policies, Building Codes, and/or promotion programs	Tunisia, Morocco, Egypt
Wind generators	Egypt, Morocco
Biomass cogeneration – supportive policies, policy and institutional framework	Mauritius

Source: REN21, 2008; AFREPREN/FWD, 2007

With the exception of Mauritius, the aforementioned policies, however, have not led to dramatic expansion of renewables. It appears that supportive policies are not sufficient to trigger exponential growth and expansion of renewable energy options. There seems to be other additional prerequisites that should be in place before a major sustained expansion of renewable energy investments is realized. An understanding of the prerequisites can be drawn from one of the countries that have registered notable success in RE policy development and implementation, namely Mauritius, which has been successful in promoting biomass (bagasse) co-generation (see Box 7 and 8 for detailed case studies).

Box 8: Case Study of Bagasse Based Cogeneration in Mauritius

A clearly defined government policy on the use of bagasse for electricity generation has been instrumental in the successful implementation of the cogeneration programme in Mauritius. Plans and policies have constantly been worked out over the last decade for the sugar industry in general. First, in 1985, the Sugar Sector Package Deal Act (1985) was enacted to encourage the production of bagasse for the generation of electricity. The Sugar Industry Efficiency Act (1988) provided tax incentives for investments in the generation of electricity and encouraged small planters to provide bagasse for electricity generation. Three years later, the Bagasse Energy Development Programme (BEDP) for the sugar industry was initiated. In 1994, the Mauritian Government abolished the sugar export duty, an additional incentive to the industry. A year later, foreign exchange controls were removed and the centralization of the sugar industry was accelerated. These and other measures are summarised in the table 32.

Table 29: Policy Measures for Bagasse Cogeneration Development in Mauritius

Year	Policy initiatives	Key objectives/Areas of focus
1985	Sugar Sector Action Plan	- Bagasse energy policy evoked
1988	Sugar Industry Efficiency Act	- Tax free revenue from sales of bagasse and electricity - Export duty rebate on bagasse savings for firm power production - Capital allowance on investment in bagasse energy
1991	Bagasse Energy Development Programme	- Diversification of energy base - Reduction of reliance on imported fuel - Modernisation of sugar factories - Enhanced environmental benefits
1997	Blue Print on the Centralisation of Cane Milling Activities	- Facilitated closure of small mills with concurrent increase in capacities and investment in bagasse energy
2001	Sugar Sector Strategic Plan	- Enhanced energy efficiency in milling - Decreased number and increased capacity of mills - Favoured investment in cogeneration units
2005	Roadmap for the Mauritius Sugarcane Industry for the 21st Century	- Reduction in the number of mills to 6 with a cogeneration plant annexed to each plant
2007	Multi-annual Adaptation Strategy	- Reduction from 11 factories to 4 major milling factories with coal/bagasse cogeneration plants (Belle Vue, FUEL, Medine and Savannah) - Bio-ethanol production for the transport fuel markets. Spirits/rum and pharmaceutical products e.g. aspirin - Commissioning of four 42MW and one 35MW plants operating at 82bars - Promotion of the use of cane field residues as combustibles in bagasse/coal power plants to replace coal

As a result of consistent policy development and commitment to bagasse energy development in Mauritius, the installed capacity of cogeneration power has increased over the years (Table 33). In 1998, close to 25% of the country's electricity was generated from the sugar industry, largely using bagasse, a by-product of the sugar industry. By 2001, electricity generation from sugar estates stood at 40% (half of it from bagasse) of the total electricity supply in country (Veragoo, 2003). It is estimated that modest capital investments combined with judicious equipment selection, modifications of sugar manufacturing processes (to reduce energy use in manufactured sugar) and proper planning could yield a 13-fold increase in the amount of electricity generated from sugar factories and sold to the national Mauritius power utility.

Table 30: Policy Measures for Promoting Cogeneration

Year	Policy Measures
1979	Prior to Sugar Sector Reform
1985	Sugar Sector Action Plan
1988	Sugar Industry Efficiency Act
1991	Bagasse Energy Development Programme
1997	Blue Print on the Centralisation of Cane Milling Activities
2001	Sugar Sector Strategic Plan
2006	Multi-Annual Adaptation Strategy for Sugar Sector

Bagasse cogeneration has delivered a number of benefits including reduced dependence on imported oil, diversification in electricity generation and improved efficiency in the power sector in general. It is available 100% of the time as long as bagasse production is in place thus enhancing Mauritius' energy security. Bagasse, which is a waste product can lead to environmental problems if not disposed off well (fire hazards and methane emissions which are considered potent green house gases) – thus its use for power generation delivers significant local environmental as well as climate benefits. In addition, carbon dioxide produced by bagasse-based cogeneration is minimal as it is considered a carbon-neutral option.

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

An important policy incentive for promoting renewables is the provision of pre-determined feed in tariffs for electricity generated from renewable energy options. In growing number of cases, the introduction of a feed in tariff has resulted in an increase in RE development. Pre-determined feed in tariffs provide incentives for investors as they are able to reliably work out their return on investment. A pre-determined feed-in tariff is also a guarantee for securing financing for RE projects and promoting market stability for investors in renewable energy electricity generation.

Feed in tariffs also reduce transaction and administrative costs by eliminating the conventional bidding processes and encourage private investors to operate renewable energy power plants prudently and efficiently so as to maximize returns. If well structured, feed in tariffs in combination with standard power purchase agreements and appropriately amended electricity Acts can ensure that RE sourced electricity is given priority to access the grid. It also obliges grid operators and utilities to purchase electricity from renewable sources.

Favourable pre-determined feed in tariffs have seen the expansion of RE in Mauritius, Kenya and Uganda and have stimulated interest in renewable based power production in South Africa and Tanzania (see Box 8).

Box 9: Renewable Energy Incentives – Feed in Tariffs in South Africa, Mauritius and Kenya

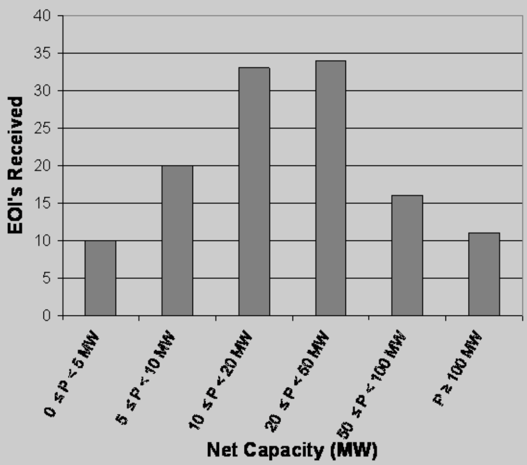
South Africa

Eskom launched a Cogeneration Programme in 2006, with a target of 900MW of cogeneration projects, to be achieved within a 5 year window, ending March 2011. The programme was in line with the National Electricity Regulator of South Africa (NERSA) initiative to established a cogeneration framework (guidelines) that will promote new cogeneration projects. Eskom set up a cogeneration workgroup to support the initiative and worked jointly with the NERSA and others in industry in developing the project.

One of the key innovations of the programme is that Eskom set a ceiling tariff offer for the cogenerated power, which was that the price should not not exceed the ceiling price set by Eskom's avoided cost model, there by effectively pre-determining the tariff. "Cheapest bids" from technically and commercially qualified bids would win contracts for up to 15 year contracts. A standard contract/Power Purchase Agreement (PPA) was developed for the cogeneration projects

With these two important ingredients in place (Feed-in tariff offer and standard PPA), the call for expression of interest was a success, and received an overwhelming response, with 5,000MW worth of EOIs received by end of September 2007 – which is approx. 10% of South Africa's current installed capacity.

Figure 13: Summary of EOI's received: Generator net output



Source: Higgo, 2007

After consultation process with a number of stakeholders, the South African feed-in tariff scheme was approved by Nersa in March 2009. The newer draft guaranteed tariff payment for minimum of 20 years, while the older draft (released in 2008) stipulated tariff payment duration of 15 years. The newer draft also incorporated newer technologies such as landfill gas, wind power, concentrating solar power (CSP) and small hydropower (less than 10MW) (Nersa, 2009). The feed-in tariff level has increased significantly in comparison to the first draft (also due to the increase of capital costs due to the global financial crisis). For new installations every year, the tariffs will be adjusted to the inflation.

Table 34: Feed-in Tariffs in South Africa, 2009

Technology	1st tariff proposal (2008) in Euro cent	Tariffs as approved in 2009 in Euro cent
Landfill gas	3.3 € cent/kWh (43.21 c)	7.5 € cent/kWh (90 c)
Small hydro	5.7€ cent/kWh (73.76 c)	7.8 € cent/kWh (94 c)
Wind power	5.1€ cent/kWh (65.48 c)	10.4 € cent/kWh (1.25 R)
CSP	4.7€ cent/kWh (60.64 c)	17.5 € cent/kWh (2.10 R)

Source: Jacobs & Kiene, 2009

Mauritius

Mauritius has over the years developed a pricing policy on co-generated power, which has been the key driver for increased production of bagasse co-generated power. The institution of an attractive feed-in tariff for firm power generation was very instrumental in promoting biomass cogeneration in Mauritius (Table 35). The development of a feed-in tariff in Mauritius was as a result of close collaboration between policy makers, the sugar industry and other stakeholders. The government played "honest broker" key role in power purchase agreements and setting feed-in tariffs (key factor). This reduced the lengthy and sometimes acrimonious tariff negotiations (Deepchand, 2003).

Table 31: Energy Pricing in Mauritius

Energy Pricing				
Power mode	**Power Plant**	**Price – Rs (us ¢)/kWh**	**Year**	**Characteristics**
Intermittent	-	0.16 (0.6)	1982	Price frozen since 1982
Continuous	Medine	0.55 (1.9)	1982	No change in price since 1982 –no changes brought to the plant

Continuous	6 PPs	1.05 (3.7)	1997	44% of kWh price indexed to changes in oil price and the other 56% is fixed
		1.40 (4.9)	2000	
Firm	FUEL	coal - 1.63 (5.7) bag. - 1.56 (5.5)	1985	Invested in new equipment Indexed to coal price
Firm	DRBC	coal - 1.53 (5.4) bag. - 1.46 (5.1)	1998	Invested in second hand equipment Indexed to coal price
Firm	CTBV	both - 1.72 (6.0)	2000	Indexed to coal price, cost of living in Mauritius, foreign exchange rate fluctuations

Source: Deepchand, 2003

Kenya

Kenya recently introduced a feed-in tariff policy for wind, biomass and small-hydro resource generated electricity. The policy is expected to boost exploitation of abundant local renewable energy sources in the country by attracting private sector capital investments in renewables. The policy document defines the pre-determined tariffs (Table 36) for both firm and non-firm power, with a more attractive tariff offered for firm power. In addition, the policy defines a window for accessing these initial feed-in tariffs, which would be applicable for the first 100MW of firm small hydro power and 50MW of non-firm small hydro power; the first 150MW of wind power; and the first 150MW of firm biomass power and 50MW of non-firm biomass power (Ministry of Energy, 2008).

Table 32: Feed-in Tariffs Kenya

Source	**Power plant effective generation capacity (MW)**	**Firm power Tariff US Cents/kWh)**	**Non firm power tariff (US Cents/kWh)**
Small hydro	<1	12.0	10.0
	1-5	10.0	8.0
	5-10	8.0	6.0
Wind	<50	9.0	-
Biomass	<40	7.0	4.5

Source: Ministry of Energy Kenya, 2008

The feed-in tariff was introduced in the last quarter of 2008, and informal consultation with Ministry of Energy officials in Kenya confirm that there has been growing interest from renewable energy project developers ever since the tariffs were announced. One year after the implementation, several power producers have expressed their intention to start projects for renewable electricity generation. Reports from the Ministry of Energy indicate that already 6 possible producers are carrying out site specific feasibility studies for wind power. The 6 projects have a total capacity of 500MW (Ondari, 2009). Tanzania also announced feed in tariff (see Annexes).

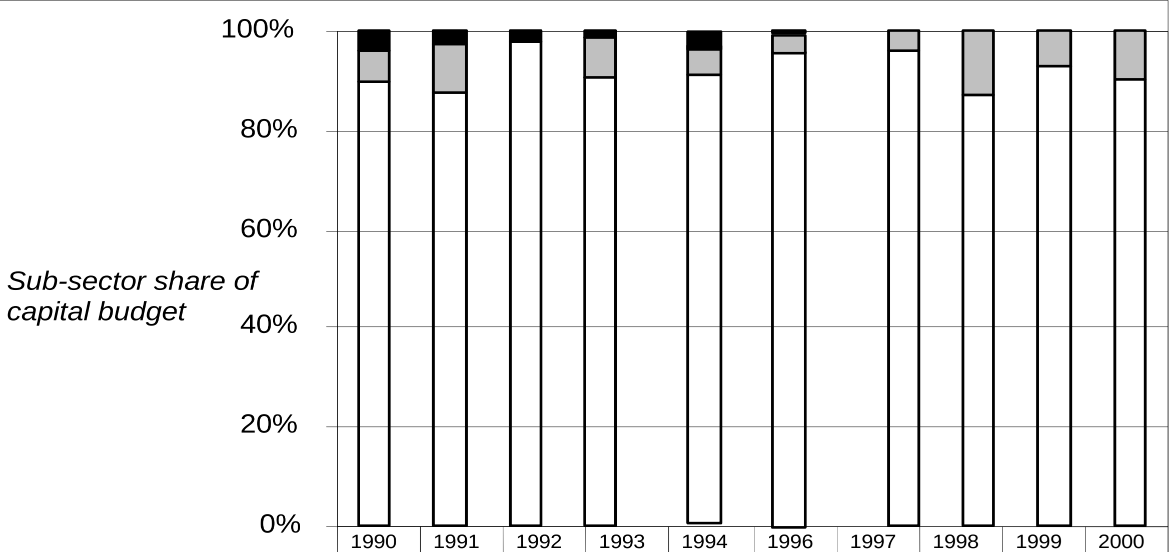
The key lesson that can be discerned from the case studies is that supportive policy, while crucial, is only one of the ingredients in successful implementation and development of renewables. Provision of a pre-determined feed in tariff and a standard power purchase agreement were important stimuli for renewable energy development, as demonstrated in the case studies. Special focus on one key renewable seems to have been another key prerequisite that led to the success of biomass cogeneration in Mauritius. Long term commitment was instrumental in the success of the programme - biomass cogeneration development was initiated in Mauritius in the 1920s, and is still ongoing. In addition, biomass co-generation development was built around the sugar industry, which meant that it did not require the creation of a whole new industry-a very efficient piggy-back strategy. The presence of local champions (the sugar industry) who advocated for continued support for the cogeneration programme is an additional factor that contributed to the success of the programme.

4.2. Financial Barriers

Financing plays a major role in the promotion of renewable options. Securing finance for renewable energy investments is complicated by competition among investment projects for limited funds and is compounded by unfavourable macro-economic conditions found in much of

Africa. The problem of financing is demonstrated by the low national budgetary allocations to renewables (with the exception of large-scale hydro) in most countries. In addition to large-scale hydro power, most countries place more emphasis on the petroleum and power sectors, which supply a small portion of the population in comparison to renewables (especially biomass), which meet the energy needs, (basically non-electric energy), of the overwhelming majority of Africans. For example, investment trends in Ethiopia's energy sector reveal heavy investments in the electricity and petroleum sub-sectors. As shown in figure 14 investments in petroleum quadrupled from 1990-2000, while investments in electricity (primarily large-scale hydro) almost tripled in the same period. In contrast, expenditure on traditional and alternative energy (which includes other renewables) has steadily decreased from about 1% of total expenditure in 1990, to 0.1% of total expenditure in the year 2000 (Wolde-Ghiorgis, 2002). A similar expenditure pattern can be observed in other countries in the region.

Figure 14: Energy sector capital budget as a percentage of total budget



	1990	1991	1992	1993	1994	1996	1997	1998	1999	2000
■ Traditional and alternative	14.2	5.9	4.0	4.1	10.5	0.7	0.5	0.5	0.4	0.5
▢ Petroleum	21.8	19.8		20.1	16.9	5.5	36.1	81.0	93.2	94.3
□ Electricity	314.0	182.0	187.0	240.0	267.0	145.0	861.0	539.0	1,209.	886.0

Note: The figures in the last 3 rows are in million Birr for Ethiopia
Source: Wolde-Ghiorgis, 2002

Excluding geothermal power, only 1% of total proposed investment cost for the energy sector in Kenya was allocated to alternative/renewable energy, as shown in Table 37 (a significant chunk of 18% was allocated to charcoal conservation strategies and a significant proportion of electricity investment is directed toward large-scale hydro and geothermal power investments). In addition, the public investment plan indicates that only 1% of priority project investment for the energy sector was allocated to alternative energy (outside large-scale hydro and geothermal power) in 1999/2000 (Ministry of Finance and Planning, 1998).

Table 33: Proposed Investment Cost for Energy sub-sectors in Kenya: Years 2002 - 2012

Department/Sub-sector	Budget (million Ksh)	Percentage Share (%)
Administrative Services	484.6	7
Fuel Supply Strategies	3,219.4	45
Charcoal Conservation Strategies	1,322.7	18
Petroleum Products	19.1	0.3
Electricity	1,914.0	27
Alternative Energy	***86.1***	***0.7***
Energy Education	150.9	2
Total	**7,196.8**	**100**

Source: Kamfor, 2002

Renewable energy policies in Africa are unlikely to register significant success without the requisite budgetary allocations.

Governments and private enterprises must seek creative ways of financing renewable projects. One important option would be to factor in investment analysis the enhanced energy security factor of renewables which should attract a beneficial premium in comparison to liquid fossil fuels that are often imported at high as well as unstable prices. The lower transmission costs associated with many renewables also need to be taken into account when comparing generation costs. In addition, fossil fuels are often subsidised i.e. consumers are charged prices which do not cover the full cost of generating the electricity. If the tariffs were raised to cost-recovering rates then renewables would be more competitive (GTZ, 2008).

The benefits of renewable energy vis-a-vis the disadvantages of conventional technologies are often not well articulated in renewable energy plans and policies. There is a need for a more level playing field between RE technologies and conventional energy technologies (Martinot, 2004). The benefits of renewables which should be quantified and included in cost comparisons include:

- Security of fuel supply (substitution of fuel imports with indigenous resources)
- Local benefits (primarily employment) (IEA, 2008)
- Grid integration (primarily extra costs to electrical infrastructure, power balancing costs and reduced capacity value for wind turbines and additional reserve capacity for centralized conventional power plants)
- Environmental externalities (reduction of CO_2 which can attract carbon credits and other air pollutants)

With regard to financing for renewable energy projects from the private sector, financing institutions in Africa are generally not familiar with renewables. With the exception of large-scale hydro, there is limited experience in conventional banks in financing renewable energy on commercial terms in the region. 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 in Africa 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 in many parts of Africa. There is also a shortage of funds from which renewable energy projects can access concessionary financing (http://cogen.unep.org).

Other barriers to mobilizing financing for renewable energy include: inadequate skills to prepare high quality pre-feasibility and feasibility projects; limited technical capacity on renewable energy within financial institutions; and, uncertainty of the market for renewable energy (e.g. absence of a PPA or transport fuel blending ratio[42], or market survey on demand for renewable energy options).

The challenge of financing projects for renewables is to develop models that can provide these technologies to consumers (including the very poor) at affordable prices while ensuring that the nascent African renewable industry continues to grow and remains sustainable. As described in the previous sub-section, a poor policy environment with minimal support for renewables among state agencies shifts the responsibility of providing financing for renewables to the small and embryonic African private sector.

The relatively high cost of renewables in Africa, compared to other developing countries, is a major barrier hindering greater penetration of renewables in the continent. This can be partly attributed to high duties imposed on imported components, high transaction costs in acquiring them and relatively low volume of purchases. For example, cases have been reported of solar PV systems being three times more expensive in Ghana than in Bangladesh and small hydro being twice as expensive in African countries as in Sri Lanka. The significance of lower or no import duties for renewables has been demonstrated in Tanzania where duty on PV imports was removed, resulting in end-user prices dropping by a half. A similar experience was witnessed in Kenya where import duty on some components was removed. However, there are reported cases where customs authorities do not recognize certain components as parts for PV systems thereby charging exorbitant duties (Saghir, 2009).

Local production and/or assembly have often been proposed as constituting an attractive option for lowering the cost of renewables. The viability of local production or assembly of advanced renewables in Africa, however, has not been unequivocally demonstrated but there are some embryonic successes in selected non-advanced renewable energy technologies. Under the current macro-economic conditions in Africa, investment costs for manufacturing of advanced renewables can be prohibitive. Energy planners, investors and policy makers need to develop innovative ways to attract capital or minimize the total cost per unit produced.

A regional approach to developing markets for renewables can assist investment in manufacturing, for example with common standards, zero internal customs duties for renewable energy equipment and services and thus become more attractive across the various economic blocks i.e. the Common Market for Eastern and Southern Africa (COMESA), Economic Community of West African States (ECOWAS), Southern Africa Development Community (SADC) and the East African Community (EAC).

With regard to funding of renewables, past financing initiatives for renewable have not registered widespread success. Often, renewable energy projects collapse after the initial donor/funding institution withdraws (see Box 8 - case study on solar water heaters in South Africa).

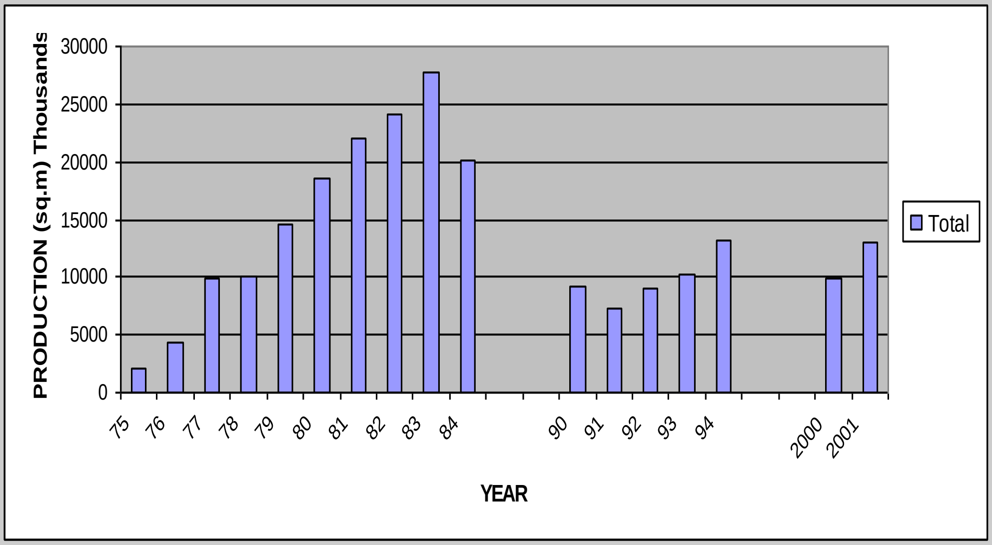
[42] Blending policies create a market for renewable energy fuels, and increase the viability of renewable energy investments. Blending policies could be developed at national, regional and/or regional level, to enhance exchange of information, after establishment of appropriate sustainability indicators. It is, however, important to ensure that appropriate sustainability criteria are in place before mandatory blending policies for biofuels are enacted. For countries that are worried about the potential adverse impact of blending guidelines, a more prudent approach would be to establish regulations that require the production of biofuels from wastes which will not adversely affect any existing food-fuel trade-off.

Box 10: Case Study of Solar Water Heaters in South Africa

SWHs were rapidly distributed in South Africa in the late 1970s and early 1980s and then their uptake substantially declined (see Figure 15). They have been marketed to the general public and made available to poor households in specially targeted projects.

There are three types of collectors used for SWH: glazed, unglazed, and evacuated tubes. The glazed collectors are used for domestic solar water heating, the unglazed collectors are generally installed for swimming pools. Evacuated tubes, which are more efficient than either, are more recently being imported into the local market mainly from China.

Figure 15: SWH dissemination in South Africa can be divided into three historical phases



Phase 1: 1978-1983 Widespread acceptance and installation of SWH
The government supported the promotion of SWHs. The Centre for Scientific and Industrial Research (CSIR) developed effective communication strategies and projects, which motivated home-owners to install them. Home owners would pay, either with a home improvement loan, or paying cash. The SWH market grew, and six major companies manufactured, marketed and/or installed SWHs, focusing on middle- to high-income customers. The average heater cost around R3500 for a 200-litre system, which most houses installed. The industry flourished, and in 1983 about 27 000 m^2 of solar collectors were produced. In that year the SWH communication project came to an end, and following the discontinuation of the CSIR promotion, the market collapsed and has not yet recovered since (see Figure 14) although there are encouraging signs of an industry revival more recently.

Phase 2: 1984-2003 Collapse of the SWH market
In this period, SWH installations dropped and annual glazed collector installations were about half of what they had been in the previous phase. Some solar water heaters were installed in social housing projects, such as that in Lwandle near Cape Town, where a workers' hostel was transformed into family units

Phase 3: New initiatives starting about 2003/2004 - the SWH by-law for middle- and high-income households and SWH for the poor
The White Paper on Renewable Energy gave a new perspective and created renewed interest in the field. The City of Cape Town has taken the initiative to support RE and is committed to ensuring that 10% of households have SWH systems by 2010, and has initiated a number of activities to promote the technology. The City has drafted a by-law (see Appendix) and is currently consulting stakeholders to promote the use of SWHs in middle- and high-income homes to contribute to the RE target.

Ubushushu Bendalo – meaning 'heat from nature', was founded in August 2004 as a joint initiative by civil society organisations and the City of Cape Town. The Ubushushu Bendalo strategy is to harness the expertise, knowledge and capacity in Cape Town to provide a channel for resources to enable effective and efficient implementation of RE and energy efficiency technologies, in particular SWHs. The City plans to retrofit 2 300 SWHs in low-income homes in Kuyasa in Khayelitsha township.

The Central Energy Fund (a government-supported company working on meeting the future energy needs of the country) subsidized 500 SWHs with funding from GEF and UNDP, which were installed in the first half of 2007. In each of the three major cities (Johannesburg, Durban and Cape Town) 165 systems were installed. The project was advertised in the newspapers and it had a positive demonstration effect and renewed customer interest in SWH and encouraged the SWH industry.

A project to explore the institutional, financial, social and technical feasibility of providing the poor with retrofitted SWHs is being implemented in the township of Kuyasa, Khayelitsha in Cape Town. A pilot project has fitted ten houses with SWH. Besides the water heater, a ceiling is added and compact fluorescent lights (CFLs) are distributed, to improve the thermal performance of the houses and the lighting and water heating efficiency. This will result in reduced electricity consumption and avoided CO_2 emissions (from coal-generated electricity). The project developed the methodology and procedures for receiving certified emission credits of the Clean Development Mechanism (CDM) and the CDM credits were approved.

More recent developments

The SWH industry is currently experiencing a revival. The media have included more coverage; notably an advertisement in several local and national newspapers from the CEF and two articles by Eskom encouraged the industry, and sentiment is generally positive. SESSA50 is another project which installed subsidized SWH and collected data for a detailed assessment of the technology. Eskom presented its new approach to solar water heating and its inclusion into Eskom's Demand Side Management Programme in 2007. This is expected to have a major positive impact on the SWH industry.
Source: Prasad, 2008

The case study on solar water heaters in South Africa provides the following lessons:

- Financing packages for renewable energy options should be designed to ensure that they are sustainable, and continue to deliver results after the initial campaign period.
- Marketing the benefits of renewables is essential, to continuously expand the demand for the renewable energy option, and ensure that renewables are targeted at meeting end users needs and abilities (including affordability).
- Renewables that generate electricity or reduce electricity consumption are best disseminated with the support of the national utility (its key reason is likely to be reducing peak loads).

On the other hand, it also appears that the presence of financing is not sufficient to trigger the needed momentum for growing the renewable energy industry. An analysis of the case study of the Solar PV Market Transformation Initiative in Kenya (see Box 11 for detailed case study) demonstrates key financial barriers to renewable energy development.

Box 11: Case Study of Solar PVMTI in Kenya[43]

The IFC/GEF Photovoltaic Market Transformation Initiative (PVMTI) was a $30-million initiative designed to accelerate the sustainable commercialization and financial viability of energy services, based on solar electricity (solar PV) technology in India, Kenya and Morocco. The initiative was launched in 1998 and is still operating to date (www.ifc.org).

A summary of the project structure, performance and results in Kenya is provided below:

"In Kenya, which had a dynamic solar PV market with 150,000 solar PVs sold without any formal credit facilities, PVMTI was expected to provide working capital and end-user financing in a market dominated by small-scale enterprises. The $5 million project in Kenya sought to make PV financing funds available to banks and PV companies and thereby 'transform' the solar PV market. One of the projects selected for the initiative was the Muramati District Tea Growers Savings and Credit Cooperative Ltd. (Muramati SACCO). The concept for which the PVMTI funds were dedicated was relatively simple. Muramati would work in partnership with a local solar home systems supplier, which would supply and maintain the systems, while Muramati would market the systems and provide potential customers with the financing to purchase the systems. The customer would be required to pay a deposit on the system and maintain monthly payments" (www.ifc.org).

The project did not meet its expected targets due to various reasons. No market survey, unfortunately, had been undertaken during the preliminary stages of the project to determine the level of demand for SHS among Muramati members. The initial phases of the project recorded limited demand for financing for solar PV systems from members of the Muramati SACCO. This could have been an indication that solar PV systems were ill suited for the target users.

Another factor that was detrimental to the projects operations was the weakness in enforcing standards for solar PV products. In addition, the lack of a reliable solar PV network exacerbated the problem. As a result, Muramati saw systems fail and installations

[43] Most of the information on this case study is based on material obtained from the IFC website (www.ifc.org).

delayed because of faulty batteries.

Disbursing of the funds to purchase SHS proved to be difficult. Even at the project's concessional rates, PV companies and banks were not interested in the loans. Muramati SACCO officials did not see financing SHS as a main line of business and it was difficult to get many of them to move expeditiously on the projects. On the other hand, many solar PV businesses found the $500,000 minimum investment too steep.

In a market where 15,000 systems are sold annually on a commercial basis, only about 170 systems have been installed by the PVMTI project (Table 38). http://www.renewable-energy-world.com/display_article/273240/121/ARCHI/none/none/1/Fresh-ideas-needed:-Building-the-PV-market-in-Africa/; IFC website).

Table 34: PVMTI in Kenya – Units Installed

Project	Commitment (million US$)	Units Installed
Barclays Bank, Kenya	2.0	0
Equity Building Society, Kenya	2.1	0
Muramati Tea Growers Sacco, Kenya	0.6	170
Total	**4.7**	**170**

Source: www.ifc.org

Due to the slow pace of the initiative, adjustments were made to restructure the project with the hope of achieving better results. The key adjustments included:

- Extension of program implementation period by two years, in order to achieve higher level of disbursements
- Setting-up a stand-alone technical assistance and capacity building program, which increased the allocation to technical assistance (training, capacity building and information dissemination) to 20% of overall project budget.
- Credit terms were changed to remove down-payment and increase loan repayment periods

However, despite the adjustments, the programme failed to register robust growth in disbursements for the Muramati SACCO, and was abandoned. The SACCO asked to discontinue the programme, citing that the programme was too cumbersome to manage as it was outside its core business. The project is still ongoing in other financial institutions in Kenya, although the results have not been significantly different.

The key lessons learnt from the unsuccessful case example of Muramati SACCO can be summarized as follows:

- The project demonstrated that creating an enabling environment, where technical issues and suitability of technology options are sorted out, was as important as providing finance.

- The low levels of technical expertise in rural Kenya meant that the maintenance of the systems was difficult. The key shortfall of this solar PV initiative is that it did not piggy back on an existing industry, and requires the setting up of a completely new assembly, sales, distribution, and maintenance network. This would require a long time to set up, as demonstrated by the solar PV industry in developed countries which required decades to reach maturity.

- Studies in Kenya confirm that most poor rural households cannot afford even the low-end 18Wp PV solar systems (Karekezi and Kithyoma, 2002). In addition, the limited uses of solar PV at household level (mostly for lighting) present an additional problem of suitability. It is likely that renewable energy options that can allow end users to generate an income would be more suitable, since they may be able to generate the needed repayments.

- High initial investment was not well suited for small-scale solar suppliers targeted by the project. Small scale businesses perennially face huge challenges in accessing financing, especially for slow-moving goods. In the case of PVMTI, the selection of solar PV which registered low demand with the end users may have been a major factor in low level of interest from small scale suppliers. One could argue that had the RE option been one with potential for income generation, there would have been significant interest both from the end users as well as the small scale suppliers.

A successful financing initiative in the energy sector in Africa is summarized in Box 12. The case of Kenya Electricity Generating Company (KenGen) provides useful lessons for raising financing for renewable energy development in Africa and demonstrated the ability to generate local investment finance, which remains untapped in many African countries. KenGen's successful Initial Public Offer (IPO) has provided it with funds to finance its investment in geothermal power stations. This model could be used to generate local funds for renewable energy projects. KenGen successful IPO also demonstrated the importance of having a well established local champion such as KenGen, the country's pre-eminent power generation company.

Box 12: Success Stories in Financing: The Case of KENGEN and other Notable Experiences

Kenya Electricity Generating Company (KenGen) is a public limited liability company wholly owned by Government of Kenya. Its principal activity is to generate and sell electricity to the country power utility Kenya Power & Lighting Co (KPLC). KenGen is the largest electricity-generating company in Kenya accounting for 85% of the total electricity produced. KenGen has been at the forefront of geothermal power development in Kenya, and has recorded notable success in this field (KenGen, 2006).

The KenGen Initial Public Offer (IPO) issue

In 2006, KenGen raised substantial investment finance through the issue of an Initial Public Offer on the Nairobi Stock Exchange. The Government of Kenyan offered 659.5 million of its shares in KenGen to the public. The shares were priced at Kshs. 11.90 (US¢0.17) with the minimum number of shares set at 500 shares (additional shares could be applied for in multiples of 100 shares).

The offer shares were divided into two categories each with a separate allocation criteria as shown in the following table:

Pool	% Offer	No. of shares offered
Pool A – KenGen employees	5	32,975,422
Pool B – Other citizens	95	626,533,015
Total		**659,508,437**

Source: KenGen, 2006

The IPO attracted interest from all cadres of society, and long queues were witnessed throughout the sale period. The KenGen IPO was an unexpected success, and the company was able to not only meet the targeted amount (over US$ 112 million), but in addition, the share offer was oversubscribed by Kshs. 16 billion (US$228.5 million).

Some of the factors that made the KenGen IPO successful include the following:

1. ***Attractive & affordable pricing:*** At an offer price of Kshs 11.90 (US$ 0.17), KenGen was one of the cheapest and most affordable stocks on offer in the market to retail investors.

2. ***Dominant market position:*** KenGen is by far the largest and lowest cost power producer in the country commanding an 80% market share of the Kenya electricity generating market. Many retail investors considered ownership of KenGen a sound addition to their investment portfolio.

3. **High trading & market liquidity:** KenGen's free float of 659.5 million shares was the largest at the NSE providing room for a large number of retail investors to take up the stocks.

Key Lessons learnt from the KenGen IPO

1. The KenGen IPO (Initial Public Offer) demonstrated to African governments the effectiveness of IPOs in raising local financing.

2. Significant disposable savings exist in Africa that could be channeled towards implementing renewable energy projects provided such projects are well packaged and marketed to public sector, through transparent mechanisms such as the KenGen IPO.

There are a few other relatively attractive but untapped financing opportunities for renewable energy development in Africa. These opportunities include the Global Environment Facility (GEF) which has registered encouraging results in channelling finance to cleaner energy investments in Africa, particularly sub-Saharan Africa. The GEF provides a good model for other financing initiatives and provides an ideal platform for expanding clean energy financing in Africa. Other financing opportunities include European Commission funding mechanisms (Jarvilehto, 2009) such as EU-ACP Energy Facility; Global Energy Efficiency and Renewable Energy Fund (GEEREF); Environment and Sustainable Management of Natural Resources, including Energy Thematic Programme (ENRTP), as well as carbon trading-related financing mechanisms such as Clean Development Mechanism (CDM), Carbon Finance (CF) and the recently established Climate Investment Funds (CIFs).

According to a study by the World Bank (de Gouvello, et al, 2008), the sub-Sahara African region is losing out on the carbon trading-related financing mechanisms. For example, in 2008, the region had only 53 projects in the CDM pipeline – representing a paltry 1.4% of the total number of projects in the pipeline. The aforementioned study estimated that 44 African countries could generate about 3,200 clean energy projects (including renewables) – equivalent to over 80% of the total number of projects in the CDM pipeline in 2008 (de Gouvello, et al, 2008). The study further estimated that the identified potential clean energy project could lead to 170 GW of electricity installed capacity – more than twice the prevailing electricity generation capacity.

4.3. Skills Barriers

The introduction of unfamiliar renewable energy technologies requires the development of technical skills. The importance of technical know-how in the increased utilisation of renewables has been recognised in the region, but there remains a continuing shortage of qualified personnel (Baguant and Manrakhan, 1994; Karekezi and Ranja, 1997; Karekezi, 2002). Technical knowledge is needed to build a critical mass of policy analysts, economic managers and engineers who will be able to manage all aspects of renewables development (World Bank, 1991; Karekezi, 2002). Trained manpower capable of developing and manufacturing renewable energy technologies is a prerequisite for their successful dissemination.

Capacity building in Africa can be viewed as twofold: capacity building for new technologies, which are not well disseminated in the region – this requires significant investment in training and capacity building over a long period of time; and capacity mobilization for mature renewable energy technologies, which are well developed in the region with an existing industry established – this would require more modest investment aimed at facilitating the utilization of existing skills base.

In contrast to conventional energy technologies that are mature and have evolved into large-scale investment industries, most renewables are relatively new technologies that do not require large amounts of capital. They are also relatively less sophisticated meaning that a significant industry could be developed in Africa even where technical expertise is limited. This is especially true for renewable energy options that are mature and have been implemented in the region over a long period of time.

The chances of an African country (with the exception of South Africa) becoming a significant player in the world's conventional energy market are slim but, with increased financial support, it may be possible for an African country to become a significant player in the small and medium-scale renewable energy market. For example, Kenya is now a global leader in geothermal energy development, with experts from Kenya offering their expertise in developing geothermal power plants in other countries in the region, and even developed countries (Mariita, 2002).

Majority of renewable energy entrepreneurs or project developers do not have the capacity to assemble "bankable" business plan or project proposals, which highlight the economic and technical benefits of renewable energy, and take advantage of feed-in tariffs and power purchase agreements where these are available (World Bank 2008). There is need to build the skills and know-how for undertaking feasibility studies.

In a growing number of cases, African countries have established robust renewable energy industries, and overcome the skills barriers. The analysis of the following case study (Box 13) demonstrates the key factors that are important in overcoming capacity/skills barriers.

Box 13: Case Study of Geothermal for Electricity Generation in Kenya

Kenya was the first country in Sub Saharan Africa to exploit geothermal energy for power generation in a significant fashion. Exploration for geothermal energy in Kenya started in the 1960's with surface exploration that culminated in two geothermal wells being drilled at Olkaria. In the early 1970's, more geological and geophysical work was carried out between Lake Bogoria and Olkaria. This survey identified several areas suitable for geothermal prospecting and by 1973, drilling of deep exploratory wells commenced with funds from UNDP. Additional wells were thereafter drilled to provide enough steam for the generation of electricity, and in June 1981, the first 15 Mwe generating unit was commissioned. This was the first geothermal power plant in Africa. The second 15 MWe unit was commissioned in November 1982 and the third unit in March 1985, raising the total to 45 MWe. Olkaria 1 is owned and operated by KenGen, a state-owned power generation utility. Since 1997, private companies have entered into the generation of electricity using geothermal resources. Currently Orpower4 Inc. is generating 12 MWe with plans to generate a total of 64 MWe in the next few years in the Olkaria West field (Mbuthi, 2005; Karekezi and Kithyoma, 2005). Kenya has so far exploited 127 MW of its total potential and plans are underway to increase geothermal generation capacity by 504MW by 2019 (KPLC, 2001).

Both the private and public sector were involved in the development of geothermal power in Kenya (BCSE, 2003). So far, 103 geothermal wells have been drilled in Kenya for exploration, production, monitoring and re-injection with depths varying between 180 and 2,600m. Of these, 97 wells are in the Olkaria area[44] and the rest in the Eburru Field (Mbuthi, 2005). A feasibility study carried out to evaluate Olkaria's potential for generating electricity found that the geothermal field covered 80km^2 and steam for 25,000 MW years. The present area covering 11km^2 has steam for 400 MW years, assuming that re-injection is not instituted.

The strong policy support for geothermal power has been one of the key factors that led to its successful exploitation. Kenya's Least Cost Power Development Plan (LCPDP) in 2000 recognizes geothermal as an important energy source for the future (Table 39) Government commitment to exploration showed that it was willing to bear part of the risk of developing the resources, which attracted private developers and investors (Mbuthi, 2005).

Table 35: Summary of Additional Planned Power Generation in Kenya (2004 – 2019)

	MW			
Fiscal year	**Hydro**	**Geothermal**	**Diesel**	**Total**
2004	60	56		116
2005				
2006			40	40
2007		64		64
2008	80.6		20	100.6
2009		64		64
2010	140			140
2011		64	20	84
2012			80	80
2013		64	20	84
2014			100	100
2015		64	20	84
2016			100	100
2017		64	40	104
2018			150	150
2019		64	60	124
Totals	280.6	504	650	1434.6

Adapted from KPLC, 2001

[44] The Olkaria area has a total of 3 power plants code named Olkaria I, II, and III, respectively. Olkaria I and II belong to KenGen while III belongs to OrPower Inc.

Kenya Electricity Generating Company, KenGen - a public utility, has an installed capacity of 115 MW while the rest is provided by an IPP, OrPower Inc. The geothermal power plants meet 11% of the total national electricity supply (Karekezi and Kithyoma, 2005). In addition, geothermal has boosted energy security, as it is available 100% of the time and at one time constituted an important alternative to hydropower during the 1999 – 2000 drought experienced in Kenya.

Geothermal power plants have near zero emissions, (true for modern closed cycle systems that re-inject water back to the earth's crust) and very little space requirement per unit of power generated (Karekezi and Kithyoma, 2005). The re-injection technology is in use in Olkaria II geothermal power plant in Kenya.

Geothermal energy use has also contributed to poverty reduction, although there is significant unexploited potential for increasing the positive impact of geothermal on poor communities, especially in the areas where geothermal is harnessed. For instance, a geothermal heat resource is being used on a pilot basis in a horticultural farm near Lake Naivasha to control night-time humidity levels in order to alleviate incidence of fungal diseases. Similarly, low-temperature geothermal steam is also used in Eburru for the drying of pyrethrum flowers and for various domestic purposes including water for livestock, drinking and irrigation which could yield significant benefits for the poor (Mbuthi, 2005). As mentioned earlier, Kenya is now a global leader in geothermal energy development, with experts from Kenya offering their expertise in developing geothermal power plants in other countries in the region, and even developed countries (Mariita, 2002).

An additional factor that led to the success of geothermal in Kenya is long-term commitment to skills development. As mentioned earlier, geothermal power is included in the country's power master plan, and has been prioritised. Overtime, the special focus on geothermal has resulted in the steady growth of geothermal power engineers and specialists in the country. Kengen, Kenya's electricity generating company, has an entire unit of geothermal specialists dedicated to geothermal power development. Recent reports indicate that the unit will be spun off to be an independent entity, to further drive geothermal development. Long-term commitment by both the private and public sectors in Kenya, through significant and long-term investments contributed to the development of local skills and expertise in geothermal energy. This critical mass of geothermal specialists have acted as the local champions for geothermal, and have been able to convince policy makers of the benefits of geothermal energy development.

Using illustrative case studies, this chapter has reviewed key opportunities and barriers to the development of renewable energy in Africa. The next chapter will summarize the lessons learnt from the successful and unsuccessful case studies discussed in this chapter and earlier chapters as well as policy experiences, and provide recommendations for future renewable energy projects and strategies in Africa.

5. Key Lessons and Recommendations

5.1. Key Lessons

Although this study does not provide an exhaustive list of case examples of renewable energy projects, the selected case examples provide useful lessons for future renewable energy initiatives in Africa.

The key lesson that can be discerned from the Mauritius example is that a supportive renewable energy policy, while important, is only one of the ingredients in successful implementation and development of renewables. Special focus on biomass-cogeneration seems to have been another key factor that led to the success of biomass cogeneration in Mauritius. Long term commitment was instrumental in the success of the programme - biomass cogeneration development was initiated in the 1920s, and is still ongoing. In addition, biomass co-generation development was built around the sugar industry, which meant that it did not require the creation of a whole new industry - a very efficient piggy-back strategy. The presence of local champions (the sugar industry) who advocated for continued support for the cogeneration programme contributed to the success of cogeneration in Mauritius.

The case examples on renewable energy strategies in North Africa (Morocco and Tunisia) and South Africa demonstrate the role of renewable energy targets in development and growth of renewable energy. Combined with a clear strategy for implementation and adequate financial support, targets can contribute to renewable energy development in Africa.

There are a number of key lessons learnt from the unsuccessful case example of the PVMTI project in Kenya. The project demonstrated that creating an enabling environment, where technical issues and suitability of technology options are sorted out, was just as important as providing finance. It also shows that renewable energy options that allow end users to generate an income are likely to be more successful. In addition, the high initial investment stipulated by the PVMTI was not well suited for small-scale solar suppliers that are prevalent in Africa, particularly sub-Saharan Africa.

The case study on solar water heaters in South Africa demonstrated that financing packages for renewable energy options should have a longer-term perspective to ensure that results are sustained after the initial campaign period. It also underlined the need for a strong and robust local champion such as the national utility. In South Africa, solar water heaters initiatives supported by the national utility, ESKOM, appear to have a better chance of success. The case of KenGen demonstrated Africa's ability to raise local investment finance for renewables, which remains untapped in many countries dramatically showed the importance of having a strong local champion, in this case Kenya's predominant power generation company.

One of the key factors that led to the success of geothermal in Kenya is long-term commitment to skills development. As mentioned earlier, geothermal power is included in the country's power master plan, and has been prioritised. Overtime, the special focus on geothermal has resulted in the steady growth of geothermal expertise in the country. Long-term commitment by both the private and public sectors in Kenya, contributed to the development of local skills and expertise in geothermal energy. This trained critical mass of geothermal experts championed geothermal development in Kenya, and have been able to convince policy makers of the benefits of geothermal energy development.

The success story of the KCJ can be attributed to the long-term commitment by both the private and public sector in its development, and specialized focus on the KCJ and sustained support from local champions. In addition, through innovative use of the piggy back principle, the KCJ developed around the existing artisanal industry, which dramatically reduced the cost of dissemination. Another key feature of the KCJ initiative is additional income it generated for the rural and urban poor who manufacture the stoves.

5.2. Prerequisites

Based on this study review and selected experiences and case studies of renewable energy in Africa, it appears that the formulation of supportive policies or financial mechanisms is not sufficient to stimulate expansion and scale-up of renewable energy use in the continent. As mentioned earlier, there seems to be important pre-requisites necessary for the success of renewable energy initiatives. The case studies analysed point to the following key prerequisites for successful renewable energy interventions in Africa:

- ***Special Focus:*** A key aspect of the all the successful programmes is the special focus on one technology option. This was true in the case of KCJ stoves, cogeneration in Mauritius, and geothermal in Kenya.

- ***Long term commitment:*** A second key aspect of the successful case studies was their long-term perspective. As mentioned earlier, the bagasse-based cogeneration in Mauritius, geothermal development in Kenya and the KCJ were all long-term initiatives. The commitment of both public and private sector to these initiatives over the long term allowed elimination of barriers and contributed to their success.

- ***Piggy-back principle:*** The piggy-back principle refers to building energy initiatives around existing networks, as opposed to creating completely new networks or initiatives. The piggy back principle reduces the cost of setting up a whole new network and facilitates accelerated scale up. This approach was key to the success of the KCJ in Kenya which was modelled around the informal sector, and bagasse-based cogeneration in Mauritius, which was built around the country's sugar sector. Both these initiatives built on a mature existing industry that provided a useful stepping stone for development of the technology. The geothermal industry has also been built around a strong and capable power generation company, KenGen.

- ***Local champions:*** The presence of local champions was also a key feature of the success stories. In the case of bagasse based cogeneration, the sugar sector in Mauritius was the local champion. For geothermal power in Kenya, the state utility (KENGEN-previously integrated in the national utility Kenya Power and Lighting Company - KPLC) was the local champion, while in the case of the KCJ, the informal sector, local NGOs and the Government acted as local champions. Local champions ensure that the momentum for implementation of the programmes is maintained and that there is regular monitoring of the project. Local champions are also useful in convincing policy makers of the viability of RE initiatives.

- ***Income generation:*** There appears to be a strong link between the success of renewable energy programmes and the opportunity for the renewable energy options to generate an income, for key stakeholders. The revenue sharing mechanism that is in place in the Mauritius cogeneration programme has contributed to the success of the programme. In the case of the KCJ, the success of the stove is also linked to the creation of employment opportunities for the informal sector and the higher revenues it generated for the informal sector based producer of KCJ improved cookstoves and related components.

5.3. Recommendations

The key recommendation is that government, private sector, donors and renewable energy practitioners should all work towards ensuring an enabling environment for renewable energy development; by identifying and putting in place the aforementioned prerequisites. Once the pre-requisites are in place, subsequent policies, incentives and supportive measures for renewable energy are likely to succeed. The pre-requisites provide the framework for implementation of the following key supportive policies.

Long term financing mechanisms[45] – Financing for RE is a major barrier, and innovative funding mechanisms, e.g. renewable energy levy need to be put in place. The financing mechanism for renewable energy could be modelled on Rural Electrification Levy/Rural Electrification Funds, which are now in place in most African countries. The funds would be used to support local champions, and finance long-term renewable energy programmes and capacity building initiatives. Other innovative financing options that could be pursued include:

- Placing technology development teams within financing institutions;
- Working with micro-credit associations and/or savings and credit cooperatives

African countries can tap into the various international (including bilateral and multilateral arrangements) and regional initiatives which can provide concessional finance for renewable energy projects. These initiatives include: Global Environment Facility (GEF), the UNFCCC-related Clean Development Mechanism (CDM), Carbon Finance (CF), Climate Investment Funds (CIFs), EU-ACP Energy Facility, Global Energy Efficiency and Renewable Energy Fund (GEEREF), Environment and Sustainable Management of Natural Resources, including Energy Thematic Programme (ENRTP).

Incentives and attractive pricing for renewable energy[46] – A standard PPA can limit market uncertainty which stands in the way of substantial investment in renewable energy-based electricity generation in the region. A PPA, linked to a pre-determined standard-offer or feed in tariff, from the national utility to purchase all energy produced by specific renewable energy-based firms can be instrumental in the successful scaling up of small renewable energy investments in the power sector (UNEP/GEF, 2006).

Targets for Renewable Energy[47] – Targets have led to growth of renewables in South Africa and Northern Africa. However, targets need to be home-grown, realistic and reflective of local conditions, to ensure their success. In addition, targets should be bound by law and accompanies by concrete monitoring mechanisms on progress. This way they can be useful signals for encouraging investment in renewables.

Other Supportive Measures – Key additional measures that are needed include: research studies on new and emerging renewable energy options and required local technological adaptations; collection, compilation and analysis of data on renewable energy, to fill the huge gap in availability of up-to-date data on renewable energy in Africa[48]; and, training initiatives to build a critical mass of skilled renewable energy professionals in Africa.

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[45] See case study in box 12
[46] See case studies in box 8 and 9.
[47] See case study in box 6 and 7
[48] GTZ and REN21 continued support to renewable energy data collection and compilation will significantly address this challenge.

5.4. Stakeholders and their Role

Governments

Governments play a major role in formulation of renewable energy policies. Conducive policies are central to the development and sustaining of renewable energy production and markets. Supportive policies have proved to be instrumental in the successful implementation and development of for example, biomass cogeneration in Mauritius. The policies should provide an enabling environment for the development of renewable energies by addressing issues such as tariffs and standard PPAs. Long-term commitment by governments is vital to the success of renewable energy projects.

Business and Private Sector

Private sector includes small local businesses and multinational companies. These have an important role in development of new renewable energies as well as enhancing existing technologies. In Mauritius, involvement of the private sector sugar industry, which advocated for continued support for the cogeneration programme, is a key factor that led to the success of the programme. Private financial and investment institutions should also seek to benefit from the huge investment opportunities in the sector. As emphasized in the Bonn 2004 Conference issue paper, access to energy is still a challenge for many African countries and private sector participation is needed to help meet these needs while still maintaining a commercial orientation.

Donors

Donor agencies through provision of grants, loans and aid can play a vital role in development of renewable energy in Africa. Through innovative initiatives such as the "Cogen for Africa" project (cogen.unep.org) donors can provide concessional finance for developing renewable energy projects. The REN21 (www.ren21.net) network has consistently contributed to building a knowledge base on renewables and more substantial donor support would allow the network to accelerate the expansion of renewables in Africa.

Renewable Energy Practitioners

Renewable energy practitioners including, NGOs, research institutions, energy consultants etc. can play an important role of information dissemination and creating awareness. By undertaking research studies on renewables in Africa, renewable energy practitioners can provide vital information particularly with respect to investment-relevant renewable resource assessments on new and emerging renewable energy options. They can also lobby policy makers to enact favourable policies and be instrumental in developing a sustainable energy industry in Africa.

Institutions

Where pro-renewable energy policies have been enacted, it appears that the exisiting and newly established energy institutions, especially those affiliated to the Government, tend to lack the capacity to translate renewable energy policies into regulations and operationalize them. Consequently, renewable energy development has been slower than anticipated partially due to the aforementioned capacity challenge, but also due to entrenched or vested interests, bureaucratic complexities, inadequate planning and lack of political will (Saghir, 2009). Therefore, a significant amount of institutional support and capacity building is required to strengthen Ministries of Energy and energy utilities as well as other key institutions in the energy sector such as the newly established energy regulatory bodies and rural electrification agencies.

6. References and Bibliographies

Addis Fortune (Addis Ababa) 15 May 2007 Posted to the web 15 May 2007 by Wudineh Zenebe. Addis Ababa

AfDB FINESSE, 2006. "Sustainable Production and Consumption of Biomass for Energy in Africa" Subregional synthesis report – Eastern & Central Africa. AfDB FINESSE/UNEP/IEA Joint Activity.

Afrane – Okese, 2001. Energy in Botswana: Trends and use of fuel wood, gas, electricity coal and paraffin. Energy and Development Research Centre

AFREPREN, 2001. Power Sector Reform in Africa. Proceedings of a Regional Policy Seminar. Occasional paper No. 5. AFREPREN, Nairobi

AFREPREN, 2002. AFREPREN Occasional Paper No. 10: Renewable Energy Technologies in Africa. An Energy Training Course Handbook. Nairobi: AFREPREN/FWD

AFREPREN, 2004. African Energy Data and Terminologies Handbook Year 2003 - 2004. AFREPREN, Nairobi.

AFREPREN/FWD Occasional Paper No. 28. *"Renewables in Eastern and Horn of Africa:* Ethiopian Country Report*".* A Publication of AFREPREN/FWD and HBF – HA Initiative by Workeneh Gashie, AFREPREN/FWD, Nairobi, 2007

AFREPREN/FWD Occasional Paper No. 29. *"Renewables in Eastern and Horn of Africa:* Kenyan Country Report*".* A Publication of AFREPREN/FWD and HBF – HA Initiative by Stephen Karekezi, John Kimani and Oscar Onguru, AFREPREN/FWD, Nairobi, 2007.

AFREPREN/FWD, (2001b). Internal Surveys Carried Out in Various Suburbs of Nairobi. African Energy Policy Research Network (AFREPREN/FWD). Nairobi, Kenya.

AFREPREN/FWD, 2003a. AFREPREN Energy Data Handbook. AFREPREN Secretariat, Nairobi. Kenya.

AFREPREN/FWD, 2003b. Draft Proposal, The Regional Launching Workshop for Eastern Africa. Renewable Energy and Energy Efficiency Initiative (REEEP). AFREPREN Secretariat, Nairobi. Kenya.

AFREPREN/FWD, 2006. Cogen for Africa FSP (Full Size Project)Brief Final Report. AFREPREN/FWD, Nairobi.

Africa Gas Initiative (AGI). 2001. Africa Gas Initiative: Main Report February 2001. http://www.ogel.org/article.asp?key=629

African Development Bank Group , 2002, The African development Fund approves a $1 million grant to finance the renewable energy study in The Gambia, accessed October 31, 2002. http://www.afdb.org/knowledge/pressreleases2001/adf_59_2002e.htm.

African Energy. 2007. Magazine November Issue. Online. Available at: www.desertec.org/downloads/articles/2007-12-14_african_energy_magazine.pdf

African Press International (API). 2008. Ethiopia Reveals Plans to Produce 130 million litres of Ethanol Annually. http://africanpress.wordpress.com/2008/08/03/ethiopia-reveals-plans-to-produce-130-million-litres-of-ethanol-annually/

African Technology Development Forum (ATDF). 2005 ATDF Journal Vol 2 Issue 2- Energy and Africa.

ANBA, 2007. Brazil Arab News Agency: Sao Paulo, Brazil: www.anba.com.br

Arnold,M.,Kohlin, G.,Persson,R.,Shepherd, G,2003.Fuelwood revisited: What has changed in the last Decade? CIFOR Occasional paper NO.39. Jakarta:Center for International Forestty Research(CIFOR)

Asamoah.J. 2001. Replacing coal with cleaner natural gas in southern Africa- the equity dimension. (AFREPREN/FWD

Ashden Awards (2005) ITDG Kenya – 'pico-hydro' power bringing electricity to rural communities on the slopes of Mount Kenya, London, Ashden Awards

Baraka, M.L. 1991. The Kenyan Experience with Ethanol for Transportation in ATAS Bulletin on Energy Systems, Environment and Development – A Reader. New York: United Nations.

Barker, D. 2008. Shop West Coast. http://shopwestcoast.blogspot.com/2008_10_01_archive.html

Barnes D.F., Openshaw K., Smith K.R. and van der Plas R., 1994. What Makes People Cook with Improved Biomass Stoves? A Comparative International Review of Stove Programs. Washington DC, USA: The World Bank

Bartle, A. (Ed). 2008. "World Hydro Potential and Development in 2008" *The International Journal on Hydropower & Dams: World Atlas and Industry Guide*. Aqua-Media International, Surrey.

Batidzirai, B., 2007. Outlook on Biofuels in the Southern African development Community. June 2007. A paper produced for the UNIDO Regional Biofuels Assessment Programme.

BCSE, 2003. Geothermal Market Assessment Report, "The Eastern Africa Market Assessment Acceleration" Geothermal Conference Agenda. Business Council for Sustainable Energy (BCSE), Washington, DC.

Beck, F. and Martinot, E. 2004. Renewable energy policies and barriers. In: Cleveland, C. (Ed). Encyclopedia of Energy, (ed). Academic press/Elsevier Science, San Diego.

Belguedj, M. 2006. Gas to Power – Africa. Hoersholm.

Berg C., 2001. World Ethanol Production 2001, http://www.fo-licht.com/,

Bikash Pandey, 2002 "Dams and Civil Society in Nepal: Major Concerns," World Commission on Dams.

Biodiesel S.A. 2003. Media Clippings - http://www.biodieselsa.co.za/media-clippings.htm

Biofuels Digest. Zimbabwe to Revive Sugar Ethanol Industry in Emergency Move to Offset Energy Price Increases. 3rd March 2008. http://www.biofuelsdigest.com/blog2/2008/03/03/zimbabwe-to-revive-sugar-ethanol-industry-in-emergency-move-to-offset-energy-price-increases/

Biomass4Africa. 2008. Nigeria Plans Ethanol Project. http://www.biomass4africa.net/news/viewnews.php?ID=387

Biopact Team. 2007. Caltech Ventures to Produce Ethanol from Cassava in Ghana. ModernGhana.com. http://www.modernghana.com/GhanaHome/NewsArchive/news_details.asp?menu_id=1&id=VFZSUk1FMXFVVFU9

Bob Harries Engineering Ltd (BHEL). 2005. Kijito Windpumps Information Booklet. BHEL, Thika

Borchers, M., Qase, N. Gaunt, T., Mavhungu, J., Winkler, H., Afrane-Okese, Y. and Thom, C. 2001. National Electrification Programme Evaluation: Summary Report. Evaluation commissioned by the Department of Minerals and Energy and the Development Bank of Southern Africa. Cape Town, Energy and Development Research Centre, University of Cape Town.

BP Energy Statistical Review 2007. Available on:http://www.bp.com

BP Energy Statistical Review 2008. Available on:http://www.bp.com

BP, Energy Statistical Review 2006. Available on:http://www.bp.com

C. Azar and E.D. Larson, "Bioenergy and Land Use Competition in Northeast Brazil," Energy for Sustainable Development, IV(3), 2000

Carter (2001) The Politics of the Environment: Ideas, Activism, Policy. Cambridge, Cambridge University Press.

CFA (Commission for Africa), 2004. Africa for a strong and Prosperous Africa. CFA website: http://213.255.140.43/

CIA World Factsheet. Available at: https://www.cia.gov/

Cloin, J (1998) PV on Thatch: A search for opportunities of sustainable implementation of PV in Manicaland, Zimbabwe, Einhoven University of Technology, The Netherland

Coelho S.T., and Walter A.S., 2003. Indigenous Technologies for Sustainable Development. (Chapter 4). Brazil – Country study for sustainable development. Study under development funded by the IAEA. Chairman: J. Goldemberg, 2003.

Connoly, K., 2009. German blue chip firms throw weight behind North African solar project. Guardian News and Media Limited 2009. Website: http://www.guardian.co.uk/environment/2009/jun/16/solar-power-europe-africa (accessed on 30th July 2009).

D.L. Kgathi, et al, 1997. Biomass policy in Africa. AFREPREN, Nairobi and ZED Books , London.

Davidson O & Sokona Y (2002) "Think Bigger, Act faster" EDRC/ENDA, University of Cape Town, South Africa

Davidson, O. and Mwakasonda, S. 2004. Electricity Access Southern Africa sub-regional study: South Africa and Zimbabwe. Global Network on Energy for Sustainable Development. Riso, Denmark.

Davidson, O., 2007. The Oil and Gas Sector: Energy Security Sustainability In Africa. Commissioned Paper for the Forum for Energy Ministers Conference on Energy Sustainability and Security. Maputo.

Davies, M., Eberhard, A. and Clark, A. 2003. Power sector reform in Africa: Assessing the impact on poor people and influencing policy decisions. Graduate School of Business, Cape Town.

Davis, 2007. Monthly Update: Global Biofuel Trends". Available at: http://earthtrends.wri.org/updates/node/180

De Gouvello, C., Dayo, F.B. and Thioye, M. 2008. Low-Carbon Energy Projects for Development in Sub-Saharan Africa - Unveiling the Potential, Addressing the Barriers. The World Bank, Washington, DC..

Deepchand K. 2001. Occasional Paper No. 2: Bagasse-Based Cogeneration in Mauritius – A Model for Eastern and Southern Africa. African Energy Policy Research Network (AFREPREN/FWD), Nairobi

Deepchand K., 2002. Promoting equity in large scale renewable energy development: the case of Mauritius. Energy Policy, 2002. Elselvier Science, Oxford. U.K.

Deepchand, K., 2003. Opportunities for Cogeneration in a Reforming African Power Sector. : AFREPREN Occasional Paper No. 21. AFREPREN, Nairobi.15th December 2003. Nairobi, Kenya.

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ). 2004. Conference Report. Federal Ministry for Economic Cooperation and Development (BMZ) and Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). http://www.renewables2004.de/pdf/conference_report.pdf

DLR, 2005. Concentrating Solar Power in the Mediterranean Region. Online. Available at: http://www.dlr.de/tt/desktopdefault.aspx/tabid-2885/4422_read-6573/

DME [Department of Minerals and Energy]. 2004. Capacity building in Energy Efficiency and Renewable Energy. Report no. 2. 3. 4. – 19. Economic and Financial Calculations and Modelling for the Renewable Energy Strategy Formulation. Department of Minerals and Energy, Pretoria.

DME [Department of Minerals and Energy]. 2005. Capacity building in Energy Efficiency and Renewable Energy: Renewable Energy Monitoring of Targets. Report No. – 2.3.4 – D. Department of Minerals and Energy, Pretoria.
DME 2008 [Department of Minerals and Energy] Electricity Regulation Act, 2006. Promulgation of new regulations.

Du Preez, G.2005. South Africa Sows Crops to Energy seeds. Engineering News 5 December,2005. Sasol Synfuels Marketing.

Dube, I. (2001). Energy Services for the Urban Poor in Zimbabwe: Short Term Study Report. AFREPREN, Nairobi.

Dutkiewicz, R.K. and Gielink, M.L. 1991, Energy Profile - Malawi. Pretoria: National Energy Commission.

Earthlife Africa/SECCP Report, 2003. Available at: www.gefweb.org/Partners/partners-Nongovernmental_Organ/documents/NGO_forum_report_Oct.26.06.pdf

Eberhard, A A and Williams, A T (Eds). 1988. Renewable energy resources and technology development in Southern Africa, Elan Press, Cape Town

Economic Commission of West African States (ECOWAS/UMEOA),2005. White Paper for a Regional Energy Policy. ECOWAS/UMEOA, Abuja.

EcoSystems, 2002. Solar and Electric Vehicles. http://www/ecotopia.com/st/solarcar.htm

Edwards, R., Szekeres, S., Neuwahl, F., and Mahieu, V. 2008. Biofuels in the European Context: Facts and Uncertainties, Joint Research Centre, European Commission. ec.europa.eu/dgs/jrc/downloads/jrc_biofuels_report.pdf

EECG, 2004. Energy use, energy supply, sector reform and the poor in Botswana. Energy, Environment, Computer and Geophysical Applications (EECG), Botswana.

EEOA. - Indicateurs de performance, 2003.

Ekouevi, 2001. 'An Overview of Biomass Energy Issues in sub-Saharan Africa', Proceedings of the African High-Level Regional Meeting on Energy and Sustainable Development for the Ninth Session on the Commission on Sustainable Development. Denmark: UNEP Collaborating Centre on Energy and Development.

Electricity Regulatory Authority (ERA), 2008. Notice of Intended Application for a Licence for Generation and Sale of Electricity. Kampala.

Electricity Regulatory Authority (ERA). 2008. Feed - in -Tariffs for Hydropower Systems and Bagasse Up to a Maximum Capacity of Twenty Megawatts (20MW). (http://www.era.or.ug/Feed_In_Tariffs.php)

El-Khayat, M. M., 2008. Renewable Energies in the North Africa Region: Potentials, Markets And Strategies, unpublished

Energem Resources Inc, 2007. Profile of Business: Kisumu Ethanol Manufacturing Plant. Toronto, Canada. http://www.energem.com/energem_logistics_industrial.html

Energy and Water Utilities Regulatory Authority (EWURA). 2008. Natural Gas. http://www.ewura.go.tz/naturalgas.html

Energy Daily. 2008. Ghana to Produce Ethanol for Export to Sweden. Energy Daily. http://www.energy-daily.com/reports/Ghana_to_produce_ethanol_for_export_to_Sweden_999.html

Energy in Africa. 2007. http://www.energyinafrica.net/news/oil_gas/622455.htm

Energy Information Administration (EIA) 2005. The Southern African Development Community. http://www.eia.doe.gov/emeu/cabs/sadc.html

Energy Information Administration (EIA). 2006. World Electricity Installed Capacity by Type, January 1, 2004. www.eia.doe.gov/pub/international/iea2004/table64.xls

Energy Information Administration (EIA). 2008. Country Energy Profiles. http://tonto.eia.doe.gov/country/

Energy Information Administration (EIA) 2008. The Crude Oil and Total Petroleum Imports Top 15 Countries. http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/company_level_imports/current/import.html

Energy Information Administration (EIA). 2009. World Natural Gas Reserves by Geographic Region as of January 1, 2009. http://www.eia.doe.gov/oiaf/ieo/nat_gas.html

Engorait, P., 2004. HBF Cogeneration Study: Uganda. AFREPREN, Nairobi.

Engorait, S. P., 2003: Meeting the Challenges of Increased Private Sector Investments and Increased Access, Updated 3rd Draft Research Report, Energy Sector Reform Theme Group. AFREPREN, Nairobi, Kenya.

ESDA, 2003. Policy Briefing NO.5: Energy for Sustainable Development Africa.

ESDA, 2005. National Charcoal Survey: Exploring the potential for a sustainable charcoal industry in Kenya. Nairobi, Kenya: Energy for Sustainable Development Africa (ESDA)

ESDA, undated. 'Biomass Conversion Technologies'. http://www.esda.energyprojects.net/links/biomass.htm, Nairobi, Kenya: Energy for Sustainable Development Africa (ESDA).

ESI-Africa, 2007. SMALL HYDROPOWER DEVELOPMENT IN AFRICA. By Wim Jonker Klunne, Renewable energy and climate change expert http://renewables4africa.net/klunne/publications/ESI2007_2_SMALL_HYDROPWER_PG36-37_Jonker_Klunne.pdf

ESI-Africa, 2008. Kampala to generate electricity from waste. http://www.esi-africa.com/node/8903

ESKOM, 2006. About us. http://www.eskom.co.za

Ethanol Producer Magazine, 2005. 'Kenyan Ethanol Plant nears Phase One goal capacity'. http://ethanol-producer.com/article.jsp?article_id=398

European Commission, 2007. EU will demand sustainable biofuel production, mongabay.com. May 24, 2007. http://news.mongabay.com/2007/0524-eu.html

Ezzati, M. and Kammen, D.M., 2002. Household energy, indoor air pollution and health in developing countries: Knowledge Base for effective interventions. Annual review of energy and the environment Vol. 27.

Fagbenle, R., 2001. Solar Photovoltaics Technologies in Africa. In: Occasional Paper Number 10. African Energy Data and Terminology Handbook. Nairobi: AFREPREN/FWD

FAO, 1997. A system approach to biogas technology. http://www.fao.org/sd/Egdirect/Egre0022.htm FAO, Rome

FAO, 2000. Environment and Natural Resource Working Paper: Rural Energy Supply. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO)

FAO, 2003. Forest energy data, http://www.fao.org/forestry/FOP/FOPH/ENERGY/databa-e.stm, Rome, Italy: Food and Agriculture Organization of the United Nations (FAO)

FAO, 2003. Sustainable wood energy systems.

FAO/ADB, 1995 Future Energy Requirements for Africa's Agriculture, FAO, Rome

FAO/OECF. 2007. Agricultural Outlook 2007- 2016. http://www.agri-outlook.org/document/12/0,2340,en_36774715_36775671_37040780_1_1_1_1,00.html

Federal Ministry for Economic Cooperation and Development, undated. Note to CODEV: Hydropower Outlook for Africa. German EU Presidency-Commission: Africa-Europe Energy Cooperation.

Food and Agricultural organization (FAO), 2004. WWW.fao.org/WAICENT/FAOINFO/ECONOMICS/ESS/compendium_2003/default.asp.

Forum for Agricultural Research in Africa (FARA), 2008. Bioenergy value chain research and development

Fridleifsson, I. B., 2001, "Geothermal Energy: Experience of Iceland and Opportunities for Africa". Article Published in the Renewable Energy Technologies: Potential for Africa Booklet, United

GEF, 2007. Climate Change Focal Area Strategy and Strategic Programming for GEF-4. http://www.gefweb.org/uploadedFiles/Policies/Focal_Area_Strategies/GEF_4_strategy_CC_Oct_2007.pdf

GEF, 2008, Global Environment Facility (GEF). 2008. Transfer of Environmentally Sound Technologies: The GEF Experience. GEF: Washington, DC.

GENI, 2007.Avaialble on: http://www.geni.org/globalenergy/library/energytrends/electrification-ratios/index.shtml

Ghiorgis, W. 2002. Renewables and Energy for Rural Development Theme Group: Country Data and Statistics-Ethiopia. African Energy Policy Research Network (AFREPREN/FWD), Nairobi.

Global Energy Collaborators (GEC), (undated). India concentrates maximum on Rural Up-liftment through Biomass Gasifiers and Renewable Energy Systems India geared to increase Biomass Gasifier use by 88 folds in another 7 to 8 years. http://www.biomassgasifier.com/iconsmax.htm

Global Environment Facility (GEF). 2007. African Rift Geothermal Development Facility (ARGeo). http://www.gefonline.org/projectDetailsSQL.cfm?projID=2119

Global Environmental Facility (GEF). 2004. Annual Performance Report. http://www.gefweb.org/monitoringandevaluation/MEPublications/documents/signposts-apr_2004-english.pdf

Global Facilitation Partnership for transportation and trade (The United Nation Trade Facilitator Network) (http://www.see-stats.org/methdology.htm) accessed March 2007 GTZ, 1999

Goldemberg J., 2003. The Case for Energy Renewables, Thematic Background Paper for the Renewable 2004 Conference (under publication)

Government of Sudan. 2005. Sudan Renewable Energy Masterplan Study. Government of Sudan, Khartoum

Greening the Tea Industry in East Africa (GTIEA). 2008. http://greeningtea.unep.org/

Grosbois A., 2008. Hike in world food prices sparks deadly riots in Africa. Mail & Guardian Online. Dakar Senegal. http://www.mg.co.za/article/2008-04-06-hike-in-world-food-prices-sparks-deadly-riots-africa

GTZ, 2007. Successful Energy Policy Interventions in Africa. GTZ, Germany

Gwang'ombe, F., 2004. Renewables Energy Technologies in Tanzania: Biomass Based Cogeneration. African Energy Policy Research Network (AFREPREN/FWD), Nairobi.

Hall D.O. and Mao, Y.S., 1994. Biomass and Coal in Africa. London, United Kingdom: Zed Books Ltd

Hall D.O. and Rosillo-Calle, 1998. 'Evaluating Environmental Effects and Carbon Sources and Sinks Resulting from Biomass Production and Use in Developing Countries', Biomass: Data analysis and trends (293-314). Paris, France: OECD/IEA

Hankins, M., 2008. Taking A Fresh Look: Why Africa Is Re-Examining Renewables. Renewable Energy World. Peterborough. http://www.renewableenergyworld.com/rea/magazine/story?id=53846

Hausmann, R., 2001. Prisoners of Geography in "Foreign Policy". http://www.kari.org/Tech_Notes/tecNote10.pdf]. Accessed online February 2007

Hazell, P.B.R. and Pachauri, R. K. (Eds). 2006. Bioenergy and Agriculture: Promises and Challenges. International Food Policy Research Institute (IFPRI).

Heedge and Sonder, 2007. Domestic biogas in Africa; a first assessment of the potential and need: Biogas practice Team – SNV, The Netherlands.

Higgo R., 2007. 60th AMEU Convention. Eskom's Pilot National Cogeneration Project.

http://www.fao.org/forestry/foris/webview/forestry2/index.jsp?siteId=3741&langId=1&sitetreeId=11477 Rome, Italy: Food and Agriculture Organization of the United Nations (FAO)

http://www.flipkart.com/world-development-report-1986-bank/0195205189-dqw3fpmudd

http://www.gastechnology.org/webroot/downloads/en/IEA/BiomassGasificationCountryReportsOct2004.pdf http://www.who.int/indoorair/publications/impact/en.

http://www.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/p_SellingSolar_PartOne_Ch2/$FILE/PartOne_Ch2.pdf

Hydro4africa, 2008. Hydro power 4 Africa. http://hydro4africa.net/

ICTSD, 2006. Available at: www.ictsd.org/

IEA, 1998. World Energy Outlook, 1998. Paris, France: International Energy Agency (IEA)

IEA, 2000. World Energy Outlook, 2000. Paris, France: International Energy Agency (IEA)

IEA, 2002a. Energy Balances of non-OECD countries 1999-2000. Paris, France: International Energy Agency (IEA)

IEA, 2002b. World Energy Outlook, 2002. Paris, France: International Energy Agency (IEA)

IEA, 2003. Energy Balances and Statistics for Non-OECD Countries 2000-2001. Paris: International Energy Agency (IEA)

IEA, 2004a. Energy Balances of non-OECD countries 2001-2002. Paris, France: International Energy Agency (IEA)

IEA, 2004b. Energy Balances of OECD countries 2001-2002. Paris, France: International Energy Agency (IEA)

IEA, 2005. World Energy Outlook, 2004. Paris, France: International Energy Agency

IEA, 2006. Energy Balances for Non-OECD Countries. International Energy Agency. Paris, France.

IEA, 2006. World Energy Outlook 2006. International Energy Agency. Paris, France.

IEA, 2008. http://recabs.iea-retd.org/

IEA,2007. World Energy Statistics. Available at: http://www.iea.org/Textbase/stats/index.asp

IEA. 2004. Biofuels for Transport. An International Perspective. OECD. Paris.

IEI, 2001. Energy for Sustainable Development- Volume 5, Nos.1. Bangalore, India: International Energy Initiative (IEI)

IMCSA (International Marketing Council of South Africa). 2005. Ethanol Africa: clean maize fuel http://www.southafrica.info/ess_info/sa_glance/sustainable/ethanol-120905.htm

International Energy Agency (IEA). 2003. Energy Balances for Non-OECD Countries. International Energy Agency. Paris, France.

International Energy Agency (IEA). 2006. Action Plan for Renewable Energy Promotion in Mali. www.iea.org/textbase/pamsdb/detailaspx?mode
International Energy Agency (IEA). 2008. World Energy Outlook 2008. IEA, Paris.

International Finance Corporation (IFC). Undated. Case Studies 2: Photovoltaic Market Transformation Initiative. http://www.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/p_SellingSolar_PartTwo_CaseStudies2/$FILE/PartTwo_CaseStudies2.pdf

International Hydropower Association (IHA), International Commission on Large Dams (ICOLD), International Energy Agency (IEA), and, the Canadian Hydropower Association (CHA). 2000. Hydropower and the World's Energy Future: The Role of Hydropower in Bringing Clean, Renewable Energy to the World. http://www.ieahydro.org/reports/Hydrofut.pdf

International Hydropower Association. 2003. The Role of Hydropower in Sustainable Development. International Hydropower Association, Surrey.

International Monetary Fund (IMF). 2008. Africa's Power Supply Crisis: Unraveling the Paradoxes. IMF Survey online - http://www.imf.org/external/pubs/ft/survey/so/2008/CAR052208C.htm

International Small-hydro Atlas. Undated. http://www.smallhydro.com/index.cfm?fuseaction=welcome.home

IPCC (2003) Intergovernmental Panel for Climate Change. http://www.ipcc.gov.hk/report/2003/en/toc.htm

Jacobs, D. and Kiene, A., 2009. Renewable Energy Policies for Sustainable African Development. World Future Council.

Jarvilehto, 2009 Jarvilehto. P, 2009 Personal Communication

Johansson, T. B., Goldemberg, J. (Eds.), 2002. Energy for Sustainable Development – A Policy Agenda. International Institute for Industrial Environmental Economics (IIIEE) - Sweden, International Energy Initiative (IEI) – South Africa and United Nations Development Programme (UNDP).

Joint Implementation Network. 2007. Durban CDM Project will Produce Electricity from Landfill Gases http://www.jiqweb.org/durban.htm - Accessed October 2009.

Kamese G., 2004. HBF Geothermal Study: Uganda. AFREPREN, Nairobi.

Kamfor, 2002. Study on Kenya's Energy Demand, Supply and Policy Strategy for Households, Small-scale Industries and

Service Establishment. Kamfor Company Limited. Nairobi, Kenya.

Kammen, D. M. (1995a) "Cookstoves for the developing world," Scientific American, 273, 72 - 75.

Kammen, D. M. (1995b) "From energy efficiency to social utility: Improved cookstoves and the Small is Beautiful model of development," in Energy as an Instrument for Socio-Economic Development, Goldemberg, J. and Johansson, T. B. (eds.) (United Nations Development Programme: New York), 50 - 62.

Kammen, D., Bailis, R., and Herzog, A., 2001. Clean Energy for Development and Economic Growth: Biomass and Other Renewable Energy Options to Meet Energy and Development Needs in Poor Nations. University of California, Berkley

Kantai P., 2002. 'Hot and Dirty', EcoForum Vol. 24. No. 4, Hot and Dirty: Inside Kenya's 23 billion shilling charcoal industry. Nairobi: Environment Liaison Centre International

Karekezi and Kithyoma, 2005. Sustainable Energy in Africa: Cogeneration and Geothermal in the East and Horn of Africa – Status and Potential. AFREPREN/FWD and HBF, 2005

Karekezi and Ranja T. 1997.Renewables Energy Technologies in Africa. Zed Books Ltd, London.

Karekezi et al, 2004. The potential contribution of non electrical Renewable Energy Technologies (RETs) in poverty alleviation in Eastern Africa: The case of wind pumps, ram pumps and treadle pumps in Kenya and Tanzania, Nairobi , Energy, Environment and Development network for Africa (AFREPREN/FWD)

Karekezi S, Lata K and Coelho S T, 2004. Traditional Biomass Energy - *Improving Its Use and Moving to Modern Energy Use,* Thematic Background Paper for the 2004 International Conference for Renewable Energies. Bonn, Germany: Secretariat for the International Conference for Renewable Energies

Karekezi S. and Kimani J., 2002. "Impact of Power Sector Reform on the Poor" in the Energy Policy Journal – Special Issue, Vol 30, No. 11-12, Elsevier Science Limited, Oxford.

Karekezi S. and Kithyoma W., 2002. "Renewable Energy Strategies for Rural Africa: is a PV-led renewable energy strategy the right approach for providing modern energy to the rural poor of Sub-Saharan Africa?" in the Energy Policy Journal – Special Issue, Vol 30, No. 11-12 (1071-1086), Elsevier Science Limited, Oxford.

Karekezi S. and Majoro L., 2002. "Improving Modern Energy Services for Africa's Urban Poor" in the Energy Policy Journal – Special Issue, Vol 30, No. 11-12(1015-1028), Elsevier Science Limited, Oxford.

Karekezi S., et al 2003b (Unpublished). Energy Services for the Poor in East and Horn of Africa – Sub-Regional "Energy Access Study of East Africa. Prepared for the Energy Access Working Group, Global Network for Sustainable Development. African Energy Policy Research Network (AFREPREN). Nairobi, Kenya.

Karekezi S., et al, (Eds.) 2002. "Africa: Improving modern energy services for the poor" in Energy Policy Journal – Special Issue, Vol 30, No. 11-12, Elsevier Science Limited, Oxford.

Karekezi, et al, 2003a. Overcoming the Barriers to the Use of Renewable Energy and Energy Efficiency Systems in the Reforming Power Sector of Eastern Africa - Background Paper for East African Renewable Energy and Energy Efficiency Partnership Regional Consultation Workshop. AFREPREN, Nairobi.

Karekezi, et al, 2007. The Promise of Biofuels in Africa - Status, Challenges and Opportunities. The First High Level African Union/Gov of Brazil/UNIDO Bio-Fuels Seminar in Africa. Nairobi.

Karekezi, S and Karottki, R., 1989. A Contribution to the Draft Paper on the Role of New & Renewable Sources of Energy from the Perspective of the Environmental Problems Associated With the Current Patterns of Energy Use and Consumption, United Nations Environmental Programme, Nairobi, Kenya, July, Pp. 13,15

Karekezi, S. and Kithyoma, W., 2007. Bioenergy and the Poor. IFPRI

Karekezi, S. and Sihag, A.R. 2004. Energy Access Theme Results: Synthesis/Compilation Report. Global Network on Energy and Sustainable Development, Risoe

Karekezi, S., Kimani, J., Mutiga, A. and Amenya, S., 2003c. Energy Services for the Poor In Eastern Africa: Sub-Regional "Energy Access" Study of East Africa. Paper prepared for the Global Network on Energy for Sustainable Development. AFREPREN/FWD, Nairobi.

Kayo, D. 2001. The Power Sector in Zimbabwe: Increasing Electrification and Strengthening Local Participation

Kebede B., 2002. Energy Services for the Urban Poor Theme Group: Country Data and Statistics Compilation-Ethiopia. AFREPREN, Nairobi.

Kellner and Nhete,2007. Biogass for a better life: An African Inititative: https://www.biogasafrica.org/SiteCollectionDocuments

KenGen 2003: Various Papers presented during the 2nd KENGEN Geothermal Conference: Sustainability of Geothermal Energy and Strategies for its Development in the East African Rift Valley.

KenGen 2006. Annual report,2006, Nairobi, Kenya Electricity Generation Company(KenGen)

KENGO, 1991. How to make and use the KCJ, KENGO/Regional wood energy programme for Africa (RWEPA), Nairobi.

Khennas,S., Anderson, T., Doig, A. and Rees, D., 1999. Rural Energy Services: A hand book for sustainable Energy development. Intermediate technology publications, London.

Kingdom of Lesotho, Undated. Launch of the Lesotho Utilities Project: Remarks by Minister of Natural Resources. www.lesotho.gov.Is/articles/Speech

Kinyanjui, M. and Minae, S. (1982) "Extension/training programme in renewable energy technology: an implementation strategy," Kenya Renewable Energy Development Project (KREDP: Nairobi, Kenya).

Kiva (2008). Large Scale Hydropower, Renewable Energy Adaptation & Climate Change & Energy Security in East & Horn of Africa: A paper presented at HBF Regional Workshop on 21st November, 2008

Knecht, K. 2004. Wind Regimes of Africa Comparative Evaluation of Wind Data from Selected Countries. InWEnt, Berlin.

Kojima, et al 2007. Considering Trade Policies for Liquid Biofuels. The International Bank for Reconstruction and Development/The World Bank. Washing DC. Website: http://esmap.org/filez/pubs/9282007123516_Consideringtradeforliquidbiofuels.pdf (accessed on 23rd July 2009).

KPLC (2003).Annual report, 2002-2003, Nairobi, Kenya Power and Lighting Company Co. Ltd (KPLC).

KPLC (2008).Annual report, 2007-2008, Nairobi, Kenya Power and Lighting Company Co. Ltd (KPLC).

KPLC, 2001/2002. Annual Reports and Accounts, 2001/2002. Kenya Power and Lighting Company. Nairobi, Kenya.

Krewitt , W., Simon, S. and Pregger, T. 2008. Renewable Energy Deployment Potentials in Large Economies. German Aerospace Center (DLR), Stuttgart. http://www.ren21.net/pdf/Renewable_energy_deployment_potentials_in_large_economies.pdf

Kruschen, G., 2008. Plotting a future for renewable energy in South Africa. http://cms.privatelabel.co.za/pls/cms/iac.page?p_t1=2851&p_t2=0&p_t3=0&p_t4=0&p_dynamic=YP&p_content_id=897480&p_site_id=125

Kuria, D. 2002. Evolution of biogas technology in South Sudan; current and future challenges http://www.mekarn.org/procbiod/kuria.htm

Kwant, 2004., Status of Biomass Gasification in countries participating in the IEA Bioenergy Task 33 Biomass Gasification and EU Gasnet; Available at:

Kyalo, J.M., 1992. 'Firm's Efforts Praised', Daily Nation, Nairobi. Larson E.D. and Kartha S., 2000. 'Expanding Roles for Modernized Biomass Energy', *Energy for Sustainable Development, Vol. 4 No. 3*. Bangalore, India: International Energy Initiative

Lindlein, P., 2007. Bioenergy for Development in Africa. International Consulting Economists & Engineers. Frankfurt

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Mapako, M. and A. Mbewe(eds) 2002. Renewable and energy for rural development in sub-Saharan Africa. AFREPREN, Nairobi and ZED Books , London.

Mangwengwende, S Wamukonya, N., 2007. Challenges and way forward for the Power Sector in Africa.

Mapako, M. Renewables and Energy for Rural Development in Zimbabwe, Short Term Study Report, AFREPREN/FWD, Nairobi

Mariita, N., 2002. The Socio-Economic and Environmental Impact of Geothermal Energy on the Rural Poor in Kenya. AFREPREN Occasional Paper Number 12. AFREPREN/FED, Nairobi, Kenya.

Martinot, E., 2004. Global Renewable Energy Markets and Policies. University of Maryland, College Park. New Academy Review special edition on climate change, Spring 2004

Martinot, E., 2007. Status of renewables in Africa. Tsinghua, China

Masera, O.R., Saatkamp, B. D., and Kammen, D. M., 2000. Energy and health transactions in development: fuel use, stove technology, and morbidity in Jaracuaro, Mexico. Energy for sustainable Development. 4 no.2 (7-16). International Energy Initiate, India.

Matinga, M. 2004. Supply and demand side benefits and costs of low cost urban electrification in Malawi: A case of Mbayani Township. MSc thesis. Energy Research Centre, University of Cape Town.

Mauritius Sugar Industry Research Institute (MSIRI), 2006. A presentation on strategy towards enhanced bio-energy production from cane biomass. LJC Autrey, KTKF Kong Win Chang and AF Lau

Mbuthi, P. and Yuko, D. (2005). AFREPREN Occasional Paper 26: Renewables in Kenya's Electricity Industry: A review of Geothermal and Cogeneration Technologies, Nairobi, Energy, Environment and Development Network for Africa (AFRPEREN/FWD)

Mbuthi, P., 2004. HBF Geothermal Study: Kenya. AFREPREN, Nairobi.

Ministry of Energy (MoE) and Ministry for Foreign Affairs (MFA). 2005. Intervention Planning Mission for Energy Sector in Kenya.

Ministry of Energy (MoE), 2002. The National Energy Policy 2002. http://www.ecs.co.sz/energy/.htm

Ministry of Energy (MoE), 2004. Draft National Energy Policy. MoE, Nairobi

Ministry of Energy and Mineral Development (MEMD), 2002. The Energy Policy for Uganda, MEMD, Kampala

Ministry of Energy and Minerals (MEM), 2003. The National Energy Policy. MEM, Dar es Salaam

Ministry of Energy and Mines (MEM), 1997. Energy Policies and Strategies. MEM, Eritrea.

Ministry of Energy and Power (MEP), 2004. The Energy Policy for Sierra Leone. MEP, Freetown

Ministry of Energy and Power Development (MEPD). Draft National Energy Policy. MEPD, Harare

Ministry of Energy and Water Development (MEWD), 1994. National Energy Policy, MEWD, Lusaka

Ministry of Infrastructure (MoI), 2004. Energy Policy for Rwanda. MoI, Kigali

Ministry of Mineral Resources and Water Affairs (MMRWA), 1996. Botswana Energy Masterplan – Final Phase. MMRWA, Gaborone

Ministry of Mines and Energy (MME), 1998. White Paper on Energy Policy. MME, Windhoek.

Minstry of Energy. 2008. Feed-In-Tariffs Policy on Wind, Biomass and Small Hydro Resource Generated Electricity. MoE, Nairobi.

MOE, 2006. Geothermal Potential in Kenya. Ministry of Energy MOE, Nairobi, Kenya. http://www.energy.go.ke/geothermal.php - accessed on 22 January 2007

MOEPD (Ministry of Energy and Power Development). 2007. The National Biodiesel Feedstock Production Programme. Zimbabwe. http://www.energy.gov.zw/renewableenergy/Biodiesel.htm

Mulugetta, Y Nhete, T and Jackson, T (2000) 'Photovoltaics in Zimbabwe: Lessons from the GEF Solar Project' in Energy Policy Volume 28, Elsevier Science Ltd, London.

Nation Media Group (NMG), 2008. Power suppliers eye thermal sources to bridge deficit. Business Daily Africa, 1st July 2008. http://www.bdafrica.com/index.php?option=com_content&task=view&id=6723&Itemid=5810

National Electricity Regulator (NER). 2001 Electricity Supply Statistics for South Africa 2001, National Electricity Regulator, Pretoria

Natural Gas Liquid Extraction in Angola http://www.mbendi.co.za/indy/oilg/gas_/af/an/p0005.htm;

New Partnership for Africa's Development (NEPAD). 2004. Annual Report 2003/2004. www.nepad.org/2005/files/documents/165.pdf

Niyimbona, P. 2005. The Challenges of Operationalizing Power Pools in Africa. United Nations Economic Commission for Africa, UNDESA Seminar on Electricity Interconnection. Cairo, Egypt.

Nyoka, B. I. 2003. State of Forest and Tree Genetic Resources in Dry Zone Southern Africa Development Community Countries. Forest Genetic Resources Working Papers. Working Paper FGR/41E. Forestry Department. FAO, Rome, Italy

Obulutsa, G. 2008a. Sekab Plans 100 mln litre Tanzania Ethanol Plant. Thomson Reuters. http://uk.reuters.com/article/idUKLH54668720080917

Obulutsa, G. 2008b. UK Firm Eyes Ethanol Plant in Tanzania. Thomson Reuters. http://www.planetark.com/dailynewsstory.cfm/newsid/50310/story.htm

Oilprice.net. 2008. http://www.oil-price.net/dashboard.php?lang=enq

Ondari, J., 2009. Renewable Energy Spurs investor interest, Daily Nation, Monday, 16th March 2009, Online: http://www.nation.co.ke/business/news/-/1006/538268/-/view/printVersion/-/13tgqkf/-/index.html

Openshaw, K. 1982. " The development of improved cooking stoves for urban and rural households in Kenya," Report of the Beijer Institute (Beijer Institute/Royal Swedish Academy of Sciences: Stockholm, Sweden).

Oserian. 2008. Kenya Special: Geothermal Well is Crown Jewel of Oserian. http://www.boschinveka.com/files/Media,%20in%20de%20-%20Geothermal%20well.pdf

Pedley, J. and Hertzog, H., 2008. Financing strategies for growth in the renewable energy industry in South Africa. Graduate School of Business, University of Cape Town. Cape Town. http://www.erc.uct.ac.za/jesa/volume17/17-4jesa-fosterpedley.pdf

People's Daily Online, 2008. China's domestic-made biomass gasification power system. http://english.people.com.cn/90001/90781/6543969.html

Policy Journal – Special Issue, Vol 30, No. 11-12, Elsevier Science Limited, Oxford.

Prasad, G. 2006. Energy sector reform and the poor: energy use and supply, a four country study: Botswana, Ghana, Honduras and Senegal. ESMAP Technical Paper 95. World Bank, Washington.

Prasad, G. 2008. Renewable Energies for Africa Potential, Markets and Strategies: Southern Africa. Energy Research Centre, Cape Town

Prasad, G. and Visagie, E. 2006. Impact of energy reforms on the poor in Southern Africa. Global Network on Energy for Sustainable Development (GNESD) Access III theme. Riso, Denmark.

ProBEC. 2006. http://www.probec.org

Rao Kathakrishna, 2007., Biomass gasification: available at; http://www.tribuneindia.com/2007/20070420/science.htm#2

Reddy K.N., Williams R.H. and Johansson T.B., 1997. Energy After Rio: Prospects and challenges. United Nations Development Programme, New York

REN21 Renewable Energy Policy Network. 2005. "Energy for Development: the Potential Role of Renewable Energy in Meeting the Millennium Development Goals." Washington, DC: Worldwatch Institute.

REN21, 2007. WIREC 2008 Pledges. http://www.ren21.net/wiap/wirec.asp

REN21, 2008. Renewables 2007 – Gobal Status Report (unpublished)

REN21. 2008a. Washington International Action Programme. http://www.ren21.net/wiap/wiap.asp

Renewable Fuels Association (RFA). 2005. Industry Statistics, http://www.ethanolrfa.org/industry/statistics/#E

Republic of Uganda, 2007. Available from: http://www.energyandminerals.go.ug/renenergy/Renewable%20Energy%20Source.html

Reuters, 2006. "SA company says it will make biodiesel from algae".,Reuters-November 29, 2006. Available at:http://www.motoring.co.za/index.php?fArticleId=3566349

Sachs J.D., Mellinger A.D., Gallup J.L., 2001. The Geography of Poverty and Wealth, Center for International Development at Harvard University, in Scientific American Magazine, March.

SADC TAU. 1997. FINESSE Activitites in the SADC Region. Zimbabwe Country study. SADC/UNDP. Luanda.

Saghir, 2009 Saghir J. 2009 Personal Communication

Salazar, C.M., 2008. An Overview of CSP in Europe, North Africa and the Middle East. CPV Today. USA

Sarr, S., Dafrallah, T., 2006a. 'Access to the Energy Services: Good Practices for a Scaling', paper prepared for the Successful Policy Initiatives in Africa. ENDa

Sarr, S., Dafrallah, T., 2006b. Focus on Electrification for Poor: Lessons from West Africa Access III; ENDA –GNESD, November 2005. - 31p.

Sarr, S., Dafrallah, T., 2007. Policies and measures for large-scale dissemination of improved stoves in West Africa: the case of Senegal; ENDA –GNESD, November 2006.- 57p.

Schirnding, Y., 2001. 'Gender differences in the impact of biomass fuel on health'. In Energia News 4(4). Energia, Netherlands.

Schirnding, Y., N. Bruce, K. Smith, G. Ballard-Tremeer, M. Ezzati and K. Lvovsky. 2002. Addressing the Impact of Household Energy and Indoor Air Pollution on the Health of the Poor: Implications for Policy Action and Intervention Measures. Paper prepared for the Commission on Macroeconomic and Health. Publication no. WHO/HDE/HID 02.9. World Health Organization: Geneva, Switzerland.Available at

Science and Technology Commission (ESTC), 1994. National Mines, Water, Energy and Geo-Information Science and Technology Policy. ESTC, Addis Ababa

Scully J., 2002. (Ed). *Ecoforum, Vol.25 No. 4*. Nairobi, Kenya: The Environment Liaison Centre International.

Scurlock, J. and Hall, D.O. 1991. Fuelling the Future - Power Alcohol in Zimbabwe. ACTS Press, Nairobi

Seeger, C. 2009. Personal Communication.

Smeets, E. and Faaij, A. 2006. Bioenergy Potentials from Forestry in 2050. An Assessment of the Drivers that Determine the Potential. Climatic Change (in press at thetime of writing)

SNV Netherlands, 2007.Biogas for a better life: an African Initiative. Available at: https://www.biogasafrica.org/Documents/Forms/AllItems.aspx

Socolow, H. (Ed), 1992. Annual Review of Energy and The Environment, Vol. 21. Annual Review Inc Palo Alto

Sokona, Y, Sarr, S and Wade, S. 2003. Energy Services for the Poor in West Africa. Dakar: Enda

Sokona, Youba 2007. Personal Communication

Southern African Development Community (SADC), 2006. SADC Protocol on Energy.

Stakes and Opportunities. FARA Secretariat and the International Institute for Water and Environmental Engineering (2iE), Ouagadougou.

Tafere, H., 2008. Ethiopia: Power Shortfall Bogs Down Economy. 10th June 2008. Addis ababa, Ethiopia. http://allafrica.com/stories/200806100478.html

Takavarasha, T., Uppal, J. and Hongo, H. August 2006. Feasibility Study for the Production and Use of Biofuel in the SADC Region. SADC. Gaborone.

TaTEDO, 2006. Potential of Liquid Biofuels for Transport in Tanzania: Article on TaTEDO magazine, Issue No.4 January – August, 2006; Dar e salaam.

TATEDO. 2007. Piloting Multifunctional Platforms for Productive Uses and Services in Rural Tanzania - http://www.tatedoease.or.tz/mfp.html

Teferra, M. 2000. Energy Sector Reform Theme Group: Data and Statistics Compilation - Ethiopia. African Energy. Policy Research Network, Nairobi

Teferra, M. 2001c. Power Sector Reform in Ethiopia: Implication for Rural Electrification. AFREPREN/FWD, Nairobi.

Teferra, M., 2001a. Energy for Rural Development in Ethiopia – Proceedings of a national Policy Seminar, AFREPREN, Nairobi, Kenya.

Teferra, M., 2001b. Ethiopia Workshop Proceedings, 2000, Working Paper No. 286, AFREPREN, NAIROBI, Kenya.

The Manila Times, 2001. 'Charcoal,yes;Wood,No'. Manila Times Publishing Corporation. Available from <URL-http://www.manila times.net/national/2005/apr/12/yehey/enter/20050412ent2.html>

The Organization of Arab petroleum Exporting Countries (OAPEC). 2007. Annual Statistical Report 2007. OAPEC, Safat

Thom, C. and Banks, D.I. 1994. Biogas as a rural domestic energy source: A pilot study. Journal of Energy R&D in Southern Africa, 5(4): 121-125.

Togola, I., 2008. Renewable Energies - status and potential for development in the Sahelian countries; Mali, Burkina Faso and Niger. Mali.

Traditional biomass energy. Thematic background paper January 2004. http://www.renewables2004.de/pdf/tbp/TBP11-biomass.pdf

Treehugger, 2007.Available from: http://www.treehugger.com/files/2005/07/biogas_poopower_1.php

UFH (University of Fort Hare). 2007. Implementation, evaluation and performance monitoring of a Biomass Gasifier. http://www.ufh.ac.za/fhit/

UNDESA, 2007. Small scale production and use of Liquid Biofuels in Sub-Saharan Africa: Perspective for sustainable development. New York, UNDESA.

UNDP, 2003. Human Development Report 2003, Oxford and New York: United Nations Development Programme.

UNDP, 2007. United Nations Development Programme. Human Development Report. New York, UNDP

UNEP Riso Centre (April 2004), "Prospects for Renewable Energy Technologies in the Middle East and North Africa Region," Sami Kamel.

UNEP Risoe, 2006 Promoting Modern Bio-energy Under the Clean Development Mechanism

UNEP/GEF, 2006. Cogeneration for Africa Project, Full Scale Project Brief. Nairobi, AFREPREN/FWD

UNIDO, 2008. Dakar Declaration On Scaling Up Renewable Energy In Africa. http://www.unido.org/fileadmin/media/documents/pdf/Energy_Environment/senegal_Dakar_Declaration.pdf

United National Framework Convention on Climate Change (UNFCCC), 2009. Recommendations on future financing options for enhancing the development, deployment, diffusion and transfer of technologies under the Convention - Report by the Chair of the Expert Group on Technology Transfer. Bonn, United Nations, Website: http://unfccc.int/resource/docs/2009/sb/eng/02sum.pdf. accessed on 28th July 2009.

United Nations (UN) 1993. Agenda 21: Earth Summit - The United Nations Programme of Action from Rio. http://www.un.org/esa/dsd/agenda21/res_agenda21_00.shtml

United Nations Environment Programme (Content Partner); Lori Zaikowski (Topic Editor). 2007. "Forests and woodlands in Africa." In: Encyclopaedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). [First published in the Encyclopaedia of Earth December 29, 2006; Last revised April 13, 2007; Retrieved November 26, 2008].

United Nations Framework Convention on Climate Change (UNFCCC). 2009. Solar Water Heater Programme in Tunisia. http://cdm.unfccc.int/ProgrammeOfActivities/Validation/DB/OXEVYP45BDLBC0N23JPOLZ72NDRBMO/view.html

United Nations Statistics Division, 2005. Available from: http://mdgs.un.org/unsd/mdg/Resources/Attach/Products/Progress2005/goal_1.pdf

United Nations, 1997. Glossary of Environment Statistics, Studies in Methods, Series F, No. 67. UN, New York

University of Capetown (UCT). 2003. Nations Spoil for West African Oil and Gas. Monday Paper Archives. http://www.uct.ac.za/mondaypaper/archives/?id=4043

Vanderhulst, P., Lanser, H., Bergmeyer, P. and Albers, R. 1990. Solar Energy: Small Scale Applications in Developing Countries. (Amsterdam: TOOL).

Veragoo D., 2003. Cogeneration: The Promotion of Renewable Energy and Efficiency in Mauritius. Central Electricity Board: Mauritius. p. 11 (2003).

Vita, Ghana, 2006. Clean Energy for Household Cooking in Kenya. (http://www.enterpriseworks.org/display.cfm?id=3&sub=15&cont=7)

Walubengo, D.(1995) "Commercialization of improved stoves: The case of the Kenya Ceramic Jiko (KCJ)", in stove images: A documentation of Improved and Traditional Stoves in Africa, Asia and Latin America, Westholf, B.and German, D.(eds), (Comission of the European Communities: Brussels, Belgium).

Wamukonya, N. 2003. Power Sector Reform in Developing Countries: Mismatched agendas', in N. Wamukonya (ed), *Electricity Reform: Social and environmental Challenges*, Roskilde: United Nations Environmental Programme, pp. 7-47.

Ward M, Ashworth JH, Burrill G. 1984. Renewable Energy Technologies in Africa: An Assessment of Field Experience and Future Directions. Washington: Bureau for Africa/Agency for International Development.

WEC (WEC). 2007. World Energy Council: Survey on Energy Resources 2007. http://www/worldenergy.org/publications/survey_of_energy_resources_2007/hydropower/default.asp, WEC, London.

WEC, 2004. Comparison of Energy Systems Using Lifecycle Assessment. World Energy Council

WEC, 2005. World energy Council: Survey on Energy Resources, www.worldenergy.org/wec-geis/publications/reports/ser/solar/solar.asp, World Energy Council, London.

Wegner, L. 2005. Privatisation: "A Challenge for Sub-Saharan Africa", Policy Insights No. 14 OECD Development Centre Study. Moulineaux, France.

WHO, 2006. Fuel for Life; Household Energy and Health. World Health Organization, Geneva, Switzerland

Wikipedia, 2008. South Africa wind farms. http://en.wikipedia.org/wiki/Wind_farm

Winrock International Brazil, 2002. Trade Guide on Renewable Energy in Brazil - October 2002.

Winrock, 2007.Biogas for a better life: an African Initiative. https://www.biogasafrica.org/Documents/Forms/AllItems.aspx

Wolde-Ghiorgis, W. (2002), 'Renewable Energy for Rural Development in Ethiopia: The Case for New Energy Policies and Institutional Reform', Energy Policy, Vol. 30 Nos. 11-12, Oxford, Elsevier Science Ltd

World Bank - Sustainable and participatory energy management project. - Energy Group, June, 2005 - 72p.

World Bank 1986 – world Development Report 1986

World Bank, 2000. World Development Report, 2000. Washington DC, USA: The World Bank

World Bank, 2003. World Development Report, 2003. Washington DC, USA: The World Bank

World Bank, 2004. World Development Indicators. World Bank, Washington D.C.

World Bank, 2005. World Development Report, 2005. Washington DC, USA: The World Bank

World Bank, 2006, World Development Indicators. World Bank, Washington, DC.

World Bank, 2007. World Development Report, 2005. Washington DC, USA: The World Bank

World Bank. 1986. Agricultural Residue Briquetting Pilot Projects for Substitute Household and Industrial Fuels. The World Bank, Washington, DC.

World Bank. 2008. World Development Report 2008. The World Bank, Washington, DC.

World e-Parliament Report 2008 http://www.ictparliament.org/index.php?option=com_content&task=view&id=245

World Summit for Sustainable Development (WSSD). 2002. http://www.rrcap.unep.org/wssd/wssd.htm

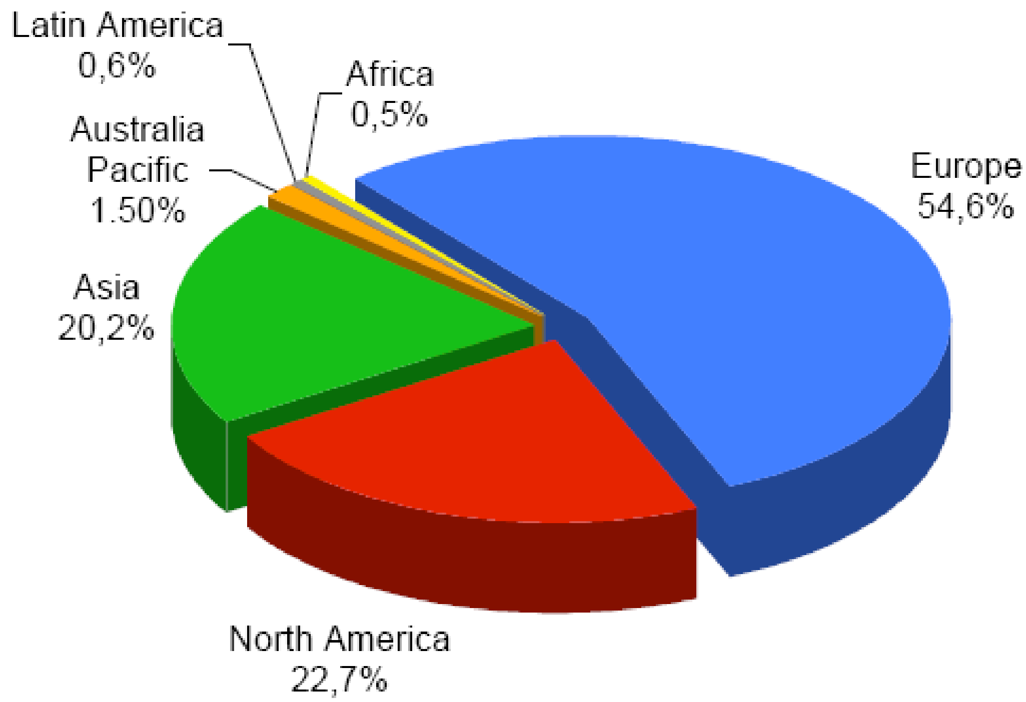
World Wind Energy Association (WWEA). 2009. World Wind Energy Report 2008. WWEA, Bonn. http://www.wwindea.org/home/images/stories/worldwindenergyreport2008_s.pd

Yamamoto Y., Fujino J., and Yamaji K., 2001. 'Evaluation of Bioenergy Potential with a Multi-Regional Global-Land-Use-And-Energy Model', Biomass & Bioenergy, 21(185-203). Oxford, United Kingdom: Elsevier Science Ltd

Yuko, D. N., Ogwayo, A.W., Litondo, J.M. and Misango, Q.B., 2003. Revitalising the Sugar Industry, Strengthening the Power Sector: Putting the sweetness back into the sugar industry-electricity generation from sugarcane residual fuels. M &E Consulting Engineers, Nairobi

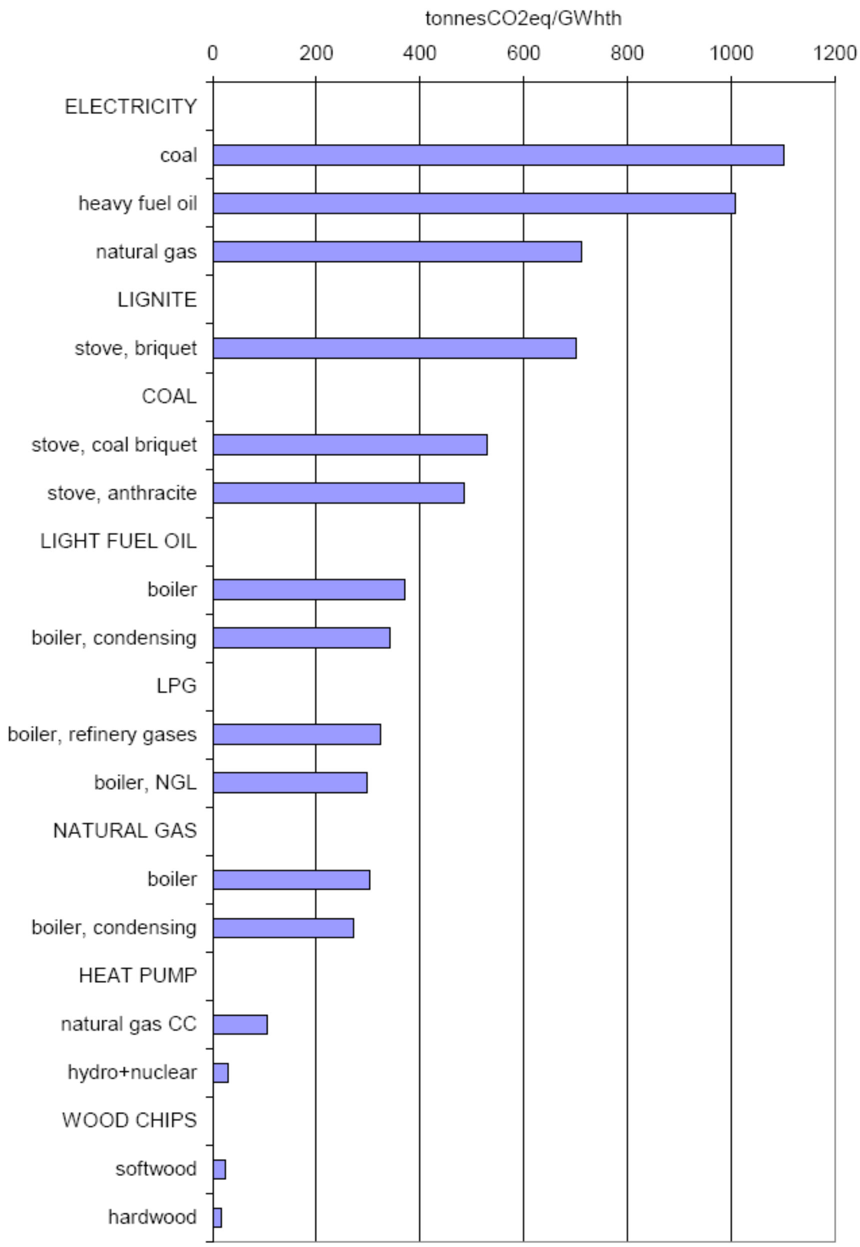
Zekeyo, J.P. 2001. Rural electrification reform and programme in Cameroon. In Wamukonya, N(ed), Proceedings of the African High Level Regional Meeting on Energy and Sustainable Development for CSD9, 2001. UNEP: 39-46

Annex 1: Share of Worldwide Wind Energy Installation by Continent in 2008 (Total: 121.2 GW)



Source: WWEA, 2009

Annex 2: Greenhouse gas emissions from alternative space heating systems (tones of carbon dioxide equivalent per GWh of heat generated)



Source: World Energy Council, 2004

Annex 3: Production of Energy (by Source) in Africa (2005)

Type	Amount (Mtoe)	Percentage
Geothermal/solar/wind/tide	0.9	0.15
Nuclear	2.9	0.49
Hydro	7.8	1.29
Petroleum Products	-13.2	-2.1
Gas	73.0	12.05
Coal	102.0	16.84
Biomass *	286.8	47.37
Crude Oil	145.1	23.97
Electricity	0.02	0.002
Heat	0.04	0.006
Total	***605.36***	***100.00***

** Biomass refers to combustible renewables (mainly fuelwood, charcoal and agro-residues) and waste*

Source: IEA, 2008

Annex 4: Common Barriers to Renewable Energy

Category	Barriers
Cost and pricing related	Conventional fuels receive large public subsidies while renewables may not. Renewables have high initial capital costs but lower operating costs, making them more dependent on financing and the cost of capital. It is difficult to quantify future fuel-price risks for fossil fuels and incorporate monetary values for those risks into economic decision-making. Transaction costs are often higher for small, decentralized renewable energy facilities than for large centralized facilities. The real economic costs of environmental damages from fossil fuels (on human health, infrastructure, and ecosystems) are rarely priced into fuel costs.
Legal and regulatory	Independent power producers (IPPs) may be unable to sell into common power grids in the absence of adequate legal frameworks. Transmission access and pricing rules may penalize smaller and/or intermittent renewable energy sources. Permitting requirements and siting restrictions may be excessive. Utilities may set burdensome interconnection requirements that are inappropriate or unnecessary for small power producers. Requirements for liability insurance may be excessive.
Market performance	Consumers or investors may lack access to the credit required for capital-intensive renewable energy investments. Financiers, developers, and consumers may unfairly judge technology performance risks. Market participants may lack sufficient technical, geographical, and/or commercial information to make otherwise sound economic decisions.

Source: adapted from Beck and Martinot, 2004

Annex 5: Subsidies for Renewable Energy

Emerging Lessons: Equipment Subsidies and Market Distortions

Donors are still undermining markets with capital cost subsidies and donated equipment

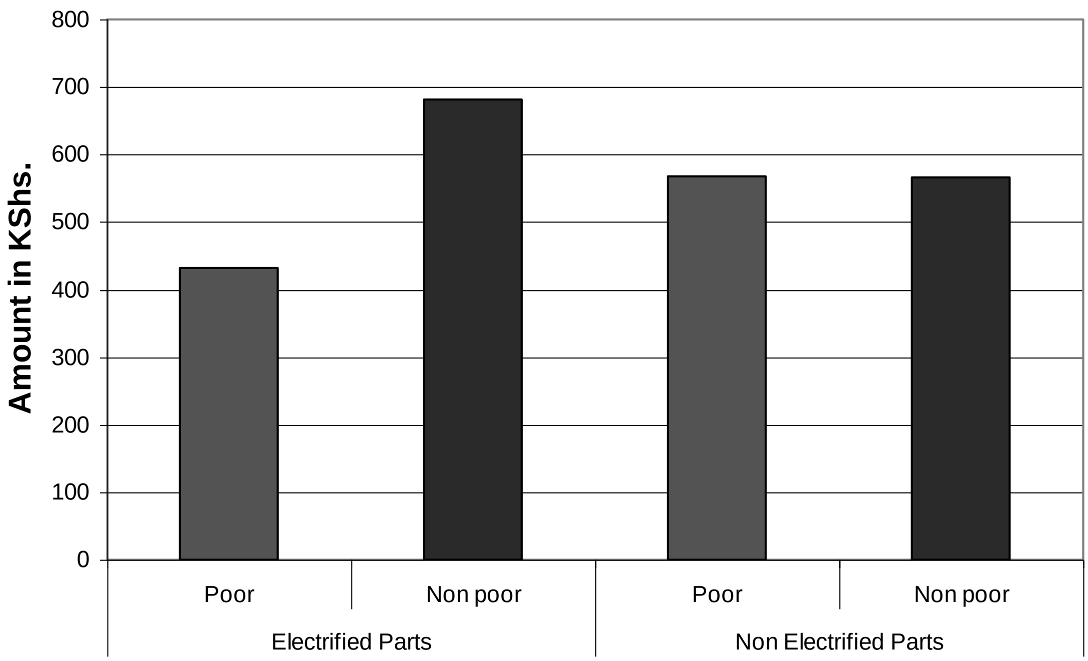
- Subsidies are unlikely to lead to sustainable markets unless they explicitly create the conditions whereby they are no longer needed (i.e., "smart" subsidies)
- Subsidies can undermine private investments and business in new markets and should be applied with attention to private-sector conditions in a particular market
- Subsidies can be used effectively to build up initial market volume, local expertise, user awareness, appropriate technology adaptation, quality standards, and entrepreneurial activities
- Subsidies are more effective when tied to operating performance rather than investment
- Continuing subsidies may always be needed for poorer segments of the population

Source: Martinot, 2004

Annex 6: Average Cost of Grid Extension in rural Kenya

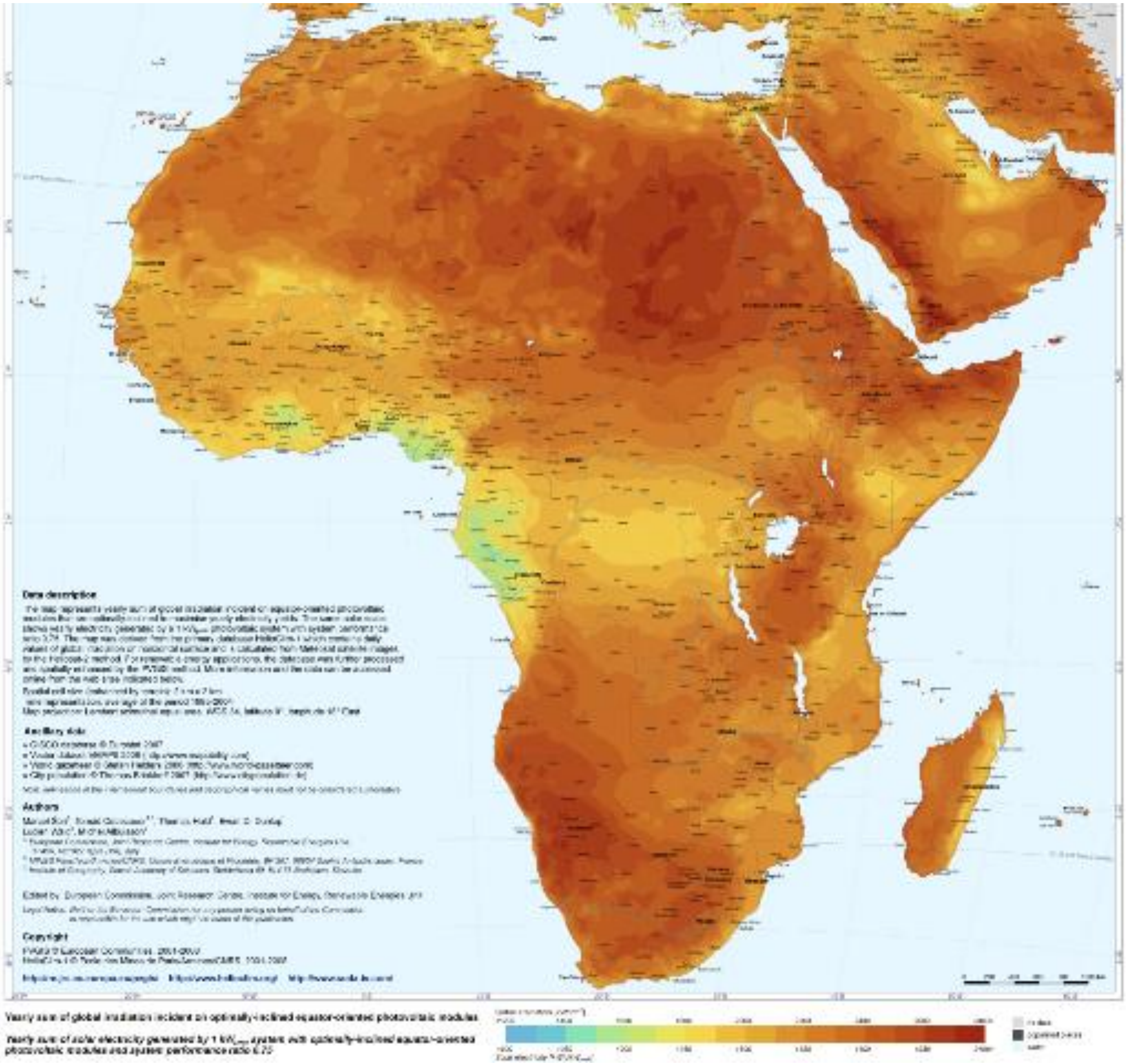
According to a socio-economic survey carried out in three different rural areas in Kenya to determine: (i) the levels of access to electricity and other modern energy services by various income groups in these areas and (ii) to establish how much the unelectrified respondents were willing to pay for grid electricity connection, the survey, as shown in Figure 16, revealed that the majority of the rural population cannot meet the requisite connection fee. In fact, the poor in both electrified and non-electrified parts of the three areas appear to indicate that they can afford only less than half of the aforementioned connection fee (Karekezi, Kimani and Ayago, 2005).

Figure 15: Average Amount of Grid Electricity Connection Fee Households Willing to Pay



Source: MoE, 2005

Annex 7: Solar PV Potential in Africa



Source: PVGIS, 2001-2007

ANNEX 8: Successful Model of Feed-in Tariffs Policy for Renewable Energy: Case example of Uganda and Tanzania

(a) Feed - in -Tariffs for Hydropower systems and bagasse up to a maximum capacity of twenty megawatts (20MW) in Uganda

In accordance to Clause 56(1) g of the Electricity Act 1999, Cap 145, Uganda Electricity Transmission Company Limited, the holder of transmission license was designed by the Electricity Regulatory Authority to publish standardized tariffs based on avoided cost of the system for sales to the grid of electricity generated by renewable energy systems of up to a maximum capacity of 20 MW.

The published feed-in-tariffs by the Uganda Electricity Transmission Company Limited, in consultation with the Electricity Regulatory Authority are shown in the table below:

	Hydropower			**Cogeneration**		
Time of Use	Year 1 to 6	Year 7 to 20	Simple Weighted Average	Year 1 to 6 (Bagasse)	Year 7 to 20 (Bagasse)	Weighted Average
Peak (1800-2400hrs) (US$/KWh	12.00	9.00	9.00	12.00	8.00	9.60
Shoulder (0600-1800hrs) (US$/KWh)	6.40	5.40	5.70	6.00	4.50	5.10
Off-Peak (0000-0600hrs) (US$/KWh)	4.00	1.50	2.25	4.10	4.00	4.04
Average Tariffs	7.20	5.33	5.89	7.03	5.25	5.96

Source: ERA, 2008 (http://www.era.or.ug/Feed_In_Tariffs.php)

(b) Standardized Power Purchase Agreement (SPPA) and Standardized Power Purchase Tariff for Small Power Projects (SPPs)

The Government of Tanzania (GoT) through the Ministry of Energy and Minerals (MEM), has established a framework for development of small power projects utilizing the abundant renewable energy sources in Tanzania. The move is in a bid to accelerate electricity access and promote the development and operation of small power projects among local and foreign private investors. The framework includes introduction of Standardized Power Purchase Agreement and Standard Tariff Methodology, which is applicable between the developer and the buyer. Eligible Small Power Projects are those of capacity ranging from 100 kW to 10 MW and utilizing renewable energy sources, intended to supply commercial electricity to the National Grid or isolated grid in Tanzania. The framework is being developed pursuant to the Electricity Act, 2008. The framework will reduce negotiation time and cost, and opens the possibility of implementing rural electrification projects.

After several consultations with various stakeholders, EWURA has approved the following Standardized Documents for Small Power Projects:

Standardized Small Power Purchase Agreements (SPPA)

- Main Grid Connection
- Isolated Mini Grid Connection

Standardized Tariff Methodology

- Main Grid Connection
- Isolated Mini Grid Connection

Detailed Tariff Calculations

- Main Grid Connection
- Isolated Mini Grid Connection.

Source: EWURA, 2007/2008 (http://www.ewura.go.tz/sppselectricity.html)

Annex 9: Sample Executive Summaries for some African Energy Policies

Country	Executive Summary
Ethiopia	Formulation of detailed sectoral science and technology (S&T) policies is the next fundamental step towards the implementation of the National Science and Technology Policy which was issued recently by the transitional Government of Ethiopia. This sectoral S&T policy has been formulated by merging together the mines, water, energy and geo-information sub-sectors which are interrelated and complementary to each other. Despite the fact that Ethiopia is one of the African countries that are endowed with high potential of water resources, the country has been ravaged by repeated drought and famine due to its inability to use these resources effectively. It is estimated that the country has 3.5 million hectares of land suitable for large scale irrigation development, out of which only 3% has been developed so far. The hydropower generation potential of the country is estimated to be about 650 billion kilowatt hours, of which, according to some studies, an estimated potential of 120-160 billion kilowatt hours per annum could have currently been put into use. However, only about 1% of this potential is being used at the present. Source: Science and Technology Commission (ESTC), 1994. National Mines, Water, Energy and Geo-Information Science and Technology Policy. ESTC, Addis Ababa
Sierra Leone	Sierra Leone is reasonably well endowed with energy resources particularly biomass energy, hydroelectricity and other renewable energy sources (e.g. solar energy). There is an extensive network of rivers and tributaries that provide a large hydroelectric power potential conservatively estimated at 1,200MW. These resources can play a catalytic role in sustaining Sierra Leone's development. The country however faces difficulties with commercial energy supplies, particularly electric supply. The Sierra Leone constitution states as one of its economic objectives that the state shall "harness all natural resources of the nation to promote national prosperity and an efficient, dynamic and self reliant economy." An energy policy that exploits the vast potential from biomass, hydro resources and other renewable energy resources is certainly geared towards meeting this economic objective. Firstly, it is necessary to adopt a policy that has short, medium and long term perspectives on how to address the energy needs of the country. Secondly, an environment must be created for the sustainable supply of affordable energy services. A critical factor in this direction will be improvement in the governance of the sector including the efficient management of the sector, affordability of the service and widened access to cover rural productive sectors. Sources: Ministry of Energy and Power (MEP), 2004. The Energy Policy for Sierra Leone. MEP, Freetown
Tanzania	The first national energy policy for Tanzania was formulated in April 1992. Since then, energy sub-sectors as well as the overall economy have gone through structural changes, where the role of the Government has changed. Hence the policy document has been revised taking into account structural changes in the economy and political transformations at the national and international levels. However, the national policy objective for the development of the energy sector remains to provide an input in the development process by establishing an efficient energy production, procurement, transportation, distribution and end user systems in an environmentally sound manner and with due regard to gender issues. The revision has, therefore, focused on the market mechanisms and means to reach the objective, and achieve an efficient energy sector with a balance between national and commercial interests. An interactive and participatory process between government, other stakeholders and relevant groups has been necessary as part of the formulation process in order to incorporate views of market actors and energy consumers to address the complex nature of the sector. An interactive and participatory process between government, other stakeholders and relevant groups has been necessary as part of the formulation process in order to incorporate views of market actors and energy consumers to address the complex nature of the sector. Source: Ministry of Energy and Minerals (MEM), 2003. The National Energy Policy. MEM, Dar es Salaam
Uganda	The 1995 constitution of the Republic of Uganda provides the mandate to establish an appropriate energy policy when it states: "The state shall promote and implement energy policies that will ensure that people's basic needs and those of environmental preservation are met." This constitutional requirement makes it incumbent upon Government to formulate an energy policy that will not only sustain the impressive economic growth of the last decade or so, but also ensure widespread access to affordable modern energy services for improving the living standards of all the people of Uganda.

	This policy document provides Governments vision for increased and improved modern energy supply for sustainable economic development as well as improving the quality of life of the Ugandan population. To translate it into reality, an indicative short and medium plan has been developed and appended. Enormous resources will be required to implement this action plan. It is, therefore, now incumbent upon all those Government agencies that have a stake in this matter to work together to realize this vision. Source: Ministry of Energy and Mineral Development (MEMD), 2002. The Energy Policy for Uganda, MEMD, Kampala
Kenya	The overall national development objectives of the Government of Kenya are accelerated economic growth and the rising productivity of all sectors, equitable distribution of national income, alleviation of poverty through provision of basic needs, enhanced agricultural production, industrialization, accelerated employment creation and improved rural-urban balance. The extent to which these objectives can be realized on a sustainable basis and in an environmentally sound manner is dependent on the degree of economic efficiency with which crucial factors of production are made available and combined with each other optimally to produce desired results. The realization of these objectives is only feasible if quality energy services are made available in a sustainable, cost effective and affordable manner to all sectors of the economy. The need for an integrated national energy policy cannot therefore be gainsaid. This energy sessional paper therefore sets out the national policies and strategies for Kenya's energy sector in the short to long term. Source: Ministry of Energy (MoE), 2004. Draft National Energy Policy. MoE, Nairobi
Rwanda	Since 1994, the energy sector as well as the overall economy has gone through structural modifications, where the role of the Government has changed, markets have been liberalised and private sector initiatives encouraged. Hence, the energy policy document has to take into account structural changes in the economy and political transformations at national and international levels. The national policy objective for the development of the energy sector is to provide an input in the development process by establishing an efficient energy production, procurement, transportation, distribution, and end-user systems in an environmentally sound manner. The Energy Policy has, therefore, to focus on market mechanisms and means to reach the objective, and achieve an efficient energy sector with a balance between national and commercial interests. An interactive and participatory process between Government, other stakeholders and relevant groups has been necessary as part of the formulation process in order to incorporate views of market actors and energy consumers to address the complex nature of the sector. Specifically, the energy policy takes into consideration the need to: (a) Have affordable and reliable energy supplies country wide; (b) Reform the market for energy services and establishes an adequate institutional framework, which facilitates investment, expansion of services, efficient pricing mechanisms and other financial incentives; (c) Enhance the development and utilization of indigenous and renewable energy sources and technologies, (d) Adequately take into account environmental considerations for all energy activities, (e) Increase energy efficiency and conservation in all sectors; and (f) Increase energy education and build gender-balanced capacity in energy planning, implementation and monitoring. Source: Ministry of Infrastructure (MoI), 2004. Energy Policy for Rwanda. MoI, Kigali
South Africa	The South African government last published a white paper on energy policy in 1986. With the end of apartheid South Africa experienced fundamental shifts resulting in significant changes in the energy policy context. The election of a new government necessitated a review of existing policy. In response to democratization, a number of negotiating processes began spontaneously within the energy sector, usually in stakeholder-based forums such as the Liquid Fuels Industry Task Force and the National Electrification Forum. Government's wish to integrate these and provide policy stability led to it

	formally launching the energy policy white paper process in 1994. The general approach to policy formulation has also changed and places greater emphasis on transparency, inclusiveness and accountability. The energy white paper process has therefore attempted to make government's approach more transparent; to build public confidence; to clarify organisational roles; to communicate policy effectively; and to integrate policy processes. The process commenced with the drafting of an Energy Policy Discussion Document by a multi-disciplinary team of experts. It described the energy sector and identified 111 major energy policy issues. Informally known as the 'Green Paper', it was released by the Minister of Mineral and Energy Affairs in August 1995 for analysis and comment. Formal and informal workshops were then held with interested parties. In August 1995, a team of expert 'issue rapporteurs' was appointed to draw up the first draft white paper. Their contributions were then edited for review by an editorial committee. The Draft White Paper was revised during 1997/98 in the Department and Cabinet approved its release in July 1998. The general approach to policy formulation is to recognise problems; to identify causes and solutions; to analyse their implications and make choices; and to implement, monitor and evaluate the effects of policy. In his historic, budget speech in Parliament on 21st May 1997, the Minister of Minerals and Energy, Dr P M Maduna, set forth a new vision for energy, especially for the liquid fuels industry. He identified the opportunity which exists to restructure and consolidate the state's assets in the industry, whilst achieving maximum value for them. Such restructuring was to be informed, inter alia, by the need to redress economic and social power imbalances. Emphasis was also placed on the pursuit of cooperation among African countries and the need for a Pan-African energy strategy. This speech has helped to illuminate South Africa's policy challenges. Broadly speaking the energy sector can be viewed from demand and supply perspectives. The South African energy sector has historically tended to promote policies, which predominantly address supply side issues. In South Africa the demand side is generally analysed in terms of the energy requirements of households, industry, commerce, mining, transport and agriculture. Supply sub-sectors include the coal, electricity, nuclear, liquid fuels, gas and renewables industries. From a policy perspective, social problems can arise in both demand and supply sub-sectors. Identifying the causes of these problems can be difficult. Causal linkages may extend beyond the energy sector. Energy policies must, therefore, be carefully coordinated with other social sectors and also be coordinated between energy sub-sectors. To cope with multiple causal linkages, energy policy analysis usually commences with the demand side by means of the process entitled- 'integrated energy planning'. This recognizes that energy is not an end-good but is rather consumed as a means to an end. Policy must facilitate optimal energy consumption and production to meet social needs. This requires consumer choice and the operation of market forces. Integrated energy planning suffers from the same drawbacks as other ideal models. It requires a great deal of data and analysis to implement, of which South Africa has a scarcity. Nonetheless, this white paper identifies integrated energy planning as the most suitable base for planning purposes and also addresses the issue of data scarcity. The logical components dealt with in each demand, supply and cross cutting section are: a background to the sector; the key policy challenges; government's proposed policies with motivations where necessary; implementation; and monitoring and evaluation. Clear policy objectives have been established. Source: Department of Minerals and Energy (DME), 2004. Draft Energy Efficiency Strategy of the Republic of South Africa. DME, Pretoria
Zambia	The advent of the third republic on November 2, 1991 brought in a re-organisation of government administration. One of the important changes made was the creation of the ministry of energy and water development, in line with the movement for multiparty democracy manifesto. The government of Zambia recognizes the need for the evolution of an energy policy that would guide developments in the supply and demand of the various energy resources in the country. This has become especially important in view of the changed macro-economic environment in which liberalization and private enterprise have become the norm. Furthermore, the energy sector has for a long time been functioning without explicit policy guidelines.

	In an effort to develop such a policy the ministry of energy decided to hold a series of workshops at which all stakeholders were invited to discuss each energy source in detail and make relevant policy proposals for government consideration. Altogether six workshops dealing with coal, electricity, woodfuel, petroleum, renewable energy and energy conservation were synthesized into a consolidation document that was extensively discussed at the final workshop. This document is organized into three main sections. Chapter one provides the background to the energy policy and highlights the role of energy in national development, the current energy resource base and the use patterns in the country. Chapter two contains the main policy measures for each subsector and outlines strategies for implementation. The last chapter presents the institutional and legal reforms required to implement this policy. Source: Ministry of Energy and Water Development (MEWD), 1994. National Energy Policy, MEWD, Lusaka
Swaziland	The energy sector has been undergoing rapid transformation in recent years at a global, regional and national level. These changes have included market reforms and the introduction of appropriate regulation. Governments have been withdrawing from directly managing markets and their role has progressively moved towards setting up sound rules which are administered by impartial regulators. There has also been a progressive movement towards pricing energy to reflect the true costs of supply. Consequently, in many cases this has resulted in higher energy prices, which have in turn stimulated greater efficiency of energy supply and use. However, there is also strong emphasis towards ensuring access and affordability of energy services to all of the population. The major task for the Government of Swaziland therefore is to achieve a balance between its economic and social responsibilities. Within the Southern African Development Community (SADC) region, the energy sector reform process has been moving at a fast pace during the last five years. The prime objectives have been to increase efficiency and attract and facilitate participation by private investors and financiers. In 1996, the SADC Heads of States approved the SADC Energy Protocol. The main objective of the Energy Protocol is to promote the harmonious development of the regions' national energy policies and matters of common interest for the balanced and equitable development of the regional energy resources. During recent years the Kingdom of Swaziland has made major efforts to formulate and reach consensus regarding overall national development policies and action plans. These have culminated in the National Development Strategy (NDS), which embodies the long-term vision for the development of Swaziland. The overall vision set out in the NDS is that "By the year 2022, the Kingdom of Swaziland will be in the top 10% of the medium human development group of countries founded on sustainable economic development, social justice and political stability". Underlying the vision in the NDS is the focus on the quality of life in the country. The critical dimensions of the quality of life are poverty eradication, employment creation, gender equity, social integration and environmental protection. These are, in turn, crucially linked to education, health and other aspects of human resource development. When translated to energy policy development, the vision infers that the energy policy should therefore also strive to promote sustainable economic development, social justice and political stability, by supporting poverty eradication, employment creation, gender equity, social integration and environmental protection. An energy policy needs to be based on the overall development policies and in particular policies with relevance to the energy sector, such as public-private partnerships, environment, business promotion, privatisation, etc. Source: Ministry of Energy (MoE), 2002. The National Energy Policy 2002. http://www.ecs.co.sz/energy/.htm
Eritrea	The efficient, reliable and sustainable production and supply of affordable energy throughout Eritrea is the primary objective of the Government's policy in the energy sector o both grounds of economics and social development. This policy incorporates the management of energy utilization and promotional and regulatory activities of energy conservation. To achieve this goal, the Ministry of Energy and Mines is entrusted with the task of designing and refining policies, strategies and regulatory issues in the energy sector, approving the corresponding plans and programmes formulated in the sector and supervising their implementation. This document aims at refining and updating the policies and strategies that were in operation for the last three years. Source: Ministry of Energy and Mines (MEM), 1997. Energy Policies and Strategies. MEM, Eritrea.
Zimbabwe	The energy sector in Zimbabwe accounts for 8-9% of GDP and public revenue, mainly from excise duties on liquid fuels, but it contributes only 1% to formal employment. More significant is its share in aggregate investment, foreign borrowing, and debt. Investment in the electricity and fuels sectors during 1996 – 1998 totaled around Z$700 million. The energy sector is capital and foreign exchange intensive and its requirements, petroleum products need to be imported in their entirety at a cost of about US $ 3.5 billion in 1997, and US $4 billion in 1998. Most of the investments have been financed through debt rather than retained earnings as net

	financial savings in the public sector are generally negative. The basic issue is that the Government's energy policy, and subsequent strategies, are consistent with the overall objective of enhancing the efficiency and resilience of the economy through supplying energy reliably and at least cost. Since security of supply is not synonymous with self sufficiency, it becomes important to assess energy projects in terms of their impact on supply reliability rather than their physical location. Source: Ministry of Energy and Power Development (MEPD). Draft National Energy Policy. MEPD, Harare
Namibia	This White Paper embodies a new, comprehensive energy policy aimed at achieving security of supply, social up-lift, effective governance, investment and growth, economic competitiveness, economic efficiency and sustainability. Policies will affect energy demand (mainly households), supply (electricity, upstream oil and gas, downstream liquid fuels, downstream gas, and renewable energy) and a number of cross-cutting issues (economic empowerment, environment, energy efficiency and regional energy trade and co-operation). Government is committed to ensuring that energy demand by the productive sectors of the economy continues to be met through reliable competitively-priced energy. Special attention is given in the White Paper to those demand sectors which have been neglected historically, namely, poor urban and rural households. Policies proposed for these households include those for widening access to electricity as well as other commercial fuels. Generally, not enough is known about the problems and needs in this sector so national studies will be initiated as a basis for future policy development, including the pressing issue of sustainable biomass usage in rural areas and the role of women. Rural energy policies will also be integrated with development initiatives in other ministries. Government has embarked on the reform of the electricity sector and a study has been commissioned to look at possible rationalization and restructuring, as well as competition and ownership changes. At the same time, an Electricity Act is being drafted which will put in place an electricity regulator to govern the industry. Tariffs and electrification targets will be governed through a licensing system. The creation of a rural electrification fund is also proposed. New investment in the sector will be encouraged through appropriate regulatory, fiscal and environmental frameworks, harmonized with those in SADC countries. The legislative framework governing upstream oil and gas is well developed, and the White Paper merely clarifies an accepted policy framework which seeks to optimize possible national benefits while achieving the necessary balance of interests to attract investment. The policy identifies the different roles and functions of industry participants, and lays out the basic legal and fiscal criteria. Namibia does not yet, but soon will, have a downstream gas sector. The key challenge is to create a policy and legislative framework which attracts initial investment into the sector, while maintaining options for competition in the future and the fair distribution of economic rents. A new Gas Act is proposed, but it is thought premature to install a Gas Regulator. Licensing requirements will include the need for separate accounting for the different operations of gas production, transmission, distribution and marketing, allowance for third party access, and the application of fair and reasonable tariffs. The downstream liquid fuels sector will be subject to controlled and phased deregulation with regard to price setting, subject to competitive behavior being evident. Government will, however, require obligations in terms of diversified imports, international product specifications, strategic stocks, third party lease access to uncommitted infrastructure, security of forecourt jobs, health and safety, and adequate rural service in terms of access and pricing. Government will promote the use of renewable energy through the establishment of an adequate institutional and planning framework, the development of human resources and public awareness and suitable financing systems. It also seeks to meet development challenges through improved access to renewable energy sources, particularly in rural electrification, rural water supply and solar housing and water heating. The energy policy goal of sustainability will further be promoted through a requirement for environmental impact assessments and project evaluation methodologies which incorporate environmental externalities. Energy efficiency will be promoted through policies on better information collection and dissemination, and particularly with respect to energy efficiency and conservation practices in households, buildings, transport and industry. The White Paper reaffirms Namibia's commitment to constructive engagement in SADC and SAPP in order to maximize economic benefits. Security of supply will be achieved through an appropriate diversification of economically competitive and reliable sources, but with particular emphasis on Namibian resources. Finally, the Ministry of Mines and Energy is mindful that the effective implementation of these policies is dependent on the creation of adequate institutional and human resource capacity. Policies have been proposed in each sector to address this issue.

	Source: Ministry of Mines and Energy (MME), 1998. White Paper on Energy Policy. MME, Windhoek.
Malawi	Developments in the energy sector have an important bearing on the success of development initiatives in any economy. Energy is a crucial input into any industrial processing and services as the life blood for modern transport systems, be it road, water, rail or air services. Countries that have made greatest strides in their development efforts are also the ones that use the greatest quantity of energy resources per capita. The structure of the energy sector also dictates the development path of a country can possibly take. Countries that depend on modern energy sources are associated with energy intensive manufacturing industries, whereas those that depend on traditional fuels are linked to low energy intensive primary commodity based economies, specializing in the export of a few unprocessed agricultural products and minerals. These positive attributes notwithstanding, the full potential of the energy sector in Malawi remains far from being realized owing to a number of structural, operational and institutional challenges. Malawi never had an integrated energy policy since independence. Energy policy statements do exist, but these are scattered in various government memoranda and reports. Moreover, although linkages exist among the various energy subsectors of biomass, electricity, coal, petroleum and other renewables, existing policies and strategies focus on addressing specific sub sector issues. Secondly, although some structural problems affecting the energy sector still prevail, some of the strategies promulgated from the existing policies are largely redundant. The absence of an integrated policy has contributed to inefficiencies, resource wastage through duplication and unplanned investment, institutional fragmentation and conflicts. The Ministry of Natural Resources and Environmental Affairs through the Department of Energy Affairs formulated an integrated Malawi Energy Policy in an attempt to minimize these constraints. The energy policy is intended to provide an operational framework for the energy sector as well as guidelines on issues related to energy development, supply, consumption, distribution and pricing. The government expects the policy to reform the energy sector into a robust and efficient sector that adequately supports the national socio economic agenda of the country. The government also expects that the energy policy will result into a more liberalized, private sector driven energy sector where pricing will reflect the competition and efficiency that will be developed.
Lesotho	Energy is an essential input to economic development of any society. In order to alleviate poverty, energy in one form or another has to be expended for income generating activities. However, this resource, like all others, is not always in abundance. In general, not all kinds of energy sources are available to any given country. Lesotho does not have reserves for petroleum fuels, and coal. Therefore, it relies entirely on imports, especially from South Africa. Electricity has also been imported from South Africa until 1998 when the hydropower station at Muela started operating. Given that energy is a critical input to poverty reduction and economic development, and at the same time a scarce resource, its supply and utilization has to be managed effectively and efficiently in a sustainable manner. For this condition to be satisfied, a conducive environment has to be created through policy instruments. Source: Kingdom of Lesotho, Undated. Launch of the Lesotho Utilities Project: Remarks by Minister of Natural Resources. www.lesotho.gov.Is/articles/Speech
Botswana	This document is the major written output of the final phase of the Botswana Energy Master plan (BEMP). The BEMP process started in 1985 and has gone through three phases. The first phase sought to collect and collate data on energy resources, energy technologies and energy supply and demand and to set up a database for energy planning. The second phase sought to develop and refine the data and database from phase 1, to appraise energy projects and to make recommendations on energy policy. The first two phases were a success in terms of developing good information on the Botswana energy sector. However, the official appraisal of the first two phases identified a shortcoming in the process in that adequate local institutional structures had not been developed including the development of personnel. The report consists of two sections: Section A provides information on the energy policy development methodology used. This includes: Chapter 1: A description of the participatory approach used Chapter 2: A definition of energy policy development terms and a structure for energy policy development Chapter 3: An identification of national, social and economic policies and the linkages between these and the overall energy policy objectives.

	Sources: Ministry of Mineral Resources and Water Affairs (MMRWA), 1996. Botswana Energy Masterplan – Final Phase. MMRWA, Gaborone
Sudan	Before delving into discussion of Sudan's energy resources, it is first important to review key general characteristics of Sudan that have important implications for the country's energy sector and renewables industry, in particular. With an area of 2,376,000km2 (World Bank, 2004 & AFREPREN, 2005;), Sudan is Africa's largest country which increases the cost of ensuring adequate energy services to all its communities found in different parts of the country. Sudan's population is estimated at over 35million, growing at an average annual rate of 2.18% (World Bank, 2004) with a significantly large proportion of young people who require employment. The energy sector could be an important contributor to job generation that would employ the growing number of young people entering to the job market every year. The urban population is estimated at 38%, and is expected to grow rapidly in the near future. Consequently, urban energy demand is expected to grow rapidly. While traditionally, it was believed that the bulk of the poor were found in rural areas, the picture is changing with rapid urbanization. A growing number of the poor are now found in urban areas and their need for adequate energy services will need to be addressed by Sudan's policy makers. Sudan's GDP increased from US$5billion in the early nineties to almost $15billion in 2002. The GDP growth rate in 2002 was estimated at 5.5% (World Bank, 2002; Sudanese source?) close to double the population growth rate. A large proportion of the growth is attributed to the energy sector – primarily revenues flows from a rapidly growing oil industry that is able to meet the bulk of local petroleum demand as well as generate a very substantial growth in oil exports. The per capita income was estimated at US$340 in 2002. A significant proportion of the population lives in poverty, with limited access to resources and incomes. The southern region of the country has registered the highest poverty levels over the years primarily due to political instability and simmering conflict that has now been brought under control with the recent signing of major peace agreements. The current political process in Sudan is likely to lead to a significant change in the development of the country. A peace agreement signed in December 2004 is currently being implemented, and is expected to result in better integration of the Southern Sudan in the national development process. Of particular interest has been the agreement to share oil revenues in an equitable fashion. Several processes have been initiated to build on the peace dividend with one of the most important being the Joint Assessment Missions, that have highlighted key development projects that should be given priority in the South; and the preparation of an interim poverty reduction strategy for Southern Sudan, which is ongoing and which will be merged with the existing draft poverty reduction paper and which is expected to provide the basis for more equitable development of the country as well as drastic reduction in poverty levels. A national initiative on Sudan's strategies for achieving the MDGs has also been launched by the Ministry of Finance. These initiatives are likely to result in a significant reduction in poverty levels, and accelerated as well as more equitable development of Sudan. Sources: Government of Sudan, 2005. Sudan Renewable Energy Masterplan Study, Government of Sudan, Khartoum
Mali	The placement of the framework of poverty reduction strategy by the government has been intensified. For this purpose it proposes to give a clear vision of the actions it has to undertake by Mali for the promotion of the energy sector, to contribute to an action plan on renewable energies in Mali. it will be a question of carrying the share of renewable energy in the energy balance of the country of less than 1% in 2002 to 15% in 2020 The ministry of mines, energy and water through the national directorate of energy, has the major aim of ensuring access to clean and affordable energy to majority of the population. Source: International Energy Agency (IEA), 2006. Action Plan for Renewable Energy Promotion in Mali. www.iea.org/textbase/pamsdb/detailaspx?mode

Annex 10: Africa Renewable Energy under the CDM – all levels

TITLE	COUNTRY	YEAR
Akouédo Landfill Rehabilitation and Electricity Generation Project	Côte d`Ivoire	2005
Zafarana Wind Power Plant Project	Egypt	2006
Al-Sindian 13 MW Natural Gas based Cogeneration Package Project, Egypt	Egypt	2006
Egyptian brick factory GHG reduction Project	Egypt	2006
Waste Gas-based Cogeneration Project at Alexandria Carbon Black Co., Egypt	Egypt	2007
Naga Hammadi Barrage Small Hydropower Project	Egypt	2007
Land Filling and Processing Services for Southern Zone in Cairo	Egypt	2008
35 MW Bagasse Based Cogeneration Project" by Mumias Sugar Company Limited (MSCL)	Kenya	2006
Olkaria II Geothermal Expansion Project	Kenya	2007
Chemelil Sugar Cogeneration Plant	Kenya	2008
Redevelopment of Tana Hydro Power Station Project	Kenya	2008
Optimisation of Kiambere Hydro Power Project	Kenya	2008
Essaouira wind power project	Morocco	2004
Tétouan wind farm project for Lafarge cement plant	Morocco	2005
Photovoltaic kits to light up rural households in Morocco	Morocco	2005
Jorf Lasfar heat recovery enhancement for power project	Morocco	
Surac Bagasse Plant Project	Morocco	2008
Low-cost urban housing energy service upgrades, Khayelitsha (Cape Town; South Africa)	South Africa	2004
Mondi Richards Bay Biomass Project	South Africa	2005
Bethlehem Hydroelectric Project South Africa	South Africa	2005
PetroSA biogas to energy	South Africa	2005
Emfuleni Power Project	South Africa	2006
Tugela Mill Fuel Switching Project	South Africa	2006
Durban Landfill-gas-to-electricity project – Bisasar Road Landfill	South Africa	2006
Mondi Richards Bay Biomass Project	South Africa	2006
Bethlehem Hydroelectric Project	South Africa	2007
Alton Landfill Gas to Energy Project	South Africa	2007
Humphries Boerdery (Edms) Bpk, piggery methane capture and electrical generation	South Africa	2008
Bethlehem Hydroelectric project	South Africa	2008
West Nile Electrification Project (WNEP).	Uganda	
Kakira Sugar Works (1985) Ltd. (KSW) Cogeneration Project	Uganda	2008

Annex 11: GEF Projects Approved in Africa on Energy

Approved Regional Projects								
GEF ID	**Country**	**Project Name**	**Focal Area**	**GEF Agency**	**Project Type**	**GEF Grant**	**Co financing Total**	**Project Status**
2597	Regional	Cogen for Africa	Climate Change	UNEP	Full Size Project	5,615,565.0	61,586,350.0	IA Approved
2119	Regional	African Rift Geothermal Development Facility (ARGeo)	Climate Change	UNEP	Full Size Project	17,750,000.0	55,550,000.0	CEO Endorsed
3789	Regional	SPWA-CC: GEF Strategic Program for West Africa: Energy Component (PROGRAM)	Climate Change	UNIDO	Full Size Project	146,000,000.0	100,000,000.0	Council Endorsed
2683	Regional	Greening the Tea Industry in East Africa	Climate Change	UNEP	Full Size Project	2,854,000.0	25,614,000.0	IA Approved
2385	Regional	First Regional Micro/Mini-Hydropower Capacity Development and Investment in Rural Electricity Access in Sub-Saharan Africa	Climate Change	UNDP	Full Size Project	19,173,968.0	121,335,659.0	Council Approved
1513	Regional	Building Sustainable Commercial Dissemination Networks for Household PV Systems in Eastern Africa	Climate Change	UNEP	Medium Size Project	718,000.0	539,630.0	Project Closure
2950	Regional	Lighting the "Bottom of the Pyramid"	Climate Change	IBRD	Full Size Project	5,400,000.0	6,750,000.0	IA Approved
Sub totals						**197,511,533.0**	**371,375,639.0**	**7 Projects**

Approved National Projects

GEF ID	Country	Project Name	Focal Area	GEF Agency	Project Type	GEF Grant	Co financing Total	Project Status
1235	Botswana	Renewable Energy-Based Rural Electrification Programme	Climate Change	UNDP	Full Size Project	3,000,000.0	5,388,608.0	IA Approved
2660	Burkina Faso	Transformation of the Rural PV Market (prev. Energy Sector Reform)	Climate Change	UNDP	Full Size Project	1,700,000.0	4,130,000.0	Council Approved
444	Cape Verde	Energy and Water Sector Reform and Development	Climate Change	IBRD	Full Size Project	4,700,000.0	60,070,000.0	Project Closure
1040	Egypt	Solar Thermal Hybrid Project	Climate Change	IBRD	Full Size Project	49,800,000.0	97,200,000.0	IA Approved
1335	Egypt	Bioenergy for Sustainable Rural Development	Climate Change	UNDP	Full Size Project	3,000,000.0	13,300,000.0	CEO Endorsed
1136	Eritrea	Wind Energy Applications	Climate Change	UNDP	Full Size Project	1,950,561.0	2,995,000.0	IA Approved
1686	Ethiopia	Renewable Energy Project	Climate Change	IBRD	Full Size Project	4,930,000.0	211,270,000.0	IA Approved
333	Ghana	Renewable Energy-Based Electricity for Rural, Social and Economic Development in Ghana	Climate Change	UNDP	Full Size Project	2,472,000.0	600,000.000	IA Approved
2886	Ghana	Energy Development and Access Project (formerly) Development of Renewable Energy and Energy Efficiency	Climate Change	IBRD	Full Size Project	5,500,000.0	157,000,000.0	IA Approved
1245	Lesotho	Renewable Energy-based Rural Electrification	Climate Change	UNDP	Full Size Project	2,500,000.0	4,255,500.0	IA Approved
641	Malawi	Barrier Removal to Renewable Energy Programme	Climate Change	UNDP	Full Size Project	3,353,000.0	7,304,000.0	IA Approved
52	Mali	Household Energy	Climate Change	IBRD	Full Size Project	2,500,000.0	8,600,000.0	Project Closure

GEF ID	Country	Project Name	Focal Area	GEF Agency	Project Type	GEF Grant	Co financing Total	Project Status
1274	Mali	Household Energy and Universal Rural Access Project	Climate Change	IBRD	Full Size Project	5,200,000.0	10,800,000.0	Project Closure
371	Mauritania	Decentralized Wind Electric Power for Social and Economic Development (Alizes Electriques)	Climate Change	UNDP	Full Size Project	2,000,000.0	73,552.0	Project Closure
2386	Mauritania	Adrar Solar Initiative and Decentralized Electrification in the Northern Coastline of Mauritania through Hybrid (Wind/Diesel) Systems	Climate Change	UNDP	Full Size Project	2,700,000.0	9,357,000.0	Council Approved
646	Morocco	Market Development for Solar Water Heaters	Climate Change	UNDP	Full Size Project	2,965,000.0	2,400,000.0	IA Approved
647	Morocco	Integrated Solar Combined Cycle Power Plant (formerly Solar Based Thermal Power Plant)	Climate Change	IBRD	Full Size Project	43,200,000.0	70,460,000.	IA Approved
935	Namibia	Barrier Removal to Namibian Renewable Energy Programme, Phase I	Climate Change	UNDP	Full Size Project	2,600,000.0	4,730,000.0	IA Approved
2256	Namibia	Barrier Removal to Namibian Renewable Energy Programme (NAMREP), Phase II	Climate Change	UNDP	Full Size Project	2,600,000.0	7,636,000.0	IA Approved
2918	Rwanda	Sustainable Energy Development Project (SEDP)	Climate Change	IBRD	Full Size Project	4,500,000.0	22,350,000.0	CEO Endorsed
118	Senegal	Sustainable and Participatory Energy Management	Climate Change	IBRD	Full Size Project	4,700,000.0	15,200,000.0	Project Closure
921	Senegal	Electricity Services for Rural Areas Project	Climate Change	IBRD	Full Size Project	5,000,000.0	115,580,000.0	Project Closure

GEF ID	Country	Project Name	Focal Area	GEF Agency	Project Type	GEF Grant	Co financing Total	Project Status
805	South Africa	Solar Water Heaters (SWHs) for Low-income Housing in Peri-Urban Areas	Climate Change	UNDP	Medium Size Project	727,500.000	4,702,500.0	IA Approved
19	South Africa	Concentrating Solar Power for Africa (CSP-Africa)	Climate Change	IBRD	Medium Size Project	230,000.000	180,000.0	Project Closure
1311	South Africa	Pilot Production and Commercial Dissemination of Solar Cookers	Climate Change	UNDP	Medium Size Project	800,000.0	2,850,000.0	Project Closure
1338	South Africa	South Africa Wind Energy Programme (SAWEP), Phase I	Climate Change	UNDP	Full Size Project	2,000,000.0	8,565,187.0	IA Approved
1894	South Africa	Renewable Energy Market Transformation (REMT)	Climate Change	IBRD	Full Size Project	6,000,000.0	11,300,000.0	IA Approved
1196	Tanzania	Transformation of the Rural Photovoltaics (PV) Market	Climate Change	UNDP	Full Size Project	2,250,000.0	4,734,071.0	IA Approved
2903	Tanzania	Tanzania Energy Development and Access Project (TEDAP)	Climate Change	IBRD	Full Size Project	6,500,000.0	32,300,000.0	IA Approved
86	Tunisia	Solar Water heating	Climate Change	IBRD	Full Size Project	4,000,000.0	16,900,000.0	Project Closure
967	Tunisia	Private Sector Led Development of On-Grid Wind Power in Tunisia	Climate Change	UNDP	Full Size Project	10,250,000.0	95,735,000.0	IA Approved
295	Uganda	Uganda photovoltaic pilot project for rural electrification	Climate Change	UNDP	Full Size Project	1,800,000.0	1,800,000.0	Project Closure
787	Uganda	Rural Energy for Development	Climate Change	IBRD	Full Size Project	8,900,000.0	232,000,000.0	Council Approved
1831	Uganda	Energy for Rural Transformation Project (APL)	Climate Change	IBRD	Full Size Project	12,100,000.0	111,100,000.0	IA Approved

GEF ID	Country	Project Name	Focal Area	GEF Agency	Project Type	GEF Grant	Co financing Total	Project Status
3892	Uganda	Energy for Rural Transformation Project II	Climate Change	IBRD	Full Size Project	9,000,000.0	84,000,000.0	CEO Endorsed
1358	Zambia	Renewable Energy-based Electricity Generation for Isolated Mini-grids	Climate Change	UNEP	Full Size Project	2,950,000.0	4,556,000.0	IA Approved
1607	Zambia	Increased Access to Electricity Services	Climate Change	IBRD	Full Size Project	4,500,000.0	22,100,000.0	IA Approved
Sub totals						**232,878,061.0**	**912,231,418.0**	**37 Projects**

Annex 12: Consolidated Results of Potential Clean-energy Project Opportunities for Sub-Saharan Africa (All) [Gouvello, et al, 2008]

Technology	No. of projects	Projects' emissions reductions: millions tCO_2/yr	Projects' emissions reductions: % of country total	Reductions over projects' life span (millions tCO_2)[1]	Value of projects' emissions reductions (millions US$): US$5/tCO_2	Value of projects' emissions reductions (millions US$): US$10/tCO_2	Electricity generation: Projects (GWh/yr)	Electricity generation: Projects (% country total)	Added power of projects (MW): 90% load factor	Added power of projects (MW): % of total installed	Total investment cost of projects (billions US$)
Second-cycle addition to open-cycle gas turbine	204	36.1	5.3	360.8	1,804.0	3,608.1	51,912	0	5,931	8.6	7.1
Combined heat and power for industry	373	72.9	10.7	729.4	3,647.0	7,294.0	156,314	0	17,844	25.9	17.8
Combined heat and power in sugar mills	67	2.4	0.4	24.4	122.1	244.2	3,489	0	661	1.0	1.0
Agricultural residue	553	140.8	20.7	1,408.4	7,042.2	14,084.3	216,842	1	27,504	40.0	38.5
Forest residue[2]	321	62.6	9.2	625.8	3,128.9	6,257.9	98,415	0	12,483	18.1	17.5
Wood-processing residue[2]	406	20.3	3.0	203.4	1,029.9	2,053.9	31,987	0	4,057	5.9	5.7
Typha australis	40	3.1	0.5	31.0	155.1	310.3	4,675	0	593	0.9	0.8
Jatropha biofuel	555	176.8	26.0	3,712.0	18,560.0	37,120.0	218,767	1	27,748	40.3	53.6
Hydroelectricity	26	25.2	3.7	528.6	2,643.1	5,286.3	35,961	0	6,443	9.4	9.4
Landfill gas	3	0.9	0.1	9.0	44.8	89.6	49	0	10	0.0	0.0
Grid-loss reduction	20	1.1	2.2	11.3	56.6	113.2	31,974	0	4,056	5.9	--
Non-lighting electricity for industry	20	1.5	0.2	1.4	6.9	13.9	5,837	0	740	1.1	--
Switch to compact fluorescent lamps	49	13.3	2.0	132.7	663.4	1,326.8	17,269	0	15,246	22.1	4.8
Energy-saving household appliances	30	7.4	1.1	74.4	372.0	744.0	11,131	0	1,412	2.1	--
Flared gas recovery	55	91.8	13.5	917.6	4,588.0	9,176.1	353,409	1	44,826	65.1	--
Coal mine methane	18	2.5	0.4	24.7	123.6	247.2	809	0	109	0.2	0.1
Waste gases in crude oil refinery	26	4.3	0.6	43.4	216.9	433.8	5,777	0	659	1.0	0.9
Improved steam system	211	36.6	5.4	366.4	1,831.8	3,663.6	--	--	--	0.0	--
Reduced clinker use in cement manufacturing	46	2.8	0.4	28.4	142.1	284.1	--	--	--	0.0	0.1
Shift to Bus Rapid Transit (BRT)	63	12.4	1.8	260.2	1,301.0	2,602.0	--	--	--	0.0	--
Biodiesel from Jatropha	60	3.2	0.5	66.2	330.9	661.8	--	--	--	0.0	--
Improved charcoal production	68	22.5	3.3	224.8	1,123.8	2,247.5	--	--	--	0.0	0.2
Reduced methane leakage in pipelines[3]	13	0.1	0.0	0.7	3.6	7.2	--	--	--	0.0	--
Total	**3,227[4]**	**740.7**	**109.0**	**9,785.0**	**48,937.8**	**97,869.7**	**1,244,618**	**4**	**155,078**	**225.3**	**157.6**

Note: In 2003, the region's total electricity generation was 327,079 GWh per year and total installed power was 68,841 MW.

[1] With regard to projects' life span, a carbon-crediting period of 21 years was used for Jatropha biofuel, hydroelectricity, shift to BRT, and biodiesel from Jatropha; for all other technologies, a 10-year crediting period was assumed.

[2] Results for forest and wood-processing residues are disaggregated in this table.

[3] This technology does not have a corresponding chapter section.

[4] The 3,227 projects include 361 Programs of Activities.