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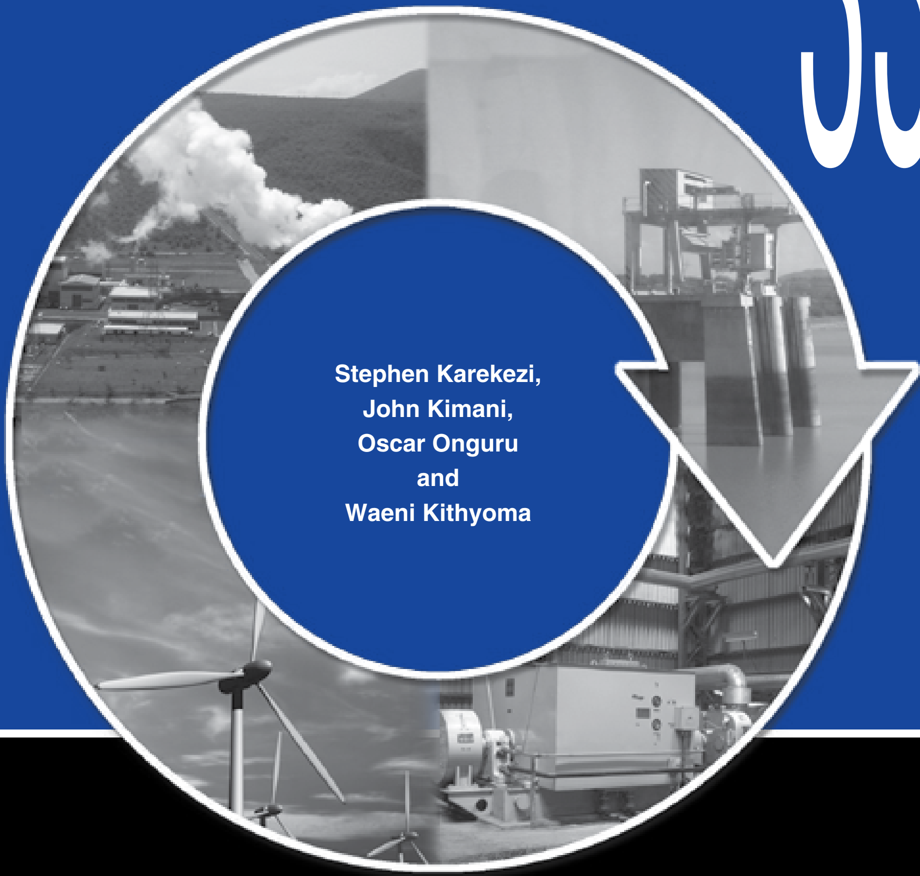
HEINRICH BÖLL STIFTUNG
EAST & HORN OF AFRICA

OCCASIONAL PAPER

No. 33

Large Scale Hydropower, Renewable Energy and Adaptation to Climate Change:
Climate Change and Energy Security in East and Horn of Africa



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Large Scale Hydropower, Renewable Energy Adaptation and Climate Change:

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About AFREPREN/FWD

Who is AFREPREN/FWD

AFREPREN/FWD is a registered Non-Governmental Organization (NGO) based in Nairobi, Kenya, with vast expertise on energy in East and Southern Africa and some experience in West and North Africa.

AFREPREN/FWD, brings together over 300 African energy researchers and policy makers from Africa who have a long-term interest in energy research and the attendant policy-making process. AFREPREN/FWD has initiated policy research studies in 19 African countries namely: Angola, Botswana, Burundi, Eritrea, Ethiopia, Kenya, Lesotho, Malawi, Mauritius, Mozambique, Rwanda, Seychelles, Somalia, South Africa, Sudan, Tanzania, Uganda, Zambia and Zimbabwe. AFREPREN/FWD also maintains close collaborative links with energy researchers and policy makers from Cote D'Ivoire, Ghana, Nigeria, Sierra Leone and Senegal.

AFREPREN/FWD has a separate consultancy arm registered as African Energy Policy Research Network Limited.

Objective

The key objective of the Energy, Environment and Development Network for Africa (AFREPREN/FWD) is to strengthen local research capacity and to harness it in the service of energy policy making and planning . Initiated in 1987, AFREPREN/FWD is a collective regional response to the widespread concern over the weak link between energy research and the formulation and implementation of energy policy in Africa.

Who Sets the Agenda of AFREPREN/FWD?

AFREPREN/FWD members decide on the structure, direction and mode of operation of the Network. A Secretariat, established in Nairobi, Kenya, coordinates the research program of AFREPREN/FWD and provides the requisite administrative and technical support.

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HEINRICH BÖLL STIFTUNG
EAST & HORN OF AFRICA

About Heinrich Böll Foundation

The Heinrich Böll Foundation (HBF) is the Green Political Foundation, affiliated to the "Greens / Alliance '90" political party represented in Germany's federal parliament. Headquartered in Berlin and with offices in more than 25 different countries, HBF conducts and supports civic educational activities and projects world-wide. HBF understands itself as a green think-tank and international policy network, working with governmental and non-governmental actors and focusing on gender equity, sustainable development, and democracy and human rights. HBF's Regional Office for East & Horn of Africa operates in Nairobi, Kenya, since 2001.

HBF is committed to develop and promote concepts to combat dangerous climate change, taking seriously the principle of "common but differentiated responsibilities" as stated in the United Nations Framework Convention on Climate Change (UNFCCC).

While having contributed next to nothing to climate change, Africa is the continent that will be hit hardest by it. At the same time, Africa's poor have the least capacity to adapt. Support for mitigation and adaptation action in Africa, therefore, is a matter of global climate justice.

- HBF supports the **"Appeal: Africa Speaks Up on Climate Change"** under the auspices of 2004 Nobel Peace Price laureate Prof. Wangari Maathai (www.africanclimateappeal.org).
- HBF produced the video documentation **"Hotspots: The Consequences of Climate Change in Africa"** (http://www.hbfha.com/web/103-173.html).
- HBF promotes the **"Greenhouse Development Rights Framework"** (GDR) as an innovative concept for an equitable financing of climate change-related mitigation and adaptation costs (http://www.hbfha.com/web/103-154.html).
- HBF supports the provision of **current and critical information about the emerging global climate change-related financing structures** (http://www.climatefundsupdate.org/).

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Executive Summary

Key challenges facing the economies of East and Horn of Africa region include the recurrent droughts (thought to be linked to climate change) which have had negative impacts on the region's power sector. Drought induced reduction in hydropower generation has become a persistent feature in the region's power sector. The adverse impacts of what is thought to be "climate change-related" power crises have had far reaching and devastating impacts on both the power sectors and the economies of the countries within the East and Horn of Africa region. These impacts are expected to become even stronger in the next years; hence their consequences are likely to become ever more serious as well.

As a result, during power crises, the most common response option from governments in the East and Horn of Africa region has been to procure very high cost emergency thermal electricity to meet the shortfall in power supply.

As was witnessed in Uganda between 2004 and 2006, the reduction in water levels at Lake Victoria resulted in reduction in hydro-power generation by 50 MW and this led to the adjustment of the GDP growth rate from 6.2% to 4.9% (Baanabe, 2008). The country had to turn to costly thermal generators to ease the supply deficit. During this period, electricity supply was more intermittent than usual, and the price of electricity increased.

In Kenya, Tanzania and Ethiopia, drought-related power shortages and their impacts were similar to Uganda.

Table 1: Impact of Emergency power generation on GDP

Country	Date	Contract Duration (MW)	Emergency Capacity	Percentage total installed capacity (%)	Estimated annual cost as % GDP	Drought Related?
Rwanda	2005	2 years	15	48.4	1.84	Yes
Uganda	2006	2 years	100	41.7	3.29	Yes
Tanzania	2006	2 years	180	20.4	0.96	Yes
Kenya	2006	1 year	100	8.3	1.45	Yes

Source: Eberhard et al, 2008

Tanzania announced a major power load-shedding that has adversely affected industrial and commercial sectors. In Kenya, the drought that occurred between 1999 and 2002 drastically affected the hydro power generation and in the year 2000, hydropower generation was reduced by 25% capacity. The resultant cumulative loss was variously estimated to be about 1-1.5% of the total GDP (Karekezi and Kithyoma, 2005).

Kenya's GDP is equivalent to US$ 29.5 Billion; the estimated loss during the aforementioned drought induced power crisis was about 1.45% of GDP. This translates to US$ 442 Million lost which could have been used to install 295 MW of new renewable power capacity (assuming a MW installed costs US$ I.5 million per MW).

That is almost 3 times the installed emergency power capacity from diesel and it is twice the loss of hydro power during drought periods. If Kenya had invested the US$442 million in renewable power option the crisis could have been largely avoided.

Governments and electricity utility companies within the East and Horn of Africa region need to adopt more robust, resilient and well thought out response options for addressing drought induced power crises. A key response option is the adoption of mature renewable energy technologies that provide multiple benefits. Renewables are ideal candidates for development as complements to hydropower generation. Renewable energy options such as geothermal, small hydro, biomass cogeneration and wind are attractive since the resources are widely available in the region. These options are not only environmentally friendly but also provide additional developmental benefits such as job creation and reduction of oil import bills.

In light of the drought related problems facing the power sector in the East and Horn of Africa region, and the environmental, commercial and social benefits of the aforementioned renewable energy options, this study[1] calls for an urgent implementation of renewable energy options in the East and Horn of Africa region. The development of renewables can protect the region's power from what is thought to be climate change induced drought that affects its hydroelectric power generation. It is worth noting that, although large-scale hydro is a renewable energy, it is likely to be more vulnerable to the impacts of drought than decentralized approaches.

1 The study involved desk studies and computer based data collection on climate change patterns and impacts on large-scale hydropower. This report largely focused on climate change with respect to the centralized power sector i.e. the impacts of climate change on national grid-based electricity generation in the East and Horn of Africa Region.

In addition, there are additional benefits of investing in renewable energy as a precautionary measure to the drought that affects the power sector in the region. These benefits include;

(i) Greater energy security through wider use of locally available and more secure renewable energy resources such as geothermal, small hydro, biomass cogeneration and wind. Some of these renewables are available even during periods of drought.
(ii) Higher job creation potential of renewables.
(iii) Poverty reduction benefits of renewables. This is particularly true of small-scale renewables that are made locally and operate on the basis of solar, thermal or animate power that can be used by local communities for income generation activities.
(iv) Rural development benefits of renewables. As the bulk of renewable resources are found in rural areas, investment in renewables would result in increased rural development.

To better illustrate the potential benefits of renewables, this report provided examples of two specific renewable options with a track record of offering viable and sound alternatives to hydropower generation. These technologies are cogeneration and geothermal power.

As earlier mentioned, over the last couple decades, there have been severe droughts that affected hydropower generation in all East and Horn of Africa countries from the late 1990s to date. However, countries using renewables to diversify sources of electricity generation appear to survive the impacts of severe droughts better than those that rely almost exclusively on hydropower for electricity generation.

For example, In comparison to Uganda and Ethiopia, Kenya appears to be more resilient to drought induced power generation shortfalls. This is largely due to the fact that Kenya has a higher level of diversification of its electricity generation sources mainly through the promotion and use renewable energy such as geothermal, biomass-based cogeneration and to a lesser extent, wind energy. As a result, Kenya's electricity supply is more secure in comparison to the neighboring countries.

An important renewable that has contributed to the resilience and adaptation of Kenya's energy sector to drought induced power generation shortfalls is geothermal energy. Just over 10% of the Kenya's electricity generation is from geothermal energy. During the recent droughts in the country, geothermal energy played a critical role as it continued to operate at nearly 100% availability when many of the hydropower stations in the country were crippled by the dry spell.

Mauritius provides a very good example of a highly successful use of cogeneration to limit investment in oil fired thermal generation, thereby limiting a country's exposure high cost of oil imports, especially for electricity generation. Mauritius currently meets over 20 per cent of its electricity demand using bagasse from the sugar industry. Over the 10-year period (1993-2002), the installed capacity of the sugar industry located power plants increased from 43 MW to 242 MW with the concurrent increase in electricity exported to the grid. In the early years i.e. in 1996. 119 GWh of electricity from bagasse based cogeneration was exported to the national grid. This was achieved through investment mostly by private sugar mills implementing cogeneration technology with their own private funds. By the year 2002, co-generated electricity increased significantly with investment in more efficient bagasse-to-electricity processes and in a greater number of units, so much so that the electricity exported to the grid from bagasse increased to 300 GWh and the total electricity exported from the sugar industry rose to 746 GWh in 2002, representing about 43.5% of the total electricity exported to the grid for the island (Deepchand, 2006).

It can therefore be argued that renewable energy systems offer diversification in energy supply, thus strengthening energy security by broadening national energy generation portfolios. Countries with diversified energy generation sources are better-off compared to those which heavily depend on centralized large-scale hydro or conventional thermal plants that use imported petroleum fuels which have a degree of uncertainty in supply and cost. Based on the study's findings, the following are some of the key recommendations that will assist the fast tracking of renewables based power in the East and Horn of Africa:

Institution of attractive and pre-determined feed-in tariffs and standard Power Purchase Agreements (PPAs) for co-generated power: A standard PPA can limit market uncertainty, which stands in the way of substantial investment in renewables 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 renewable energy plants can African power sector (UNEP/GEF, 2006).

Innovative Financing: Innovative financing schemes should be developed by financial institutions in collaboration with project developers. Interaction between financiers and project developers could help bridge the knowledge gap on both sides – financiers would gain a better understanding of renewables while project developers would have a better appreciation of pre-requisites for raising financing for renewable energy investments. Bundling of smaller/medium sized projects would help them access funds that have minimum investment caps, and lower the upfront cost of financing.

African countries can tap into the various international and regional initiatives that can provide funding for renewable energy investments. These initiatives include: the Global Environment Facility (GEF) and the Kyoto Protocol's Clean Development Mechanism (CDM). One drawback of the CDM, however, is its high transaction costs and specialized skills requirements that have tended to limit the participation of African countries and experts to date.

Innovative Revenue-Sharing Mechanisms: One way of ensuring support for the development of renewables is by instituting appropriate revenue-sharing mechanisms. The benefits of renewables such as biomass cogeneration should trickle down to the small-scale farmer involved in growing the feedstock. A model revenue sharing mechanism has been implemented in Mauritius, where proceeds from the sale of co-generated electricity are shared equitably among the key stakeholders - including the small-scale farmers who provide sugar cane to the factories. Similar revenue sharing mechanisms can be used as incentives for local participation in developing geothermal resources and other renewables, and are useful for building local support for scaled-up renewables development.

Profile of Authors

Stephen Karekezi is the Director of Energy Environment and Development Network for Africa (AFREPREN/FWD). He holds a MSc. in Management from Birmingham University, U.K. and a BSc. In Engineering from the Loughborough University, UK, and has close to 20 years experience in the energy sector. From 1995 to 2002, he was on the Scientific and Technical Advisory Panel (STAP) of the Global Environment Facility (GEF). He has served on the Partner Board of the Global Village Partnership as well as the Board of Trustees for the Centre for International Forestry research, a CGIAR (Consultative Group on International Agricultural Research) member-institution. Credited with over 100 publications and reports on sustainable energy and associated environmental issues, Mr. Karekezi received the Development Association Award in Sweden in 1990 for his work on efficient household energy technologies in Africa. Mr. Karekezi is currently coordinating the implementation of a clean energy initiative known as 'Cogen for Africa' project which aims to increase power supply reliability in sugar factories in the African region and in the process reduce green house gas emissions.

John Kimani is a graduate in Economics and Sociology from Egerton University, Kenya. He is a Senior Programme Manager, Power Sector Specialist and Lead Energy Economist at AFREPREN/FWD. His main responsibilities include developing and managing the AFREPREN/FWD energy database, coordinating Energy Sector Reform Studies and Special Studies. He has assisted in the writing of numerous research papers and publications and co-authored and edited publications and reports on the African power sector, renewables and African energy data. He has also assisted in the coordination of an international team of researchers from Centres of Excellence in developing countries working on the "Energy Access" Theme under the auspices of the Global Network on Energy for Sustainable Development (GNESD). Mr. Kimani is also currently involved in the implementation of a clean energy initiative known as the 'Cogen for Africa' Project which aims to increase power supply reliability in sugar factories in the African region and in the process reduce greenhouse gas emissions.

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Oscar Onguru holds a Diploma in Building and Civil Engineering and a Higher National Diploma in Building and Civil Engineering from The Kenya Polytechnic University College. Mr. Onguru is a Project Officer at AFREPREN/FWD in Nairobi. He has undertaken extensive research on renewable energy and technologies with specific emphasis on small scale renewables and how they can benefit the poor. He has co-authored several energy reports and articles on renewable energy, urban poor energy access, energy security in Africa, climate change and energy security in Africa and short papers on different kinds of renewable energy technologies in Africa.

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Chapter 1: Introduction to the study

Energy is considered an essential ingredient for economic growth and social development in the East and Horn of Africa region. The growth of energy demand is often driven by several factors namely, population growth, economic growth, urbanization, rural energization programmes, increasing penetration of energy intensive appliances and industrialization. Energy is consumed by all sectors of the economy and therefore growth in the economies of countries in the region leads to a consistent rise in the quantity of energy consumed. While the region is experiencing significant growth in energy demand, energy supply appears to have stagnated or dwindled. The security of energy supply especially electricity generation in East and Horn of Africa seems to be threatened by climate change induced phenomenon[2], chief among them, drought (Karekezi and Kithyoma, 2005; GoK 2004; GoK 2005; GoK 2006; GoK 2007; GoK 2008).

There is growing evidence of a relation between climate change and energy security within the East and Horn of Africa region. For example, varying rainfall patterns have led to severe drought and, in some cases unprecedented flooding, affecting almost all the countries in the East and Horn of Africa region. Since electricity generation in the region is largely dependent on hydro, the advent of drought severely affects the power sector leading to massive load shedding programmes and massive losses in the region's economies. On the other hand, excessive flooding contributes to a rapid siltation build up in hydropower dams thereby affecting the amount of water available for electricity generation.

The recurrence of what appears to be climate change related power crises in the region is an area that has drawn significant interest from policy makers, energy practitioners and the general public. It is against this background that AFREPREN/FWD, with support from the Heinrich Boll Foundation (HBF), launched a regional study on these issues covering East and Horn of Africa. The study analyzed, in depth, climate change and its possible impacts on energy security in the region with a specific focus on the power sector.

2 The primary cause of global warming is known to be the high concentration of greenhouse gases trapped within the atmosphere. There have been studies showing that the gases trap the heat from the sun thereby preventing them from escaping through the ozone layer. The subsequent result is the creation of the greenhouse effect, which in the process, increases the earth's temperature.

1.1 Study Objectives and Justification

The impacts of drought (which in turn, is thought to be due to climate change) related hydropower crises and the possible response options is the subject of this study. The objectives of the study are to:

i) Assess the impact of drought-related power crises on national economies, national energy security and low-income electricity users;
ii) Recommend energy supply and adaptation strategies (focusing on renewables) for government and end users that strengthen power supply security;
iii) Suggest options for improving the capacity of national governments/utilities to integrate climate change impacts into their energy planning;

The justification for this study is that there are no known widely publicized regional studies that have focused on the linkage between climate change and energy security in East and Horn of Africa. Drought related power crises constitute a key energy security-related climate change impact in the region that has not been investigated in detail (Magadza, 2000). Furthermore, there is no major study that has examined the link between climate, energy security and the poor in East and Horn of Africa. As noted in the 2001 IPCC report, "Impacts, Adaptations, and Vulnerability", *".. Disruption of energy supplies will have ripple effects in the social fabric through impacts in economic activity."*

1.2 Methodology

The study involved desk studies and computer based data collection on climate change patterns and impacts on hydropower within the East and Horn of Africa region. The methods used to achieve the study objectives involved the following:

Data and statistics compilation: This involved compiling existing data and statistics on large hydro and the contribution of large hydro to the power sector of the countries in the region[3] An important data resource was an AFREPREN-FWD/ REEEP/ University of Warwick database on energy and power sector in Africa (See Appendix 4) that AFREPREN-FWD continues to update and refine.

Literature review: A review of available statistical publications on energy, the power sector, renewables and poverty, and research reports and publications on climate change as well as the contribution of renewables to the power sector in the region was undertaken.

Review of Power Master Plan, Energy Policy and Rural Electrification Master Plan: This involved an analytical review of current energy policies, power master plan as well as rural electrification master plans of the countries in the region, where the documents were available.

The key challenges and limitations in undertaking the study was the limited time and availability of data. The study duration was brief (9 months) and limited the level of detailed analysis. Access to recent data and information was difficult, especially information regarding the direct impacts of climate change to the power sector in the East and Horn of Africa region. In addition, information that was available was based on a few empirical studies and not on a regional comprehensive assessment of the power sector.

Government sources and other reports often provide different and conflicting definitions and figures on climate change and its effects to the power sector. However, efforts were made to compile available data and estimates, and present hypotheses that could be subjected to further testing subject to availability of resources[3].

1.3 Structure of the report

Chapter 1 introduces the study, highlighting the study objectives and the justification for the study. The methodology employed in undertaking the study is also presented.

Chapter 2 presents the characteristics of East and Horn of Africa countries and discusses the socio-economic similarities, the importance of energy in the region and the developments in the power sectors of the different countries in the region.

Chapter 3 defines climate change and reviews the increasing evidence of climate change in the region. In addition, this chapter discusses climate change models and scenarios mainly used in Africa, highlighting the data requirements and the difficulty of accessing the data in Africa. This chapter also examines the projected impacts of climate change as well as the vulnerability of East and Horn of Africa countries to climate change effects. The final two sections of this chapter discuss the role and benefits of adaptation to climate change and the impacts of climate change on energy.

Chapter 4 is a brief analysis of the impacts of drought on hydropower generation this chapter discusses the dependency of the region's power sector on hydro sources

3 A more thorough analysis of the issues discussed in this paper is expected to be undertaken in 2009, and is scheduled to be completed in late 2009. The analysis will address the key gaps in this study as well as provide more empirical evidence for testing the hypotheses proposed in this study.

and reviews the impact of drought on both the region's power sector and the national economies of East and Horn of Africa.

Chapter 5 discusses the "template" response options to drought related power crises that the respective Governments in the region have often adopted. The chapter reviews the National Adaptation Plans of Action (NAPAs) from the different countries and highlights the planned and implemented adaptation programmes and identifies gaps in the national adaptation programmes and proposed responses in the NAPAs. The chapter then discusses the benefits of renewables and proposes viable renewable energy options that can be developed for adapting to drought induced power crises in the region. This is illustrated by selected case studies of successfully implemented renewable energy technologies (RETs) that have been implemented and assisted african countries to adapt to drought related power crises.

Chapter 6 summarizes the key study recommendations for responding to drought related (and possibly climate change induced) electricity crises and how the various stakeholders can play their part. Areas of additional study are also proposed.

Chapter 2
Characteristics of the East and Horn of Africa Countries

2.1 Socio- Economic Characteristics of East and Horn of Africa

The economies of the East and Horn of Africa countries have recorded improved growth over the past few years. Many countries have predicted improved economic performance in the coming years but the recent global financial crisis is expected to lower economic growth rates. In addition, all the countries in the East and Horn of Africa region are experiencing rapid population growth rates accompanied by even more rapid urbanization. For example, in Kenya, it is estimated that 40% of the population is urban and nearly half of the entire population will be urban by the year 2020 (GoK, 2007; GoK, 2008). Rapid growth of the country's urban population has led to growing demand for energy services, in particular, electricity and refined petroleum products.

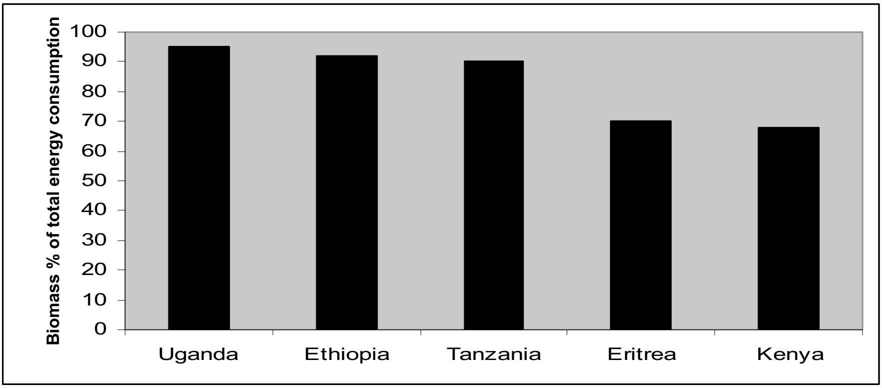
2.2 Energy Use in East and Horn of Africa

Being near the equator, all the countries in the East and Horn of Africa region enjoy long sunshine hours and have a daily average solar insolation of about 4.5–6.5 kWh/m^2 (Kiva, 2008; Baanabe, 2008; Mwihava, 2008).

The energy sector in the East and Horn of Africa region is characterized by two key factors - an over-reliance on traditional biomass energy resources (to meet the energy needs of most rural households), and a heavy dependence on imported petroleum (which meets the demand of the modern economy). In Kenya, biomass accounts for up to 68% of the total energy consumed (See appendix 4) and this pattern is replicated in several other East and Horn of African countries as shown in Figure 1.

The consumption of modern energy in the region is still very low in spite of the growth of respective national economies. This is demonstrated by very low levels of electricity consumption for example, the per capita consumption of electricity in Tanzania is alarmingly low and stands at 65 kWh (Mwihava, 2008), which is about 2.4 % of world consumption of 2,751 kWh/per capita. The picture looks even grimmer in the case of Uganda. Only 10% of the population has access to electricity and the per capita electricity consumption stands at 44 kWh (Baanabe, 2008). Kenya's per capita

Figure 1: *Biomass energy as a percentage of total energy for selected Eastern and Horn of African countries (2005)*



Source: Karekezi et al, 2004; IEA, 2007

electricity consumption is estimated at 128 kWh per capita (GoK, 2004) which is the highest in the region but still very low (See appendix 3) compared to the global average of 2,751 kWh per capita (World Bank, 2007). Table 1 shows the electricity access levels and the per capita electricity consumption in the region, which demonstrates that a large portion of the population has no access to electricity.

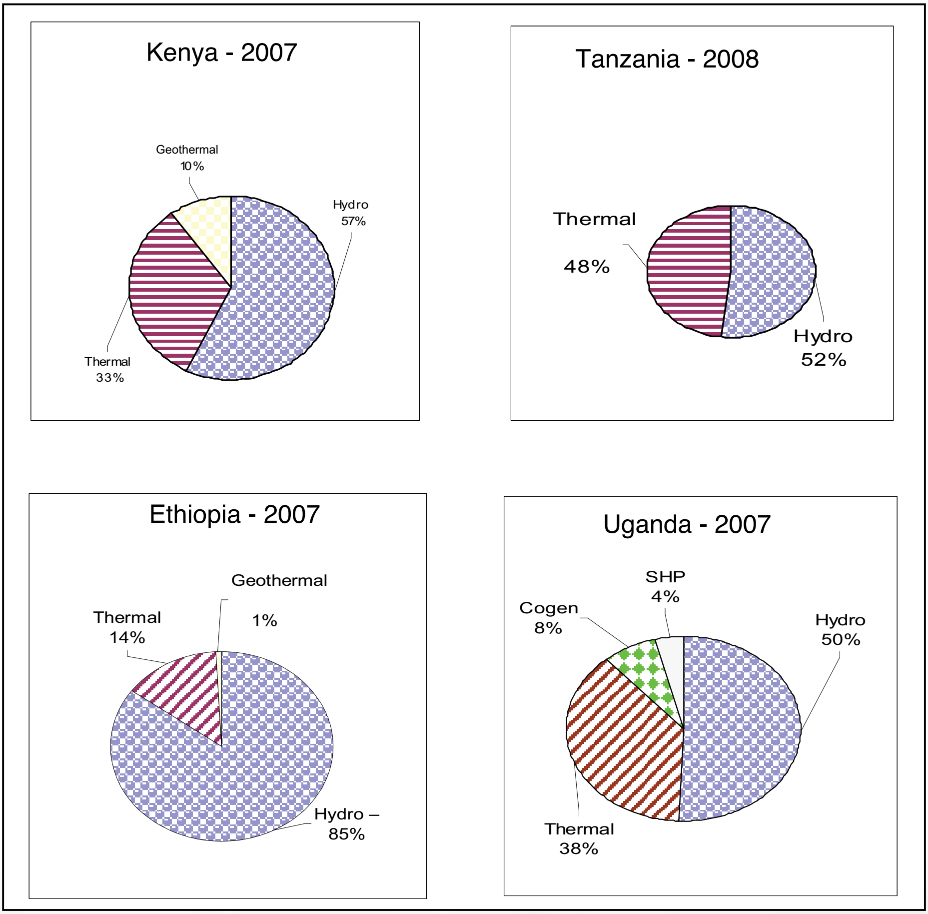
Table 2: *Electrification Levels in East Africa (2006)*

Electricity Access Levels	Kenya	Tanzania	Uganda	Ethiopia*	World Average**
National %	16	12	10	17	
Urban %	51	39	47	86	
Rural %	5	2	3	2	
Electricity consumption per capita	**128 kWh**	**65 kWh**	**44 kWh**	**40 kWh**	**2,751 kWh**

*2005 data
** 2007 data
Source: World Bank, 2007; World Bank, 2007b, AFREPREN/FWD, 2008, GoK, 2004; Baanabe, 2008; Mwihava, 2008.

The main source of electricity in the East and Horn of Africa region is hydro. All the countries record over 50% dependency on hydro power generation, with Ethiopia's power sector being the most dependent with 85% of total electricity generation coming from large hydro sources. Figure 2 presents the level of hydro electricity generation in the respective countries:

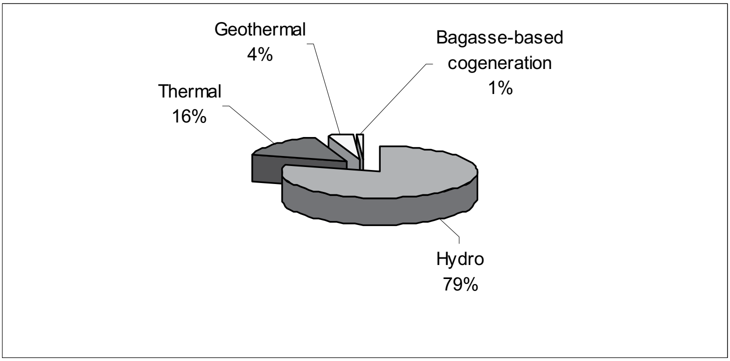
Figure 2: *Electricity generation in East and Horn of Africa*



Source: GoK, 2008; IEA, 2008

This high level of dependency on hydro electric power generation is also replicated at regional level. Figure 3 shows the different sources used for electricity generation in the region, demonstrating the extent to which the region's power sector is dependent on hydro-electric power generation[4].

Figure 3: *Electricity Generation in East Africa*



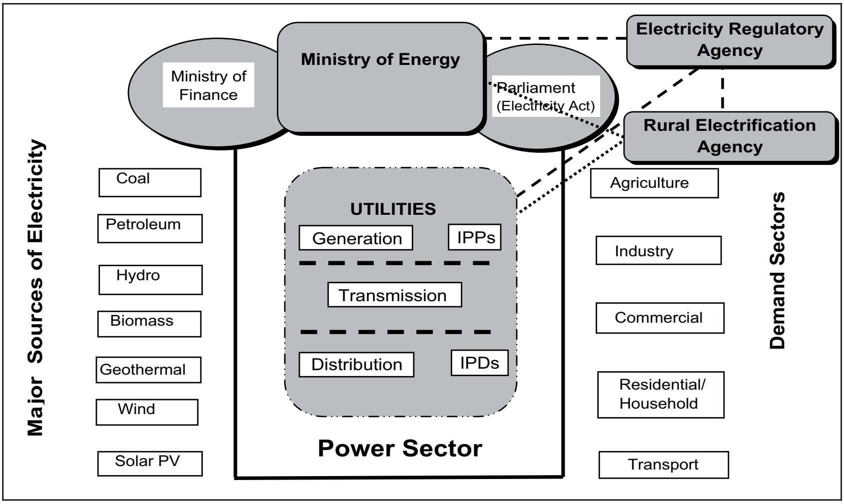
Source: IEA, 2007

4 Hydropower has a number of drawbacks. Hydropower projects in Africa have generally been large-scale and require relatively large loans, contributing to high external debt levels. Since large hydro projects are usually donor funded through development loans, the repayment of these loans normally consumes a large portion of the countries foreign exchange reserves. Large hydro projects directly benefit only a small section of the population i.e. the middle and upper class with access to electricity, which leads to inequitable distribution of resources in the economy. In addition, the large amounts of capital involved have attracted allegations of corruption. This has often led to the stalling or lengthy delays in many hydro power projects.

2.3 Developments in the power sector

Figure 4 illustrates the typical institutional structure of the power sector prevailing within the region.

Figure 4: *Typical Institutional Structure of the Power Sector*



KEY:
IPPs = Independent Power Producers
IPDs = Independent Power Distributors
Source: Compiled by authors

The institutional structure shown in Figure 4 depicts an idealized reformed power sector. Prior to power sector reforms, the Electricity Regulatory Agency, IPPs and IPDs were non-existent. With the on-going reforms, IPPs and IPDs appear in the institutional framework alongside the state-owned utility at generation and distribution levels. In addition, the Electricity Regulatory Agencies have been established as independent bodies with "arms-length" relationships with the Ministry of Energy as well as the state-owned and private utilities.

Another important development is the establishment of Rural Electrification Agencies whose responsibilities have been to increase access to electricity among the rural population through investments in electricity transmission and distribution infrastructure and, in some cases, subsidising capital investment in rural electricity generation. Kenya, Uganda and Tanzania have established rural electrification entities.

Power sector reforms have transformed the Parliaments in the region into a crucial institution in the sector due to parliaments' mandate of formulating and amending the Electricity Acts that govern the power sector. The Ministry of Energy[5] has continued playing a significant role in the reformed power sector by ensuring that the policies are in line with the overall objectives of power sector-reforms. The Ministry of Finance is also an important institution in the framework playing the role of making key financing and investment decisions within the power sector.

In addition, Governments' expenditure on the electricity sector has started to rise. For example, in Kenya, over the last 5 years, the Government has increased budget allocation to the electricity sector. It has reactivated the rural electrification programme and set ambitious targets which have seen the total number of electrified customers in the country rise by 117% from a low of 426,500 in 1997 to about 924,329 customers in the year 2007 (KPLC, 2007).

The following chapter discusses climate change and its impacts on the region's economy in general and the region's energy sector in particular. The projected risks associated with climate change and the extents to which the power sector of countries in the region are vulnerable to impacts of climate change are discussed. This chapter ends up with a description of the climate models and scenarios available.

Conclusion:
This chapter provides an overview of the characteristics of the countries in East and Horn of Africa. The general consensus is that the region is heavily dependent on hydropower generation, one of the reasons for the high levels of vulnerability to drought (which may be climate change related) in East and Horn of Africa.

5 For some countries in Africa, the Ministries in charge of the energy sector may not always be the Ministry of Energy. Others could be: - Ministry of Natural Resources or Ministry of Mines and Energy.

Chapter 3
An Overview of Climate Change and Its Impacts

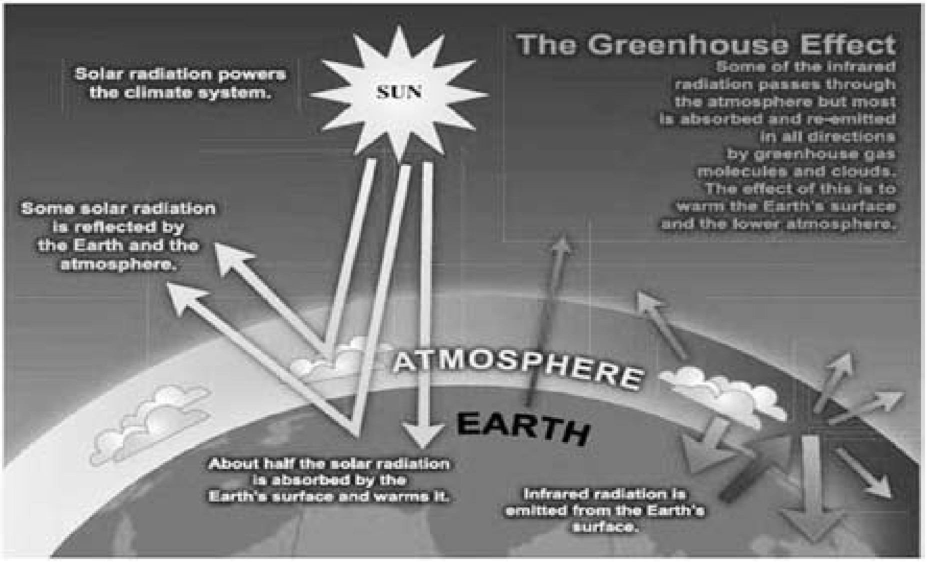
3.1 What is Climate Change?

There are several definitions that can be used to define climate change. According to a leading researcher, Von F. Diederichs, climate change can be described as "the variation in the earth's global climate or in regional climates over time which involves changes in the variability or average state of the atmosphere over durations ranging from decades to millions of years. These changes can be caused by dynamic processes on the earth, external forces including variations in sunlight intensity, and more recently by human activities" (Diederichs, v.F, 2007).

In addition, several climatic factors (commonly referred to as climatic forcing) play a big part in changing and shaping climate. Factors such as the variation in solar radiation, greenhouse gases concentration in the atmosphere as well as the earth's orbit are commonly known for this. However, there are other non-climatic factors that also play a major role in shaping the climate. They include (Diederichs, v.F, 2007):

1. Greenhouse gas emissions,
2. Plate tectonics,
3. Solar variation,
4. Orbit variations,
5. Volcanism,
6. Aerosols

Figure 5: *Green House Effect*



Source: www.creationcaregr.com/images

Globally, scientists and researchers concede that accurate prediction of the specific impacts of climate change is yet to be realized. However, the majority of scientists, researchers and a large number of world leaders all agree that climate change is real and is already happening. To date, there is a growing body of relatively convincing evidence pointing at climate change. The following section briefly discusses recent climate change related developments in the world and within the East and Horn of Africa region and other parts of the African continent.

3.2 Evidence of Climate Change

Scientists recently confirmed that the Earth's average temperature has increased by approximately 0.74°C over the past century (UNEP, 2007). This rise in temperature is said to contribute to the rising sea-levels, increased frequency and intensity of heat waves, storms, floods and droughts experienced world over in recent years. For example, the Greenland and Antarctic ice sheets have recorded a decline in their area of coverage. Available data from NASA show that Greenland lost about 150 to 250 cubic kilometers (36 to 60 cubic miles) of ice per year between 2002 and 2006 (NASA, 2009).

Figure 6: *Melting Ice Sheet of Greenland*

Source: (NASA, 2009)
http://globalclimatechange.jpl.nasa.gov/evidence/

The Antarctica is reported to have lost about 152 cubic kilometers (36 cubic miles) of ice during a similar period (2002 – 2005). In addition, there are increasing reports of disappearing mountain glaciers. To this end, there are fears that the Himalayas glaciers might be none existent by the year 2030 (NASA, 2009).

Nicholas Stern (2007) argues that "due to the increased melting of glaciers and the expansion of warmer oceans, sea levels are currently rising globally at around 3 mm per year and rapidly accelerating. According to the IPCC TAR, sea levels are projected to rise by 9 - 88 cm by 2100. However, because warming only penetrates the oceans very slowly, sea levels will continue to rise substantially more over several centuries" (Stern Review, 2007).

Furthermore, there are increased incidences of frequent wildfires globally, with the most notable being the wild bush fires in the Australian outback and in several States of the United States of America (USA). In the USA alone, the acreage affected by wildfires has increased from just over 700,000 acres in 2000 to over 1.3 million acres in 2008 (nearly 100% increase) largely attributed to climate change (NIFC, 2009).

Researchers and scientists studying climate change project that wildfires are more likely to increase. In addition, the number, duration and intensity of tropical storms are set to increase around the globe. This is thought to be mainly due to the distortion of weather patterns triggered by climate change that will lead to increased incidences of severe weather.

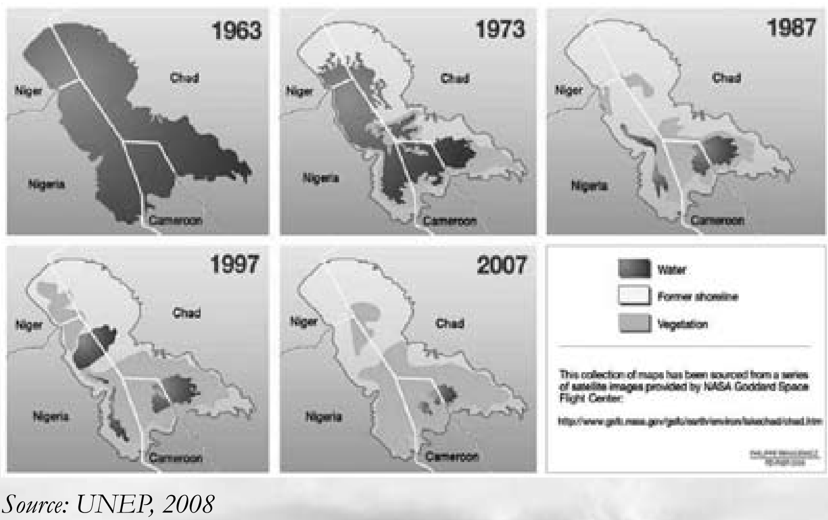
Within the East and Horn of Africa as well as other parts of Africa, there are recent events that provide significant evidence of occurrence of climate change. These events are discussed in the following sections:

3.2.1 Drought and Famine

Scientists and researchers attribute the recent increased incidences and intensity of drought and famine in the region to changes in rainfall patterns due to global warming (Stern Review, 2007). Increased evaporation has increased the risk of droughts in areas already at risk. Drought has severe effects in Africa due to the continent's low adaptive capacity. Some of the largest catchment basins of Niger, Lake Chad, and Senegal, are said to have been affected by climate change and currently, the total available water has decreased by 40 to 60 percent largely due to climate change and partially due to high demand for agricultural water (UNEP, 2007).

Figure 7 shows the satellite images from 1972 (on the left hand side) and 2007, of how water-levels have declined in Lake Chad, once the world's sixth largest fresh water lake. The lake is now one-tenth it's former size, due to drought and declining rainfall. Lake Chad was once a source of livelihood through fishing and irrigation. Its loss is reported to have resulted in lack of water, crop failures, livestock deaths, collapsed fisheries, increased soil salinity and increasing poverty (UNEP, 2008).

Figure 7: *Satellite Images of the Impact of Climate Change on Lake Chad*



Source: UNEP, 2008
http://www.unep.org/dewa/vitalwater/article116.html

In the East and Horn of Africa, frequent and recurrent episodes of drought in the past have resulted in huge losses of life and property, migration of people, loss of crops and livestock, decline in hydro electric power generation and displacement of wildlife across the continent (IPCC, 2001; Stern Review, 2007, RoE, 2007; RoR 2006 ; GoU 2007; URT 2007). In Uganda, for example, prolonged and severe droughts have led to low water levels in rivers, underground aquifers and reservoirs thereby affecting the hydrology, biodiversity and water supply. The most severe impacts of drought were felt during the drought of 2004/05, which led to a reduction of water levels in Lake Victoria and Nile River, leading to serious impacts on the entire economy (GoU, 2007).

Agriculturally productive areas in East and Horn of Africa experienced shortages in rain between years 2000 to 2004. Eritrea, Ethiopia, Kenya, Tanzania and Uganda had drought throughout this period. However, Tanzania did not experience shortage of rainfall in the year 2001 and Uganda in the year 2004 (World Bank, 2005).

3.2.2 Floods

An increase in flooding incidences as a result of sporadic and excess rainfall have been reported in recent times in East and Horn of Africa (GoU, 2007). Floods lead to waterlogged fields and washing away of crops, causing loss of food crops. Heavy and unpredicted rainfall in the region has also led to increased incidences of flash floods that have resulted in outbreaks of waterborne diseases such as diarrhea and cholera. Flooding has also contributed to the damage of critical infrastructure such as roads, power transmission and distribution lines, bridges and communication as well as displacing communities from their homesteads. Most countries in the East and Horn of Africa are dependent on hydropower generation. Floods affected their electricity generation capacity due to the rapid build up of silt in hydropower dams (Karekezi and Kithyoma, 2005). Figure 8 shows the impact of floods in one remote village in Uganda.

Figure 8: *Flooding in a Remote Village in Uganda*

Source: GoU, 2007

3.2.3 Shorter Rainy Seasons

The economies of the East and Horn of Africa are dependent on rain-fed agriculture. In recent years, the rainy seasons have become shorter than usual impacting negatively on food production in the region. For example, in Uganda, a large proportion of the population depends on streams, which have tended to dry up fast due to the shorter rainy seasons which do not produce enough water to regenerate the streams and rivers. This appears to have caused crop failures (GoU, 2007) (See appendix 6 for additional evidence) and serious water stress for a large proportion of the rural communities leading to migrations into neighboring districts. Figure 9 illustrates the impact of shorter rainy seasons on maize in Uganda. In addition, reduced income levels due to a decline harvests has triggered laying off of casual workers and subsequent loss of income for a large number of casual laborers.

Figure 9: *Maize Crop Failure Due to Shorter Rainy Seasons*

Source: GoU, 2007

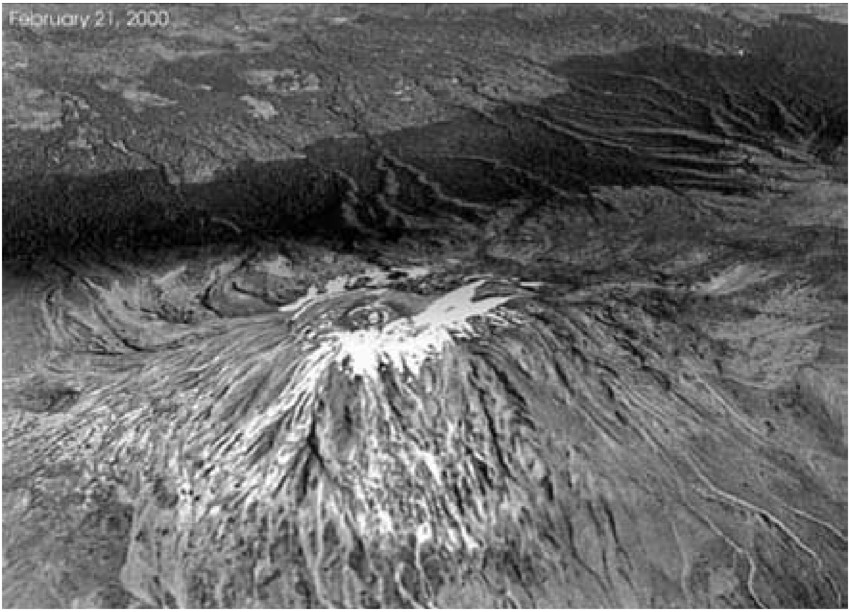
3.2.4 Increased Temperatures

Increased temperatures have broad and far-reaching impacts on the region. Apart from causing water loss due to increased evaporation, high temperatures at the wrong time of the crop cycle inhibits yields of crops such as wheat, rice, maize, potato, and soybean, especially during the key development stages. In addition, livestock, such as rabbits, pigs and poultry are severely impacted by extreme heat. In addition, increased temperatures reduce milk production and cattle reproduction.

A clear sign of increased temperatures in the region is the loss of glaciers on top of Mounts Kilimanjaro and Kenya. Glacial retreat on Mount Kilimanjaro is better documented and it is reported that its glacial area has decreased by 80% since the early 20th Century (URT, 2007). Figure 10 demonstrates the dramatic glacial retreat between 1976 and 2006:

Figure 10: *Glacial Retreat on Mt. Kilimanjaro, Tanzania*

Source: URT, 2007



3.3 Projected Impacts of Global Climate Change and their Relevance to the African Continent

The Intergovernmental Panel on Climate Change (IPCC) has stated that "Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations" (IPCC 2001). Scientists anticipate that, in the coming decades, as atmospheric concentrations of greenhouse gases continue to rise, average global temperatures and sea levels will continue to rise and as a result, precipitation patterns will change. However, what is not certain is the extent of the effects of climate change i.e. how much warming will occur, how fast it will occur, and how the warming will affect the rest of the climate system including precipitation patterns and storms (EPA, 2007).

Box 1: *Climate Models*

Climate models predict a range of impacts on developing countries from a decrease in agricultural output and food security to a loss of vital river flows. According to the Stern Review (2007) and IPCC (2001), the following are the most common models that provide possible climate change impact scenarios. A description of these models is quoted below from the Stern Review (2007):

"The 'Mendelsohn' model: It estimates impacts only for five 'market' sectors: agriculture, forestry, energy, water and coastal zones. According to this model, the global impact of climate change is estimated to be very small (virtually indistinguishable from the horizontal axis) and is positive for increases in global mean temperature up to about 4°C above pre-industrial levels.

"The 'Tol' model: It uses input data to estimate impacts for a wider range of market and non-market sectors: agriculture, forestry, water, energy, coastal zones and ecosystems, as well as mortality from vector-borne diseases, heat stress and cold stress. Costs are weighted either by output or by equity-weighted output. The model estimates that initial increases in global mean temperature would actually yield net global benefits. Since these benefits accrue primarily to rich countries, the method of aggregation across countries matters for the size of the global benefits. According to the output-weighted results, global benefits peak at around 2.5% of global GDP at a warming of 0.5°C above pre-industrial. But, according to the equity-weighted results, global benefits peak at only 0.5% of global GDP (also for a 0.5°C temperature increase). Global impacts become negative beyond 1°C (equity-weighted) or 2 - 2.5°C (output-weighted), and they reach 0.5 - 2% of global GDP for higher increases in global mean temperature.

"The 'Nordhaus' model: It measures economic activity on a geographic scale which includes data on a range of market and non-market impact sectors such as agriculture, forestry, energy, water, construction, fisheries, outdoor recreation, coastal zones, mortality from climate-related diseases and pollution, and ecosystems. It also includes what were at the time pioneering estimates of the economic cost of catastrophic climate impacts (the small probability of losses in GDP running into tens of percentage points). These catastrophic impacts drive much of the larger costs of climate change at high levels of warming. At 6°C warming, the 'Nordhaus' model estimates a global cost of between around 9 - 11% of global GDP, depending on whether regional impacts are aggregated by output (lower) or population (higher). The 'Nordhaus' model also predicts that the cost of climate change will increase faster than global mean temperature, so that the aggregate loss in global GDP almost doubles as global mean temperature increases from 4°C to 6°C above preindustrial levels. This reflects the fact that higher temperatures will increase the chance of triggering abrupt and large-scale changes, such as sudden shifts in regional weather patterns like the monsoons or the El Niño phenomenon".

According to various sources quoted in the following section, the impacts of climate change for Africa and other developing countries are predominantly negative and include the following:

i. "Water pressures may be intensified as rainfall becomes more erratic, glaciers retreat and rivers dry up. While there is much uncertainty about flow of the Nile, several models suggest a decrease in river flow. Nine recent climate scenarios show impacts ranging from no change to more than 75% reduction in the Nile's flow by 2100" (IPCC, 2001).

ii. "With the increased incidences of global warming, there is prediction of the re-emergence of the "mega-droughts" in Africa. Droughts, some of which can last for centuries, have become the norm in many parts of sub-Saharan Africa. However, coupled with the added stress of a continuous global warming, it is predicted that dry spells more severe than those already experienced would continuously recur making it more difficult for the people who live in these drought prone areas, especially in West Africa" (Monitor Publications, 2009; Shanahan, M.T. et al, 2009).

iii. "Tens of millions of additional people could be at risk of malaria by the 2080s. Previously unsuitable areas for malaria, such as Zimbabwe and East Africa's highlands, could become suitable for transmission with slight temperature and precipitations variations. In South Africa, the area prone to malaria may double with 7.8 million people at risk by 2100" (IPCC, 2001; Stern Review, 2007).

iv. Land degeneration as a result of continuous heavy rains could lead to the weakening of the earth's surface due to absorption of excess water. This is likely to result in increased incidents of landslides or could lead to large volumes of surface run-off water, which heavily contributes to soil erosion. Climate projections indicate that this scenario is likely to be replicated in most moderately wet African countries.

v. "Between 250–550 million additional people in the developing world may be at risk of hunger with a temperature increase of 3°C, with more than half of these people concentrated in Africa and Western Asia. Climate change is also predicted to decrease - and/or shift - the areas of suitable climate for 81% to 97% of Africa's plant species. By 2085, 25% - 42% of plant species in Africa could find they no longer have any suitable habitat" (Stern Review, 2007).

vi. "Many large cities in Africa that lie on or are very close to the coast could suffer severe damages from sea level rise. According to national communications to the UNFCCC, a 1 meter sea-level rise (a possibility by the end of the century) could result in the complete submergence of Banjul, the capital city of Gambia, and losses of more than US$ 470 million in Kenya for damage to three major cash crops in its coastal province i.e. mangoes, cashew nuts and coconuts" (Stern, Review, 2007).

3.4 Vulnerability of East and Horn of Africa Region to Climate Change

The gloomy portrait of the impacts of climate change in Africa, as discussed in the previous section, underscores the need for the continent to be well prepared to deal with the catastrophic events expected to occur. The East and Horn of Africa is vulnerable to climate change mainly due to its exposure to an already fragile environment, an economic structure (agro-based) that is highly sensitive to an adverse and changing climate and low incomes that constrain the region's ability to adapt. While the effects of climate change in the region is expected to vary from country to country, the following discussion highlights areas of greatest vulnerability in the region:

The Power Sector: As has already been mentioned, the region is heavily dependent on hydropower electricity generation – accounting for 79% of total electricity generated in East and Horn of Africa (See Figure 4). In spite of the past experiences and warnings of foreseeable reduction in precipitation, several countries in the region continue investing heavily in ambitious hydropower projects. Notable examples are in Uganda with the Bujagali hydropower plant and, more recently, Ethiopia's ambitious 2,000 MW Mendeya large hydropower plant that is to be located at the junction of the Abay and Dedessa (Xinhua News Agency, 2009).

With most of the countries in the region lacking a diversified power sector, a combination of increased drought and shortened rainy season is likely to cripple the power sector. This could lead to sharp drops in their respective GDPs. In addition, the prevailing encroachment of water catchment areas for agricultural use appears to make hydropower development more vulnerable.

Agricultural Sector: All countries in the region are dependent on rain-fed agriculture which contributes substantially to the GDP of the individual countries. For example, for a very long time, Kenya's number one foreign exchange earner was the agricultural sector which accounted for about 23% of total GDP (GoK, 2008) and over half the country's jobs. The main limitation in the agricultural sector is the dependence on rain-fed agriculture. Therefore, the absence of advanced farming practices such the use of irrigation, exposes the agricultural sector to massive crop failure and poor harvests due to the predicted drought and shorter rainy seasons. This could be catastrophic for the region's economy as agriculture and agro-industries provide employment for up to 80% of the population (See appendix 7).

Tourism: In most countries within the region, tourism has become a major source of foreign exchange. East Africa, particularly Tanzania and Kenya, has become a major tourist attraction due to its wildlife and pleasant summer weather conditions. However, should climate change lead to extreme climatic conditions, the tourism sector may no longer be a lucrative source of livelihood for many in the region due to a decline in wildlife population arising from migration or deaths related to drought or diseases.

Health: There has been documented evidence that an increase in ambient temperature in the highland areas of East Africa has led to infestation by mosquitoes, which spread the deadly malaria disease. It is predicted that malaria incidences are likely to increase. In addition, poor waste disposal measures coupled with increased flooding could lead to increased outbreaks of water borne diseases. Unfortunately, the region's state of health infrastructure is currently weak and, is unlikely to be able to cope with the projected increases in diseases.

Potable water supply: With the rapid population growth in East and Horn of Africa, there is increasing pressure on the available surface and ground water sources. However, like many other developing countries, the East and Horn of Africa has made very little investment in artificial water storage (including irrigation systems, dams, and ground water). For example, Ethiopia has less than 1% of the artificial water storage capacity per capita of North America. African countries do not have enough water storage to manage annual water demand based on the current average seasonal rainfall cycle. Adequate water storage is expected to be critical for the survival of the region's population should the gloomy climate change predictions occur.

3.5 Adaptation to Climate Change

According to the IPCC, adaptation to climate change is defined as:

"Any adjustment in natural or human systems in response to actual or expected climatic stimuli or their effect, which moderates harm or exploits beneficial opportunities."

According to the Stern Review (2007), the objective of adaptation is to "reduce vulnerability to climatic change and variability, thereby reducing their negative impacts. Adaptation should also enhance capability to capture any benefits of climate change. The gross benefit of adaptation can then be summed up as the damage avoided while the net benefit of adaptation is the damage avoided, less the cost of adaptation."

The main advantage of adaptation is the fact that it acts as a precautionary measure where corrective steps are taken by encouraging governments to invest early in addressing issue of climate change impacts before they become irreversible. Adaptation to anticipated climate change is now a global priority and most Governments are working hard to address the issue. According to Stern review (2007), adaptation can be perceived at two levels namely:

Building adaptive capacity – in other words, developing and strengthening technical, regulatory, management and institutional capacity to design and prepare effective adaptation approaches.

Delivering adaptation actions – which refer to actual implementation of adaptation measures that reduce vulnerability. Examples include: diversifying energy resources, agricultural crops and building defences against sea level rise.

3.6 Climate Change, Adaptation and Energy

There are virtually no known widely acclaimed experts or major reliable regional studies focusing on the linkage between climate change, adaptation and energy security. In addition, no major study has examined the link between climate, energy security and the poor in East and Horn of Africa. A key energy security-related climate change impact that has been acknowledged but not investigated in detail, especially in East and Horn of Africa, is drought-related power crises (IPCC 2001; Magadza 2000; UNEP 2005). However, there are recent studies that place Africa's adaptation to climate change at the forefront. These studies include the African Climate Appeal initiative led by Heinrich Boll Foundation as well as the United Nations Department for Early Warning Assessment (UNDEWA), Global Environment Outlook 2007 report that portrays the impacts of climate change in Africa and proposes some adaptation measures.

The implications of climate change for energy supply and demand appear to be unclear. This is because, the impacts of climate change on energy supply and demand will not only depend on climatic factors, but also on patterns of economic growth, land use, population growth, distribution, technological change and social and cultural trends that shape individual and institutional actions. For example, changes in temperature due to climate change could affect demand for energy in that the rising ambient air temperatures will most likely lead to substantial increases in energy demand for air conditioning.

On the other hand, there has been little research carried out to date on how climate change may affect energy supply. Some of the better known impacts are as discussed below:

i. Climate change induced drought could cripple hydropower dependent power sectors

ii. Increased incidences of floods could result in increased siltation of hydro power dams and damage hydro turbines

iii. Infrastructure for energy production, transmission and distribution could be affected by climate change. For example, in a warmer climate characterized by more extreme weather events such as windstorms, ice storms, floods, hurricanes and hail, the transmission systems of electric utilities may experience a higher rate of failure, with attendant maintenance costs.

iv. Power plant operations can be affected by extreme heat levels. For example, intake water that is normally used to cool power plants could become warm enough during extreme heat events thereby compromising power plant operations.

Some renewable sources of energy could be affected by climate change, although the expected changes would be very difficult to predict. If climate change leads to increased cloudiness, solar radiation could be reduced thus affecting the effectiveness of solar electric and thermal systems. On the other hand, wind production would be drastically reduced if wind speeds increase above or fall below the acceptable operating range of the technology. In addition, changes in temperature and precipitation could affect the growing condition of biomass, thus affecting the development of various biomass - based renewable energy options such as cogeneration and bio-fuels which are starting to receive considerable attention in the region. In general however, the decentralized and diversified nature of renewables provides inherent resilience to climate change.

The remaining part of this study attempts to analyze how climate change related drought, may have impacted on electricity generation in the East and Horn of Africa region with specific emphasis on hydropower generation within the region. Recommendations for adaptation to climate change for the power sector are also proposed.

Chapter 4
Impact of Drought on Hydropower Generation and National Economies

4.1 Climate Change and Drought

Africa, with the exception of the Congo/Zaire river basin is normally considered one of the driest continents (apart from Australia) and experiences the most unstable rainfall regime. Droughts are frequent in most African countries and each year more people are at risk from the effects of inevitable droughts of greater or lesser severity. Recent World Bank studies on incidences of drought indicate that, since 1991, East and Horn of Africa has been experiencing significant rainfall shortages (Table 3) which are increasing in frequency.

Table 3: *Years of Significant Rain Shortages in Agriculturally Productive Areas*

Country	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Burundi								D	D	D				
Djibouti									D	D				
Eritrea						D	D		D	D	D	D	D	D
Ethiopia	D	D		D			D		D	D	D	D	D	D
Kenya		D	D				D	D	D	D	D	D	D	D
Rwanda					D	D		D	D	D				
Sudan					D		D			D	D	D	D	D
Tanzania		D					D	D	D	D		D	D	D
Uganda							D		D	D	D	D	D	

D = Year in which there was a significant rain shortage in agriculturally productive areas

Source: World Bank, 2005

There is a direct relation between climate change and energy security, in that varying rainfall patterns have led to severe drought affecting hydro power generation, and in some cases, flooding. Excessive flooding on the other hand contributes to a rapid build up of silt in hydropower dams affecting the amount of water available for electricity generation. Silt can also damage turbines of hydropower stations. Flooding also leads to spillage of excess water, which cannot be stored for use during water shortages.

Since electricity generation in the region is largely dependent on hydro, the occurrence of drought severely affects the power sector and leads to the following drastic and negative effects;

i. Massive load shedding programmes which in turn, result in:
ii. Massive losses in the region's economies.

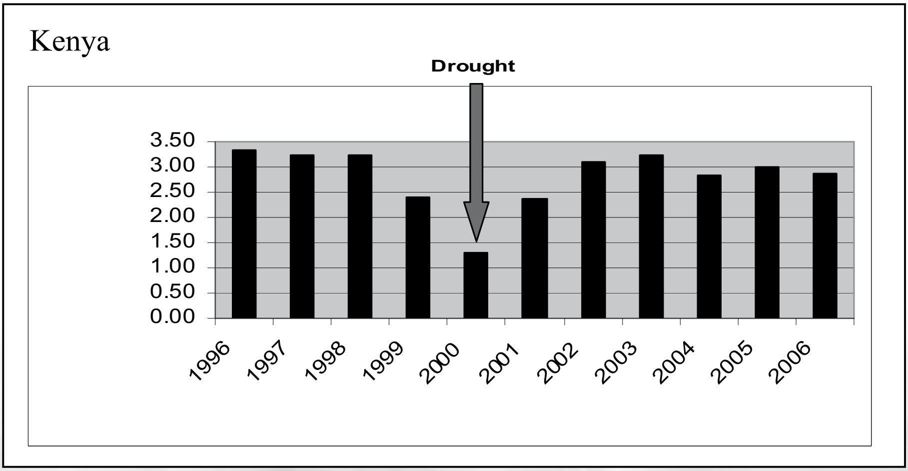
The impacts of climate change on hydro power generation can be summarized as shown below;

- Reduced levels of water in catchment areas
- Reduced hydro-electricity generation capacity
- Reduced ability to meet growing demand for power
- Increased cost of electricity

4.2 Drought Impact on the Power Sector

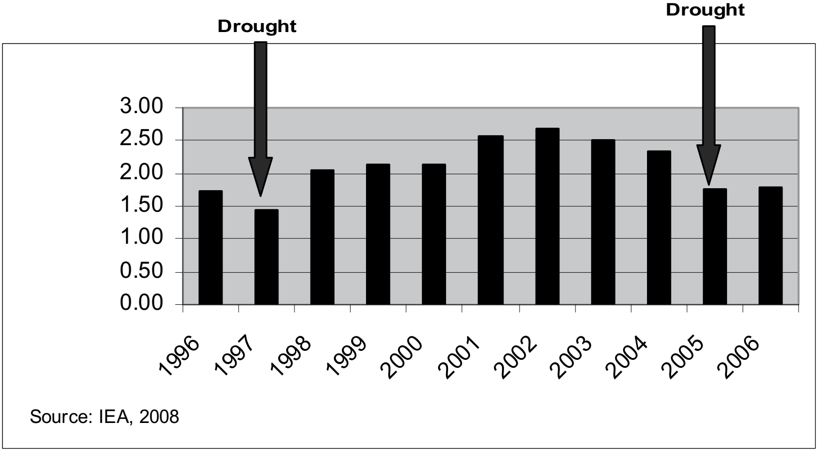
Increased incidents of drought (which are thought to be climate-related) have had negative impacts on the region's power sector. Drought severely affects the power sector leading to massive load shedding programmes and huge losses to the region's economies. Figure 11 shows the impact of drought on hydro electric power generation in selected countries in of East and Horn of Africa.

Figure 11: *Hydroelectric Power Generation in East Africa (1996-2006 in Billion Kilowatt hours)*

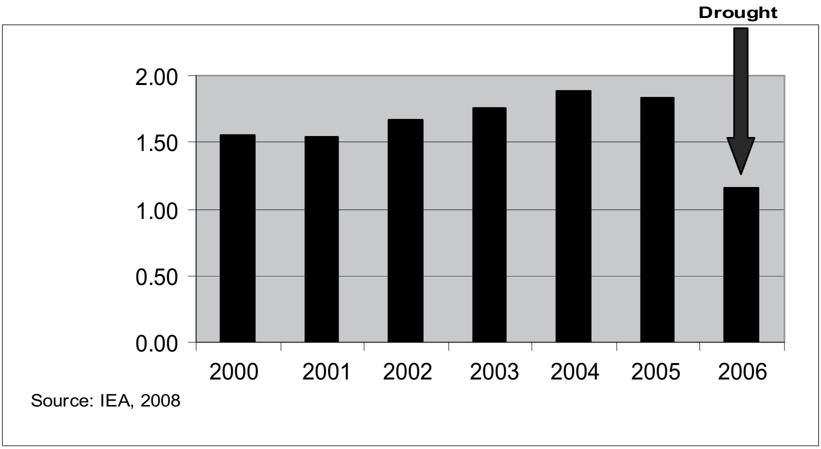


Source: IEA, 2008

Tanzania



Uganda



Source: IEA, 2008

Table 4 shows the incidences of drought in East and Horn of Africa and other selected sub-Saharan African countries and the subsequent consequences of the drought on the respective countries' hydropower sub-sector.

Table 4: *Drought and its effect on Hydropower generation*

Country	Drought period	Consequences
Ethiopia	2006-2008	Experienced more than six months of power cuts due to low water levels in hydro dams – scheduled blackouts initially once a week, but as the drought wore on, customers lost power for 15 hours two days a week
Uganda	2004/2005	Reduction in water levels at Lake Victoria resulting in reduction in hydro-power generation by 50 MW
Kenya	1998–2001	Massive drought decreased hydro generation (25% in 2000), which had to be replaced by more expensive fuel-based generation. Power rationing in 1999–2001.
Malawi	1997–1998	Engineering operations affected by drought. Amount of hydro energy generated was 6% less than in years of normal rainfall.
Mauritius	1999	Massive drought led to 70% drop in normal annual production of electricity.
Tanzania	1997	The Mtera dam reached its lowest ever level resulting in a 17% drop in hydro generation. Use of thermal generation to meet the shortfall, and power rationing.

Source: Karekezi and Kithyoma, 2005

Drought related power crisis often leads to the installation of emergency power generation to meet the electricity supply deficit. The experience with emergency power in the region is that it is expensive and leads to higher costs for consumers (Table 5).

Table 5: *Impact of Emergency power generation on GDP*

Country	Date	Contract Duration	Emergency Capacity (MW)	Percentage total installed capacity (%)	Estimated annual cost as % GDP	Drought Related?
Rwanda	2005	2 years	15	48.4	1.84	Yes
Uganda	2006	2 years	100	41.7	3.29	Yes
Tanzania	2006	2 years	180	20.4	0.96	Yes
Kenya	2006	1 year	100	8.3	1.45	Yes

Source: Eberhard et al, 2008

The impact of drought on the region's power sector has adversely affected national economies. In Uganda, for example, the hydroelectric generating capacity dropped by half following Lake Victoria's nearly 2 metre drop in water levels (Wines, 2007). As a result, economic growth projections dropped from 6.2% - 5.3% (Baanabe, 2008; Bloomberg, 2006; Oxford Country Briefings, 2007). The country had to turn to costly thermal generators to ease the supply deficit. Electricity supply was more intermittent than usual, and the price of electricity increased.

In Kenya, Tanzania and Ethiopia, drought-related power shortages and their impacts paralleled Uganda, but to a lesser extent, with Tanzania announcing a major power load-shedding progress that adversely affected industrial and commercial sectors. In Kenya, the drought that occurred between 1999 and 2002 drastically affected the hydro power generation and in the year 2000, hydropower generation was reduced by 25% capacity. The resultant cumulative loss was variously estimated to be about 1-1.5% of the total GDP (Karekezi and Kithyoma, 2005). Box 1 and 2 summarize the impacts of drought related hydropower crises in Kenya and Uganda.

Box 2: *Case Study of the Impact of Drought Related Power Crisis on the Kenyan Economy*

The first spell of drought that affected hydropower generation in Kenya occurred in 1992, when failure of rains led to power rationing between April–May. In 1999/2000, a severe drought, decreased hydro generation (by up to 25% in 2000) and led to unprecedented power supply shortfall resulting in a serious power rationing program. In 2006-2008, low water levels at hydro dams (due to both drought and siltation) resulted in a decrease in power generation - Emergency Diesel Power Plants are currently supplying high cost 100 MW to the national grid (KPLC, 2007; GoK, 2007; KenGen, 2007).

Emergency power generation resulted in higher costs of power, since the cost of diesel used for generating power was passed on directly to the consumer. The estimated loss of GDP due to power sector crises was estimated at about 1.45% of Kenya's GDP (the country's GDP is about US$ 29.5 billion). This loss in GDP translates to US$ 442 Million. Assuming this loss in GDP was used to develop renewable energy options to compliment hydro power resources, about 295 MW worth of renewable energy power could be generated, assuming 1 MW costs US$ 1.5 Million to install. This equates to about 3 times the installed emergency power capacity, and twice the capacity of hydro power lost during drought periods. It is safe to suggest that if the equivalent sum of money was spent on diversifying sources of electricity generation through greater use of renewables drought related hydro power crises could be avoided in the future (these hypotheses will be tested in the proposed follow up study).

The tariff increases due to installation of emergency diesel generated electricity are likely to indirectly affect low income urban residents who have electricity. Energy costs form a significant share of total household expenditure and low income households in East and Horn of Africa spend a significant share of their income on energy. For example, the poor in South Africa spend up to 20% of their income on energy. (AFREPREN/FWD, 2008).

Box 3: *Case Study of the Impact of Drought Related Power Crisis on Ugandan Economy*

In Uganda, electricity generation from hydro accounts for about 50% of total electricity generated. Lake Victoria dropped by at least six feet over a period of three years. The reduction of water in Lake Victoria resulted in reduced power generation at the Kira and Nalubale hydropower stations. The energy crisis led to the adjustment of the GDP growth rate in 2005/2006 from 6.2% to 5.3%. This necessitated the need to acquire alternative sources of energy, which increased operation costs across the board, though the impact varied across industry.

Power shortages were of particular concern to the industrial sector owing to the huge demand for electricity for their operation. The electricity supply shortage negatively impacted on GDP which dropped from an average of 6.5% over the last 10 years to 5% in 2005/2006.

As mentioned earlier, the introduction of emergency electricity plants in Uganda led to increased power tariff. In 2005, the domestic tariff was UShs 216.9 per kWh, and at the height of emergency electricity generation, the tariff rose to UShs 426.1 per kWh, a 96% increment (Baanabe, 2008). This impacted negatively on low income users as they were forced to either reduce or stop using electricity all together.

The drought induced power crises result in poor, unreliable, and costly electricity supply, which affects low-income electricity users in rural, peri-urban and urban areas directly and indirectly. Low-income users such as informal sector manufacturers, small-scale farmers, and rural and peri-urban service institutions like schools and health clinics have experienced extended power shortages. In addition, the limited electricity supplied during the rationing period is normally subject to frequent voltage fluctuations which could damage household electronic and small and micro enterprise (SME) equipment. This has a negative effect on the income generation activities operated by low income users, such as powering machines in home based workshops, operating TV and video shows and lighting in food kiosks.

Other impacts on low income users include[6]:

- Increase in production costs and cost of products to end users
- Power outages and increased loss of jobs, especially for low income earners.

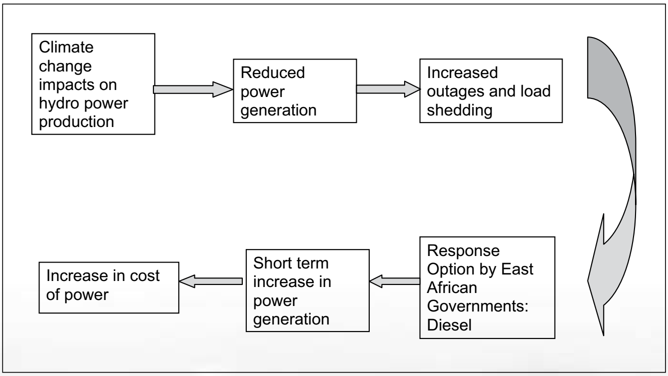
6 The impacts of drought related power crises on the poor will be analysed in greater detail in the planned follow up study.

Chapter 5
Response Options to Drought Related Electricity Crises in the Region

As mentioned earlier, one major shortcoming of Governments in the East and Horn of Africa is the failure to plan adequately on how to tackle the crises in the power sector, and more specifically drought induced reduction in hydropower generation, which is now a recurrent feature in the region's power sector (See table 4). As a result, during power crises, the immediate response option is to procure emergency thermal electricity generation to meet the shortfall in power supply.

As mentioned earlier, emergency thermal electricity is expensive. In some cases, it is double the amount charged for planned and installed thermal generated electricity, as was the case in Uganda at the height of the power crisis in 2006 (Baanabe, 2008). The high cost of emergency thermal power is also partly linked to the fluctuating world oil prices. Figure 12 demonstrates the trap that most of the Governments in East and Horn of Africa are stuck in when it comes to responding to what appears to be climate change induced drought that affects the power sector.

Figure 12: *East and Horn of African Governments Response to Climate Change Induced Drought.*



** The use of diesel to generate electricity also leads to increased emissions of greenhouse gases. However, emissions from the energy sector in the region are negligible and would not have an immediate impact on climate change.*
Source: Compiled by Authors

The volatility of the world oil prices (as was witnessed in 2008 when the price of oil peaked at an all time high of US$ 140 per barrel), is one of the key factors that have led to the persistent quandary that governments and power utilities find themselves in, whenever drought related power crises occur. When a shortage in power supply due to drought coincides with escalating oil prices (which occurred in 2007-2008), governments, utilities and end users are faced with exorbitant electricity bills, which have a serious ripple effect on the economy. Since it is impossible to predict the occurrence of drought or the nature of fluctuation in world oil prices, Governments and electricity utility companies within the East and Horn of Africa region need to adopt more robust, resilient and well thought out plans for dealing with drought induced power crises, especially with respect to hydropower generation.

5.1 Reducing Vulnerability of Large Scale Hydropower Generation

Renewable energy options are ideal candidates that can be developed to complement large scale hydropower generation. Options such as geothermal, small hydro, biomass cogeneration and wind are attractive since the resources are widely available in the region. These renewable energy options are not only environmentally friendly but they possess additional benefits including being suitable options as adaptation responses to the adverse impacts of drought (which could be climate change related) to the power sector.

Harnessing of renewable energy sources has a higher job creation potential than conventional energy sources such as hydro and thermal power plant installations. Renewable energy options create a wide range of jobs in all grades ranging from manual labor in small scale sugar farms (as in the case of cogeneration in Mauritius), casual labor for the local community residing around renewable energy installations (as in the case geothermal energy harnessing in Kenya), to management level positions in power plants/companies for the citizens of the respective countries. Most of the manual and casual labor jobs are normally created in the rural areas thus leading to a higher impact at the grass root level. Table 6 shows a comparison of job generation potential for renewable energy options compared to conventional energy options.

Table 6: *Job Creation Potential Renewables - Electricity Generation*

Conventional Energy Technology	Jobs Per MW	Renewable Energy Technology	Jobs Per MW
Coal (current)	1.7	Solar thermal	5.9
Coal (future)	3.0	Solar Panels	35.4
Nuclear	0.5	Wind	4.8
Pebble Bed Modular Reactors	1.3	Landfills	6.0
Gas	1.2		

Source: AGAMA Energy, 2003

The development of renewables such as biomass cogeneration and small hydro power also impacts positively on the national economies. For example, in Kenya, close to 30% of population are directly or indirectly dependent on sugar and tea sub-sectors. Cogeneration in sugar sector and small hydro in tea sectors can enhance competitiveness of sugar and tea sub-sectors, respectively, thus improving the lives of about 11 million people. Similar benefits can also accrue from development of renewable energy resources in other countries in the region. Another suitable adaptation measure is energy efficiency[7]. The following section discusses the potential role of renewables in the adaptation to climate change, especially with regard to what is thought to be climate change induced electricity crises discussed earlier.

5.2 Role of Renewables and Energy Efficiency in Adaptation to Climate Change

The following discussion provides suggestions on how renewables and energy efficiency could play an important role in the adaptation to climate change in the energy sector by achieving the following:

- Increasing diversification of electricity generation options
- Avoiding investment in thermal electricity generation options

5.2.1 Increasing Diversification of Electricity Generation Options

Over-reliance on one source of energy such as large-scale hydropower can place a country/region in a position of high vulnerability. This would not only have serious implications to the energy sector but to the entire economy as whole. As already witnessed in the region, over the last couple decades, there have been severe droughts

7 To be examined in greater depth in the planned follow up study

that affected hydropower generation in all East and Horn of Africa countries from the late 1990s to date. However, countries using renewables to diversify sources of electricity generation appear to survive severe droughts better than those relying on hydropower of electricity generation.

For example, Kenya appears to be more resilient than Uganda and Ethiopia to drought induced power generation shortfalls. This is largely due to the fact that Kenya has a higher level of diversification of electricity generation sources mainly through the promotion and use renewable energy such as geothermal, biomass-based cogeneration and to a lesser extent, wind energy. As a result, Kenya's security of electricity supply is much more secure (in comparison to the neighbouring countries)

An important renewable energy option that has contributed to the resilience and adaptation of Kenya's energy sector to drought induced power generation shortfalls is geothermal energy. Just over 10% of the Kenya's electricity generation is from geothermal energy. During the recent droughts in the country, geothermal energy played a critical role as it continued to operate at nearly 100% availability when many of the hydropower stations in the country were crippled by the dry spell.

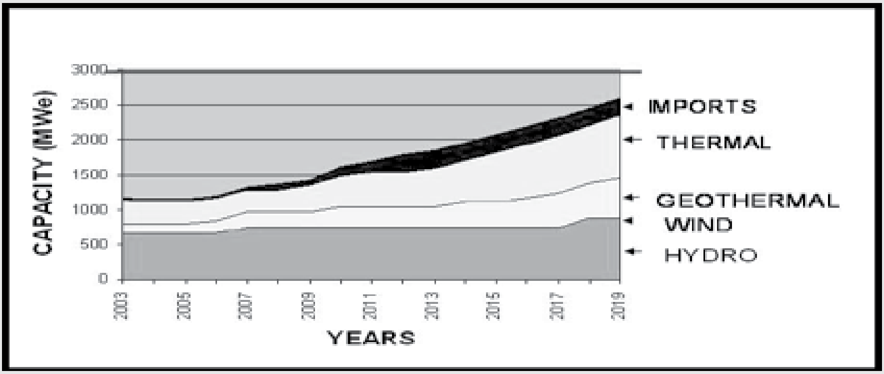
It can therefore be argued that renewable energy systems offer diversification in energy supply, thus strengthening energy security by broadening national energy generation portfolios. Countries with diversified energy generation sources are better-off compared to those which heavily depend on centralized large-scale hydro or conventional thermal plants that rely on imported petroleum fuels which have a degree of uncertainty in supply and cost. The following case study discusses geothermal development in Kenya.

Box 4: *Case Study of Geothermal Development in Kenya*

Geothermal energy is energy from depths of the earth, which is exploited after exploration, drilling, power plant construction and operation for electricity generation and other direct uses. The medium of this energy transfer are geothermal fluids. On the surface, these are manifested as hot grounds, fumaroles, geysers, mud-pools and hot springs (source: Simiyu, 2006).

Currently, the installed geothermal capacity in Kenya is 128 MW. Kenya geothermal power plants account just over 10% of the country's total installed capacity. In the Least Cost Power Development Plan (LCPDP), geothermal is a low-cost source of power that provides some protection against high and fluctuating oil prices and drought-related hydropower problems. There is renewed interest in the development of geothermal in Kenya, and the Ministry of Energy has set out explicit and specific targets for geothermal development and by the year 2020, geothermal power is expected to account for a quarter of total power installed capacity up from current 10% (GoK, 2004b).

Current Installed capacity and Projected Future Contribution of Various Energy Sources Used for Electricity Generation in Kenya



Source: Simiyu, 2006

During the drought period of 1999-2002 in Kenya, when hydro electric power generation in Kenya was severely affected, national demand for electricity was partially met by the generation from geothermal sources, which was not affected by the prevailing drought at that time and was operating at a nearly 100% capacity, 24 hours a day during the drought period.

The main advantages of geothermal are that it generates continuous reliable "base load" power whenever needed. Owing to its modular nature, geothermal offers investors with incremental development opportunities as one can start with small installations of about 10 MW and increase them slowly over time. In addition, geothermal energy has the potential to provide power to remote sites that are far away from the national grid owing to the location of the stations i.e. deep in the rural areas.

The main key success factors that led to the speedy development of geothermal in Kenya include:

Long-term commitment to supportive policies and local skills development: Geothermal development in Kenya began in the 1970s, and has been growing in a modular fashion over the years. Geothermal is now fully integrated in the country's long-term national power master plan.

Specialization: A dedicated team focused on geothermal power development is stationed at the source of geothermal power in Kenya's Rift valley. Kenyan geothermal experts are beginning to provide technical assistance in the region and even outside Africa

All the countries in the East and Horn of Africa region could reap significant benefits from, and hedge their respective power sectors from the effects of what is believed to be climate change induced drought by investing in the development of geothermal energy sources. The potential of geothermal energy in East and Horn of African countries is shown in the table below. It is estimated that a portion of the geothermal potential, would be sufficient to hedge against drought related power crises in East and Horn of Africa[8].

Geothermal Potential in East and Horn of Africa Region.

Country	Potential Capacity in MW
Kenya	3,000
Ethiopia	1,000
Djibouti	230-860
Tanzania	150

Source: Karekezi and Kithyoma, 2005

5.2.2 Avoiding Investment in Thermal Electricity Generation Options

Countries in the East and Horn of Africa (with the exception of Sudan) are all dependent on the imports of oil to meet their energy demands (including using oil for electricity generation). The import of oil has a negative impact on the countries' economies as it accounts for a substantial portion of their national import burden. In addition, the countries do not have much say in the international oil negotiations. High oil prices invariably imply high cost of generating thermal-based electricity – translating into an exorbitant electricity bill for the end-user.

8 There is need for additional research to test this hypothesis.

As mentioned earlier, a knee-jerk response to drought induced electricity generation shortfall is investing in oil-based thermal generation. However, in light of high oil prices, this option can be very expensive and, at the same time, not environmentally-friendly.

Mauritius provides a very good example of a highly successful use of cogeneration to avoid investment in thermal generation, thereby limiting a country's exposure to high cost of oil imports, especially for electricity generation. Mauritius currently meets over 20 per cent of its electricity demand using bagasse from the sugar industry. Over the 10-year period (1993-2002), the installed capacity of the sugar industry-located power plants increased from 43 MW to 242 MW with the concurrent increase in electricity exported to the grid. In the early years i.e. in 1996, 119 GWh of electricity from bagasse based cogeneration was exported to the national grid. This was achieved through investment mostly by private sugar mills implementing cogeneration technology with their own private funds. By the year 2002, co-generated electricity increased significantly with investment in more efficient bagasse-to-electricity processes and in a greater number of units, so much so that the electricity exported to the grid from bagasse increased to 300 GWh and the total electricity exported from the sugar industry rose to 746 GWh in 2002, representing about 43.5% of the total electricity exported to the grid for the island (Deepchand, 2006).

The following case study discusses cogeneration development in Mauritius. It is worth noting that the basis for cogeneration development and pricing of cogeneration electricity in Mauritius is based on the avoided cost of investment in thermal power plants.

Box 5: *Case Study: Cogeneration Development 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.

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 Modernization of sugar factories Enhanced environmental benefits
1997	Blue Print on the Centralization 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 42 MW and one 35 MW plants operating at 82 bars 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. 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.

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).

The current status of cogeneration (primarily, sugar industry-based) in selected Eastern and Southern Africa countries is provided in the table below. Although cogeneration currently contributes small amounts as compared to installed capacity, the potential for cogeneration in the East and Horn of Africa remains largely untapped. If a portion of the cogeneration potential (say 10%) was exploited, it would be sufficient to hedge against the power sector crises occasioned by what is thought to be climate change related drought in East and Horn of Africa[9].

Current Cogeneration Installed Capacity in Selected African Countries

Country	Current Cogeneration Installed Capacity (MW)	Installed National Capacity (MW)	As % of total of National Power Generation Installed Capacity
Ethiopia	13.4	814	1.65%
Kenya	73.0	1,197	6.10%
Malawi	18.5	300	6.17%
Sudan	55.3	1,023	5.41%
Swaziland	53	128	41.41%
Tanzania	33.3	1,080	3.08%
Uganda	20.0	380	5.26%

9 Additional research is needed to develop more comprehensive and detailed recommendations on this subject.

Chapter 6: Key Conclusions and Recommendations

Governments and electricity utility companies within the East and Horn of Africa region need to adopt more robust, resilient and well thought out response options for addressing drought induced power crises. This study concludes that mature renewable energy options with multiple benefits are ideal candidates and can be developed to complement hydropower generation. Options such as geothermal, small hydro, biomass cogeneration and wind are attractive since the resources are widely available in the region. These renewable energy options are not only environmentally friendly but provide additional developmental benefits such as job creation and reduction of oil import bills.

In light of the numerous problems facing the energy sector in the East and Horn of Africa region, and the environmental, commercial and social benefits of the above mentioned renewable energy technologies, there is urgent need for East and Horn of African Governments to implement renewable energy options such as biomass based cogeneration and geothermal energy in order to protect their power sectors from what is thought to be climate change induced drought that affects hydro electric power generation within the region. Some of the benefits of investing in renewable energy as a pre-cautionary measure to the drought that affects the power sector in the region include;

i. Greater energy security through wider use of locally available and more secure renewable energy resources such as geothermal, small hydro, biomass cogeneration and wind. Some of these renewables are available even during periods of drought.

ii. Higher job creation potential of renewables.

iii. Poverty reduction benefits of renewables. This is particularly true of small-scale renewables that are made locally and operate on the basis of solar, thermal or animate power that can be used by local communities for income generation activities.

iii. Rural development benefits of renewables. As the bulk of renewable resources are found in rural areas, investment in renewables would result in increased rural development.

To better illustrate the potential benefits of renewables, this report provided examples of two specific renewable options namely: cogeneration and geothermal power. Based on the study findings, the following are some of the key recommendations[10] that will assist the fast tracking of renewables-based power.

Institution of attractive and pre-determined feed-in tariffs and standard Power Purchase Agreements (PPAs) for co generated power: A standard PPA can limit market uncertainty, which stands in the way of substantial investment in renewables 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 renewable energy plants can be instrumental in the successful scaling up of renewables-based power investments in the African power sector (UNEP/GEF, 2006).

Innovative Financing: Innovative financing schemes should be developed by financial institutions in collaboration with project developers. Interaction between financiers and project developers could help bridge the knowledge gap on both sides – financiers would gain a better understanding of renewables while project developers would have a better appreciation of pre-requisites for raising financing for renewable energy investments. Bundling of smaller/medium sized projects would help them access funds that have minimum investment caps, and lower the upfront cost of financing.

African countries can tap into the various international and regional initiatives that can provide funding for renewable investments.These initiatives include: the Global Environment Facility (GEF) and the Kyoto Protocol's Clean Development Mechanism (CDM). One drawback of the CDM, however, is its high transaction costs and specialized skills requirements that have tended to limit the participation of African countries and experts to date.

Innovative Revenue-Sharing Mechanisms: One way of ensuring support for the development of renewables is by instituting appropriate revenue-sharing mechanisms. The benefits of renewables such as biomass cogeneration should trickle down to the small-scale farmer involved in growing the feedstock. A model revenue sharing mechanism has been implemented in Mauritius, where proceeds from the sale of co-generated electricity are shared equitably among the key stakeholders - including the small-scale farmers who provide sugar cane to the factories. Similar revenue sharing mechanisms can be used as incentives for local participation in developing geothermal resources and other renewables, and are useful for building local support for scaled-up renewables development.

10 More comprehensive and detailed recommendations are expected to be developed in the planned follow-up study

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APPENDICES

Appendix 1: Hydropower: Status of Development at End – 2005 (all schemes)

	In Operation		Under Construction		Planned	
	Capacity (MW)	Actual Generation in 2005 (GWh)	Capacity (MW)	Probable Annual generation (GWh)	Capacity (MW)	Probable Annual generation (GWh)
North Africa						
Algeria	275	555				
Egypt	2850	12644	110	780	30	180
Tunisia	62	145				
Morocco	1498	1597	44		5	
Sub Saharan Africa						
Benin	65	172	100		150	
Burkina Faso	32	102			75	
Cote d' Ivore	606	1433			270	1116
Mali	155	500			370	
Mauritania	30	120				
Ghana	1198	6100	400		1205	
Niger					125	
Nigeria	1938	8200	52		4850	
Guinea	129	445			836	
Senegal	64	256				
Sierra Leone	4	19	50		85	
Togo	66	175				
Cameroon	723	3 772			455	
Central African Republic	19	120			20-137	
Chad					6	
Comoros	1	2				
Congo (Brazzaville)	89	352	120		1 621	
Congo (Democratic Rep)	2 406	5 800			42 776	271 000

	In Operation		Under Construction		Planned	
	Capacity (MW)	Actual Generation in 2005 (GWh)	Capacity (MW)	Probable Annual generation (GWh)	Capacity (MW)	Probable Annual generation (GWh)
Equatorial Guinea	1	2				
Gabon	170	814			590	3640
Reunion	125	500				
Sao Tome & Principe	6	10				
Burundi	46	150			225	
Ethiopia	662	2848	3050	10457	1250	4909
Kenya	677	2869	440		70	
Tanzania	561	1800			580	3110
Uganda	318	1986	330		250-777	
Sudan	323	840	1250		300	
Rwanda	27	90			104	
Angola	440	2 219			610-16500	
Lesotho	76	200			26	
Malawi	283	1100			365	
Zambia	1698	8445			2010	
Zimbabwe	754	3000	1		800	6097
Swaziland	60	124	19		20	
Mauritius	59	100				
Mozambique	2136	11548			2898-3898	
Namibia	249	890			360	1792
Madagascar	105	540	12		4	
Somalia	5	10				
South Africa	653	1141				

Source: WEC, 2007.

Appendix 2: Small Hydropower Utilisation in the Region

Country	Small hydro potential (MW)	Small hydro installed (MW)
North Africa	N/A	
Algeria	N/A	54.0
Morocco	N/A	30.0
Tunisia	N/A	15.0
Egypt	N/A	10.0
Sub-Saharan Africa		
Kenya	600	44.7
Tanzania	70	10.8
Uganda	210	17.0
Malawi	N/A	4.5
Rwanda	20	1.1
Zambia	N/A	12.5
Mozambique	N/A	10.7
Mauritius	N/A	6.7
Cote d'ivoire	N/A	5.0
Ethiopia	N/A	7.0
Gabon	N/A	6.0
Guinea	N/A	11.0
Lesotho	N/A	8.7
Swaziland	N/A	0.3
Botswana	N/A	1.0
Burundi	42	2.9

Sources: 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; IED, 2006a; IED, 2006a; IED, 2006c; IED, 2006d; IED, 2006e; IED, 2006f.

N/A: Data not available.

Appendix 3: 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
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

Countries	Annual Electric Power Consumption per Capita – kWh (2004/2005)	Rate of electrification (%)
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: UNDP, 2008, IEA, 2007, World Bank, 2008

**2005 data*

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Kenya	**Tanzania**	**Uganda**
1. Energy Provision			
Main sources of energy	Primary energy: Biomass - 68% Petroleum - 22% Electricity - 9% Others - 1% Total installed capacity: 1,177 MW (2006) Hydro- 57% Thermal - 31.7% Geothermal -11% Wind and others - 0.3%	Primary Energy: Biomass - 90% Petroleum - 8% Electricity - 1.2% Others – 0.8% Total installed capacity: 1081 MW (2008) Thermal - 48% Hydro - 52%	Primary Energy: Biomass - 93% Petroleum - 6% Electricity - 1% Total installed capacity: 380 MW (2007) Thermal - 0.7% Hydro - 99.3%
Degree of reliance on imported energy	Kenya relies heavily on imported petroleum for local consumption. In 2007 Kenya imported 57,000 bbl/d of crude oil.	Tanzania is a net importer of petroleum products. Oil imports were estimated at 24,800 bbl/day (2004).	All petroleum products are imported. These products account for a significant percentage of the country's per capita income. The petroleum import bill is estimated at US$ 160 million per year. This constitutes about 8% of total national imports and represents slightly above 20% of total export earnings. Oil imports stood at 10,870 bbl/day (2004).
Extent of the network	Urban electrification level – 51% Rural electrification level – 5%	Urban electrification level – 39% Rural electrification level – 2%	Urban electrification level – 47% Rural electrification level – 3%
Capacity concerns	The country's present installed capacity is 1,177 MW (inclusive of 100 MW emergency power purchased in 2006). The demand in 2005 was 885 MW. Over the past 4 years, the country has experienced significant economic growth, which has translated to vibrant industrial growth resulting in increased demand for electricity. To meet this challenge, the country expects to inject an additional 201 MW by 2009/10 from projects that have already been committed.	As of December 2006 installed capacity 939 MW. Tanzania also imports between 5-10 MW from Uganda. Demand for electric power in 2006 was 603 MW.	Peak power demand is about 340 MW. Due to drought related problems, power generation from the Owen falls dam has reduced to 140 MW, leading to a serious shortfall in supply. Emergency Power Plants were put in place. Ina addition, Uganda imports about 20 MW of power from Kenya. The government has revived the stalled Bujagali project with the aim of addressing the power shortage crisis in the country.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa

	Kenya	Tanzania	Uganda
Potential for RE for EE	Solar: 4-6 kWh per square metre per day of solar insolation. Wind: wind speeds of 3-10 m/s. Estimated installed capacity from wind generated power is 0.55 MW. It is estimated that about 300-350 wind pumps have been installed in the country. Geothermal: technical potential estimated at about 3,000 MW but only 127 MW has been exploited Biomass: resource base is estimated at a standing stock of 35 million cubic meters. There is great potential of generating electricity from agricultural residues e.g. bagasse and rice husks. Currently, an estimated 38 MW capacity is installed in Kenya's six operational sugar factories which use bagasse to generate electricity. The Kenya Association of Manufacturers (KAM) provides its members an opportunity to cut energy costs through training and energy audits on energy efficiency through the Centre for Energy Efficiency & Conservation (CEEC). KAM also manages the Energy Management Award (EMA) through CEEC. EMA, which is an annual award, recognizes enterprises that have made major and sustainable gains in energy efficiency through the application of modern energy management principles and practices, and have made significant energy and cost reductions in the process http://www.kam.co.ke/ http://www.ema.co.ke/	Solar: The average daily insolation is about 4.5 – 6.5 kWh/m^2. Wind: wind speeds average 3 m/s in Tanzania. Wind turbine installations amount to 8.5 kW. It is estimated that about 58 wind pumps have been installed in Tanzania. Small hydro: Tanzania's small hydro potential is estimated at 70 MW. Biomass: Tanzania has 4.39 billion m^3 of woody growing stock with an annual increment of 140 million m^3. There are about 15 million tonnes per annum of crop residues available for use as fuel. The estimated theoretical cogeneration potential in Tanzania is over 395 MW. Currently, the country has an installed capacity of 33 MW from both sugar and wood-based industries.	Solar: 5-6 kWh /m^2/day insolation. Geothermal: Uganda has an estimated geothermal resource potential of 450 MW mainly located in the Western Rift valley part of the country. Ministry of Energy and Mines in collaboration with the German Development Cooperation (GTZ) to promote energy efficiency and renewable energy. The government is also promoting the use of energy saving bulbs by distributing about 800,000 of them to poor households.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Kenya	**Tanzania**	**Uganda**
2. Energy market			
Ownership	Electricity: The Kenya Power and Lighting Company (KPLC), which is 51% government owned, is responsible for the transmission, distribution and retail of electricity throughout Kenya. KPLC is currently under a Management Contract under Canadian managers seconded from Manitoba Hydro International. Generation of electricity involves has several players with Kenya Electricity Generating Company {KenGen] (70% state owned) being the major player. There are several independent power producers (IPPs) Liquid fuels market: The petroleum sector comprises a mix of state-owned and private companies. This is as a result of the liberalization of the oil industry in October 1994. National Oil Corporation of Kenya (NOCK), Kenya Pipeline and Kenya Petroleum Refinery Ltd. (KPRL) represent the government in the sector. KPRL is operates the only oil refinery in the country. A number of multinational oil companies are involved in distribution and marketing of oil products in the country.	Electricity: Tanzania Electric Supply Company Limited (TANESCO) is the sole public utility responsible for the generation, transmission and distribution of electricity. There are several IPPs involved in power generation. Petroleum and Gas: Tanzania Petroleum Development Corporation (TPDC) spearheads, facilitates and undertakes oil exploration and development in the country. The natural gas company, Songas, is jointly owned by Globeleq, TANESCO, TPDC, Tanzania Development Finance Company Ltd. (TDFL) and Finance for Development (FMO) http://www.songas.com/	Electricity: The electricity sector was unbundled in 2001 and the responsibilities previously solely carried out by Uganda Electricity Board (UEB) transferred to various companies. Transmission is the monopoly of UETCL. Electricity generation is carried out by various private companies including Eskom (U), Aggreko (U) Ltd, Kasese Cobalt Company Ltd (KCCL) and Kilembe Mines Ltd (KML). Power distribution is the responsibility of Umeme Ltd., which is jointly owned by Gobaleq (56%) and Eskom (44%), under a 20-year concession. Two asset-owning companies, namely Uganda Electricity Generation Company Ltd (UEGCL) and Uganda Electricity Distribution Company Ltd (UEDCL), leased their assets to Eskom (U) Ltd and Umeme Ltd respectively. http://www.umeme.co.ug http://www.eskom.co.za The state owned Uganda Electricity Transmission Company is responsible for electricity transmission.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Kenya	**Tanzania**	**Uganda**
Structure/ extent of competition	There is some level of competition in electricity generation. KenGen generates over 80% of the country's power output with the balance provided by IPPs. KPLC has monopoly in the distribution and transmission of electricity in the country. Despite the liberalization of the oil industry, there are only a few companies actively trading due to tariff and non-tariff barriers to entry.	At present TANESCO is vertically integrated but there are plans for unbundling with separation of the functions of generation, transmission and distribution of electricity.	There is some level of competition in generation and distribution of electricity.
3. Energy policy framework			
Existence of an Energy framework and programmes to promote sustainable energy	The Energy Act of 2006 establishes an Energy Regulatory Commission, which is mandated to regulate the energy sector, including renewable energy. The Act empowers the Minister of Energy to promote various forms of renewable energy e.g. promoting co-generation of electric power and consequently the sale of any such power generated to through the national grid to consumers. The Energy Act of 2006 was assented into law by the president on 30th December 2006.	The national energy policy formulated in 2003 supports research and development of renewable energy and also promotes the use of efficient biomass and end-use technologies. The Rural Energy Act of 2005 was assented into law by the president on 6th June 2005. The Act established the Rural Energy Board, Fund and Agency responsible for promotion of improved access to modern energy in rural areas.	There is a national energy policy, formulated in 2002, which promotes the use of renewable energy technologies. The Environmental Impact Assessment guidelines for the Energy sector, 2004. Electricity Act of 1999, which established the Electricity Regulatory Authority.
Current energy debates or legislation	KenGen is considering creating a separate entity to pursue geothermal development. KPLCs management contract faces several challenges. There is a proposal to split KPLC into distribution and transmission entities.	Unbundling of the electricity utility, TANESCO, is under consideration	Development of a large scale hydro plant, Bujagali, has been a controversial issue in Uganda for the past few years.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa

	Kenya	Tanzania	Uganda
Major energy studies	A major study on Kenya's Energy Demand, Supply and Policy Strategy for Households Small Scale Industries and Service Establishment was commissioned by the Ministry of Energy in 2002. In 2005, AFREPREN/FWD and HBF-HA commissioned a study to examine the status and prospects of RETs in the Eastern and Horn of Africa region which focuses on the potential of biomass cogeneration and geothermal energy with emphasis on Ethiopia, Kenya, Tanzania and Uganda.	In 2005, AFREPREN/FWD and HBF-HA commissioned a study to examine the status and prospects of RETs in the Eastern and Horn of Africa region which focuses on the potential of biomass cogeneration and geothermal energy with emphasis on Ethiopia, Kenya, Tanzania and Uganda.	Technical Assistance for Renewable Energy Resource Information and Capacity Building Assessment undertaken by KAMFOR Company Ltd. Recent study has confirmed that electricity generation through wind is feasible especially in small industries and in rural areas. Further studies are being carried out countrywide to generate further potential geothermal sites. In 2005, AFREPREN/FWD and HBF-HA commissioned a study to examine the status and prospects of RETs in the Eastern and Horn of Africa region which focuses on the potential of biomass cogeneration and geothermal energy with emphasis on Ethiopia, Kenya, Tanzania and Uganda.
Role of government/ department	The Ministry of Energy is in charge of energy policy and development. The ministry also oversees the implementation of the policies.	The Ministry of Energy and Minerals is responsible for coordinating and putting in place appropriate policies, laws and regulations.	The Ministry of Energy and Mines is tasked with the responsibility of drafting enabling policies and legislation for sustainable development.
Government agencies in sustainable energy	The Renewable Energy department under the Ministry of Energy has the mandate of promoting and developing appropriate renewable energy technologies. It also plays a lead role renewable energy policy formulation, review and analysis. Under the Energy Act 2006, the Rural Electrification Authority (REA) is mandated to develop and update the rural electrification master plan and promotion of the use of renewable energy sources.	The Renewable Energy section under the Ministry of Energy and Minerals (MEM) coordinates sustainable energy activities. Rural Energy Agency (REA) established under the Rural Energy Act of 2005 also undertakes sustainable energy activities.	The Energy Resource Department in the Ministry of Energy and Mineral Development (MEMD) is responsible for promoting and coordinating the development of energy sources. The Rural Electrification Agency, which is under MEMD, promotes the equitable distribution of rural electrification in Uganda. http://www.rea.or.ug

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa

	Kenya	Tanzania	Uganda
Energy planning procedure	Energy planning is mainly undertaken by the Ministry of Energy, which has a strategic plan for the period 2004-2009.	Energy planning is guided by the national energy policy formulated 1992 and revised in 2003.	Energy planning is guided by the Rural Electrification Strategy and Plan covering the period 2001- 2010.
4. Energy regulation			
Energy regulator Date of creation	Energy Regulatory Commission (ERC), which came into effect with a gazette notice on July 7, 2007. ERC was formerly the Electricity Regulatory Board established under the Electric Power Act of 1997. http://www.erb.go.ke/	Energy and Water Regulatory Authority (EWURA) established under Cap 414 of the laws of Tanzania. EWURA commenced its operations on 1st of October 2005. http://www.ewura.com/	The Electricity Regulatory Authority (ERA) was set up following the enactment of the Electricity Act 1999. http://www.era.or.ug/
Degree of independence	The chairperson of the ERC is appointed by the president. The Minister of Energy appoints commissioners of the ERC.	The president appoints the chairperson of EWURA. The minister of Energy has powers to give directions of a specific or general nature to the Authority.	The Minister of Energy, with the approval of the cabinet, appoints 5 members to the board of the Electricity Regulatory Authority. The minister also selects the chairperson of the board.
Regulatory framework for sustainable energy	The Energy Regulatory Commission is mandated to regulate renewable energy sector amongst other forms of energy.	EWURA is mandated to regulate all aspects of the energy sector including sustainable energy.	The Electricity Act (1999) mandates the minister of energy to table in parliament an annual report on the progress of the Rural Electrification Strategy and Plan that contains, amongst other things, information relating to renewable energy power generation for sale to the main grid and for mini-grids.
Regulatory roles	Energy Regulatory Commission is mandated to: - Regulate all forms of energy, - Protect stakeholder interests, - Maintain a list of accredited energy auditors, - Ensure principles of fair competition are adhered to, - Provide information to Minister when required, - Collect and maintain energy data and prepare a national energy plan.	EWURA is responsible for: - Promoting effective competition, - Protecting consumers and suppliers, - Taking into account the need to protect the environment and - Enhancing consumer knowledge of the regulated sectors.	ERA is responsible for: -Issuing licenses for electricity generation, transmission, distribution, supply, import and export - Reviewing and approving tariffs - Establishing and enforcing sector standards - Advising minister on matters affecting electricity sector.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Kenya	**Tanzania**	**Uganda**
Role of government department in energy regulation	Government departments prepare policies, strategic plans and legislations.	Government departments coordinate and put in place appropriate policies, laws and regulations and provide their oversight to ensure sustainable development.	Government departments are involved in preparing policies, setting standards, preparing strategic plans and drafting legislations.
Regulatory barriers	The Energy Regulatory Commission is not yet functioning fully.	The level of independence of the regulatory body is limited.	The level of independence of the regulatory body is limited.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Rwanda	**Burundi**	**Ethiopia**
1. Energy Provision			
Main sources of energy	Primary energy: Wood - 80.4% Agricultural residues-10.7% Fuel – 6% Charcoal-1.9% Electricity – 0.9% Peat & gas- 0.1% Total installed capacity: 41.25 MW (2007) Hydro – 65% Thermal – 35%	Primary energy: Biomass – 86% Petroleum – 11% Electricity – 3% Total installed capacity: 49 MW (2004)	Primary energy: Biomass – 96.28% Petroleum – 3.32% Electricity – 0.41% Total installed capacity: 493 MW (2004). Hydro – 91.7% Thermal – 6.9% Other – 1.4%
Degree of reliance on imported energy	The country imports electricity from eastern DRC to serve parts of the Western province. All petroleum products are imported, as the country has neither oil resources nor a refinery. Petroleum imports in 2003 were equivalent to 85% of total export value. Oil imports stood at 5,165 bbl/day (2004)	Burundi imports all its petroleum products from Kenya and Tanzania. Oil imports are estimated to be 2,687 bbl/day (2004)	Ethiopia totally depends on imported petroleum products. Oil imports are estimated at 28,460 bbl/day (2004) The country does not import electricity but exports to neighbouring Djibouti.
Extent of the network	Urban electrification level: 27% Rural electrification level – 1%	1% of the population has access to electricity	Urban electrification level – 86% Rural electrification level – 2%

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Rwanda	**Burundi**	**Ethiopia**
Capacity concerns	In late 2005, the available power was 33 MW and the maximum demand was 55 MW. Rwanda faces electricity deficits of up to 40% due to reduced hydro power capacity. In addition, growing electricity needs required to run the expanding industrial sector and general business environment are largely unmet	In 2005, electricity production was 137 MWh as compared to consumption of 161.4 MWh. Burundi imported some electricity from the Democratic Republic of the Congo.	Ethiopian electricity generation is susceptible to droughts due to the overdependence on large hydros.
Potential for RE	Solar insolation: 5.5 kWh/ m^2/ day Hydropower potential is estimated to be 500 MW and only 72 MW have been exploited. Geothermal – potential of between 170 – 320 MW. Biomass: an estimated 2.3 million tons of wood fuel annually. Wind: The ministry of energy recently commissioned a feasibility study to determine the wind power capacity of Rwanda	Solar insolation: 4-5 kWh/ m^2/day Hydropower: Burundi's theoretic hydropower capacity is 1,700 MW but only 32 MW has been exploited. Geothermal: resources have been identified but there is little data to assess commercial viability.	Biomass: major potential biomass resource is the natural forest, woodlands and bush lands which cover over 30.1 million hectares. There is also potential of using agricultural residues for co-generation. The country's co-generation installed capacity is estimated at 13.4 MW (from bagasse). Small hydro: the economically unexploited resource is estimated to be between 15,000-30,000 MW. Geothermal: A study carried out between 1970 and 1972 by the government with the assistance of UNDP indicated that the country's geothermal potential is about 700 MW. Solar: average insolation is 5.20 kWh/ m^2/day. Wind: wind speed of between 3.5-6.7 m/s has been recorded over various parts of the country.
Potential for EE	The National Energy policy has an objective of ensuring energy audits are carried out in industries, particularly the energy intensive ones, in order to enhance energy efficiency.	N/A	The Ethiopia Rural Energy Development and Promotion Centre (EREDPC) is charged with the responsibility of helping create the conditions for the development and promotion of rural energy efficient supplies and technologies.
2. Energy market			

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Rwanda	**Burundi**	**Ethiopia**
Ownership	Electricity: Electrogaz is the only power utility and is wholly owned by the government. In 2003, Electrogaz was placed under a 5-year management contract with Lahmeyer International. The contract was terminated on 31st March 2006. Liquid fuels market: The parastatal PETRORWANDA controls 40–45% of the market for petroleum imports. The parastatal was taken over by Shell Rwanda in 1999. Upegaz, a specialist unit within the Ministry of Infrastructure, is responsible for developing natural gas on Lake Kivu.	Electricity: Régié de Production et Distribution d'Eau et d'Electricité (Regideso) is the national power authority. The utility owns all the country's power plants, excluding those below 150 kW. Société Internationale des Pays des Grands Lacs (Sinelac) was established by Burundi, Rwanda and Zaire to develop international electricity projects. Regideso purchases power from the Sinelac site at Rusizi. Liquid fuels market: The petroleum sector falls under the Ministry of trade and industry, which supervises all imports.	Electricity: Ethiopian Electric Power Corporation (EEPCO) is wholly owned by the government and is solely responsible for electricity generation, transmission, distribution and sale across the country.
Structure/ extent of competition	Electrogaz is a monopoly, solely responsible for generation, transmission and distribution of power.	There are only two players in the electricity sector. Regideso controls transmission and distribution while Sinelac generates and sells power to Regideso.	The electricity sector is dominated by a monopoly. EEPCO is the sole player in the sector.
3. Energy policy framework			
Existence of an Energy framework and programmes to promote sustainable energy	There is a national energy policy formulated in 2004 that promotes the use of affordable and sustainable energy especially in the rural areas. There is an energy development programme instituted by the Ministry of Energy, Water and Natural resources (MINERENA) and partly funded by the Austrian government. The programme calls for the implementation of sustainable energy options.	The poverty reduction strategy paper of 2006 highlights the measures the government will take to expand national power capacity by disseminating information on alternative energy sources affordable to low-income households. UNDP Energy Thematic Trust Fund (TTF) project, which closed in 2003, had the objective of strengthening national policy framework to support energy for poverty reduction and sustainable development.	The Ethiopian Rural Energy Development and Promotion Centre (EREDPC) has a 5-year strategic rural energy plan in place. The plan incorporates use of renewable energy resources for power generation. The National Energy Policy was drafted in 1994.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Rwanda	**Burundi**	**Ethiopia**
Current energy debates or legislation	Current focus of energy sector stakeholders is how to meet the growing demand for electricity.	N/A	Major issues in the energy sector include the development of several large hydro power plants and interconnection with neighbouring countries (Kenya and Djibouti).
Major energy studies	A study on feasibility of wind energy in Rwanda by Rwindalectric Inc. is currently under way (2008) http://www.rwindalectric.org	Burundi Research Centre for Alternative Energies (CEBEA) undertook a rural solar electrification in Burundi.	A study (2006) undertaken by Workener Gashie in collaboration with AFREPREN/FWD and HeinrichBoll Foundation on the potential contribution of renewables to Ethiopia's energy sector. In 2004, AFREPREN/FWD commissioned a study on The Regulation of the Power Sector in Africa which covered Zimbabwe, Tanzania, Ethiopia, Kenya and Malawi.
Role of government/ department	The Ministry of Energy, Water and Natural resources has overall responsibility for the energy sector.	The Ministry of Energy and Mines through the General Directorate of Water and Energy drafts and implements the energy policy.	The Ministry of Mines and Energy is the principal government organ responsible for the formulation of energy policy, laws and directives that influence the development of energy resources.
Government agencies in sustainable energy	MINERENA is involved in planning of alternative energy supplies including the use of renewable energy technologies. www.minerena.gov.rw	The Directorate of Water and Energy is the main government agency involved in sustainable energy.	Ethiopian Rural Energy Development and Promotion Centre.
Energy planning procedure	The Ministry of Energy, Water and Natural resources (MINERENA) has put in place an energy development plan which covers hydropower, energy saving and geothermal energy.	The Ministry of Energy and Mines, through the General Directorate of Water and Energy lays down and implements the energy policy.	The Ministry of Mines and Energy is the principal government organ responsible for the formulation of energy policy, laws and directives that influence the development of energy resources.
4. Energy regulation			
Energy regulator Date of creation	Rwanda Utilities Regulatory Agency (RURA) regulates both the electricity and gas sectors. The regulator was created on 13th September 2001. http://www.rura.gov.rw	N/A	Ethiopian Electricity Agency, which became operational in 2000.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Rwanda	**Burundi**	**Ethiopia**
Degree of independence	The board of directors of the regulator is appointed by the Prime Minister.	N/A	Under the Electricity Proclamation and the Electricity Operations Regulations, the Ethiopian Electricity Regulatory Agency is autonomous.
Regulatory framework for sustainable energy	RURA is mandated to control and regulate an efficient, sustainable and reliable energy sector.	N/A	The ministry of Mines and Energy is in charge of monitoring and control of activities in new and renewable energy sub sectors.
Regulatory roles	RURA is responsible for promoting effective competition, advising government during formulation of energy policy, protecting consumers, educating stakeholders, approving contractual undertakings with regard to distribution and transmission of electricity and gas and assessing the tariff structure http://www.rura.gov.rw	N/A	The role of the Ethiopian Electricity Agency includes to: - Ensure electricity sector activities are carried out in accordance to regulations and directives issued -Ensure quality and standards are maintained -Issuing and revoking of licenses -Recommend tariffs and supervise their implementation -Collect license fees -Assist in the technical development of electricity.
Role of government department in energy regulation	The Ministry of Energy, Water and Natural resources (MINERENA) is in charge of overall sector regulation.	N/A	The Ministry of Mines and Energy is in charge of overall energy regulation. The Ministry of Trade and Industry is charged with supervision of the petroleum sector. The authority to set and monitor petroleum product prices is granted to the ministry through a Distribution Agreement (DA).
Regulatory barriers	The regulatory body is not independent, as members are appointed by the Prime Minister	N/A	The Regulatory Agency to discharge its licensing responsibilities.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Sudan	**Somalia**	**Zimbabwe**
1. Energy Provision			
Main sources of energy	Primary energy: Biomass: 87% Petroleum – 12% Hydropower- 1% Total installed generating capacity: 760 MW (2004): Thermal – 76% Hydro – 24%	Biomass is the main source of energy in the 3 regions of Somalia i.e. Puntland, Somaliland and Somalia. Total installed generating capacity: 80 MW (2006). Thermal – 100%	Biomass – 64% Coal – 22% Petroleum – 7% Hydro – 5% Total installed generating capacity: 1,990 MW (2004) Hydro: 34% Thermal: 66%
Degree of reliance on imported energy	Sudan is an oil producer, largely self sufficient and able to export refined as well as crude petroleum products. However, Sudan still needs to import jet fuel. The country's proven oil reserves are 5 billion barrels (2007). Oil exports estimated at 279,100 bbl/day (2004), while imports amounted to 7,945 bbl/day (2004). The country does not import electricity.	The country relies heavily on imported petroleum for production of electricity. The country had one refinery, which ceased operation with the onset of war in 1991. Oil imports estimated at 4,800 bbl/day (2004).	Electricity consumed is sourced one third from thermal production, nearly half hydro and just less than 20% from imports. It currently Imports electricity from South Africa, DRC and Mozambique.
Extent of the network	30% of the population has access to electricity. The government hopes to increase this to 90% and there are several projects underway to achieve this goal (2007).	Somalia is currently divided into three regions; Somaliland, Puntland and South and Central Somalia. The regions have a disintegrated electricity network. In Puntland, electricity is mainly accessible to major towns like Bosaso. In South and Central Somalia, 60% of the households in Mogadishu and 23% of the households in Merka have access to electricity for lighting.	Electricity access rate (2005): Urban: 84% Rural: 19%

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Sudan	**Somalia**	**Zimbabwe**
Capacity concerns	Electricity production in 2004 was 3.8 billion kilowatt hours compared to consumption of 3.6 billion kilowatt hours.	A survey recently carried out by AFREPREN/ FWD and Candlelight and sponsored by UNDP found that the electricity demand of both households and commercial sectors in the three regions surveyed i.e. Somaliland, Puntland and South/Central Somalia, outstrips the available supply. Puntland, for example, requires at least 15 MW in order to meet the current electricity demand.	Electricity consumed is sourced one third from thermal production, nearly half hydro and just less than 20% from imports. It currently Imports electricity from South Africa, DRC and Mozambique.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Sudan	**Somalia**	**Zimbabwe**
Potential for RE	Solar insolation: 6.1 kWh/ m^2/day Wind: wind speeds are estimated at 3-6 m/s; Higher speeds recorded along the red sea coast. Geothermal: geothermal potential is estimated at 400 MW of power generation capacity. Biomass: there is a vibrant cogeneration industry in Sudan with installed capacity estimated at 55.5 MW in sugar factories, mainly for own use. Hydropower potential is estimated at 4,920 MW. This is only 10% of the hydro electric power is currently utilized.	Wind: wind speeds vary from 3-11.4 m/s for various localities. Solar insolation: 5-7 kWh/ m^2/day Biomass: In 1985, wooded areas in Somalia were estimated to be about 39 million hectares - roughly 60% of Somalia's land area. Due to overexploitation and deforestation, these figures have reduced significantly. In 2001, statistics indicate that the forest cover may have been as low as 10% Hydropower potential is estimated at 100-120 MW. As at 1985, this hydropower potential was largely untapped, with only 4.8 MW exploited on the lower Juba valley (pre-war estimates). Geothermal: Available data indicate that the geothermal energy potential is too low to be commercially exploited for power generation.	Wind: wind speeds estimated at 3.5 m/s. Average solar insolation: 5.7 kWh/ m^2/day Biomass: Cogeneration potential (bagasse) is estimated at 633 GWh. Apart from sugarcane there is also potential for wood waste. The timber industry in Zimbabwe is almost entirely based on plantation timber, which generates over 70,000 tons of biomass waste annually. While at the largest mills a small fraction (~10%) of the wood waste generated is currently consumed in process steam boilers for lumber drying kilns, the vast majority is burned in the open air or dumped. Sugar Estates in the Lowveld are generating electricity for their own consumption (cogeneration), - Rusitu Hydro, a mini hydro plant (750 kW) constructed and operated by private entrepreneurs is selling power to ZESA http://www.zesa.co.zw
Potential for EE	Measures are being taken to ensure that existing hydro facilities are protected from the extreme climate which results to silt build up reducing their generation capacities.	N/A	Through the draft national energy policy, the government through the ministry plans to ensure efficient utilization of energy resources.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Sudan	**Somalia**	**Zimbabwe**
2. Energy market			
Owner ship	Electricity: The sector is dominated by the national power utility - National Electricity Corporation of Sudan (NEC). NEC is responsible for electricity generation, transmission and distribution. The government wholly owns the utility. Regions not covered by the utility's grid rely on privately owned small diesel-fired generators. Liquid fuels market: Foreign investors dominate Sudan's oil industry. The Sudan Petroleum Corporation acts as a regulator for the industry.	Electricity: The main electricity supplier in Puntland is a publicly owned entity Ente Nazionale Energia Elettrica (ENEE). Private companies also supply electricity in the region. In Somaliland, apart from the National Electricity Company based in Hargeysa, all the other electricity companies are private companies. All the companies providing electricity in South and Central Somalia are private. Liquid fuels market: The country imports all its petroleum products. Exploration activities were focused in northern Somalia before the war, and several foreign firms, including Agip, Amoco, Chevron, Conoco and Phillips, held concessions in the area. The firms all declared force majeure1 following the collapse of the central government	Electricity: Following an act of parliament 92002), ZESA was transformed into ZESA holdings, which now has five subsidiary companies. Zimbabwe Power Company (ZPC), formed in October 1996 and a subsidiary of ZESA holdings generation manages all power generation assets and operations The distribution assets and supply functions fall under the Zimbabwe Electricity Distribution Company (ZEDC). ZESA Enterprises, another subsidiary of ZESA Holdings comprises of four business units namely ZESA Technology Centre, Production and Services, Transport Logistics and Projects. It is a flexible investment arm for ZESA Holdings that has a diversified business portfolio. Transmission grid assets and operations fall under the Zimbabwe Electricity Transmission Company (ZETCO), http://www.zesa.co.zw/911/background.htm Liquid fuels market: National Oil Company of Zimbabwe (NOCZIM) is the state owned oil company responsible for procurement, storage and bulk distribution of petroleum products to oil marketing companies

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Sudan	**Somalia**	**Zimbabwe**
Structure/ extent of competition	There is little competition in the electricity sector. NEC is responsible for all activities in the sector. There are a few privately owned diesel-powered generators that provide electricity in regions outside the coverage of the national grid. The liquid fuels market is vertically integrated. Exploration and production are regulated by the Sudan National Petroleum Corporation with involvement of foreign companies. There are various companies involved in distribution and marketing of petroleum products in the country including Agip, Exxonmobil, Shell and Nile petroleum.	Private companies in the three regions dominate electricity generation and supply. There is a significant level of competition with as many as 30 companies in some of the regions.	There are three distinct companies in charge of electricity in Zimbabwe i.e. Zimbabwe Power Company (ZPC) – solely involved in generation; Zimbabwe Electricity Transmission Company (ZETC) – charged with transmission and Zimbabwe Distribution Company (ZEDC) - distribution of electricity. ZESA's role is to hold shares on behalf of the government in the successor companies (ZPC, ZETC, ZEDC).
3. Energy policy framework			
Existence of an Energy framework and programmes to promote sustainable energy	Sudan has a renewable energy master plan drafted in 2005. Notable programmes include the Gabat Gas Project that aims to change attitudes by encouraging the use of other biomass alternatives in order to protect forests and preserve the environment.	A key programme in Somaliland is the Somaliland Energy Policy Dialogue (SEPD) project launched by Adventist Development and Relief Agency (ADRA) with the support of the EU. The SEPD project places a high priority on access to improved energy services to households and businesses leading to improved livelihood. The programme has developed a draft energy policy (February 2007), which encompasses use of wind, solar and PVs.	A draft policy energy framework was in place in 2008. The objectives of the Energy Policy are: • to ensure accelerated economic development • to facilitate rural development • to promote small-medium scale enterprises • to ensure environmentally friendly energy development, and • to ensure efficient utilization of energy resources http://www.energy.gov.zw/zimba.htm The Electricity Act 2002 led to the unbundling of ZESA into separate generation, transmission, distribution and supply units. This process aimed to allow new and independent players to enter into the industry. The Ministry of Energy and Power Development is still to come up with a Renewable Energy Policy and this is being addressed through a number of initiatives already in place.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Sudan	**Somalia**	**Zimbabwe**
Current energy debates or legislation	The government is in the process of amending the old legislation covering the electricity sector, with the specific intention of encouraging foreign investors. The new laws will introduce changes in the NEC's traditional role as the state monopoly producer and distributor of electricity in the country, with openings for private investors in the sector.	Drafting of the Energy Policy in Somaliland.	Zimbabwe faces demand shortfall; - Country remains dependent on imported power; -Financial situation of unbundled ZESA entities not known, - Some key links on the national grid remain to be constructed.
Major energy studies	The Government formulated a 10-year strategic plan for the period 1992-2003, which set overall goals for economic development. This plan included The supportive role of the power sector in achieving these goals. In November 2005, a household survey was done on efficient stoves for Darfur camps of Internally displaced persons. Sudan renewable energy master plan drafted in 2005.	A household survey was undertaken between August and November 2006 targeting 200 households in low, medium and high residential areas in urban and peri-urban settlements. Energy consumption pattern was also surveyed, targeting 73 commercial enterprises and service institutions. Draft energy policy document has been prepared by ADRA Somalia	A study on Energy for Rural Development in Zimbabwe was done by the Beijer Institute in the 1988. So far various studies have been carried out to determine the barriers to cleaner energy technologies in Zimbabwe. In addition there are research studies underway to try sweet sorghum as a replacement of sugarcane in cogeneration. In 2004, AFREPREN/FWD commissioned a study on The Regulation of the Power Sector in Africa which covered Zimbabwe, Tanzania, Ethiopia, Kenya and Malawi.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Sudan	**Somalia**	**Zimbabwe**
Role of government/ department	The Ministry of Energy and Mining regulates the Sudanese energy sector.	In Somaliland, the Government role is the coordination of the energy sector, and energy policy making.	The government through the Ministry of Energy and Power Development oversees the entire energy sector. The ministry's mission is to provide adequate and constant supply of energy resources and promote environmentally friendly alternative sources of energy for sustainable economic growth. The ministry has the following departments: Petroleum – responsible for the oil sector Power- responsible for the power sector Energy conservation and renewable energy – responsible for promoting renewable energy Policy planning and legal Finance
Government agencies in sustainable energy	The Energy Research Institute (ERI) undertakes renewable energy research and development as well as pilot project implementation. Forestry Research Institute is involved in biomass energy technologies Khartoum University and the University of Science and Technology which undertake research on renewables	The Somaliland government is in the process of creating institutions to coordinate various energy sub-sectors. Currently, there are 7 government ministries involved in the energy sector; although lack of coordination mechanisms means that these ministries operate independently. They also lack capacity to develop, enforce and monitor the sector.	Department of Energy Conservation and Renewable Energy, both under the Director of Conservation and Renewable Energy. - Energy Conservation - the sub-department strives for self-sufficiency in energy resources through promotions of efficiency in the uses of energy in all sectors of the economy, also responsible for addressing environmental problems resulting from production and use of energy resources. -Renewable Energy: The sub-department strives to reduce dependency on imported energy products through the development of fuel substitute, diversify local power generation options and promoting the use of renewable energy technologies such as solar energy.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Sudan	**Somalia**	**Zimbabwe**
Energy planning procedure	The Government of Sudan plays a lead role in policy formulation and planning.	Not clearly defined due to the war. Development partners, e.g. ADRA Somalia, are assisting the government in Somaliland in developing a framework for policy making and planning.	The Department of Energy formulates, implements, monitors and reviews the energy policies; gathers and disseminates energy related information and prepares energy related plans and strategy. In addition, Zimbabwe Electricity Supply Authority (ZESA) set out policies on rural electrification, which started in 1993/4. It set out a Rural Electrification Fund, which is autonomous to spearhead rural electrification.
4. Energy regulation			
Energy regulator Date of creation	Sudanese Petroleum Corporation (SPC) regulates the petroleum sector http://www.spc.sd/	The country lacks mechanisms to regulate electricity generation, transmission and distribution. The petroleum sub-sector is also largely unregulated.	The Zimbabwe Electricity Regulatory Commission (ZERC) is a statutory body established in terms of the Electricity Act, (Chapter 13:19) No. 4 of 2002, (the Act) as amended by the Electricity Amendment Act No. 3 of 2003. It became effective in August 2003. http://www.zerc.co.zw/about.html The Petroleum Act, passed in 2006, provides for the establishment of the Petroleum Regulatory Authority (PRA), which will licence and regulate the petroleum industry; promote the development of efficient procurement, sale and distribution of petroleum products as well as safeguard the interests of consumers of petroleum products. The PRA also has advisory role to the Minister. The PRA is still to be established.
Degree of independence	SPC is a state corporation	N/A	The President appoints the commissioners. The Commission operates independently in order to be an effective regulator. The Commission is funded from licence fees and levies imposed on licensees in the generation, transmission and distribution business.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Sudan	**Somalia**	**Zimbabwe**
Regulatory framework for sustainable energy	Sustainable energy falls under the Ministry of Energy and Mining, which regulates the Sudanese energy sector.	Presently, ADRA Somalia is facilitating an energy policy initiative in Somaliland. The project, - Somaliland's Energy Policy Dialogue (SEPD) - was launched in February 2006. The specific objective of the initiative is to facilitate the development of an energy policy and regulatory framework document for Somaliland.	The Department of Energy is charged with policy formulation and implementation in the renewable energy technologies (RETs).
Regulatory roles	SPC is responsible for exploration, production, refining, transportation, mining, financing, planning, arranging licenses, supervision and new legislation.	N/A	The Zimbabwe Electricity Regulatory Commission (ZERC) has the Authority to fully and independently regulate the Industry and no entity can generate, transmit or distribute or import electricity even for its own consumption, without ZERC's permission. The permission is granted in the form of a licence that stipulates strict rules of operation that have to be complied by the licencee. The Commission is the only legal authority that can approve a tariff increase.
Role of government department in energy regulation	The oil and energy industry is regulated by the Ministry of Energy and Mining but the Exploration and Production Authority exercise day-to-day control of the oil industry.	Limited due to war.	The Ministry of Energy and Power Development oversees the entire energy sector, including the regulator.
Regulatory barriers	No regulator for electricity and other sectors. SPC, the regulator for the petroleum sector, is not independent.	The energy sector operates in a policy vacuum, with no legal and regulatory framework.	Lack of independence, since the regulator is under the government ministry and commissioners are appointed by the president.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa

	Zambia	Mauritius	Ghana
1. Energy Provision			
Main sources of energy	- Biomass - 80% - Proven coal reserves 30 million with several hundred millions probable reserves. - petroleum – 14% Total installed generating capacity: 1,750 MW (2007) Hydro: 99.5% Thermal: 0.5%	Total installed generation capacity: 670 MW (2003) Hydro: 6% Thermal: 94%	Biomass - 90-95% Hydro - 5-10% Solar - <1 Total installed generation capacity: 1,650 MW (2007) Hydro: 66% Thermal: 34%
Degree of reliance on imported energy	Petroleum 100% imported, 421,100 tonnes of crude oil imported in 1999. Zambia imports 200 MW of electricity during its peak demand.	Mauritius is self sufficient in electricity supply.	Electricity: In 2004, Ghana imported 28.3% of its electricity, which was equivalent to 878 GWh. Oil: Ghana imported 1,813,464 tonnes of crude oil and imported 579,476 tonnes of petroleum products in 2004.
Extent of the network	Electricity access rate (2005): Urban: 25% Rural: 2% According to the Poverty Reduction Strategy Paper (PRSP) 2002-2004, Zambia intends to create new energy infrastructure, which will include the Zambia-Tanzania-Kenya Interconnector, Zambia-DRC Interconnector	Electricity access rate: Urban: 100% Rural: 100%	Overall Electricity access rate 54% (2006) Urban: 78% Rural: 24%
Capacity concerns	Zambia's total demand currently exceeds internal generation as a result of the thriving mining sector.	In 2006, the Mauritian electricity supply outstripped the demand.	Effects of oil price rises and prolonged and severe drought during the 1980s led to the most difficult era. By 1983 power generation had declined to only 30% of its 1980 level and the distribution infrastructure had deteriorated badly.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa			
	Zambia	**Mauritius**	**Ghana**
Potential for RE	- Solar energy, 3,000 sunshine hours annually, - Solar insolation: 5.6kWh/m²/day. - Wind speed-averaging 2.5 m/s at 10m above the ground, mainly suitable for mechanical applications. - Small hydro potential of 4 MW - Biogas – 341,000 units of biogas digesters.	- Solar energy potential - Bagasse from sugarcane industry and woody biomass. - Potential for further 30-50 MW of hydro sites still exists. Wind speed average: 8 m/s.	- In order to further develop the solar and renewable energy programmes, the Ministry established on the Renewable Energy Services Project (RESPRO) with funding support from the Global Environment Fund through the United Nations Development Programme. - Solar energy for production of electricity is relatively negligible; about 140 tonnes of oil equivalent. There are 68 sites for constructing mini or micro hydro power plants. The total capacity of these mini/micro hydro plants has been estimated as 25 MW.
Potential for EE	The Energy Regulation Board's is involved in Regional & Country Energy Efficiency: - Promoting energy awareness and disseminating useful information on energy efficiency measures and on recommended procedures for all sectors of the economy. - Carrying out technical audits on business such as farmers, and advising them appropriately on the usage of energy, and - Developing appropriate license conditions on EE such as metering all customers. - Developing Integrated Regional & Country Institutional Frameworks Involving Regulators & Southern African Power Pool	Mauritian sugar cane companies have invested in high efficient boilers to increase the efficiency of cogeneration. - Use of solar water heater for domestic purposes to reduce use of electricity in residential areas. - Development of wind energy projects through a build operate and transfer scheme in order to reduce dependence on imported fuel for electricity production. www.gov.mu	New information on Energy Efficiency has been provided: - Ghana implemented an impressive Energy Demand Management Program (EDMP) through power factor correction and load management in industry which resulted in savings of over 30 MVA. - Ghana went into partnership with the government of Netherlands in 2002-04 to improve energy efficiency in Public Buildings which resulted in US$ 148,000 annum in electricity cost savings to the Government - An Efficient Lighting Initiative where 6 million incandescent lamps were replaced with 6 million compact fluorescent lamps (CFL) in 2007 for free was successfully implemented. - Incandescent lamps were to be phased out through legislation in Parliament - Local manufacturing facilities for producing CFLs were established in Ghana - Standards and labels for air conditioners and CFLs were established. (Ahenkorah, 2008)

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa

	Zambia	Mauritius	Ghana
2. Energy market			
Ownership	- Zambia Electricity Supply Corporation (ZESCO) is Zambia's biggest power utility and is government owned. http://www.zesco.co.zm/ - Copperbelt Energy Corporation PLC (CEC) is a privately owned company that operates and maintains a network comprising transmission, distribution and generation assets and a control centre on the copper belt. (http://www.copperbeltenergy.com/) - Lunsemfwa Hydro Power Corporation active in power generation.	The Central Electricity Board (CEB) is responsible for the transmission, distribution and supply of electricity in the country. www.gov.mu	The Electricity Corporation of Ghana (ECG) has been transformed into a private company limited by shares to be subsequently broken up into distribution concession companies. The operations of VRA have also been unbundled into separate business units for its hydropower generation, transmission services and distribution business in the Northern Electricity Department (NED) operational area. http://www.energymin.gov.gh/electricity.htm http://www.ghana.gov.gh/
Structure/ extent of competition	ZESCO Limited is government owned monopoly with vertically integration.	CEB is government owned monopoly with vertically integration. There are three independent Power Producers (IPP) bagasse/coal power stations owned by CEL (22 MW), CTBV (62 MW) & FUEL (27 MW) and seven Captive Power Plants (CPPs) - these are sugar factories that export energy to CEB which they may have in excess during the crop season only July to December and can generate up to 39 MW at peak.	- VRA is a dominant market player. This is a potential barrier to competition and market development. - Western Power Company Limited and Takoradi Power Company (both thermal plants) new generators enhancing competition in the generation of power. http://www.vra.com/

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa

	Zambia	Mauritius	Ghana
3. Energy policy framework			
Existence of an Energy frame work and programmes to promote sustainable energy	Energy & Environmental Concerns for Zambia (EECZ) a grouping of researchers, academics and policy makers, are involved in the promotion and development of sustainable energy in Zambia with the following objectives: - To contribute to the development, promotion and wider use of energy in a sustainable manner to the environment. - To provide a forum for interaction and exchange of ideas between individuals and organisations involved in the planning, development and sustainable utilization of energy. - To foster education, scientific research and development in the field of energy and environment as well as promote the national wide dissemination of information on energy and environment. The promotion of efficient production and use of wood fuel is well captured in the PRSP. Under this programme, charcoal consumption will be reduced by 400,000 tones by the year 2010.	- The Ministry of Economic Development and Regional Cooperation in conjunction with the ministry of public Utilities is responsible for the planning and financing aspects of energy projects. - The Forestry Service is responsible for the management of forest products, including woody biomass used as cooking fuel. - The Mauritian National Energy Policy places emphasis on the use of locally available bagasse from the sugar industry in combination with imported coal for production of electricity in order to reduce dependence on imported oil.	In order to further develop the solar and renewable energy programmes, the Ministry established on the Renewable Energy Services Project (RESPRO) with funding support from the Global Environment Fund through the United Nations Development Programme. www.energymin.gov.gh The Renewable Energy Division is responsible for developing and elaborating national policies and strategies for all renewable resources, technologies, demand and supply side management and generation: solar photovoltaic systems for both stand-alone and grid connected; wind energy resource assessment and generation, small hydro development in Ghana covering mini, micro; biomass/biofuel and wood fuel resource assessment, development and generation.
Current energy debates or legislation	The Zambian government is working on a Rural Electrification Master Plan at a cost of 500 million U. S. dollars to cover the period from the year 2008 to 2030. Zambia is in the process of developing National Energy Strategy 2008-2030 with focus on: Electricity, petroleum, renewable Energy and biofuels. In addition, there are plans for the formulation of the RE strategy with focus on: Solar Energy, Small Hydropower Energy Crops, Biomass Environmental Framework for biofuels	Review of the National Energy Policy is currently ongoing. The draft NEP document has been prepared. The draft document has been submitted to line Ministries for comments.	A new power sector regulatory law has been passed establishing a Public Utilities Regulatory Commission (PURC) to regulate the delivery of public utility services including electricity. An Energy Commission Bill has also been passed by the parliament, which provides legislative backing for the new structure of the electricity market and regulation of the technical aspects of the operations of the electric utility companies.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa

	Zambia	Mauritius	Ghana
Major energy studies	The Zambia Electricity Supply Corporation (ZESCO) has completed feasibility studies for the development of two hydro power stations with a combined capacity of 870 MW and construction is set to begin soon.	The Solar Energy Project in Eastern Province has been evaluated and an evaluation report is being prepared.	A recent study conducted has identified some 68 sites for constructing mini or micro hydro power plants. The total capacity of these mini/micro hydro plants has been estimated as 25 MW.
Role of government/ department	- The Ministry of Energy and Water Development (MEWD) is responsible for policy and strategy development principally for the petroleum sector, and for monitoring the implementation of policies and strategies through autonomous energy utilities, agencies, and organizations.	Ministry of Public Utilities is charged with the responsibilities of ensuring a reliable supply of electricity to all sectors of the economy, maximising the use and benefits of renewable local sources of energy and ensuring the provision of efficient, effective and quality services by organisations under its supervision. CEB: charged with preparation and carrying out development schemes with the general object of promoting, coordinating and improving the generation, transmission, distribution and sale of electricity in Mauritius. ESD: promote energy efficient state of art technology http://cebweb.intnet.mu/	The Ministry of Energy and Mines (MME) has ministerial oversight responsibility for the power sector. In discharging its functions, the MME also played the role of regulator in the area of electric tariff review and approval.
Government agencies in sustainable energy	- Energy Regulation Board (ERB) has jurisdiction over electricity (including nuclear, solar and wind), petroleum and petroleum products, Coal and its derivatives, firewood, charcoal and other wood derivatives and uranium and other nuclear fuels.	- Ministry of Public Utilities – through maximising the use and benefits of renewable local sources of energy. - Energy Services Division – through promoting energy efficient state of art technology.	The Renewable Energy Division is responsible for developing codes and standards for solar, wind, bioenergy systems, to support the deployment of Renewable Energy Technologies (RETs), particularly for rural development and environmental care, as well as to enhance energy efficiency and supply for economic growth,

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa

	Zambia	Mauritius	Ghana
Energy planning procedure	The MEWD is the principal institution with the national mandate for carrying out Zambia energy planning and policy development. ZESCO is responsible for generation, transmission and distribution of power and the Energy Regulation Board is responsible for regulating the energy sector by monitoring the efficiency and performance of energy sector undertakings.	The Ministry of Public Works is charged with formulation of policies in the energy sector.	The Energy Commission (E.C.) is required by law to prepare, review and update periodically indicative national plans to ensure that all reasonable demands for energy are met in a sustainable manner. The Commission has developed and elaborated a Strategic National Energy Plan (SNEP) for the period 2006 & 2020.
Energy regulator Date of creation	ERB, created under the Energy Regulation Act of 1995 Chapter 436 of the Laws of Zambia and become operational in 1997 http://www.zesco.co.zm/	CEB, established in December 1952. http://cebweb.intnet.mu/	The Energy Commission of Ghana, (EC) established in 1998 by the Energy Commission act 1997 (Act 541) is the statutory regulatory body on energy in Ghana. http://www.energycom.gov.gh/
Degree of independence	The ERB is appointed by the Minister of Energy and Water Development	The CEB board is appointed by the Minister of Public Utilities http://cebweb.intnet.mu/	The Commission consists of seven Commissioners appointed by the President. The Commission's secretariat is run by an executive secretary who is also a member of the board, and comprises four main divisions: Power, Petroleum, Renewable Energy and Strategic Planning and Policy.
Regulatory framework for sustainable energy	GVEP in association with the Department of Energy, Ministry of Energy and Water Development are working on a working on a mechanism to increase access to reliable affordable and environmentally sustainable energy services as a means of enhancing economic and social development. The ERB safe guards the interests of the consumer, licences energy undertakings to, receive and investigate complaints from consumers on prices and services.	The Ministry of Public Utilities, the Central Electricity Board (CEB) and the Energy Services Division, (ESD) work hand in hand to encourage the use of renewables energy technologies efficiently.	The Energy Commission recommends national policies for the development and utilization of indigenous energy resources, including renewable energy.

Appendix 4: Overview of the Energy Sector in Sub-Saharan Africa

	Zambia	Mauritius	Ghana
Regulatory roles	- Ensuring that utilities earn a reasonable rate of return on their investments that is necessary to provide a quality service at affordable prices to the consumer, - Ensures that all energy utilities in the sector are licensed, - Monitors levels and structures of competition, investigates and remedies http://www.zesco.co.zm/	- Preparation and carrying out development schemes with the general objective of promoting, coordinating and improving the generation, transmission, distribution and sale of electricity in Mauritius. http://cebweb.intnet.mu/	The Commission's foremost mandate is issuance of licenses to all operators in the energy sector and the establishment and enforcement of standards of performance for public utilities, petroleum product marketing companies and their retail outlets.
Role of government department in energy regulation	The Ministry of Energy and Water Development has the overall responsibility for power. ZESCO, which is responsible for the generation, transmission, distribution and supply of electricity, and ERB reports to the ministry.	The ministry of public utilities through the CEB ensures reliable supply of electricity to all sectors of the economy.	The Energy Commission (EC) is a sector institution responsible for regulating, developing and managing the utilization of energy resources. The Commission is also responsible, in particular, for preparing indicative plans for the development of the energy sector, licensing of public utilities for transmission, wholesale supply, distribution and sale of electricity and natural gas and enforcing performance standards of the utilities.
Regulatory barriers	There is very limited regulatory independence, consumer participation in the energy sector and limited support for sustainable rural and peri-urban development.	There is limited independence as CEB is under the ministry of Public Utilities.	VRA is a dominant market player. This is a potential barrier to competition and market development.

Source: REEEP, 2008 (AFREPREN/FWD has contributed to this study and continues to update the database).

Appendix 5: East African Feed-In Tariff Policies.

Kenya: - Feed in tariff policy for Kenya published and is open to first 500 MW, after which, it is likely to be reviewed.

Source	Power plant capacity (MW)	Firm power Tariff (US cts/kWh)
Small hydro	<1	12.0
	1-5	10.0
	5-10	8.0
Wind	<50	9.0
Biomass	<40	7.0

MoE, 2008

Tanzania:

Category	Period	Tariff (US cents)
Standardised average small power purchase	NA	12
Seasonal adjusted	Aug - Nov	10
	Jan – Jul & Dec	14

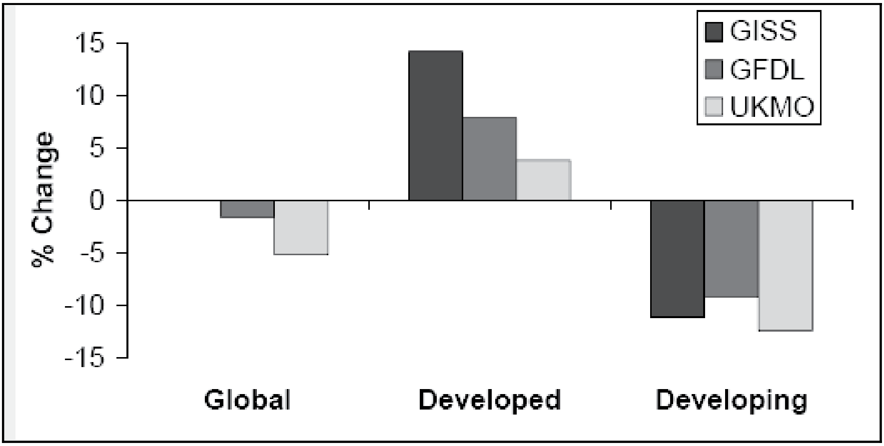
EWURA, 2008

Uganda:

Time of use	Year 1-6	Year 7-20
Peak (1800-2400hrs) (US$/kWh)	12.00	8.00
Shoulder (0600-1800hrs) (US$/kWh)	6.00	4.50
Off-Peak (0000-0600hrs) (US$/kWh)	4.10	4.00
Average Tariffs	7.03	5.25

ERA, 2008

Appendix 6:
Change in Cereal Production in Developed and Developing Countries*



Source: Parry et al. (2005) analysing data from Rosenzweig and Parry (1994).

Simulation for a doubling of carbon dioxide levels (equivalent to around 3°C of warming in models used) simulated with three climate models (GISS, GFDL and UKMO Hadley Centre).

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