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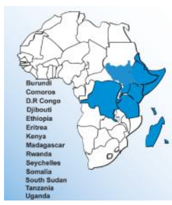

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Table of contents

List of Tables

List of Figures

List of Boxes

EXECUTIVE SUMMARY

The 2011 World Energy Outlook indicates that globally over 1.3 billion people lack access to electricity, 2.7 billion people lack clean cooking facilities, concentrated largely (95%) in Africa and developing Asia, and 84% in rural areas. The International Energy Agency stipulates that even with $14 billion per year investment between 2010 and 2030 to on-grid electricity connections, 1 billion people will still be without electricity, and with population growth billions will still live without access to clean cooking facilities by 2030. Some $48 billion per year during 2010 to 2030 will needed to be invested for universal access to modern energy, with majority of the investment going to Africa.

In the Eastern African sub-Region, most countries have population biomass reliance in excess of 90%. In comparison with developing Asian countries (54%), Latin American countries (19%) and the Middle East (0%), reliance on biomass is still quite high. Electricity access rates range from 1% in the new State of South Sudan (leaving 9.3 million people without access), to 9% in Uganda (leaving more than 28 million people without access) (though recent reports have it at 12%), 11% in D.R. Congo (leaving nearly 59 million people without access), 13.9% in Tanzania (leaving nearly 38 million people without access), 16.1% in Kenya (leaving more than 33 million people without access) and 17% in Ethiopia (leaving nearly 69 million people without access). Africa, and particularly the Eastern Africa sub-Region, therefore represents the most significant challenge to addressing the global energy access problem.

With dwindling forest biomass resources due to rapid growth in demand for wood and charcoal, affordability and reliability of electricity supply and rising petroleum consumption in the Eastern Africa sub-Region have also raised concerns about energy security. In terms of percentage changes in forest cover based on 1990 forest resources as a base reference, nearly 20% stock decline is observed in Somalia, Ethiopia and Tanzania, nearly 40% decline in Uganda and Burundi, and 75% decline in Comoros. Between 4 to 8% forest stock declines are observed in Madagascar, Kenya, Eritrea and D.R. Congo. In the D.R. Congo, while a 4% decline seems marginal, given the size of the stock reaching 160 million hectares in 1990, one of the largest in the world, the magnitude of deforestation is quite large. Rwanda is the only country managing its forest resources quite well, showing forest resource recovery by 117,000 hectares between 1990 and 2010. In absolute figures, the losses were highest in Tanzania, with more than 8 million hectares of forest lost; over 6.2 million hectares in D.R. Congo; 2.8 million hectares in Ethiopia; and between 1.3 million – 1.7 million hectares in Madagascar, Somalia and Uganda. The state of forest resources, and biomass energy production capacity, in the Eastern Africa sub-region is skidding towards greater insecurity, with potential consequences of rising wood and charcoal prices, and greater concern about the long-term ability to sustain biomass supply. The state of household energy security, under current trends, is likely to worsen.

In terms of the energy security impacts form the electricity sub-sector, it is noted that the legacy of electricity in the Eastern Africa sub-region was predominantly hydroelectricity. Lack of energy planning and growing energy demand have pushed the region to technology choices that brought more thermal generation, growing overtime as a share of total electricity generation. The shift in energy conversion technology of the sub-Region to thermal options has energy security implications. In terms of all-round dependency on imported fuels consumption, the global share of petroleum consumption in Africa has gradually increased from around 3.25% to about 4% over the last decade. In the same period, the share of the Eastern African sub-Region in Africa's petroleum consumption increased from about 8% to close to 10%. While the shares seem to have increased only gradually, comparison of absolute consumption levels of petroleum from 2000-2011 shows that while consumption at the continental level increased by slightly more than 40%, the rise in the Eastern African sub-region was 67%. This constitutes a

significant increase in exposure to global energy markets and associated sources of energy insecurity. A decade-by-decade analysis of the price shifts reveal that oil prices were indeed declining before the 1970s oil crisis, only to increase by nearly 3,000% in the 1980s, but receding in the 1990s, and slightly increasing from 1990 to 2000. In the 2000s, though the price hike is not as detrimental as the 1970-1980 decade, has nonetheless broke from norm and increased sharply, by nearly 170%. Dominant growth prospects in China, India, Brazil and Russia (BRICs) and global growth in per capita income is are likely to put further pressure on energy prices, with energy security impacts on fuel importing countries.

The World Summit on Sustainable Development in 2002 promoted the role of energy, and through the Johannesburg Plan of Implementation solidified the importance of considering energy in promoting development and reducing poverty. The UN Rio+20 Outcome of Conference of 2012 passes that since 1992, insufficient progress in sustainable development was aggravated by the global energy crisis, particularly in developing countries, and urged countries to address challenges of access to sustainable modern energy services. The Conference further outlined that energy is crucial component to development, as access to modern energy contributes to poverty reduction, improvement of health, and provision of basic human needs, making "reliable, affordable, economically viable and socially and environmentally acceptable energy" crucial in developing countries. The UN Secretary General, Mr. Ban Ki-moon, declared that he "made Sustainable Energy for All a top priority because it is central to all aspects of sustainable development."

Despite numerous challenges in the energy sector of Eastern Africa, opportunities abound. Member States are endowed with significant clean energy resources, development potential of trans-boundary hydropower systems is ripe, energy trade is barely leveraged in the sub-region, private sector participation and capital infusion is a real possibility, and institutional and policy reforms can address the pent-up demand for rapid energy development. Discovery of oil and gas resources in the sub-region, and growing interest in biofuel development also offer pathways to meeting energy insecurity through regional frameworks. These, and other opportunities, constitute the possibility of an *energy transformation and revolution* in the sub-Region.

Recognizing that energy access and security are indispensable to economic transformation, member States of the Eastern Africa sub-region are advised to consider: strong commitment to energy sector development consistent with their socioeconomic development aspirations; increasing private sector engagement, and private-public partnerships to enhance investment resources in the energy sector; pursuing regional opportunities to engage in energy trade and benefit from lower energy costs and economies of scale; pursue renewable energy initiatives aggressively; commit to energy access sub-regional and country targets and strive to achieve Sustainable Energy for All objectives by 2030; strengthen energy planning while synergizing with economic planning; institute and stock strategic reserves of petroleum to lower the economic costs of energy disruptions while developing partnerships for a regional procurement framework; strengthen regional cooperation on development of strategic energy resources such as oil and gas; engage in exchange of information and experiences pertaining to enhancing energy access and security and ultimately addressing the energy constraint to resilient economic transformation through workable strategies implemented in the Eastern Africa sub-region and beyond.

This report offers a sub-regional picture on energy access and security, reviews case studies from select member States to highlight lessons on energy access and security, looks at

the environmental, trans-boundary energy resources, infrastructure and trade, technology and energy and economic performance issues at length. Policymakers, decision-makers and energy sector stakeholders may find it useful as they deliberate, advocate and implement programs and strategies that will collectively enhance the state of energy access and security. The United Nations Economic Commission for Africa (UNECA), including its Sub-Regional Office for Eastern Africa (SRO-EA), will continue to engage policymakers and energy sector stakeholders, particularly in the regional dimension of energy sector development, to simultaneously encourage regional integration, a central objective that will be enhanced by regional energy integration.

ACRONYMS

AAGR	Average growth rate
ADER	Madagascar's Rural Electrification Agency
AEEP	Africa-European Union Energy Partnership
AfDB	African Development Bank
AFREA	African Evaluation Association
AMCOW	Abuja Declaration of the African Ministers Council on Water
APERC	Asian Pacific Energy Research Center
BCF	Billion standard cubic feet
BEIA	Biomass Energy Initiative for Africa
BG	British Gas Group
BRICs	Brazil, Russia, India and China
BTU	British Thermal Unit (about 1,055 joules)
CAA	Concession and Assignment Agreement
CAPP	Central African Power Pool
CBD	UN Convention on Biological Diversity
CCI	Crisis Capability Index
CDM	Clean Development Mechanism
CEMAC	Economic and Monetary Community of Central Africa
CHP	Combined heat and power
CICOS	Congo-Oubangui-Sangha International Basin Commission
CIF	Climate Investment Funds
CNOOC	China National Offshore Oil Corporation
COP11	11th Meeting of the Conference of Parties to the Convention on Biological Diversity
CPA	Comprehensive Peace Agreement, South Sudan
CSP	Concentrating Solar Power
DPOC	Dar Petroleum Operating Company, South Sudan
E-10	A 10% ethanol blending mandate
EAC	East African Community
EAPP	East Africa Power Pool
ECOWAS	Economic Community of West African States
EDI	Energy Development Index
EEA	Ethiopian Energy Agency
EELPA	Ethiopian Electric Power Corporation
EEPCo	Ethiopian Electric Power Corporation
EIAs	Environmental Impact Assessments
EISD	Energy Indicators for Sustainable Development
EPP	Emergency Power Plan, Tanzania
ERA	Electricity Regulatory Agency, Uganda
EREDPC	Ethiopian Rural Energy Development and Promotion Center
EWURA	Energy and Water Utilities Regulatory Agency, Tanzania
FAO	UN Food and Agriculture Organization
FCPF	Forest Carbon Partnership Facility

FDI	Foreign Direct Investment
FIP	Forest Investment Programme
G8	Group of Eight, forum for eight of the most industrialized nations
GACC	Global Alliance for Clean Cookstoves
GDC	Geothermal Development Company, Kenya
GDP	Gross Domestic Product
GHG	Green House Gas
GPOC	Greater Pioneer Operating Company, South Sudan
GTP	Growth and Transformation Plan, Ethiopia
HDI	UNDP's Human Development Index
HIPC	Heavily indebted poor countries
HRW	Human Rights Watch
IAEA	International Atomic Energy Agency
IAP2	International Association for Public Participation
ICS	Interconnected systems
ICT	Information and Communication Technology
IEA	International Energy Agency
IFC	International Finance Corporation
IMF	International Monetary Fund
IPPs	Independent Power Producers
IT	Information technology
IWRM	Integrated Water Resource Management
JIRAMA	Madagascar's national power and water utility
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KPLC	Kenya Power and Light Company Ltd
kWh	Kilowatt hour
LDPs	Local Development Plans
LNG	Liquefied natural gas
LTWP	Lake Turkana Wind Power project
LWSPs	Local Water and Sanitation Plans
M&E	Monitoring and Evaluation
MA	Mitigation Assessment
MDGs	Millennium Development Goals
MEPI	Multicriteria Energy Poverty Index
MHLPU	South Sudan Ministry of Housing, Lands and Public Utilities
MRC	Mekong River Commission
MRV	Measure, Report and Verify
MT CO_2e	Metric tons of carbon dioxide equivalent
MW	Mega Watt
NATO	North Atlantic Treaty Organization
NATOIL	Uganda National Oil Company
NBI	Nile Basin Initiative
NEPAD	New Partnership for Africa's Development
NOIT	Noor Oil Industry Technology

NRECA International	National Rural Electric Cooperative Association
NREL	US Department of Energy's National Renewable Energy Laboratory
NRODA	National Reserve Oil Depots Administration, Ethiopia
ODA	Official Development Assistance
OECD	Organization for Economic Cooperation and Development
PAU	Petroleum Authority of Uganda
PES	Primary Energy Sources
PIDA	Programme for Infrastructure Development in Africa
PPP	Private-Public Partnership
PSA	Petroleum Supply Act, Uganda
PSAs	Product Sharing Agreements
PSR	Petroleum Supply Regulation, Uganda
PV	Photovoltaic
R&D	Research and Development
RA	Risk Assessment
REA	Rural Electricity Agency, Tanzania
RECs	Regional Economic Communities
REDD	Reducing Emissions from Deforestation and Forest Degradation
REFIT	Feed-in Tariff, Uganda
REN21	Renewable Energy policy Network for the 21st Century
REPN	Regional Energy Planning Network
RETs	Renewable energy technologies
RNDBP	Rwanda national Domestic Biogas Programme
R-PPs	Readiness Preparation Proposals
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SCS	Self-contained systems
SEAs	Strategic Environmental Assessments
SEFA	Sustainable Energy For All initiative of the UN
SHS	Solar Home Systems
SINELAC	Societe d'Electricite des Pays des Grand Lacs
SNEL	Société nationale d'électricité, D.R. Congo
SNNP	Southern Nations, Nationalities and People, Ethiopia
SPOC	SUDD Petroleum Operating Company, South Sudan
SPS	Solar Pico Systems
SREP	Scaling Up of Renewable Energy Program in Low Income Countries
SRO-EA	ECA's Sub-Regional Office for Eastern Africa
SSA	Sub-Saharan Africa
SSEC	South Sudan Electricity Corporation
STI	Science, Technology and Innovation
STOIIP	Stock tank oil initially in place
TANESCO	Tanzania Electric Supply Company Limited

TCF	Trillion standard cubic feet
TDBP	Tanzania Domestic Biogas Program
TECCONILE	Technical Committee for the Promotion of the Development and Environmental Projection of the Nile Basin
TEPAD	Tanzania Energy Development and Access Expansion Project
TPDC	Tanzania Petroleum Development Corporation
TWh	Tetawatt hour
TWRM	Trans-boundary Water Resources Management
UEDCL	Uganda Electricity Distribution Company Limited
UEGCL	Uganda Electricity Generation Company Limited
UETCL	Uganda Electricity Transmission Company Limited
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNEP	UN Environmental Programme
UNFCCC	UN Framework Convention on Climate Change
US$	United States Dollar
USAID	US Aid for International Development
WAPP	West African Power Pool
WB	World Bank
WEO	World Energy Outlook
WHO	World Health Organization
WWF	World Wildlife Fund
ZAMCOM	Zambezi Watercourse Commission
ZECO	Zanzibar Electric Corporation

1. INTRODUCTION

1.1 OBJECTIVE OF THE REPORT

The objective of this study is to inform Eastern African energy policymakers, regulators, regional energy development partners, Regional Economic Communities and energy stakeholders - at regional, national and local levels - about the state of Energy Access and Security in the fourteen[1] Eastern African States, existing barriers to enhancing energy access and security in the sub-region and regional and country opportunities and pathways to improving on energy access and security.

By raising key issues related to energy access and security in the sub-region, by measuring and evaluating in-depth the state of energy access and security and by engaging possible pathways to enhancing access and security, including regional frameworks, the report further aims to deepen the policy discussion among stakeholders, increasing greater awareness about the issues and encouraging consideration of policy opportunities to enhance energy access and security in the sub-region, as well as in each member State.

1.2 SCOPE OF THE REPORT

Eastern Africa constitutes fourteen countries. The study will offer sub-regional analysis on energy access and security. This analysis is supplemented by review of cases from D.R. Congo, Ethiopia, Madagascar, South Sudan, Tanzania and Uganda. Both D.R. Congo and Ethiopia will enable looking at the role of countries with energy potential, yet internal energy development constraints, in enhancing sub-regional energy access and security.

The case of South Sudan will enable discussion of challenges a new State with energy potential but poor access faces. The case of Uganda and Tanzania will feature the role of energy-constrained countries with new found potential, and the implication of energy development in the gas and oil sector to sub-regional energy access and security. The case of Madagascar will bring forth unique challenges of Island States, and pathways to strengthen energy access and security in their context.

The study is therefore focused on providing a sub-regional analysis and overview of energy access and security, followed by select in-country case assessments. The country case studies are based on missions undertaken to the five countries, and consultations conducted with the respective ministries of energy, petroleum/hydrocarbon, rural electrification agencies, energy regulatory agencies, energy access institutions and with development partners. The sub-regional and country specific discussions are brought together within the context of the socioeconomic transformation agenda in the sub-region, and how reducing energy constraints will support such transformative visions. Particular focus is given to the stated goal of some member States to reach Middle Income status within a decade or so, and long with it the structural transformation of their economies. Energy indeed plays a facilitating, or constraining, role, depending on how energy sector development is addressed within the socioeconomic transformative agenda. These set of complex issues are explored in this report.

[1] The Eastern African sub-region referred to in this report constitutes: Burundi, Comoros, D.R Congo, Djibouti, Ethiopia, Eritrea, Kenya, Madagascar, Rwanda, Seychelles, Somalia, South Sudan, Tanzania and Uganda.

1.3 ENERGY ACCESS

1.3.1 The Global Energy Access Challenge

Access to modern forms of energy has been a structural constraint to socioeconomic development in the developing world for decades. Recently, *energy access* has entered the global policy priority agenda. This policy prioritization seems to be informed by the realization that achievement of development milestones are related to access to energy services. The International Energy Agency (IEA) stipulates that to meet Millennium Development Goals (MDGs) by 2015, it will be necessary to expand access to clean energy to 395 million more people, and clean cooking facilities to over 1 billion people worldwide, perhaps requiring additional investment of $41 billion per year between 2010 and 2015 (WEO, 2010).

Globally, over 1.3 billion people lack access to electricity, 2.7 billion people lack clean cooking facilities, concentrated largely (95%) in Africa and developing Asia, particularly (84%) in rural areas (WEO, 2011). The International Energy Agency stipulates that even with $14 billion per year investment between 2010 and 2030 to on-grid electricity connections, 1 billion people will still be without electricity, and with population growth billions will still live without access to clean cooking facilities by 2030. Some $48 billion per year during 2010 to 2030 will needed to be invested for universal access to modern energy, with majority of the investment going to Africa (WEO, 2011).

A joint WHO-UNDP study (2009) has shed further light on the challenge of energy access particularly in developing countries, where 1.5 billion lack access to electricity, and 9% have access to modern fuels. Within such disparities to access to energy, the urban-rural gap in developing countries is also wide. The study further demonstrates that 87% of rural population lack access to electricity, compared with 56% in urban areas in developing countries; and 27% of urban residents have access to modern fuels, compared with 3% of the population in rural areas. About 70% of the developing countries' population relies on wood and its by-products as main cooking fuel. Furthermore, penetration of improved cooking stoves is minimal, at about 4% in sub-Saharan Africa.

Energy access is indeed a global challenge. Closer look at the regional disparities on access to energy reveals that much of the *energy access* problem is concentrated in less developed countries, particularly in Africa and southern parts of Asia (see Fig. 1). While energy access has slightly improved since 2008, the structure of the global access disparity is nonetheless captured by figure 1. In terms of access to electricity, while there are quite high levels in parts of south Asia, sub-Saharan Africa, except South Africa, has a regional electricity access deficiency in urban, but particularly in rural areas. The picture is similar inters of access to modern fuels, where sub-Saharan Africa has lower levels of penetration, compared with other regions of the world.

While access to modern fuels in Africa are slightly better compared with the least developed countries, access to electricity, particularly to rural areas, is however much lower compared with the average for the least developed countries (see Fig. 2). In essence, the global energy access challenge is intrinsically tied, to a large part, with what will happen to energy sector development in Africa. Changing the global energy access problem will necessarily involve rapidly improving the energy profile of Africa, and addressing key structural and policy

constraints and improving the economic development context within which energy access solutions will be sought.

Figure 1: Percent of population without electricity (panel 1) and modern fuels (panel 2) – global view.

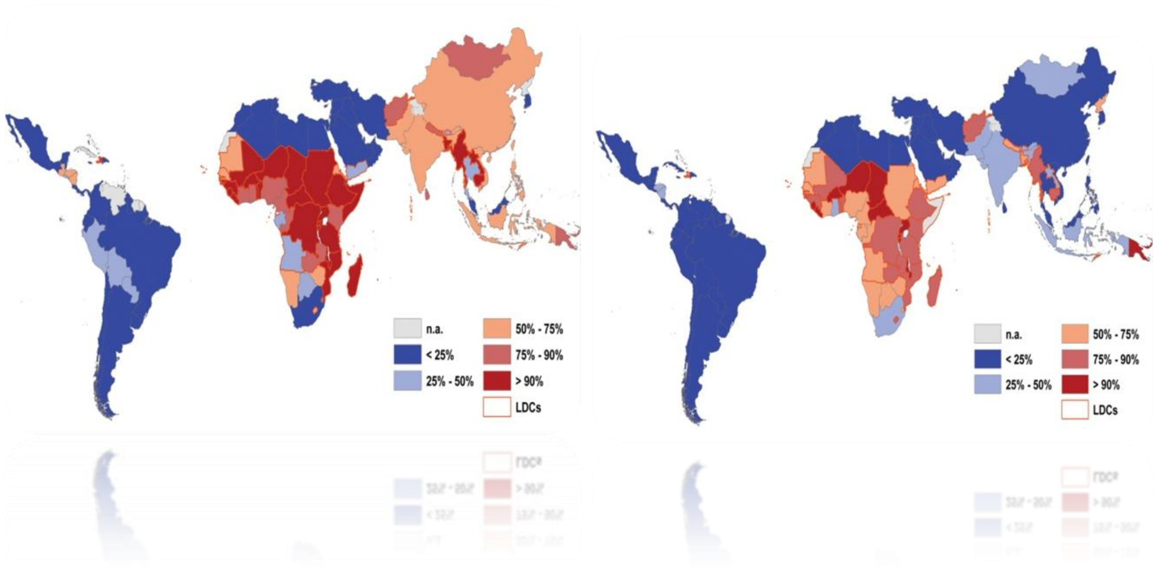
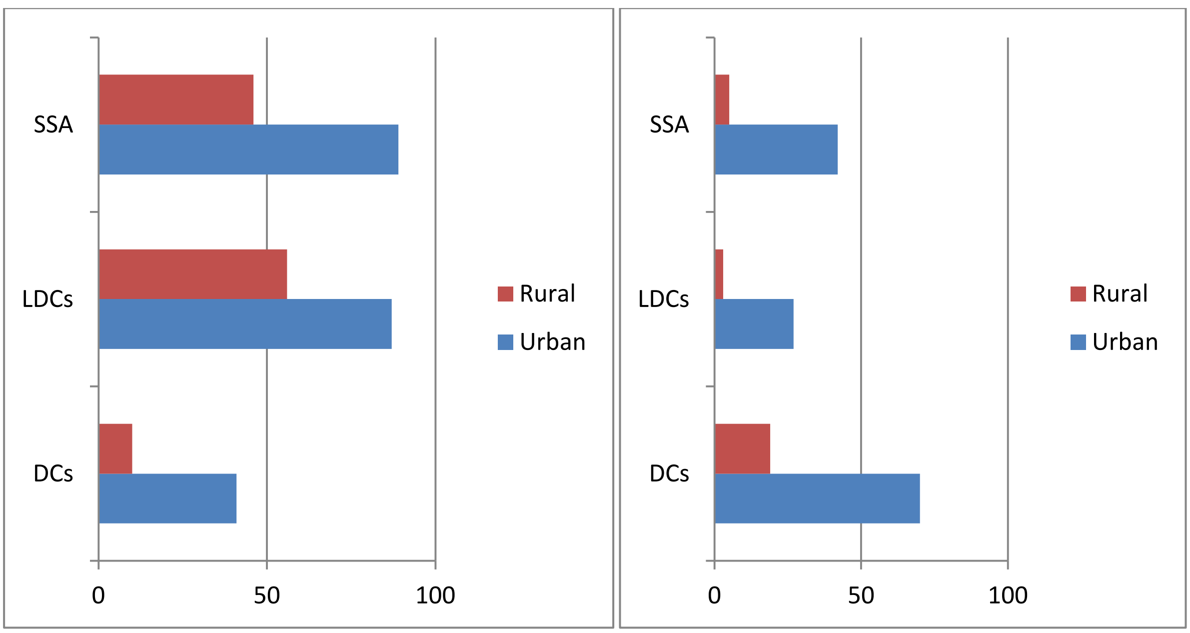


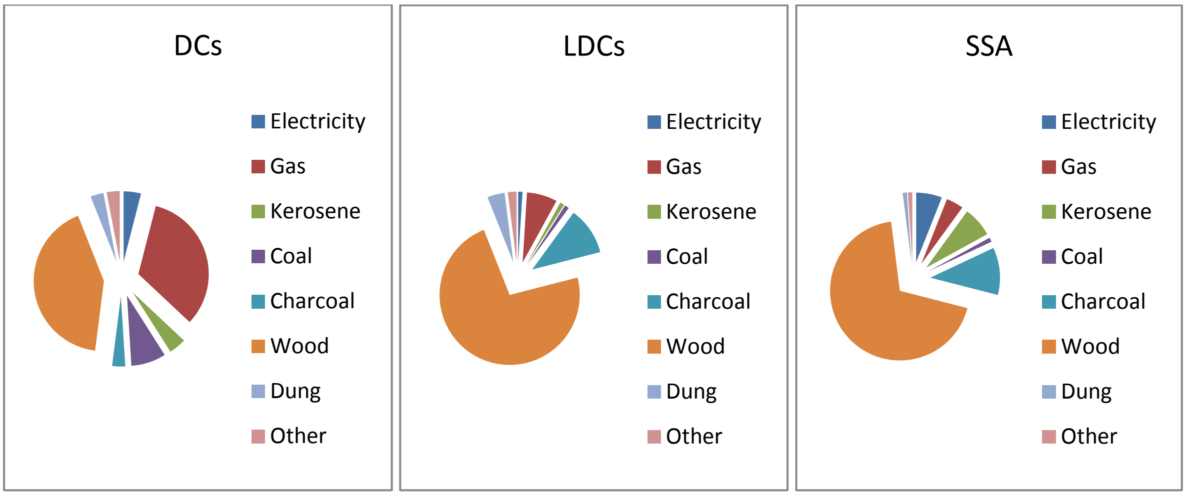
Figure 2: Percent of population without electricity (panel 1) and with access to modern fuels (panel 2) – urban and rural regional variation.



Sources: Adapted from WHO, UNDP (2009).

The global energy access challenge is also reflected in the energy sources portfolio, the degree to which access to modern forms of energy is constrained and transition to the later. In least developed countries, cooking fuels are largely sourced (see Fig. 3) from wood (73%) and charcoal (11%), with minimal access to gas (7%) and electricity (1%). In sub-Saharan Africa, cooking sources of energy are similarly sourced from wood (69%) and charcoal (11%), with minimal, but slightly higher, shares of kerosene (7%) and electricity (6%). There is therefore excessive dependence on biomass as the major source of energy. Combined with the limited general access to electricity, access to modern energy sources and the nature of its portfolio composition is a profound structural challenge.

Figure 3 Percent of population using different types of cooking fuels.



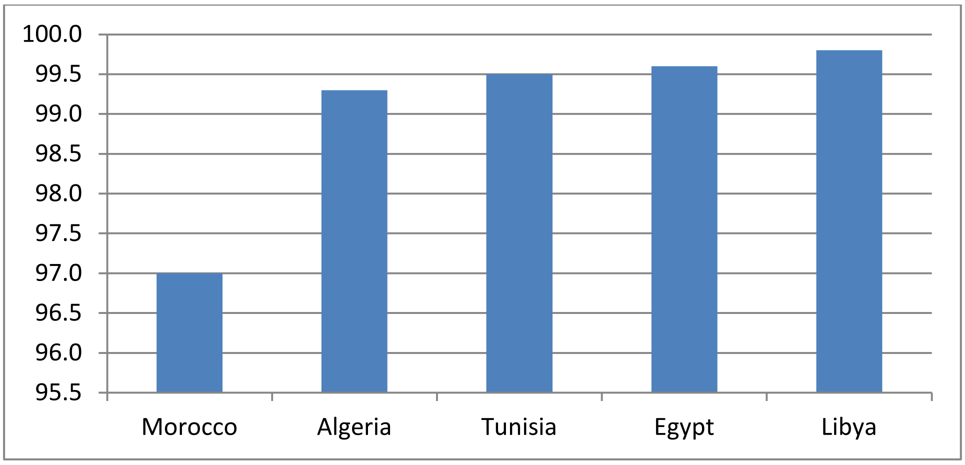
Source: Based on data from WHO, UNDP (2009).

1.3.2 The Energy Access Challenge in Africa and the Eastern Africa sub-Region

Africa is a transforming continent, featuring favorable GDP growth rates the last decade, and increasing pace in recent years. The global recession was largely believed to have slowed down Africa's economic performance, but the continent remained resilient, with forecasted growth of 5-7% between 2012 and 2015. The infamous declaration of Africa as the hopeless continent by the *Economist* magazine is replaced in recent issues as *hopeful* with bullish economic prospects. IMF (2012) report on Regional Economic Outlook in Africa indicates asserts that growth in sub-Saharan Africa in 2012 continues at a solid pace, anticipating growth rates of 51/4 in both 2012 and 2013. Supporting the economic progress in Africa will require, among others, addressing the structural constraint energy poses to the economies of Africa.

The energy sector constraint, as discussed in the global overview, is more prominent in Africa. In sub-Saharan Africa, access to electricity is around 30% (WEO, 2011), but with significant disparity between urban (89%) and rural (46%) areas (WHO, UNDP, 2009). The focus on sub-Saharan Africa separately in discussing the energy challenge is largely due to better access rates in Northern Africa. Access rates in the Northern African countries (see Fig. 4) of Morocco (97%), Algeria (99%), Tunisia (100), Egypt (100) and Libya (100%) attests the structural nature of the energy access problem in Africa, thus the focus on sub-Saharan Africa. The limited biomass resources in Northern Africa, favorable policy environment, level of economic development, climatic conditions and endowment of vast energy resources may explain the disparity in achieved energy access levels, and the type of energy portfolio chosen.

Figure 4 : Electricity access rate in high-performing African countries.



Source: Based on data from World Energy Outlook, 2010.

Access to modern energy for household cooking is also limited in Africa, with unsustainably large and growing population directly relying on biomass. An estimated 657 million people (65%) in Africa rely on biomass for cooking, about 74% in sub-Saharan Africa, and only 3% in Northern Africa (see Table 1). Eastern African countries of D.R. Congo, Tanzania and Ethiopia have population biomass reliance in excess of 90%. In comparison with the developing Asian countries (54%), Latin American countries (19%) and the Middle East (0%), reliance on biomass is still quite high. Africa thus represents the most significant challenge to addressing the global energy access problem.

Table 1: Number and share of people relying on traditional biomass, 2009.

	Relying on traditional use of biomass for cooking	
	Population (million)	Share of Population
Africa	657	65%
Nigeria	104	67%
Ethiopia	77	93%
D.R. Congo	62	94%
Tanzania	41	94%
Kenya	33	83%
Other sub-Saharan Africa	335	74%
North Africa	4	3%
Developing Asia	1,921	54%
Latin America	85	19%

Middle East	0	0%
Developing Countries	2,662	51%

Source: World Energy Outlook, 2011.

If sub-Saharan Africa poses a formidable challenge to solving the energy access problem, Eastern Africa is a particular concern. Electricity access rate ranges from just 1% in the new state of South Sudan (leaving 9.3 million people without access), to 9% in Uganda (leaving more than 28 million people without access), 11% in D.R. Congo (leaving nearly 59 million people without access), 13.9% in Tanzania (leaving nearly 38 million people without access), 16.1% in Kenya (leaving more than 33 million people without access) and 17% in Ethiopia (leaving nearly 69 million people without access) (see Table 2).

While these access numbers can be comparable with some African countries, such as Malawi (9%) and Zambia (18.8%), they trail behind Zimbabwe, Senegal, Botswana, Cote dÍvoire, Cameroon, Nigeria, Ghana and Mauritius where access rates are above 40%. Eastern African countries also under-perform in energy access (at around 23%) compared with the sub-Saharan average of 30.5%. The limited development of vast clean energy resources in the region, energy infrastructure inadequacy, limited investment in generation capacity for a prolonged time, low income levels[2] and energy policy reform and market organization may explain the peculiarly low levels of energy access in the region. If urgent solutions to rapid expansion of energy access are globally needed, they are particular timely in the Eastern Africa sub-region.

Table 2: Energy access rates in select countries in Eastern and sub-Saharan Africa.

Country	Electrification rate (%)	Population without electricity (millions)	Country/Region	Electrification rate (%)	Population without electricity (millions)
Select Eastern Africa Countries			Angola	26.2	13.7
South Sudan	1	9.3	Namibia	34.0	1.4
Uganda	9.0	28.1	Sudan	35.9	27.1
DR Congo	11.1	58.7	Gabon	36.7	0.9
Tanzania	13.9	37.7	Congo	37.1	2.3
Kenya	16.1	33.4	Zimbabwe	41.5	7.3
Ethiopia	17.0	68.7	Senegal	42.0	7.3
Madagascar	19.0	15.9	Botswana	45.4	1.1
Eritrea	32.0	3.4	Cote d'Ivoire	47.3	11.1
Select Sub-Saharan Africa Countries			Cameroon	48.7	10.0
Malawi	9.0	12.7	Nigeria	50.6	76.4
Burkina Faso	14.6	12.6	Ghana	60.5	9.4
Lesotho	16.0	1.7	Mauritius	99.4	0.0

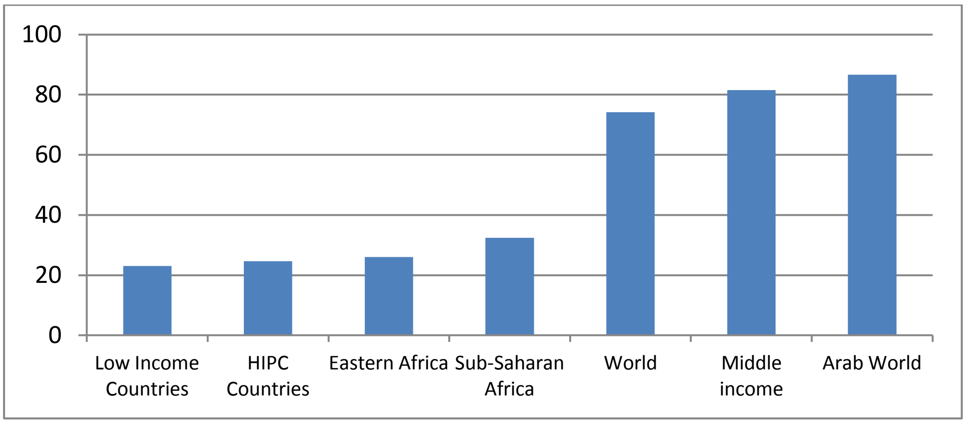
[2] The low levels of sub-regional income are reflected in the 2011 World Bank reported per capita incomes of $274 for Burundi, $230 for D.R. Congo, $374 for Ethiopia, $482 for Eritrea, $466 for Madagascar, $487 for Uganda and $529 for Tanzania. Urban residents are often better connected (and have better access rate to electricity) than rural residents partly due to better urban incomes, and hence effective demand.

Zambia	18.8	10.5			
Benin	24.8	6.7	**Sub-Sahara**	**30.5**	**585.2**

Source: Adapted from WEO data, 2011.

Comparison of energy access in Eastern Africa with other regions can put the picture in perspective. Particularly, comparison with access rates in Middle Income countries of over 80% (see Fig. 5) is note worthy, as one central goal in the economic development agenda in Eastern African countries is the transition to Middle Income status. There is ample optimism as economic growth in Eastern African member States demonstrated strong performance, bringing Middle Income status within policy sight. If energy development does not take a rapid pace, this economic agenda will like face an energy road block.

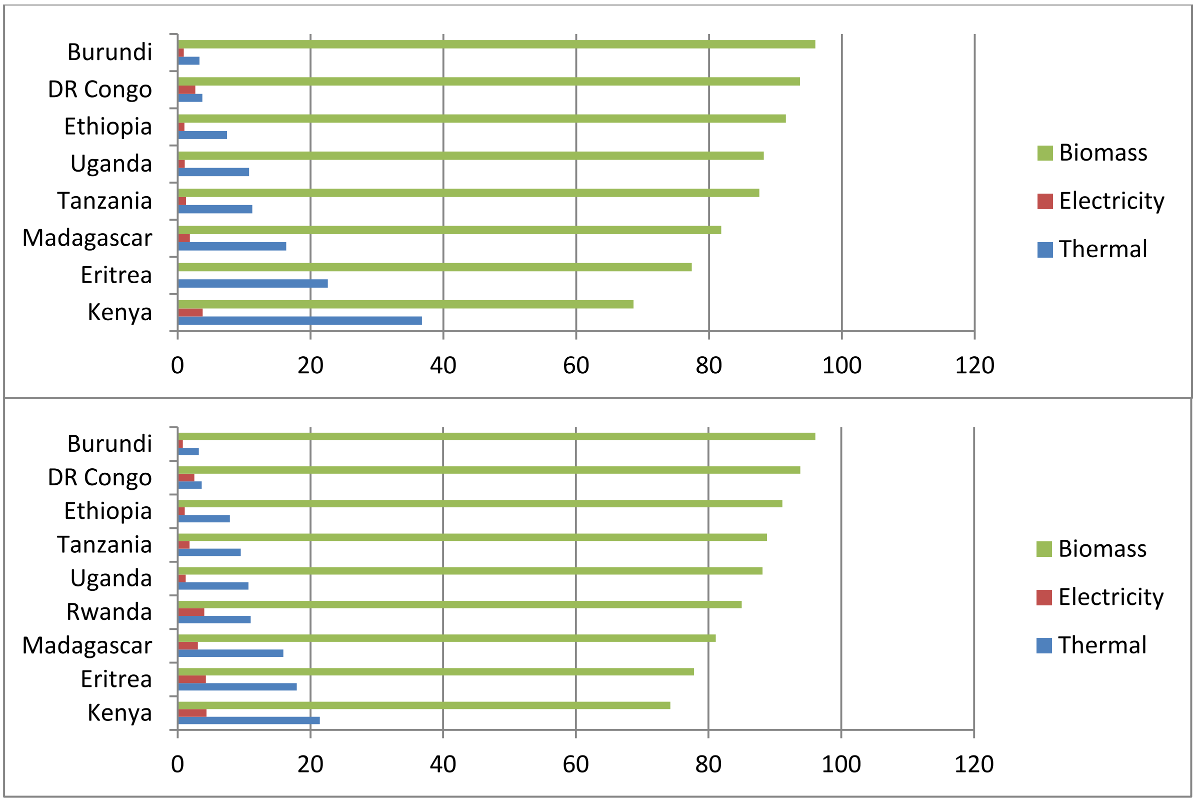
Figure 5: Comparison of electricity access in Eastern Africa with other regions.



Source: Based on data from World Energy Outlook, 2010.

The sources of energy production and energy consumed in Eastern Africa have similar structural composition as in most developing countries – excessive reliance on biomass as a source of energy. Biomass supports 60-70% of the energy production and consumption in Kenya and Eritrea, and above 80-90% in most Eastern Africa member States (see Fig. 6). Electricity and other forms of modern energy sources are relatively minimally utilized. The reliance on biomass is high in countries with both vast forest resource endowment (such as D.R. Congo) and scarce forest resources (such as Ethiopia).

Figure 6: Sources of energy in energy production (panel 1) and consumption (panel 2) in select countries in Eastern Africa.

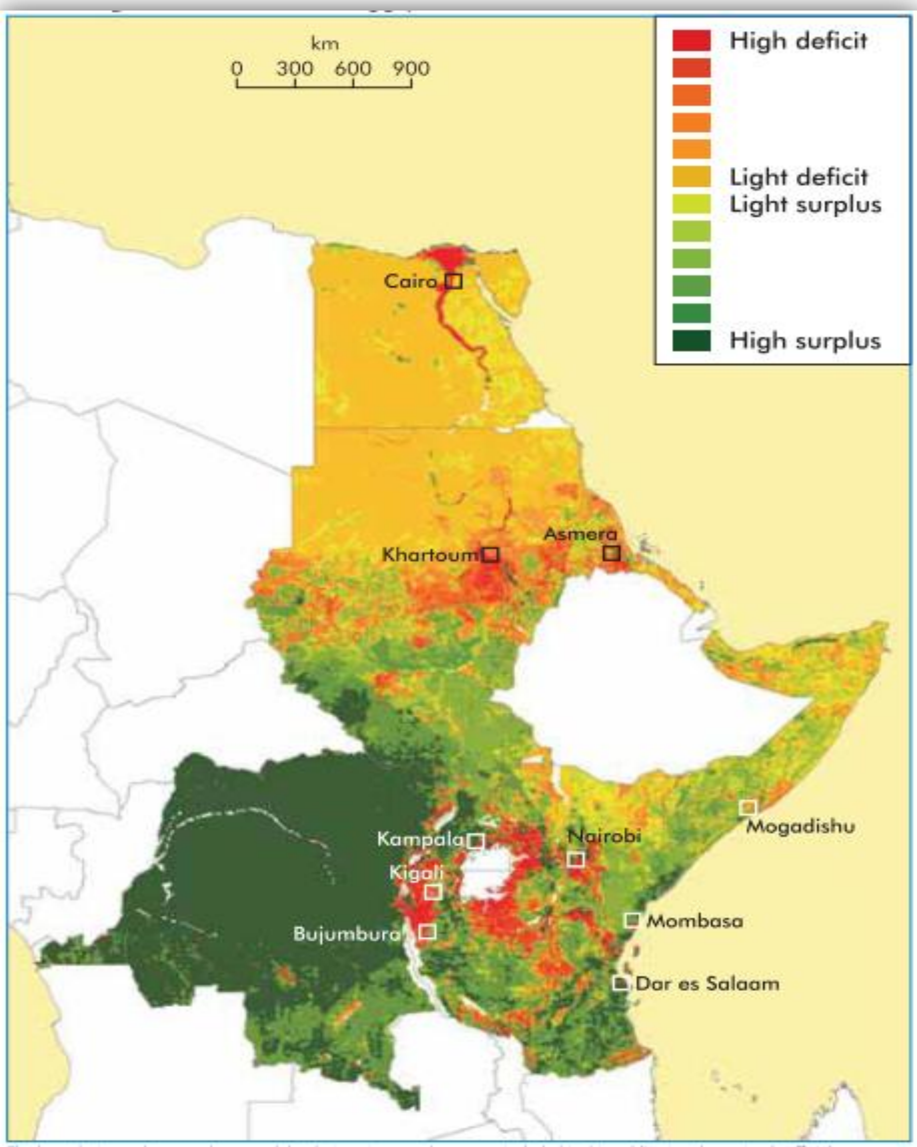


Source: Based on UN Statistics, *Energy Balances and Electricity Profiles, 2009*.

It is worth to note that in countries with relatively lower levels of biomass dependence, biomass energy is displaced with relatively more thermal sources of energy than electricity, demonstrated by strong thermal responses in Kenya and Eritrea. This has energy security implications, as thermal sources of energy are largely imported to the Eastern Africa sub-region. The energy security context is a topic that will be discussed in later sections.

A growing concern for continuing dependence on biomass for energy, with limited transition to modern energy sources, is the unsustainability of the status quo. The demand for wood in the Eastern Africa sub-region is increasing, with declining resource base. Comparison of demand and supply conditions in the sub-region (see Fig. 7) demonstrates that much of the region is either in light or high deficit, particularly in urban areas. This complicates the solution to the energy problem, requiring a fast move to energy transition while sustainably managing the biomass resources of the sub-region.

Figure 7: Firewood demand and supply condition in Eastern Africa.



Source: FAO. 2006. Woodfuel Integrated Supply/Demand Overview Mapping Methodology: Spatial Woodfuel Production and Consumption Analysis of Selected African Countries.
Note: Data not available for Ethiopia, Djibouti and Madagascar in the FAO study.

1.3.3 Why Energy Access Matters in the Eastern Africa sub-Region?

It is not often that we ponder the simple question 'why energy access,' since energy has become mundane, and its service wide spread in many parts of the world, albeit millions still live without it. Beyond its basic services of lighting, and powering energy end uses, *access to energy* is redefining economic and social progress, facets of transformation that are increasingly depending on energy availability, affordability and reliability. Discovering pathways to deliver energy to millions more, enabling them access to clean energy services, quality social services and enhanced economic opportunities constitutes the *energy revolution*.

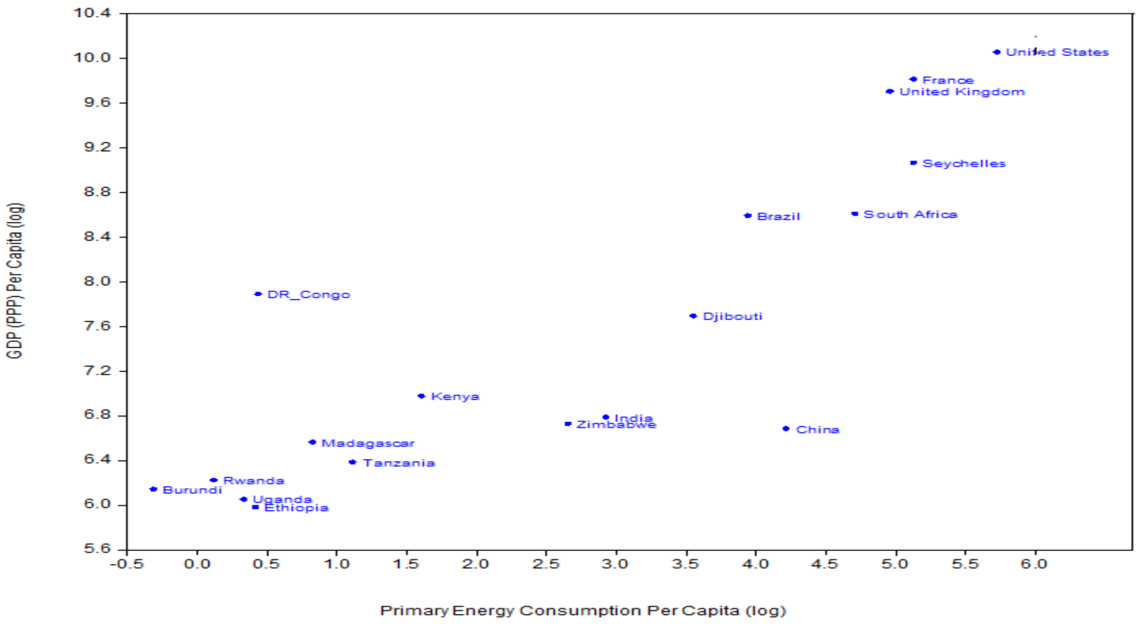
Energy access is an important dimension because the development and proper functioning of present day societies, including their social affairs, economic exchange, information sharing, provision of public services and overall quality of life depends on the availability and reliable supply of energy. Energy availability has become central to global, regional and local systems that its expansion and secure supply has long become a core goal of

States. The UN Rio+20 Outcome of Conference states that since 1992, insufficient progress in sustainable development was aggravated by the global energy crisis, particularly in developing countries, and urged countries to address challenges of access to sustainable modern energy services. The Conference further outlined that energy is crucial component to development, as access to modern energy contributes to poverty reduction, improvement of health, and provision of basic human needs, making "reliable, affordable, economically viable and socially and environmentally acceptable energy" crucial in developing countries.

Energy access is also an important consideration in envisioning socioeconomic transformation. Countries with lower levels of energy access and consumption have lower levels of economic development. The reasons for this observation can be many folds. At the micro-level, the productive use of energy is tied to economic empowerment and poverty alleviation. Access to energy helps stimulate the development of micro-enterprises, particularly in energy-poor regions in developing countries (Fakira, 1994; Foley 1990), contributing to the creation of employment opportunities and reduction of poverty. Even access to some electricity for productive use in off-grid communities can support seeding business development (Allerdice and Rogers, 2000). At the macro-level, energy is tied to development due to its direct input in production (Apergis and Payne, 2009) and indirectly complementing labor and capita inputs (Toman and Jemelkova, 2003). Therefore, at the aggregate level, energy consumption and economic growth are interlinked. Based on a study during the 1980-2005 period in the COMESA region, Nando, et al. (2010) concluded that the long-run relationship between energy and GDP in the region show strong relationship, and that they tend to move together.

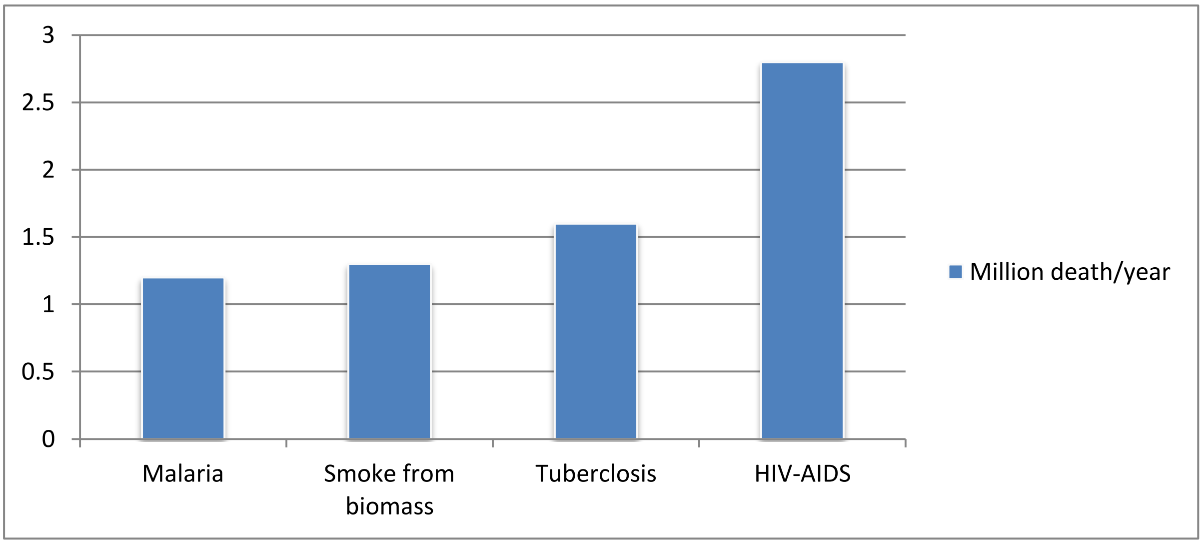
Observation of economic development and energy consumption globally reveals similar evidence, leading to a similar conclusion. Comparison of GDP per capita and primary energy consumption per capita, shown in Fig. 8, shows a strong and direct relationship between energy and economic growth. This implies that economic growth requires access to increasing levels of energy. Therefore, access to energy can act as a constraint to economic growth and poverty alleviation (UNECA, 2004). As countries strive to accelerate socioeconomic transformation, and as growth takes hold in many parts of Eastern Africa, sustaining it with proper development and accessibility of affordable energy is quite important.

Figure 8: Energy Consumption and GDP per capita.



Energy accessibility is also crucial beyond economic growth considerations, to broader social development. At the micro-level, the existing heavy-reliance on biomass and limited transition to modern energy sources has social costs, including indoor pollution and the opportunity cost of retrieving firewood. Based on WHO data, the IEA estimates that globally, some 1.3 million lives are lost to health complications resulting from inhalation of smoke from biomass burning (see Fig. 9). This impact is largely a burden on women.

Figure 9: The health impact of traditional biomass use.

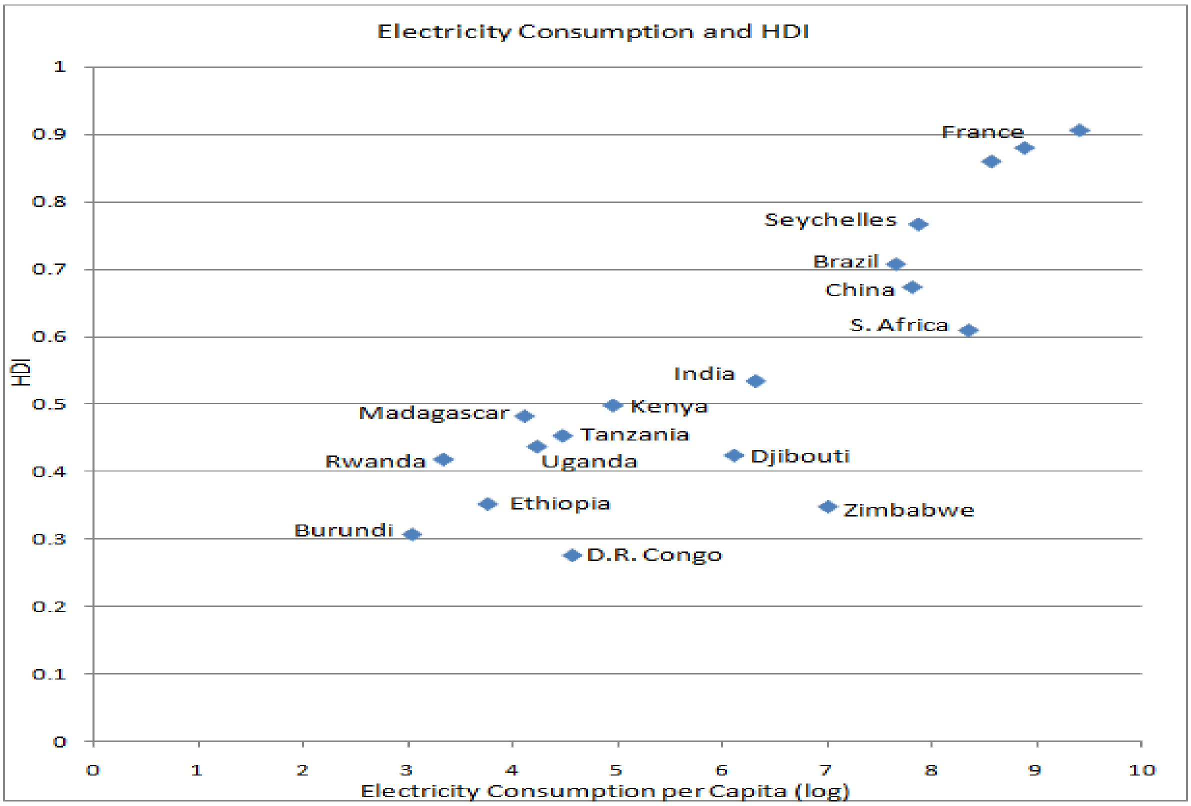


Source: IEA estimates based on WHO data.

Moreover, with declining forest resources, the cost of fetching firewood and other biomass has increased markedly, requiring more time being spent on wood energy collection that could otherwise have been spent on other productive uses. A study of this issue in Tanzania by Modi, et al. (2005) reveals that females spend around 250 hours in Tanzania, per person per year, in fetching water, and about 700 hours per person per year in collecting firewood. A study by Nanthuni and Findes (2003) further demonstrates the strong association between time spent on resource collection and a reduced likelihood of school attendance, particularly for girls. Therefore, energy services have a significant role in social development and uplifting, as energy services that allow community-level deliverty of social services, in terms of health, education, potable water and agricultural extension, would position even the poorest to benefit from such services (the Energy and Resource Institute, 2007).

At the macro-level, countries' human capital development, across health, education and other indicators is closely related with the level of energy consumption (see Figure 10). Countries with lower levels of energy consumption demonstrate lower levels of human capital development.

Figure 10: Energy Consumption and human development index (HDI).



Since the provision of quality public services, such as health, education, clean water and others rely partly on the quality of accessible energy, poor development and provision of energy will hinder broader social capital development, and consequently economic transformation. In essence, energy input has become an ingredient, so to say, that enables economic development, and the achievement of the Millennium Development Goals (MDGs) (Modi et al. 2005, Nussbaumer, et al 2011).

1.3.4 The Global and sub-Regional Energy Access Agenda

As discussed thus far, the structural challenges in the energy sector globally (excessive reliance on unsustainable energy resources), and particularly in developing countries (excessive reliance on biomass as a major energy source), has resulted in deficiency to energy access and constrained productive end uses, with negative implications to socioeconomic development. To address the energy challenge, global efforts are spearheaded, particularly in line with the global consensus around promoting and grounding *sustainable development*, which has recently evolved to *the green economy*. The fundamental challenge remains to focus on shifting the energy system towards a more efficiency, broadly accessible, affordable and sustainable path while supporting broad-based development, in this case sustainable development. To steer the energy system in this strategic direction required a concerted effort in prioritizing energy, and particularly energy access, at the global level, and setting key visions and strategies to take hold at regional, sub-regional and country levels.

Elevating the energy agenda at the global stage has rested on the efforts preceding it. The Commission on Sustainable Development has recognized the role of energy in sustainable development, particularly at the 11th session, where a multi-year programme of work considered the role of energy in sustainable development (TERI, 2007). The World Summit on Sustainable Development in 2002 further promoted the role of energy, and through the Johannesburg Plan of Implementation solidified the importance of considering energy in promoting development and reducing poverty. The "new consensus" communicated through the Johannesburg Plan of Implementation recognizes:

> Energy services as essential catalyst to economic and social development, particularly the achievement of MDGs;
>
> The difficulty of expanding energy services to the poor in developing countries due to prevailing economic conditions;
>
> The need for the public sector to act decisively to promote the conditions that allow greatly expanded access to energy services.

The Johannesburg agenda promoted international consensus to the importance of access to energy, and broader movement in Africa, partly supported by the Regional Energy for Poverty Program (REPP) of UNDP (UNDP, 2007). The development of regional power pools in Africa built momentum on the energy access agenda in the continent with charting action plans to implement the energy agenda. Regional Economic Communities (RECs), such as ECOWAS[3] in West Africa (developed whitepaper on regional strategy adopted by Heads of State by the 15 member States), CEMAC[4] in Central Africa (since the Brazzaville gathering in 2005 of the Energy Ministers of CEMAC, Energy Action Plan was requested, and delivered to the CEMAC Heads of State meeting in 2006), and EAC[5] in East Africa (launched the East Africa Power Master Plan, the Regional Strategy on Scaling up Access to Modern Energy Services, and a regional energy access strategy (adopted by EAC council of Ministers in 2006)) actively engaged in the energy access policy vision. The SADC[6] in Southern Africa also took action through the SADC Energy Ministers Roadmap, SADC Energy Activity Plan and strengthening the Regional Energy Planning Network (REPN).

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[3] ECOWAS is the Economic Community of West African States.
[4] CEMAC is the Economic and Monetary Community of Central Africa.
[5] EAC is the East African Community.
[6] SADC is the Southern African Development Community.

The EAC strategy seeks ambitious goals of: access to modern cooking energy for 50% of biomass users; access to *reliable* electricity for all urban and peri-urban poor; access to energy to all schools, clinics, hospitals and community centres; and access to mechanical power for productive use for all communities. Moreover, the mainstreaming of energy planning into budgetary processes, building national capacity, developing pro-poor energy policies and promotion of suitable business models were anchored as national intervention opportunities.

These ambitious regional energy vision and strategies are also spearheaded at the continental level, through the promotion of the energy agenda through NEPAD. The NEPAD continental vision advocates for increasing access to *reliable* and *affordable* energy supply for 35% of the population by 2015 and access to modern energy for cooking to 50% of the population. The vision and goals also call for improving the cost of energy supply to enable economic growth (of 6% per annum), improve the distribution of unevenly distributed energy resources, enhance renewable energy development, reverse the negative impact of traditional biomass reliance on the environment, integrate energy infrastructure and reform and harmonize regulations and legislations.

Table 3: Linkages between MDGs and access to energy services.

MDG Goal	The role of Energy
MDG 1: Eradicating extreme poverty and hunger	Energy input helps increase production, business development, affordable fuel saves needed income.
MDG 2: Universal primary education.	Energy can enhance the educational environment, through water, sanitation, lighting and commuting to school.
MDG 3: Promoting gender equality and empowering women	Affordable and available energy spares the opportunity cost of time for women from collecting firewood to manual farm labour.
MDG 4, 5: Reducing child mortality and improving maternal health	Energy services support access to health services, and improve clean water availability and reducing water-borne diseases.
MDG 6: Combating HIV/AIDS, malaria and other diseases	Energy services for refrigeration of medicine, distribution system for medicine, and access to health education through ICT.
MDG 7: Ensuring environmental sustainability	Enabling mechanical power in agriculture, that can reduce demand for land expansion; cleaner energy sources can reduce dependence on biomass; and renewable energy can reduce impact on the environment from the energy sector.

Source: Adapted from U.K. Department for International Development.2002. Energy for the Poor: Underpinning the Millennuum Development Goals.

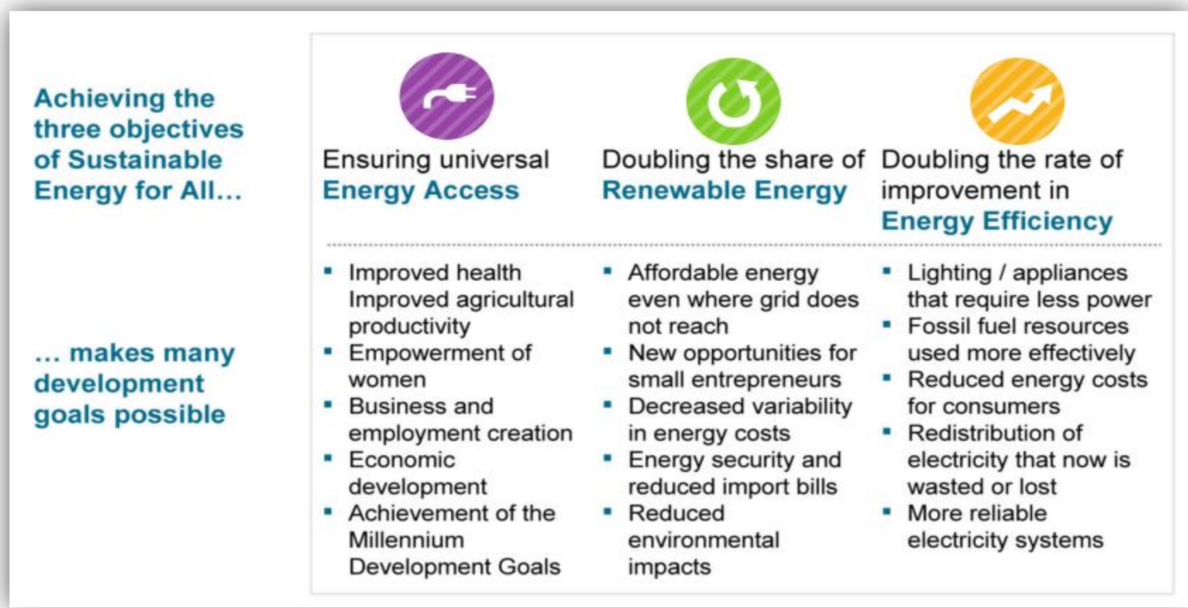
From the global to the regional and sub-regional levels, broader consensus is achieved at the policy level about the relevance of dealing with the energy access challenge heads-on to get momentum on achieving the tenets of the MDGs (see Table 3). MDGs 1 through 7 are directly or indirectly linked to the state and availability of energy, including its affordability and sustainability.

The UN Secretary General, Mr. Ban Ki-moon, declared that he "made Sustainable Energy for All a top priority because it is central to all aspects of sustainable development." As the debate on a post-2015 development agenda has intensified at the UN, member States and development policy and implementations stakeholders, the issue of access to energy is likely to enter the post-2015 agenda.

1.3.4.1 The Sustainable Energy for All (SEFA) Global Agenda

Building on the momentum of the energy access agenda at global, regional and sub-regional levels, Mr. Ban Ki-moon launched an ambitious global vision for energy access, targeting major achievements by 2030, at the opening of the UN General Assembly in September 2011. The year 2012 is named "Year of Sustainable Energy for All" to promote the energy access global vision. The core tenets of the SEFA vision are: (1) ensuring universal access to modern energy services by 2030; (2) doubling the share of renewable energy in the global energy mix; and (3) doubling global rate of improvement in energy efficiency. These three goals are related to development objectives (see Fig. 11).

Figure 11: The SEFA agenda and development.



Source: Sustainable Energy for All: A Global Action Agenda (the Secretary-General's High-Level Group on Sustainable Energy for All), 2012.

It is recognized that to achieve these objectives, *business as usual* will not deliver these results. Instead, four enabling action areas are recommended: (1) energy planning and policies at all levels; (2) business model and technology innovations; (3) finance and risk management; and (4) capacity building and knowledge sharing. In specific key areas of intervention to advance the three goals of SEFA, high-impact opportunities are also identified (see Table 4). Picking the low-hanging fruits, so to say, are expected to accelerate the path towards SEFA targets globally. Many developing countries have expressed interest in participating in the SEFA initiative (The UN Secretary General's High-level Group on SEFA, 2012), including Ghana

developing a national energy plan and programme of action, and in the Eastern Africa sub-regional Uganda, developing a national strategy for SEFA. The agenda of energy access has come to the global policy center, and it is expected that much progress will follow.

Table 4: Intervention areas for SEFA and high-impact opportunities.

Improvement Area	High-Impact Opportunities
Modern cooking appliances and fuels	Develop industry standards for efficiency, safety and emission
	Develop efficient stoves
	Implement policy frameworks, train entrepreneurs and develop value chains
Distributed electricity solutions	Provide regulatory support for scalable business models
	Develop and implement small-scale renewable energy solutions
Grid infrastructure and supply efficiency	Improve smart grid technology solutions
	Build sufficiency local and regional implementation capacity
	Expand national/regional integration of generation and transmission projects
Large-scale renewable power	Craft robust renewable policies and power purchase agreements
	Coordinate grid-connected infrastructure strategies
	Develop monitoring and best-practice sharing facilities
Industrial and agricultural processes	Provide sustainable energy access to agriculture and SMEs
	Address the energy-water nexus
	Improve access to modern energy services
Transportation	Improve and scale-up the use of sustainable biofuels
	Invest heavily in public transportation infrastructure
	Offer ability to tele-commute
Appliances	Encourage regulatory phasing out of inefficient appliances.
Energy planning and policies	Develop a framework
	Develop technology roadmaps
	Rationalize and phase out inefficient fossil fuel subsidies
Business models and	Develop innovative payment approaches to reduce consumer

technology innovation	resistance to high up-front costs
	Provide support for research, development and demonstration
	Promote and support widespread use of new inventions and innovations
Finance and risk management	Use public funds for loan guarantees
	Develop a coordination mechanism for sustainable energy finance
	Focus support on funds that target specific sectors
Capacity building and knowledge sharing	Expand best practices
	Leverage academic research
	Create easy-to-use set of policy and planning tools

Source: Adapted from Sustainable Energy for All: A Global Action Agenda (the Secretary-General's High-Level Group on SEFA), 2012.

The implication is clear – solving the energy access challenge releases economies to expand their potential, and the good news is now there is a global policy support behind solving it.

1.4 ENERGY SECURITY

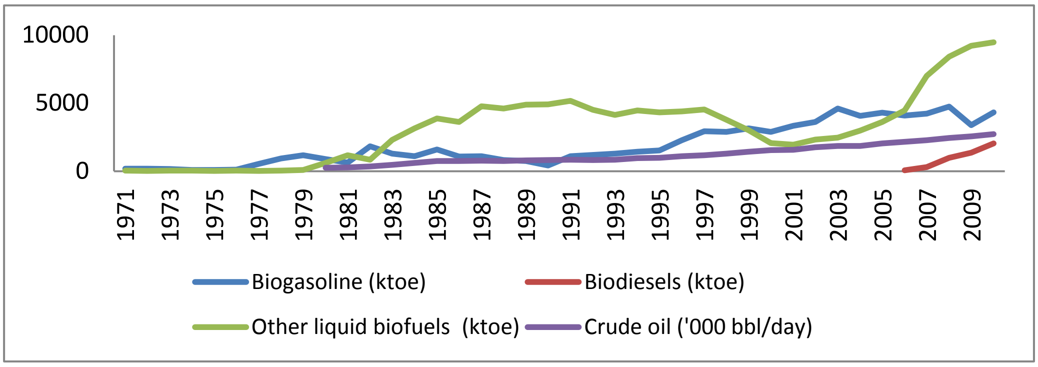
1.4.1 The Global Energy Security Challenge

Since the Arab-Israeli wars of the late 1960s (the Six Day War) and in the early 1970s (Yom Kippur War), embargo from OPEC countries and resulting price hike, in the range of quadrupling, left the global economy descending into recession between 1973-75. The consequences of the recession were far reaching, as sluggish economic growth in the 1970s and inflation (or *stagflation*) left economic and social damage. Soon after the oil embargo and price hike, energy security, particularly *availability* and *affordability* of crude oil, has dominated the global energy security and macroeconomic stability agenda. The severe impact of the oil embargo by OPEC countries and the price-hike has left a serious policy question – *how can global energy security be maintained and managed to shield the impact of oil shock on the economy*?

Early efforts at advancing the goal of energy security around oil led to the creation of the International Energy Agency (IEA) in 1974, with the initial central goal of "helping countries co-ordinate a collective response to major disruptions in oil supply through the release of emergency oil stocks." The IEA coordinated a series of energy security policies, including strategic reserve management, in Western Countries, shielding their economies from subsequent oil disruptions. In more recent years, with cooperation of OPEC in oil market stability and growing interest in maintaining stable global macroeconomy, the objective of IEA shifted to broader ideals such as "energy security, economic development, environmental awareness and engagement worldwide." The concept of energy security is also expanded to other energy commodities, such as coal and natural gas, and continues to evolve towards the entire energy system, as it should.

Countries that did not participate in IEA framework pursued their own energy security strategies. For example, the successful Brazilian model of diversification after the global oil shock brought indigenous sources of energy, particularly in the transportation sector, in greater play in Brazilian society. Review of data from 1971 (pre-crisis) to 2010 for biofuels in Brazil (see Fig. 12) reveals that Biogasoline and other liquid biofuels increased sharply in the post-crisis period, largely to the concerted fuel diversification strategy pursued.

Figure 12: Biofuels and crude oil production of Brazil: 1971-2010.

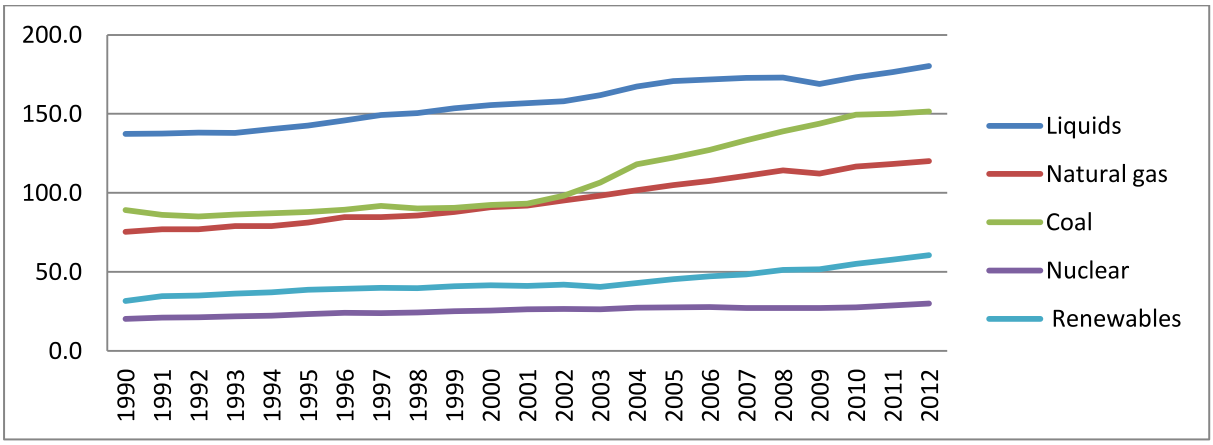


Source: Based on data from IEA. Crude oil data source is US EIA.

The effort only intensified over the decades, taking new momentum in the last decade (2000s), perhaps due to sharp rise in oil prices yet again in recent years. In fact, biofuels production in Brazil peaked after the 2009 spike in oil prices. The production of crude oil since the 1970s, at a growing rate, seems not to have deterred the increasing diversification of fuel in Brazil to enhance security.

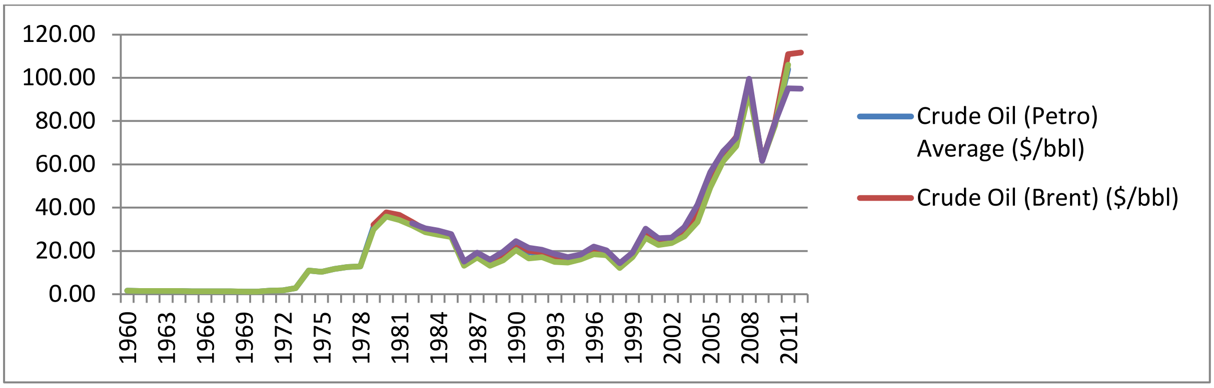
While the oil crisis in the 1970s spurred policy and regulatory reform and new management schemes to stabilize energy markets locally, the resurgence of rapid price increases in energy commodities has initiated concern about the state of the global energy security. This concern is well placed, as prices shifts within an increasing quantity of energy commodity consumption can cause macroeconomic impacts that can be far-reaching. Consumption of liquids, natural gas and coal have surged (see Fig. 13), particularly in liquids, coal and natural gas, along with renewables. The demand pressure on energy sources has largely led to sharp increases in energy prices in recent years.

Figure 13: World energy consumption in quadrillion Btu.



Source: Based on data from US EIA, International Energy Outlook, 2011.

Figure 14: Crude oil price trends.

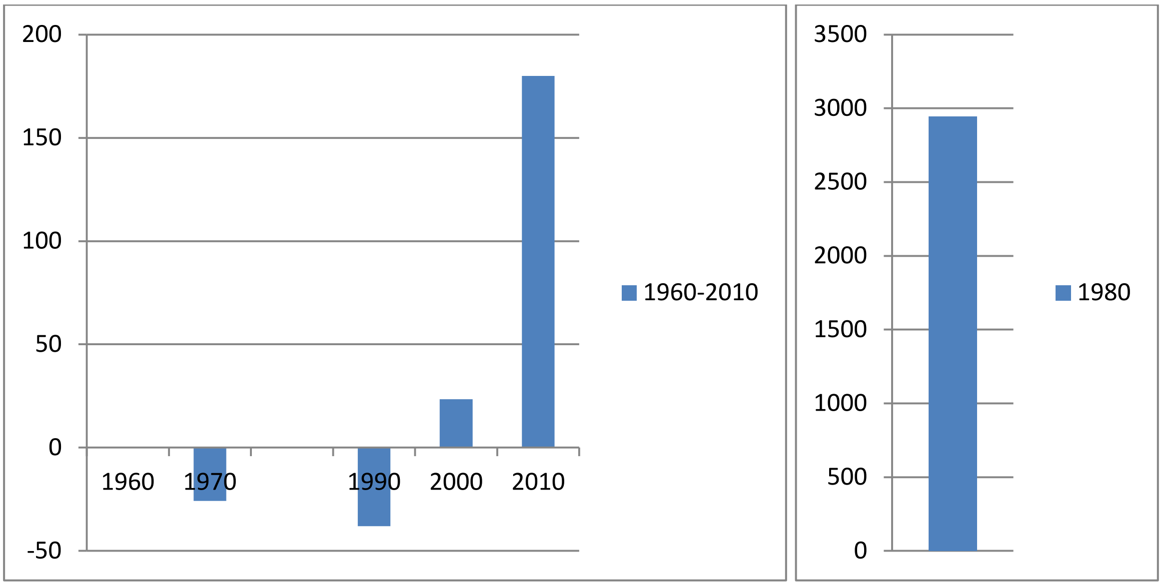


Source: World Bank Commodity Price Data (Pink Sheet) 1960-2011, and US Energy Administration for 2012 data.
Note: Except for Crude Oil (Petro) average, all prices are in real 2005 dollars.

The price of crude oil (Petro, Brent, Dubai and WTI[7]) has all increased rather gradually until 2000 (bar the oil crisis of the 1970s and 80s), but particularly since 2008 prices per barrel in excess of $80 has become a norm, in subsequent years, exceeding $100/bbl (see Fig. 14). This phenomenon of price volatility and surge reduces energy affordability, one tenet of energy security. The burden on the global economy, particularly to the economy of developing countries is palpable. A decade-by-decade analysis of the price shifts reveal that oil prices were indeed declining before the 1970s oil crisis, only to increase by nearly 3,000% in the 1980s, but receding in the 1990s, and slightly increasing from 1990 to 2000. In the 2000s, though the price hike is not as detrimental as the 1970-1980 decade, has nonetheless broke from norm and increased sharply, by nearly 170% (see Fig. 15).

[7] WTI is the West Texas Intermediate crude oil.

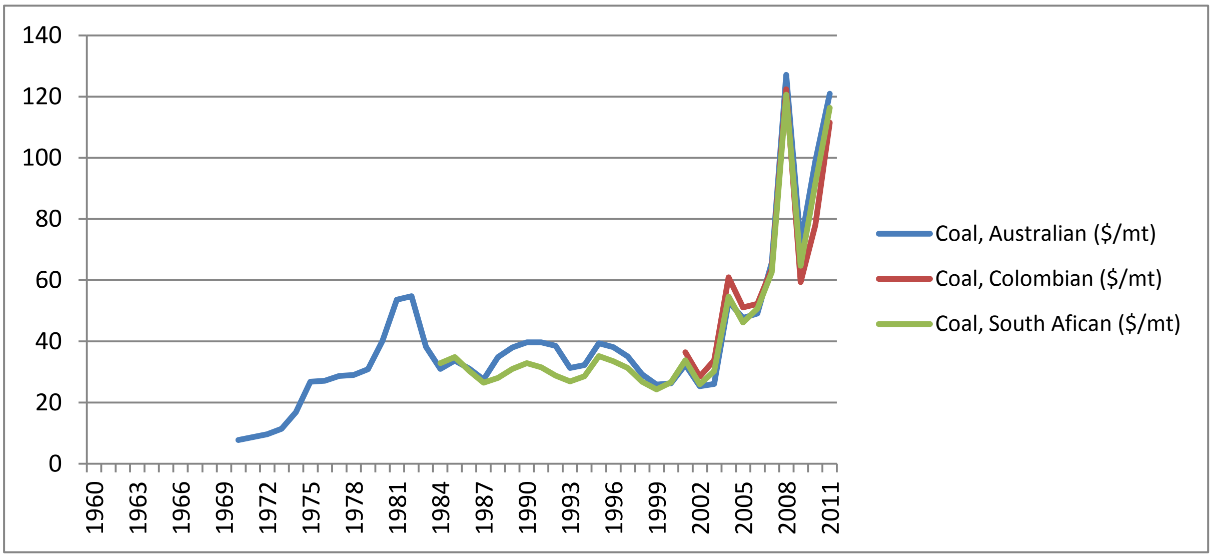
Figure 15: Percentage change in crude oil prices by decade.



Source: World Bank Commodity Price Data (Pink Sheet) 1960-2010.
Note: 1960 is the initial reference period for 1970 values, therefore showing starting point value.

The energy source affordability challenge is not limited to *liquids* alone. A look at the coal market reveals a similar global trend. Energy markets tend to co-influence prices. After a relatively long stable period in the coal market till the early 2000s, post-recession (2008) coal prices for Australian, Colombian and South African coal has also surged sharply (see Fig. 16).

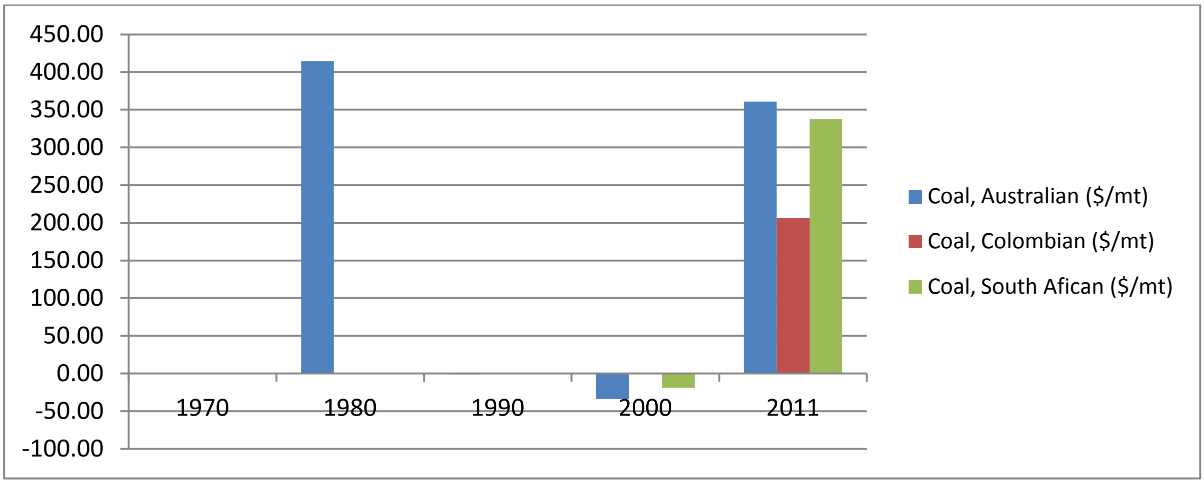
Figure 16: Coal price trends.



Source: World Bank Commodity Price Data (Pink Sheet) 1960-2011.

A decade-by-decade look at coal prices demonstrates that the oil crisis of the 1970s has also lead to Australian coal prices increases in the decade to 1980 by over 400%. Coal prices stabilized and declined ever since until the 2000-2011 period, where prices for Australian, Colombian and South African coal surged by 361%, 206% and 338%, respectively (see Fig. 17). The challenge for economies that may not rely on coal but on imported liquids is that prices seem to walk from one energy commodity market to the other, due largely to *speculation*.

Figure 17: Percentage change in coal prices by decade.

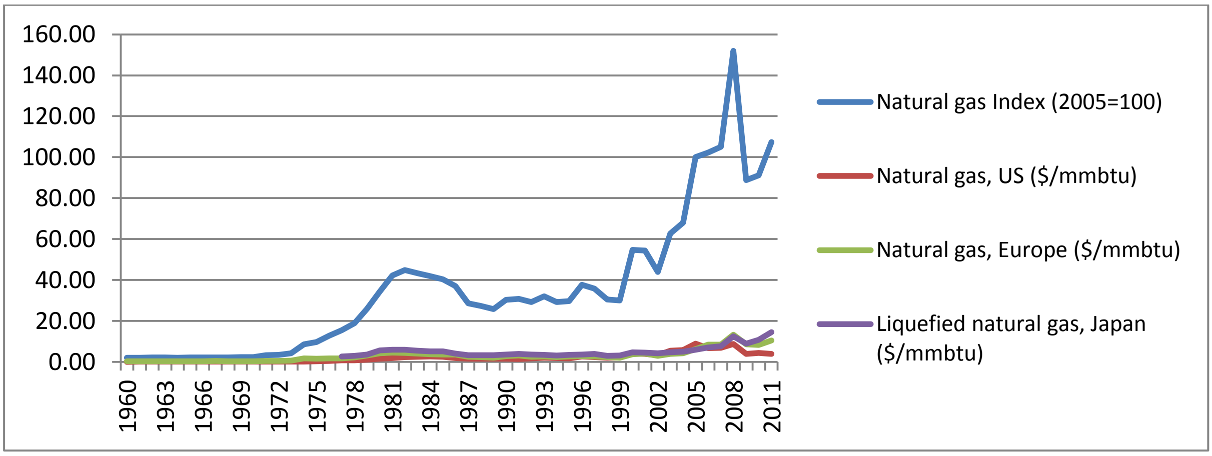


Source: World Bank Commodity Price Data (Pink Sheet) 1970-2011.

Note: 1970 is the initial reference period for 1980 values, therefore showing starting point value. Data for Colombian coal prices available from 2001-2011; the value shown is comparison from 2001-2011. The data for South African coal is available from 1984-2011. Comparison for 1980-1990 period is based on data from 1984-1990 (growth rate of only 0.01%). Comparison for the last period is from 2000-2011.

The natural gas market has seen momentum in the last decade due to climate change and environmental concerns around the use of coal, its relative affordability and discovery of sizable natural gas resources globally. Speculation in the energy market in general and increased interest in natural gas use, including LNG, has led to a similar price surge. The natural gas price index, a composite index of gas price, shows significant surge since 2005 (see Fig. 18).

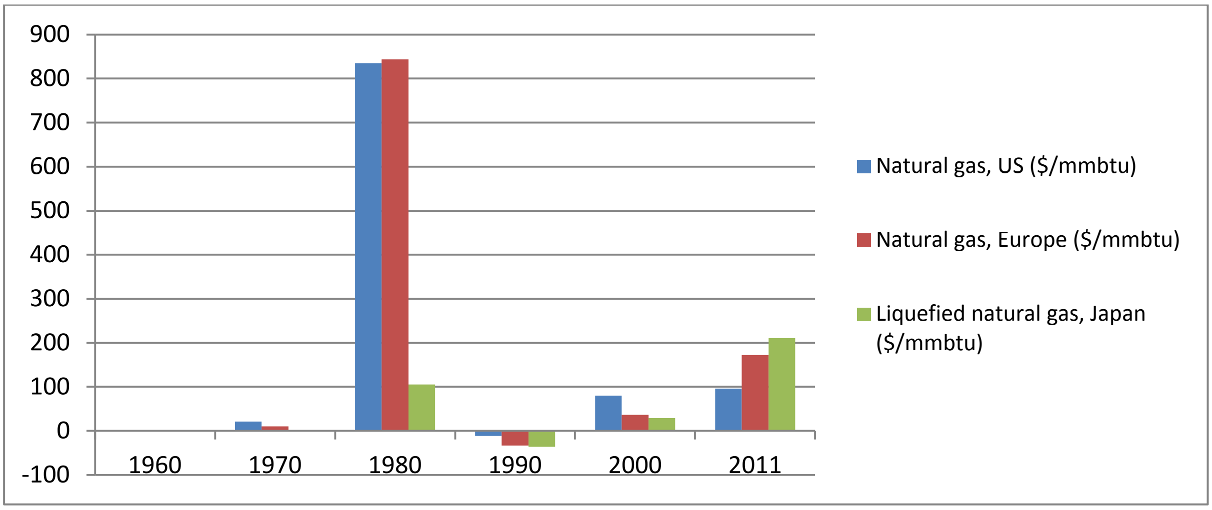
Figure 18: Natural gas price trends.



Source: World Bank Commodity Price Data (Pink Sheet) 1970-2011.

Analysis of the price trends decade-by-decade reveals that apart from the 1970-1980 price hike of over 830% (see Fig. 19), prices has actually went down in the 1980-1990 decade. Prices surged again in the 1990-2000 decade, largely in US natural gas market, followed by a sharper increase in the 2000-2011 period, particularly in LNG market in Japan.

Figure 19: Percentage change in natural gas prices by decade.



Source: World Bank Commodity Price Data (Pink Sheet) 1960-2011.

Note: 1960 is the initial reference period for 1970 values, therefore showing starting point value. Data for Japan liquefied natural gas is from 1977-2011, therefore the 1970-1980 decade change is calculated based 1977-1980 data. Comparison for the last period is from 2000-2011.

The implication is clear – volatility and price surge in global energy markets pose serious energy security and economic stability challenge to countries, particularly in the developing world.

1.4.2 The New Sources of Global Energy Insecurity

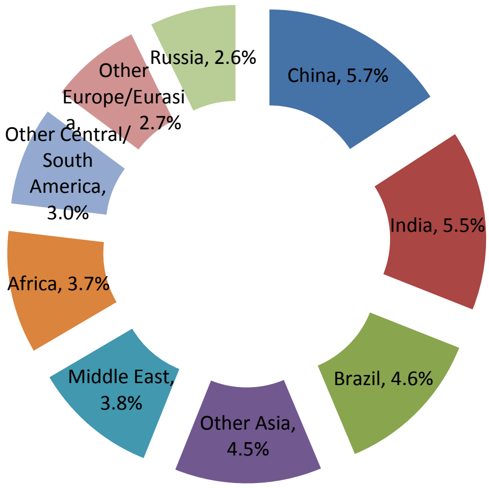
Traditional sources of energy insecurity, stemming from supply and demand conditions, speculation, market dependence, political instability, diversity of supply sources and other factors are widely discussed in the energy security literature (see for example IEA, 2007; Toman, 2002; Jenny, 2007; Scheepers et al., 2007; Jansen et al., 2004; Awerbuch, 2006; Frondel and Schmidt, 2008; Grubb et al., 2006). But long-term structural changes are introducing a new dynamics in the global energy market. One such factor is a structural shift in the origin of global growth. The global economy is growing, largely due to strong performance in emerging economies and growth in BRIC[8] economies. The growth rate projection from 2008 through 2035 (see Fig. 20) demonstrates robust global economy uptake over the next three decades. Africa is peaking, at what seems to be a conservative growth projection of 3.7%. The Middle East at 3.8%, Central and South America at 3% and much of Asia at 4.5%, among others, the global economy is in an expansion mode, increasing the global demand for energy commodities, particularly hydrocarbons.

Dominant growth prospects are expected in China, India, Brazil and Russia (BRICs) (see Fig. 20). Except for Russia (projected to grow at 2.6% through 2035), the BIRC countries are projected to experience 4.6% plus growth rates till the mid 2030s. Global growth is accompanied by a rise in income per capita. Personal incomes, particularly in Russia and Brazil, and also in China are expected to increase quite sharply, 2-5 times by 2017 from levels in 2000 (see Fig. 21). Growth in GDP and personal income will put added pressure on energy markets, with likely price response in the short-term, when new supplies are limited. The impact of BRICs on global energy market volatility and oil equity returns depends on the extent that BRICs are net importers or exporters of oil (Bhar and Nikolova, 2009). While the degree if impact

[8] BRIC is reference to Brazil, Russia, India and China, fast growing countries in the global economy.

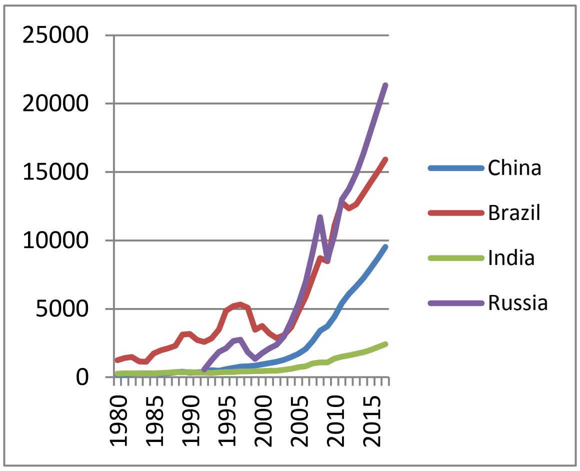
depends on net import, export position, Chousa, et al. (2008) find that the rapid economic growth will increase energy consumption, caused by increases in investment, population and trade in energy intensive products.

Figure 20: Projected growth: 2008-2035.



Source: Based on data from US EIA, International Energy Outlook, 2011.

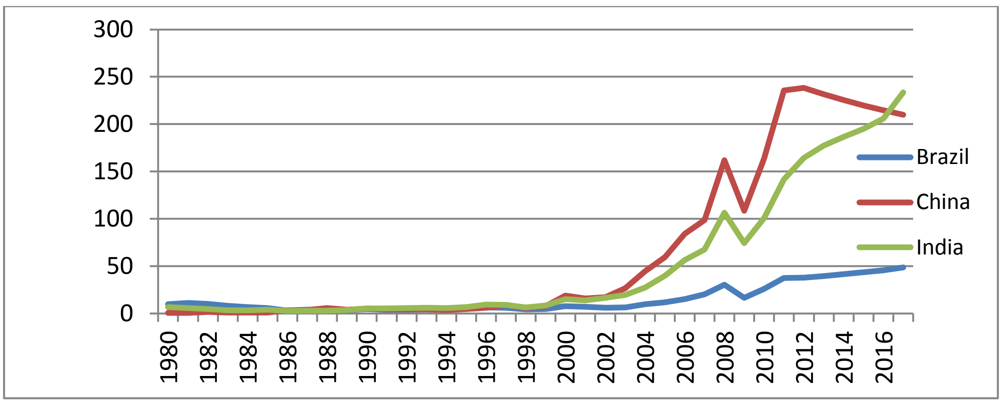
Figure 21: GDP per capita in BRICs: 1980-2017.



Source: Based on IMF, World Economic Outlook data.

While Bhar and Nikolova (2009) advice that the impact of BRICs on global energy prices is dependent on their net trading position. All indications are that BRICs are increasing their presence in global energy markets. The total import bill for China, India and Brazil (Russia is net exporter of energy) from 2000-2012 reveals that their oil import bill increased by 54%, 215% and 164%, respectively, between 2000-2005. In the 2006-2012 period, the oil import bill of China, India and Brazil further grew by 146%, 183% and 192%, respectively. This rapid surge in oil imports is projected to increase rapidly in the foreseeable future (see Fig. 22), increasing the competition for existing oil supplies and contracts, putting upward pressure in energy commodity prices in the *futures market*, and putting an upward pressure on short-term energy prices, impacting the global energy security, particularly in the context of developing countries likely to be exposed to rising energy import bills, drawing resources that could have been used for other productive activities.

Figure 22: Oil import bills of Brazil, China and India (in billion USUS).

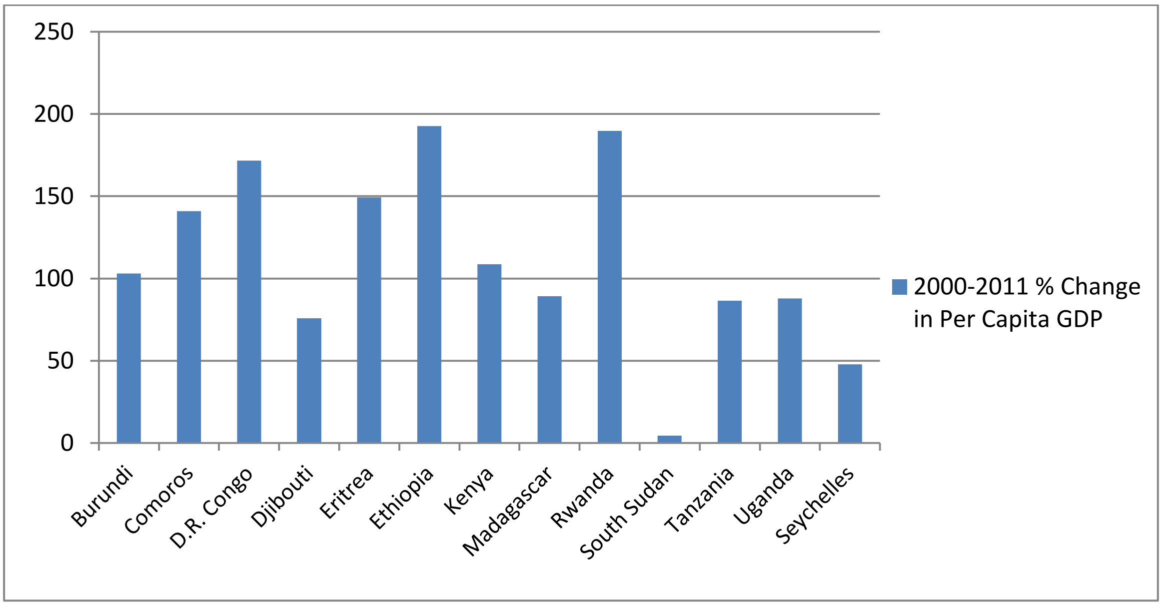


Note: Russia has no oil imports, and is net energy exporter.

1.4.3 Energy Security in Eastern Africa

In the Eastern Africa sub-region, the economic resurgence of member states has given optimism to economic transformation in the region. The fast growth of Rwanda and Ethiopia, and good economic performance in Kenya, Uganda, Tanzania and Burundi has led to positive sub-regional outlook. While concerns remain about the inclusiveness and broad-based nature of such growth in the sub-region, leading to policy focus on *quality of growth*, GDP per capita figures show robust improvement over the last decade (see Fig. 23). Burundi, Comoros, D.R. Congo, Eritrea, Ethiopia, Kenya and Rwanda have seen their per capita GDP more than double during 2000-2011, with growth rates above 180% in Ethiopia and Rwanda.

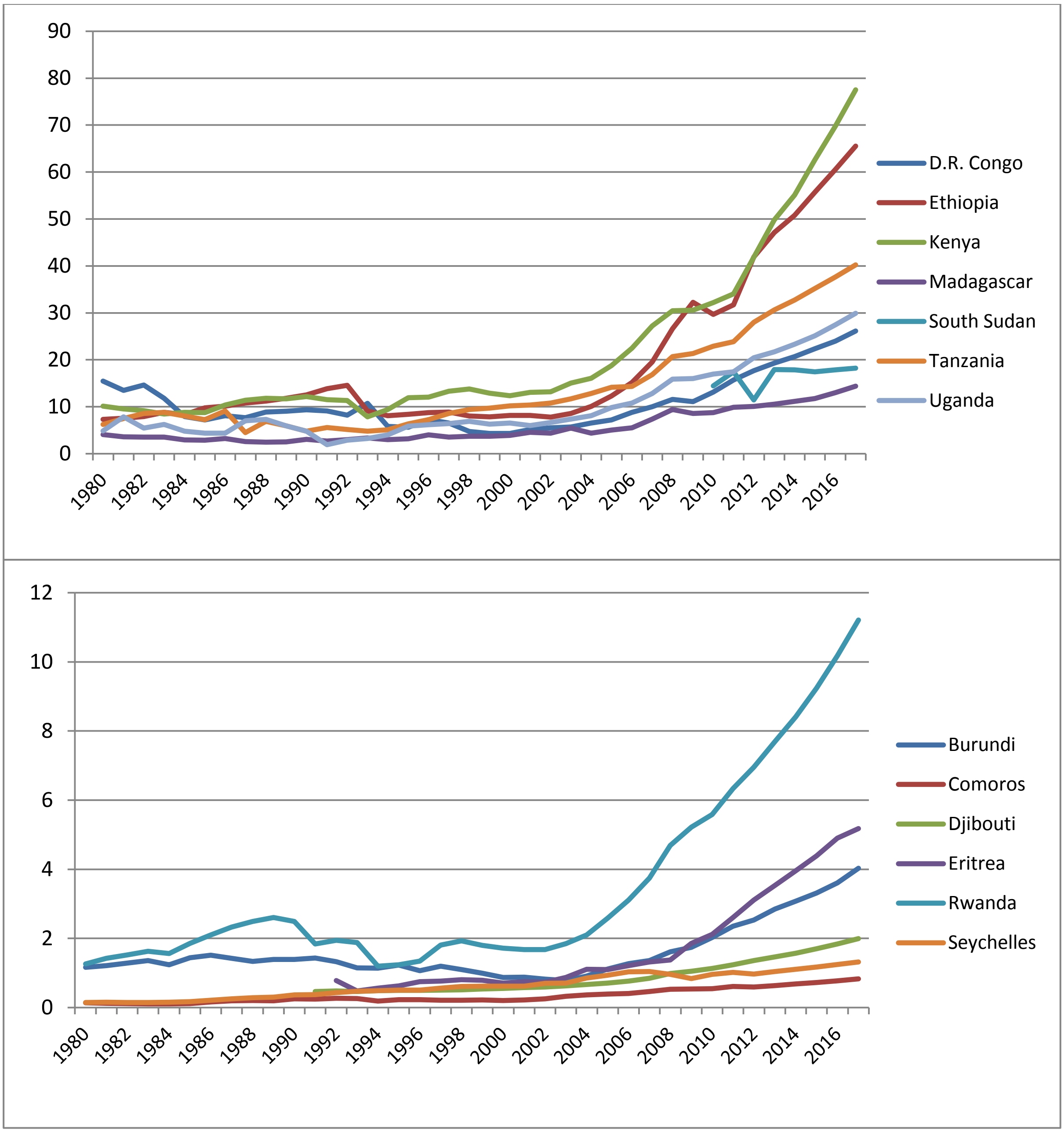
Figure 23: Per capita GDP growth in Eastern African sub-region member states: 2000-2011.



Source: Based on IMF, World Economic Outlook data.
Note: South Sudan growth rate computed from 2010-2011.

GDP projections by the IMF about the global economy, through the World Economic Outlook effort, offer robust assessment for the sub-region going to 2017. In both small and island states and in large states, GDP is expected to expand markedly, particularly so in Rwanda, Eritrea, Burundi, Kenya, Ethiopia and Tanzania, though the entire region is expected to see expansion (see Fig. 24). Sustaining the economic momentum through energy security is likely to enter the policy debate as robust growth will require increasing supply of energy input. A number of factors can affect the projected scenario, including global energy prices through 2017, the degree of energy intensity of the economy of Eastern African member states, and the degree to which they are exposed to the global energy market. Since all member states import their petroleum requirements (except some net usage in D.R. Congo and limited refining based on imported petroleum), the region is maximally exposed to global energy market shocks. Shielding economic gains from these shocks in the future will require a regional focus and strategy.

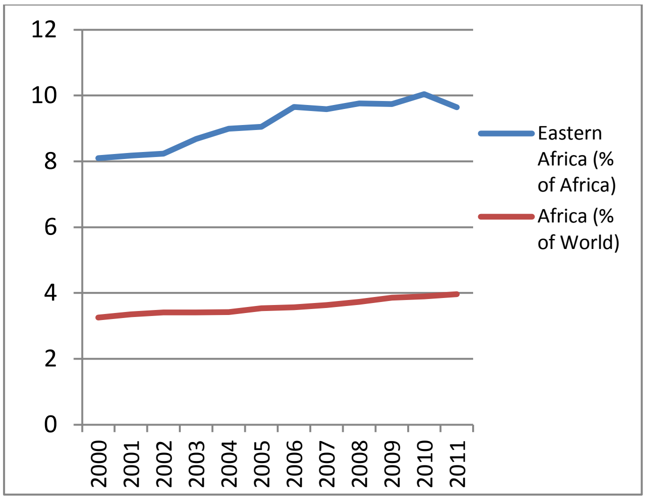
Figure 24: Real GDP (in billion USUS) of Eastern Africa sub-region member States: 1980-2017.

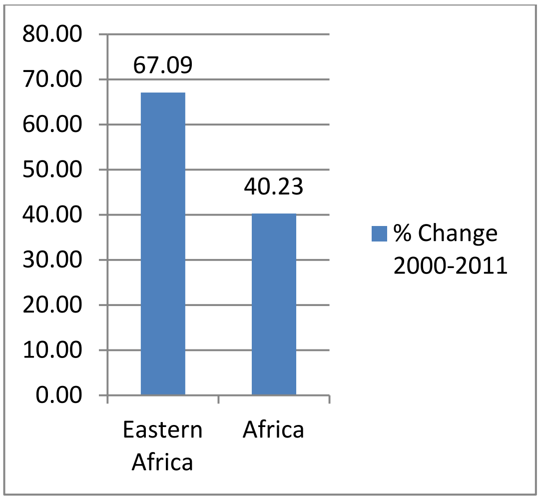


Source: Based on IMF, World Economic Outlook data.

Petroleum consumption is already surging in the Eastern Africa sub-region. The global share of petroleum consumption in Africa has gradually increased from around 3.25% to about 4% over a decade (see Fig. 25). In the same period, the share of the Eastern African sub-region in Africa's petroleum consumption increased from about 8% to close to 10%. While the shares seem to have increased only gradually, comparison of absolute consumption levels of petroleum from 2000-2011 shows that while consumption at the continental level increased by slightly more than 40%, the rise in the Eastern African sub-region was 67%. This constitutes a significant increase in exposure to global energy markets.

Figure 25: Petroleum consumption shares of Africa and the Eastern Africa sub-region and consumption percentage changes: 2000- 2011.

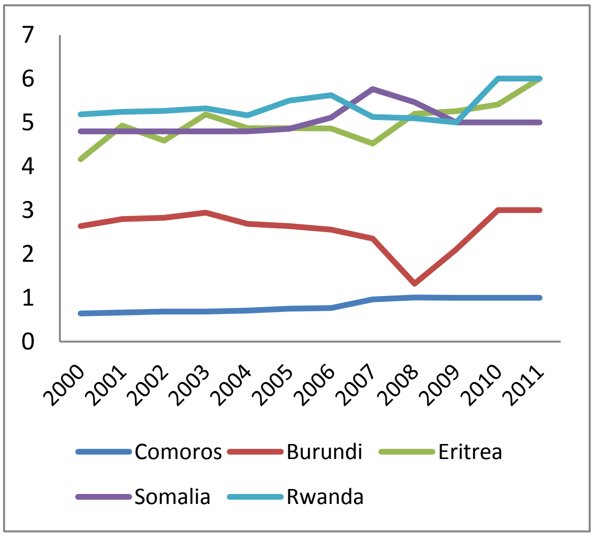


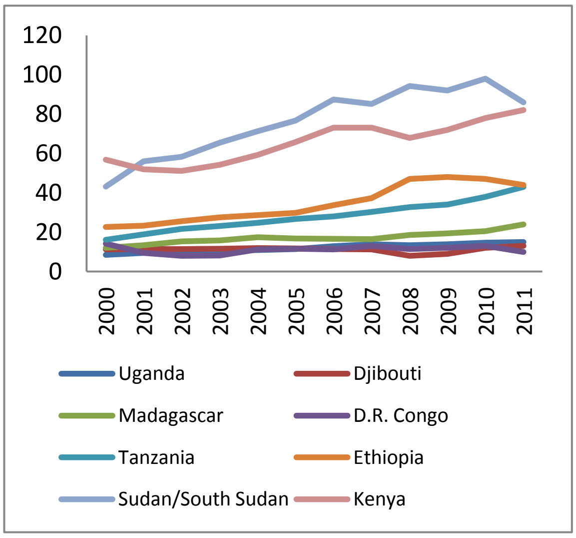


Source: Based on data from US EIA.

To identify the source of growth in petroleum growth in the Eastern Africa sub-region, a country-by-country trend analysis will be informative. Three observations can be made about petroleum consumption patterns in the Eastern Africa sub-region. First, comparing smaller economy countries with relatively large population and economy countries, the trend is revealing (see Fig. 26). Much of the sub-regional growth in petroleum consumption did not come from smaller economies, such as Somalia, Burundi, Rwanda, Djibouti and Eritrea (though Eritrea's increase in petroleum consumption is largely related to its confrontation with neighboring Ethiopia, and the need to maintain a large active army resulting from the 1998-2000 war). The growth came from Island States and larger economies, such as Comoros, Madagascar, Uganda, Ethiopia and Tanzania. Second, as a result, large economies and Island States in the sub-region are more exposed to international market risks and the impact there-of. Third, the trend is likely to continue at least in the short-term since it takes time to alter the structure of the energy system in the region.

Figure 26: Petroleum consumption in thousands bbl/day: 2000-2011.



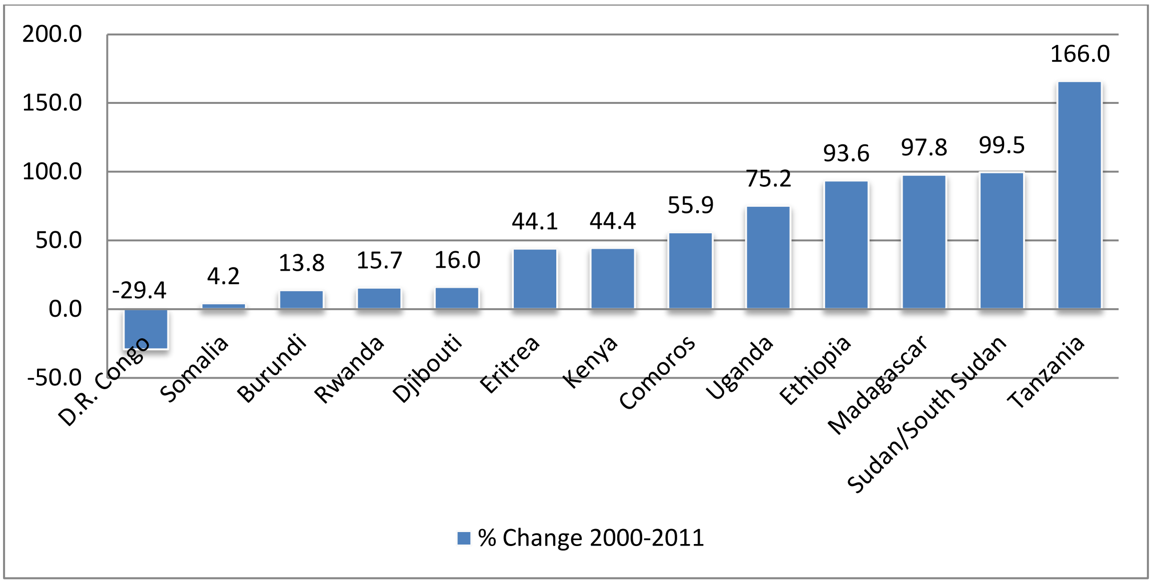


Source: Based on data from US EIA.

Comparison of percentage changes in petroleum consumption from 2000-2010 further supports the previous proposition. Island States of Comoros and Madagascar saw consumption increases of 56% and 98%, respectively. Larger economies such as Uganda, Ethiopia and

Tanzania saw increases in the rage of 75%, 94% and 166%, respectively (see Fig. 27). Smaller economies saw change in the rage of 4.2% in Somalia, 14% in Burundi, 16% in Rwanda and Djibouti, which are modest for a decade change.

Figure 27: Percent change in petroleum consumption in thousands bbl/day: 2000-2011.



Source: Based on data from US EIA.

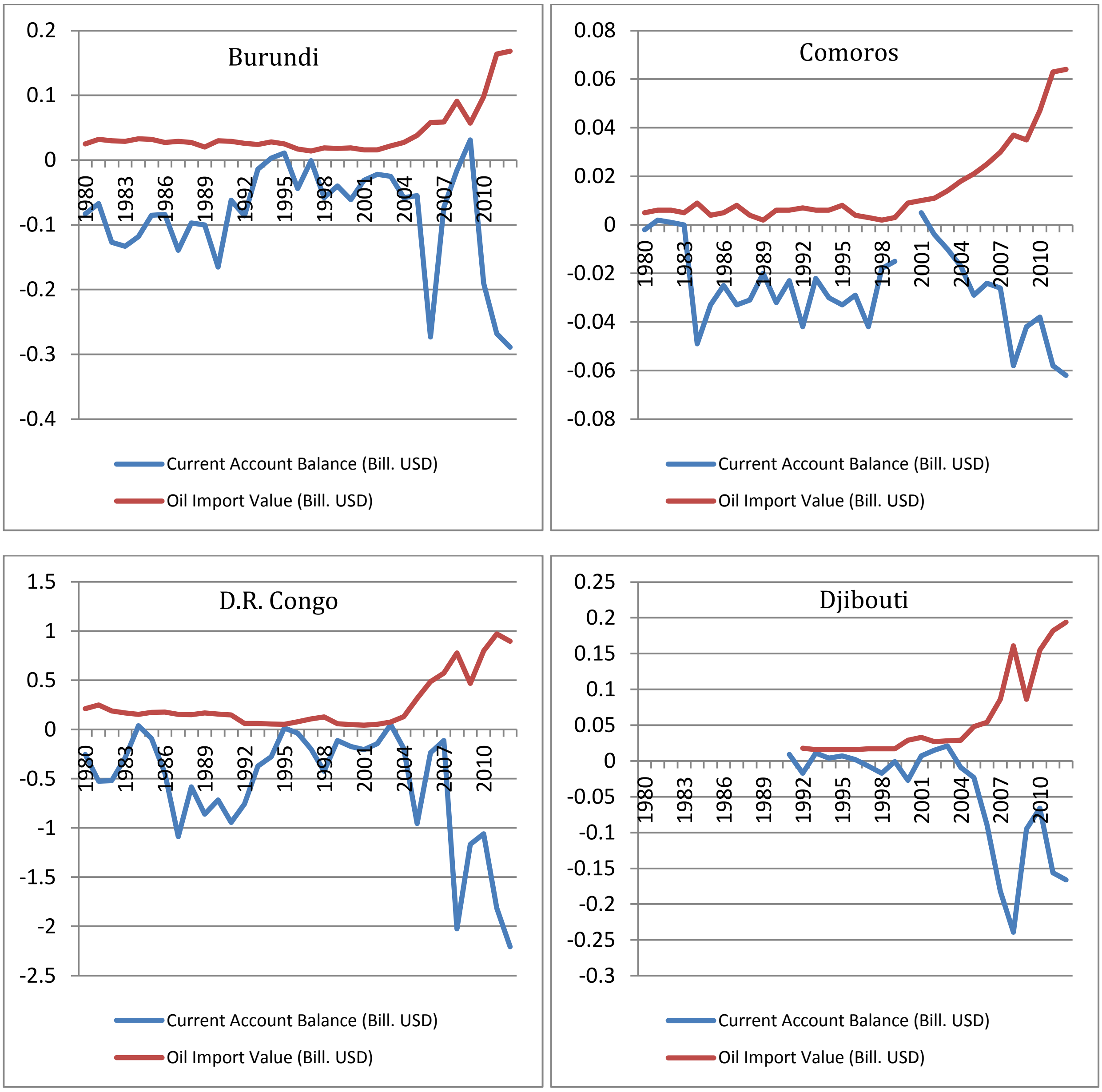
1.4.4 Why Energy Security Matters in the Eastern Africa sub-Region?

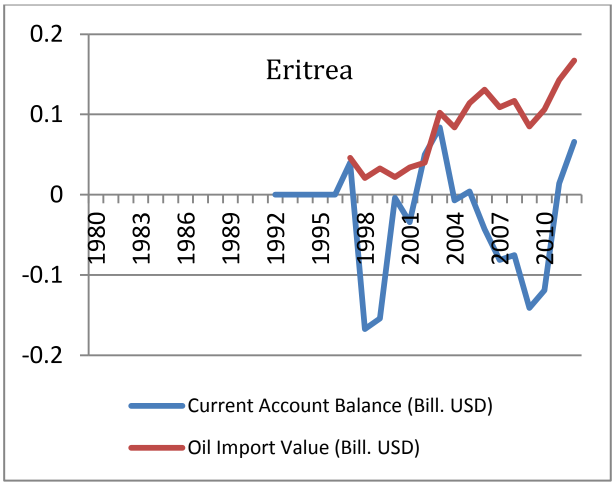
Energy security in this context will need to be understood broadly, inclusive of electric generation and distribution and the use of bio-energy sources, from traditional and processed biomass. Biomass is largely resourced locally, and is governed partly by biological processes that respond to long-term harvest and environmental regeneration patterns. Electricity generation from clean energy sources, such as hydro, is governed by hydrological patterns, related to climate change risks and draught incidents. Dependence on imported energy poses a serious risk as many of the factors that determine its supply and price are outside the control of decision-makers. In this context, the discussion in this section will focus on the latter, returning to the biomass and electricity components in the next chapter.

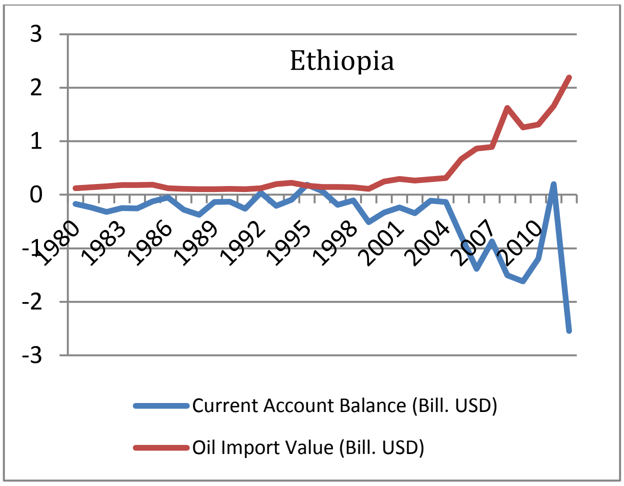
The nexus of energy with economic and social development has been discussed in earlier sections. The achievement of the MDGs is argued to rely partly on the availability and accessibility of modern forms of energy. Energy security can be visualized within the same framework. Disruption in the supply of imported energy, particularly hydrocarbons, and/or sharp swings in their price, will introduce macroeconomic impacts that can undermine the momentum of economic developing taking root in the Eastern Africa sub-region. Disruption can hamper proper functioning of the socio-economic system, and lack of affordability can withheld economic activities, particularly in energy intensive industries. Therefore, energy security is a component to economic stability and proper functioning, to the extent it can shift long-term growth patterns from *trend*.

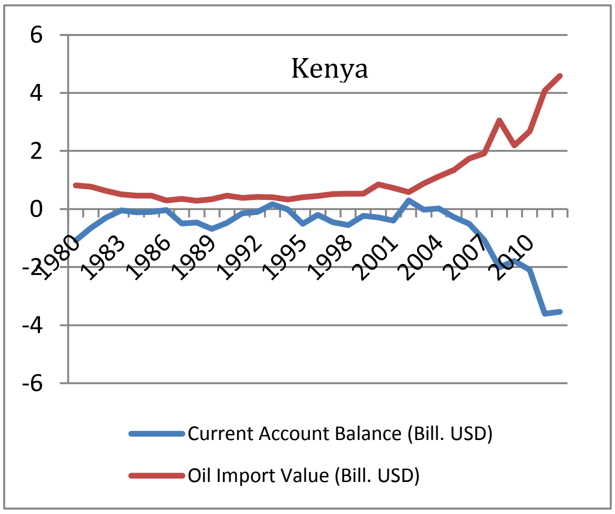
The most direct impact of dependence on imported oil is through price hikes in global markets. Comparison of oil import values and current account balance for countries in the sub-region (see Fig. 28) demonstrates the importance of energy security. Increases in oil prices in recent years (post 2008) has led to a drift in current account balance of sub-regional member states from trend. The observation is consistent throughout the region, except in Eritrea (trend reversed due to kicking-in of mining sector revenues from gold exports in the same time period). Increased negative balances in the current account is likely to lead to drawdown of foreign reserves, or lead to increasing public debt to finance deficits, both posing risk to sustained robust economic growth in the region.

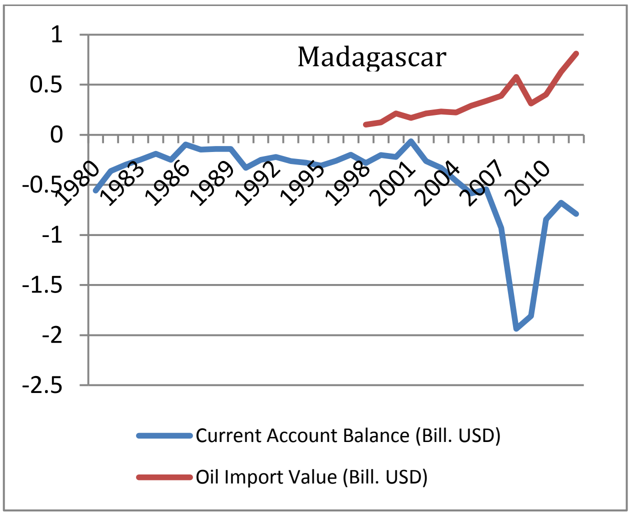
Figure 28: Oil import values and current account balances in Eastern Africa sub-Regional member States, in billion USUS: 1980-2011.

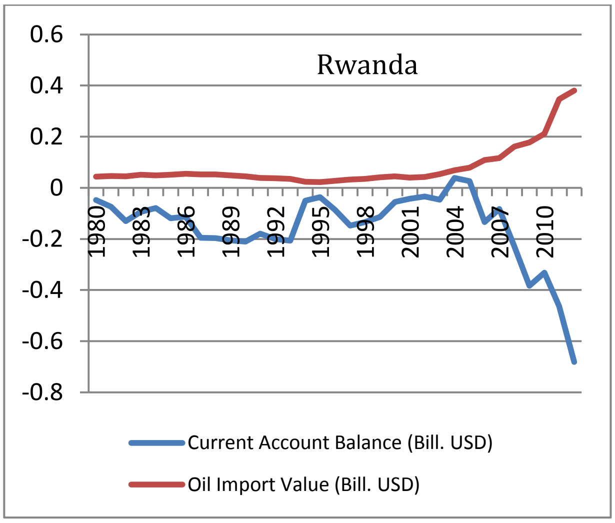


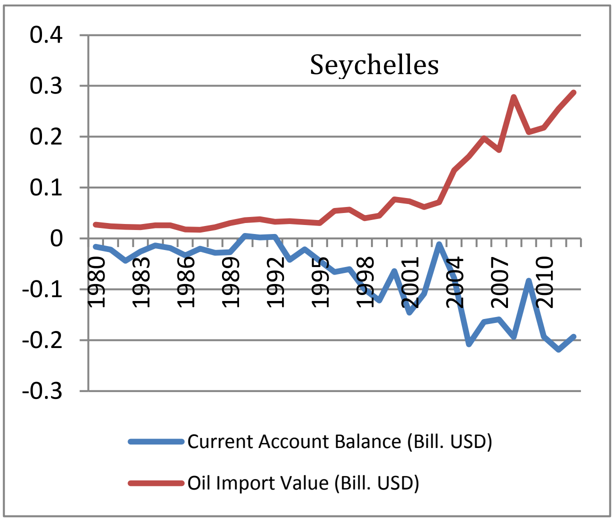

Eritrea
Current Account Balance (Bill. USD)
Oil Import Value (Bill. USD)

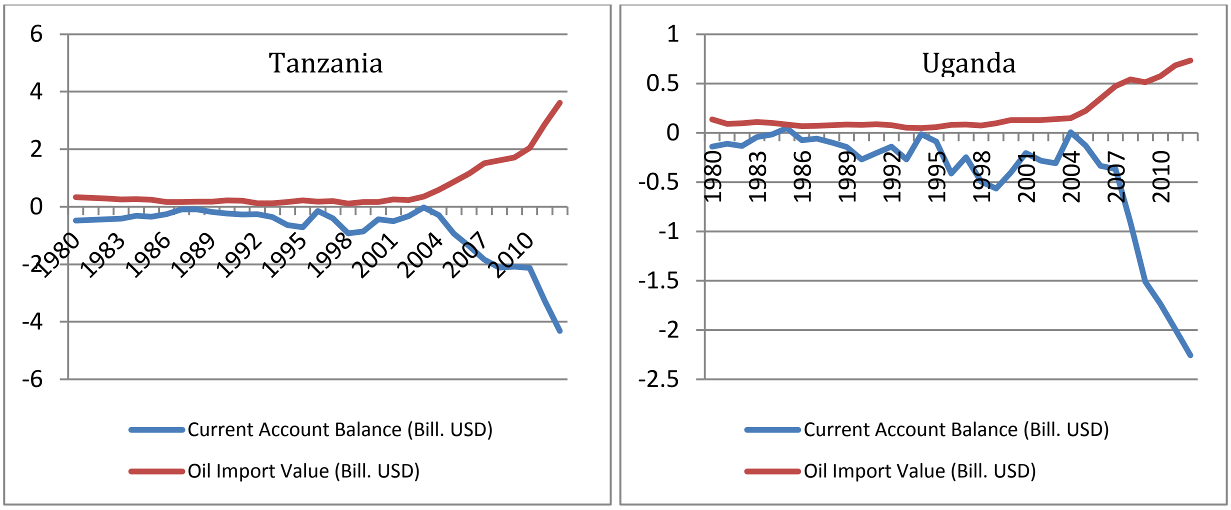

Ethiopia
Current Account Balance (Bill. USD)
Oil Import Value (Bill. USD)


Kenya
Current Account Balance (Bill. USD)
Oil Import Value (Bill. USD)


Madagascar
Current Account Balance (Bill. USD)
Oil Import Value (Bill. USD)


Rwanda
Current Account Balance (Bill. USD)
Oil Import Value (Bill. USD)


Seychelles
Current Account Balance (Bill. USD)
Oil Import Value (Bill. USD)



Source: Analysis conducted based on IMF, World Economic Outlook data.

It is evident that managing energy insecurity in the sub-region in itself is a pro-development agenda. Energy insecurity poses risk to economic growth in the sub-region, one that can be mitigated with proper regional energy security management.

2 MEASURING THE STATUS OF ENERGY ACCESS IN THE EASTERN AFRICA SUB-REGION AND POTENTIAL MONITORING FRAMEWORKS

2.1 MEASURING ENERGY ACCESS

Enhancing energy access is a policy objective being embraced as a policy priority. To trace energy access goals to the degree to which they are pursued and implemented, a proper measurement and monitoring mechanism is needed. That in itself depends on what is meant by *energy access*. There is no globally accepted definition of energy access. Nor is there consensus across countries. Before proceeding to measurement and monitoring issues to support policymakers with proper information and policy feedback, a review of what energy access is and how it is understood seems important.

The UN's *Sustainable Energy for All* (*SEFA*) initiative does not directly define what energy access is, but expounds on the goal of universal access. However, SEFA reports provide insights into what energy access is: "universal access to modern energy services would facilitate a giant leap in human well… Electric light extends the day, providing extra hours for reading and work. Modern cookstoves save women and children from daily exposure to smoke that damages their health. Refrigeration allows local clinics to keep needed medicines on hand. Access to energy provides consumers with the means to generate income and improve productivity…" (UN Secretary General's High-Level Group on SEFA, 2012b). From this statements, one can draw the idea that energy access is related to access from generated source perspective (access to electricity and cookstoves) and from end use and productive services (access to refrigeration and income generating productive activity). This seems a broad and inclusive meaning of access.

The International Energy Agency (IEA) defines energy access as "a household having *reliable* and *affordable* access to clean cooking facilities, a first connection to electricity and then an increasing level of electricity consumption over time to reach the regional average" (IEA, 2011a). The IEA definition emphasizes the *economic* context of affordability, the *security* element of reliability, and a focuses on access to electricity and cookstoves, with a long-term progress to increasing level of energy consumption to some regional standard. Therefore, access to electricity and cookstoves is emphasized.

The Asian Development Bank (ADB) defines energy access as "provision of electricity power to households, improvement in the delivery of energy services to households, provision of modern fuels and efficient devises for cooking and heating to households, and provision of finance to households to access energy" (ADB, 2010). This ADB definition emphasizes on households along the dimensions of energy services, modern fuels, improved devices and finance.

From a technical point of view, AGECC (2010) utilizes stages to describe the concept of energy access. In stage 1, access to basic human energy needs, i.e., 50-100 kwh/person/year and 50-100 kgoe of modern fuel is deemed necessary. In stage 2, access to productive uses of energy is required. In stage 3, access to energy usage around 2,000 kwh/person/year is

required to sustain modern societal energy needs. This definition emanates from technical standards on which the issue of energy access is expounded.

As can be clearly noted, a concrete and widely-accepted definition of energy access is lacking, though the big picture and notion in these discussions often point in the same direction. The challenge is that countries measure energy access progress on a set of measures that define policy setting and implementation strategies. For example, Ethiopia promotes a definition of energy access that focuses at the community- or village-level, and aims to make energy accessible at that level. The central argument in the Ethiopian definition is that energy access is needed to spur rural economic development by supporting high-impact socioeconomic activities, such as mechanized agriculture, schools and hospitals and, small businesses which can justify the economic supply of energy. Once electricity access is provided at the village level, it is the responsibility of households to choose to connect or not. Therefore, access is defined as giving households in a community the ability to connect if they choose, and not necessarily the number of household connections. In much of the Eastern Africa sub-region, energy access is defined as the number of households with connection to electricity on grid or off-grid options, and to clean cooking devices, though the economic use of energy is also emphasized. However, in Uganda, energy access is viewed in conjunction with the economic strategy to revitalize the agricultural sector, and in D.R. Congo energy is viewed in conjunction with the mining sector.

While the meaning of energy access can be technically configured from conditions of a base level of energy load to economic conditions of effective access, the need to expand the level of access to modern forms of energy for multiple uses encompasses the issue of energy accessibility. Articulating what energy access is goes a long way to inform how it should be measured and monitored to support its long-term enhancement.

Energy access can generally be defined as the availability of modern energy sources to household and production end uses. It can economically be defined as the availability of energy at costs affordable to a significant portion of the population, thus ensuring effective, as opposed to nominal, access to energy services.

2.2 ENERGY ACCESS MEASUREMENTS, ISSUES AND CHALLENGES

A country embarking on the goal of enhancing energy access to achieve a target is best supported with monitoring and evaluation frameworks and measurements/indicators. The notion of utilizing indicators to guide public policy is nothing new in sectors outside energy. Economists utilize a slew of indicators to gauge the performance of the economy and trends toward set economic targets. These indicators include GDP, inflation, interest rate, balance of payment accounts, unemployment, business cycles and others. These indicators sufficiently inform decision-makers about the pace and path of the economy. Within the context of broader development, measurements/indicators are also developed, including institutional quality index and economic competitiveness index, guiding policy-makers to pursue economic and social policies for the greater development objective. In social policy, indicators such as the Human Development Index, educational achievement, governance indicators and gender empowerment index inform on the state of social progress towards an enhanced state. In areas of environmental policy, sustainability index, environmental quality index and ecological health and diversity are some of the indicators to inform on green policies. The use of indicators and monitoring measurements in these fields provide an appropriate basis to contextualize and

develop and measurement and monitoring framework to support decision-makers in the translation of energy access goal and targets into practice.

There are similar precedents in the energy sector itself that can lend credence to placing energy access within a measurable and traceable space. Indicators for energy security, energy diversification and energy intensity are some of the examples (Hailu, 2012). Extension of these experiences to measuring and monitoring energy access with a goal to enhance it seems a natural transition. There is already momentum in the energy literature giving valuable insights. Bazilian, et al. (2010) reviewed energy sector indicators and observed that they are: single metric indicators; series of single indicators (*dashboard*); or composite indices that summarize a series of information in one measure. The simplicity of single indicators can be attractive, compared to complex indices that may require advanced analysis and data intensity. However, simple indicators may also be difficult to serve as indicators applicable in large number of countries, perhaps due to the context- and resource-specific nature of energy. The lack of solid theoretical and conceptual backing of indicators in the energy sector can be a serious shortcoming (Munda and Nardo, 2005; Saisana and Tarantola, 2002; Freudenberg, 2003).

The World Bank puts forth a *dashboard* of energy access indicators to monitor progress in energy projects. These include grid infrastructure expansion, electricity losses in the system and degree of interruptions, among others. These measures require access to technical information that could be difficult to find for a large number of countries publicly. The UN Department of Economic and Social Affairs utilizes aggregated measures to assess progress in energy sector development. These include energy consumption patterns, energy intensity (such as the level of energy used per unit of national output) and the share of households who lack access to electricity. The aggregated nature of these measurements and the relative easy to acquire data can make these indicators appealing. Foster, et al. (2000) proposes a measurement regime around *energy poverty*. By establishing a *fuel poverty live*, the study advices that the number of households below the fuel poverty line can be determined. Broader applicability of this measure is constrained by the context-specific nature of energy poverty and the need for extensive surveys to generate data for many countries, and repeatedly to utilize it for measuring progress.

Along the energy poverty line concept, Mirza and Szirmai (2010) develop a rather composite index intended to inform on energy poverty based on survey data that captures numerous dimensions of energy at the household-level. This approach faces similar challenges – ability to repeat the information overtime, and reliance on survey that may prove difficult to conduct across countries. Similarly, Practical Action (2010) also proposes the identification of a minimum level of energy service requirement based on which assessments can be made. This approach faces similar challenges. Based on the *energy deprivation* concept, the Multicriteria Energy Poverty Index (MEPI) develops an indicator based on measurement of multiple dimensions of energy deprivation including access to basic appliances and cooking facilities. While these complex indicators require the look at household-level energy conditions, aggregated measures based on complex tracking indices are also proposed. Two such examples are the Energy Indicators for Sustainable Development (EISD) (see Vera and Langlois, 2007) and IEA's Energy Development Index (EDI) (see IEA, 2010), largely based on aggregate energy consumption.

The development, or selection, of a particular energy access enhancement measurement and monitoring framework will have to consider at least eight factors (Hailu, 2012): the availability of data on a continual basis; the degree to which the indicators are statistically sound; the ability to compare across different political units (e.g. countries); validation of the method; cost of utilizing the indicator for analysis; the degree to which urban and rural access are differentiated; the degree to which policy and regulatory improvements are accounted for; and political acceptability. Considering these potential criteria, a selection of a measurement and monitoring indicator(s) can support decision-makers to monitor progress towards ambitious energy access targets.

2.3 THE ROLE OF ENERGY ACCESS TARGETS

Measuring and monitoring energy access requires a policy pre-set: the existence of an energy policy, vision or strategy that lays down a clear target. Targets offer the finish-line on the basis of which interim progress can be measured and monitored. Energy access targets in the Eastern Africa sub-region are complemented by continental and intra-country policy targets. At the continental level, NEPAD lays a vision for the energy sector in measurable and qualitative terms:

- Increasing the access to reliable and affordable commercial energy supply in Africa from 10% to 35% within 20 years.
- Improving energy reliability and lowering its cost to sustain a 6% economic growth.
- Reducing the environmental impact of traditional biomass use.
- Integrating grid and gas pipeline infrastructure to facilitate cross-border energy trade.
- To harmonize regulations and legislations.

Subsequently, the Forum of Energy Ministers of Africa in 2006 advised on a set of targets (see Brew-Hammond, 2010), including:

- Doubling the consumption of modern fuels to expand energy access for productive uses.
- Increasing rural access to modern coking energy by 50%.
- Increasing electricity access to 75% for urban and peri-urban areas.
- Increasing electricity access to schools, clinics and community centres by 75%.
- Making motive power for productive uses available in all rural areas, along with the use increased use of bio-fuels.

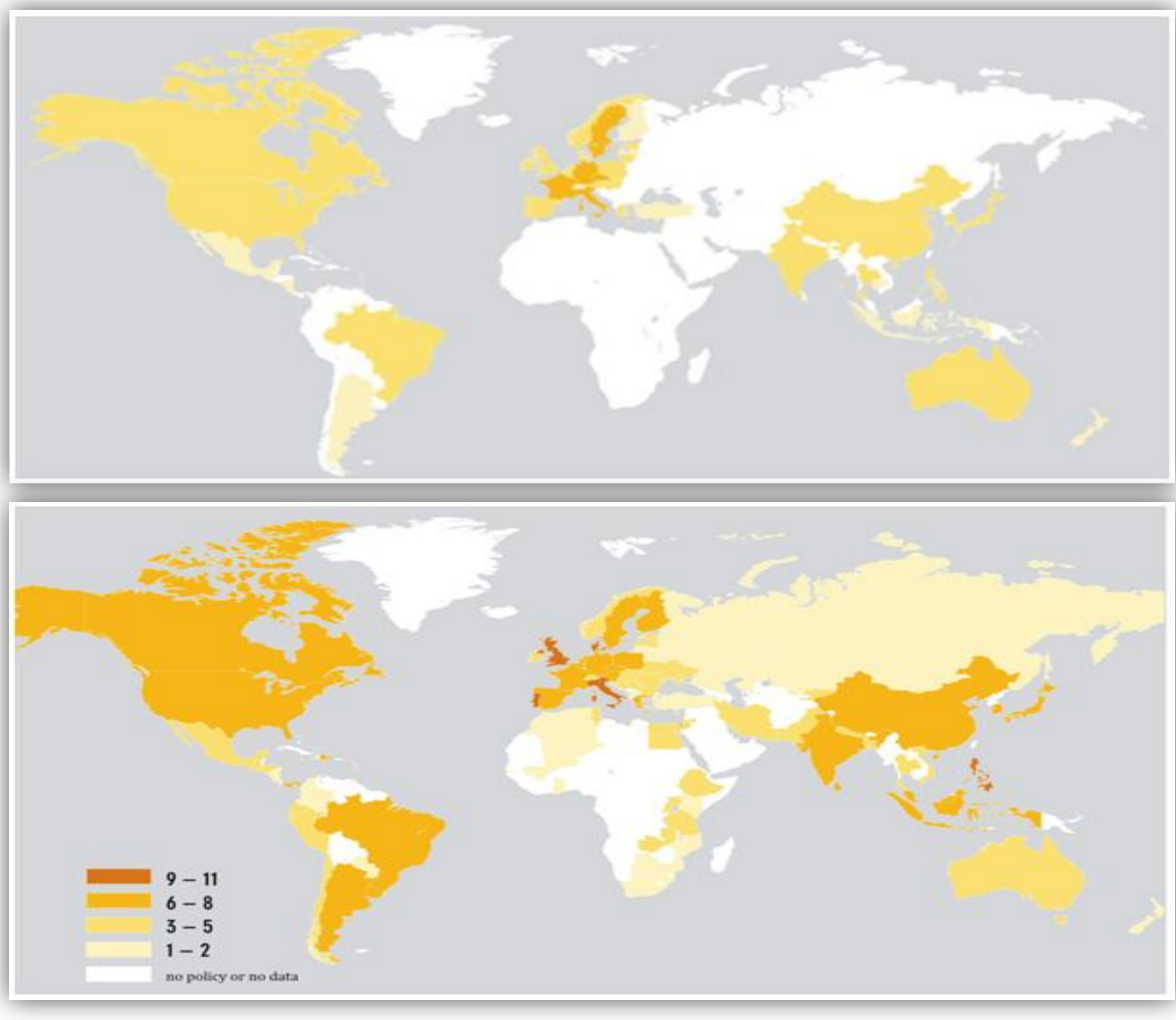
These continental initiatives set the policy tone at the regional level. In the Eastern Africa sub-region, unilateral and Regional Economic Community (REC) driven targets are also advanced. The EAC member States have advanced a common targeting of energy along the following policy benchmarks for the Community:

- Access to modern cooking energy for 50% of biomass users.
- Access to energy to all schools, clinics, hospitals and community centres
- Access to energy services for 100% of urban and peri-urban residents.
- Access to mechanical power for 100% of communities for productive use.

Energy access measurement and monitoring initiatives can use these regional benchmarks to monitor progress. Comparison of particularly renewable energy policy

evolution, with the potential to enhance access, in 2005 and 2011 (see Fig. 29) demonstrates that Africa, and particularly the Eastern Africa sub-region, has made progress as the sib-region introduces new policy tools to expand access, particularly in Ethiopia, Uganda, Rwanda and Burundi. Target setting is, however, more complex, as countries also engage in unilateral energy access targets and benchmarking, offering different layers of benchmarks to monitor and evaluate progress. Whether or not intra-country or regional targets carry proper evaluation weight, or the degree to which they reference to each other is an open question, requiring broader energy policy cooperation and coordination.

Figure 29: Energy policy evolution: comparative view of 2005 (panel 1) and 2011 (panel 2).



Source: REN21. 2012. Renewables 2012 Global Status Report (Paris: REN21 Secretariat).

Benchmarks for energy access in the Eastern Africa sub-region are more dynamic, with the setting of benchmarks in intra-country policy environments. For example, Ethiopia has set a 75% electricity access by 2015, from the current level of 45%.[9] Rwanda has targeted a national

[9] Ethiopia's articulation of what energy access means for policy purposes is discussed earlier. It refers to access at community and village levels where households would have the opportunity to connect, and not necessarily actual number of connected households.

70% access rate by 2012.[10] Rwanda also targets a 70% access rate by 2017.[11] As part of its Vision 2020, it foresees 35% of the population with access to electricity by 2020. Tanzania sets a target for rural electrification of 30% of the population by 2015, from the current level of 2%. South Sudan set a 70%-80% target for electrification.[12] On the transportation fuel side, Ethiopia remains the only country in the sub-Region with a bio-fuel blending mandate (E10) through the experimental program in Addis Ababa, with plans to expand it to more cities.

Energy sector targets are not only related to energy access, but also deal with the way energy itself is produced. To ensure the sustainability of the energy system, to source more indigenous energy sources and to reduce dependence on imported energy fuels, some member States in the Eastern Africa sub-region have set targets for increasing the share of renewable energy in electricity production. Small and Island States have taken the lead in setting policy goals to scale-up renewable energy integration into the electricity system. Rwanda's plan is the most ambitious that plan to realize 90% share of electricity production to come from renewables, and to achieve it by 2012.

Table 5: Eastern African Countries' target for integrating renewable energy into electricity production.

Country	Renewable Energy Share in 2010	Renewable Energy Target	Target Year
Eritrea	~ 0	50%	Not set
Madagascar	57%	75%	2020
Rwanda	-	90%	2012
Seychelles	-	5%	2020
		15%	2030
Uganda	54%	61%	2017

Source: REN21. 2012. Renewables 2012 Global Status Report (Paris: REN21 Secretariat).

In some member States in Eastern Africa, renewable energy targets are also set at the energy source level. Eritrea, Ethiopia, Rwanda and Uganda have such specificity. Eritrea's 50% renewable energy in the electricity production portfolio is expected to come from wind energy. Ethiopia targets wind energy (770 MW by 2014), hydro-electricity (10,642 MW by2015), geothermal (75 MW by 2015, 450 MW by 2018, and 1,000 MW by 2030) and bagasse (103.5 MW) (REN21, 2012). The Rwanda renewable energy target is reliant on small-hydro projects, expected to bring 42 MW by 2015. The Uganda strategy targets 188 MW from small hydro, biomass and geothermal by 2017, 30,000 m^2 installed solar water heaters by 2017 and 100,000 biogas digesters by 2017 (REN21, 2012).

These advances in prioritizing and setting clear policy targets for energy access and integration of sustainable forms of energy into the electrify generation portfolio are

[10] Rwanda's "energy rollout" targets to provide energy access to 350,000 households, and to 100% of health and administrative centers and more than 500 schools by the end of 2012 (REN21, 2012).

[11] See http://www.mininfra.gov.rw/index.php?id=88&tx_ttnews[tt_news]=34&cHash=76786f8e21177530e 9df931c700ac7c4.

[12] South Sudan electrification target from: http://www.goss-online.org/magnoliaPublic/en/Business-and-Industry /Infrastructure.html.

encouraging. Given the multiple layers of targets for energy access from continental, sub-regional and country-level, coordination and harmonization will be key to effectively measuring and monitoring progress towards established targets.

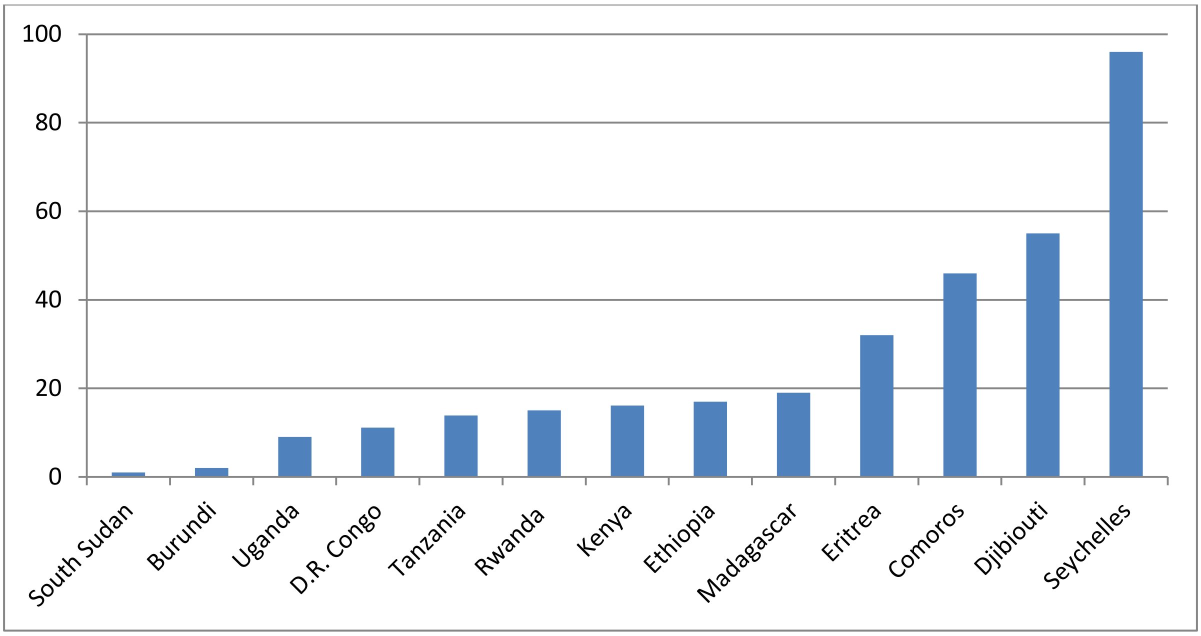
Similar targets are not common in the improved cookstoves policy space. However, there are significant advances in integrating cookstoves into the energy access implementation framework. In Rwanda, more than 50% of households already own improved cookstoves by 2008, with much progress since then. *Development partners* play a valuable role in enhancing access to improved cookstoves. For example, "…more than 550,000 improved cookstoves have been disseminated in Benin, Burkina Faso, Burundi, Ethiopia, Kenya, Senegal, and Uganda since 2009 with support from Germany's GIZ; … the ongoing project in Kenya, which is jointly implemented with the Ministries of Energy, Agriculture, and Education, has disseminated approximately 850,000 stoves since it was established in 2005; … with support from Dutch agency SNV, 8,432 new biogas plants had been installed in nine African countries, and production rates of biogas plants were up 100% compared to 2010… In Uganda, another joint venture of private companies aims to provide low-income communities with access to energy-efficient household cookstoves; at an estimated cost of US$ 20 million, representing one of the largest carbon-finance commitments made to clean cookstoves in the sector's history" (REN21, 2012). The Rwanda National Domestic Biogas Programme aims to bring biogas technology to the household-level, at least 15,000 biogas digesters, to rural households with cows.

A number of Eastern African member States have set energy access targets of different intensity and target year, prioritized the integration of renewable energy into the electricity generation portfolio, and set fuel source targets as a pathway to meet the renewable energy targets. Dissemination of improved cookstoves is also part of their energy access enhancement strategy.

2.4 THE STATE OF ENERGY ACCESS IN EASTERN AFRICA

The state of energy access in member States of the Eastern Africa sub-region is generally quite low, ranging from 1% in South Sudan, 2% in Burundi, 9% in Uganda and 11% in D.R. Congo to relatively better performance in Comoros (46%), Djibouti (55%) and Seychelles (96%) (see Fig. 30). In eleven of the fourteen member States, electricity access rates are below 20%, with large urban-rural gap. Rural electricity access is rather in single digit in many of the member States. Comparison of access gaps within the Eastern Africa regional average, and with the average for sub-Saharan Africa, middle income countries and the universal access target can reveal the depth of the energy access challenge in the sub-region.

Figure 30: Percent of population in Eastern Africa member States with access to electricity.



Sources: IEA, World Energy Outlook 2010; data from country missions.

Comparison within the sub-region can help map member States with comparative intensity of the access challenge. Comparison with sub-Saharan (as North Africa achieved almost universal access) countries on energy access provides a profile of energy access in the sub-region relative to the performance of a wide range of African countries. Comparison with middle income countries on energy access is particularly useful as member States such as Ethiopia, Kenya, Rwanda and Uganda aspire to be middle income in within the next decade or so. Comparison with the universal access agenda provides an assessment of the depth of the challenge in member States. Such comparative analysis is summarized in Fig. 31. The assessment includes thirteen of the fourteen member States, leaving Somalia due to lack of accurate access data.

Within the Eastern Africa sub-region, the regional average electricity access level is about 26%, mainly due to the high access rate in Seychelles (96%). The sub-regional average without Seychelles drops to just 20%. Of the thirteen countries depicted in Fig. 26, four have electricity access rates above the sub-regional average of 26%: Eritrea (up 6%), Comoros (up 20%), Djibouti (up 29%) and Seychelles (up 70%). *Sub-regional access rates tend to be higher in coastal small States and Island States*. The relatively small population that is reachable through gird access can be one reason. Relatively large concentration of people in major cities could be another. However, higher access levels are achieved through more expensive generation fuel source. Thermal generation accounts for nearly all electricity generated in Djibouti (now electricity trade with Ethiopia has improved per unit cost), Eritrea and Seychelles, and to a similar level in Comoros baring the slight contribution from hydropower. On the contrary, in nine of the thirteen countries in the analysis, access levels are below the sub-regional average. The intensity of gap between sub-regional and country access is the largest in South Sudan (down by 25%), Burundi (down by 24%), Uganda (down by 17%) and D.R. Congo (down by 15%). Tanzania, Rwanda, Kenya, Ethiopia and Madagascar have gaps of 12%, 11%, 10%, 9% and 7%, respectively. Countries with access gap from sub-regional average constitute those with vast hydropower potential (D.R. Congo and Ethiopia), small landlocked countries (Burundi and Rwanda), countries with oil and gas potential (Tanzania, Kenya and South Sudan), and a large Island State with indigenous energy resources potential (Madagascar).

In sub-Saharan Africa, the average access rate is around 32%, slightly higher than the Eastern African sub-regional average (26%). Comoros, Djibouti and Seychelles have electricity access levels significantly above the sub-Saharan average, with Eritrea at that average. The rest of the member States in the sub-region underperform compared with the sub-Saharan level, by a margin ranging from 31% to 13%. This reveals the degree to which the sub-region faces an alarming energy access challenge.

A number of sub-regional member States have but transition to a middle income country as a medium- to long-term economic development objective. Transformation will require rapid economic growth, lifting many from poverty. Transformation will also require rapid expansion of energy capacity to sustain economic growth to the middle income post. Middle income countries, on average, have electricity access rate at 82%. With the exception of Seychelles in the sub-region (up 14%), all other member States have significant access deficit from the middle income level. The deficit is 80% and above in South Sudan and Burundi, in the 70% and up in Uganda and D.R. Congo, between 60%-70% in Tanzania, Kenya, Rwanda, Ethiopia and Madagascar, and between 27% - 50% in Eritrea, Comoros and Djibouti.

All member States in the sub-region have gaps compared to "universal access," of course with targets to be met by 2030, not 2012. But the current gap is reflective. It is in the range of 45% to 99%, with Seychelles just 4% deficit. *The energy access challenge in the sub-region is massive, requiring far-reaching vision, implementation strategy and regional cooperation*.

2.5 THE STRUCTURE OF LOW ENERGY ACCESS IN EASTERN AFRICA

Strategies to expand energy access will need to reflect on the underlying causes of poor access levels in the Eastern African sub-region. Energy access challenges have broad similarity in the sub-region, and in the wider African and international context. The root causes for the level of achieved energy access are rooted on the demand and supply sides of the energy system in a country, and the institutions, policies and regulatory bodies that govern their management.

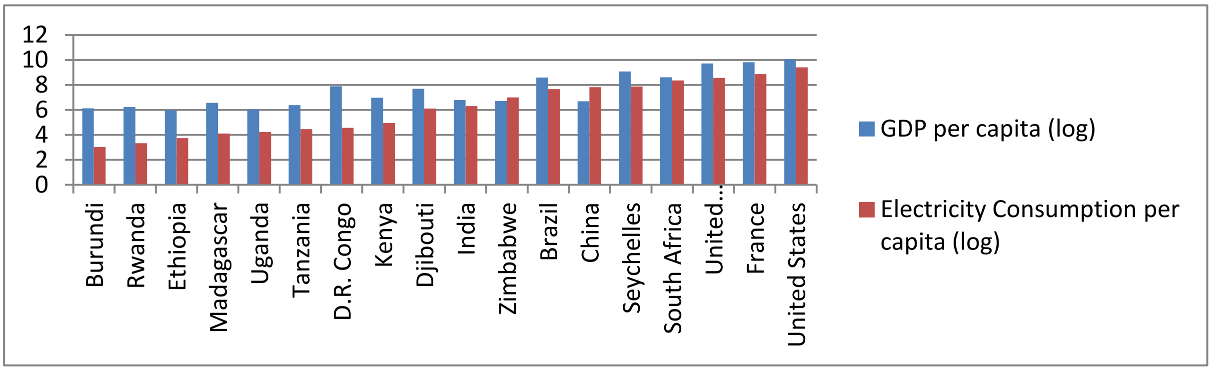
2.5.1 Demand Side Constraints

Income, effective demand and access levels: The demand for modern forms of energy, including electricity, as in any other commodity in a market, is dependent on the level of income of consumers. It is intuitive to expect that as income levels increase over-time, the level of demand for modern forms of energy also increases. The willingness to pay for modern energy is income sensitive. A study by KIPPRA (2010) based on interview of 6,346 households in Kenya demonstrate that the willingness to pay per kWh/month for households in urban areas was KSh132.41 (~US$1.6), compared with KSh88.84 (~US$1.1) for rural areas and KSh35.45 (~US$0.44) for low income households. Leach's (1992) energy ladder hypothesis ascertain that switching to modern energy services for cooking, lighting and eclectic appliances is dependent on the level of income, and its change overtime. The implication of this hypotheses is that at the lower income level, consumption of biomass and charcoal are predominant, switching to electricity, LPG, fossil fuels and appliances with income shifting to higher brackets (Masera, et al., 2000, Heltberg, 2005). The speed of transition to modern energy services will be dependent on their relative affordability, which is relative to income (IEA, 2004).

This relationship between income levels and electricity consumption is evidenced in the Eastern Africa sub-region, as shown in Fig. 32, where countries at relatively higher levels of

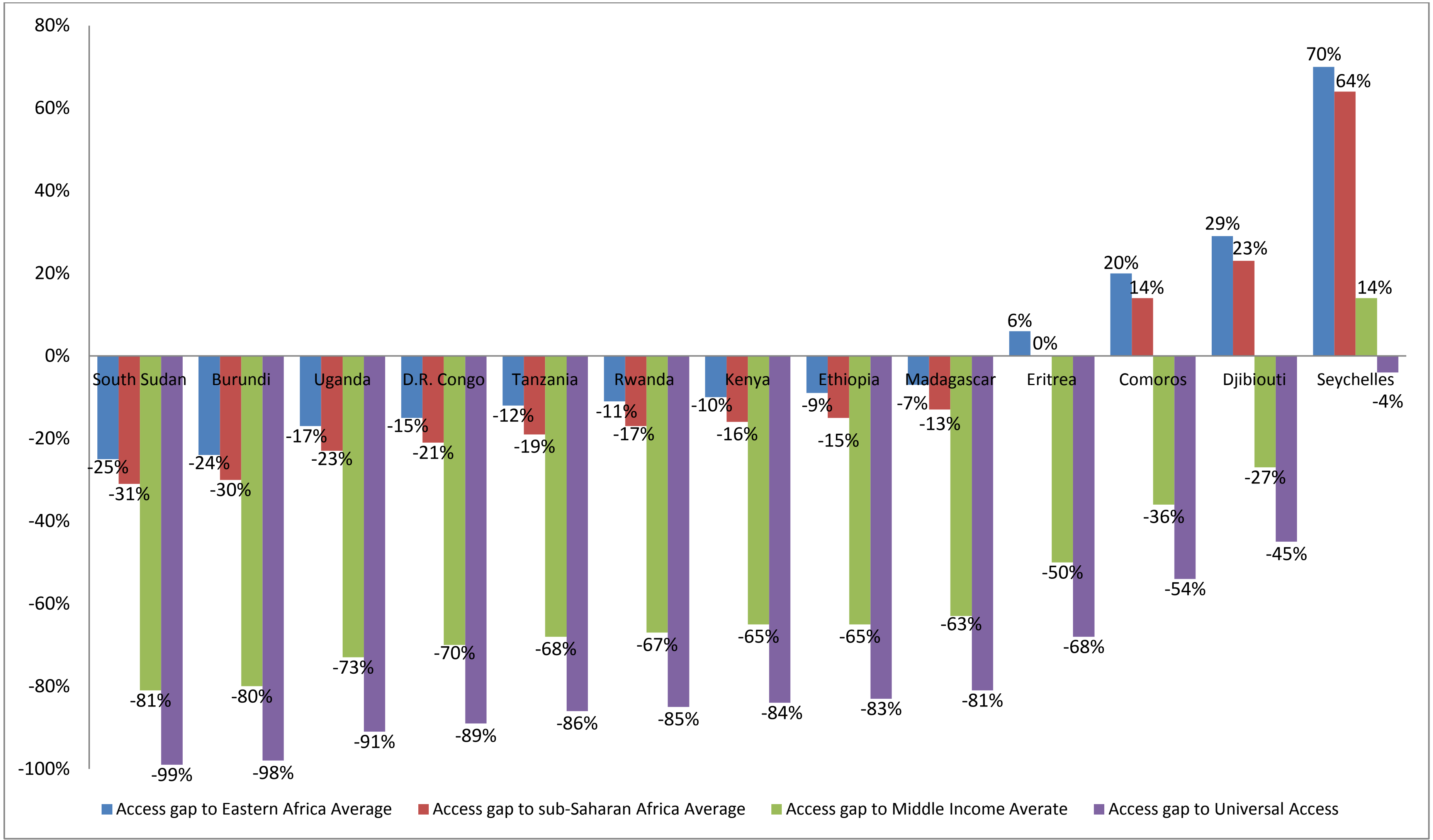
income per capita exhibit higher per capita electricity consumption levels. This pattern is further demonstrated in countries outside the sub-region demonstrated in the figure. Therefore, the low level of income, on the demand side, is a key deterrent in accessing electricity.

Figure 31: The relationship between per capita income and electricity consumption (kWh).



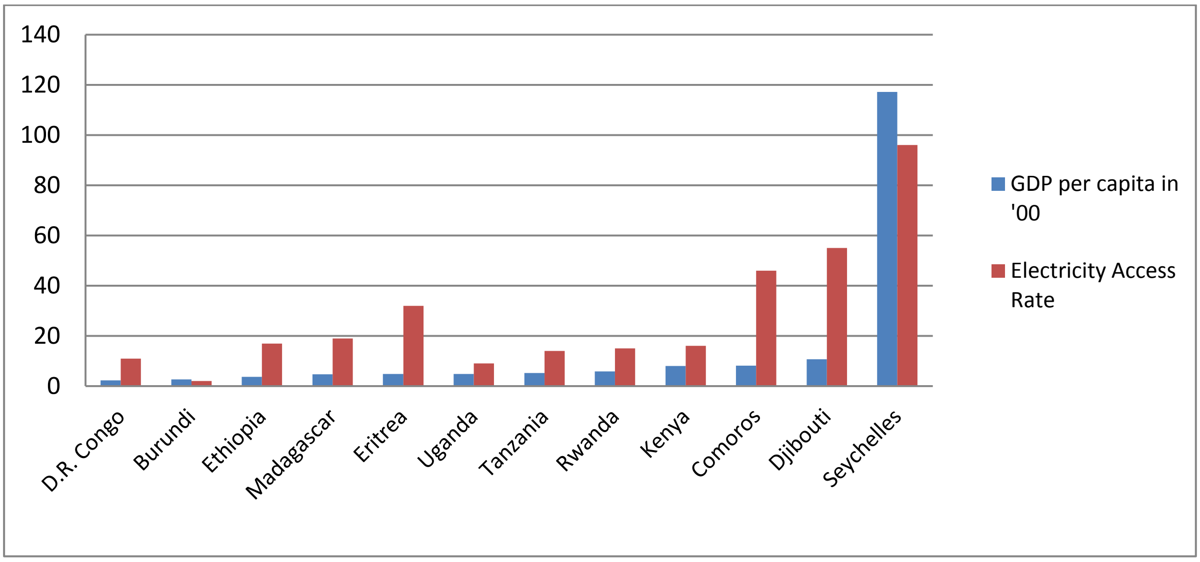
Source: World Bank national accounts data, and OECD National Accounts data files, IEA, World Energy Outlook 2010 and data from country missions.

Figure 32: Assessment of the electricity access gap in Eastern African countries relative to sub-regional, sub-Saharan, middle income and "universal access" levels.



The electricity consumption constraining nature of the level of income in countries in the sub-region has implication to access levels. Low income levels lead to lower *effective demand* for energy services, and hence lower levels of energy consumption and access. The access constraining nature of lower income levels are demonstrated in Fig. 33, which depicts that countries in the sub-region with better development levels, and better per capita income, have higher electricity access rates. These observations demonstrate that energy sector development is linked with economic development and transformation in the region that will determine the pace of income growth. The relatively lower level of economic development in the sub-region is one reason why observed energy access levels are quite low. *Addressing energy access in the sub-region is interlinked with advancing economic development and enhancing consumer income.*

Figure 33: The relationship between per capita income and electricity access levels.



Source: World Bank national accounts data.

Despite these strong linkages for policy makers to leverage, Mekonnen and Kohlin (2008) warn that higher income levels not necessarily lead to rapid increase in the use of modern energy services. By using the case of urban Ethiopia, they argue that urban residents, even with rising income levels, may still consider biomass a *normal*, as opposed to *inferior*, good the consumption of which need not decline with growing income. This phenomenon, known as *fuel stacking*, mean that growing income encourages higher consumption of modern energy sources, but in conjunction with a diverse traditional energy source portfolio, slowing the speed of switching to modern energy.

Sticky preferences and attitudes: switching to energy technologies, and accessing modern forms of energy away from traditional ones, faces the challenge of culture, attitudes and preferences. Consumers often prefer energy sources they have come to rely and use for a long time, and demonstrate resistance to switch. Murphy (2001) demonstrated that in the context of rural areas of Eastern Africa, cultural factors limit the ability of the population to rapidly switch to alternative energy technologies. Existing strong preferences can also pose a challenge (Horst and Hovorka, 2009). Mekonnen and Kohlin (2008) also demonstrated, using data from Ethiopia, that preferences for traditional fuels tend to stick even with rising urban income, partly due to sticky preferences for traditional fuels. In providing the cultural and attitudinal factors,

Erumban and Jong (2006) demonstrate their importance in the context of differences in the adoption of ICT across countries. They find that the ICT adoption rate of a country is closely related with national culture, particularly the dimension of *uncertainty avoidance*. Greater access to modern energy sources will therefore need to consider demand side constraints, including the role of strong preferences, culture and attitudinal factors that shape the demand for modern energy

Settlement patterns and physical accessibility: settlement of population away from major grid network poses access challenges, given the limited diffusion of off-grid energy systems in many parts of the Eastern Africa sub-region. Illegal settlement and land use patterns pose legal and physical barriers to the urban poor. Illegal tenancy arrangements (largely unrecognized by utilities and city administration) and settlements away from the national grid pose difficulties in the face of demand (Fall, et al. 2008; Dhingra, et al., 2008). In progressive energy programs that attempt to deliver energy access to the urban poor and slum residents pose cost difficulties, attempting to deliver energy from grids that could be as far as 30 kms away, and the need for higher up-front costs that can limit access expansion to the urban poor. The high infrastructure and connection cost to most of the urban poor and rural population currently unconnected reduces their capacity to effectively demand it without some form of price-support. While rural electrification programs attempt to deal with the lack of physical accessibility of grid-based power to rural residents, UN Habitat (2009) notes that slum electrification programmes are often not prioritized and mainstreamed into national policies and programmes.

Figure 34: Electricity access in slum areas.

Source: In2EastAfrica, Photo - Residents fighting fire which destroyed over 5,000 houses in Mukuru-Mariguini, Mukuru-Kanaro, Mukuru-Chakati, Mukuru Fuata-Nyayo and Mukuru slums in South B, Nairobi, on February 28, 2011.

Targeted subsidy, price support programs and affordability: affordability of energy is a relevant consideration in energy access promotion strategies. Subsidizing energy prices is a common feature in the Eastern Africa sub-region. While costly, these policy efforts reduce the effective price of energy to households, increasing access and consumer welfare. However, these programs often come at a hefty cost to governments and utilities. The announcement from the Government of Uganda in January, 2012 about removal of electricity generation subsidies has drawn much attention. The government spent nearly Shs 1.5 trillion in electricity subsidies since 2005, and with the commissioning of new hydroelectric systems has decided to no longer commit such sizeable subsidies. As a result, the Electricity Regulatory Authority (ERA) announced the rise in consumers pay from Shs 385.6 to Shs 524.5 per unit, a rise in commercial users pay from 358.6 to Shs 487.6 per unit, a rise in medium industries pay from Shs 333.2 to Shs 458.9 per unit and large industries' tariff increased from Shs 184.8 to Shs 312.8 per unit. The savings from these subsidy changes is planned to finance the other hydroeclectic projects, including Karuma Hydro Power project. The challenge of keeping electricity rates affordable and that of keeping the system financially sustainable is an on-going challenge in the sector.

Moreover, electricity subsidies that reduce the tariff to consumers largely benefit those who are already connected, and may benefit the population that have not yet accessed it, demonstrated from Eastern and Southern Africa experiences (Hosier and Kipondya, 1993; Dube, 2003; Kebede, 2006[13]) and from Asian experience (Shelar, et al., 2007). Since consumers already connected to access modern energy are at a relatively higher income, most of the subsidy schemes, if untargeted, goes to them, with limited impact on population access rates. One model program is from South Africa, where subsidies are targeted to poor households who are provided access to 20-50 kWh of energy per month for free, beyond which they are exposed to rates (UNDP, 2010).

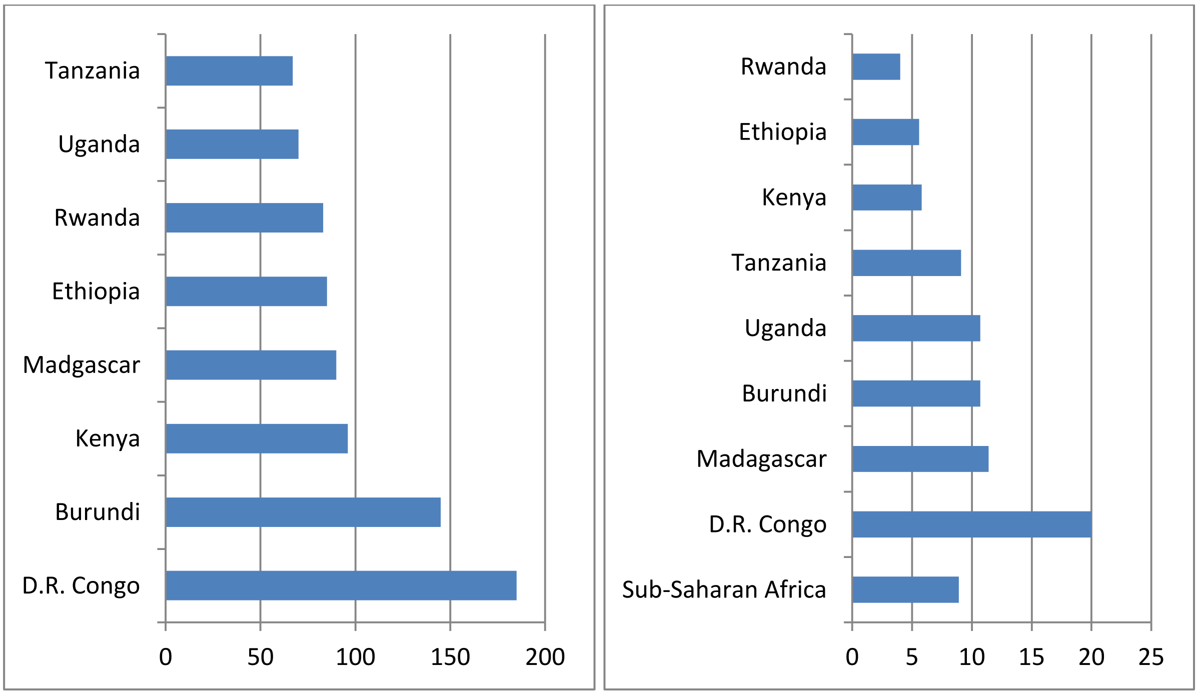
The utilization of improved cookstoves and energy efficient appliances by households is also constrained by affordability factors in the Eastern Africa sub-region. Karekezi, et al. (2008) identify that accessibility to cleaner energy sources are impeded due to taxes on imported kerosense stoves, reaching as high as 51% of the value which prices majority of households out. Karekezi and Kithyoma (2002) also note that the cost of clean energy technologies, reaching 131% to 363% of per capita GNP in Eastern Africa, and in the face of fluctuating household income, poses serious impediment to switching to modern energy supplies.

System reliability: the demand for electricity is dependent on how reliable the energy system is over-time. The reliability of the energy system can be observed by consumers based on degree of service interruptions, the cost imposed by such interruptions, and the duration of interruptions when they occur. The frequency and intensity of power outage in select countries in the Eastern Africa sub-region is depicted in Fig. 35. While most recent data on outages is not available for most of the sub-regional countries, the indicative measures in Fig. 29 demonstrate that outages, in terms of number of days per year, are anywhere between 65-185. The number of outages per month range from less than 5 in Rwanda to close to 20 in D.R. Congo. Such systemic and frequent power outages discourage reliance of consumers on the grid, and encourage household and business investment in alternative energy supplies. Power outages in Eastern Africa exceed even sub-Saharan average by significant margins. The quality of power is

[13] Kebede, B. 2006. "Energy Subsidies and Costs in Urban Ethiopia: the Cases of Kerosene and Electricity." *Renewable Energy* 31(13): 2140-2151.

also a related problem. Households are required to install load regulators to protect household appliances from irregular currents, particularly during interruption and resumption of electrical services. Power quality is particularly a challenge to industry, where costly appliances and technology can be damaged by irregular and poor quality power supply.

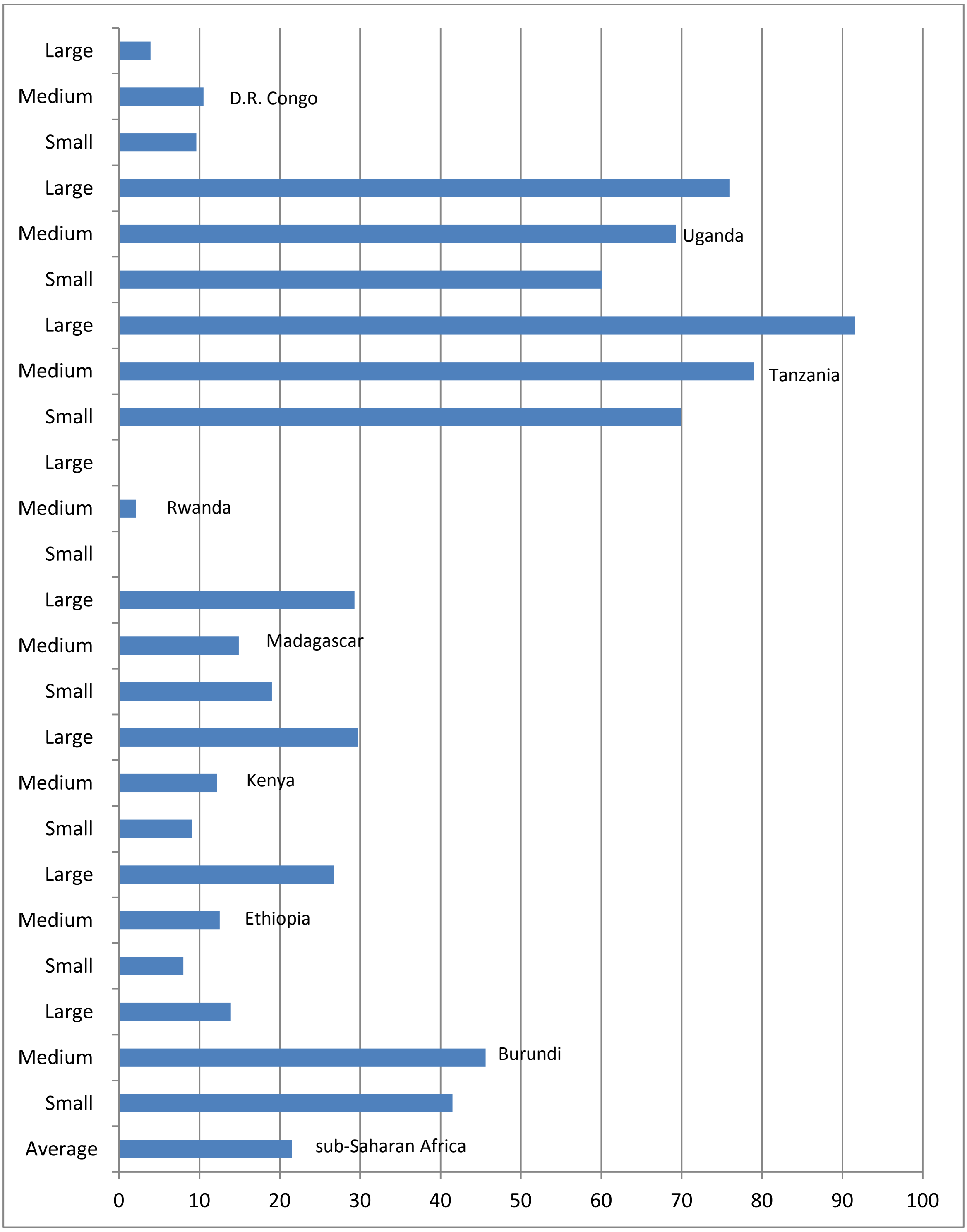
Figure 35: Power outage days per year (panel 1) and number of electrical outages in a typical month (panel 2) in select countries in the Eastern Africa sub-Region.



Source: Based on data from World Bank Enterprise Survey.
Note: Data is for the following years: D.R. Congo (2010); Madagascar (2009); Uganda (2006); Burundi (2006); Tanzania (2006); Kenya (2007); Ethiopia (2011) and Rwanda (2011).

The industrial demand for consistent and reliable energy is affected by the power interruption challenge. Based on World Bank Enterprise Survey data, Fig. 36 depicts out of the total constraints to business identified in sample of countries, the share related to electricity. The data allows looking at the energy constraint to industry by three industrial classes: small (with 5-19 employees); medium (with 20-99 employees); and large (with 100+ employees) enterprises. In Uganda and Tanzania small, medium and large enterprises have identified electricity accounting 60 to 90% of their business challenge, even when one considers issues of crime and theft, customs and trade regulation, available human capital, labor regulations, political instability, corruption, business licensing and permits, access to land and finance, and transportation. The scale of the energy problem to industry is quite sizeable in these countries. In Burundi, small and medium enterprises consider energy to account to over 40% of their business operation challenge, though large enterprises see energy accounting to about 16% of their business constraints. In Ethiopia, Kenya and Madagascar, large enterprises consider energy to account to over 20% of their business challenge, though small and medium enterprises put the level at relatively lower level. In D.R. Congo and Rwanda, while the share of concern enterprises allocate to electricity is relatively lower, it is nonetheless viewed as a barrier.

Figure 36: Enterprises identifying electricity as a share of overall business constraints (%).

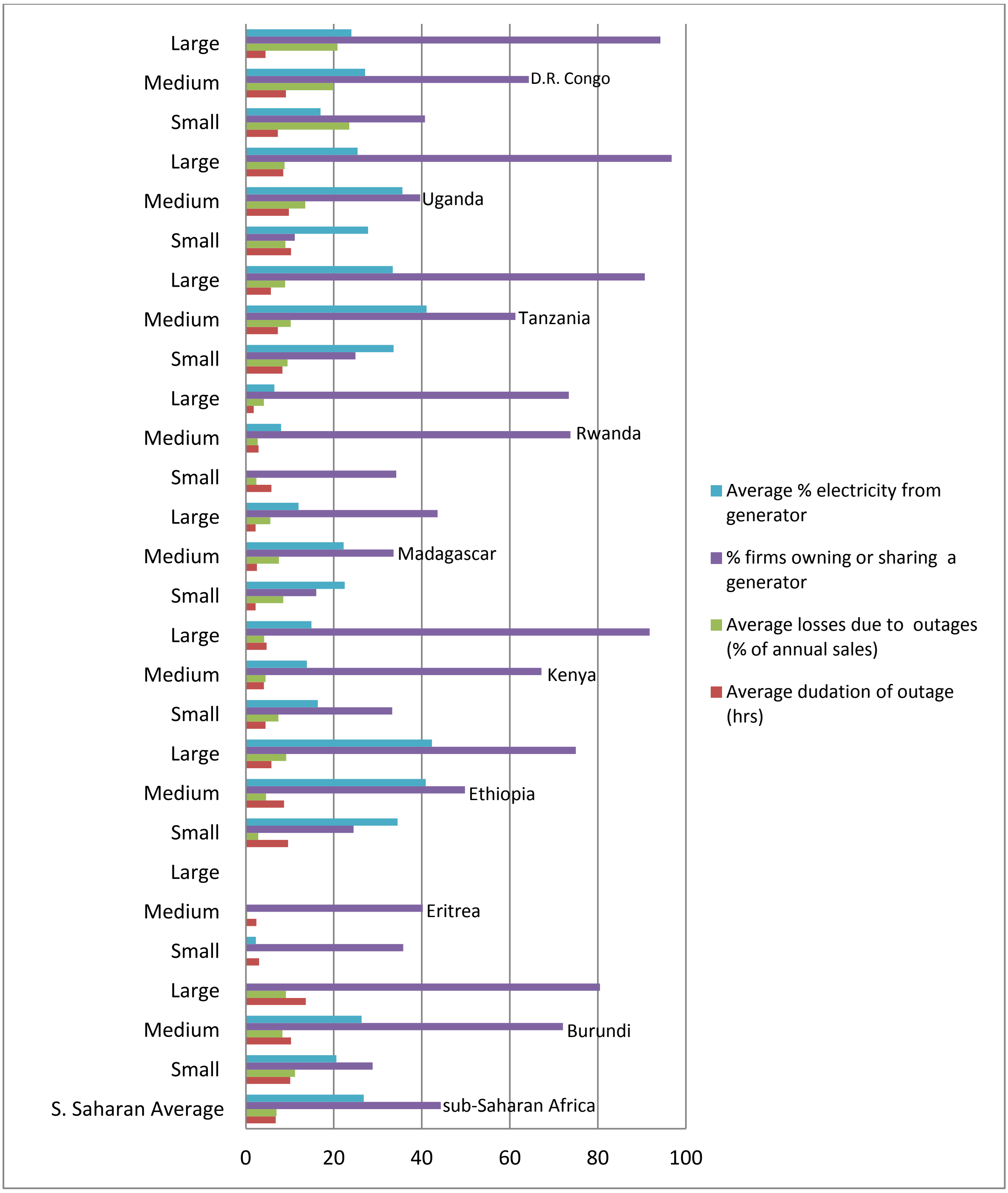


Source: Based on data from World Bank Enterprise Survey.
Note: Small=small enterprises with employment of 5-19; Medium = medium size enterprises with employment of 20-99; and Large=large enterprises with employment of 100+.

Furthermore, Fig. 37 demonstrates the share of enterprises who own or share generators as a back-up and self-generation system. Compared to the sub-Saharan average of 44%, the share of large enterprises who own or share generators reaches 81% in Burundi, 75% in Ethiopia, 92% in Kenya, 44% in Madagascar, 73% in Rwanda, 91% in Tanzania, 97% in Uganda and 94% in D.R. Congo. The level of energy self-generation and losses due to outages are

also sizeable, even by sub-Saharan average. *Electricity demand in the Eastern African sub-region is therefore impacted by the reliability and consistency of supply to households and industry.*

Figure 37: Enterprises owning generators and self-generating given power outages and revenue losses.



Source: Based on data from World Bank Enterprise Survey.

Note: Data is for the following years: D.R. Congo (2010); Madagascar (2009); Uganda (2006); Burundi (2006); Tanzania (2006); Kenya (2007); Ethiopia (2011) and Rwanda (2011).

: Small=small enterprises with employment of 5-19; Medium = medium size enterprises with employment of 20-99; and Large=large enterprises with employment of 100+.

2.5.2 *Supply Side Constraints*

Generation capacity: the structurally low level of electricity access in the Eastern Africa sub-region is related to existing low power generation capacity. In looking at the structure of energy production and consumption in the sub-region (see Table 6), the share of thermal and electricity production and consumption are low compared with energy generated from biomass. In much of the sub-region, the share of electricity in final consumption is below 5%, and thermal ranging from 3.18% in Burundi to a high of 21.43% in Kenya. The structure of energy production and consumption demonstrates the low contribution of electricity to final consumption, partly due to poor levels of generation.

Table 6: Energy balances in East Africa, 2009.

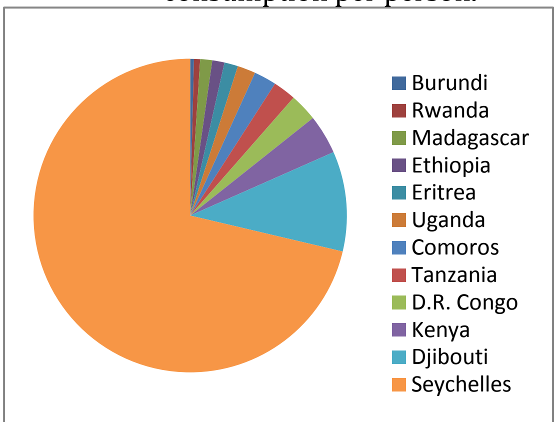
	Total energy Production (%)			Final consumption (%)		
Country	Thermal	Electricity	Biomass	Thermal	Electricity	Biomass
Burundi	3.28	0.88	95.99	3.18	0.74	96.07
D.R. Congo	3.72	2.63	93.66	3.63	2.51	93.82
Eritrea	22.59	0.02	77.39	17.95	4.25	77.80
Ethiopia	7.42	1.01	91.56	7.83	1.03	91.14
Kenya	36.74	3.75	68.63	21.43	4.32	74.25
Madagascar	16.34	1.82	81.84	15.89	3.03	81.08
Rwanda	-	-	-	11.00	4.00	85.00
Uganda	10.72	1.06	88.22	10.67	1.21	88.12
Tanzania	11.20	1.23	87.57	9.47	1.75	88.79
East Africa	14.00	1.55	85.61	11.23	2.54	86.23

Source: UN Statistics, Energy Balances and Electricity Profiles, 2009; Rwanda related data is from National Energy Policy and Strategy, Rwanda 2011.
Note: East Africa average doesn't include Comoros, Djibouti, Seychelles, Somalia and South Sudan due to lack of data.

Existing generation capacity in half of the sub-regional countries is much below 500 MW (see Fig. 39), ranging from Comoros (24), Burundi (49) and Seychelles (95), to Rwanda (103), Djibouti (123) and Eritrea (139). Larger countries similarly demonstrate lower level of generation, ranging from Uganda (822) to D.R. Congo (2,300). Even though the generation level is quite low in small States, the per capita consumption (see Fig. 38) is relatively better in Sychelles, Djibouti and Comoros than in large States, such as Uganda and Ethiopia. But the small states of Burundi and Rwanda have low generation and consumption levels. The growing population, economy and demand for electricity in the region put pressure on existing generation capacity.

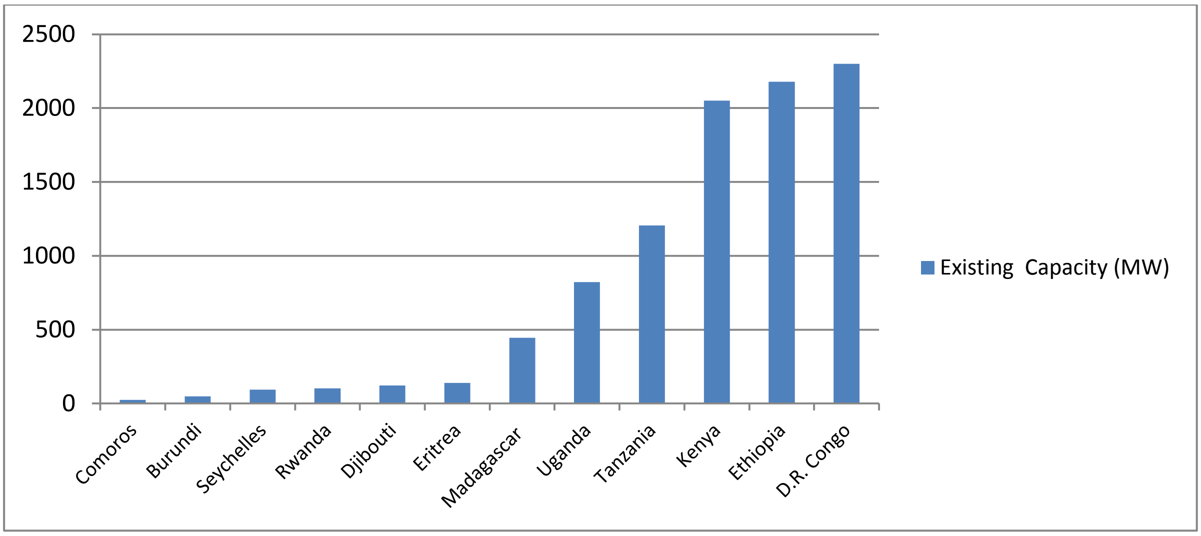
Figure 38: Sub-Regional distribution of energy

consumption per person.



Meeting the country and regional electricity access targets will require enhancing the weak electricity generation capacity in the sub-region.

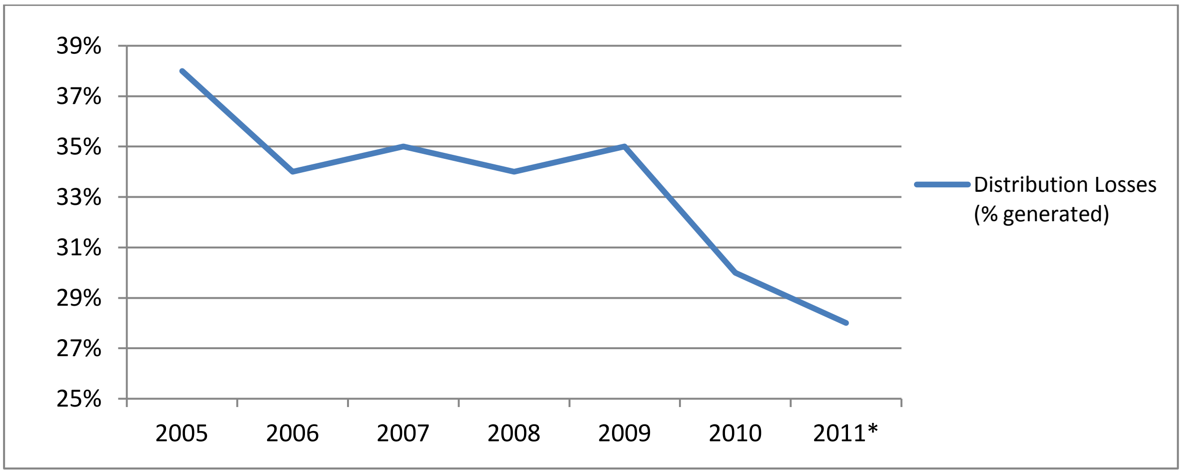
Figure 39: Existing generation capacity of countries in the Eastern African sub-Region.



Source: EAC Regional Power System Master Plan and Grid Code Study (SNC Lavalin International Inc and Parsons Brinckerhoff, 2011); Renewable Energy and Energy Efficiency Partnership; and country mission data.

Transmission and distribution: Despite low electricity generation capacity in the Eastern Africa sub-region, posing a supply constraint, further power shedding from the transmission and distribution lower the available generated power for end users. Transmission and distribution losses are quite high in the sub-region. For example, Tanzania's transmission and distribution loss is in excess of 20% of generated electricity, with 15% or more coming from technical and non-technical (theft and misuse – see announcement from TANESCO to deal with the problem on next page) losses. In the D.R. Congo, losses are estimated between 20-30%, with significant illegal connections. In Uganda, transmission and distribution losses are also quite high, distribution losses alone accounting to 38% of generated electricity, which in recent years declined to 29% (see Fig. 40). *Such high levels of transmission and distribution losses reduce the available energy, curtailing effective supply.*

Figure 40: Distribution losses in the Uganda electricity distribution network.



Source: Based on data from the Uganda electricity distribution company (UMEME). The value for 2011 is estimated.

SURRENDER YOURSELF BEFORE THE CAMPAIGN TO STAMP OUT ELECTRICITY THEFT BEGINS IN OCTOBER, 2011

1. The Tanzania Electric Supply Company (TANESCO) hereby informs its customers and the general public that it will soon launch a special operation which will be known as "Operation KAWEU" aiming at identifying and taking legal action against people who are involved in electricity theft.

   TANESCO Management conducted a market research on the consumption of electricity in Tanzania and was startled to learn that a large and growing number of people are stealing electricity. Electricity theft leads to loss of revenue which subsequently reduces the company's ability to provide electricity to new customers.

2. TANESCO hereby issues a one month (from 12th September to 12th October 2011) notice of amnesty to all customers who are stealing electricity. Those who will visit TANESCO offices at their respective districts, regions or zones and admit they have been stealing electricity will be pardoned and their electricity system restored to normal connection.

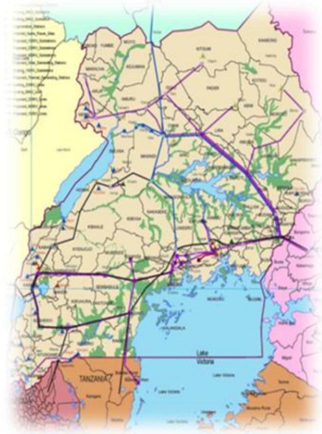
   From 12th October 2011, TANESCO will send its special investigation gangs who will go house to house inspecting services lines and electricity meters. Customers who will be caught stealing electricity will have their electricity supply permanently disconnected and legal action taken against them.

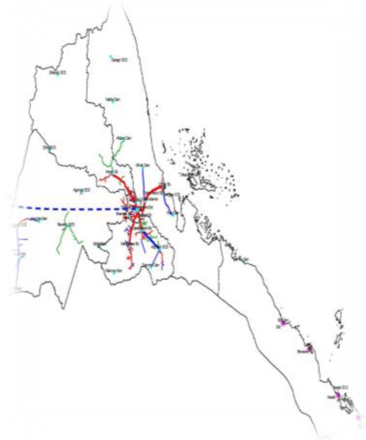
Investments are increasing in the sub-region for interconnections and transmission and distribution upgrade to reduce losses. Some of these projects include: the D.R. Congo, Burundi and Rwanda interconnection from a shared hydro power station Ruzizi II; inter-State connections between Uganda and Rwanda (to be commissioned in 2014), Tanzania and Uganda, Kenya and Tanzania (2015), Ethiopia and Djibouti (commissioned in 2011), Ethiopia and the Sudan, Ethiopia and Kenya (2013), the Kenya-Uganda interconnection (2014), the Ethiopia-Sudan-Egypt connection (feasibility study completed), Rwanda and Burundi (2014), Uganda and Rwanda (2014) and other intra-country projects.[14]

Intra-country investments in transmission and distribution networks are expected to drive system power losses down. Current and planned transmission networks are shown for Tanzania, Uganda and Eritrea. The Tanzania grid expands to Kenya and Zambia, the Uganda grid to Kenya, Rwanda, Tanzania and D.R. Congo, and the Eritrean grid to the Sudan.

Figure 41: Current and planned transmission networks of Tanzania, Uganda and Eritrea.

[14] See EAC Regional Power System Master Plan for details.





Energy Planning and Technology Choice: energy sector development has not received adequate attention for much of the period between1980-2000 in many sub-regional countries. Comparison of the total existing capacity with the capacity expansion since 2000 (see Table 7) demonstrates that investments were largely marginal, and the last investment year dates back to the 1990s or 1980s. For nearly two decades, energy planning was inadequate, and generation capacity expansion was not at par with the demand pressure. Since 2000, the lagging generation capacity development is met with growing demand for more energy, driving most of the sub-region into emergency generation. In the 2000s, Kenya, Rwanda, Tanzania and Uganda, for example, have added 51%, 45%, 68% and 52% of their total capacity, respectively.

Table 7: Electricity generation capacity enhancement: emergency expansion.

Electricity Generation Planning in Select sub-Regional Countries

Country	Total Installed Capacity	Capacity Added since 2000	Last capacity Investment
Burundi	48.5 MW	0 MW	5.5 MW in 1996
Kenya	1916 MW	982 MW	148 MW in 1999
Rwanda	105 MW	46.8 MW	1.8 MW in 1985
Tanzania	1205 MW	824 MW	68 MW in 1995
Uganda	822 MW	427 MW	-

The emergency generation scheme has pushed sub-regional countries to opt for technologies that offer quick capacity upgrade, which in many cases was thermal generation. As early as 2006, the cost of emergency generation has been substantial, costing sub-regional countries between 0.96%-3.29% of GDP (see Table 8). In the case of Rwanda and Uganda, by 2005 and 2006, emergency generation has already accounted for over 40% of total power supply, largely from thermal technology options, which are more expensive.

Table 8: Impact of emergency power generation on GDP.

Country	Year	Contract Duration (yr)	Emergency capacity	% of installed capacity	Cost as % of GDP

Kenya	2006	1	100	8.3	1.45
Rwanda	2005	2	15	48.4	1.84
Tanzania	2006	2	180	20.4	0.96
Uganda	2006	2	100	41.7	3.29

Source: Eberhard et al. (2008).

A detailed look of Table 9 demonstrates the generation capacity expansion path of select sub-regional countries, the energy planning and investment path, the timing of capacity expansion and the technology choice for capacity development since the 2000s.

Table 9: Electricity generation structure and technology in EAC countries.

Plant	Installed Capacity (MW)	Plant Factor	Year on Power
	Burundi		
	Hydro Existing		
Rwegura	18	0.44	1986
Mugere	8	0.44	1982
Ruvyironza	1.3	0.44	1984
Gikonge	0.9	0.44	1982
Nyemanga	2.8	0.44	1988
	Thermal Existing		
Bujumbura	5.5	0.75	1996
	Imports/Sharing Existing		
Ruzizi II	12	-	1989/1991
Total	**48.5**		
% local generation from thermal	15%		
	Rwanda		
	Hydro Existing		
Mukungwa	12.5	0.52	1982
Ntaruka	11.3	0.52	1959
Gihiria	1.8	0.52	1985
Gisenyi	1.2	0.52	1969
Small/mini hydros	10	0.52	2012
	Thermal Existing		
Gatsata	4.7	0.75	1975
Jabana	7.8	0.75	
Mukungua	4.5	0.75	2006
New Diesel	20	0.75	2009

RIG Kivu gas pilot	4.5	0.75	2009
	Imports/Sharing Existing		
Rusizi I	14	-	
Rusizi II	12	-	
Uganda	1		
Total	**105**		
% local generation from thermal	53.2%		

Kenya

	Hydro Existing		
Miscellaneous plants	10		
Tana	20	0.21	1932-55
Wanji	7	0.61	1952
Kambaru	94	0.56	1974
Gitaru	225	0.45	1978
Kindaruma	40	0.48	1968
Masinga	40	0.55	1981
Kiambere	164	0.63	1988
Sondu Miriu	60	0.77	2008
Turkwell	106	0.47	1991
Sangoro	21	0.78	2011
Kindaruma U3	25	0.48	2012
Tana - Extension	10	0.3	2010
	Thermal Existing		
Olkaria 1	45	0.9	1981
Olkaria 2	105	0.9	2003
OrPower 4a	13	0.9	2000
OrPower 4b	35	0.9	2008
Olkaria 3 geothermal	35	0.75	2010
Kipevu 1 diesel	75	0.8	1999
Kipevu new GT	60	0.75	1987/1999
Nairobi Fiat	13	0.8	1999
Diesel	120	0.75	2010
Iberafrica IPP	56	0.8	2000

Athi river diesel IPP (Thika)	240	0.75	2012
Rabai diesel IPP	89	0.75	2009
Iberafrica 3 IPP	53	0.75	2009
Tsavo IPP	74	0.75	2001
Cogen	26	0.75	2001
Aggreko IPP	60	0.8	
	Wind Existing		
Ngong	20	0.75	2012
Total	**1916**		
% local generation from thermal	57.4%		
	Uganda		
	Hydro Existing		
Miscellaneous Plants	15	0.00	
Nalubaale	180	0.49	
Kira 11-15	200	0.43	
Bujagali 1-5	250	0.90	2012
Smal hydros (committed)	50	0.00	2011
	Thermal Existing		
Kakira	17	**0.75**	
Namanve	50	0.75	
Invespro HFO IPP	50	0.75	2010
Electromax IPP	10	0.75	2009
Total	**822**		
% local generation from thermal	**15.5%**		
	Tanzania		
	Hydro Existing		
Mtera	80	0.48	1988
Kidatu	204	0.51	1975
Hale	21	0.44	1967
Kihansi	180	0.42	2000
Pangani Falls	68	0.49	1995
Nyumba ya Mungu	8	0.48	1968
	Thermal Existing		

Songas 1	42	0.75	
Songas 2	120	0.75	
Songas 3	40	0.75	
Ubongo GT	100	0.75	
Tegeta IPTL	100	0.75	
Tegeta GT	45	0.75	2009
Mwamza	60	0.80	2010
Ubongo EPP	100	0.75	2011
Cogen	37	0.75	2011
Total	**1205**		
% local generation from thermal	53.4%		

Source: Adopted from EAC Regional Power System Master Plan and Grid Code Study (SNC Lavalin International Inc and Parsons Brinckerhoff, 2011).

In each of the cases, new capacity addition has largely come from generation sources that are quite costly (thermal sources) but have the advantage of lower project gestation period from investment gestation period to commissioning. The energy planning lapse and resulting generation portfolio shift emerges. *Delayed energy planning and investment in the face of growing demand for electricity are likely to drive the energy portfolio to thermal technology choices that have lower gestation period but higher per unit cost of generation, undermining the ability to supply affordable and reliably available electricity.*

Solvency of public utilities: as mentioned in the aforementioned, the sub-region has numerous challenges on the supply side of electricity, ranging from limited generation capacity, significant transmission and distribution losses, emergency generation and the rise of thermal technology in the generation portfolio. To public utilities operating the transmission and distribution network, and in some cases the whole chain from generation to distribution, utilities in sub-regional countries are under financial duress. For example, TANESCO has been facing financial insolvency for years, keeping tariff at regulated levels (around $0.13/kWh) even in the face of growing emergency generation from more thermal sources. JIRAMA, the utility in Madagascar, is under similar challenge. While the energy sector is deregulated by reform, JIRAMA operates the transmission and distribution system. The emergence of rapid thermal generation in Madagascar, in the face of regulated tariff (around $0.10/kWh) has exposed JIRAMA to financial insolvency. In D.R. Congo, the public utility company, SNEL, operates from generation to transmission and distribution. It too has faced financial insolvency. Finance-strapped utilities are less likely to invest in grid improvement and quality service delivery, and are largely unable to re-invest in generation capacity expansion. In much of the sub-region, where energy sector reform has taken shape, regulated tariffs with rising generation cost due to rapid integration of thermal technologies, has left utilities ill-equipped to plan for capacity expansion. In Uganda, regulators have already removed part of the subsidy going to keep tariffs low, leading by some estimates to a 42% rise in tariffs. The pressure of keeping tariffs at "socially desirable" levels through regulated tariffs in the face of rising generation costs has created a wedge between keeping

tariffs cost-reflective (hence improving the financial solvency of utilities) and keeping rates low to enhance socio-economic development on cheaper energy. This wedge is likely to continue in the foreseeable future.

Energy trade and enhanced electricity supply: energy trade, given the energy potential of the sub-region, is low, largely due to constrained generation capacity in sub-regional member States and the limited inter-connection among them. The trend, however, is changing. Table 10 demonstrates potential energy trade in the near future in select sub-regions member States. Joint investment ventures and power sharing are likely to boost electricity supply in Burundi and Rwanda, while Kenya, Tanzania and South Sudan are anticipating integration into the Ethiopian grid for major electricity export, particularly to Kenya.

Table 10: Anticipated electricity trade in select countries in the Eastern Africa sub-region.

Projected Energy Trade in Select sub-regional Countries

Country	Import/Sharing Scheme	Import Country	Trading/sharing Year
	Lake Kivu gas plant 2 = 66.7 MW		
Burundi	Rusumo = 20 MW	-	2015
	Rusizi III = 48.3 MW		2018
	Rusizi IV = 95.7 MW		2019
Kenya	Phase I = 1,000 MW	Ethiopia	2013
	Phase II = 1,000 MW (200 to Tanzania)		2013, Tanz. 2015
	Kivu gas plant 2 = 66.7 MW		2015
Rwanda	Rusumo = 20 MW		2015
	Ruzizi III = 48.3 MW		2018
	Ruzizi IV = 89 MW		2019
Tanzania	Ethiopia = 200 MW	Ethiopia	2014
	Zambia = 200 MW	Zambia	2015
South Sudan	Ethiopia = 50-100 MW (for Malakal)	Ethiopia	-

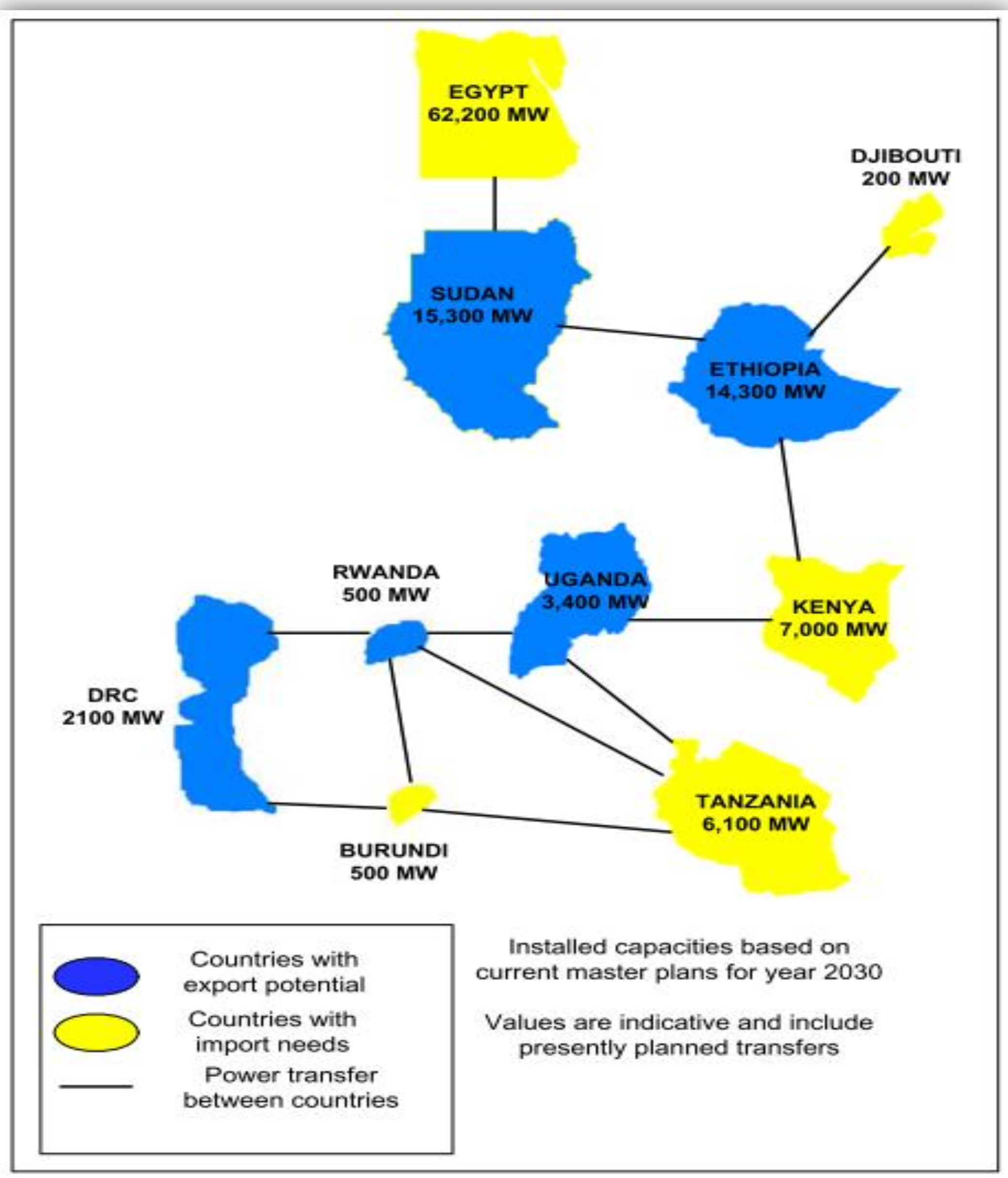
Source: Country mission data (2012) and EAC Regional Power System Master Plan and Grid Code Study (2011).

The long-term potential trade scenario is depicted in Fig. 42. Egypt, Djibouti, Kenya, Tanzania, Burundi and South Sudan are energy import destinations, to be fed largely from enhanced export capacity in Ethiopia, D.R. Congo, Rwanda and Uganda. Sub-regional electricity trade and joint investment ventures have promising potential to vastly expand electricity supply in the sub-region.

Generation capacity limits, delayed energy planning and investment, high transmission and distribution losses, limited infrastructure development, integration of thermal generation and technology choice pose supply constraints in the sub-region, but trade potentials and

greater attention to indigenous energy resources development by member States represent as a positive shift in the supply side.

Figure 42: Long-term electricity trade scenario in the Eastern Africa sub-Region.



Source: EAC Regional Power System Master Plan and Grid Code Study (2011).

3 MONITORING THE STATUS OF ENERGY SECURITY IN THE EASTERN AFRICA SUB-REGION AND MONITORING FRAMEWORK

3.1 MEASURING ENERGY SECURITY

In an interdependent global economic system, which is reliant on growing consumption of energy, with underlying uneven distribution of energy resources, energy security has become a global challenge. The impact of energy insecurity on economic systems is negative, but the degree to which regions and countries are prepared to mitigate these impacts differs markedly.

Energy insecurity is a cause of concern for many reasons. The increasing *import-dependence* of countries on few oils and gas exporting countries is a concern. The Middle East alone accounts for 62% of global proven oil reserves, and 56% of global proven reserves of gas are in just three countries – Russian Federation (26%), Iran (16%) and Qatar (14%) (Lefévre, 2010). The concentration of oil and gas resources supply in few countries and the unstable political environment in these countries fuels concern for energy insecurity.

Geopolitical events also shape the state of global energy security. The Iraq war of 2003, the gas dispute between Russia and Ukraine in 2005/6, strikes in Venezuela in 2002/3, ethnic and religious violence in Nigeria, hurricane Katrina in the US in 2005, the Libya Arab uprising, the Iran-US confrontation over the Strait of Hormuz, and others are few of the recent *geopolitical tensions* that had direct bearing on energy insecurity. The continuing instability in the Arab world and central Asia continue to be a source of concern for energy supply security.

Social and political disturbances in both exporting and importing countries, terrorism and damage to energy infrastructure, natural disasters and limited transportation capacity continue to pose energy security challenges (Bohi and Toman, 1996; Greene and Leiby, 2006; Arnold, et al., 2007; Stern, 2002). Reductions in living standards, rising socioeconomic inequality and increasing environmental costs are some of the long-term social costs of energy insecurity (Jansen and Seebregts, 2010). Over the long-term, climate change is another concern in the energy system, where lack of adaptation and impact management can generate new sources of global energy insecurity. In the face of these concerns, and potential sources of energy insecurity, governments have little analytical support to complement expert judgment in properly evaluating energy security challenges (Lefévre, 2010).

The meaning of what policymakers mean by energy security is an important consideration. Scheepers, et al. (2007) articulate *energy security* as risk to a shortage in energy supply that is either relative shortage (mismatch between demand and supply inducing price shifts) or physical disruption of energy supplies. Therefore, energy security is the uninterrupted availability of energy to consumers. Loschel, et al. (2010) summarize the meaning of energy security in many studies to constitute the physical energy availability, energy prices and their volatility. By extending the meaning of energy security to long-term considerations, Jansen and Seebregts (2010) express energy security as a proxy for a certain level at which the population in a given area has uninterrupted access to fossil fuels and

fossil-based energy carriers in the absence of over exposure to supply side market power for ten year or longer. The Clingendael International Energy Programme (2004) further defines energy security as the physical availability of energy at all times in sufficient quantities and at affordable prices.

Departing from a focus on physical availability energy to more economic interpretations, Boni and Toman (1996) identify energy security to mean the loss of economic welfare that may result from a change the price or availability of energy, which is reflected in energy imports and energy price volatility. Lefévre (2010) puts forth similar definition. Since shortages of energy reflect on prices and their short-term fluctuation (Toman, 2002), energy security have moved from consideration of only physical supply to definisions that include prices of energy (Jenny, 2007). The economic definition recognizes the importance of physical disruptions, but puts emphasis on the welfare impacts of energy price shocks. In broadening the concept of energy security further, the Asia Pacific Energy Research Center (APERC, 2007) puts forth four components of energy security: physical availability (geological), accessibility (geopolitical), affordability (economic) and acceptability (social and environmental).

The European Commission (2001) targets long-term energy security to ensure, for the wellbeing of citizens and the functioning of the economy, the uninterrupted physical availability of energy products in the market at affordable prices to consumers. Similarly, the IEA (2007a) elucidates energy insecurity in terms of the physical availability of energy supply to satisfy demand at given prices. This implies that energy insecurity emanates from the physical interruption of supply and energy price shocks. *In this report, energy security is referred to as the physical disruption in the supply of energy sources and price/affordability shifts in energy commodities and supplies overtime.*

The impact of energy insecurity is often far-reaching, particularly in countries where energy security management policies and mechanisms are inadequate. The degree to which vulnerabilities to energy insecurity are amplified, or mitigated, partly depends on the fuel mix in the energy system of a country, whether or not primary energy sources are imported or locally sourced, the nature of energy infrastructure, the growth rate of energy demand and the presence of policy/regulatory capacity and monitoring, evaluation and enforcing practices. In places like the Eastern Africa sub-region where economic transformation is taking shape, energy security challenges pose risks to sustaining the momentum of economic development.

3.2 ENERGY SECURITY MEASUREMENT, ISSUES AND CHALLENGES

Tracing and monitoring the state of energy security requires developing and adapting indicators and indices, similar to the indicators to measure the performance of the economy, improvements in education and health, the state of governance improvements, the state of environmental health, the state of social progress and others. The state of energy security can be measured by a series of simple and complex indicators that can inform monitoring and management practices. Proper evaluation of energy security through quantitative and qualitative assessment brings quality information and knowledge to decision-makers to pass informed decisions that can limit the undue impact of energy security on socioeconomic development.

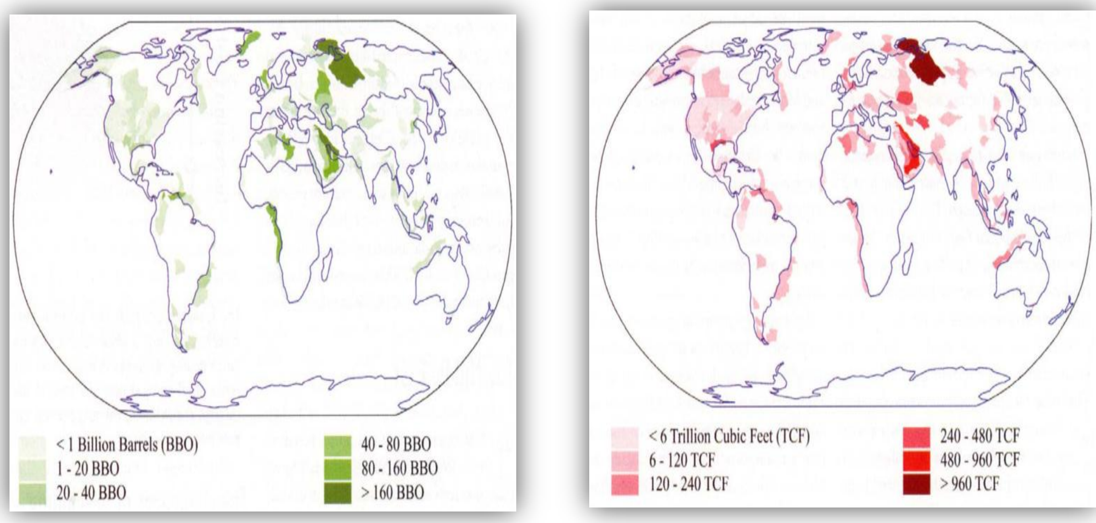
3.2.1 *Simplified Energy Security Measurement and Monitoring*

Energy security deals with both the physical disruption of energy supplies, and with price shifts that can alter the affordability of energy supplies. Based on the physical disruption aspect of energy security, particularly on imported hydrocarbons, a set of indicators are developed to trade the vulnerability of countries to short-term disruptions of supply.

Geological availability of resources and supply risks: concern on long-term supply continuity of particularly oil, particularly by advocates of the *peak oil* phenomena.[15] Such concerns have led to examine the extraction potential of known geological hydrocarbon resources. In 2000, the US Geological Survey conducted a global assessment of oil and gas resources and their extraction potential (see Fig. 43). This assessment is widely viewed to offer an optimistic view of the global state of oil and gas. Some, based on peak oil arguments, have criticized these estimates as optimistic (Greene, et al., 2005). In the context of Eastern Africa, oil and gas resource finds since 2000 have significantly expanded the potential of hydrocarbons in the sub-region. The rate of reserve draw down, due to extraction, at current global consumption levels, is taken as one aggregate energy security indicator. One variation of this indicator is the reserves to production ratio showing the number of years left before current reserves are depleted at current rates of consumption (for example, Feygin and Satkin, 2004).

The challenge with this indicator is that discovery of new oil and gas reserves, technological progress and ability to access previously uneconomical fields and shifting pattern of oil consumption based on price signals have introduced enough dynamics to solely rely on this measure. As a result, its use as a policy-relevant indicator seems limited.

Figure 43: Global petroleum and natural gas resources.



Source: US Geological Survey 2000, assessment of global petroleum and natural gas resources.

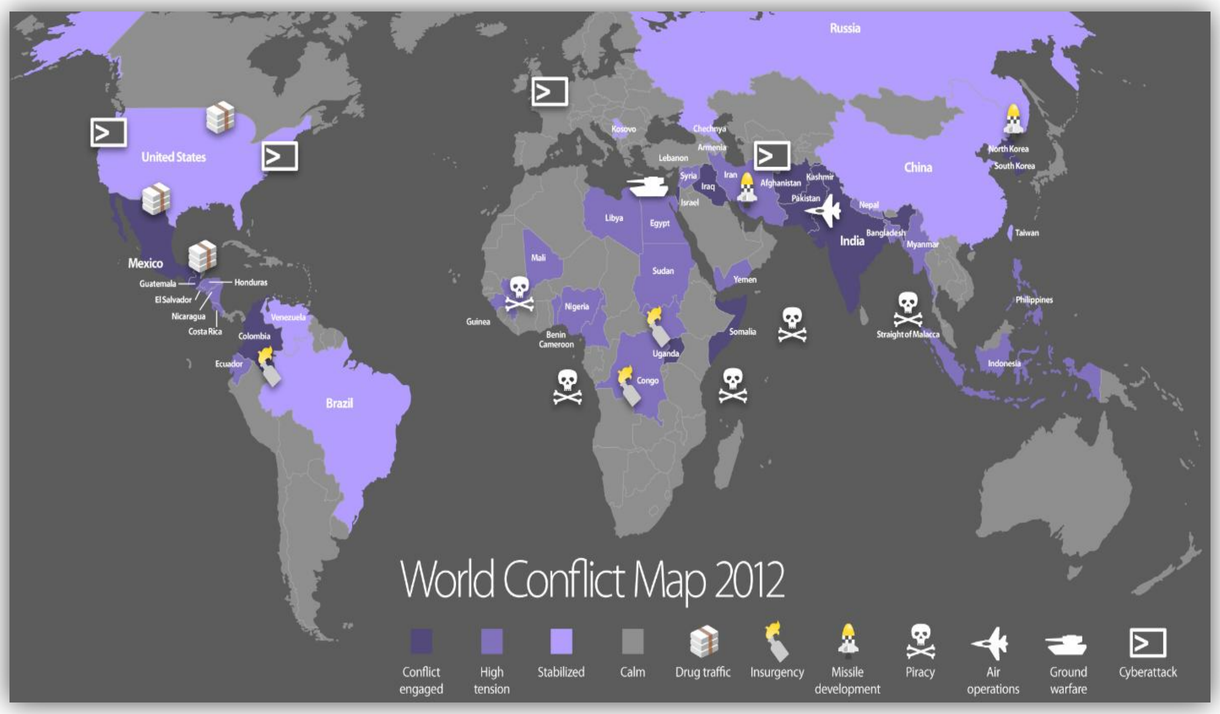
[15] *Peak oil* advocates warn that the available global oil production has reached a plateau and will decline as the world runs out of sufficient oil, making sustenance of current consumption levels an impossibility.

Import dependence: this is a common single indicator of energy security. The greater the dependence of a country on imported energy, such as oil, the greater the energy insecurity. There are different variations of this measure, including the share of imported oil satisfying domestic consumption (see Alhajji, et al., 2003), and net energy imports. The concentration of oil and gas resources in select regions and countries of the world (62% of oil in the Middle East and 56% of gas in Russia, Iran and Qatar) exposes majority of the countries to have some level of import dependence, the risk accumulating the highest in those that are totally dependent on imported hydrocarbons.

Diversity of import sources and political stability: diversity is a proven risk management strategy – the same is the case with respect to energy security. The concentration of oil and gas supply in few countries in the world is likely to lead to concentration, and not diversity, of import sources for energy import-dependent countries. However, the degree to which energy import sources are diversified in the context of a concentrated supply market is one indicator of energy security risk. A highly concentrated, and less diverse, import source increases the risk of oil and gas supply disruption in the case of unexpected events in energy-exporting countries.

As demonstrated in Fig. 44, oil and gas exporting countries are in politically unstable regions of the world, and a less diversified import source will sooner or later lead to higher disruption risks. In addressing the impact of political instability on energy security, Jansen, et al. (2004) propose the use of UNDP's Human Development Index (HDI) arguing that it encompasses indicators that can be proxy for long-term socio-political stability in a country. The IEA utilizes the World Bank's governance indicator, particularly the political stability and absence of violence indicator and the regulatory quality indicator as proxy for the possibility of political instability in energy exporting countries.

Figure 44: Global wars and conflicts in 2012.



Source: GIZMODO.com, World Map of All Wars and Conflicts Happening in 2012.

Price of hydrocarbons: another single indicator of energy security that is commonly utilized is the price of hydrocarbons. The short- and long-term trends in oil, gas, coal and uranium prices and the degree of their volatility is taken as an indicator of potential energy scarcity and insecurity. Due to the immediate impact of the price of these energy sources on the global economy and on consumers, and the ease of data availability has made this indicator prevalent amongst energy experts and useful to decision-makers and the general public alike.

Energy-dependence of economy: a set of indicators are also widely utilized to assess the degree of vulnerability of the economy to energy disruptions. These include the *energy intensity* of the economy (in the entire economic system or in sectors), spending on energy imports, and the share of oil utilized in the transportation sector.[16] Energy-intensive economies with much of the imported oil going to inelastic industries poses a high risk on the impact of supply disruption on the economy.

Biomass sustainable supply: in economies where the share of biomass still quite high as a share of total energy provision (which is above 65%, reaching 95% in the Eastern Africa sub-region), the sustainability of biomass supply is a major energy security risk. Unsustainable forest and other biomass harvest undermine energy security. Forest harvest measurements relative to regenerative capacity of the forests can serve as a potential indicator.

Based on a series of single indicators, *dash-board* and *composite* indicators of energy security are also in use. For example, Gupta (2008) introduces an *Oil Vulnerability Index* based on: the consumption of oil per unit of GDP, the ration of oil imports to GDP, per capita GDP, the share of oil in total energy supply, the share of oil consumption coming from domestic sources, geopolitical risk and market liquidity. These series of indicators are summarized in one composite energy security indicator through application of the principal components method. The IEA's *Energy Security Index* also utilizes two indicators to compute an energy security index. The first looks at the possibility of physical unavailability of oil, based on the share of total demand met by pipeline infrastructure, with the view that pipelines are less flexible. The second is based on the price risk resulting from concentration of imports (measured by Herfindhal-Hirschman concentration index).

3.2.2 Advanced Energy Security Measurement and Monitoring

The single, or dash-board, indicators of energy security are useful in offering preliminary assessment of the state of energy security, and in signaling trends based on available data and in offering broadly understandable and easy-to-measure metrics. The energy system, however, is more complex, and understanding energy security of a complex system may require designing and implementing indicators that offer a comprehensive assessment to decision-makers who can benefit from concrete assessment and indicators that inform on the vulnerability and impact of the whole energy system, beyond fuel-based assessment. Scheepers, et al (2007) offer two comprehensive energy security assessment indicators geared towards short-term disruption risks in the *energy system*, and energy

[16] The transportation sector is widely viewed as inelastic to oil price changes; therefore, if the share of oil consumption in the transportation sector is large, the impact of oil disruption is amplified as flexibility is reduced due to the nature of the sector and the structural necessity of oil in its functioning.

security risks in the long-run, with the energy system as a central consideration. These indicators are the Crisis Capability Index (to assess short-term energy security risks) and the Supply-Demand Index (to assess long-term energy security risks), finding application in energy security assessment of countries, such as Ireland and more recently the IEA Clean Coal Center long-term coal security assessment (see Loschel, et al., 2010).

The Crisis Capability Index: the crisis capability index (CCI) is a comprehensive assessment of short-term energy security risks based on two category of information: *Risk Assessment* (RA) and *Mitigation Assessment* (MA).

Risk factors indicate on the sources of vulnerability in a country's energy system. As shown in Table 11, risk assessment is evaluated across four areas of the energy system: primary production risks; energy conversion risks; energy import risks and domestic and import transportation routes. In domestic production of oil, gas, coal and renewable energy, the challenge can emerge from the location of production, the degree to which applied technology is obsolete and management and operational efficiency. Places that are hard to access domestically, employing outdated or less reliable technology and that are mismanaged increase the risk of domestic supply disruption.

Table 11: Risk assessment (RA) of sudden supply interruptions.

Category	Energy System Element	Risk Factors
	Domestic oil production	Technical and organizational (a), human (b), political (c) and natural (d) factors
	Domestic natural gas production	(a), (b), (c), (d)
Domestic Primary Energy Production	Domestic coal production	(a), (b), (c), (d)
	Domestic renewable energy production	(a), (b), (c), (d)
	Domestic biomass production	(a), (b), (c), (d)
	Power plants	(a), (b), (c), (d)
Energy Conversion	Refineries	(a), (b), (c), (d)
	Improved and modern cookstoves	(a), (b), (c), (d)
	Gas pipelines	(a), (b), (c), (d)
Inland energy transport	Electricity lines	(a), (b), (c), (d)
	Biomass distribution system	(a), (b), (c), (d)
	Oil import	(a), (b), (c), (d)
	Natural gas import	(a), (b), (c), (d)
Energy import	Electricity import	(a), (b), (c), (d)

	Biomass import	(a), (b), (c), (d)
	Sea transport routes - gas	(a), (b), (c), (d)
	Land transport routes - gas	(a), (b), (c), (d)
	Gas pipelines	(a), (b), (c), (d)
Energy import transport	Sea transport routes - oil	(a), (b), (c), (d)
	Land transport routes - oil	(a), (b), (c), (d)
	Oil pipelines	(a), (b), (c), (d)
	Land transport – biomass	(a), (b), (c), (d)

Source: Adapted from Scheepers, et al. (2007). Indicators for biomass, relevant in the Eastern Africa sub-region, are added by authors.

In the case of domestic biomass production, which accounts a large share of primary energy source in the Eastern Africa sub-region, the sustainability of harvest, forest management practices, the technology employed in forest harvest and the location of the bulk of biomass resources have a bearing on the security of biomass supply. Domestic production can also be disrupted by political instability and natural disasters.

Risk assessment, beyond domestic production source and challenges, should look at energy conversion. With stable and secure primary energy supply, energy security is also determined by the effectiveness of the *energy conversion* system, including power plants and refineries. Power plants can be riddled with obsolete technology, lack of proper maintenance, poor management and generation below capacity. The degree to which these factors limit the efficiency of converting primary energy source into electricity can lead to electricity shortages, outages or out-right blackouts, severely constraining energy security. The recent blackout in India putting millions of consumers and producers out of service, largely due to power-taking beyond regional allocated quota is one such example. In the Eastern Africa sub-region, policy, operation, technological and investment and upgrade challenges to many of the power stations have long been a source of energy insecurity.

Another risk factor is the domestic and sea/land import routes security. Sea transportation of energy sources has to deal with the risk of piracy and sea transportation accidents. Import inland routes also pose challenges of infrastructure capacity, maintenance, safety and affordability, particularly to land-locked countries. The quality of domestic energy infrastructure, including road and pipelines, can also determine the nature of transportation-related energy security risks. Finally, risk assessment also considers energy import challenges, including exposure to international market price shocks, supply disruption risks emanating from political instability in exporting countries, geopolitical challenges, and other factors that impact the global flow of energy resources and their prices. The greater the import dependence, particularly from vulnerable countries, the greater is the energy security risk.

With regard to mitigation assessment (MA), as shown in Table 12, five factors are often considered: the existence of emergency, or strategic, reserves/stocks; existence of

demand management schemes; technological flexibility with fuel switching capacity in electricity generation; and reserve and locked-in capacities.

Emergency stocks offer a short-term mitigation capacity if any of the risk factors materialize. Strategic reserves set-up, its draw-down and injection to markets are governed by response mechanisms governed by the energy policy or energy security management procedures. Effective strategic reserve policies and procedures, sound reserve management and coordinated release mechanisms help markets stabilize while short-term disruptions are dealt with by decision-makers. Lack of strategic reserves exposes countries to the full impact of energy disruptions. In the case of biomass, since its wood and charcoal production are predominantly artisanal, and often lack coordinated production and distribution management at large-scale, strategic reserve options are quite limited.

Strategic reserves are complemented by demand restraint measures in times of disruptions. Demand restraint could be rationing remaining supplies equitably while markets stabilize and natural reply on prices as the distributive mechanism, or it could be allocation to prioritized sectors of the economy, such as public service providers, strategic industries and public safety and security institutions. Particularly for electricity, the technological capacity of power plants to switch to alternative power generation source is a factor in mitigation strategy. Excessive reliance in one source, such as hydro, which can be exposed to severe draught and water shortage, can drastically impact power output in the face of no fuel switching option. Demand restraint options for biomass (wood and charcoal) are also limited due to the highly decentralized and artisanal nature of the industry that offers limited regulatory oversight and control.

Table 12: Mitigation assessment (MA) of sudden supply interruptions.

Category	Energy System Element	
	Oil	Oil stocks
Emergency Stocks	Coal	Coal (peat) stocks
	Gas	Gas stocks (e.g. LNG)
	Biomass	Wood and charcoal stock
	Electricity	Rationing
Demand restraint and rationing	Gas	Rationing
	Transport fuels	Primary users, rationing
	Biomass	Rationing
Fuel switching capability	Electricity	Multi fuel power plants
	Electricity	Import capacity, generation reserves
Reserve capacity	Gas	Reserve capacity, pipeline capacity
	Refineries	Spare capacity

	Oil	Domestic oil production
Locked-in production	Coal	Domestic coal production
	Gas	Domestic gas production
	Biomass	Domestic biomass production

Source: Adapted from Scheepers, et al. (2007). Indicators for biomass, relevant in the Eastern Africa sub-region, are added by authors.

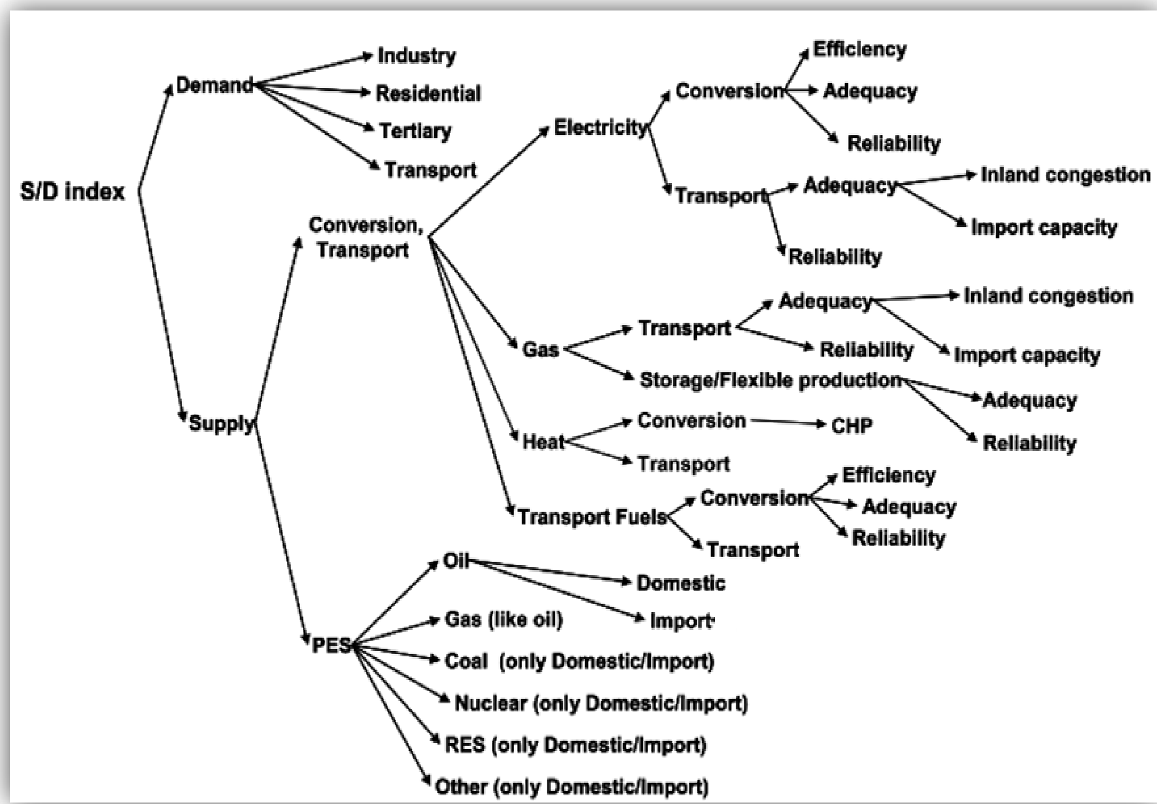
Domestic reserves and locked-in capacities are additional mitigation strategies in times of energy shortages. Reserve capacity in electricity supply can come from imports, if the national grid is connected to neighboring and regional power sources, or it can come from reserve generation capacity locally. This is the case for refineries as well. For gas production, additional production capacity and distribution pipeline remaining capacity are part of the domestic reserve capacity. Locked-in production offers added flexibility in utilizing more of domestic energy resources. Again, the decentralized and artisanal nature of the wood and charcoal supply chain limits possibilities of utilizing domestic reserves (partly biological) and locked-in capacities to manage disruptions.

The Supply-Demand Index: the crisis capabilities index focuses on the sources of short-term energy insecurity and their mitigation management. Energy security, however, has long-term trends, where the entire energy system can shift to more insecure or secure path based on choices taken and external factors a country is exposed to overtime. The supply-demand index is designed to measure long-term energy security based on information on the demand and supply sides of the energy market. It is based on both quantitative and qualitative assessment of energy systems. Long-term energy security had often been assessed from primarily the supply side (Jansen, et al., 2004; Blyth and Lefévre, 2004). Scheepers, et al (2007) include demand side assessments in the supply-demand index.

The demand for energy is generated in the industrial residential, services and transport sectors. The rate of growth of demand in these sectors and the ability of the supply side to match demand determines long-term energy security. Energy efficiency industry, efficient household appliances, fuel standards in the transportation sector and other demand containment schemes help manage the rate of demand expansion without severely constraining socioeconomic activities.

On the supply side, as shown in Fig. 45, the adequacy and stable supply of primary energy sources (PES) such as oil, gas, coal, biomass and others are part of the energy security supply side challenges. On conversation and transportation aspects, the efficiency, adequacy and reliability of electricity, gas and transportation fuels will drive the state of supply side energy security challenges. Determining the long-term energy security of a country through the supply-demand framework requires extensive data, consultation with stakeholders and identification of security challenges across time in the entire energy system.

Figure 45: Framework for supply-demand energy security assessment.



Source: Scheepers, et al. (2007).

3.3 THE STATE OF ENERGY SECURITY IN THE EASTERN AFRICA SUB-REGION

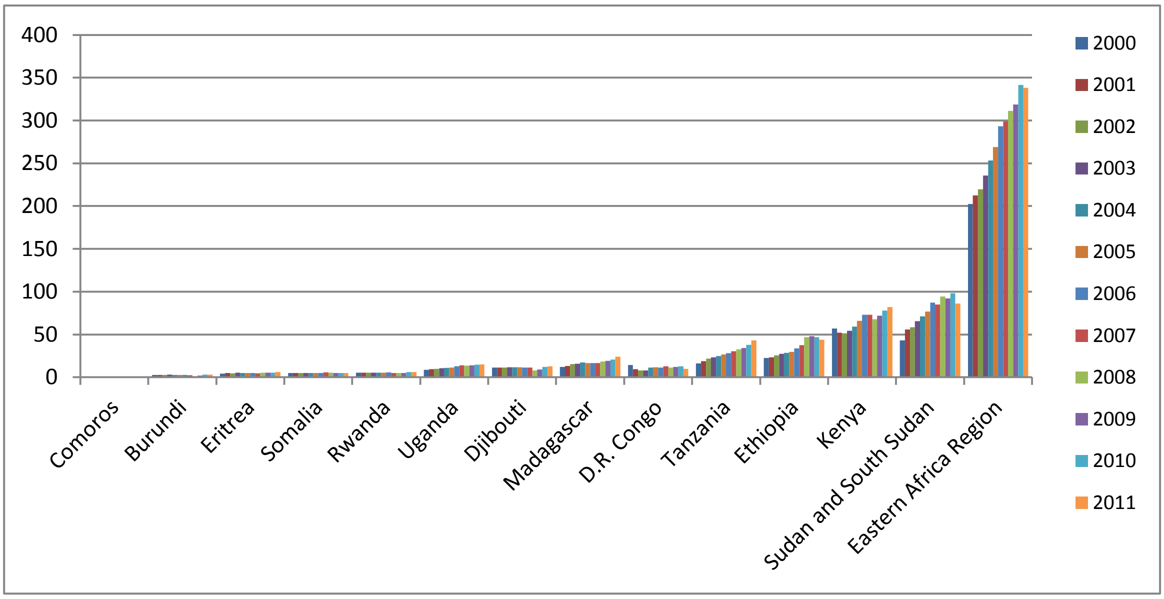
The state of energy security in the sub-region is assessed looking at oil and gas, electricity and biomass systems. Applying the measurements and indicators in section 3.2, an overview of the energy security condition and challenges in the sub-region is provided below, based on single indicators and series of indicators informing on the short- and long-term energy security status and challenges.

3.3.1 Petroleum Import Dependence and Energy Security in Eastern Africa sub-Region

*T*he consumption of petroleum products in the Eastern Africa sub-region has grown markedly over the last decade (see Fig. 46). Lager economies of Kenya, Ethiopia and Tanzania saw steeper increases in petroleum consumption. The sub-region as a whole saw an increase from about 200,000 bbl/day to nearly 350,000 bbl/day in a decade, increasing the dependence on imported fuels.

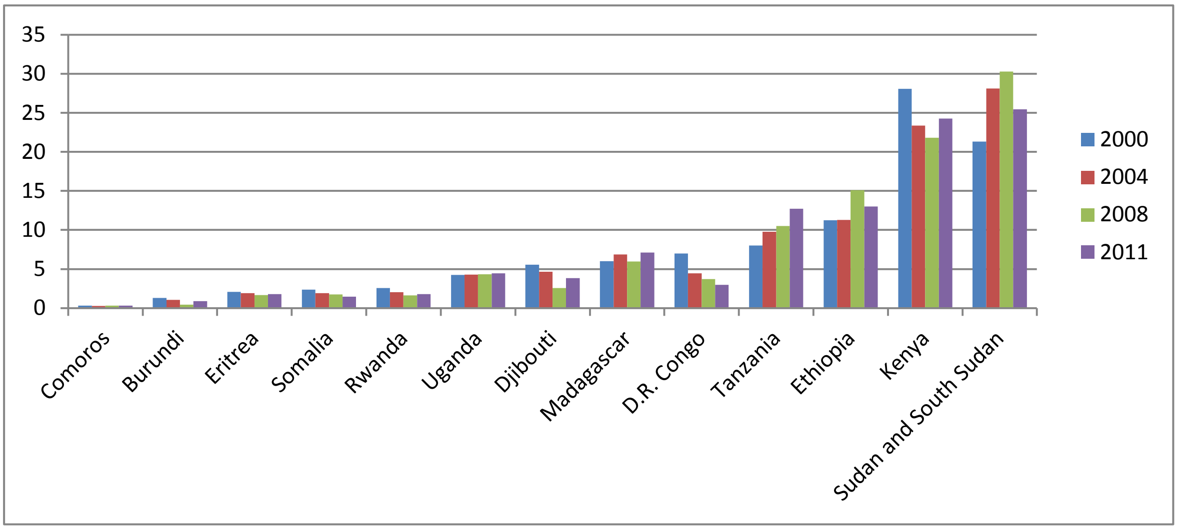
Within the sub-region, the share of sub-regional consumption declined in Comoros (by 0.02%), in Burundi (by 0.42%), in Eritrea (0.28%), in Somalia (0.89%), in Rwanda (0.79%), in Djibouti (1.69%), in D.R. Congo (4.04%) and in Kenya (by 3.82%) between 2000 and 2001. The sub-regional share increased in Uganda (by 0.2%), Madagascar (1.1%), Ethiopia (1.78%), Tanzania (4.73%) and Sudan/South Sudan (by 4.13%). *Despite these variations, the exclusive reliance of member States on imported fuel, at increasing volume, has raised the level of energy insecurity.* There are indeed new discoveries of oil and gas in Uganda, Tanzania and Kenya, and promising prospects. But until these new found resources are properly integrated into the domestic and sub-regional energy markets, the current exclusive reliance on imported petroleum causes specific concerns.

Figure 46: Petroleum consumption intra-regional pattern ('000 bbl/day): 2000-2011.



Source: Based on data from IEA.

Figure 47: Countries' share of sub-Regional petroleum consumption.



The level of petroleum import dependence is considered low if it is below 15%, medium in the 40-65% range, and high above 85%. With the exception of Kenya, with 70% reliance on imported motor gasoline, 50% reliance on imported kerosene type jet fuel and 75% reliance on imported diesel (due to domestic refining capacity), all remaining countries in the sub-region rely totally on imported oil products, that is at 100% (see Table 13). In the case of South Sudan, crude oil production and refining capacity at refineries in Khartoum had introduced energy independence for motor gasoline, and significantly alleviated kerosene type jet fuel and diesel import dependence, at just 37% and 16%, respectively. With the independence of South Sudan and the separation of the two States, South Sudan continued to produce crude oil, but entirely for export. This has led to total import dependence on refined petroleum products, making South Sudan as vulnerable as other member States in the sub-region.

The state of oil-import dependence in the sub-region is therefore the most severe, at 100%, exposing the States and their economies to the vagaries of global oil markets.

Table 13: Degrees of refined oils import dependence (%) in the Eastern Africa sub-region.

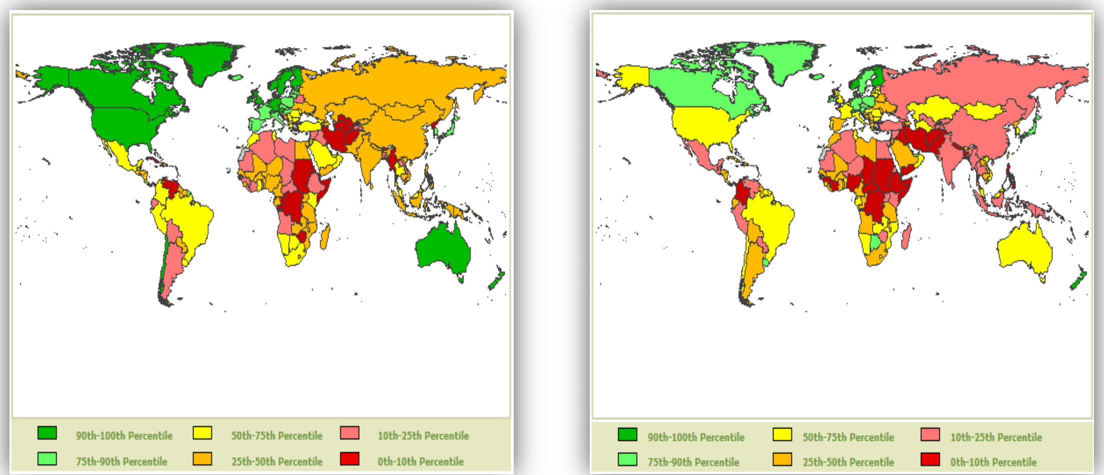
	Motor Gasoline	Aviation Gasoline	Kerosene Type Jet Fuel	Gas/Diesel
D.R. Congo	100	NA	100	100
Djibouti	100	100	100	100
Eritrea	100	100	100	100
Ethiopia	100	100	100	100
Kenya	69.6	100	50	74.5
Sudan/ South Sudan	0	NA	37	16.2

South Sudan	100	NA	NA	100
Tanzania	100	NA	100	100
Uganda	100	100	100	100
Rwanda	100	100	100	100
Burundi	100	NA	NA	100
Seychelles	100	NA	NA	100
Comoros	100	NA	NA	100
Madagascar	100	NA	NA	100

3.3.2 Oil Market Volatility and Political Instability in Oil-exporting Countries

Excessive import dependence poses two immediate risks: *oil market volatility* and *political instability* in oil exporting countries, and additional political risks for land-locked countries emanating from fuel routing States. The political risk in oil exporting countries has traditionally been high, and has increased further in the Middle East and North Africa with the advent of the "Arab Spring", with rising tension in the Strait of Hormuz resulting from confrontations about the nuclear program of Iran, and due to conflicts between Sudan and South Sudan. The World Bank puts forth two indicators of governance that are often utilized as indicators of political stability for short-term energy security assessment: regulatory quality and political stability/absence of violence. The regulatory quality of oil exporting countries is ranked average and below, and their political stability ranking is between 0 – 25% percentile globally (see Fig. 48), making the region politically risky as a source of continual petroleum supply. *Any political instability in oil exporting countries, in the face of almost total sub-regional reliance on imported fuels, will result in maximum energy security exposure of member countries, and their economies.*

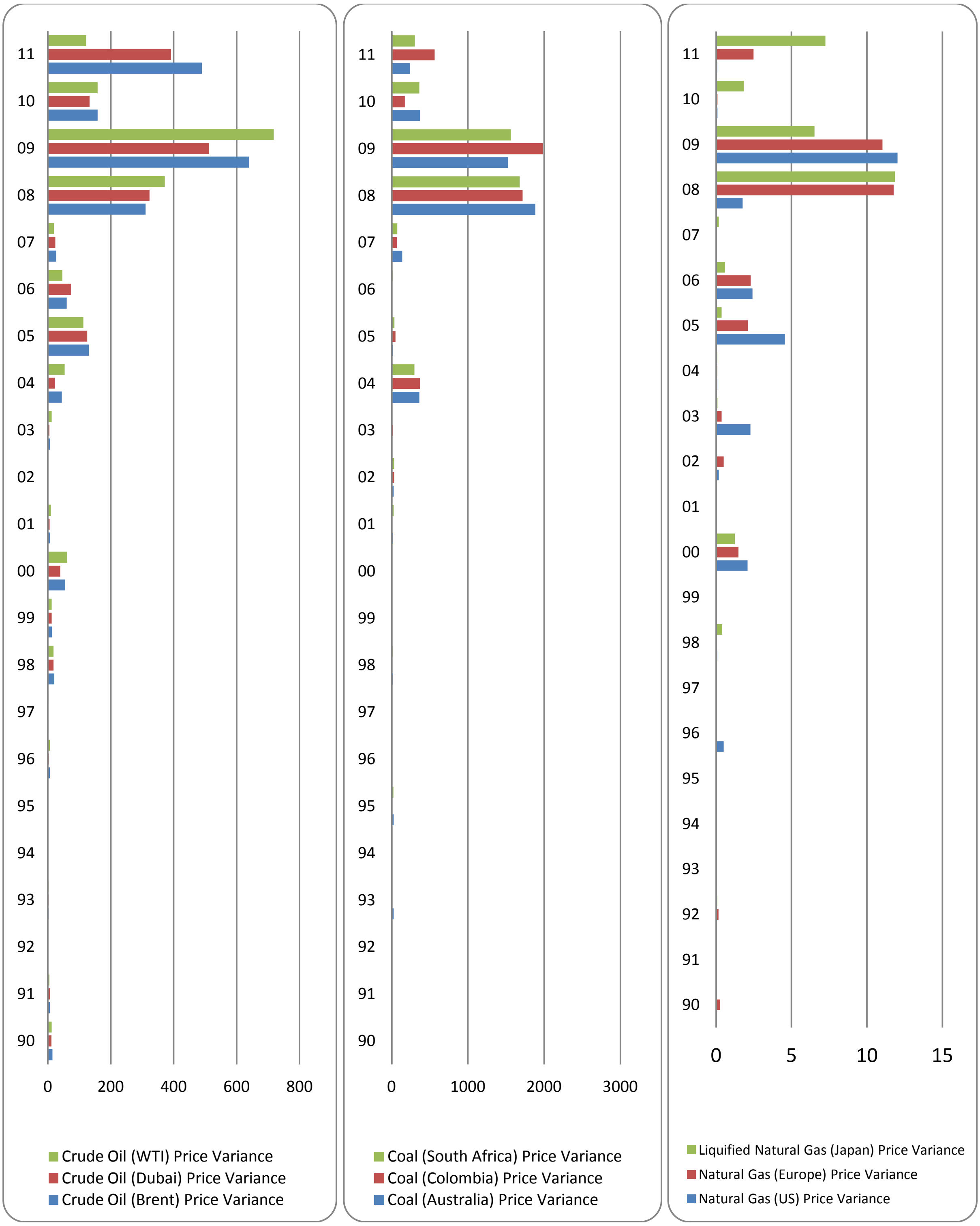
Figure 48: Regulatory quality and political stability/absence of violence map.



Source: Kaufmann D., A. Kraay and M. Mastruzzi (2010), the Worldwide Governance Indicators: Methodology and Analytical Issues.

The second immediate concern for member States is market risk resulting from unmitigated volatility in the oil market. The emergence of rapidly expanding BRIC's economies (see Fig. 20, 21) with growing oil import demand (see Fig. 22), concerns about supply shortages, stability concerns in the Middle East, North Africa and the Arabian Sea, population growth and rising per capita income and rampant speculation in oil commodities have shifted the structure of oil market volatility in ways that have not been seen in previous decades. In the estimated year-to-year price volatility for crude oil, coal and natural gas prices from 1990-2011 (see Fig. 49), energy price volatility were largely stable from 1990-2004, with temporary volatility spikes of limited amplitude. From 2005-2011, energy price volatility has taken a structural shift, with sharp volatility particularly in 2008 and 2009, with resurgence of volatility back in 2011. *The brunt of these market volatility, particularly in up-swing prices, are felt by member States, who would now need to commit more resources to meet the same fuel import requirements in an import-dependence energy structure*. The impact on the economy can be seen through declining current account balances and rising fuel import bills, leading to macroeconomic management challenges (see Fig. 23).

Figure 49: Crude Oil (panel 1), coal (panel 2) and natural gas (panel 3) estimated price volatility: 1990- 2011.

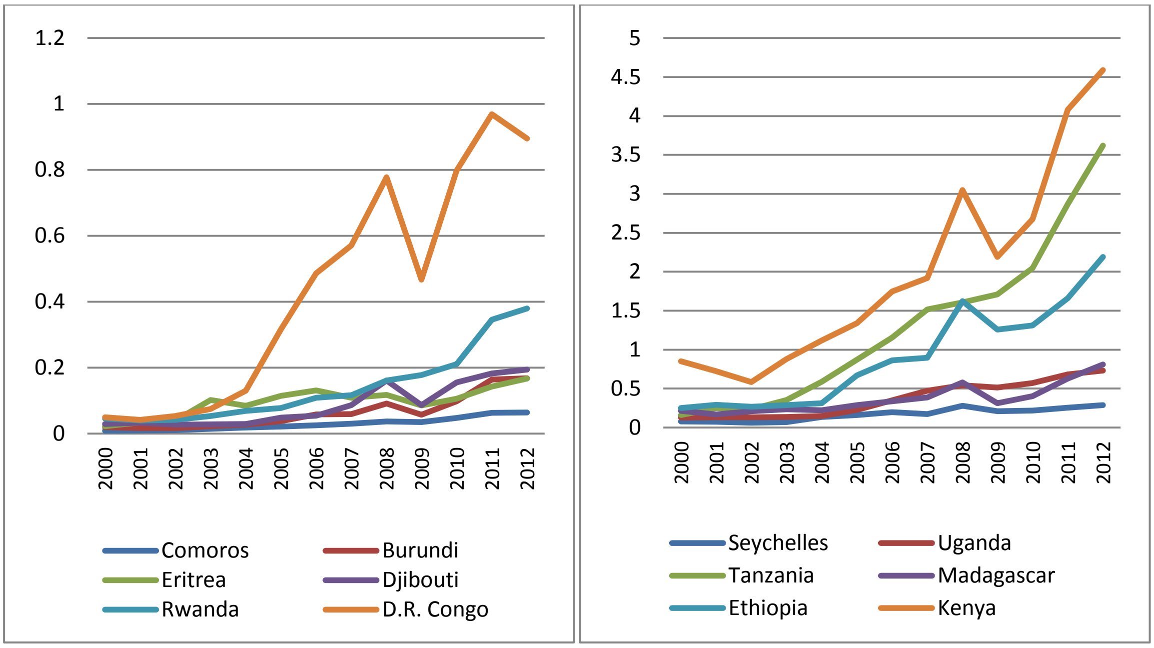


3.3.3 Expenditure on Oil Imports and Economy Oil Vulnerability (Oil Vulnerability Index)

The degree of public expenditure on oil imports is a reflection of the exposure to imported forms of energy. This is particularly the case for Eastern African member States where scare foreign exchange reserves can be alternatively utilized for development finance. The oil import bill for 2000-2012 demonstrates increases throughout the member States, but

sharply rises for Tanzania, D.R. Congo, Burundi, Ethiopia, Rwanda, Eritrea, Comoros and Djibouti (see Fig. 50). The rise in oil import expenditure is far more than the rate of GDP growth in the sub-region, putting strain on resources.

Figure 50: Oil import bills, in billion USUS: 2000-2012.



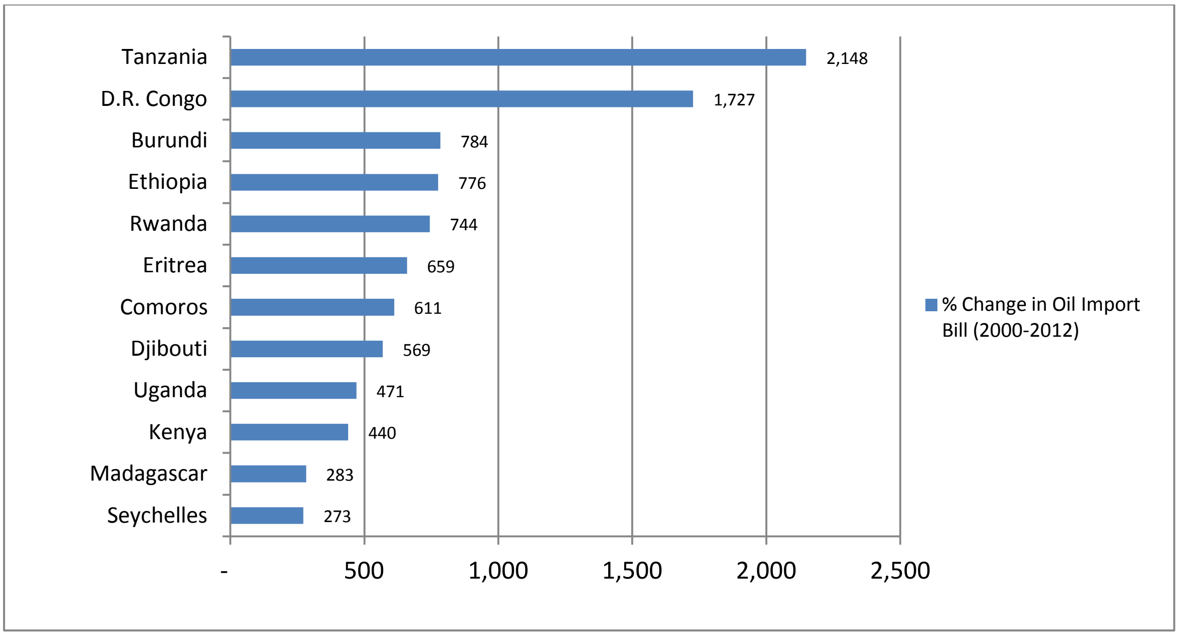
Source: Based on data from IMF World Economic Outlook 2012.

Note: The 2011 and 2012 values are estimates for Comoros, Rwanda, Uganda, Tanzania, Madagascar, and Kenya. The 2012 values are estimates for Djibouti, D.R. Congo, Seychelles and Ethiopia. For Burundi, data is estimate for 2010 to 2012. For Eritrea, data is estimate from 2009-2012.

To provide a frame of reference, the percentage change in oil import bill in the last decade is depicted in Fig. 51. The slowest growth in the sub-region in public spending on imported oil is in Seychelles, which grew by an estimated 273% and in Madagascar by 283%! Import bills grew 4.4 and 4.7 folds in Kenya and Uganda, 5 times in Djibouti, more than 6 times in Comoros and Eritrea, between 7 and close to 8 fold in Rwanda, Ethiopia and Burundi, and by a whopping 17 times in the D.R. Congo and 21 times in Tanzania! The result has been a sub-regional current account deficit rise (see Fig. 28).

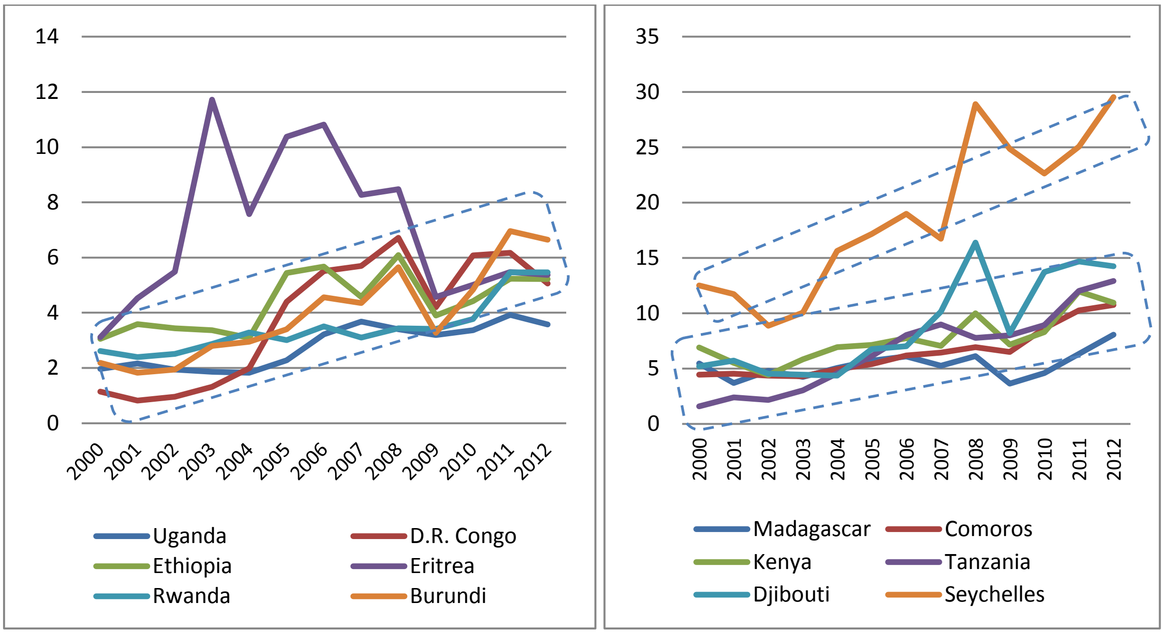
The rapid rise in public expenditure on imported oil in a decade, by a margin between 273% to 2,148%, demonstrates the state of growing energy insecurity in the Eastern Africa sub-region.

Figure 51: Percentage changes in oil import bill: 2000-2012.



The rise of energy import expenditures near proportional to GDP growth rates may be justifiable, though remain a concern for energy security. The share of oil import expenditure in GDP is also a measure of oil vulnerability, and short-term energy insecurity. In all of the member States in the Eastern Africa sub-region, the GDP share of oil import bills has increased, and the slope of increase overtime is significant (see Fig. 52). The sub-region is devoting a growing share of its GDP on fuel imports, not only transferring wealth to oil-producing countries, but continuing to expose their economies to the energy insecurity impacts.

Figure 52: Oil import bills as a share of GDP (oil vulnerability index).

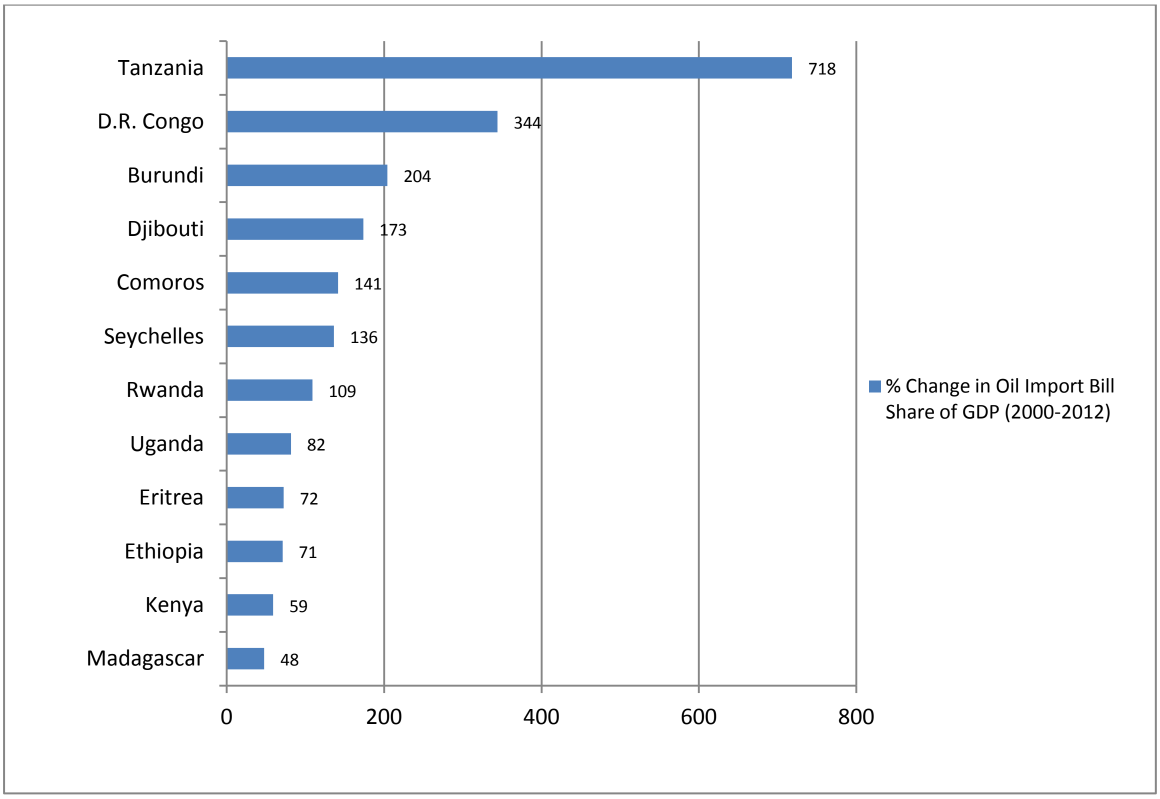


Source: Based on data from IMF World Economic Outlook 2012.

The change in oil import share of GDP from 2000-2012 (see Fig. 53) similarly demonstrates the energy security challenge of member States. The GDP share increased from

a low of 48% in Madagascar, to between 100%-200% in Rwanda, Seychelles, Comoros, Djibouti and Burundi. In D.R. Congo and Tanzania, the increase was by 344% and 718%, respectively. *By this measure, energy security vulnerability has increased throughout the sub-region, in small, large and Island States.*

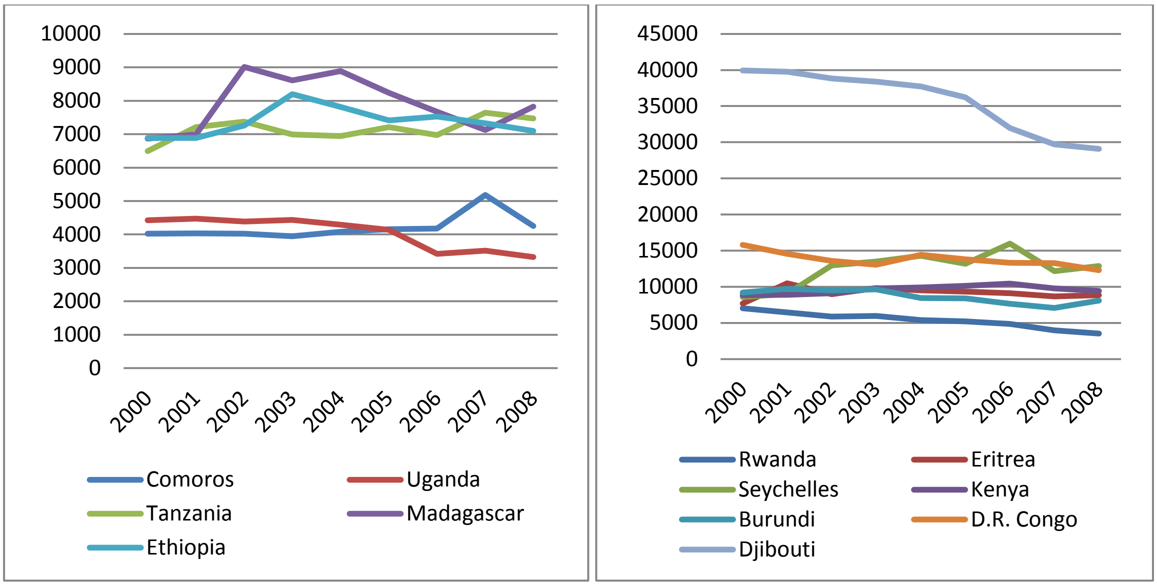
Figure 53: Percentage change of oil import bills as a share of GDP.



3.3.4 Energy Intensity and Inelastic Oil Demand Sectors

Another indicator of short-term energy security is the state of energy intensity in the economy. The value of goods and services generated per unit use of energy is important information to evaluate the energy-efficiency and dependence of the economy. Energy consumption (in BTU) per unit of GDP (in US$) is taken as an energy intensity measure. The state of energy intensity of the economy of Eastern African countries is shown in Fig. 54. Review of energy intensity from 2000-2008 shows that for most countries in the sub-region, energy intensity has remained more or less similar, or showed marginal change. However, significant improvements in energy intensity are shown in 2008, compared with 2001, in Uganda, D.R Congo, Djibouti and Rwanda. In these countries, the GDP value added per unit of energy input has increased, which over reduces the growth impact on energy demand. *In most of the sub-region, however, energy intensities have remained more or less the same, utilizing similar level of energy input per unit of GDP generated, therefore limited progress in aggregate energy efficiency per unit of growth generated.*

Figure 54: Energy intensity: energy consumption per dollar of GDP (BTU/2005 US$ GDP).

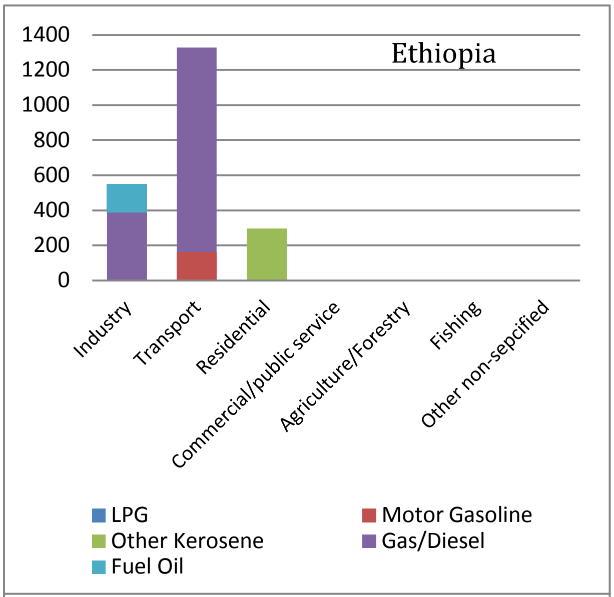


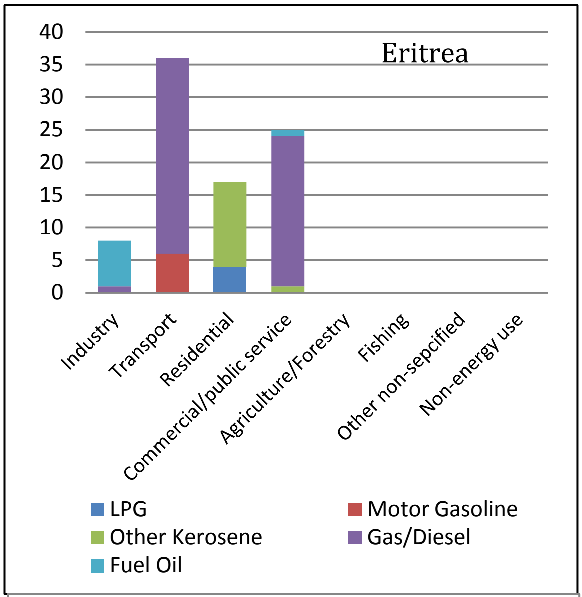
Source: Based on data from the US EIA.

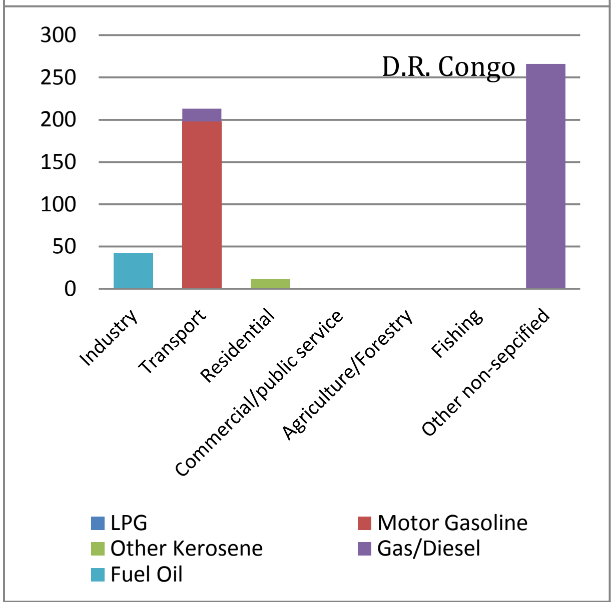
The consumption of oil by sector indicates on the nature of flexibility on the use of imported fuel, or its draw-down when necessary. The higher the share of imported oil consumption in the transportation sector, the greater is the risk of energy security. The transportation sector is known to have inelastic fuel demand, as there are no available feasible switching alternatives in the sub-region (with the exception of the experimental biofuel program in Addis Ababa, Ethiopia). The sectoral distribution of oil-products consumption (see Fig. 55) shows variation across countries. In Ethiopia, the diesel is primarily used in the transportation sector, with sizeable use in industry, and kerosene largely utilized in the residential sector. *The transportation sector locks a large share of oil use in Ethiopia, increasing vulnerability to energy insecurity but the industrial sector has switching alternatives in the long-run*. In Eritrea, similarly the transportation sector is a major sector for diesel consumption, but the share allocated to the public service is also large, mainly due to entirely thermal power generation, also offering few switching options. The residential sector sees more kerosene and LPG use. The large share of the fuel is locked in transportation and power generation uses, which are both less flexible. These enhance energy insecurity in Eritrea. The transportation sector absorbs a large share of diesel and motor gasoil in Kenya and Tanzania as well, with similar implications to energy security. Kenya's domestic refinery capacity mitigates this vulnerability to the extent it displaces imported refined fuel. The D.R. Congo is a unique case, transportation is largely reliant on motor gasoil, and almost the entire diesel use is in other, non-specified, sector. The exposure to inflexible fuel use is on motor gasoil product.

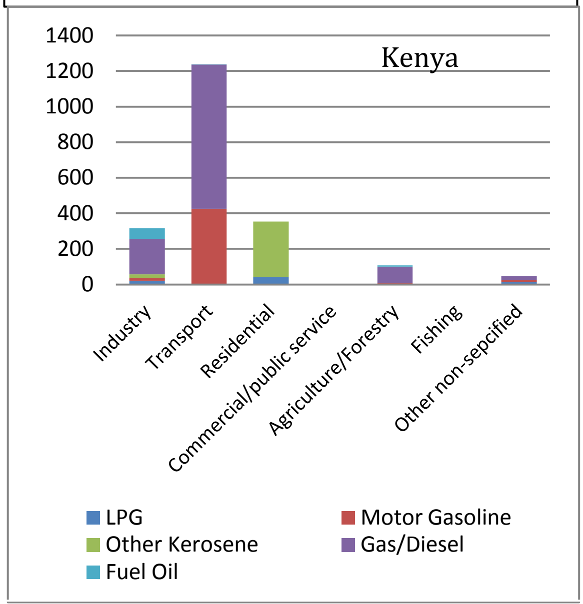
The large concentration of use of imported fuels in the transportation sector, and in power plants, sectors that offer limited fuels substitutability, reduces the ability to respond to energy price or quantity disruptions through fuel switching due to their inherent inelasticity of demand.

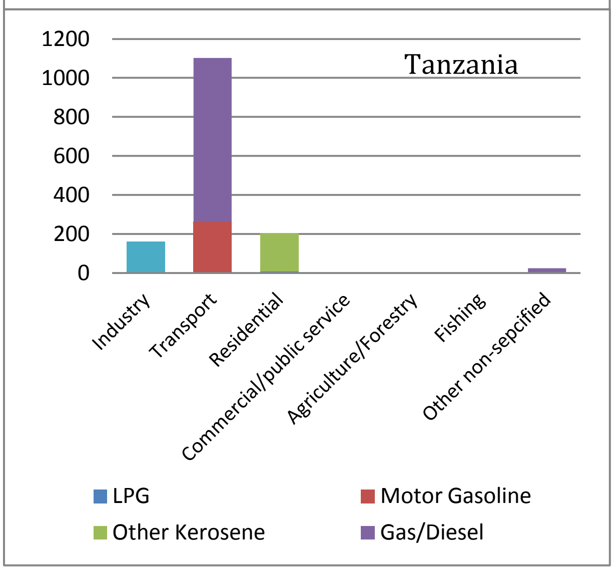
Figure 55: Oil products use by sector in select countries in Eastern Africa (in '000 tonnes).











Source: Based on IEA data, 2009. Similar data was not available from IEA for other members states in the Eastern Africa sub-region.

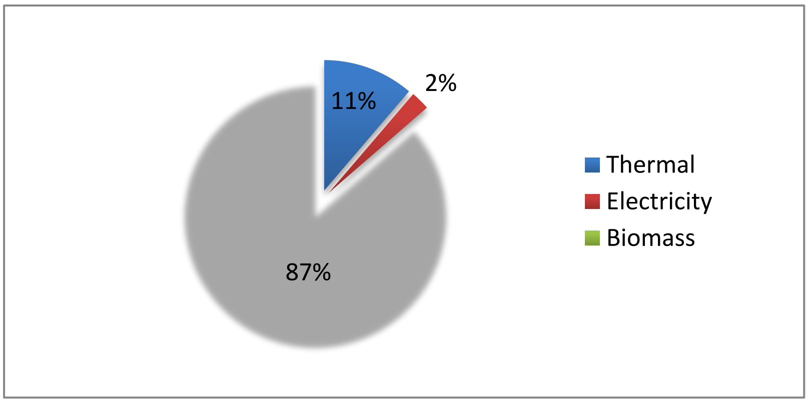
3.3.5 Energy Crisis Management Capability

The energy crisis management capacity of a country depends on risk factors, some of which are discussed in previous sections, and in the mitigation capacity. The risk factors relate to: the production capacity of primary energy; energy conversion capacity through power plants; refineries; improved cookstoves; inland and import transportation safety and energy import possibilities, particularly for electricity.

3.3.5.1 Production Capacity Risks

The *production capacity* risk relates to oil, gas, coal, renewable energy and biomass production. With the exception of South Sudan, and limited oil production activities in D.R. Congo, the emerging gas production activity in Tanzania, the Eastern Africa sub-region relies on biomass and imported energy for a large share of primary energy supply. About 87% of primary energy source in the sub-region is biomass, 11% from thermal energy largely depending on imported fuels and just 2% sourced from electricity. Therefore, on the production capacity side, until the energy system sufficiently transitions to modern fuels, will largely depend on the management of biomass resources. Domestic production capacity of thermal energy sources is rather limited, and currently will not substantially alter the structure of energy security risks. But efforts to increase local primary energy supply from discovered resources can make a long-term difference.

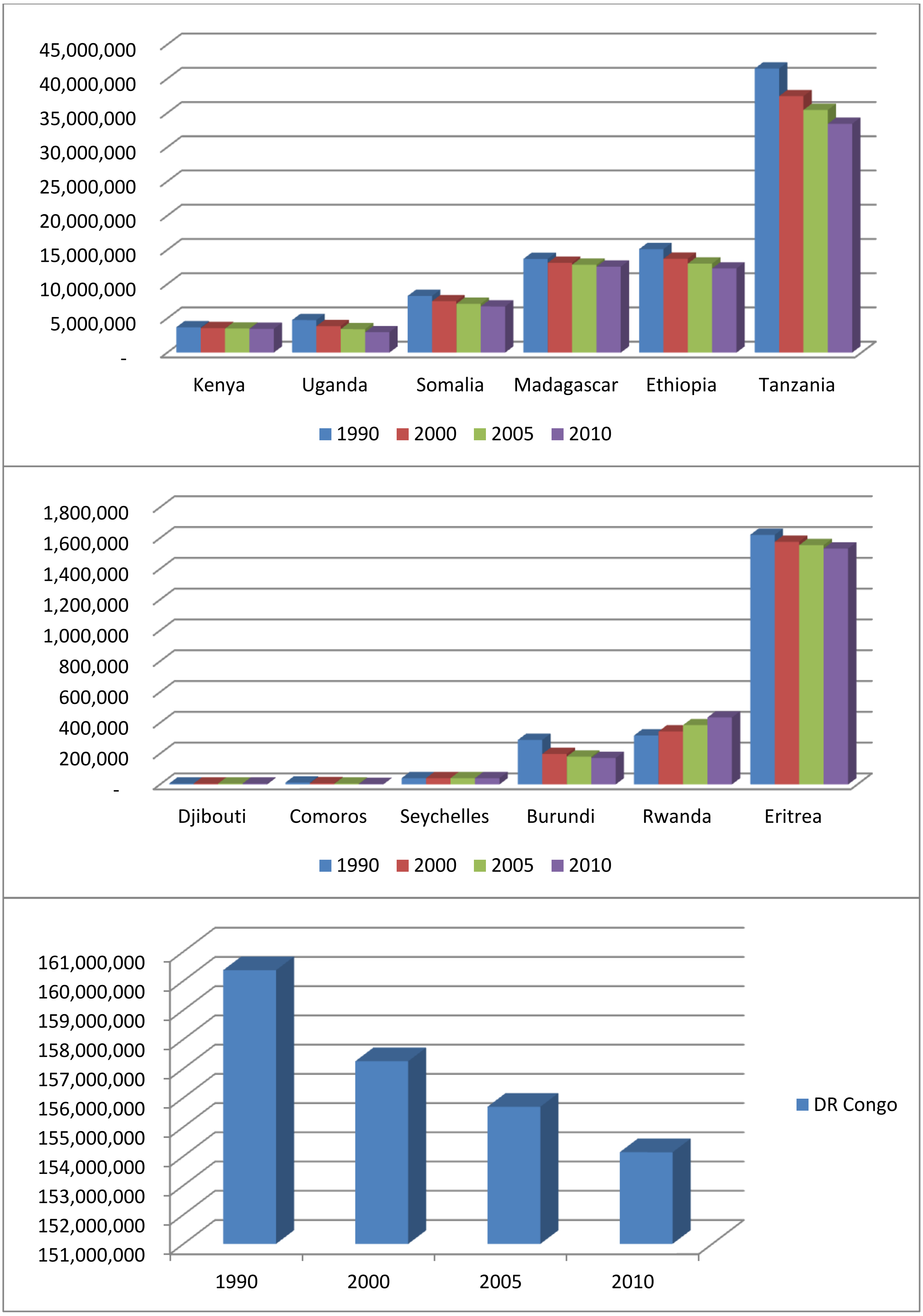
Figure 56: Energy balance of the Eastern Africa sub-Region, 2009.



Source: UN Statistics, *Energy Balances and Electricity Profiles,* IEA 2009.
Note: East Africa average doesn't include Comoros, Djibouti, Seychelles, and Somalia because of lack of data.

The capacity to sustain biomass energy supply in the sub-region, particularly wood and charcoal, is already put under concern, fearing that household energy security, particularly to the poor, will be severely undermined. Assessment of the state of forest resources in the sub-region reveals major concerns, as forest resources show sign of unsustainable and rapid decline (see Fig. 57). In Tanzania, D.R. Congo, Ethiopia, Uganda, Somalia and Madagascar, forest resources have shown noticeable decline. The only country in the sub-region with successful forest resource recovery is Rwanda, followed by no noticeable change in Djibouti and Seychelles, where the local climate is not conducive to forestry.

Figure 57: Forest covers change in the Eastern Africa sub-Region (in hectares): 1990-2000.



Source: Based on data from FAO Forest Department.

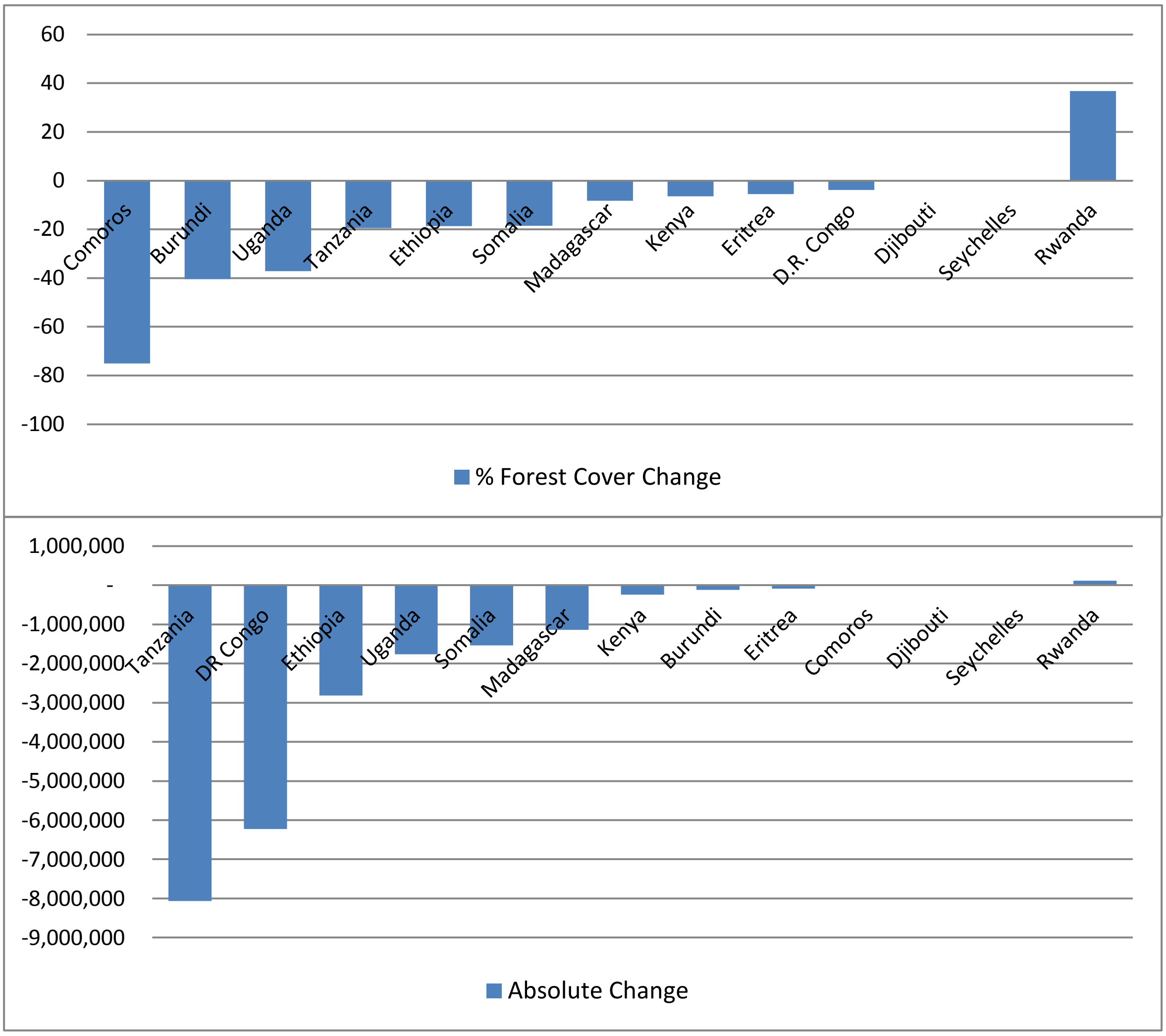
In terms of percentage changes in forest cover based on 1990 forest resources as a base reference, nearly 20% stock decline is observed in Somalia, Ethiopia and Tanzania, nearly 40% decline in Uganda and Burundi, and 75% decline in Comoros (see Fig. 51).

Between 4 to 8% forest stock declines are observed in Madagascar, Kenya, Eritrea and D.R. Congo. In the D.R. Congo, while a 4% decline seems marginal, given the size of the stock reaching 160 million hectares in 1990, one of the largest in the world, the magnitude of deforestation is quite large. Rwanda is the only country managing its forest resources quite well, showing forest resource recovery by 117,000 hectares between 1990 and 2010.

In absolute figures (see Fig. 58), the losses were highest in Tanzania, with more than 8 million hectares of forest lost; over 6.2 million hectares in D.R. Congo; 2.8 million hectares in Ethiopia; and between 1.3 million – 1.7 million hectares in Madagascar, Somalia and Uganda.

The state of forest resources, and biomass energy production capacity, in the Eastern Africa sub-region is skidding towards greater insecurity, with potential consequences of rising wood and charcoal prices, and greater concern about the long-term ability to sustain biomass supply. The state of household energy security, under current trends, is likely to worsen.

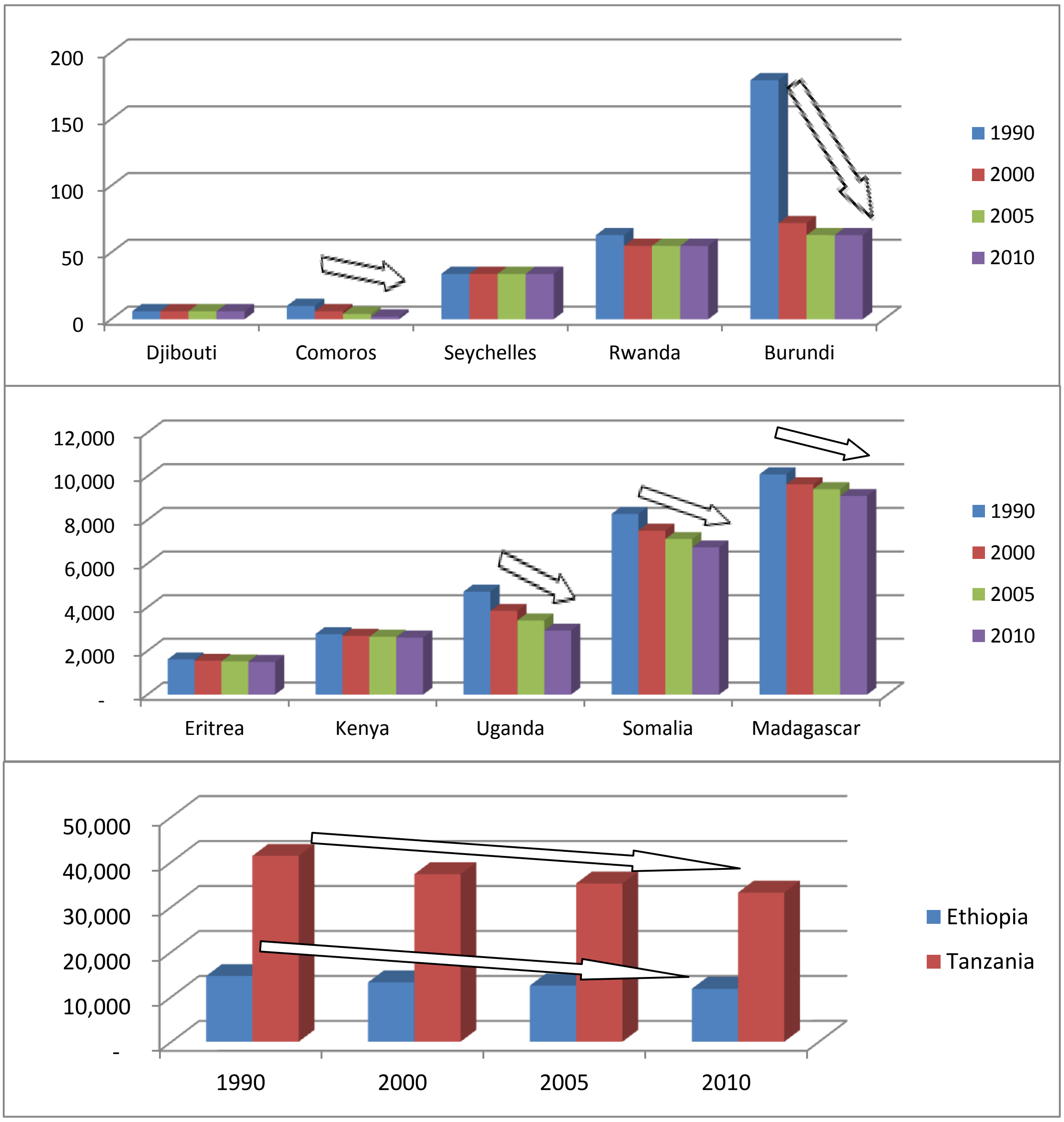
Figure 58: Absolute and percentage change in forest cover: 1990-2010 (in %, hectares).



Mitigation of deforestation can come from the natural regeneration capacity of the forest resource and from reforestation programs. Trends in the natural regeneration capacity of the forest in the sub-region (see Fig. 59) demonstrate declining regeneration in all member

States, except in Djibouti and Seychelles where there are no noticeable changes. The capacity of the forest to regenerate and grow the stock is therefore declining, imposing a *biological risk* on long-term household energy security.

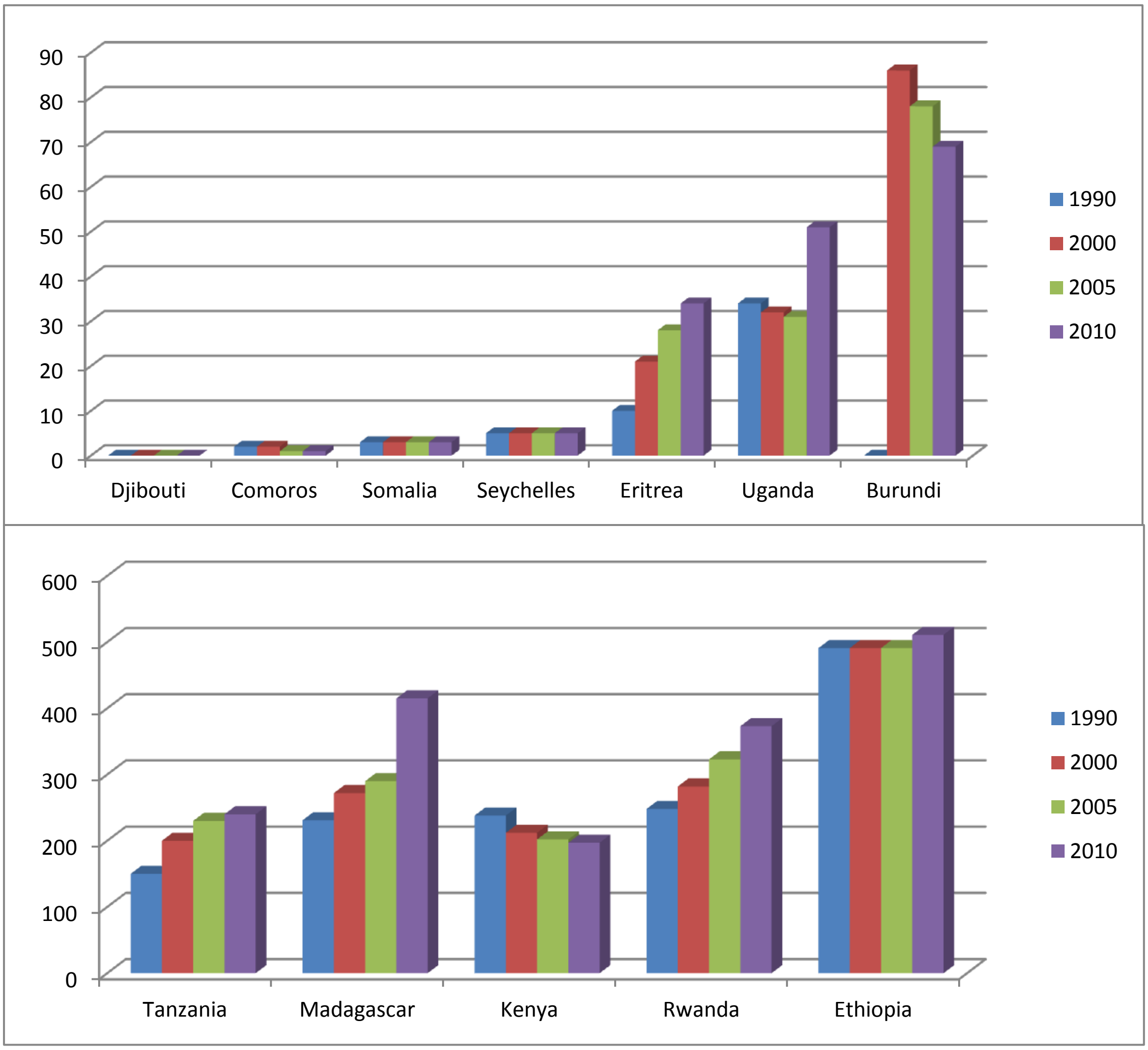
Figure 59: Naturally regenerated forest (in ' 000 hectares): 1990-2010.



Source: Based on data from FAO Forest Department.

Reforestation efforts to limit further stock decline are common through the sub-region. Even though reforestation efforts have slowed in 2000, compared with 1990, in Burundi, Comoros and Kenya, improvements are observed in Uganda, Tanzania and Madagascar, with sustained large increases in Eritrea and Rwanda (see Fig. 60). The scale of reforestation, in the face of limited natural regeneration, is nowhere sufficient to replace stock drawdown, but encouraging reforestation efforts are undertaken in the sub-region.

Figure 60: Planted forest (in '000 hectares): 1990-2010.



Source: Based on data from FAO Forest Department.

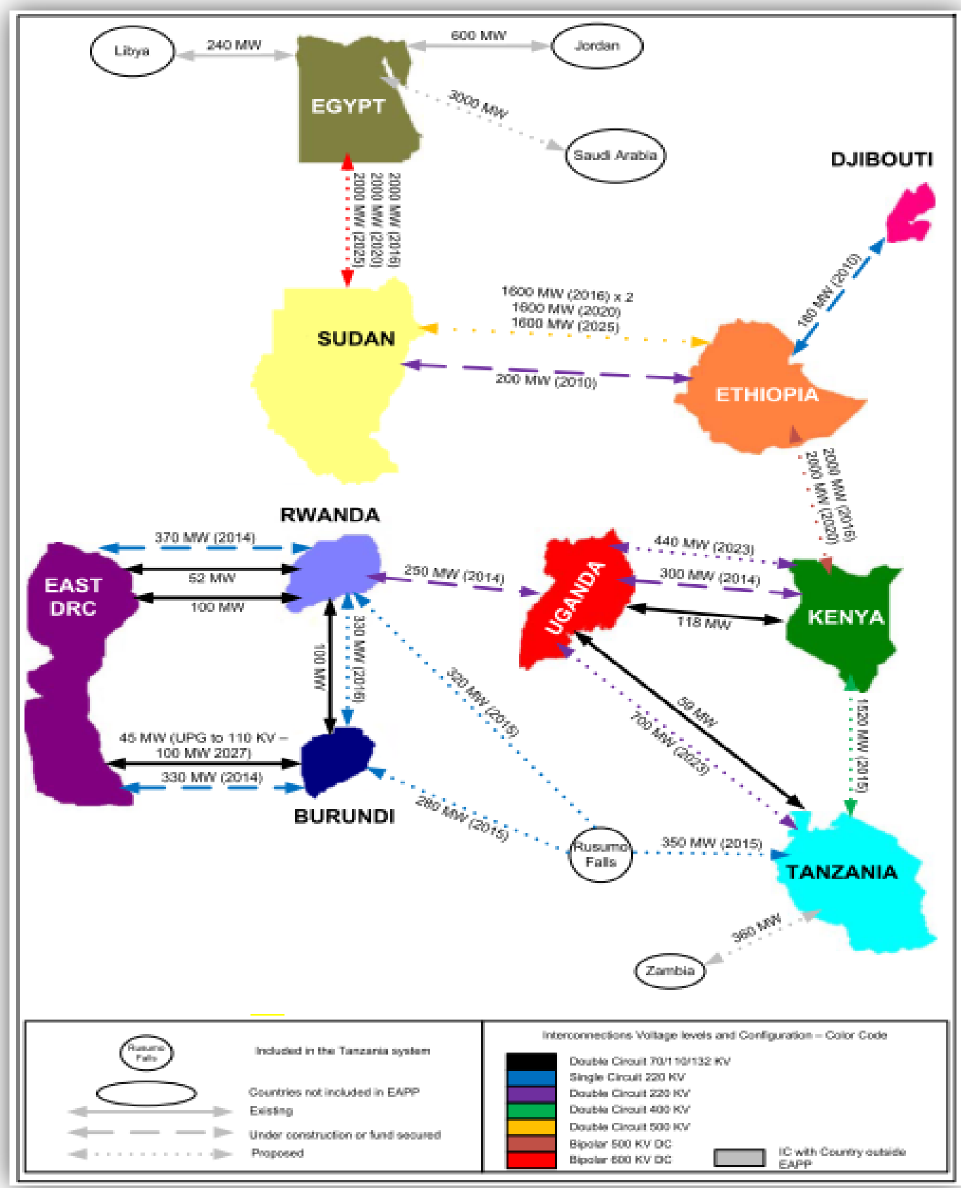
The structure of primary energy supply from biomass is breaking – with limited regeneration capacity of the forest stock and insufficient re-plantation efforts, the current rate of stock drawdown, given 87% reliance on it, will impact household energy security in the Eastern Africa sub-region negatively.

3.3.5.2 Energy Conversion Capacity through Power Plants

In discussing energy access challenges, the demand and supply side constraints to energy conversion are identified. The power conversion challenges in the energy sector of the Eastern Africa sub-region are epitomized by frequent power outages (see Fig. 29), energy constraint to businesses (Fig. 30), self-generation by households and businesses outside the national grid (Fig. 31), limited power generation capacity (Fig. 33), high power distribution losses (Fig. 34), minimal transmission interconnection (Fig. 35) and the prominence of emergency power generation (Table 6). These characteristics of the electricity sector demonstrate key energy conversion capacity challenges affecting *energy crisis management capacity*. New generation capacity addition efforts (see Table 8), anticipated energy trade in the sub-region (Table 9) and anticipated expanded regional grid interconnection schemes

(Fig. 61) will help enhance energy conversion capacities and accessing energy locally and regionally and improve on *electricity crisis management*.

Figure 61: Future regional grid interconnection and trade scenario.



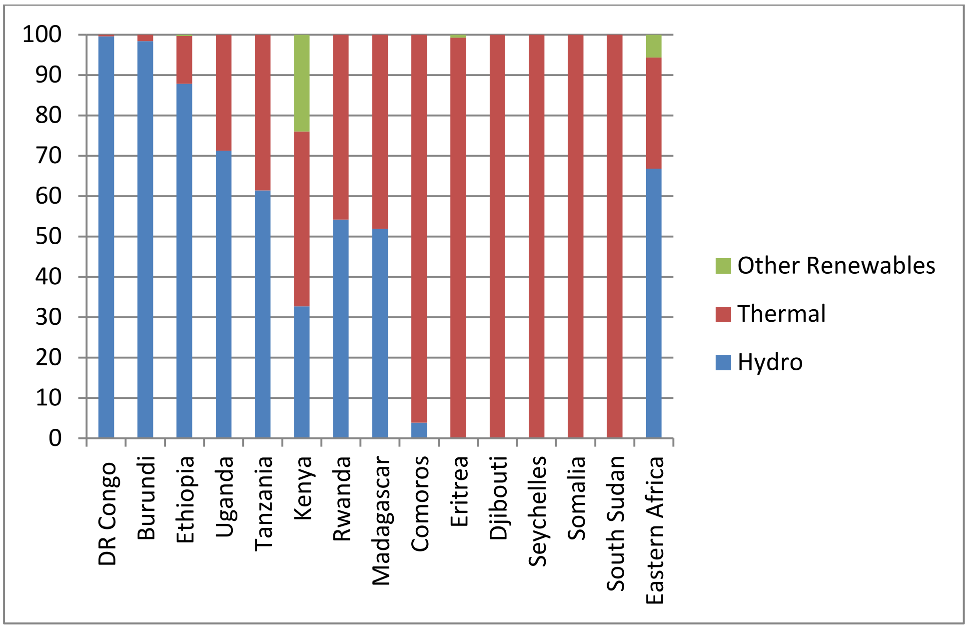
Source: EAC Regional Power System Master Plan and Grid Code Study (2011).

It is noteworthy to bring attention to the technology shift in electricity conversion. The legacy of electricity in the Eastern Africa sub-region was predominantly hydroelectricity. Lack of energy planning and growing energy demand have pushed the region to technology switches that brought more thermal generation, growing overtime as a share of total electricity generation. As shown in Fig. 62, energy conversion in the region, in terms of technology, comes from thermal generation entirely in South Sudan, Somalia, Seychelles,

Djibouti[17], and almost entire in Eritrea and Comoros. The thermal generation share of Madagascar, Rwanda, Kenya and Uganda are also sizable.

The shift in energy conversion technology of the sub-region to thermal options has energy security implications: generation is becoming increasingly based on imported fuel, which has increased energy insecurity and reduced the energy crisis management capability of member States.

Figure 62: Share of thermal generation in total electricity supply.



Source: Energy Information Administration and country mission data.

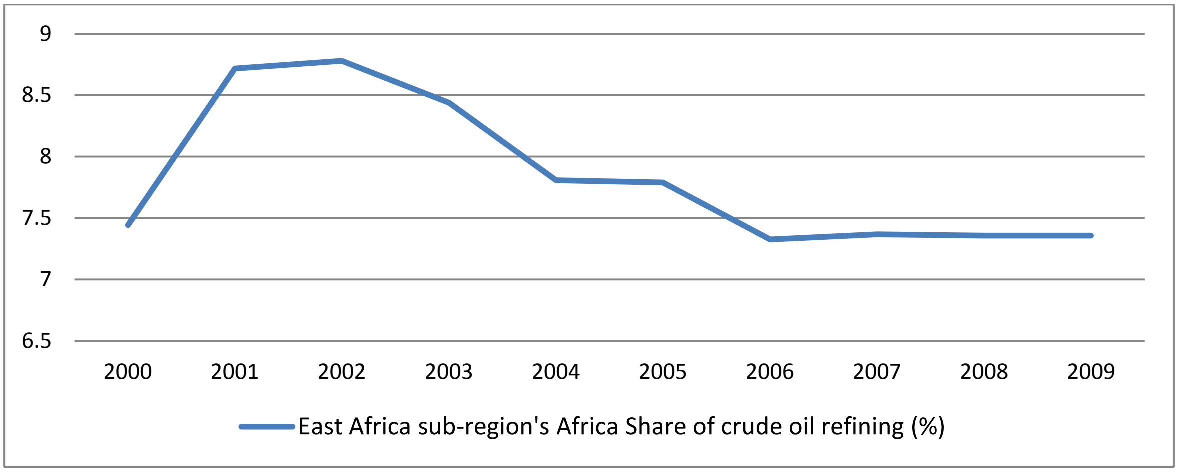
3.3.5.3 Oil Refinery and Natural Gas Distribution Capacity

Capacity to refine crude oil offers a layer of crisis management capacity by increasing domestic refined oil products output. The state of refinery operation in the Eastern Africa sub-region has actually declined. Refinery operations in Eritrea, Madagascar, D. R. Congo and Tanzania have closed down, leaving Kenya the only member state with significant refining activity. As a result, the share of Eastern Africa sub-regions total refinery capacity as a share of Africa's capacity has declined from close to 8.8% in 2001 to below 7.5% by 2006 and remained at that level till 2009 (see Fig. 63). New efforts to increase investment in oil refining capacity in Kenya, and possibility to refine South Sudan crude oil offer new hopes for the region to mitigate energy insecurity. The most promising and heated debate is in Uganda, with the government long-term plan to refining Uganda's crude oil found at Lake Albert. The government plan envisages first starting refining crude oil locally at 20,000 bbl/day, gradually increasing the capacity to 60,000 bbl/day and beyond to meet regional refined oil-products demand. Disputes about refining or raw export are not yet resolved with oil companies.

[17] Djibouti's electricity profile changed with resumption of hydropower imports from Ethiopia in recent years.

Uganda's ambitious plan will alter the energy security profile of Uganda, and has the potential, if the regional-focused refinery plan gets to implementation, to reduce energy insecurity in the EAC countries and in South Sudan.

Figure 63: Eastern Africa sub-Region's share of Africa's oil refining capacity: 2000-2009.



Source: Based on data from the US EIA.

Tanzania's natural gas find, the largest in the region, also has the potential to alter the nature of energy security in the sub-region. Natural gas pipeline infrastructure schemes in Tanzania to evaluate the gas off-shore and in southern deep water rigs to electricity production site and sites of industrial activity will certainly improve the energy security profile of Tanzania in the near future. However, as the refining strategy of Uganda has faced difficulties, the sub-regional natural gas distribution scheme of Tanzania will face constraints emanating from *economics* and *contract negotiation*. Natural gas extraction in Tanzania is currently linked with investment interest in off-shore LNG plants, which can load natural gas storage fitted sea-cruisers that can reach Asian and Japanese markets where gas prices are more promising. Industry experts believe that price disparities, LNG production capacity and cheaper cost of transporting natural gas over longer distance can shift Tanzanian natural gas to export markets, away from sub-regional consumers. This concern is strengthened by contracts entered between the Republic of Tanzania and the gas exploring and extracting companies, such as BG Tanzania, where it is believed that 5-15% of the gas finds are likely to be committed to the domestic market, and the rest will see overseas markets.

While current natural gas contracts offer great room to improve energy security in Tanzania from the use of LPG and gas-fired power plants, and boost its economy from natural gas proceeds, the sub-regional energy security mitigation benefit of Tanzania's natural gas remains in doubt beyond the potential of some connection to Kenya's electricity sector.

3.3.5.4 Energy Imports Transportation

Another risk factor affecting the energy crisis management capability is exposure to energy import risks emanating from import corridor safety: sea transportation safety and the added risk for land transportation through third countries for land-locked States. Land transportation for land-locked countries in the EAC countries has largely been open, facing no major sustained disruption due to political instability. However, the risk level is demonstrated during the post-election violence in Kenya after the 2007 presidential elections that halted land transportation and disrupted fuel deliveries over pipelines. Uganda

has attempted to diversify to Tanzanian road transportation route to deal with such risks by offering subsidy of USh 150/litre of fuel routed through the *Southern Corridor*. Road restrictions in Tanzania, including limits on the wheel capacity of trucks, remain a concern to Uganda. Similarly, Rwanda and Burundi are affected by their land-locked status. There are plans to expand oil-pipeline infrastructure to Rwanda to mitigate such inland transportation risks.

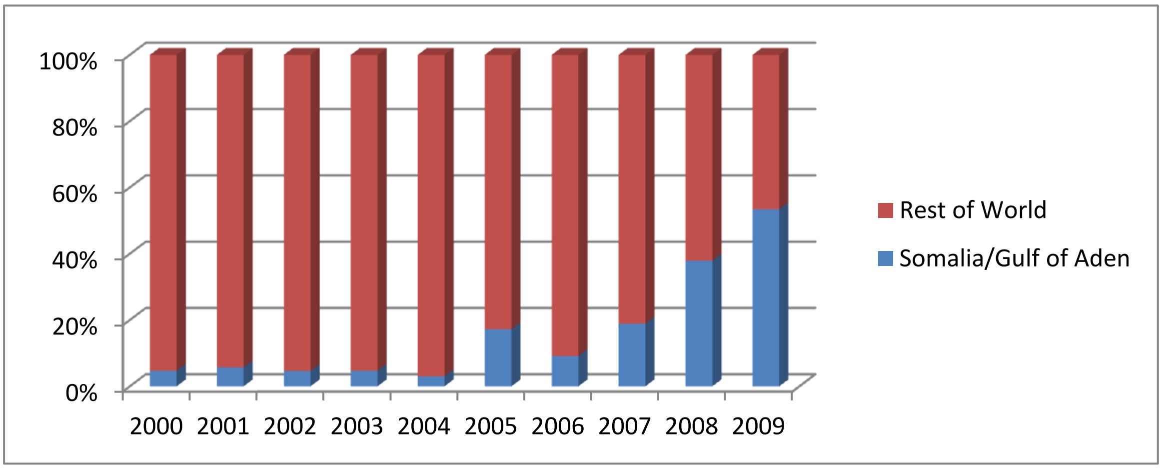
South Sudan also relies on oil import routes through Kenya. Due to the state of poor road conditions, particularly during raining seasons, supplies are frequently disrupted. Connections through the Uganda corridor are being pursued, including with the improved road connection with Uganda, partly funded by the US government. Ethiopia is also impacted by road transportation.

The dispute with Eritrea has led to the shut-down of road transportation routes to all portal cities of Eritrea since 1998, and its use of the Assab oil refinery in Eritrea has been severed since then (the refinery also stopped operation in 1997/1998). This has forced Ethiopia to rely on the Djibouti route. The railway connection between Djibouti and Addis Ababa has largely been ruled out for oil transportation due to the narrow width rail lines insufficient to accommodate oil tanker rails. Transportation over land is also exposed to risks of sabotage by rebel groups. Plans to build a parallel new railway line that can accommodate oil shipments is in the works, which will alleviate some of the inland tracking challenges.

Fuel import transportation is particularly impacted by the surge of Red Sea and Indian Ocean piracy activity emanating from the crisis in Somalia. The incidence of piracy activity in the Gulf of Aden, compared to global total incidents, has increased from 4.7% in 2000 to 17.2% by 2005, reaching 53.4% in 2009 (see Fig. 64). This alarming increase in piracy activity in sea transportation routes has heightened the cost of fuel delivery due to sharp increases in insurance premiums and elevation of risk to physical disruption. Seizure of oil tankers by Somali pirates have caused fuel supply disruptions in Kenya and Uganda, and threatened deliveries to Red Sea States of Eritrea and Djibouti as piracy threats spread northwards. The geographic distribution of piracy activity is concentrated mainly around the Somali territory around Gulf of Aden. But the *piracy risk* has gradually shifted as far north as the Eritrean waters in the Red Sea, as far south as the Indian Ocean territories of Mozambique and as far as the Arabian Sea and Gulf of Oman (see Fig. 65).

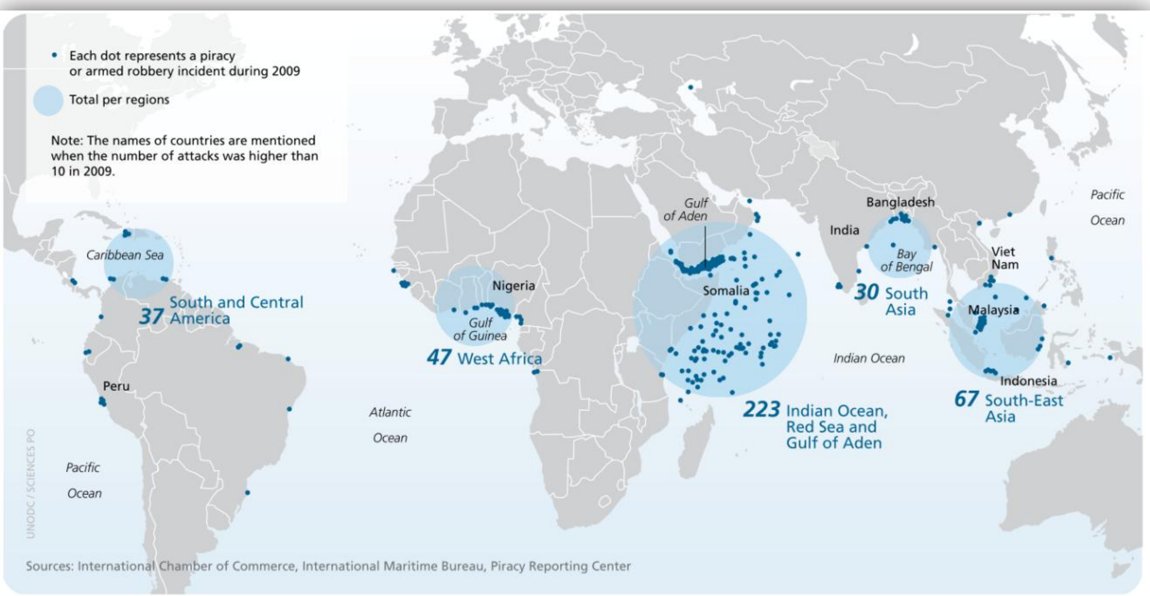
In essence, the wider geographic distribution of the Somali piracy problem from the Red Sea and the Gulf of Eden to the Indian Ocean, the Arabian Sea and the Gulf of Oman has severely undercut energy security of the Eastern Africa sub-region, emanating from unsafe sea transport routes for imported fuels and rising cost of insuring shipments.

Figure 64: Incidence of piracy in the Gulf of Aden: 2000-2009.



Source: IMB-ICC annual reports, 2003-2009.

Figure 65: Geographic distribution of piracy activity in Eastern Africa, 2009.



Source: International Chamber of Commerce, International Maritime Bureau, Piracy Reporting Center.

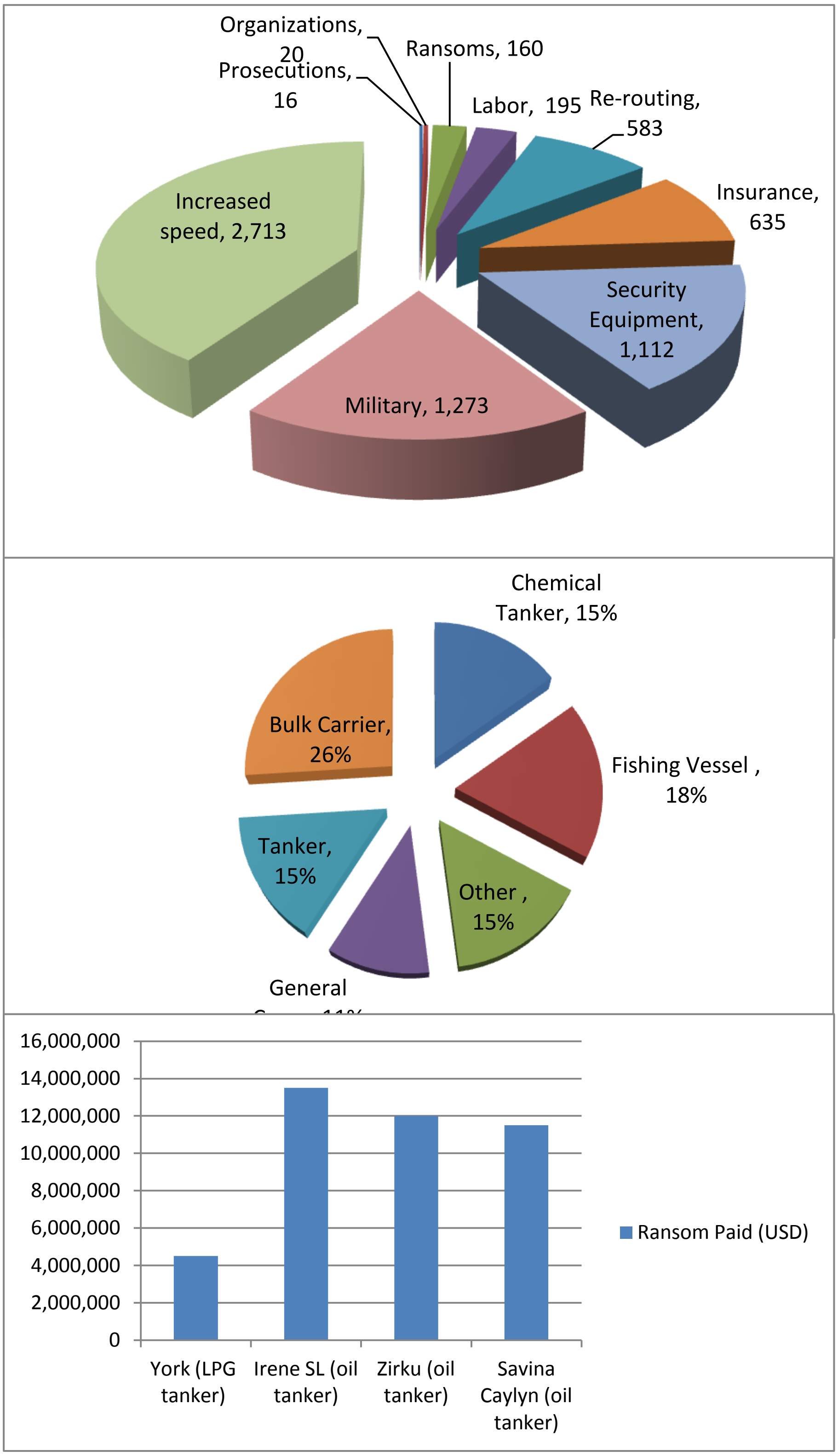
The economic impacts of piracy is no simple matter either. The One Earth Future Foundation, in its 2011 report on the economic cost of the Somali piracy crisis estimated the cost for 2011 to reach USUS 6.6-6.9 billion. Increasing the speed of ships to evade pirates capture costs, in 2011 USUS 2.7 billion. Military presence to guard against piracy incurred an estimated US$ 1.3 billion and insurance premiums an added USUS 635 million (see Fig. 66). *In successful piracy captures, 15% of the cases involved oil takers, which is almost 1 in 9.* The ransoms are equally exorbitant, reaching US$ 160 million in 2011. Carrier extortions ranges, but can reach as high as US$ 13.5 million, which was the case with the Irene SL oil tanker (see Fig. 59).

The total economic cost of the Somali piracy reaches close to USUS7 billion in 2011, with 635 million insurance premium costs, involving 15% of the oil tankers. Its wide geographic

coverage, change of involving nearly 1 in 9 oil tankers and the prevalence of attack has driven the Eastern Africa sub-region to greater fuel import cost, undercutting affordability, and posing greater physical disruption risk, meaning from unsafe sea fuel transportation.

Figure 66: The cost allocation of Somali piracy (in million USUS), the

share of vessels afflicted and sample ransom paid, 2011.



Source: One Earth Future Foundation. 2011. 'The Economic Cost of Somali Piracy 2011.

The energy crisis management capacity of a country, beyond the risk factors mentioned, is also determined by the energy security mitigation factors. These include holding emergency stocks, demand restraints and rationing, fuel switching capacity and reserve capacity.

3.3.5.5 Strategic reserves/Emergency Stocks

Fuel disruptions can occur due to the materialisation of any of the risk factors. The resiliency of the energy security status of a country, in such occasions, depends on built-in mitigation strategies, frameworks and implementation efficiencies. Maintaining a strategic reserves, or emergency fuel stock, is one effective mitigation mechanism. The state of strategic reserve policy and implementation is observed for Ethiopia, Eritrea, South Sudan, Tanzania and Uganda (see Table 14). The new State of South Sudan has no strategic reserve policy or coordinated implementation scheme, exposing to immediate impacts of any disruption in fuel shipments, which is the case in rainy seasons (poor condition of roads connecting it to Kenya). Disruption risks complemented by lack of mitigation policy, in terms of strategic reserves, has heighted the state of energy insecurity in South Sudan.

Table 14: Strategic reserve policy and implementation in select countries.

Country	Strategic Reserves
Ethiopia	90 days policy, at around 1 month supply due to price hike
Eritrea	Signs of stock depletion
South Sudan	No policy, no strategic reserve
Tanzania	2 weeks policy, no public strategic reserve
Uganda	Stock depleted, restocking in the works

Source: Country mission and secondary data, 2012.

Eritrea has drawn its strategic reserves down, leading to fuel rationing and frequent interruptions of electricity supply. Ethiopia has a 3 month fuel stocking practice, which would put it at par with international best practice. But strategic stocks are drawn down to one month supply, largely due to financial difficulties to restock fuels in its thirteen or so strategic reserves. The decision of government to revise and announce regulated fuel prices at the end of each month, and ask operators to pay if price revisions are upward, creating windfall gains for remaining stock at end of month, but failing to compensate distribution operators of government revises prices down, exposing them to losses to unsold fuel stock has led to unintended, but rampant speculation. This system of pricing and windfall extraction with no loss compensation has introduced artificial fuel shortages towards the end of months. Some have also delayed receivership of oil shipments in Djibouti, waiting to see the new prices to determine shipment schedules. Stock drawdown due to financial challenges and systemic speculation are introducing challenges to managing short-term fuel supply security.

Tanzania's requirement is two weeks of stock to be held by private operators, which already is significantly lower than international best practice. Coupled with lack of effective

regulation if the private sector is keeping mandated stocks has increased energy insecurity. The government is already rolling out a new plan to introduce public strategic reserves to mitigate fuel supply disruptions and insecurity.

In Uganda, a public strategic reserve does exist, but its stock is depleted partly due to non-technical reasons. The strategic stock system was tested during the 2007 post-election crisis in Kenya, where fuel supplies where temporarily shut, and plunged Uganda, with no effective strategic reserves, in to short-term fuel disruption. Investment in to an expanded strategic reserve system is in consideration in Uganda.

Emergency stocks in biomass are largely disregarded, and such a system is nearly non-existent, expect for households stocking their own supplies. The practice of energy security in the biomass area requires further look, and designing proper frameworks to manage its continual supply and disruption management scheme.

3.3.5.6 Demand Restraints

Demand restraints assist in mitigating the widespread manifestation of fuel shortages. Rationing is the most commonly utilized approach in demand restraint in times of energy shortages. In the Eastern Africa sub-region, demand restraints are often exercised to deal with fuel supply disruptions. In recent years, the sub-region has been exposed to numerous fuels supply disruptions.

The 2008 post-election violence in Kenya was widespread, and affected fuel shipments to neighbouring countries, undermining short-term fuel supply. In Uganda, following the violence and unrest, fuel stocks dwindled, triggering oil distribution companies, such as Total and Engen to exercise fuel rationing. Uganda also saw fuel shortages in 2010, due to devaluation of the Shilling, delays in Mombasa port, Nairobi-Eldoret pipeline constraints and rising global oil price, leading to price increases from Shs 10,000 for 4.5 litres down to 3 litres.[18] Uganda also faces other sources of supply disruptions, such as Kenya's three-axle rule that reduced the amount of fuel trucks can carry on the road, Mombasa-Eldoret pipeline condition and other delays in clearing shipments. Timing of oil procurement can also introduce risks, such as in July 2008 when oil companies procured at higher prices, though prices receded subsequently, the stock was acquired at high prices (Kojima, et al., 2010).

In Rwanda, similar fuel rationing was put immediately in place following post-election violence in Kenya, due to disruptions to fuel supply from the port of Mombasa and declared a 10 litres petrol cap for small cars and 20 litres cap for SUVs. It has also engaged Tanzanian authorities to facilitate the routing of fuel trucks through Tanzania, up to 4 million litres and to lift non-tariff barriers to reduce fuel shipment delays. Rwanda also released state petrol reserves to distributors who run out of fuel. Prices were also kept frozen with tax incentives of 68% for diesel and 78% for petrol[19]. Rwanda's coordinated response was well targeted, and the then Minister of Commerce, Mr. Protais Mitalli, assured markets by stating "there should not be panic. There are adequate fuel reserves to take the country through the

[18] See Adrew Nkurunziza's article in *The Monitor*, April 16, 2010.
[19] See Eddie Mugaaya's article in *Sunday Times*, December 21, 2008.

crisis, but contracts are currently on to have the first delivery of four million litres of fuel to be on standby."[20] Similar shortages were experienced in Burundi, resulting in fuel rationing.

Burundi also faced its own oil supply shortages in August 2007, and started fuel rationing, after the General Prosecutor ordered the impounding of fuel trucks and tankers of the Interpetrol Company. Later the Company's bank accounts were frozen. Since the company supplied 50% of fuel supplies in Burundi, supply shortages were quickly felt, necessitating smuggling of fuel from Rwanda in Ngozi Province, and leading to fuel price hikes, and in the case of Rumenge town almost doubled.[21]

Eritrea also faced fuel supply disruptions, including in 2004 where fuel rationing was imposed. Later, Eritrea banned sale of petrol to the public, conserving it for "essential uses." Petrol prices went up 40%, and diesel 25%. Rationing continued to 2005, and for the most part through 2012. Priority of petrol use is provided to public services and development programs. In Ethiopia, 2006 saw fuel shortages and rationing resulting for timely transportation and distribution of fuel stocks. Cities of Dire Dawa, Jimma and Addis Ababa experienced disruptions, which were resolved by replenishments. However, speculative disruptions are monthly occurrences in Ethiopia largely due to the policy of stock valuation. Fuel prices are evaluated each month, and revised at the end of the month. If prices are raised and there are remaining stocks in inventory, distributors are requested to pay windfall gains to government on their remaining stock balance. However, when prices are revised downwards, government payout to compensate for value losses on remaining inventory is not a common practice. This has led to rife speculation, and delays in taking stock from the port of Djibouti until prices are known to mitigate for windfall losses. These responses often cause temporary fuel shortages particularly in Addis Ababa.

Shortages in electricity similarly are handled through rationing of power to end users, by location, time and customer category. Tanzania, for example, has seen severe power shortages leading to electricity rationing, as has Uganda and Eritrea. *Demand restraints in times of fuel and electricity shortages are common in the sub-region, but in the case of fuels are often not sufficiently complemented by strategic reserve stock releases.*

3.3.5.7 Reserve Capacity

Existence of sizeable reserve capacity in the energy system can help mitigate the impact of short-term energy disruptions. Dependence on imported fuel of the sub-region, and lack of local production of fuels, limits the exercise of reserves to manage fuel shortages. Kenya is the only country in the sub-region with a refinery capacity, offering it domestic capacity to refine and supply fuel, reducing imports by sizeable margins. Limited existing capacity to import and quickly distribute fuel through pipelines (capacity is limited) and road transportation introduce challenges. In the electricity sector, there is often limited power, and power shortage is the norm, not surplus. The fact that the sub-region is poorly interconnected limits the potential of electricity imports to deal with peak-demand shortfalls. *Expanding reserve capacity in electricity and fuels stocking and transportation will assist in managing short-term energy disruptions.*

[20] Ibid.
[21] See Jean Pierre Nkunzimana's article in *NewVision*, Uganda daily newspaper, August 28, 2007.

3.3.5.8 Fuel Switching Capacity

A long-term strategy to mitigate the impact of dependence on imported fuel is switching to alternative fuel sources. In the transportation sector, fuel switching is pursued through policy and program in Ethiopia, where the only fuel blending mandate of the sub-region is exercised. The plan, which is an experimental program for Addis Ababa, requires a 10% ethanol blending, with a plan to raise it to 20% by 2015. New sugar factories are opened, generating more supplies of ethanol, potentially meeting higher blending mandates. A blending factory is set-up in Sululta, just outside Addis Ababa, to produce standardized blended fuel. By 2010, 314,000 tons of ethanol were produced, with a goal to increase production to 2.2 million tons by 2015. Some 2.5 million hectare of land is set aside for biofuels, for both local consumption and exports. Ethiopia's blending program is the only in the sub-region that puts a tangible plan to switch fuel, and mitigate imports. It is claimed that the program is saving US$ $20 million in fuel import bills.

In electricity sector, fuel switching is either in the plans or implementation in the sub-region. Tanzania has successfully expanded the share of its indigenous gas resources in electricity generation, and plans to expand integration of gas and coal in the generation portfolio. Uganda and South Sudan plan to divert some crude oil to generate electricity from crude-driven thermal generation systems. The possibility of small-scale nuclear energy use is considered in Kenya and Tanzania. Fuel switching for cooking is also widely pursued in Rwanda where 50% of households already have improved stoves by 2008, with a plan to increase coverage to 100% of households by 2012. Through its national Domestic Biogas Programme, it aims to install at least 15,000 biogas digesters in rural households owning 2-3 cows by 2011, and expanding biogas services to public institutions such as schools, hospitals and the prison system.

Fuel switching in the transportation sector is limited in the sub-region, but the electricity sector and household cooking is in a transition to integration of indigenous energy sources, such as gas, coal, crude oil and biogas. Supporting and expanding such programs will enhance energy security in the sub-region.

4 ENERGY ACCESS AND ENERGY SECURITY: CASE STUDIES IN THE EASTERN AFRICA SUB-REGION

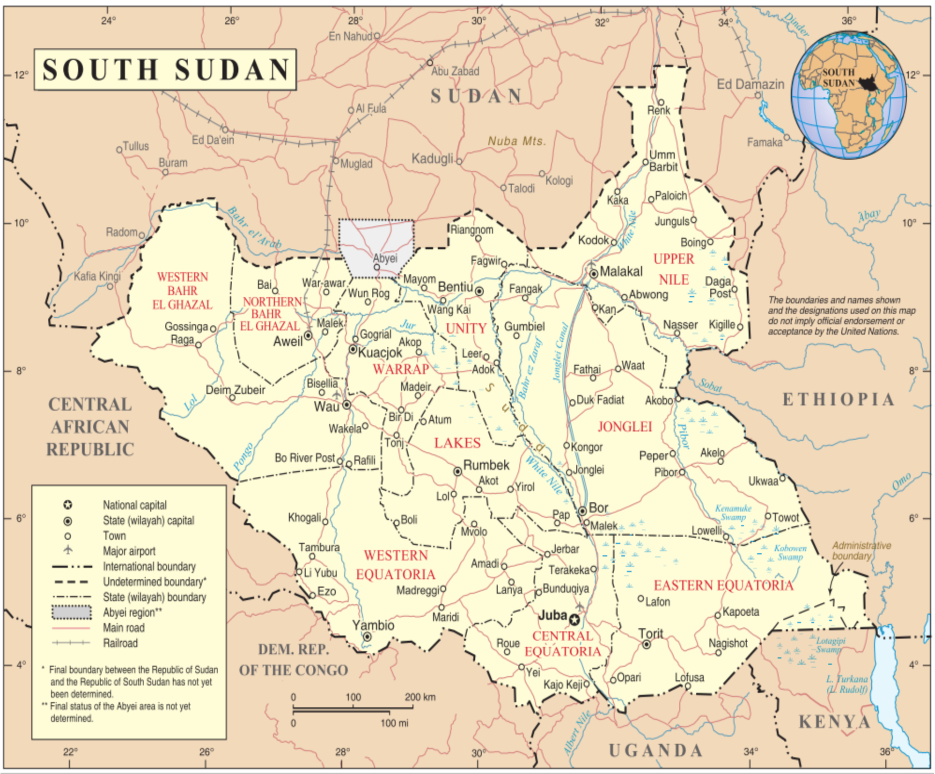
For closer look at lessons on energy access and security, the cases of six sub-regional countries are provided: South Sudan, Ethiopia, Tanzania, Uganda, D.R. Congo and Madagascar. The sub-regional analysis offered broader evaluation of the energy access and security, inclusive of the state of biomass energy. The focus in the case studies is on electricity for energy access and hydrocarbons for energy security.

4.1 SOUTH SUDAN

4.1.1 Background

Since 1956, when the Sudan became independent, the issue of South Sudan was a burning point. The first Sudanese civil war culminated in the formation of the Southern Sudan Autonomous Region in 1972, an arrangement which lasted until 1983. Subsequently, the Sudan entered a protracted and costly second civil war, which came to a political settlement in 2005 through the Comprehensive Peace Agreement (CPA), or the Naivasha Agreement, establishing a transitional Autonomous Government in Southern Sudan, simultaneously providing for a referendum after six years to determine the future of South Sudan. Following the referendum, an independent Republic of South Sudan emerged, on July 9, 2011, officially accepted shortly after into the UN and AU as an independent State.

Figure 67: The map of Republic of South Sudan.



Source: UN Cartographic Section, Department of Field Support, Map No. 4450 Rev. 1, October 2011.

The economy of South Sudan is dependent on the petroleum sector, where the export of crude oil accounts for nearly 98% of State revenue. The agricultural and industrial sectors

are yet to be built, and challenges of social and economic development and governance are among the areas the new State will have to confront. The energy sector of South Sudan, particularly its crude oil, makes the State relevant in energy security regional strategy, as the only major crude oil exporting country in the sub-region (though D.R. Congo produces a much smaller crude oil output). As a landlocked country, the economy of South Sudan is closely linked with Uganda, Kenya and Ethiopian economy, and despite hostilities, with the Sudan as well.

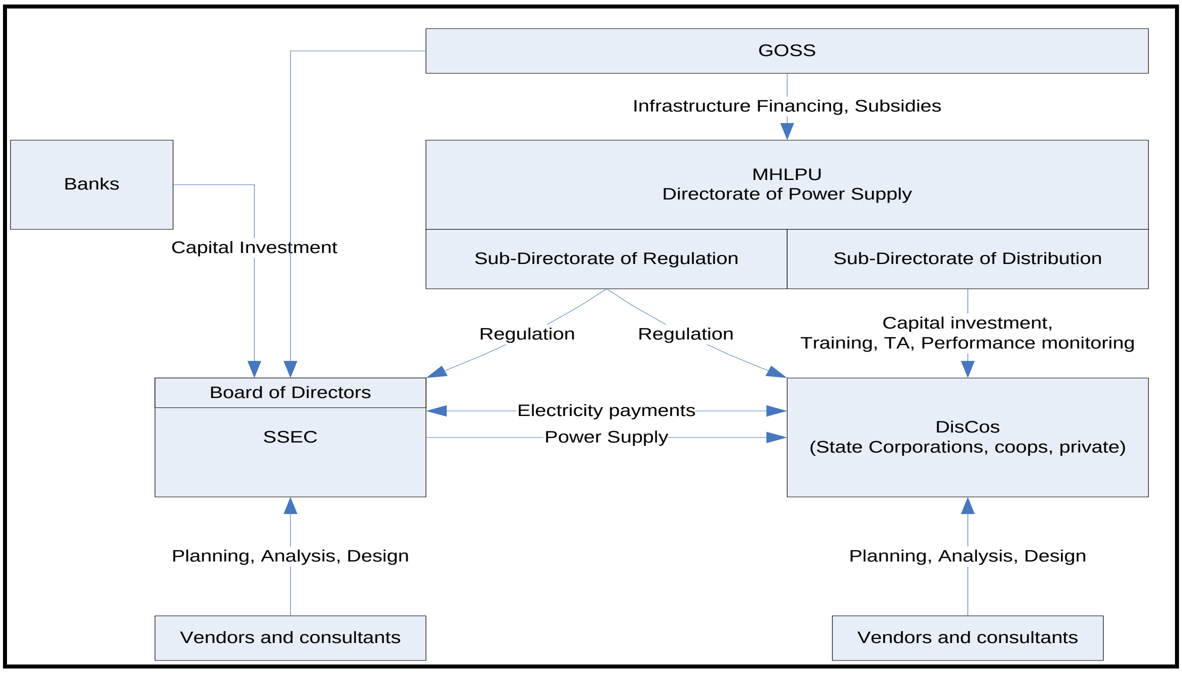
4.1.2 Energy Institutions and Policy

The energy sector in South Sudan is institutionally governed by the Ministry of Electricity and Dams and the Ministry of Petroleum and Mining, and is linked with the Ministry of Housing, Lands and Public Utilities (MHLPU), Ministry of Environment and the Ministry of Agriculture and Forestry. The Petroleum Bill has passed the National Assembly, but is not yet operational. The Electricity Bill of 2012 establishes regulatory framework for the electricity sub-sector. The Bill delineates the power and function of the Minister, the establishment of the South Sudan Electricity Corporation (SSEC), State distribution companies and other entities, rural electrification and other provisions. The Bill regulates the generation, transmission, distribution, supply, export and import of electricity within South Sudan. It also authorizes the Minister to give directions to prevent or mitigate the effects of any emergency or natural disaster, in the interest of national security, to limit disruption of electricity supply. The South Sudan Electricity Corporation is given the principal responsibility for the development and management of electricity from transmission to distribution. But the Bill also leaves a provision that Independent Power Producers (IPPs) and non-governmental entities may develop and operate electricity generation plants. The Bill also calls for the set-up of the Rural Electrification Committee from multiple Ministries, including Agriculture, Commerce and Rural Development. It also requires the establishment of a Rural Electrification Fund, financed through National Assembly appropriations, levy on transmission bulk purchase from generating stations and through donations, grants and loans.

The Ministry of Housing, Lands and Public Utilities, with assistance from NRECA International (financed by USAID) developed legal, regulatory and institutional framework for the electricity sub-sector, through the National Electric Policy (NEP). The NEP recognizes the vast energy resources of South Sudan, including hydrocarbon, hydroelectric, solar, wind and biomass resources, and requires prioritization for energy development. The policy recommends the following institutional framework for the electricity sector.

The policy paper recognizes that generation of electricity from high-cost liquids results in economic sots and poses a constraint to the national economy as sustaining such energy sources requires subsidies to keep rates at affordable levels. Smaller power plants are also less efficient and prone to supply failures. Therefore, evaluation of "least cost technology to be employed for power generation development" is flagged as an important policy consideration. The policy considers the power transmission grid as an "asset of strategic importance" and commits its development and ownership to the Government of South Sudan, with planning and management responsibility of the SSEC.

Figure 68: Institutional framework for the energy sector of South Sudan



Source: South Sudan Electric Sector Policy, Ministry of Housing, Lands and Public Utilities.

The rural electrifications strategy, in the policy paper, is outlined as follows:

"Rural electrification projects will include but will not be limited to extension of grid networks to rural communities; construction of isolated grid systems powered by thermal and small hydroelectric power plants; implementation of solar photovoltaic energy systems; and other renewable and conventional energy technologies that may fit the needs of specific projects that are evaluated and approved for financing. Thus, cooperatives may own and operate distributed generation. SSEC may be requested to assist with technical situations, if and as needed. Technology selection and project prioritization will be made on the basis of least economic cost and highest economic benefit. The evaluation methodology will be developed by the MHLPU, and will be shared with the State Governments through technical assistance and training programs.

Therefore, the generation, transmission and distribution service will be offered by "government-sponsored independently governed corporations, and by private independent power producers and energy companies".

4.1.3 The State of Energy Access and Key Lessons

4.1.3.1 The State of Energy Access

The rate of electricity access in South Sudan is at 1%, the lowest in the Eastern Africa sub-region. The first power plant in South Sudan was initiated in 1936 (thermal) with a purpose of generating electricity to pump water and deliver electricity to British settlers. By 1956, with the independence of the Sudan, the electricity access condition in the South was still meager. The civil war left little investment in the power sector in South Sudan, which continues to pose structural constraint to socioeconomic functions in the country. Today, Central Equatorial (the city of Juba), Western Bahr Al Gazal (the city of Wau) and Upper Nile State (the city of Malakal) have some level of electricity, but the rest of the country is without, or if at all negligible, electricity access (see Table 15).

Table 15: Installed electricity capacity by year (2005-2010) and State, South Sudan.

State

Capitals	2005	2006	2007	2008	2009	2010
Juba	5 MW	10 MW	5 MW	5 MW	17 MW	17 MW
Malakal	2.8 MW	2.8 MW	2.8 MW	2.8 MW	4.8 MW	4.8 MW
Wau	1.6 MW	1.6 MW	1.6 MW	1.6 MW	3.6 MW	3.6 MW
Bor	0	0	0	0	0	2 MW
Yambio	0	0	0	0	0	2 MW
Rumbek	0	0	0	0	0	0
Kuajok	0	0	0	0	0	0
Torit	0	0	0	0	0	0
Aweil	0	0	0	0	0	0
Bentiu	0	0	4 MW	4 MW	4 MW	4 MW
Total	9.4 MW	14.4 MW	13.4 MW	13.4 MW	29.4 MW	33.4 MW

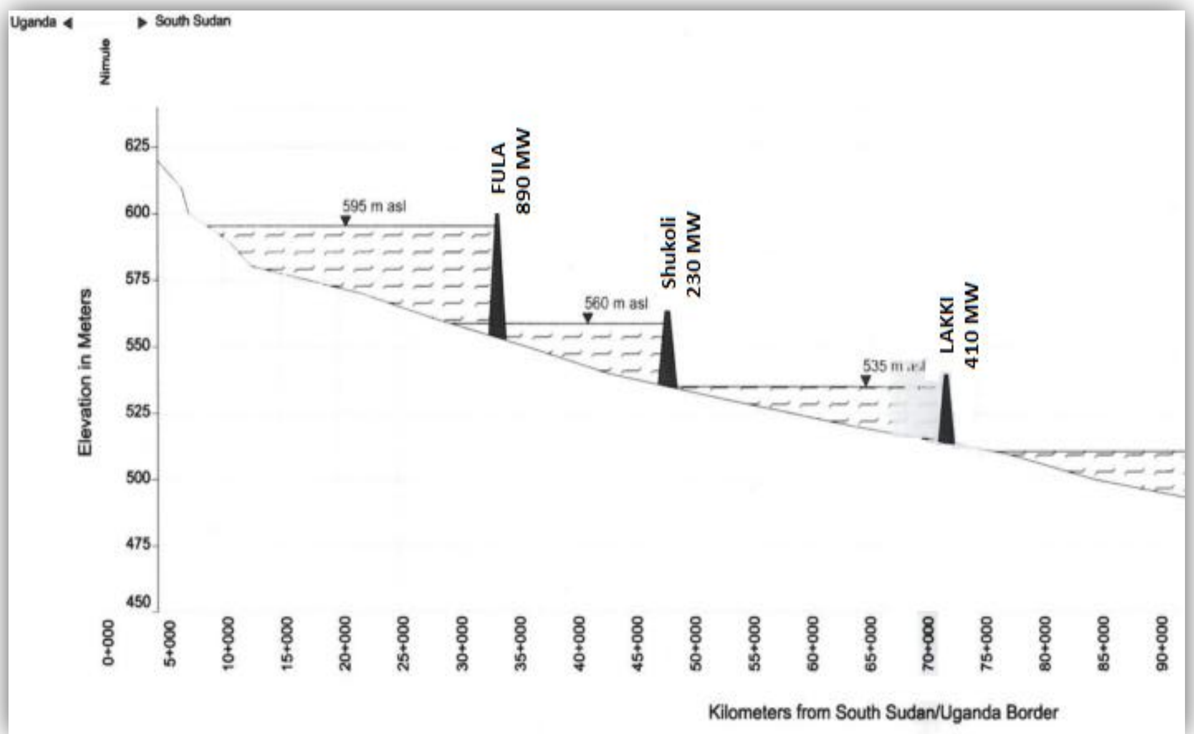
Source: South Sudan Energy Sector Needs Assessment Study.

During the six years transitional period before the referendum, 5 MW thermal capacity was added to Juba (2005), doubled to 10 MW (2006), but 50% capacity lost in 2007 and 2008. Investment in 2009 saw capacity for Juba expanded to 17 MW, continuing through 2010 though since then some capacity on some of the installed generators has been lost. The capacity for Malakal was 2.6 MW from 2005 – 2008, which saw capacity increased to 4.8 MW during 2009-2010. In Wau, the installed capacity remained at 1.6 MW from 2005-2008, and saw capacity expansion in 2009 to 3.6 MW. Out of the ten State capitals, 3 have basic access to electricity, and 3 more are planned. As a result, the current generation portfolio in South Sudan is entirely thermal power. There are plans to add 2 MW capacity in Rumbeck (Lake State), 2 MW in Bor (Jongole State), 2 MW in Yambio (Western Equatorial State) and 1 MW combined capacity small scale projects in Maredi, Capueta and Yeia towns, financed by USAID. The South Sudan Development Plan (SSDP) foresees the expansion of Juba capacity to 40MW, and 5 MW to each State capital, along with distribution network expansion. All plans are under thermal generation.

The Government is considering power import from the Ethiopian grid, in the short – term for Malakal, projected to be 50 MW, within 3 years. The possibility of utilizing crude oil for thermal generation is also in consideration, likely to enter the generation portfolio in the short-term with the resumption of crude oil production in South Sudan oil fields. The country also has an ambitious long-term plan to develop three hydroelectric plants along the Nile (see Fig. 69). The first, Fula project, some 30-35 kms from the Ugandan boarder, has the capacity to generate 890 MW, which will be a massive increase, compared to current consumption levels. The second project, Shukoli, is 40-45 kms from the Ugandan boarder, has the capacity to generate 230 MW. The third, Lakki project, has 410 MW capacity. If the development of these hydroelectric projects become a reality, they will bring significant improvement to the current capacity, from a clean energy resource. These hydroelectric projects on a trans-boundary river, the Nile, are likely to face challenges from upstream

countries of the Sudan and Egypt. For further discussion of developing trans-boundary water resources for hydroeclectric generation and governance challenges, see related chapter in this report.

Figure 69: Planned hydropower generation of South Sudan.



Source: Ministry of Electricity and Dams, 2012.

It is clear that there is vast need to expand access to electricity to meet current demand. Assessment of demand and supply conditions in all state capitals revealed that a serious power deficiency exists in all 10 State capitals. The gap is largest in the three main state capitals of Juba, Malagal and Wau (see Table 16). Juba needs an immediate relief with supply of up to 40 MW power, and 12 MW in Malakal and 13 in Wau. The gap in most of the remaining state cities is assessed at 2 MW. With population growth and the demand from economic expansion, the power deficiency is likely to remain a structural problem, calling for immediate expansion of capacity either through boosting domestic generation, and/or electricity imports.

Table 16: Supply and demand condition in the power sector of South Sudan.

State Capitals	Current supply MW	Current demand MW	Suppress demand MW
Juba	10	50	40
Malakal	3	15	12
Wau	2	15	13

Bor	2	2	0
Yambio	0	2	2
Rumbek	0	2	2
Kuajok	0	2	2
Torit	0	2	2
Aweil	0	2	2
Bentiu	3	5	2

Source: South Sudan Energy Sector Needs Assessment Study.

Installed capacity upgrade investment plans are already in the works to install power in excess of current demand. The plan would see power supply at par with demand in Juba (with 40 MW expansion plan), 15 MW each in Malakal and Wau, and a planned 5 MW expansion in each of the state capitals (see Table 17), along with distribution network and network reinforcement investments.

Table 17: Short-term investment programmes.

State Capitals	Generation	Distribution	Network Reinf.
Juba	40 MW	-	45 km, 33kv and 30 km, 11kv
Malakal	15 MW	-	45 km, 33kv 30 km, 11kv
Wau	15 MW	-	45 km, 33kv and 30 km , 11kv
Bor	5 MW	30 km, 11 kv and 60 km, 0.415 kv	
Yambio	5 MW	30 km, 11 kv and 60 km, 0.415 kv	
Rumbek	5 MW	30 km, 11 kv and 60 km, 0.415 kv	
Kuajok	5 MW	32 km, 11 kv and 40 km, 0.415 kv	
Torit	5 MW	32 km, 11kv and 40 km, 0.415 kv	

Aweil	5 MW	32 km, 11kv and
		40 km, 0.415 kv
Bentiu	5 MW	32 km , 11kv and
		40 km, 0.415 kv

Source: South Sudan Energy Sector Needs Assessment Study.

Table 18: Number of connected customers in South Sudan state capitals: 2005-2010.

State capitals	2005	2006	2007	2008	2009	2010
Juba:						
Domestic			4190	4521	5192	6288
Commercial			1214	1435	1808	2306
Governmental			243	263	278	346
Malakal:					4000	4000
Wau:					2553	2553
Bor	0	0	0	0	0	0
Yambio	0	0	0	0	0	0
Rumbek	0	0	0	0	0	0
Kuajok	0	0	0	0	0	0
Torit	0	0	0	0	0	0
Aweil	0	0	0	0	0	0
Bentiu	0	0	0	0	0	0

Source: South Sudan Energy Sector Needs Assessment Study.

These investments will help relieve short-term demand pressure, and ensure increased access to electricity, but the challenge of expanding connections nation-wide, including rural electrification, from the current meager level (see Table 18) to a much enhanced state will remain to be a major challenge and constraint to economic revival of South Sudan. Large-scale investment ventures in the country face the prospect of self-generation, at least in the short-term, but integration of planned capacities can alleviate such constraints in the medium- to long-term.

4.1.3.2 Energy Access – Lessons from South Sudan

The new state of South Sudan offers lessons on energy access expansion. With limited energy development, but significant potential, investment and socioeconomic development in the country has met energy constraint. The following are lessons from South Sudan case:

- *Energy shortages and deficiencies will trigger an "all of the above" strategy to energy development*: electricity access in South Sudan is at 1%, and there are high expectations among the citizenry of an independent State to see economic development. High

expectations and low energy development seem to have encouraged policymakers to adopt the development of all energy sources in the country, including the burning of crude oil to generate electricity. Prioritization of *green energy* development has met the reality of need to expand capacity massively. Confronted with this challenge, a hydroelectric and other renewable sources are in play, but there is serious consideration to bring forth crude oil powered power plants that utilize indigenous resource. This lesson is transferable to the sub-region where lack of energy planning and development for decades has left an energy deficit that can induce a generation portfolio choice that is more flexible and can be put in place quickly – thus the preference for thermal generators. Without proper energy sector planning, future energy portfolios may not be characterized by the abundant energy potential of the region – *green energy*.

- *Sub-regional energy trade can offer relief and affordable energy supply*: expanding energy access in South Sudan, form the current 1% level, based solely on domestic capacity development, will take time. This recognition and the need for immediately availability of electricity to fuel development in the country has led policymakers to consider energy trade, with Ethiopia. A Memorandum of Understanding (MoU) is now reached between Ethiopia and South Sudan to supply initially 50 MW of power to Malakal, with long-term plans of 100 MW, potentially extending to Juba. Energy trade, and its potential to bring low cost energy, is a realistic possibility.

- *Institutions and domestic financial mobilization do matter*: South Sudan has engaged the energy sector through putting in place institutions to regulate and develop the sector. Aspects of generation, transmission and distribution are legally delineated, and institutionally overseen, and no power generation and sale can take place without licensing. While these are necessary steps for a new State. There are challenges with administration of rate revenues (where not all of it is available back to the energy sector), and not all energy consumers do pay for services. These indicate the need for strengthened energy sector institutions and enforcement of laws. However, the setting up of the Rural Electrification Fund, through appropriations and levy on bulk power purchase (and grants and loans) will put focus to access expansion in rural areas. The willingness of the State to devote budgetary and tax resources to fund rural electrification is a strategy that wqill induce expanded rural electricity access. These lessons highlight the importance of strengthened energy sector institutions, enforcement of the law and political willingness to mobilize domestic resources for expanded energy access.
- *Within a massive power deficiency system, off-grid energy solutions offer real choice*: the existing level of meagre energy development in South Sudan necessitated no national grid system, and existing lines are not significant in length. This posed the challenge of developing a massive electricity grid network for the country, or pursuing a mix of improved grids with decentralized power systems. South Sudan adopted the second strategy, at least for the short- to medium-range, to develop power in State capitals and rural areas with isolated grids. The long-term plan foresees interconnecting mini grid systems. The lesson from this experience is that when energy access levels are low, as they are in most of the sub-region, and the national grid rich is limited, off-grid energy access options offer a compelling alternative.

- *Private sector engagement in the transmission and distribution business will face a hurdle*: the Electricity Bill and the national energy policy paper clearly indicate that power generation, transmission and distribution are in the domain of the public sector, though private sector intervention is invited in power generation. South Sudan clearly asserts, through legislation, that energy infrastructure is regarded as a critical strategic asset of national importance, and will be the asset of the Government of South Sudan, administered by the SSEC. The invitation of the private sector in generation is potentially beneficial policy, but private public partnerships in the transmission and distribution aspects of the energy sector require broader sub-regional experience sharing and policy dialogue.

4.1.4 The State of Energy Security and Key Lessons

4.1.4.1 The State of Energy Security

South Sudan exports two types of crude oil – the Nile Blend, conventional crude with low to medium sulphur content suited to most refineries, and the Dar Blend, heavy oil with impurities, including high acid content, posing storage difficulty but offers the advantage of lower sulphur content. Assessment of remaining reserves of South Sudan show that 45% is Nile Blend and 55% Dar Blend (see Table 19) distributed in different production sites (see Fig. 70). Blocks 1a and 1b are operated by Greater Pioneer Operating Company (GPOC), in Unity State, are Nile Blend, with estimated 0.06% sulphur content. Block 5A is operated by SUDD Petroleum Operating Company (SPOC), in Unity State, also Nile Blend. Blocks 3 and 7 are operated by Dar Petroleum Operating Company (DPOC), in Upper Nile state, producing Dar Blend with 0.1% sulphur content.

Table 19: Distribution of Nile and Dar Blend crude oil reserves, South Sudan.

Crude Type	Block	Reserves (mil. bbls)
Nile Blend	1a, 1b	582.30
Nile Blend	5A	180.97
Dar Blend	3, 7	763.27
Total		1,711.63

Source: Marketing report, Ministry of Petroleum and Mining, South Sudan, Vol. 1, July 2012.

Sales data post independence shows that export of the Nile blend is largely (63%) to Chinaoil, and Unipec (20%) and Arcadia (17%) sourcing the rest. Dar oil is largely sourced by Unipec, Chinaoil, Vitol and Petronile (see Table 20). The entire crude oil resource is for export market, no diversion to local and sub-regional markets. Lack of domestic refining capacity has contributed to the interest in seeing total export.

Table 20: Sale distribution of Nile and Dar Blend crude oil reserves, South Sudan.

	Nile Blend		Dar Blend	
	Volume (bbls)	%	Volume (bbls)	%
Chinaoil	3,611,410	63.3	8,242,767	29.6

Unipec	1,140,318	20	8,748,598	31.4
Vitol	0	0	7,200,291	25.8
Petronile	0	0	3,403,951	11.1
Arcadia	950,300	16.7	0	0
Tri Ocean	0	0	600,326	2.2
Totals	5,702,019	100	27,895,933	100

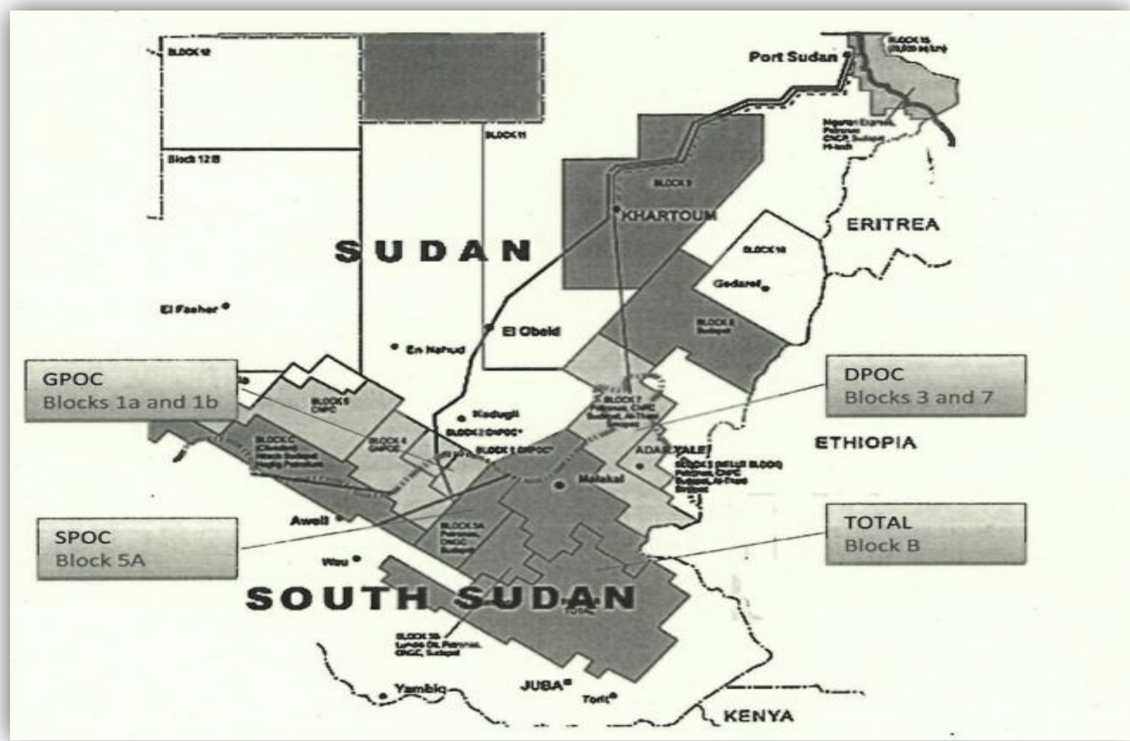
Source: Marketing report, Ministry of Petroleum and Mining, South Sudan, Vol. 1, July 2012.

The future production profile is increasingly dominated by Dar oil (see Fig. 71). Given current production sites, and no new reserves discovered and/or added to current finds, and an estimated 50,000 bblpd going to cost recovery, South Sudan production profile effectively lasts until 2025, with marginal production carrying through 2035. Further explorations and new reserve finds will alter this production profile.

South Sudan is an energy security paradox – the only country in the sub-regional with sizable crude oil production and export, but is dependent on imported refined petroleum products, making it 100% energy import dependent. The country has no crude oil refinery, and the dispute with the Sudan has terminated supplies from refineries in Khartoum, that can process up to 100,000 bbl/day.

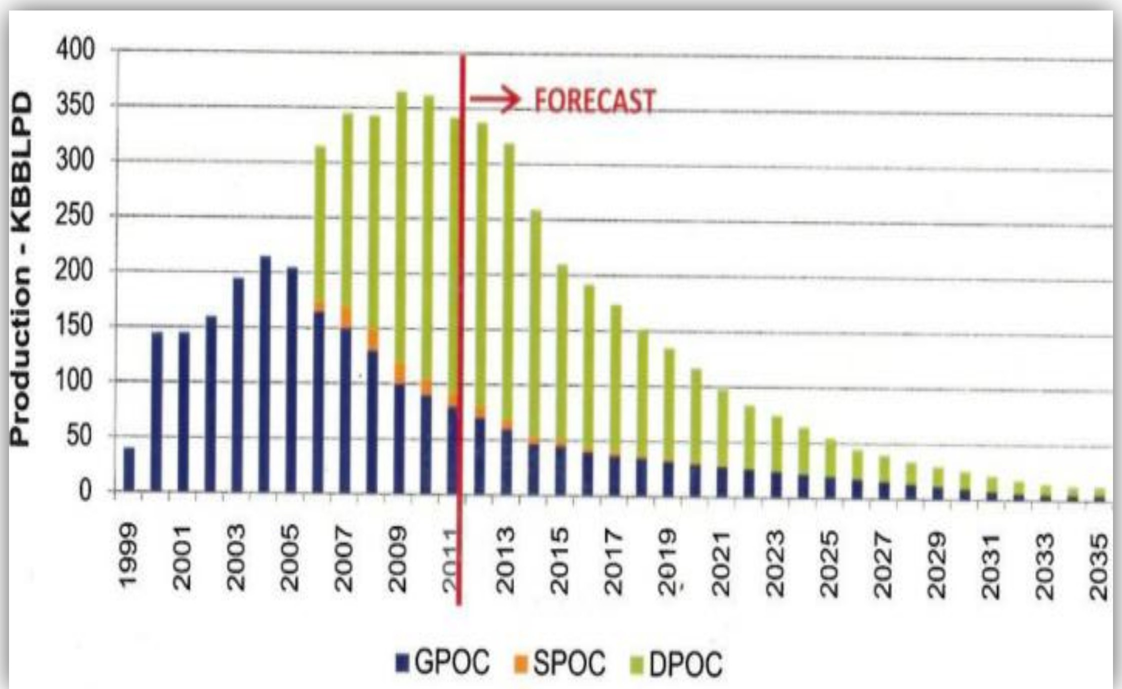
Recently, there are announcements of refining capacity developmental. A memorandum of understanding is signed with a Russian oil giant for the construction of the Bentiu Oil Refinery. Teh Tangrial Oil Refinery in Melut is also another project under consideration. Nonetheless, the conflict with the Sudan, the current lack of domestic refining capacity, poor road infrastructure for oil import routes from Kenya (particularly in the rainy seasons) and taxes and levies from Kenya already applied to the petroleum products, has left South Sudan in a vulnerable energy secure state. Lack of energy security management schemes such as energy security policy and framework and operationally strategic reserves has exposed the country to energy security vulnerabilities.

Figure 70: Crude oil production zones, South Sudan.



Source: Marketing report, Ministry of Petroleum and Mining, South Sudan, Vol. 1, July 2012.
Note: KBBLPD = thousands of barrels per day.

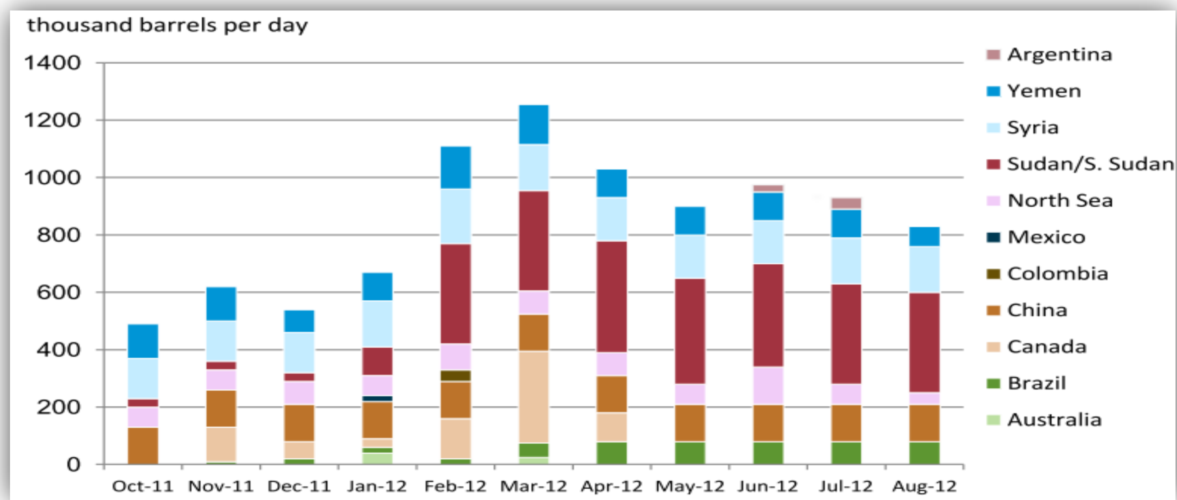
Figure 71: Crude oil production forecast, South Sudan.



Source: Marketing report, Ministry of Petroleum and Mining, South Sudan, Vol. 1, July 2012.
Note: KBBLPD = thousands of barrels per day.

Not only is South Sudan vulnerable to supply disruptions of petroleum products, production interruptions and eventual shutdown of its oil fields has been a main source of global crude oil disruption, along with the Syrian crisis, the Iranian crisis and events in North Africa and the Middle East (see Fig. 72). The closure of oil field in South Sudan starting February 2012 has been the largest source of crude oil supply disruption.

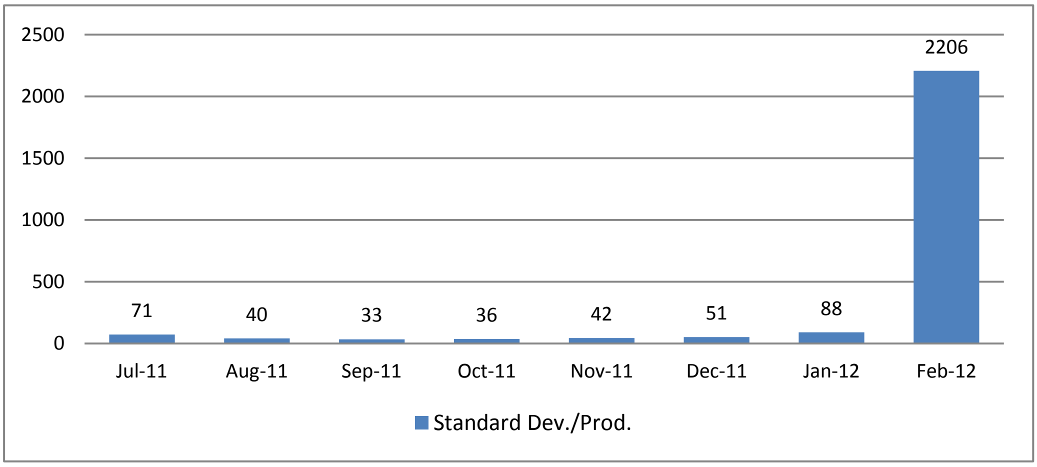
Figure 72: Global crude oil supply disruptions in non-OPEC countries: Oct. 2011 – Aug. 2012.



Source: US Energy Information Administration, 2012.

Crude oil producing countries are regarded as keeping a safe and secure flow of crude oil if the measure of their production standard deviation relative to the level of production is at 30 or lower. Since the independence of South Sudan until January 2012, the production volatility was above 30, and reaching 88 by January 2012 (see Fig. 73). In February 2012, it topped 2,206 due to the shutdown of production, increasing energy insecurity significantly, imposing global energy security implications.

Figure 73: Energy security assessment based on crude oil production volatility.

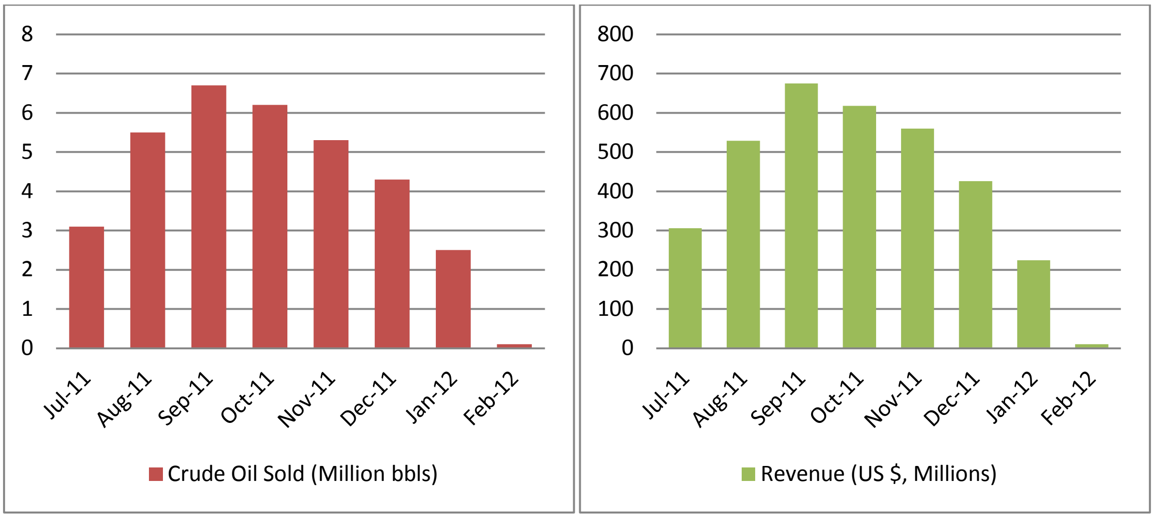


Source: Computation based on data from the Ministry of Petroleum and Mining, South Sudan.

The active conflict of South Sudan with the Sudan over dispute on crude oil transit fees through the Sudanese pipeline to Port Sudan (South Sudan believed the Sudan has

diverted crude oil illegally, while the Sudan attempted to justify that as payment for delayed oil transit fee) and over border delineation has led to the shutdown of crude oil production in South Sudan fields. This has resulted in the loss of revenue, estimated at over US$ 600 million in September and October, 2011, and nearly US$ 200 million in January, 2012 just before closure of the oil fields (see Fig. 74).

Figure 74: Production and sales volume of crude oil, June 2011-February 2012.



Source: Based on data from the Ministry of Petroleum and Mining, South Sudan.

4.1.4.2 Energy Security – Lessons from South Sudan

- *Cross-boarder and internal conflict will undermine energy security*: at the advent of independence for South Sudan, the country faced insurmoutable challenges, mainly conflict with neighboring Sudan. Inability to resolve the differences over oil export through the norther pipeline and breakdown of political engagements has led to severe energy security deterioration in the Sudan and South Sudan, reaching the global market. Sub-regional peace and security will remain one key determinant of the state of energy security in the sub-region. Effective institutional framework and operational transparency on crude oil export through pipelines between the two countries remain crucial.

- *Discovery and development of crude oil resource withouth domestic refininng capacity leaves energy security vulnerability*: the lack of refinign capacity in South Sudan, or a framework agreeement for a sub-regional refining capacity left the country import dependent. Developmet of oil fields empwoer contries through revenue generation that assist in domest development finance. However, oil resource development will need to be tied to domestic energy security challenges and regional opportunities, a lesson Uganda seem to have taken quiet well.

- *Lack of policy and operational framework for energy security will leave countries vulnerable*: the institutional, policy and operational petroleum products management in South Sudan has left it vulnerable in the face of 100% imported dependence. An active policy, institutional and oeprational supply disruption management regime will assuage such impacts.

4.2 ETHIOPIA

4.2.1 Background

Ethiopia is one of the largest countries in the sub-region, with an estimated population of nearly 90 million. Following decades of internal conflict to overthrough the Derg regime (the military-backed socialist Ethiopian government instituted in 1974), and external conflict with Somalia, a political transition led by the Ethiopian People's Revolutionary Democratic Front (EPRDF) saw establishment of the Transitional Government of Ethiopia in 1991. In 1994, a new constitution was adopted with a bicameral legislature and a judiciary system and established the Federal Democratic Republic of Ethiopia. Elections resumed since 1995.

The economy of Ethiopia is one of the fasterst growing in the sub-region. Between 2008 to 2011, the average growth rate was reported at 10.4%, growing at 11.2% in 2008, 10% in 2009, 10.4% in 2010, 10% in 2011 and a projected 8.6% in 2012 (ECA, SRO-EA, 2012)[22]. The source of the growth are improvements in the agricultural, construction and service sectors, growth in export and improved investment flows. Ethiopia also eyes the energy sector as a pole of its future growth, by agressively developing its hydroelectric potential to meet the energy import needs of the sub-region. A number of high-impact projects are already in the pipeline, expected to be brought into the energy system in the mid to later part of the decade.

Figure 75: The map of the Federal Democratic Republic of Ethiopia.

Source: Nations Online Project.
Note: The map is not updated to July 2011 to include South Sudan. For a map of South Sudan, see Fig. XXX.
The map is representative, and not authoritative.

[22] Economic Commission for Africa (UNECA), sub-Regional Office for Eastern Africa. 2012. "Tracking Progress on Macroeconomic and Social Development in the Eastern Africa Region: Sustaining Economic Growth and Development in Turbulent Times." UNECA, Addis Ababa, Ethiopia.

4.2.2 Energy Institutions and Policy

The Energy Policy of Ethiopia, first introduced in May 1994, during the Transitional Government, recognizes that "for a country's social and economic development, productivity growth, standard of living improvement, for agricultural, industrial and social services, the energy sector plays a key role."[23] It further recognizes that "the global awareness about the impact of energy crisis on economic growth and development is growing, and the import dependence on energy technology and fuels has left countries under the burden of energy-driven public debt." Therefore, "it has become necessary to devise energy policy for energy development, as well as for supply and use balance."

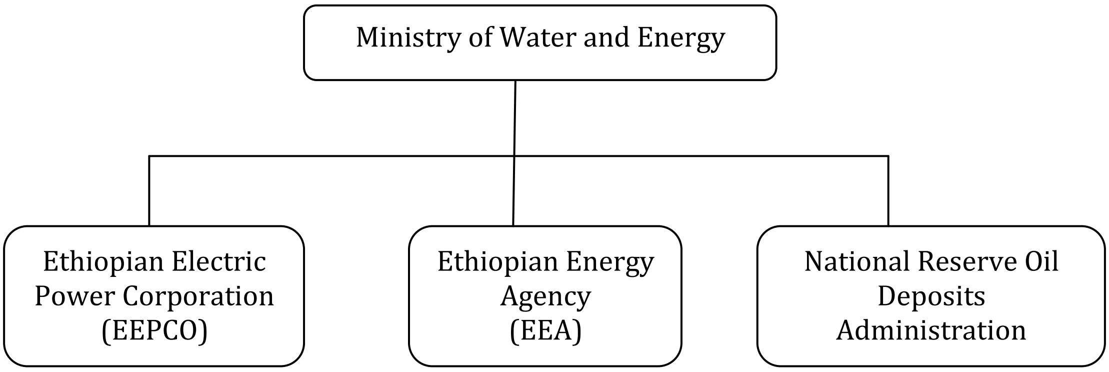
The energy policy states the following as key directions: (1) expanding hydroelectric power, particularly mini-hydro power, based on national economic and social needs; (2) encouraging exploration of oil, and development of natural gas; (3) expansion of reforestation and agroforestry; (4) putting effort to ensure that all sectors of the economy have access to alternative energy; (5) enhancing, in all economic sectors, energy efficiency; (6) ensuring that energy development is sustainable and does not undermine the environment; (7) ensuring that energy development and supply is based on the principle of "self-sufficiency"; (8) encouraging and creating conducive environment for private sector participation in energy development; (9) recognizing that energy shortage primarily affects women, enhancing the role of women in energy supply and use to save their time spent on energy source gathering that can be better spent on development; (10) linking rural development with energy sector development; (11) promoting energy science and technology; and (12) establishing energy policy coordinating and implementing institutions. The energy policy is sparse on matters of energy security, and energy security management schemes. It mentions the need to "ensure a reliable supply of energy at the right time and at affordable prices, particularly to support the country's agricultural and industrial development strategies adopted by the government." Reference is given also to the need "to replace, at least in part, transportation fuel with other energy sources produced within the country." However, key energy security strategies and management frameworks are not specified. Revision of the energy policy is currently underway, which is believed to bring forth key developments, including issues of energy security, access and the energy export strategy of the country.

The Ministry of Energy and Mines, which is subsequently reorganized and renamed the Ministry of Water and Energy, is given the primary role to monitor, coordinate and implement tenets of the energy policy. The mandates and responsibilities include development, planning and management of water and energy resources, development of policies, strategies and programs, development and implementation of laws and regulations, develop downstream petroleum operations and oversee rural electrification (formerly the responsibility of the Ministry of Agriculture and Rural Development), promote development of alternative energy, set standards for petroleum storage and distribution and determine volume of petroleum reserves and ensure its maintenance (Ministry of Water and Energy, 2011)[24].

[23] Quote based on authors' translation of the *Amharic* version of the policy document.
[24] Ministry of Water and Energy, Energy Study and Development Follow-up Directorate. 2011. "Brief Note on the Ethiopian Energy Sector." Addis Ababa, Ethiopia.

The institutional framework of the Ethiopian energy sector is based on a number of key institutions (see Fig. 76). The Ethiopian Electric Power Corporation (EEPCO), the Ethiopian Energy Agency (EEA) and the National Reserve Oil Deposits Administration (NRODA) are part of the Ministry's institutional capacity to implement the energy policy.

Figure 76: Institutional framework of the energy sector in Ethiopia.



- *Ethiopian Electric Power Corporation (EEPCO):* formerly widely known as the Ethiopian Electric Power Corporation (EELPA), since 1997, under Regulations No. 18/1997 is transformed to EEPCO. EEPCO is a public corporation which oversees and engages in power generation, transmission, distribution and sale through interconnected systems (ICS) and self-contained systems (SCS). About 98% of electricity is within the ICS. It is managed by a Board, and reports to the Ministry of Water and Energy.

- *Ethiopian Energy Agency (EEA):* also established through Regulations No. 18/1997, EEA is a regulatory body of the electricity sector engaged in issuing license, setting tariffs and supervising the generation, distribution, sale and import/export of electricity, along with energy efficiency and conservation programs.

- *National Reserve Oil Depots Administration (NRODA):* established by Proclamation No. 82/1997, it operates to maintain a reliable and sufficient national petroleum reserve of the country, to ensure security of supply.

The energy sector also has key institutions, within the Ministry of Water and Energy that are vital for the promotion of energy access and security. These include the Universal Electricity Access Program (which oversees universal electricity access activities), the Ethiopian Petroleum Enterprise (implementing fuel procurement and storage), Alternative Energy Technologies program (conducting research in technology development and adoption), and Rural Electrification Program (focused on expanding rural electricity access). Moreover, the Ministry of Finance and Economic Development oversees public finance for projects, the Ministry of Trade plays a role in petroleum pricing system, the Ministry of Mines takes responsibility of upstream hydrocarbon and geothermal resources exploration, and the Environment Protection Agency regulates environmental aspects of energy development, highlighting the need for inter-institutional collaboration.

4.2.3 *The State of Energy Access and Key Lessons*

4.2.3.1 The State of Energy Access

From the outset, it is important to clearly state that electricity access, including universal electricity access, is distinctly understood by policy makers in Ethiopia, and is measured differently. While universal access, or access, may generally imply connection of all households (universal) or connection of households in general, to electricity, the understanding is quite different in Ethiopia. Here, electricity access means bringing power to cities, towns and villages hence offering households the "opportunity to connect" if they can afford and choose to do so. Universal access implies that all cities, towns and villages are with access to electricity at that unit, and that all households in cities, towns and villages will have the *opportunity to connect* if they choose so. Therefore, if electricity is delivered to a city, town or village, all households are considered as having access, as the opportunity to connect, despite actual connections, exists. Electricity access discussion in this section is offered with this distinct definition in mind.

Ethiopia has embarked on an ambitious energy sector development strategy, largely focused on export markets in the sub-region. The Government has reported that in the 2005-2010 development plan and implementation period, the number of cities with *access to electricity* increased from 648 to 3,367, and the population with service coverage increased from 16% to 41%. Following the 2010 period, and the end of the preceding 5-years development plan, the Government introduced another plan for the 2011-2015 period, which it called the *Growth and Transformation Pla*n (GTP). With regard to electricity access, the plan stipulates the following targets: electricity population coverage to increase from 41% to 100% (universal access by 2015); increasing electricity generation capacity from 2,000 MW to 8,000 MW; reducing electricity distribution losses from 11.5% to 5.6% (close to international standard); increasing connections from 2 million to 4 million; increasing transmission lines from 126,038 kms to 258,038 kms; and re-building distribution line from 450 kms to 8,130 kms. The plan does not fall short on ambition.

The strategy is motivated by the energy resources potential of Ethiopia, which are quite significant, and enable export-oriented development strategy (see Table 21). The hydropower potential of Ethiopia is estimated between 30,000 to 40,000 MW (though some estimates show the economically affordable power estimate at 40% (CESEN, 1986)), currently exploited at barely 3%. Some 92% of electricity supply in the country is from hydroelectricity.

Though currently not part of Ethiopia's energy portfolio, it is believed that it has 113 billion m^3 of natural gas, 300 million tons of coal (EIGS, 2008) and 253 million tons of oil shale (Ministry of Water and Energy, 2011), currently under exploration. It has however made efforts to integrate solar (with potential of 4-6 kWh/m^2, particularly in northern Ethiopia) and wind energy (100,000 MW potential capacity) (see geographic distribution in Fig. 77). Wind capacity is highest in Mekelle region (northern Ethiopia) in Ashegoda, Harena and Aysha reaching wind speed of 8 m/s, Adama and Gondar reaching 6.64 m/s and 6.07 m/s, and Harar, Debre Berhan and Sululta with 4m/s potential (GTZ-TERNA, 2005). An estimated 5,000 MW geothermal capacity along the East African Rift Valley of Ethiopia offer additional resource capacity, currently bared exploited.

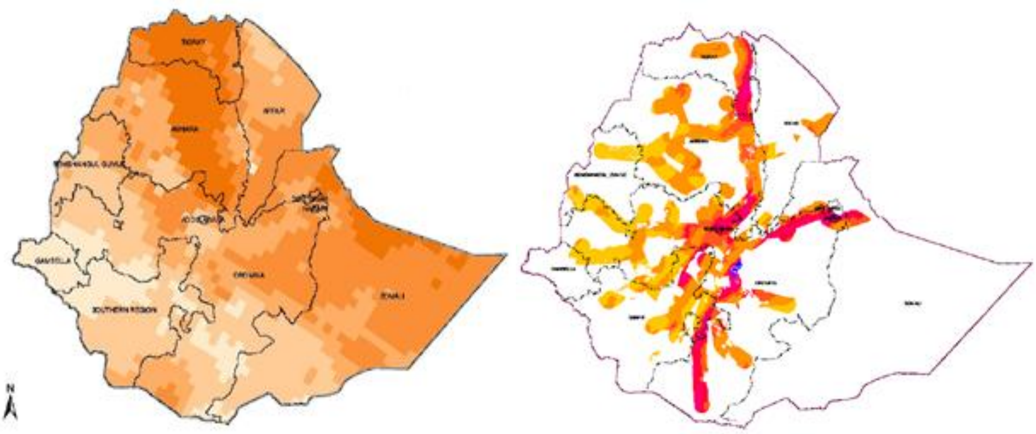
Table 21: Indigenous energy resources potential of Ethiopia.

Resource	Unit	Exploitable Reserve	Exploited	
			Amount	%
Hydropower	MW	30,000-40,000	~2,000	<3%
Solar/day	kWh/m^2	4-6		~0%
Wind:				
power	MW	100,000	120 MW	~0%
speed	m/s	> 7	Under construction	
Geothermal	MW	5,000	7.3 MW	~ 0%
Wood	Million tons	1,120	560	50%
Agricultural waste	Million tons	15-20	~ 6	30%
Natural gas	Billion m^3	113	-	0%
Coal	Million tons	300	-	0%
Oil shale	Million tons	253	-	0%

Source: GTZ and EREDPC, EEPCO, MME, EIGS and SWERA.

In addition, Ethiopia also eyes its biofuel potential, particularly to displace imported fossil fuels. The Government has made available more than 3 million hectares of land to licensed developers. Starting in October 2008, the country started a fuel blending mandate as an experimental program in the city of Addis Ababa.

Figure 77: Solar (panel 1) and wind (panel 2) energy resources distribution in Ethiopia.



Source: Ministry of Water and Energy, Energy Study and Development Follow-up Directorate of Ethiopia.
Note: For the solar map, the darker image shows highest intensity. Intensity ranging from a low of 3,046 to a high of 7,307. For the wind map, power density ranges from lowest (light yellow) at 1-50, to medium (reddish) at 300-400, and highest (the blue) at greater than 800.

To exploit these energy resources to expand access and enhance export potential, Ethiopia has embarked on an aggressive energy resource development path. In hydroelectric potential development, it has implemented a series of projects since 2001 (Tis-Abay II, Gilgel

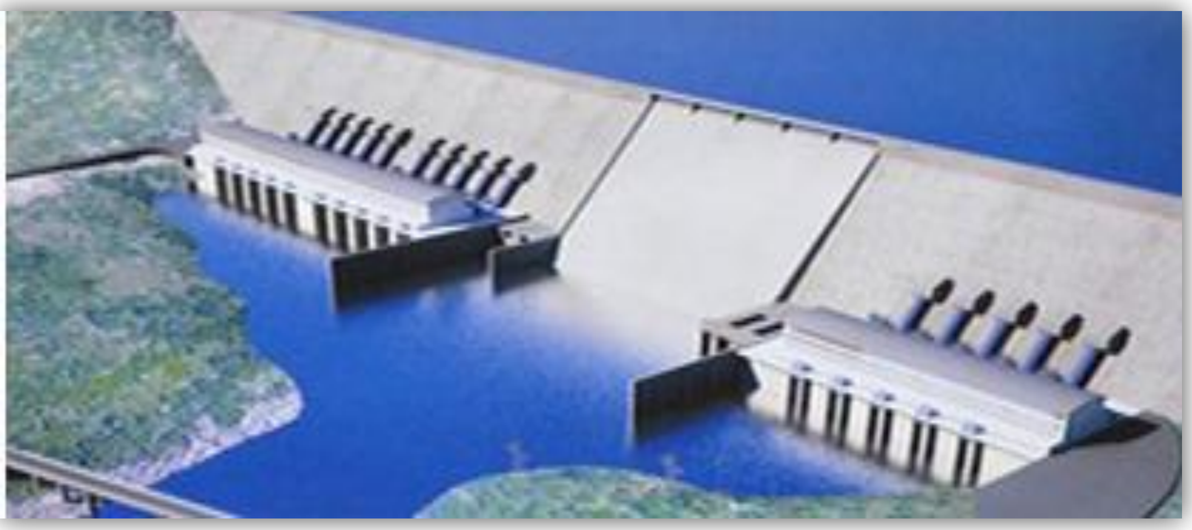
Gibe I, Tekeze, Gilgel Give II and Beles), and plans to bring even more power through mega upcoming projects (Gilgel Gibe III, Genale Dawa III, Chemoga Yeda, the Renaissance Grand Millennium Hydroelectric Power and others) (see Table 22). These projects are expected to raise the generation capacity from 2,000 MW to nearly 10,000 MW. The Renaissance hydroelectric project (see Fig. 78), with a generation capacity of 5,250 MW, will be the largest hydroelectric project in Africa, with water storage capacity of 66 billion m^3. Combined with the tapping of the Nile River for such project has drawn the attention of Nile upstream countries of the Sudan and Egypt, countries traditionally strongly opposed to development of the Nile outside treaty agreements, and have even resorted to the use of the threat of war and targeted strike of such reservoirs. Pressured with the demand for electricity to fuel development and agricultural use of water to meet food security, downstream countries are becoming increasingly vocal about their right to develop trans-boundary water resources outside the Nile water treaty, which they believe unfairly allocates the major use of all of the water to the Sudan and Egypt. For further discussion on trans-boundary water resources development for hydroelectricity, see the pertinent chapter in this report.

Table 22: Hydroelectric projects of Ethiopia: implemented and planned.

Project	Capacity (MW)	Year Operational	Investment cost in Mil. US$	Source of Finance
Tis-Abay II	73	2001	-	-
Gilgel Gibe I	184	2004	-	-
Tekeze	300	2009	-	-
Gilgel Gibe II	420	2010	-	-
Beles	460	2010	-	-
Gilgel Gibe III	1,870	~2015	1,700	Bilateral
Genale Dawa III	254	~2015	408	Bilateral, China
Chemoga Yeda	250	~2016	555	Bilateral, China
Renaissance Grand Millennium Hydroelectric Power Project	5,250	~2015	4,800	Domestic + bilateral
Other hydro projects	2,646	-	2,968	-

Source: Gebreegziabher, Z. and A. Mekonnen. 2011. "Sustainable Financing of Ethiopia's Energy Infrastructure: An Economic Analysis." Prepared for the 9th International Conferenc eon Ethiopian Economy. Addis Ababa, Ethiopia.

Figure 78: Renaissance Grand Millennium Hydroelectric Power Project.



Source: www.EEPCo.gov.et.

Solar energy development in Ethiopia is at around 6 MW, and much remains to be developed. But wind energy has taken relatively more quickly (see Table 23). The wind farm at Ashegoda, northern Ethiopia, has installed capacity of 120 MW, the largest such farm in the country, and one of the largest in the sub-region. Utility scale wind energy projects of Adama, Ayesh, Debre Berhan and Messebo are also examples of large scale development.

Geothermal energy, given its estimated potential of 5,000 MW, is currently marginally utilized in Ethiopia. The existing capacity is only 7.3 MW, thorugh the Aluto Langano Geothermal development. However, a number of feasible projects have been identified for potential development, including Aluto-Langano, Tendaho, Corbeti, Abaya, Tulu Moye and Dofan, potentially bringing 440 MW of new capacity (see Table 24).

Table 23: Wind energy development of Ethiopia.

Wind Energy Installed Capacity (MW)	
Wind Farm	
Ashegoda	120
Power Plants	
Adama	51
Ayesh	50
Debre Birhan	50
Messebo	51

Source: Ministry of Water and Energy, Energy Study and Development Follow-up Directorate, June 2011.

Bagasse energy, fuel based on the residual output of sugar factories, provides supplemental power in Ethiopia. The sugar factories of Metehara, Wenji and Fincha co-generate power for their consumption at installed capacity of 9.9 MW, 9 MW and 7 MW, respectively. Combined with ethanol production (discussed under energy security of Ethiopia later) constitute another source of renewable energy seeing increasing integration into the energy system.

Table 24: Geothermal energy development of Ethiopia.

Geothermal Energy Installed Capacity (MW)	
Aluto Langano Geothermal	7.3
Feasible Projects	
Aluto-Langano	75
Tendaho	100
Corbeti	75
Abaya	100
Tulu Moye	40
Dofan	50

Source: Ministry of Water and Energy, Energy Study and Development Follow-up Directorate, June 2011.

The Alternative Energy Development Program further aims to disseminate 9.1 million wood and charcoal making technology and improved cookstoves by 2015/16, the distribution of 300,000 solar lamps, 3500 solar heaters and 10,000 solar cookers, 3,000 wind energy water pumps by 2015 and 65 small-scale hydroelectric generation (Ministry of Water and Energy, 2011). These green energy efforts are part of the overall goal to transform the country into a climate resilient green economy by 2025 (Ministry of Water and Energy and SREP, 2012). Combined, the energy sector development of Ethiopia is likely to change the capacity and composition of the generation portfolio going to 2030 (see Table 25), while the energy sector is expected to remain predominantly sourcing *green energy*.

Table 25: Current and future generation portfolio of Ethiopia.

Type	Existing		2015		2030	
	MW	%	MW	%	MW	%
Thermal	79.2	6.9	79.2	1.4	79.2	0.57
Non-renewable Total	79.2	6.9	79.2	1.4	79.2	0.57
Hydro	1,850.6	92.5	10,641.6	90.8	22,000	87.26
Wind	-	0	772.8	4.8	2,000	4.05
Geothermal	7.3	0.6	77.3	1.4	1,000	7.49
Bagasse	-	0	103.5	1.6	103.5	0.63
Renewable Total	1,857.9	93.1	11,595.2	98.6	25,103.5	99.43
Total	1,937.1	100	11,674.4	100	25,182.7	100

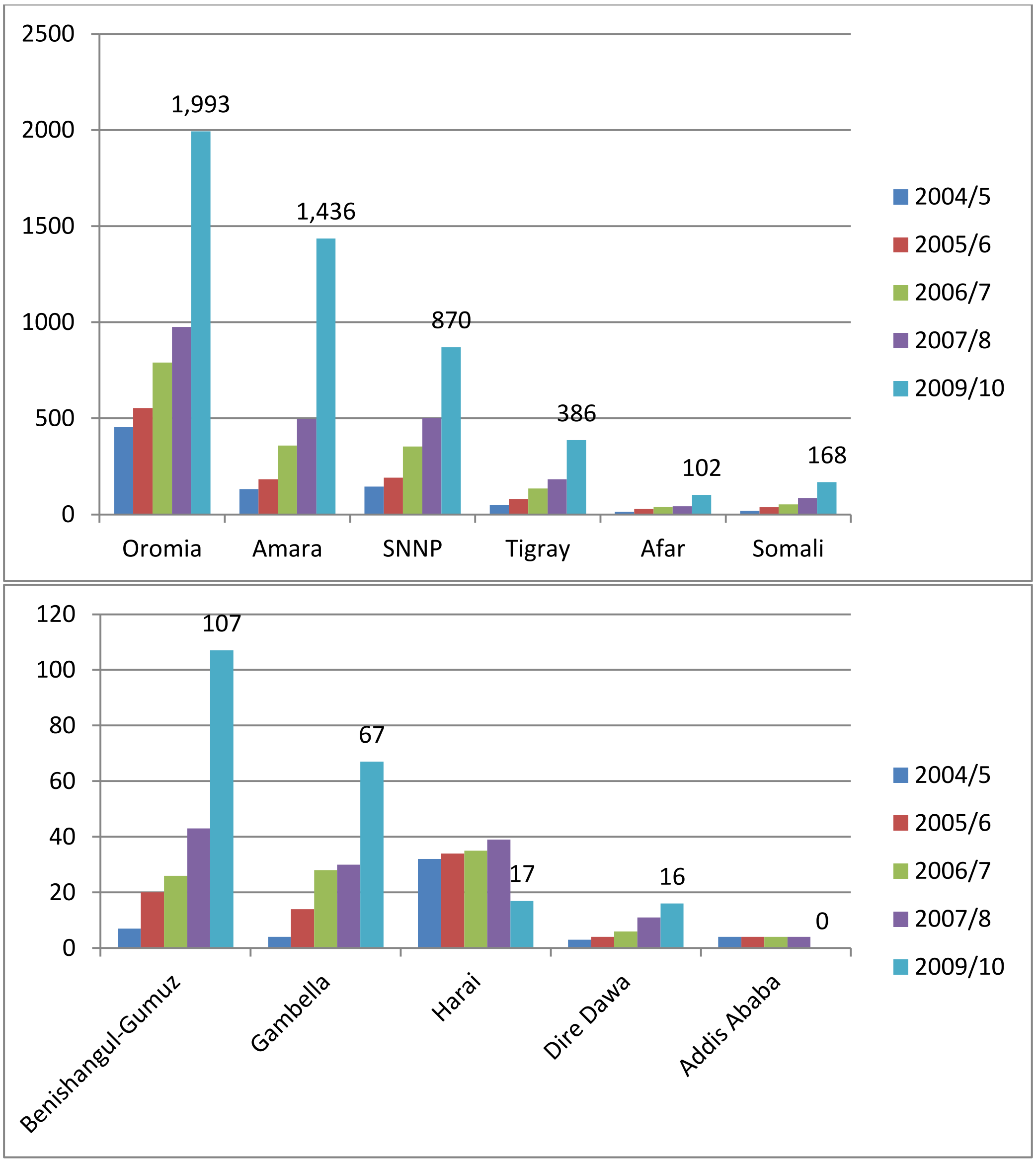
Source: Ministry of Water and Energy of Ethiopia and Scaling-up Renewable Energy Program (SREP). 2012. "Ethiopia Investment Plan." Addis Ababa, Ethiopia.

Significant expansion in power capacity of Ethiopia is expected to lead to two outcomes: enhanced electricity access in the country and increased electricity export to regional markets. In terms of access to electricity, there had been significant expansion in

electrified towns and villages from 2004/5 to 2009/10 (see Fig. 79). The number of electrified towns and villages are the highest in Oromia region (1,993 in 2009/10), Amara region (1,436) and Southern Nations, Nationalities and People (SNNP) region (870). The disparity by region is largely due to the decision criteria utilized by the Universal Electricity Access Program. The determination of which towns to electrify is an equity-based assessment, that partly considers the level of population in a region relative to the country and existing electrification rate, existence of health, education and other public service stations to anchor the access expansion and other considerations.

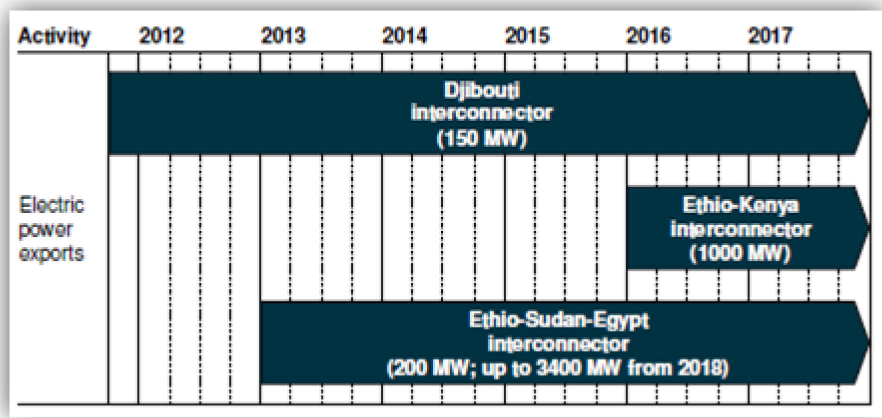
Energy capacity development in the country also eyes export markets in the region. The Djibouti-Ethiopia interconnection has already been implemented, and Djibouti imports significant amount of electricity relative to its needs from Ethiopian grid. The plan aims to continue a 150 MW export to Djibouti. The Ethiopia-Kenya interconnection, currently under construction, is targeted to come to full service in 2016, potentially enabling Ethiopia to export 1,000 MW of electricity to the Kenyan market. Negotiations are also underway to extend the network to Tanzania, to export Ethiopian power further south to Tanzanian market. The impact of gas find in Tanzania, and the potential integration of natural gas and its effect on the demand for Ethiopian power is not yet clear, but Tanzania seems interested to pursue a power import option, at least in the short- to medium-term. The Ethiopia-Sudan interconnection has already been finalized, and test power transfer is being conducted. The interconnection will come to full service shortly. The plan is to connect further north to the Egyptian power market. The initial export of 200 MW to the Sudan is likely to resume soon, and the plan targets Egyptian market with export potential of 3,400 MW by 2018 (see Fig. 80).

Figure 79: Number of electrified towns and villages in Ethiopia: 2004/5-2009/10.



Source: EEPCo, 2009.

Figure 80: Electricity export plan and implementation of Ethiopia.



Source: Ethiopia's Climate-Resilient Green Economy, Green Economy Strategy.

4.2.3.2 Energy Access – Lessons from Ethiopia

- *An active state prioritization and engagement in energy sector development matters*: the Ethiopian experience has clearly shown that prioritization of energy sector development, and active engagement of the State in energy sector positioning makes quite a difference. Ethiopia has set ambitious targets, and matches them with aggressive action that led to substantial increase not only in energy capacity, but also in expansion of domestic use and exports. Ethiopia is pressing forward with the same plan in the foreseeable future, which will likely make it an energy export center for the sub-region, while experiencing rapid capacity development. The lesson for the sub-region is that an engaged and active government is key, one that prioritizes energy sector development and sets ambitious targets and aggressive implementation. The financing aspect of the engagement, particularly domestic resource mobilization, also offers collateral lessons.

- *Balancing energy access expansion with export offers optimal beneficiation*: energy policy makers are often advised that large-scale development of energy potential is only viable under export scenario, to markets with better purchasing power to justify energy resource development. As a result, there seems to be export-bias in energy development in high-potential countries, often undermining domestic energy access goals. The Ethiopian experience demonstrates that a dual strategy can be viable. As shown earlier, both the export potential growth and domestic service expansion in the country are improving simultaneously. Therefore, energy resource development for export need not undermine efforts to achieve expanded access domestically.

- *Commitment to regional energy trade generates beneficial outcome for the sub-region*: trade is beneficial to freely participating agents, as the lesson of economics teaches. In the case of energy, it cannot be any more accurate. Energy export will bring Ethiopia hard currency that can be invested back in the sector, or utilized to finance its development. Importing countries can also benefit from cheap energy import which otherwise would have to be produced locally at higher cost, potentially undermining economic competitiveness, particularly in land-locked countries. The sub-region will benefit from reducing all barriers to energy trade.

- *Energy access will be accelerated through introduction of supportive institutional arrangements*: domestic energy access in Ethiopia is institutionally supported. There is Rural Electrification Program, Energy Technology Program and Universal Access Program, aside from traditional energy institutions. These added institutional capacity support specific targets, such as ensuring universal access targets. To countries in the sub-region with institutional gaps, the Ethiopian case study offers some perspective and applicable model.

- *Using centers of productive uses of energy to anchor energy access expansion is a useful strategy*: the decision to select towns and villages to electrify in the Ethiopian case is partly determined by the existence of productive uses of energy in towns and villages, such as schools, clinics, public administration offices, economic development activities and the like. By anchoring access expansion along these existing service centers that also provide public services, the dual objective of strengthening public service centers through energy access and supporting sustainability and affordability of connections are considered. Though ultimately the goal of universal access to electricity is to find solutions to deliver access to all households, anchoring the productive sectors as a spring-board for short- to medium-range energy access targets seems a model worth examining and considering. Ethiopia is not unique in this regard as many countries in the sub-region are utilizing a somehow similar approach.

- *How policymakers understand energy access to mean makes a difference in terms of household access*: the Ethiopia model of energy access expansion is not household-focused. It is towns and villages-focused. Therefore, policy makers assess that if a village is connected to the grid, all households in the village are considered as having access. This leads to different understanding of what *universal access* is, and Ethiopia has already declared that it will achieve that target by 2015. This is contrary to the global effort to expand access, at the household level, ensuring actual, not potential, connection of households. In this regard, the Ethiopian model is likely to face two challenges. One, economic development actually being dependent on households also having access to modern energy, a focus at the town and village level is likely to disregard this fact. This will lead to a series of connected towns and villages with potentially a sizable share of households still lacking access, though the State considers them as having "access". This will likely undermine the effort to see actual connections at the household level. Two, Ethiopia can learn from the rest of the sub-region in terms of accelerated efforts for expanded access at the household-level. Challenges of financing, initial connection cost, settlement pattern of households, intermittent income of rural households and the like are structural challenges for which countries in the sub-region are exploring innovative solutions. In this regard, Ethiopia can examine these experiences in the sub-region and expand its ambitious energy access program to include households, in line with the global agenda of universal access for all (households) by 2030.

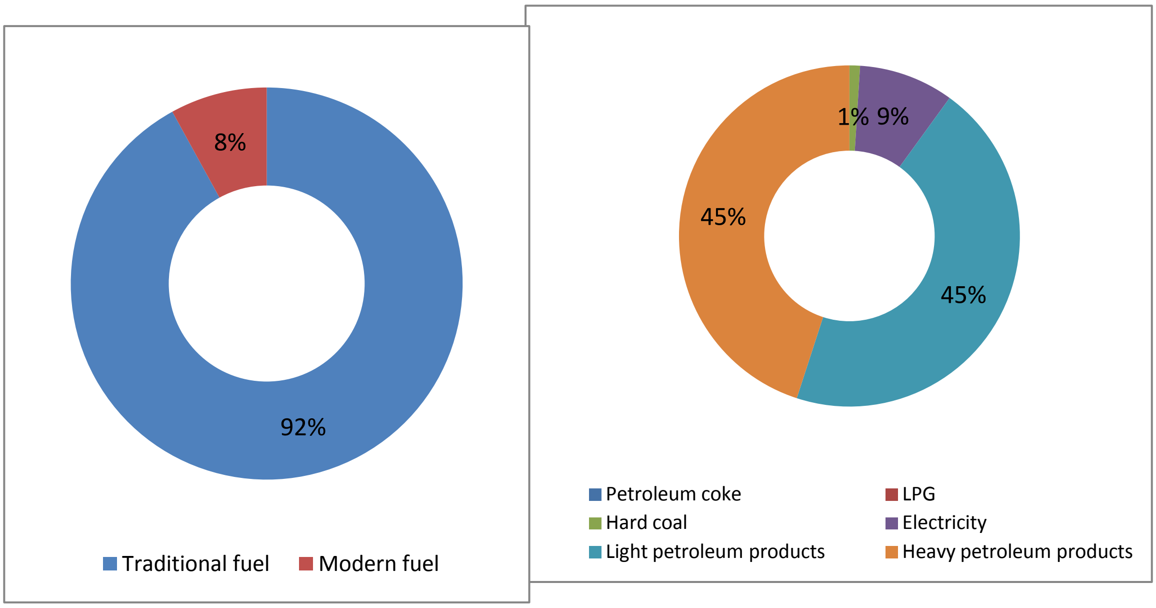
4.2.4 The State of Energy Security and Key Lessons

4.2.4.1 The State of Energy Security

Energy security depends on the structure and sources of energy to meet final energy demand in an economy for socioeconomic activities. The structure of energy consumption in

Ethiopia reveals that as many of the countries in the Eastern Africa sub-region is characterized by heavy reliance on traditional biomass (92%) and barely on modern fuels (8%) (see Fig. 81). Much of the 8% modern fuels utilized is imported, as electricity accounts for 9% of the 8% modern energy usage. The remaining 90% are in imported light and heavy petroleum products, and 1% on imported hard coal.

Figure 81: Traditional and modern energy usage structure - Ethiopia.

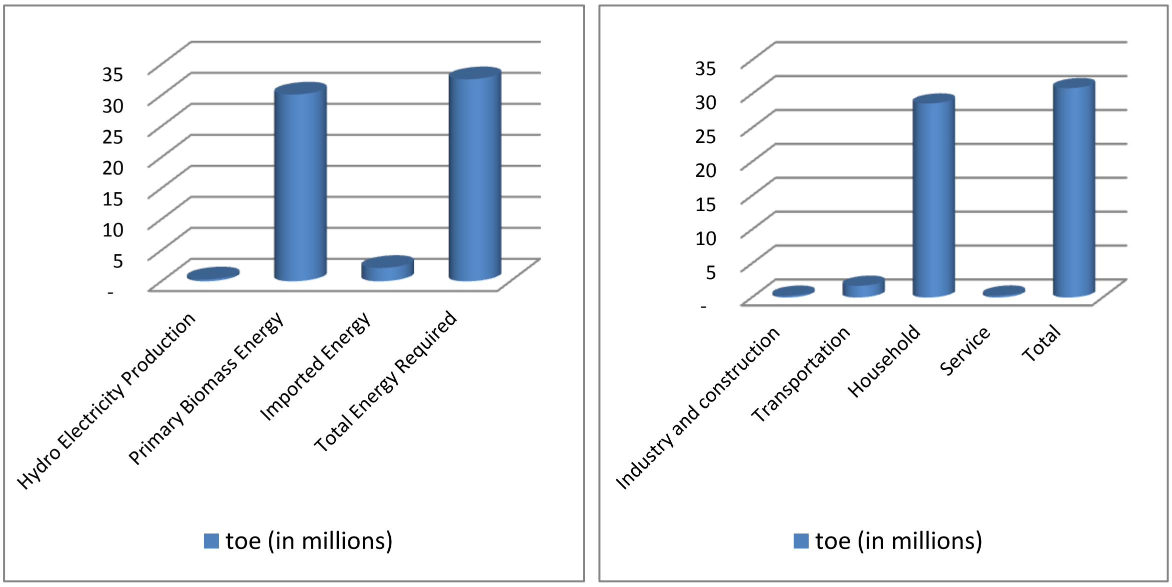


Source: Ministry of Water and Energy, Energy Balance and Statistics, 2011.

As a result, biomass accounts for a predominant share of total energy supply, followed by imported energy (see Fig. 82). Even though hydroelectric power expansion is quite signifciant, its share of total energy supply pales, and is still lower than the share of imported energy. The household sector is by far the largest energy consuming sector (using mainly biomass for cooking), followed by the transportation sector (using almost exclusively imported fuels, except recent efforts to integrate biofuels into the mix). The industrial and service sector demand a mach lower level of the energy share. Therefore, from energy security perspective, what happens to sustainable management of the biomass in the country, the trend in imported fuel dependece and progress in the electricity sector are areas to closely follow closely. In terms of biomass, detailed discussions are offered in the Environment and Energy Security Assessment chapters for the Eastern Africa sub-region. Findings suggest that rapid decline in forest bio-stock and growth in demand in Ethiopia, coupled with the largely unsustainable harvest are sources of serious concern for biomass-dependent household energy security in terms of continuity of sufficient supply and affordability of wood and charcoal, particularly in urban areas. The pace of transition to alternative indifenous green energy sources (such as electricity), integration of improved and efficient cookstoves as a mitigation technology, sustainable forest harvest and overall energy portfolio transition are going to remain structural challenges for Ethiopia.

In the electricity sector, efforts of the Government to rapidly expand generation from 2,000 MW to 10,000 MW by 2015, expansion of energy access to towns and villages and export infrastructure development and power delivery are areas of improvement. For domestic connected consumers, the reliability, affordability and availability of power is of prime energy security importance. Energy shortages in the last few years and repeated interruptions due to aging distribution infrastructure undermine the quality of electricity supply. But affordability is a key strength of the Ethiopian electricity sector, and to electricity consumers.

Figure 82: Energy requirement and consumption by sector.



Source: Ministry of Water and Energy, Energy Balance and Statistics, 2011.

The levelized generation cost of electricity is US$0.045 cents/kWh, the transmission cost is US$0.007/kWh, and distribution cost is US$0.014/kWh, making the leveled cost of power supply for the period 2011-2015 at US$0.067/kWh (Ministry of Water and Energy, 2012).[25] This makes Ethiopian power among the cheapest in the sub-region. Electricity tariff to consumers was revised in 2006, partly due to concern that the tariffs were inadequate to meet the cost of supply. The previous tariff structure remained without revision for 15 years leading to 2006. By 2006, a 22% tariff hike was introduced, keeping it at US$0.06/kWh (Ibid), with some variation by consumption type (see Table 26). Due to inflation, some argue that the real tariff today is around US$0.032/kWh. As a result, EEPCo has already submitted a request to the regulator, Ethiopian Electricity Agency (EEA) to revise the tariff to adjust to system cost recovery level to ensure financial viability of EEPCo.

To evaluate the likelihood of whether lower cost electricity, hence affordability, including to export markets, will continue or not depends on the cost of hydroelectric units in the system, including upcoming projects. Most of the large-scale hydroelectric developments have generation cost profile of at or below US$0.045/kWh, except Chemega Yeda (slightly

[25] Ministry of Water and Energy of Ethiopia and SREP. 2012. "Ethiopia Investment Plant." Addis Ababa, Ethiopia.

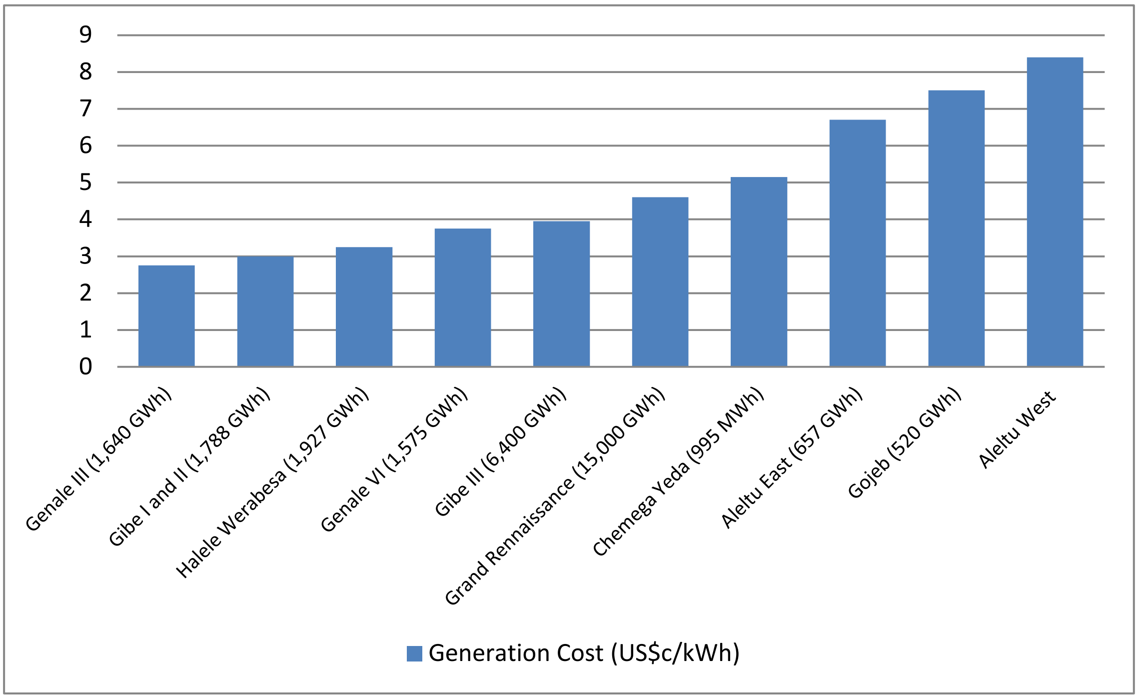
above US$0.05), Aleltu East (slightly above US$0.065/kWh), Gojeb (around US$0.075/kWh) and Aleltu West (slightly above US$0.0825) (see Fig. 83). Therefore, the bulk of capacity added will continue to remain at lower generation cost, with some projects introducing higher marginal costs. Therefore, the risk of higher generation costs for the bulk of hydroelectric generation in the short to medium-range are less likely, ensuring continued affordability of Ethiopian power for domestic and export markets, hence offering energy security buffer in Ethiopia and its electricity importing countries.

Table 26: Tariff structure from 2006 to present – Ethiopia.

Tariff Category	Consumption (kWh/month)	Tariff Rate (Birr/kWh)
Domestic Equivalent Flat Rate		0.3897
First Block	First 50 kWh	0.2730
Second Block	Next 50 kWh	0.2921
Third Block	Next 100 kWh	0.4093
Fourth Block	Next 100 kWh	0.4508
Fifth Block	Next 100 kWh	0.4644
Sixth Block	Next 100 kWh	0.4820
Seventh Block	Above 500 kWh	0.5691
General Equivalent Flat Rate		0.5511
First Block	First 50 kWh	0.4990
Second Block	Above 50 kWh	0.5691
Low Voltage Time-of-Day Industrial Equivalent Flat Rate	-	0.4736
High Voltage Time-of-Day Industrial 15 kv Equivalent Flat Rate	-	0.3349
High Voltage time-of-Day Industrial 132 kv Equivalent Flat Rate	-	0.3119
Street Light Tariff Equivalent Flat Rate	-	0.3970

Source: EPPCo, Corporate Planning Department.
Note: Exchange rate of the Birr against the dollar is 18.1597Birr per US$as of December 20, 2012 (data from National Bank of Ethiopia).

Figure 83: Generation cost profile of future hydroelectric generation portfolio – Ethiopia.



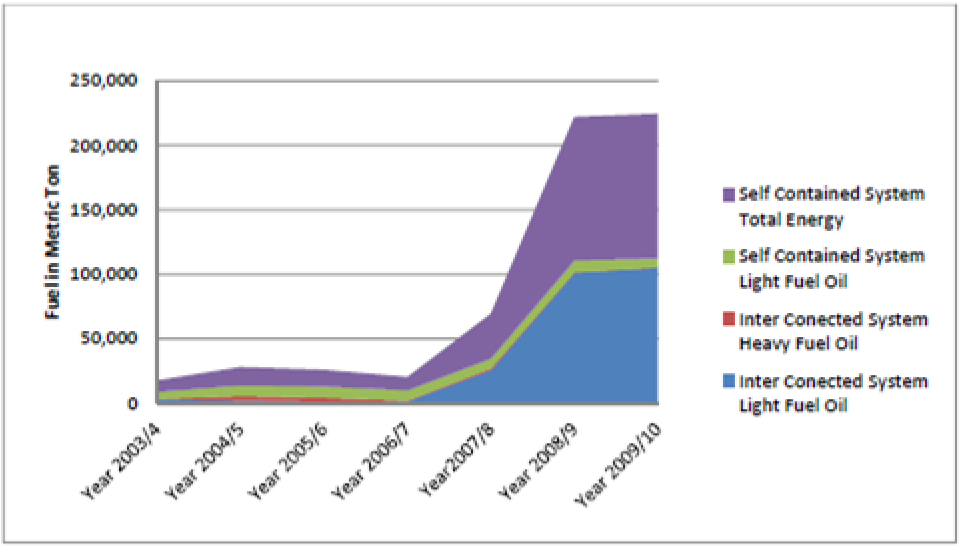
Source: EPPCo, Corporate Planning Department.

The risk to electricity supply domestically and in export markets is likely to come from weather and climate change related impacts. Ethiopia, along with hydroelectric producing countries in the sub-region, have been repeatedly impacted by draught and marked decline in volume of water flows, causing the marginal value of water to go up. Energy experts in Ethiopia believe that the network of watersheds (nine of them) that feed into the hydroelectric system are the most diverse in the sub-region, adding a layer of safety, compared with less diversified watershed systems, such as the Congo river. However, climate change, especially in draught prone areas such as the Eastern Africa sub-region, can have system-wide impacts that can hamper the security of supply of electricity in Ethiopia and its export markets.

Ethiopia's response to draught events in the recent past is demonstration of such risk. Following the draught of 2006, and water shortages in subsequent years, emergency power generation through rental thermal units had become common in much of the sub-region, including Ethiopia. Thermal fuel use for generating electricity in both the self-contained system (SCS) and the interconnected system (ICS) increased (see Fig. 84). Light fuel oil use in ICS increased sharply. Sustained draught conditions will therefore continue to pose energy security challenge in the electricity sector.

For export markets, the 14% per year electricity demand growth in Ethiopia and the 15% per year energy-intensive industries growth (Ministry of Water and Energy and SREP, 2012) can, in the absence of continued expansion of capacity, reduce available export supply. But given the short- to medium-term generation plans, this risk is likely to surface in the long-term, which may be fully mitigated if generation plans continue at full pace.

Figure 84: Consumption of fuel for diesel power plants - Ethiopia.



Source: Ministry of Water and Energy, Energy Balance and Statistics, 2011.

In the transportation sector, Ethiopia, as the rest of the sub-region, is fuel import dependent. Exposure to imported transportation fuel poses energy security challenges. Continual fuel supply and therefore energy security in the country faces numerous challenges.

- *Import dependence*: the complete import dependence of the country to transport fuel stocks exposes the country to price shocks, which makes it necessary to expend more hard currency reserves to import the same level of fuels stock, and with growing demand and increasing prices, the challenge to sustain fuel imports becomes apparent (see the Energy Security chapter to trace the economic impacts of fuel imports).
- *Landlocked country*: as a landlocked with no pipeline infrastructure, Ethiopia trucks fuel imports from the port of Djibouti, through inadequate road infrastructure. Trucking fuel hundreds of kilometers adds significantly to the cost of fuel, particularly to northern, western and southern parts of the country, undermining affordability further, particularly in an environment where fuel is sold at cost. The train connection with Djibouti is inadequate for fuel transportation, due to its narrow track, a technology from over 100 years ago. The decision of Djibouti to revise transit fees upwards has applied further pressure on affordability.

- *Price regulation and speculative behaviour*: petroleum price is regulated, and prices are revised at the end of each month. If the price, at the end of the month, is revised upwards, there will be windfall gains for distributors who still have unsold stock. The windfall gain is surrendered to the Government. On the contrary, there are reports that if prices are reduced downwards and there ware windfall losses, no compensation is given to distributors. This system has led to rampant speculation, and distributors prefer to keep their fuel stock at port in Djibouti before the revised prices are declared. This speculative risk management system of distributors, given windfall gain or loss management of Government, has introduced a series of temporary and artificial fuel shortages. It is commonplace to see fuel shortages at end of month as a result, undermining energy security.

- *Product adulteration and regulatory enforcement*: maintaining the quality of petroleum products is vital to consumers. Profit motives and lax regulation of standards has led to incidents of adulteration, which has caused concerns to regulatory institutions. The Ministry of Water and Energy is working on a new anti-adulteration bill to close loopholes. The lack of adequate enforcement presence at the distribution level will continue to be a problem, since the profit motive, with lax enforcement, offer sufficient incentive to continue to adulterate petroleum products.

- *Regional instability*: Ethiopia used to rely on oil refinery in the port city of Assab, in Eritrea. The refinery used to refine fuel supplies to both Eritrea and Ethiopia. In 1997, disagreements over fees and questions about the feasibility of continued operation led Ethiopia to pull from using the refinery, leading to significant draw down of needed refining capacity. Modernizing the refinery to meet the needs of both countries was being debated. When the Ethio-Eritrea boarder war broke out in May 1998, it completely severed Ethiopia's potential access to the refinery and the port facilities in Eritrea. Even though a legal decision has been given to resolve demarcation of their boundaries (the declared source of the conflict), following the Organization of African Unity (OAU) brokered and internationally endorsed *Algiers Agreement* both parties accepted as a framework to resolve their disputes legally, no progress has been made to restore normal relations between the two countries. Ethiopia continues to ask for dialogue and negotiation before implementing the demarcation decision by the international arbitration court, a position rejected by Eritrea, which calls for demarcation of the *final* and *binding* delimitation decision and subsequent dialogue to normalize relations. The dispute continues to severe access to Eritrean alternative port facilities to Ethiopia, particularly the northern part of the country that used to rely on the port of Massawa as an import and export route. Ethiopia also sources refined oil products from the Sudan. The dispute between the Sudan and South Sudan has led to termination of oil production, causing refining activities in Khartoum to be scaled-down, as a result ceasing fuel exports to Ethiopia. Mediation efforts by Ethiopia have led to an agreement, but there are concerns if the parties will continue to abide by the agreements reached in Addis Ababa in September, 2012. Instability in Somalia also led to rampant piracy, affecting maritime traffic, including to Ethiopia. Sub-regional efforts to tame the insecurity in Somalia have led to active military intervention. While piracy activities have been reduced markedly, following NATO anti-piracy activities in the Indian Ocean, the incidence nonetheless has continued at some rate. Regional instability impacts Ethiopia's energy security. A broader sub-regional effort to ensure peace and security will be productive to all member States.

Even though there are no known energy security response policies in the country, there are however operational safeguards to respond to energy security challenges. Ethiopia has a publicly managed strategic petroleum reserve, distributed in major cities such as Arbamench, Mekele, Addis Ababa, Bahr Dar and Dre Dawa. The main goal of the Government is to keep three months of fuel stocks to respond to disruptions. The global rise in energy prices has left maintaining such a stock challenging, given hard currency and budgetary constraints, and reserves are at around 45 days capacity. Aside from speculative holds of industries and commercial enterprises, private sector holdings are not coordinated and are outside regulatory oversight. The strategic reserve system contains an estimated 370 million

liters (370,000 m^3) of fuel. Population and economic growth have placed added pressure to the need to maintain an even larger fuel stock as an emergency buffer.

The second strategy pursued to deal with energy security of imported fuels is diversification. A Biofuels Development and Utilization Strategy was formulated in 2007 by the then Ministry of Mines and Energy (currently Ministry of Water and Energy). To enhance the role of biofuels in energy security, the biofuel development program seeks to: gain 195 million liters of ethanol by 2015; gain 1.6 billion liters of bio-diesel; earn US$ 1 billion in foreign exchange from biofuel export; increase blending mandate to 25% using 64.4 million liters of bio-ethanol for blending; enhance bio-diesel and diesel blending to 20% by using 621.6 million liters of bio-diesel for blending; and enhancing benefit from CDM programs (Ministry of Water and Energy, 2011).

By 2008, already a number of biofuel producers were operating in the country (see Table 27), particularly in the Benishangul, Amara, Oromia and SNNPR regions. Foreign investment in Ethiopian land has grown rapidly, including for biofuel production. Land deals can reach 100,000 ha and above, enabling large scale operation. There are issues of land use conflict, land right protection, community beneficiation, technology transfer and others being actively raised and debated, but the country seems intent in availing more land to investors and in integrating biofuels as part of the solution to import dependence on fossil foils.

Ethanol production of sugar factories is also part of the sector development plan. Ethanol production from Fincha is expected to grow from 8 million liters in 2006/7 to 18.6 million liters by 2011/12. The targest for Wenji/Shoa are from 12.245 million in 2007/8 to 25.153 million liters by 2011/12. By 2011/12, the plans for Methara and Tendaho are 24.48 million and 60.616 million liters, respectively (see Table 28).

Table 27: Companies growing bio-energy crops – Ethiopia.

Company	Region	Land Acquired (ha)	Out-growers Land (ha)	Crop Type
Sun Biofuels Eth/NBC	Benishangul	80,000		Jastropha
Anabasek Hastroph Project	Benishangul	20,000		Jastropha
Jastropha Biofuels Agro Industry	Benishangul	100,000		Jastropha
IDC Investment	Benishangul	15,000		Jastropha
ORDA	Amara	884		Jastropha
Jemal Ibrahim	Amara	7.8		Castor bean
BDFC Ethiopia Industry	Amara	18,000	30,000	Sugar cane/sugar beat
A Belgium Company	Amara	2.5		Castor bean
Flora Eco Power Ethiopia	Oromia	10,000	5,000	Castor bean

Petro Palm Corporation Ethiopia	Oromia	50,000		Castor/jatropha
VATIC International Business	Oromia	20,000		NA
Global Energy Ethiopia	SNNPR	2,700	7,500	Castor bean
Omo Sheleko Agro Industry	SNNPR	5,500		Palm
Sun Biofuels Eth/NBC	SNNPR	5,500		Jastropha

Source: Lakew, H. and Y. Shiferaw. 2008. "Rapid Assessment of Biofuels Development Status in Ethiopia." Proceedings of the National Workshop on Environmetnal Impact Assessment and Biofuels.

Ethiopia operates the only fuel blending mandate in the sub-region. The 5% ethanol mixing mandate, E5, is in operation in Addis Ababa for the last four years. A blending factory in Sululta offers standardized blended fuel for consumption in the city. There are plans to encourage importation of flexible fuel vehicles and courting Brazilian investment in biofuels and biofuel technology transfer. To fulfill this goal, 2.5 million hectares of land is set aside for investment, with 100,000 hectares in invested targeted land. The internal study of the Ministry of Water and Energy shows that biofuels are land-intensive. A 5% biodiesel production to displace diesel requires 50,000 hectares of land.[26]

Table 28: Biofuel development of Ethiopia.

Ethanol Production	2006/7	2007/8	2008/9	2009/10	2010/11	2011/12
Finchaa	8,000	8,000	17,000	18,600	18,600	18,600
Wonji/Shoa	-	12,245	17,809	20,836	25,153	25,153
Metehara	-	-	-	17,676	21,301	24,480
Tendaho	-	-	23,296	47,508	64,051	60,616
Total	8,000	20,245	58,105	104,620	129,106	128,849

Source: Asfaw, M.T. 2007. "Biofuels in Ethiopia." Presented at the Eastern and Southern Afica Regional Workshop on Biofuels, 28-29 June, Nairobi, Kenya.

Of the total import of fuel, 93% are diesel (60%), jet fuel (18%), kerosene, furnace oil and others, and 7% is gasoline.[27] Therefore, the current mandate targets displacing 5% of a 7% slice of the total imported fuel, and there is a share of the 7% consumed unblended outside Addis Ababa. As such, the impact of the current program on energy security mitigation is minimal. However, large-scale expansion of the program nationwide has the potential to deliver fuel displacement effects. The Government claims that the current program has already led to the saving of US$20 million per year. By such matric, the benefits of a scaled-up integration of biofuels will be sizeable.

[26] Data based on information from the Ministry of Water and Energy.
[27] Data based on information from the Ethiopian Petroleum Corporation.

4.2.4.2 Energy Security – Lessons from Ethiopia

- *Diversification*: Ethiopia's aggressive efforts to diversify its fuel mix by bringing in indigenous biofuel resources to bear are noteworthy. Large-scale experiments with biofuel programs, encouragement of bio-energy investors, utilization of sugar factories to produce ethanol and expanded efforts in biodiesel are all initial strategies of what seems to be a long-headed, Brazil-inspired, large-scale integration of bio-energy to displace imported liquids. The organization, operation and coordination of efforts from production, processing and distribution value chain can offer valuable lessons to member States in the sub-region with similar diversification strategy around bio-energy.

- *State presence and investment*: to enable effective diversification, the Ethiopian Government has introduced a mandate, E5 program, with a plan to increase the 5% mandate to the international best practice of 25%. The Government is utilizing its green policies as a vehicle to create demand for biofuels. The Government is also actively investing in ethanol production and processing, a factor that will increasingly be relevant as such operations expand significantly. An engaged Government, with policy ownership and investment has the capacity to alter the energy security future of a country – a lesson noteworthy to member States in the sub-region.

- *Infrastructure*: Ethiopia is considering various options to secure its fuel imports, including construction of a new oil-tanker compatible railway system connecting with Djibouti, considered the option of pipeline connecting it with the Sudan (a plan not actively pursued at present), considering refining and import capability of oil from South Sudan, and party to the Lamu Port and Lamu South Sudan-Ethiopia Transport Corridor (LAPSSET) project, connecting with Kenya. These infrastructure and energy access route diversification programs will enhance the energy security of the country. Landlocked countries in the sub-region with limited access and routes can consider this strategy as an option.

- *Operational effectiveness and speculation*: when it comes to strategic commodities as petroleum, operational effectiveness does matter, and speculation management proves useful. The operational management of fuel stocks in Ethiopia has lent itself to speculation, partly due to a monthly price setting scheme and handling of remaining stocks at the end of the month. Ethiopia applies a procedure that requires distributors to declare their end of month stock, and if prices are set high for the next month, the windfall gain is to be surrendered to government, but a case that will not apply compensation if prices are fixed lower than the previous month, exposing distributors to losses. A no windfall gain, but potential loss system creates incentive to manage distributors' risk through speculation. As a result, temporary and artificial fuel shortages are observed in Ethiopia. From fuel import to distribution to end users, an effective operational system that reduces the incentive for speculation will help reduce systemic fuel disruptions.

- *Regulation and enforcement*: adulteration of fuel products is a common problem in Ethiopia and the rest of the sub-region largely due to lack of effective regulation and enforcement. The challenge is such that it is requiring regulatory upgrade in Ethiopia. Adulteration of fuel impacts operation of vehicles and machineries, and diverts resources unlawfully from end users to illegal traders. To ensure quality and tackle adulteration,

strong regulatory oversight and enforcement of laws, through frequent random checks and hefty penalty, among others, can offer viable options.

4.3 TANZANIA

4.3.1 Background

The United Republic of Tanzania was proclaimed in 1964, following the independence of Tanganyika (1961) and Zanzibar (1963). Following the independence, the country had a marked legacy under the leadership of President Julius K. Nyerere, who was followed by the president of Zanzibar, Ali Mwinyi in 1985. Subsequent to the amendment of the constitution in 1992, Tanzania transitioned to a democratic system. In restoring the East African Community and advancing its goals, Tanzania engaged with Kenya and Uganda in establishing the regional parliament and court of justice in Arusha in 2001.

The economy of Tanzania is structurally similar to most African countries – reliant on agriculture, which accounts nearly for half of the GDP and a disproportionate share of export earnings. The mining and energy sectors are however becoming strong anchors of the economy. Tanzania in the 1990s was among the top gold exporters in Africa. Since the early 2000s, major discoveries of gas in shallow and deep-sea waters have confirmed the country's significant energy resources. Natural gas is already contributing to enhancing electricity production, and LPG off-shore production plans will generate finance that can support building the economy. The country has also introduced a series of reforms to encourage private sector participation in the economy and to create conducive environment for investment.

Figure 85: The map of the United Republic of Tanzania.

Source: UN Department of Peacekeeping Operations, Cartographic Section, Map No. 3667, Rev. 6 January 2006.

4.3.2 Energy Institutions and Policy

Tanzania is endowed with energy resources, demonstrated by the diversified energy supply source, albeit largely underdeveloped potential. Structurally, the energy profile of Tanzania is similar to the rest of the Eastern Africa sub-region, as 90% of total energy consumption is generated from biomass, 8% from petroleum products and barely 2% from electricity. Electricity consumption and access levels remain low. To improve on energy access, energy sector development and overall energy security, the country relies on its institutional arrangements to manage the energy sector.

The Ministry of Energy and Minerals is tasked with setting policies, strategies and laws for energy sector development, to contribute to the development of the economy. The Ministry states its mission as being "an effective institution contributing significantly to the acceleration of socio-economic development through sustainable development and utilization of energy and mineral resources in Tanzania by 2025." To meet these specific responsibilities within the energy sector, a number of institutions plays fundamental roles.

The Tanzania Electric Supply Company Limited (TANESCO) is a parastatal within the Ministry of Energy and Minerals. TANESCO is directly engaged in power generation, transmission and distribution. The utility company owns and operates most generation, transmission and distribution assets, directly supplying power to Tanzania, and to Zanzibar Electricity Corporation (ZECO).

To accelerate electricity access to rural areas, the Rural Electricity Agency was instituted in 2005, under the Rural Electrification Act. REA is tasked with improving rural access to modern energy, mainly the expansion of electricity access from a mere 2% in 2005 to a 2010 target of 10%. The Agency and its operations are funded by government appropriations to the Rural Electrification Fund, through loans and development partners' contributions.

The Tanzania Petroleum Development Corporation (TPDC) also a parastatal within the Ministry of Energy and Minerals. It was established in 1969, with operation resuming in 1973. TPDC is tasked with the promotion and support of petroleum development, including the exploration, development, productiona nd distribution of oil and gas in the mainland. The Corporation represents the government in shareholding in oil and gas enterprises. It is also mandated to deal with petroleum supply security and currently engaged in establishment of a public strategic petroleum reserves to manage short-term energy security in the mainland.

To supplement institutional capacity in the energy sector, the Ministry has launched special initiatives. The Biofuel Development Project (*Wendelezaji Wa Biofueli*) is one such Governmetn initiative in 2008, which, according to the Ministy of Energy and Minirals, aims to "put in place policy, legal, regulatory and institutional framework to support and regulate development of a sustainable biofuels industry of Tanzania." Similarly, the Energy Development and Access Expansion Project (TEDAP) (coordinated with TANESCO and REA) is a World Bank and GEF funded program that run from 2008 through 2012. The program aims to "improve the quality and efficiencty of the electricity service provision on grid, in the main three growth centers of Dar es Salaam, Arusha and Kilimanjaro and to establish a

sustainable basis for energy access expansiona nd renewable energy development in Tanzania.

These energy sector institutions are guided by the energy policies of Tanzania. The country has set its first National Energy Policy in 1992, which was subsequently revised in 2003 for reasons that both the energy sector and the overall economy has experienced structural change, and a revised policy consistent with these transformations was needed. The 2003 National Energy Policy explains this need for revision by rationalizing that "the role of Government has changed, markets have been liberalized and the private sector initiatives [need to be] encouraged."[28] One wholemark of the 2003 policy revision is the focus on market mechanisms to transform the energy sector, believed to help achieve " an efficienct energy sector with a balance between national and commercial interests." The revised energy policy states to have taken into consideration the following:

> The need to have affordable and reliable energy supplies in the whole country; reforming the market to failicate investment, expansion of services, efficient pricing mechanisms and other financil incentives; enhance utilization of indigenous energy resources; account for the environment and increase energy effiicency and conservation.

Tanzania's national energy policy is one of the most comprehensive policies in the sub-region clearly articulating specific energy policy goals in different economic sectors, laying energy access and energy security policy directions and actively encouraging regional trade and cooperation. In the Transportation, Manufacturing, Mining, Households, Agriculture and IT sectors, it lays, among others, the following energy policies:

> *Transportation sector*: promote energy efficiency; utilize more efficient modes and promote fuel switchintg from petroleum to other environmnetnaly friendly fuels.
>
> *Manufacturing sector*: ensure adequate energy supply; mandatory energy audits and regulated energy efficiency and conservation.
>
> *Mining sector*: ensure reliable supply of power to the mining sector.
>
> *Households sector*: encourage efficiency technologies; encourage altenrative sources of energfy for cooking, heating, cooling, lighting and other services; regulate safety standards of hsouhold appliances.
>
> *Agriculture sector*: ensure sufficient energy supply; encourage energy efficiency in irrigation and agro-processing; and encouraging development of appropriate energy technologies for agriculture.

Tanzania is among the severely impacted countries in the Eastern Africa sub-region by energy shortages. The effort of the Government in the last few years in this regard was devoted to significantly boost generation capacity and meet energy scarcity, while rationing exising supply. The National Energy Policy targets the folloing policy areas to enhance energy supply:

---

[28] Emphasis in brackets added.

> Introducing competition to the electricity market as a principle to attain efficiency; opening generation to both private (independnet power producers (IPPs)) and public investors; investment to be guided by financial and economic criteria; ensuring open access to the grid; prioritizing domestic power generation capacity based on indigenous resources; support for structural models of electricity distribution system will be given; introducing a governance model where policy and legislation will be undertaken by Government, regulatory functions by an independent regulator and other functions by private and public operators.

The National Energy Policy further sets the policy tone for renewable energy, rural energy and the development and exploitation of coal resources and coal-fired thermal plants, under environmental impact assessment and application of international and national environmental standards. Tanzania's policy is pragmatic and forward looking in recognizing the potential of regional energy trade and cooperation, and seeks to "increase collaboration within the East-African countries, SADC and non-SADC Strates with emphasis on future interconnections." It further calles for "collaboration in research, excahnge of data, information and documentation."

With respect of petroleum and natural gas, emerging sectors in the country, the policy intents include the following:

> *Petroleum*: safeguarding security of supply through supplier diversity; exploration of petroleum and regional and international cooperation in exploration, development of infrastructure, trade and capacity building.
>
> *Natural gas*: promoting natural gas exploration and exploitation; promoting market development and establishing appropriate regulatory frameworks for the industry.

Tanzania also has specific Acts to formalize and structure the energy sector, incluidng the Petroleum Act of 1980, the Energy and Water Utilities Regulatory Act, the Rural Energy Agency Act of 2005, the Petroleum Act of 2008 and the Electricity Act of 2008.

4.3.3 The State of Energy Access and Key Lessons

4.3.3.1 The State of Energy Access

The state of energy access in Tanzania is quite low, at just 14% of national access to electricity. In rural areas, when the Rural Electrification Agency started operation in 2007 after the Rural Electrification Act of 2005, electricity access was at 2.5%. A baseline survey in 2011 showed access levels at 6.6%, largely due to the efforts of REA. The Ministry of Energy and Mines states that strong growth in the commercial, industrial, agricultural and residential sectors will cause electricity demand to triple by 2020. Electricity demand is increasing at 12-15% per annum, while generation is increasing at 6% annually (Ministry of Energy and Minerals (Tanzania), 2011). Therefore, not only is current access levels low, but energy demand for productive and household uses can pose a challenge to efforts to expand population access to electricity. Through the energy Medium Term Strategic Plan (2012/13-2015/16), the target is to increase power supply by 1,788 MW by 2015, through generate capacity enhancement of 160 MW in 2012/13, 970 MW in 2013/14, 300 MW in 2014/15 and 358 MW in 2015/16.

To better understand the state of energy access in Tanzania and its trends, power generation structure, distribution arrangement, the energy market and operation/management of the energy system need to be contextualized. In terms of the

structure of power generation, Tanzania has an installed capacity of 1,075 MW, with normally available capacity of 991.5 MW, including imported energy (see Table 29).

Table 29: Existing generation capacity of Tanzania.

Station	Installed Capacity (MW)	Normally Available Capacity (MW)	Firm Energy Capability (GWh)	Average Energy Capability (GWh)	Comments
National Grid					
Hydro					
Kidatu	204	200	601	1,111	Hydrological limitation
Kihansi	180	180	180	492	Hydrological limitation
Mtera	80	80	195	429	Hydrological limitation
New Pangani Falls	68	66	201	341	Hydrological limitation
Hale	21	10.5	55	93	Hydrological limitation & 1 unit is out
Nyumba ya Mungu	8	4	20	36	Hydrological limitation
Uwemba	1	1			
Total Hydro	562	541.5	1,252	2,502	
Thermal					
Songas	202	185	1,212	1,232	Availability >95%
TANESCO Ubungo/Wartsila	102	100	655	666	Gas supply defines availability
Tegeta	45	41	289	294	
Tegeta IPTL	20	20	140	145	
Symbion	75	75	525	535	
Total Thermal	444	421	2,821	2,872	
Total on grid	1,006	962.5	4,073	5,374	
Others not available in July 2011					
Tegeta IPTL	83	80			
Symbion	37	37			Ex-Dowans
Off Grid					
Thermal					
TANESCO Diesel Plants	36	16			Plants are old, supply shrinking
Mnazi Bay Natural Gas	12	4			Artumas IPP, soon to be increased to 18 MW
Coal	6	1			
Total off-grid	54	21			
Imports					
Sumbawanga (Zambia)	5	3.5			
Kagera (Uganda)	8	3.7			
Namanga (Kenya)	1.8	0.8			
Import capacity	15	8			
Grand Total	1,075	991.5			

Source: Based on TANESCO and Vernstrom (2010) data, compiled in the Final Report on Joint Energy Sector Review, 2011.

Of the total generation capacity normally available, 56.68% (or 562 MW) is based on hydro power, generated at the Kidatu, Kihansi, Mtera, New Pangani Falls, Hale, Nyumba ya Mungu and Uwemba hydro power plants, connected to the national backbone grid. At Hale and Nyumba ya Mungu, power capacity is at have the installed capacity. Draught in the

2006/7 and 2010/11 periods have undermined generation capacity quite sharply, and led to severe load shedding, necessitating power rationing.

Thermal generation from gas and fuel constitute 42.46% of the normally available capacity (444 MW installed and 421 MW normally available power) from Songas, TANESCO Ubungo/Wartsila, Tegeta, Tegeta IPTL and Symbion plants. Energy shortages and shortfalls from hydro generation have led to a legacy of increased thermal generation. A minimal amount of normally available power is imported from neighboring Zambia (3.5 MW), Uganda (3.7 MW) and Kenya (0.8 MW), constituting 0.8% of total power supply. The role of energy trade in energy access and energy market in Tanzania is nearly non-existent. TANESCO is the dominant utility corporation in the country operating vertically integrated generation, transmission, distribution and sale of electricity, providing nearly 96% of the country's supply.

Following the 2010/11 power shortage and load shedding, the Parliament asked for an Emergency Power Plan (EPP) to generate supplemental power by end of 2011, and a Technical Working Group under the Ministry of Energy and Mines prepared a rapid plan within three weeks (Joint Energy Sector Review, 2011). The plan calls for emergency generation of 572 MW, half of the installed capacity through the following plan: (1) providing fuel for the 80 MW IPTL plant; (2) contracting 37 MW from Symbion (due to lack of fuel operated by JetA1 fuel); (3) contracting 205 MW from Symbion bringing fuel plant from abroad (on JetA1 fuel); (4) contracting 100 MW of diesel generation from Aggreko; and (5) installing 150 MW fuel plant, plant operated by TANESCO (Joint Energy Sector Review, 2011). The power shortage emergency has pushed Tanzania into major expansion of thermal generation at formidable costs. The final report of the Joint Energy Sector Review (2011) states that while Songas electricity cost is at US$0.066/kWh, the thermal units cost range from US$0.30/kWh to US$0.43/kWh (see Table 30), a sharply higher cost. As a result, the cost of the EPP from August 2011 to December 2012 is estimated at TZS 1.241 trillion, financed through revenues (TZS 115 billion) the rest raised from government-guaranteed loans from local commercial banks.

Table 30: Costs of electricity from different plants.

Plant	Fuel	Non-fuel cost US$/kWh	Fuel cost US$/kWh	Total cost US$/kWh
Songas	Gas	0.0213	0.0551	0.0664
Symbion	Gas	0.0499	0.0250	0.0749
IPTL	HFO	0.0410	0.2594	0.3004
Symbion	Jet A1	0.0550	0.3188	0.3738
Aggreko	Diesel	0.0577	0.3701	0.4278

Source: Emergency Power Plan, Tanzania.

For the medium to long-term, therefore, a transition to cheaper electricity is vital for both the Tanzanian economy and for efforts to expand energy access in the country. Rising average costs will make maintenance of current tariff levels difficult without driving TANESCO into insolvency. Perhaps this is why TANESCO submitted to regulators (EWURA) a tariff upgrade application in 2010, granting an 18.5% increased, compared to the requested increase of 34.6%.

Table 31: Generation capacity addition of Tanzania: 2009-2033.

Plant	Fuel	Type	Capacity (MW)	Retirement Year
Tegeta GT	Gas	GT	41	2009
Tegeta IPTL	Fuel	Diesel	100	2010
Tegeta GT	Gas	GT	-	2010
Mwanza MS diesel	Fuel	Siesel	60	2011
Cogen	Biomass	Steaj	40	2011
Ubungo EPP	Gas	GT	100	2011
Wind	Wind	Wind	50	2012
Kiwira	Coal	Steam	200	2013
Kinyerezi Gas	Gas	GT	240	2013
Rusomo Falls	Hydro	Hydro	21	2015
Interconnector I	Import	Import	200	2015
Ruhudji	Hydro	Hydro	358	2016
Igamba 2	Hydro	Hydro	8	2016
Mnazi Bay	Gas	GT	300	2017
Mtwara	Gas	GT	12	2017
Rumakali	Hydro	Hydro	222	2018
Stieglers Gorge I	Hydro	Hydro	300	2020
Interconnector II	Import	Import	200	2021
Stieglers Gorge II	Hydro	GT	600	2023
Kinyerezi HFO	Fuel	Diesel	240	2023
Ngaka 1 and 2	Coal	Steam	400	2024
Mchuchuma 1 and 2	Coal	Steam	400	2025
Stieglers Gorge III	Hydro	Hydro	300	2026
Nyasa Coal	Coal	Steam	200	2027
Kakono	Hydro	Hydro	53	2027
Masigira	Hydro	Hydro	118	2028

Local Gas	Gas	GT	200	2028
Mpanga	Hydro	Hydro	144	2028
Local Coal	Coal	Steam	300	2029
Coastal Coal I	Coal	Steam	300	2030
Ikondo-Mnyera	Hydro	Hydro	340	2030
Coastal Coal II	Coal	Steam	300	2031
New Cogen	Biomass	Steam	40	2031
Taveta-Mnyera	Hydro	Hydro	145	2031
Coastal Coal III	Coal	Steam	300	2032
New Wind	Wind	Wind	50	2032
Coastal Coal IV	Coal	Steam	300	2032
CC LNG	Coal	Steam	174	2033
CC LNG	LNG	CC	174	2033
CC LNG	LNG	CC	174	2033
Total Additions 2009-2033			7,704	

Source: Power System Master Plan, 2009, by SNC-LAVALIN International.

A number of options are in the pipeline. The discovery and development of Tanzania's gas resources is one feasible option being explored, along with other energy sources. Going forward, Tanzania's generation energy resources are going to be largely coal, hydro, gas, fuel, LNG, wind, biomass and imported electricity. This can be seen from the generation plan from 2009-2033 (Table 31), based on the 2009 Power System Master Plan conducted by SNC-LAVALIN International for TANESCO. New generation capacity until 2015 will come from gas, fuel, biomass, wind and coal, adding a short-term capacity of 831 MW. From 2015-2020, five hydro projects with a combined capacity of 909 MW will be added, while gas will bring 312 MW capacity in this period. Between 2020-2030, coal will bring in a significant capacity of 1,600 MW along with six hydro projects expected to bring 1,555 MW. The 2030-2033 period will continue to see expanded coal and LNG capacity, with some wind and biomass, and a 145 MW hydro capacity.

Therefore, the future of Tanzania's technology and generation mix will lean more towards coal and gas resources, with significant expansion of hydro capacity and limited integration of LNG, wind and biomass resources, with no noticeable role of solar and other energy technologies. This portfolio choice will certainly have implications both to the average cost of electricity in the long-run, but also on the security of electricity supply and system stability. Future energy needs of Tanzania is going to rely much on domestic resources of water and natural gas, some coal, wind and LNG, enhancing energy security on electricity, but

the rapid expansion of non-hydro options is likely to drive costs up, particularly fuels, and coal if some of the coal will be imported.

Based on observation of capacity to be added between 2009-2033, 37.17%, the largest share, will come from coal (see Table 32), followed by a 33.71% new capacity coming from hydro. Therefore, the future energy generation portfolio will see integration of 1/3 hydro power in total added capacity. Natural gas, domestically sourced, will contribute to 11.54% of added capacity, along with a 5.17% capacity from petroleum products. LNG, wind and biomass will contribute to 4.96%, 1.29% and 1.03%, respectively. While energy trade and interconnection of Tanzania to Zambia and Kenya grids to access SAPP power and import from Ethiopia are widely anticipated, they are going to account for a mere 5.17% of total capacity, the same capacity as the country plans to generate from expensive thermal generations.

Table 32: Capacity added through 2033 by energy source and share of total new capacity.

Source of Energy	Number of Projects/Plants	Total Capacity from Source	% of Total New Capacity
Coal	10	2,874 MW	37.17
Hydro	12	2,609 MW	33.71
Gas	7	893 MW	11.54
Fuel	3	400 MW	5.17
Import (interconnection)	2	400 MW	5.17
LNG	2	384 MW	4.96
Wind	2	100 MW	1.29
Biomass	2	80 MW	1.03

Source: computed based on data from Power System Master Plan, 2009.

This has significant implication to energy access enhancement. Expanding 2,609 MW total capacity from hydro by 2033 will bring into the grid cheap electricity, but coal, gas, fuel, wind and LNG can range in prices per kWh, and since they account for nearly 70% of added capacity, affordability of electricity can be a game changer to energy access progress. Moreover, while addition of 7,704 MW is quite significant from existing capacity today, which is 1/7th, whether or not it will be sufficient to see near universal access to electricity is another question that needs to be raised.

While Tanzania has not yet committed to universal access to electricity by 2030, as the UN SEFA initiative encourages countries to do, given industrial and commercial demand growth in double digits per year, the possibility of vast access expansion potential remains in doubt. For example, new mining activities in the mines of Kabanga (by 2016), Mibongo (2016), Panda Hill (2016), Buckreef (2015), Geita (2012), Golden Ridge (2015), Bunyanhulu (2013) and Williamson Diamond (2012) will require a capacity of 145 MW (SNC-LAVALIN International, 2009). Demands from mining, other industrial and commercial activities is therefore going to tap part of the new capacity, taking electricity away from efforts to expand household connections, posing obvious tradeoffs.

The untapped regional energy trade can offer a window of opportunity to bring in additional energy capacity, along with the potential from gas based power from upward revised higher natural gas finds, confirmed after 2009. The fact that only 1,158 MW of

existing capacity will be expected to be retired by 2033 is good news for Tanzania (see Table 33). Moreover, the fact that retired capacity will not include hydropower, and will include other relatively more expensive technologies is also a positive note.

Table 33: Expected retirement of existing generation capacity until 2033.

Plant	Fuel	Type	Capacity (MW)	Retirement Year
Tegeta IPTL	Fuel	Diesel	100	2022
Kinyerezi Gas	Gas	GT	240	2023
Songas 1,2 and 3	Gas	GT	187	2024
Ubungo GT	Gas	GT	100	2029
Tegeta GT	Gas	GT	41	2030
Mwanza Ms Diesel	Fuel	Diesel	60	2031
Ubungo EPP	Gas	GT	100	2031
Cogen	Biomass	Steam	40	2031
Wind	Wind	Wind	50	2032
Kinyerezi	Gas	GT	240	2033

Source: based on data from Power System Master Plan, 2009.

The nuclear electricity option was not figured in with any capacity for the 2009-2033 power master plan, but it is a demand that has opened, including in the Master Plan. It considered the feasibility of integrating small to medium scale nuclear power capacity into the national grid, based on the country's potential uranium find explored by 20 or so companies. The Master Plan recognizes that uranium deposits have been identified in the Dodoma area at Handa and Bahi North by Mantra Resources, and in the Ruhuhu area around lake Nyasa by Uranium Hunter, Atomic Minerals and Western Metals companies, bringing the possibility that Tanzania may extract uranium commercially.

However, the Master Plan outlines the hurdles of technology, where medium scale nuclear facilities are still under development (e.g. by Eskom for 170 MW capacity and China for a 195 MW prototype), with uncertain cost, and that the Government does not have yet finalized policies on uranium and nuclear generation. With small and mid-scale nuclear prototypes developed in the 2015-2020 period, and with potential policy advancement in peaceful and civilian use of nuclear energy, the debate is likely to continue as one option for Tanzania, as is the case in Kenya where the regulatory and institutional frameworks are rather put forward, and to a limited degree in Uganda where medical and agricultural applications are undertaken at small scales, with debate likely to open in the energy realm.

Finally, it is noteworthy to bring the energy sector development and environmental challenges in Tanzania, and implications to energy access. The Joint Energy Sector Review of 2011 notes that large-scale hydroelectricity projects face environmental challenges, including the Malagarasi project (relocated to Rumakali) derailed due to snail species, the

Stiegler's Gorge (the largest such project) location being in a conservation area protected following the Algiers Protocol Heritage International, requiring legislative decision, and others. Sustainable energy development, keeping pace with energy sector development needs and environmental safety will continue to be a major challenge, requiring sophisticated balance. It is also important to recognize that energy sector development can greatly benefit from environmental and climate change opportunities. As much as environmental considerations have placed challenges, and at times constraints, to energy development, a number of energy projects have benefited from international climate finance, such as CDM. The types of CDM projects in the energy sector in Tanzania include land gas recovery, wind energy, waste energy, improved stoves, biogas development, hydroelectricity project, fuel switching project, biomass project and Jatropha stove project (see Table 34).

A proper balance between energy sector development, which needs expedited investment, and resource development, and sustainability and environmental management is in order, recognizing both the challenges that require reconciling, and the great opportunities to be leveraged. For more discussion and policy options on the environment and energy development and energy access, see pertinent chapter in this report.

4.3.3.2 Energy Access – Lessons from Tanzania

The Tanzanian energy sector experiences present a number of lessons to note for Eastern African sub-region member States, with implications to efforts to rapidly expand energy access. The following are notable lessons.

- *Indigenous energy sources dictate energy sector path*: as in the case of South Sudan and Ethiopia, the Tanzanian case shows that much of the new planned power will bring coal, natural gas and hydro potential, resources with which Tanzania is endowed. While in general green energy development is an ideal goal, available local energy resources dictate the energy sector development. The path is not necessarily green, or with lower environmental footprint, but brings much needed power based on local resources. In fact, Tanzania has placed policy priority on expansion of energy capacity through development of domestic resources, a fact visible from the low level of trade emphasis in its energy master plan to 2033. Efforts to utilize domestic resources is encouraging, and needs to be part of the plan for the future, but the role of trade requires a broader sub-regional strategy and engaged policy dialogue and development of trading frameworks. Efforts so far have largely been bilateral.

Table 34: CDM projects operational and in pipeline.

Project Title	Project Owner	Location	Capacity/ Output	Life span	Status
Land Gas Recovery "Mtoni Dumpsite" Dar es Salaam, Tanzania	Consorzio Stabile Globus & Dar es Salaam City Council	Dar es Salaam	2.5 MW and 202,217 t CO_2/year	10 years	Operational
Singida Wind Electricity Project	Wind-e-Tanzania	Singida	60 MW and 70,000 t CO_2/year	10 years	PIN approved
Sisal Waste	Katani Ltd	Hale -Tanga	5 MW and	7 years	PIN

Electricity Project			44,087 t CO_2/year		approved
Improved Stoves	TaTEDO	Arusha and Kilimanjaro	36,000 t CO_2/year	10 years	PIN approved
Arusha Biogas	CARMATEC	Arusha	3,728 t CO_2/year	10 years	PIN approved
Mwenga Hydropower Project	Mwenga Hydro Ltd	Iringa	4 MW and 101,762 t CO_2/year	7 years	PIN approved
Ruhudji Hydropower Project	Aldwych International Ltd	Iringa	1,980 GW and 1.21million t CO_2/year	7 years	PIN approved
Mafia Biomass Electricity Project	Ng'ombeni Power Ltd	Mafia	1 MW and 66,580 t CO_2/year	10 years	PIN approved
Mapembasi Small Hydropower Project	Natural Resources Development Ltd	Ihanga Village	10 MW	7 years	PIN approved
Ngombezi Small Hydropower Project	Mkonge Energy systems Ltd	Korogwe	3.2 MW and 12,189 t CO_2/year	7 years	PIN approved
Mbeya Cement Fuel Switch Project	Mbeya Cement Company	Mbeya	50,343 t CO_2/year	7 years	PIN in approved
Tanga Cement Fuel Switching	Tanga Cement Company	Tanga	17.5 MW and 84,673 t CO_2/year	10 years	PIN in progress
Sagera Sisal Waste Biogas Project	Sagera Ltd	Tanga	4 MW and 50,912 t CO_2/year	7 years	PIN in progress

Mtwara Energy Project	Artumas	Mtwara	40,000 t CO_2/year	7 years	PIN in progress
Sao Hill Energy Combined and Power Project	Sao Hill Energy Ltd	Mufindi	15 MW and 54,134.7 t CO_2/year	6 years	PDD not approved
Tanzania Jatropha Stove Project	Kiwia & Laustsen Ltd	Tanzania	45 MW and 40, 750 t CO_2/year	10 years	PIN not approved

Source: Based on data from Rural Electrification Agency, compiled for the Joint Energy Sector Review, Tanzania, 2011.

- *Energy planning, emergency generation and legacy cost*: Tanzania has been hard-hit by electricity shortages, driving the country to emergency generation, that is typically more expensive, by a margin of 3 to 4 times more costly. Most of the added capacity for emergency generation is met through thermal generation, partly arranged through rental capacity. This phenomenon has introduced expensive and less sustainable energy into the generation portfolio, costing the country dearly. Emergency generation, while triggered by demand growth and draught related hydropower shortfalls, leading to substantial load shedding; it is also a reflection of insufficient energy planning in the past to deal with such scenarios. Insufficient energy planning and necessitated emergency generation has changed the face of Tanzania's generation portfolio in the short to medium-term, posing legacy costs. Recent efforts to bring energy planning at the center of energy policy in the country are commendable, and efforts to shore up capacity by engaging a range of energy resource endowments in the country through policy and investment prioritization are notable best practices. Energy planning and energy security preparedness will continue to be vital to keep stable power supply and maintain low cost generation options, aspects key to expanding energy access and enhancing security.

- *Climate change and energy security*: repeated draught in the sub-region with much of the generation depending on hydro has presented a serious challenge to cheap energy resources in Tanzania, and much of the sub-region. It has led to load shedding impactful given limited excess reserve capacity in the system. Climate change and related draught incidents have long become an energy security issue requiring effective management frameworks, including portfolio diversification. While the future generation mix of Tanzania is heading towards more diversification, new hydro capacity coming to the system through 2033 will remain to be vulnerable to draught incidents. The Tanzanian case demonstrates the need to climate change adaptation and management schemes in the energy sector to reduce energy insecurity.

- *Under-leveraged energy trade*: Tanzania's energy master plan through 2033 reveals that of all the anticipated capacity, energy trade will constitute a little over 5% import, with no export plans. Low cost generation in countries like Ethiopia present notable opportunity for the sub-region, and new gas finds in Tanzania position it to potentially generate export-quality power. Both of these options are not sufficiently integrated into the power master plan of the country. This is also largely the case in the sub-region. The

potential contribution of the energy resource position of Tanzania in stabilizing domestic and sub-regional energy markets requires further look, particularly in an environment where energy access in the sub-region is expected to rapidly increase in the coming two decades.

- *Renewable energy and electricity*: Tanzania energy path will bring in much capacity in the coming two decades, but integrates minimal amount of non-hydro renewable energy, mainly from wind which will account a little over 1% of planned new capacity. Solar energy is barely considered into the master plan for the future, aside from rural electrification initiatives. In this regard, broader reach to renewable energy sources in the medium to long-term, particularly to expand access, will be required. To do so requires policy prioritization and provision of proper incentives, aspects that can be developed beyond the crunch of emergency generation. Developments such as the Tanzania Domestic Biogas Programme, the Transformation of Rural Photovoltaic Market project, development of guidelines for sustainable liquid biofuels development, Strategic Environment Assessment on liquid biofuels, as well as Biomass Energy Strategy and Rural Energy Master Plan development are however notable progress being made.

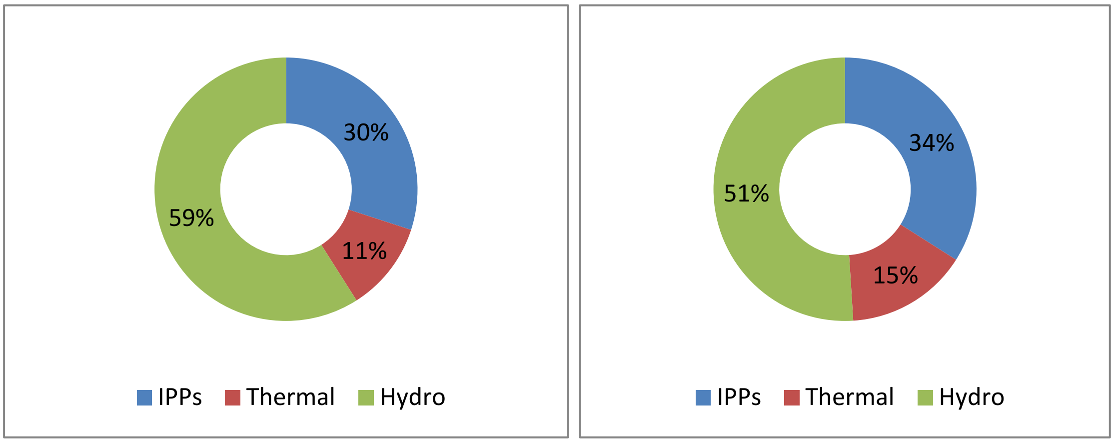
- *Energy sector reform, IPPs and TANESCO financial viability*: through the 1992 energy sector reform, Tanzania embarked on opening the energy sector to private investment, but have fallen short of liberalization efforts as seen in Uganda and Kenya which saw unbundling of generation, transmission, distribution and sale of electricity to a measurable degree. Transmission and distribution are largely within TANESCO, and the corporation is dominant in generation as well. Though the policy reform is in effect, in reality the energy market remains predominantly under the fold of the public sector. Generation, however, has seen increasing participation of the private sector, through IPPs and PPPs, particularly in meeting the country's emergency generation needs. The system, as in much of the sub-region, has internal trade-offs and challenges. First, reforming the energy sector has allowed the private sector to come into the market, but while energy capacity is supplemented through new investment, much of the power brought forth is from thermal generation, with higher per unit cost, driving the cost of energy in the system higher. Second, TANESCO has been required to purchase power from IPPs at costs commercially viable for the private sector, but not necessarily in sync with electricity tariff, driving TANESCO to financial insolvency. Third, EWURA, the regulator, reviews TANESCO tariff revision requests, but would have to balance affordability to consumers with commercial viability of TANESCO, ending up with tariffs that are not cost reflective, again pushing TANESCO to insolvency. Tariffs regulation in liberalized energy markets is an inherent challenge. The Tanzanian experience shows the need to look at the experiences of Uganda and Kenya on power sector liberalization, tariffs and energy market development. The issue of "socially appropriate tariffs" and "commercially appropriate tariffs" will continue to plague energy access and sector viability policy discussions. The Tanzanian experience highlights these challenges, which are also visible in much of the Eastern Africa sub-region.

4.3.4 The State of Energy Security and Key Lessons

4.3.4.1 The State of Energy Security

Energy security in Tanzania can be viewed from the vintage point of oil and gas, and from electricity and biomass use (the latter discussed in the environment chapter at length). With regards to electricity, short, medium and long-term challenges in the electricity sector, and their implications to energy access in the country are discussed earlier. They have energy security implications as well. Three general observations can be made about the evolving generation portfolio of Tanzania in relation to energy security: (1) the Master Plan for electricity through 2033, if implemented, implies that Tanzania will rely more on domestic energy sources to satisfy much of its energy demand, a positive step to enhancing energy security; (2) future expansion plans integrate fuels, albeit at around 5% of new installed capacity, but if current demand outpaces generation capacity enhancement, it is likely that fuel-based thermal energy will be part of the legacy, exposing the country to fuel-related energy security challenges; and (3) existing hydropower potential and the planned hydro capacity of 1/3 of the total through 2033 will introduce climate change related energy security vulnerabilities. These three factors, among others, will continue to shape the nature of energy security in the electricity sub-sector. Looking at the evidence from 2008/9 to 2009/140 (just one year) reveals that Tanzania's energy sector is in a rapid dynamics (see Fig. 86). During this period, the share of hydroelectricity dropped by 8%, which is replaced by IPP capacity enhancement of 4% and thermal generation expansion of 4%. This shift reveals two facts: (1) the reliance on hydroelectricity will continue to introduce power shortage risks; and (2) that emergencies are likely to bring thermal back to the picture without sufficient reserve capacity from cheaper and cleaner energy sources.

Figure 86: Transition of the Tanzanian generation mix: 2008/9 – 2009/10.



Source: Based on data from EWURA, 2010.

Another factor determinant of energy security in the electricity sector is the infrastructure. Transmission and distribution losses are indicative of system resilience and efficiency. Transmission and distribution losses are estimated at 20% in 2008, and 22.5% in 2009, but the Master Plan for electricity foresees losses dropping to 13% by 2033 (see Table 35). However, losses at or above 1/5th of generated power are quite high, quite costly and may add to the pressure to raising tariff on consumers, undermining energy affordability.

Table 35: Transmission and distribution losses actual (2008, 2009) and planned - Tanzania.

2008	2009	2010	2011	2012	2013	2033

Transmission	5%	4.5%	4%	3.5%	3%	3%	3%
Distribution	15%	18%	16.5%	15%	11.5%	10%	10%
Total Losses	20%	22.5%	20.5%	18.5%	14.5%	13%	13%

Source: Power System Master Plan, Tanzania, 2009.

Moreover, at the institutional and market reform level, there are uncertainties. While Tanzania's effort to reform the energy sector and bring private sector players is commendable, the reform remains to lock transmission and distribution largely within TANESCO, as well as much of generation, and integrates the private sector largely to bring in needed capacity, mainly in the form of thermal power. TANESCO's financial solvency difficulties will continue to pose energy security challenges, as a financially strapped utility is less likely to invest in system upgrade, infrastructure development and large-scale investment schemes necessary to bring in enhanced power capacity to expand access and improve on security. Efforts to tackle these issues and subject the energy sector to annual review are positive attributes, but institutional and market improvements are likely to continue to pose policy challenges to policy and decision makers.

In terms of oil and gas, the oil and gas sub-sector is in a burgeoning and promising transformation. Petroleum exploration has been underway by more than 25 companies, and at least 12 exploration blocks have been identified (see Fig. 87). There are currently no oil discoveries in Tanzania, but exploration is on-going. The country depends entirely on imported refined petroleum products, since it has no operating refinery facility. Energy crisis in both 2006 and 2010 have led to integration of imported fuel for electricity, further undermining the state of energy security in the country. Reliance on reserve capacity of petroleum distribution companies and maintenance of no public strategic reserve system has further exposed Tanzania to price shocks in the international market and short-term fuel supply management challenges. TPDC is now tasked with establishment of a public strategic reserve of petroleum, and its operational and oversight framework.

Despite these challenges, three best practices of short-term petroleum supply disruption product quality management are noteworthy.

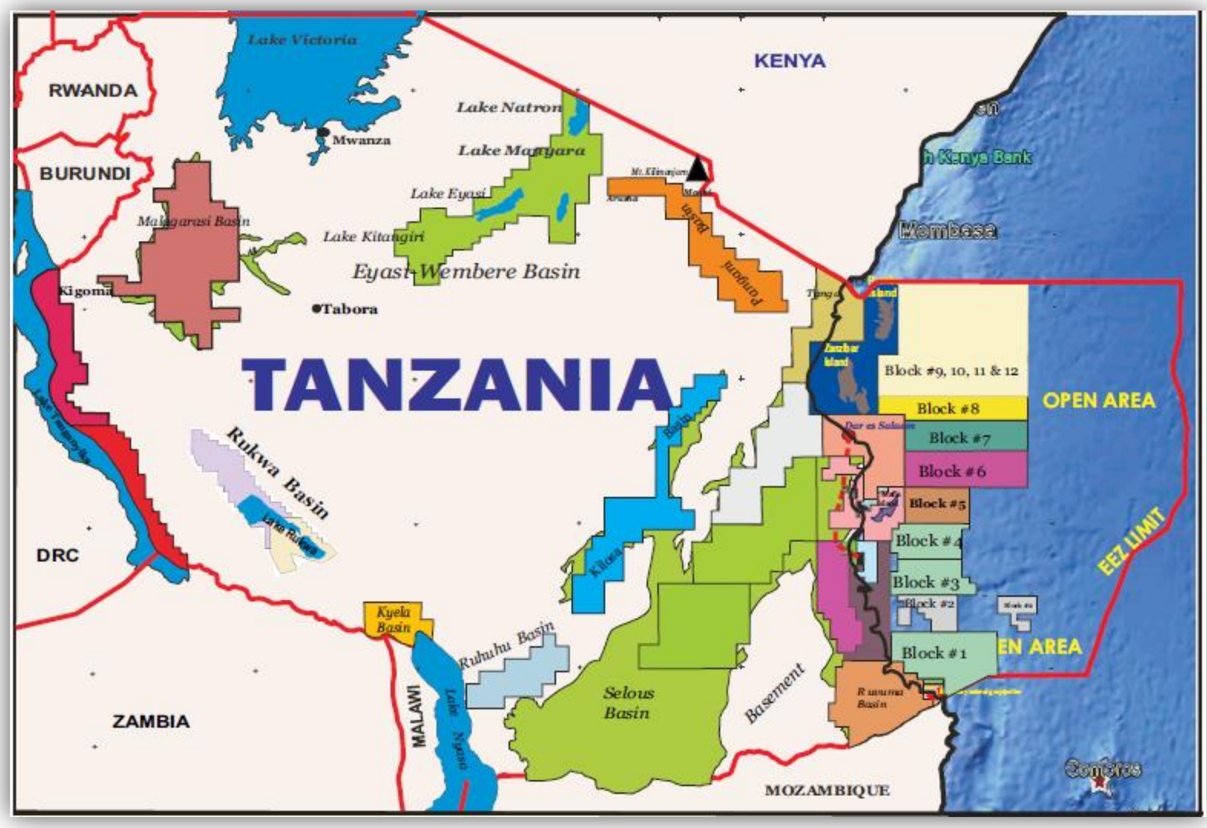
First, petroleum supply and domestic stocks are monitored through EWURA. Petroleum stocks information is compiled twice per week, and when stock is low, the Ministry of Energy and Minerals and Tanzania Ports Authority are alerted for necessary measures (EWURA, 2010). Vessels arrival is monitored for EWURA by SGS Superintendence Tanzania Ltd. Monitoring stock levels and communicating to agencies to deal with supply disruption is a vital aspect of short-term supply disruption management tool.

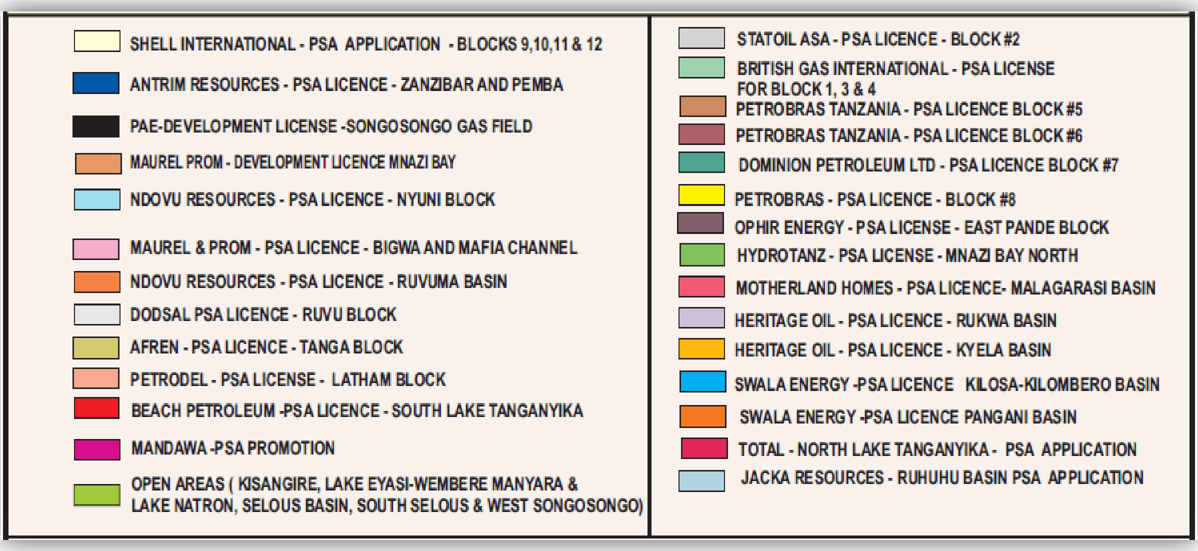
Second, petroleum products standard is monitored by the regulator, EWURA, closely working with the Tanzania Bureau of Standards and stakeholders to combat adulteration. In this regard, frequent and random inspection is undertaken. Between May 2007 and June 2010, for example, 432 retail petroleum outlets were inspected, of which 210 outlets (48.6%) were found to be selling or possessing products below quality specification (EWURA, 2010). In terms of distribution facilities, 233 petrol stations, 24 depots and 40 fuel tankers across the country were randomly inspected during the same period, and 36% of retail outlets, 29% of depots and 55% of tankers were carrying products that were out of the Tanzania Bureau of

Standards specification (Ibid). As significant and concerning as below quality oil products are, the fact that the trend seems to be on the decline, based on quarterly and semi-annually inspection assessment, is encouraging (see Fig. 88). However, more needs to be done to tackle the remaining high level of product adulteration, undermining availability of quality oil products. Regular sampling and monitoring of product adulteration is nonetheless an example of best practice to tackle the problem.

Third, the bulk petroleum products procurement by petroleum marketing companies in Tanzania is important in reducing prices and managing supply in the short-run. A Bulk Procurement of Petroleum Products report was prepared for Tanzania, and draft Bilk Procurement Rules and System Implementation Manual was prepared, presented to the Ministry of Energy and Minerals to issue appropriate regulations (EWURA, 2010). These developments are steps in the right direction to benefit from coordinated and bulk procurement that would afford better prices and coordinated supply. Members States in the Eastern Africa sub-region which have not instituted bulk procurement will benefit from such efforts.

Figure 87: Tanzania oil exploration activity by Blocks.

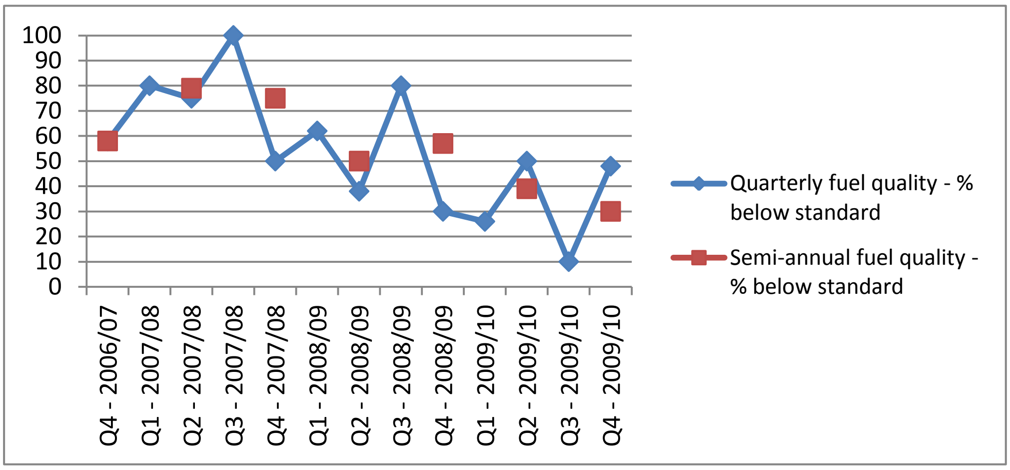




Source: Tanzania Petroleum Development Corporation.

Bulk procurement, viewed from broader sub-regional perspective offers an opportunity to benefit from large procurements even more, but will require clearing a series of regulatory and procedural hurdles across countries. Tanzania's effort, as is Kenya's, to push for bulk procurement is indeed a step in the right direction in terms of mitigating petroleum supply disruption.

Figure 88: Oil quality at retail outlets percent of sample found below standard.



Source: Based on data from EWURA 2010 Annual Report.

With regards to natural gas, remarkable discoveries have placed Tanzania in the sub-regional energy map. So far, five discoveries onshore and in shallow waters have been announced near Songo Songo Island, Mnazi Bay, Mkuranga, Kiliwani North and Nyuni. Songo Songo Island and Mnazi Bay fields are the only fields currently producing natural gas. The British Gas (BG) Group has discovered gas in Blocks 1,3 and 4 in the Mafia Depp Offshore Basin and the Ruvuma Basin. The Songo Songo gasfield is estimated to have 1.1 trillion standard cubic feet (TCF) in probable, possible and proven reserves and for the Mnazi Bay gas field the reserve estimates reach 2.2 TCF. The Government has raised overall gas reserve

estimates at nearly 33 TCF of recoverable natural gas reserves, a point which led the Deputy Energy and Minerlas Minister, Mr. George Simbachawene to declare at the oil and gas conference in Dar es Salaam in October 2012 “these discoveries are an indication that Tanzania is now becoming one of the natural gas hubs and a new frontier in oil and gas exploration in the East Africa region and the world at large” (as quoted by Reuters on October 18, 2012). The US Geological Survey estimates that some 253 TCF off Tanzania, Kenya and Mozambique fueling prospects for more gas. Mozambique is also coming as a major player in the gas industry, due to large finds in on-shore fields. In Tanzania, BG Group, Ophir Energy, Royal Dutch Shell, Aminex Plc and Brazil’s Petrobras are in the gas exploration and development business.

The potential of the sizeable natural gas finds in Tanzania offer an opportunity to enhance energy security in the country, and in the sub-region. Natural gas has already entered electricity generation, and plans are to bring added capacity from gas-fired power plants. From 2004 through 2013, at least 886 MW capacity of electricity is sourced from gas (see Table 36), with plans to bring additional capacity post 2013 (see Table 32). Natural gas will effectively enhance energy security by displacing fuel with domestic gas in electricity and by directly supplying gas to industries as an alternative and feasible local energy resource.

The economic benefits of natural gas use in Tanzania are already significant. During 2009/10, 21.73 billion standard cubic feet (BCF) natural gas was consumed by thermal power generation plants, which is equivalent to 705.53 million liters of oil equivalent; and industry had consumed in the same year 3.78 BCF of natural gas, 92.07 million liters oil equivalent, leading to US$ 789.07 million savings in 2009/10 (EWURA, 2010). These gains are expected to increase as domestic gas displaced imported fuel from generation portfolio.

Table 36: Gas-fired generation in the short to medium term – Tanzania.

Plant	Gas Added MW	Year Installed	End Year
Songas 1 (IPP)	42	2004	2023
Songas 2 (IPP)	120	2005	2023
Songas 3 (IPP)	40	2006	2023
Ubungo T	100	2007	2026
Dowans 1 (Rental)	35	2007	2008
Dowans 2 (Rental)	80	2007	2008
Aggreko (Rental)	44	2007	2008
Alsthom (Rental)	40	2007	2008
Tegeta New	45	2009	2030
Ubungo T New	100	2011	2031
Kinyerezi	240	2013	2033

Source: Power System Master Plan, Tanzania, 2009.

What the gas sector development in Tanzania means to energy security enhancement of the Eastern Africa sub-region is however uncertain. Experiences from South Sudan and Uganda on oil sector development can be indicative to the gas industry in Tanzania. South Sudan exports its oil resources to import refined petroleum, therefore commoditizing oil while the State faces energy security challenges from imported refined products. The country has now announced two refineries to change this prospect and enhance local energy security. In the case of Uganda, it is pushing refining capacity beyond domestic demand to help meet regional petro-products demand, potentially contributing to enhancement of energy security in the sub-region. Tanzania's case can be informed by these experiences. Product-sharing agreements it enters with oil and gas companies will certainly place a constraint. Indications are that after feeding much of the domestic electricity, industrial and household demand, and perhaps some export capacity to the sub-region, through a 5-20% local market tapping of gas, the rest is likely to go to lucrative export markets in China, India and particularly Japan where the appetite for gas is growing super-fast. The sub-region will need to engage Tanzania to deal with systemic energy security challenges. Access to Tanzania's gas, or converted electricity export are possibilities that require further policy engagement at the sub-regional level.

4.3.4.2 Energy Security – Lessons from Tanzania

Based on the experience of Tanzania in the electricity and oil and gas sub-sectors, the following lessons and best practices are noteworthy.

- *Local energy resources and energy security*: as mentioned in relation to energy access, local energy resources development can be targeted to mitigate energy security challenges. In the case of Tanzania, its natural gas development has allowed it to displace imported fuel in thermal power plants and industrial uses, improving its energy security profile. However, in the area of transportation, Tanzania continues to depend on fully imported fuels, and its biofuels program is not yet fully developed to reduce further imported fuel reductions, as is the case in Ethiopia. Tapping and developing domestic energy resources to mitigate imported energy in Tanzania, and continued efforts to bring gas at the center of energy sector development, is a good lesson, even to States with no natural gas but other energy resources endowment. However, the lack of sub-regional engagement on major oil and gas development initiatives and product sharing agreements, and subsequent independent energy sector development path of energy resource endowed countries requires policy attention and better sub-regional coordination.

- *Bulk procurement:* as in any other commodity, bulk purchase enables procuring products cheaper, as it offers a level of strength in negotiation and logistics management. Tanzania's efforts to strengthen fuel marketing stakeholders bulk procurement, through policy and operational guidelines, is indeed a step in the right direction. Member States in the Eastern Africa sub-region can benefit from such organization of the petroleum sub-sector. A sub-regional petroleum procurement framework has long been proposed, but concrete and coordinated efforts at engaging regional procurement procedures to benefit member States continues to be an energy security regional framework requiring urgent attention.

- *Strategic reserve*: Tanzania relies on the private sector to maintain sufficient stock supplies, often at 2 weeks level. Such stock levels are weekly monitored by EWURA. While the monitoring and regulating efforts are best practices, the lack of a public strategic reserve is a source of vulnerability to short-term oil supply security. However, Tanzania has tasked TPDC to establish a public strategic reserve system, in recognition of the vulnerabilities in the current system, and efforts are currently underway to establish a public stockpile of petroleum products. The lesson that may be drawn in this case is that private sector regulated stock piles will not be sufficient to meet short-term energy security of the country, and requires a supplemental public stockpiling mechanism. Kenya has also taken step to create a public strategic reserve, and Uganda is refurbishing its system.

- *Stock and product quality monitoring and enforcement*: Tanzania offers another best practice in the regulation and monitoring of petroleum stock levels in distribution centers and equally important is quality monitoring. Product adulteration is endemic in the sub-region, and the lack of monitoring and enforcement has made the adulteration challenge even more troubling. Tanzania has succeeded in cutting adulteration from nearly 80% by 2007 to less than half the level by 2010 through frequent and random monitoring and enforcement of quality standards in depots, distribution centers and transportation tankers. The adulteration problem is still quite high, but the progress made thus far shows the importance of a monitoring, regulation and enforcement in facing the adulteration challenge. Member States in the sub-region can look at the Tanzanian experience, and other States in the sub-region, to effectively tackle their product adulteration challenges to ensure not only petroleum supply at affordable prices, but at acceptable quality as well.

4.4 UGANDA

4.4.1 Background

Uganda became an independent State in 1962, with Milton Obote serving as the Prime Minister. A year later, Uganda declares a republic with the King of Buganda as President, which ceased with the ending of Buganda's autonomy and ascendance of Milton Obote as President until 1971, and returning as president again in 1980. The advance of the National Resistance Army to the capital saw the ascendance of President Yoweri K. Museveni in 1986. President Museveni introduced reforms, including restoration of traditional kings in 1993 and constitutional provision to legalize political parties in 1995, leading to a 1996 presidential election win for the President. Subsequent elections in 2006 and 2011 also saw continuation of the presidency. Along with Kenya and Tanzania, Uganda renewed the East African Community (EAC) in 2001, supporting economic integration of the EAC.

Uganda's economy depends on agriculture, as in much of the Eastern Africa sub-region, particularly coffee exports. But it saw gradual shift to increasing role of the service sector. Its energy and minerals sectors are promising. In 2009, Heritage Oil (concessions later acquired by Tullow Oil) has announced of a major oil find in the country, establishing the country in the energy map of the sub-region. Uganda's economy has largely undergone privatization, including major reforms in its energy sector. Reform is widely believed to lead to attraction of investment resources to the country and creation of a vibrant domestic economy. As part of the market-based reforms, the Uganda Securities Exchange was established in 1996 offering a stock market and capital market platform, including raising public funds through government securities.

Figure 89: The map of the Republic of Uganda.

Source: UN Department of Peacekeeping Operations, Cartographic Section, Map No. 3862, Rev. 4 May 2003.

4.4.2 Energy Institutions and Policy

The energy sector of Uganda is structured, guided and managed by energy policies and institutional and governance structures put in place. The Energy Policy of Uganda, adopted in 2002, is the guiding policy framework for the sector which aimes "to meet the energy needs of Uganda's population for social and economic development in an envrinmentally sustainable manner." In putting in place the national energy policy, it took into account a number of prevailing challenges in the sector, such as: widespread energy poverty; inefficient and inadequate power supply system; institutional weaknesses; and compatibility with regional and international energy policies.

The cabinet approval of the 1999 Power Sector Reform and the Privatization Strategy, enabled by the Electricity Act, the Energy Policy of 2003 further reinforced these policy regulatory measures. The policy states to have taken note of the following energy sector challenges:

> Inadequate pubic financing to develop electricity supply projects to match growing demand; high subsidy cost of the power sector arising from inability to service long-term debt; low quality of electricity supply; high technical and non-technical losses; low access; inadequate systems and metering; lack of information on environmental and social impacts of power sector development; and high tariffs due to low prior investment and low operational efficiency.

The Energy Policy of 2003, cognizant of the above nature of the power sector, therefore aims to:

> Establish the availability, potentiala nd demand of the various energy resources in the country; increase access to modern affordable and reliable energy services; improve energy governnace and administration; stimulate economic development and manage energy-related environmental impacts.

The policy aims to advance these objectives through a number of strategies, including sector-specific objectives. These include the following key goals:

> Households: provide afforable energy services for housholds and community-based services including water and sanitation, health, education, pulic lighting and communication.
>
> Industry: introduce energy efficiency measures to enhance industrial and commercial comptetiveness.
>
> Transport: promote optimum and efficient utilizsation of petroleum fuels and substitutions.
>
> Agriculture: increase the use of modern energy in agriculture as a component of agricultural modernization.

The Energy Policy is complemented by specific policies in the power sector, including the Renewable Energy Policy of 2007 and the Feed-in Tariff (REFIT), Phase 2, which approved guidelines for 2011-2012. The Renewable Energy Policy for Uganda (2007) is motivted by the fact that "a number of renewable energy technologies have come commercially viable and therefore need to be brought into the national energy supply mix." It is als motivated by "unprecedented electricity supply deficit due to the fall in Lake Victoria

water levels, escalating oil prices, electricity access to rural areas (and) reduction of greenhouse gas emissions.” Recognizing the barriers of upfront technology adoption cost, finance, legala nd institutional, technical, awareness, standards and quality of renewable energy technologies (RETs) and information and data on renewale energy resources, the policy advances strategies and programs to tackle the challenges, including:

> Power Generation Programme (small and large hydropower schemes); Rurala nd Urban-poor Electricity Access Programme; Modern Energy Services Program; Buifuels Programme; Energy Efficiency Programme and Waste for Energy Program.

Along with Kenya, Uganda has a progressive feed-in tariff policy to incentivize renewabel energy developmet. The Phase 2 program managed by Electricity Regulatory Agency (ERA), technology-sensitive tariffs are offered for power generated from renewable energy technologies application (see Table 37), offering tariffs ranging from US$0.073/kWh for hydro to US$0.36/kWh for Solar PV.

Table 37: REFIT tariffs and maximum technology capacity limits (2011-2014).

Technology	Tariff US$/kWh	Cumulative Capacity Limits (MW)				Payment Period (years)
		2011	2012	2013	2014	
Hydro (9><=20 MW)	0.073	45	90	135	180	20
Hydro (1><=8 MW)	Linear tariff	15	30	60	90	20
Hydro (500 kW ><=1 MW)	0.109	1	1.5	2	5	20
Bagasse	0.081	20	50	75	100	20
Biomass	0.103	10	20	30	50	20
Biogas	0.115	10	20	30	50	20
Landfill gas	0.089	10	20	30	50	20
Geothermal	0.077	10	30	50	75	20
Solar PV	0.362	2	3	5	7.5	20
Wind	0.124	50	75	100	150	20

Source: Uganda Renewable Energy Feed-in Tariff Guidelines, 2011/2012.

For the oil and gas sub-sector, the Energy Policy of 2003 frames broader issues in the upstream and downstream areas of the oil and gas sector. It takes note of the petroleum product import tracing through mandatory biocode since 2000 to tackle illegal imports and product adulteration. It also notes that following the 1994 deregulation of petroleum product prices, prices have risen sharply to reflect market conditions, but deregulation also brought investment. Since 1997, the sector has been oppe for oil marketing companies. The policy also notes public strategic reserve of petroleum products at Jinja Storage Tanks for strategic purposes, and to offer storage facility for new oil companies as incetive to help them with the competition.

The oil and gas sub-sector is particularly guided by the 2008 National Oil and Gas Policy for Uganda, which aims to "use the country's oil and gas reosurces to contribute to early acheivement of poverty eradication and create lasting value to society." The Policy puts forth the objectives of effiency in licensing, efficient management of oil and gas resources, the use of revenues to create *lasting* value to society, and ensuring that oil and gas activities are undertaken in a manner that conserves the environmetn and biodiversity. Recognizing the need for an institutional arrangement to carry out the policy, both the regulatory body of the Petroleum Authority of Uganda (PAU) and the commercial body of the Uganda National Oil Company (NATOIL) are instituted. The most interesting aspect of the Uganda oil and gas policy is its engaged focus on the need for a broader inter-institutional framework to implement the policy, including the following participations:

> Cabinet (approving petroleum administration, consenting to Production Sharing Agreements (PSAs)); Ministry of Energy and Mineral Development (licensing, issuing petroleum regulation, Negotiating, endorsing an administering PSAs, approving plans for field development, etc); Petroleum Authority of Uganda (monitoring and regulating Petroleum Operations, managing petroleum data, etc); Uganda National Oil Company (managing business side of State participation, administering contracts, optimizing value to shareholders, etc); Ministry responsible for Justice and Constitutional Affairs (guiding formulation and drafting of petroleum legislation); Ministry Responsible for Finance, Planning and Economic Development (ensuring appropriate management of petroleum revenues, monitoring and assessing the impact of oil and gas revenues on the economy, etc); Ministry responsible for Local Governments (guiding local governments to undertake plans and capacity building that take cognizance of oil and gas activities); Ministry responsible for Works and Transport (providing technical guidance on mechanical engineering aspects of machinery used in oil and gas activities imported into the country, issuing approvals for movement of heavy equipment on Uganda's roads, etc); Ministry responsible for Water and Environment (ensuring that oil and gas activities conform to the policies regarding the protection and utilization of water bodies and aquifers); Ministry responsible for Forests and Wetlands (ensuring that oil and gas activities are undertaken in a manner that preserves and enhances forest reserves and wetlands); Ministry responsible for Tourism and Wildlife (ensuring that oil and gas activities are in harmony with wildlife conservation and development of infrastructure and services for tourism); Ministry responsible for Labor (inspect health and safety in the oil and gas sector, and ensure employment policies); Ministry responsible for Education (promote development of education and training programmes to create national manpower expertise for the oil and gas sector); Ministry responsible for Industry (promoting development of petrochemical industry); Ministry responsible for Physical Planning (conducting physical planning for oil and gas activities areas); Ministry responsible for Foreign Affairs (advocate for joint exploration and exploitation of any oil and gas resources along the country's borders); Ministry responsible for Security (securing oil and gas activities and installations); Ministry responsible for ICT (formulating and implementing IT laws and regulations that will provide conducive secure environment for data transmission and storage for oil and gas activities); the Central Bank (advise on impact of oil and gas on the economy, ensure that oil and gas activities do not impact negatively on monetary policy and macroeconomic stability); Revenue Authority (administering collection of revenue from oil and gas activities); National Planning Authority (leading national planning for effective incorporation of oil and gas activities into the national economy); National Environment Management Authority (coordinating environmental impact assessment of oil and gas activities); the Auditor General (providing independent oversight of government petroleum operations through financial and management audits); and Civil Society and Cultural Institutions (contributing to holding the different players accountable and getting the voices of the poor into policy).

To regulate, monitor and implement energy policies and programmes, the energy sector of Uganda is constituted by key sectoral institutions, along with cross-institutional mentioned above. The Minsitry of Energy and Mineral Deelopment is the overarching institution mandated to "establish, poromote the development, strategically manage and safeguard the rational and sustainable explouitation and utilisation of energy and mineral resoruces for sical and economic development." These broader responsibilities of the Ministry is supported by the Electricity Regulatory Authority, established by the 1999 Electricity Act, undertaking licensing and regulation of generation, transmission, distribution, sale, export and import of electricity. Following the liberalization of the power sector, generation, transmission and distribution (formerly under the Uganda Electricity Board) are unbundled. The Uganda Electricity Generation Company Limited (UEGCL), which owns the Kira and Nalubaale Hydrpower Stations in Jinja, operates generation from these sites, under a private sector 20-years management deal with ESKOM, the South African power generation company, since in 2003, following the Concession and Assignment Agreement (CAA) in 2002. The Uganda Electricity Transmission Company Lmited (UETCL) owns the transmission lines above 33 kv, and acts as the *System Operator*. Therefore, UETCL is the single buyer of power to the grid system, and sales bulk power to the distribution company. The distribution network is owned by the Uganda Electricity Distribution Company Limited (UEDCL), which has also signed a 20-years lease to UMEME Limited, commencing in 2005. To address rural electrification targets, the Rural Electrification Agency (REA) is instituted, as an agency for the Rural Electrification Board. The activities of REA is supported by the Rural Electrification Fund. Private sector participation is active in Uganda, particulalry at the generation level through IPPs.

4.4.3 The State of Energy Access and Key Lessons

4.4.3.1 The State of Energy Access

Energy access in Uganda is quite low, at 9% national electricity access level (although estimates vary to 12%), and according to REA a 6% rural electrification rate from just 1% in 2002. The national access rate is much lower than the Eastern African sub-regional average access rate of 23%. Given the stated goal of energy sector development of Uganda is to tackle poverty and accelerate socioeconomic development, such low level energy access impose critical constraints to the achievement of these broader social objectives. To take key lessons on the state of energy access and strategies to tackle them, it is important to broadly review the energy sector of Uganda, particularly generation, transmission and distribution segments of the power sector.

The East African Power Master Plan stipulates that electricity demand in Uganda is growing fast, at 7-9% per annum. Therefore, rapid expansion of generation capacity seems a relevant energy planning strategy to deter power shortage crisis. Existing generation capacity comes from hydro and thermal generation (see Table 38), totaling 590 MW, receiving hydroelectric power from Nalubaale, Kiira, Bugoye, Mpanga and Ishasha large and small plants. Since the 2006 power shortage and need for emergency generation, following a drop in water levels at Lake Victoria and contraction of hydropower output, thermal energy has increased as a share of total supply. The 2012 Energy and Mineral Sector Performance Report (2008/09-2010/11) acknowledge that "current power generation mix is dominated by thermal power, which is expensive, hence accounting for the high power tariffs. A program to develop cheaper and more reliable power is being undertaken using the newly

created Energy Fund." In fact, Uganda has lifted part of the subsidy it provides to the power sector in 2012, partly due to the expensive thermal that has come to the system, causing tariff to rise, passing part of the cost to consumers.

The genesis of the generation portfolio change towards thermal generation can be partly traced to the 2006 power supply deficit, estimated at 90-210 MW, resulting in power rationing, and in some places rotational supply. Such power shortages, leading to significant load shedding, impacted the economy, where GDP contracted by 5% in 2005/2006 period, and by 6.5% in the last 10 years (Baanabe, 2012).

To address these challenges, short, medium and long-term measures are taken. The short-term measures include expansion of thermal capacity to generate emergency power[29], savings from reducing energy losses, energy efficiency and demand side management; the medium-term strategy involved development of Bujagali and Karuma hydro plants (850 combined MW), use of oil for thermal generation and use of renewable energy sources; and the long-term plan involves large-scale hydropower development (Isimba, Ayago and Uhuru, for a combined power of 1,040 MW), use of local oil for thermal generation and interconnection to the regional power grid (Ibid).

Table 38: Power generation capacity of Uganda.

Plant	Installed Capacity (MW)
Nalubaale and Kiira	380
Mutundwe (Aggreko II)	50
Namanve (Jacobsen)	50
Kakira Sugar Works	12
Electromaxx I	18
Kilembe Mines Ltd	5
KCCL	9.5
Kinyara Sugar Works	5
Imports – Electrogaz	2
Bugoye	13
Mpanga	18
Ishasha	6.5

Source: UETCL.

[29] An emergency 170 MW was generated: 50 MW from Aggreko (decommissioned in 2011); 50 MW diesel plant at Mutundwe (decommissioned in 2012 after Bujagali came onto the grid), 50 MW HFO plant by Jacobsen (with a plan to use domestic fuel in the future); and a 20 MW HFO at Tororo by Electromaxx.

To enhance generation capacity, Uganda aims to rely on its energy resources. The hydropower capacity expansion is based on largely the development of the Nile River. Some of the proposed projects in the Hydropower Development Master Plan (2010) include Kiba, Ayago, Oriang, Karuma, Michison, Isimba and Kalagala, with a combined capacity of 3,010 MW (see Fig. 90).

Moreover, there is power generation potential based on agricultural waste, for an estimated equivalent power output of 407 MW from bagasse, rice husks and straw, sun flowed and cotton seed hulls, tobacco dust, maize cobs, coffee husks and groundnut shells (see Table 39). Capacity of peat in Uganda is estimated at 6,000 million m3, about 250 Mtoe (million tonnes of oil equivalent), which at 10% of feasible exploitation can generate 800 MW for 50 years (Renewable Energy Policy for Uganda, 2007).

Figure 90: Large hydropower projects - Uganda.

Source: Hydropower Development Master Plan of Uganda (2010).
Note: capacity of Kalaga (330MW), Isimba (140 MW), Karuma (600 MW), Oriang (390 MW), Ayago (610 MW), Kiba (290 MW), and Muchison (650 MW).

Table 39: Energy production potential from agri-residuals.

Biomass Type	Annual Production ('000 tons/year)	MW e average
Bagasse	590	
Bagasse Surplus (available immediately)	3 x 25-50	67
Rice husks	25-30	16
Rice straw	45-55	30
Sunflower hulls	17	20
Cotton seed hulls	50	1
Tobacco dust	2-4	2
Maize cobs	234	139
Coffee husks	160	95
Groundnut shells	63	37
Total		407

Source: The Renewable Energy policy for Uganda, 2007.

Geothermal (450 MW), solar (200 MW), biomass (1,650 MW) and mini hydro (200 MW) are also capacities that can be developed to boost generation capacity and meet the growing energy demand (see Table 40) sourced from green energy resources.

Table 40: Renewable energy power potential - Uganda.

Energy Source	Estimated Electrical Potential (MW)
Hydro	2,000
Mini-hydro	200
Solar	200
Biomass	1,650
Geothermal	450
Peat	800
Wind	-
Total	5,300

Source: Alternative Energy Sources Assessment Report, 2004, National Biomass Assessment Study, 2003.

Based on the potential of these domestic energy resources, the Government has prioritized generation capacity expansion and access, identifying a series of new energy sources planned to be brought forth in the coming years. The power generation projects from 2012-2020, if fully developed, are expected to bring 2,217MW to 2,237 MW, nearly three-folds of current capacity (see Table 41). The 250 MW capacity of Bujagali is already

commissioned in phases in 2012, bringing much needed short-term capacity expansion to meet the rapid expansion of demand, and to relieve the energy crisis endemic of the electricity sub-sector of Uganda the last few years.

Figure 91: Aereal view of Bujagali hydropower plant.

Source: James Baanabe, Commissioner, Energy Resources, Ministry of Energy and Mineral Developmetn of Uganda, presented at the National Workshop on Promoting Sustainable Transportation Solutions for East Africa, August 1, 2012.

Table 41 Expected power generation capacity enhancements: 2012-2020.

Plant	Capacity (MW)	Expected Year of Commissioning
Bujagali	250	2011-12
Nyagak 1	3.5	2012
Albatros I	100	2014
Albatros II	130	2015
Kikagati	16	2014
Buseruka	9	2012
Electromaxx II	30	2012

Kabaale (Gas and Test Crude)	53	2014
Karuma	600	2018
Isimba	200	2016
Namugoga Solar	50	-
Kyambura	8.3	-
Kakaka	7.2	-
Maziba	1	-
Kinyara	40	2013
Kabal Peat	20-40	2014
Waki	5	-
Nyamwamba	14	2014
Muzizi	26	2015
Nyagak 3	4.4	2015
Ayago	600	2020
Muyembe	10	-
Nengo Bridge	7.5	-
Kakira	32	2012

Source: UETCL.

The strategy to bring-in new generation capacity is further explored through the hydroelectric small and large capacity development, prioritized through the Hydropower Development Master Plan, and other renewable energy sources, prioritized through the Renewable Energy Policy. The Power Generation plan foresees the expansion of capacity from 412 MW in 2007 to 1,420 MW by 2017, largely from rapid expansion of hydropower capacity. This is believed to lead to expanded rural energy access, as well as the introduction of energy efficient household appliances (see Table 42). Public and private resource mobilization is among the key constraints.

Generated power is sold in bulk to the single grid buyer UETCL. The 2012 Energy and Mineral Sector Performance Report (2008/09-2010/11) have identified core challenges to effective operation of UETCL, including:

> Restricted water release regime, lowering hydro power generation and reliance on thermal for compensation of power loss; Uganda Shilling depreciation affecting power purchase prices made in hard currency; fuel price increases and power purchase price impacts; lack of adequate reserve capacity compromising system stability; tariff being out of sync with power purchase prices; rampant vandalism of infrastructure; acquisition of

way for transmission construction; finance; procurement delays; delayed remittance of subsidy to honor power purchase costs; and taxes on power imports and exports.

These constraints reduce the efficient and effective operation of the transmission network, and introduce systemic challenges. On the distribution end, Umeme receives about 30% of electricity tariff to consumers. Umeme reports indicate that it connects on average about 27,000 new customers per year. The challenges it faces include: dilapidated distribution infrastructure requiring improvement and investment; high distribution loss, estimated at 29% in 2011; commercial losses (theft); land acquisition; high power tariff; depreciating currency; gap between finance and investment needs; and generation mix skidding to more expensive thermal sources due to hydrology constraints. Along with the transmission infrastructure constraints, these challenges necessitate a system-wide approach to addressing the challenges to accelerate the delivery of developed new generation capacity, at affordable prices to an increasing customer base to expand energy access, in ways that enhance system-wide energy stability and security.

Table 42: Renewable energy development path for Uganda.

Programmes	Baseline	Cumulative Targets	
	2007	2012	2017
Power Generation			
Large Hydro (MW installed)	380	830	1,200
Mini and micro Hydro (MW installed)	17	50	85
Cogeneration (MW installed)	15	35	60
Geothermal (MW installed)	0	25	45
Municipal Waste (MW installed)	0	15	30
Rural Electrification and Urban Access			
Electrified households	250,000	375,000	625,000
Modern energy services for households			
Improved woodstoves (#)	170,000	500,000	4,000,000
Improved charcoal stoves (#)	30,000	100,000	250,000
Institutional stoves (#)	450	1,500	5,000
Baking ovens (#)	60	250	1,000
Kilns (#)	10	30	100
Household biogas (#	500	30,000	100,000
Solar home systems (kWp)	200	400	700
Fruit driers (#)	3	1,000	2,000

Biofuels			
Ethanol, biodiesel (m^3/a)	0	720,000	2,160,000
Energy Efficiency			
Solar water heaters (m^2 installed)	2,000	6,000	30,000
Energy savers (#)	1,000,000	2,000,000	4,000,000
Industrial energy audits implemented (#)	20	70	300
Energy efficient equipment for industries implemented (#)	15	50	250

Source: The Renewable Energy policy for Uganda, 2007.

4.4.3.2 Energy Access – Lessons from Uganda

Review of the Uganda electricity sub-sector reveals important lessons for Eastern Africa sub-region member States, particularly those considering development of various domestic energy resources to expand energy capacity and access, and those considering opening-up of their energy sector for private sector participation. Some of the lessons include the following pertinent observations.

- *Progressive energy sector policies*: Uganda has put forth energy sector reform and policies to advance the sector with a goal of reducing constraints energy places on socioeconomic transformation. It has put a comprehensive national energy policy, inclusive of the power and oil and gas sub-sectors, electricity act that privatized the power sector by unbundling generation, transmission and distribution, put forth contemporary oil and gas policy, renewable energy policy and feed-in tariff structure (to boost contribution of renewable energy), put in place a biofuels program, a rural electrification authority and fund, and became one of the early move countries to implement Sustainable Energy for All (SEFA) initiative of the UN Secretary General, seeking universal access to sustainable energy by 2030. Despite the structural challenges of the energy sector in Uganda, the policy reforms and implementations have introduced marked change in the energy sector, particularly participation of the private sector, albeit with its own challenges relative to Government expectations. For countries within the Eastern Africa sub-region with old energy policies that are out of touch with current energy sector developments, and countries who are considering reform and introduction of policies to encourage growth and development of the energy sector, the Uganda experience, with its success and shortcomings, is worth taking into account. For countries looking for comprehensive national energy policy, targeted incentive policies for renewable energy, program and fund for rural electrification, how to take SEFA initiative on-board and what the outcome of a privatized energy sector would look like, Uganda offers key lessons in comparable sub-regional energy sector environment. With engaged public sector that prioritizes energy sector development, progressive energy policies/reforms development and implementation are possible, and given the timeliness of positioning the energy sector in the sub-region such efforts will also be useful.

- *Energy planning, portfolio transformation, costs*: the Uganda power sector, particularly since the 2006 power emergency generation, has revealed that power generation was not

at pace with demand growth, and that it was much exposed to drought and hydrological vulnerabilities. Energy planning was inadequate. The result has been dramatic increase in thermal emergency power generation, as in Kenya, Rwanda and Tanzania, pushing the generation portfolio into high-cost and imported fuels. This has led into system-wide rise in per unit cost of energy. The lesson seems clear – lack of proper energy planning and generation capacity development, particularly in States with hydropower dependence vulnerable to drought incidents, is risky, will lead to emergency power generation, and result in unintended consequence of raising power costs, undercutting economic competitiveness. This deficiency points in the direction of integrating cheaper and cleaner energy sources in the generation portfolio, enabled by effective short, medium and long-term energy planning.

- *Costs and subsidy program sustainability*: the Uganda experience of emergency generation and shift of generation portfolio to high-cost thermal generation leading to rising costs had further implications. The cost has risen so significantly that sustaining power subsidies had become costly, and beyond estimated budget provisions. For example, from May 2005 to October 2011, a total of UShs 1,135.20 trillion has been paid in subsidies (Ministry of Energy and Mineral Development, 2012). As a result, Uganda has scaled-down its subsidy in 2012, exposing consumers to price hike. Energy price increases discourage efforts to expand access, and reduce economic competitiveness. Commercial and industrial consumers have already placed complaint of sharp tariff increases. These challenges seem avoidable with energy planning and generation expansion efforts. Uganda has since embarked with ambitious plans of power generation with the short-term plan of expanding thermal generation, medium-term strategy of thermal, hydro and renewable energy generation and a long-term strategy of hydro, local oil use and accession power from regional interconnection. Countries in the sub-region with inadequate energy planning can take lesson from the Uganda experience.

- *Energy sector reform, private sector participation and tariffs*: power sector reform in Uganda has brought participation of the private sector, including in generation. For the private sector, the incentive is high to invest less capital and generate high return, which often leads to much interest in rental thermal generation, and relatively less up-take in large-scale hydropower projects which are often costly, require large capital and involve much risk. While reform and private sector participation in the energy sector are crucial to bring in added investment capacity and system efficiency, guiding such investments to green energy is not that straight forward. The private sector is often active in thermal generation. But private sector will also be interested to see cost-reflective tariffs, creating a wedge between "socially appropriate" and "commercially appropriate" tariffs. High generation cost, from integration of costly energy technologies, means that bulk purchase of power will be costly, and tariffs will have to increase to absorb power generated from such technologies. But tariff regulation makes that often challenging, and tariffs are often sticky. Therefore, the wedge is often taken by the public sector, in terms of subsidies. These inherent challenges faced with reform need to be taken into account, and broader policy dialogue is needed to get the best of reform from system efficiency improvement and infusion of investment capital to the energy sector with ways of guiding the portfolio to greener, cheaper and sustainable energy sources in ways that reduce the need for tariff

hikes and passing part of the cost to the public sector, in terms of subsidies, and part of the cost to consumers in the form of higher-tariffs.

4.4.4 The State of Energy Security and Key Lessons

4.4.4.1 The State of Energy Security

Uganda depends on imported petroleum products, through the Kenya route (90%) and the southern corridor through Tanzania (10%), to satisfy demand growing at 7%, requiring fuel import expenditure of US$ 113 million per month (Ministry of Energy and Mineral Development, 2012). As a landlocked country, security of petroleum supply is a concern, a fact keenly demonstrated by the disruption of petroleum products in Uganda following the post election violence in Kenya, in 2008. Oil shipments from Eldoret to Uganda were interrupted, and Uganda was hit with short-run supply disruptions, along with Rwanda and Burundi.

Aside from global and regional challenges of petroleum price hikes, political instability in exporting countries, regional challenge of piracy in the Indian Ocean, Uganda faces its own energy security challenges emanating from supply routes and domestic petroleum supply management schemes. To deal with security of supply, Uganda has put in place the Petroleum Supply Department in the Ministry of Energy and Mineral Development, based on the 2003 Petroleum Supply Act (PSA), establishing a technical committee to advice the Minister on petroleum supply matters. The PSA is strengthened by the 2009 Petroleum Supply Regulation (PSR), offering institutional and regulatory framework for management of petroleum supplies.

To deal with disruption risks, Uganda has adopted route diversification, restocking strategic reserves, improving import pipelines, tackling adulteration and initiating fuel monitoring and information system. With regard to route diversification, the Government is offering a subsidy for fuel imports through the *southern corridor* to Tanzania, amounting to USh150 per liter, to reduce excessive reliance on the Kenya route. The southern corridor offers diversification but is not without its challenges, including axel regulation on Tanzanian roads and relative cost of the route.

Maintaining a strategic reserve has been a challenge in Uganda, as demonstrated in the post-election crisis in Kenya where fuel supply shortages where not address through drawdown of strategic stock, largely due to the depletion of the stock. The existing strategic reserve capacity of Jinga Storage Tanks is sought to be operated as a PPP (private sector to restock and operate, and the public sector to own the facility), offering public and rented private storage facility. It was closed for rehabilitation and integration into the Kenya-Uganda Oil Pipeline project (Ministry of Energy and Mineral Development, 2012). The strategic reserve capacity of Uganda remains a concern. There are options being considered, including the Nakasongola National Strategic Fuel Reserves, but operational reserve capacity continues to be insufficient.

Product adulteration, as in much of the sub-region, is also a concern in Uganda. In 2011, the Fuel Marking and Quality Monitoring Program is initiated to deal with adulteration and fuel smuggling challenges, and quality is monitored against the established fuel standards. Since 2000, a biocode marking of imported petroleum was mandated. While these are good practices and initiatives, "on the side of ensuring security of supply of petroleum

product, the budget provisions do not permit regular inspections and ensuring quality of products in the local market”(Ibid). Resourcing and enforcing quality standards throughout the petroleum supply chain is indeed crucial.

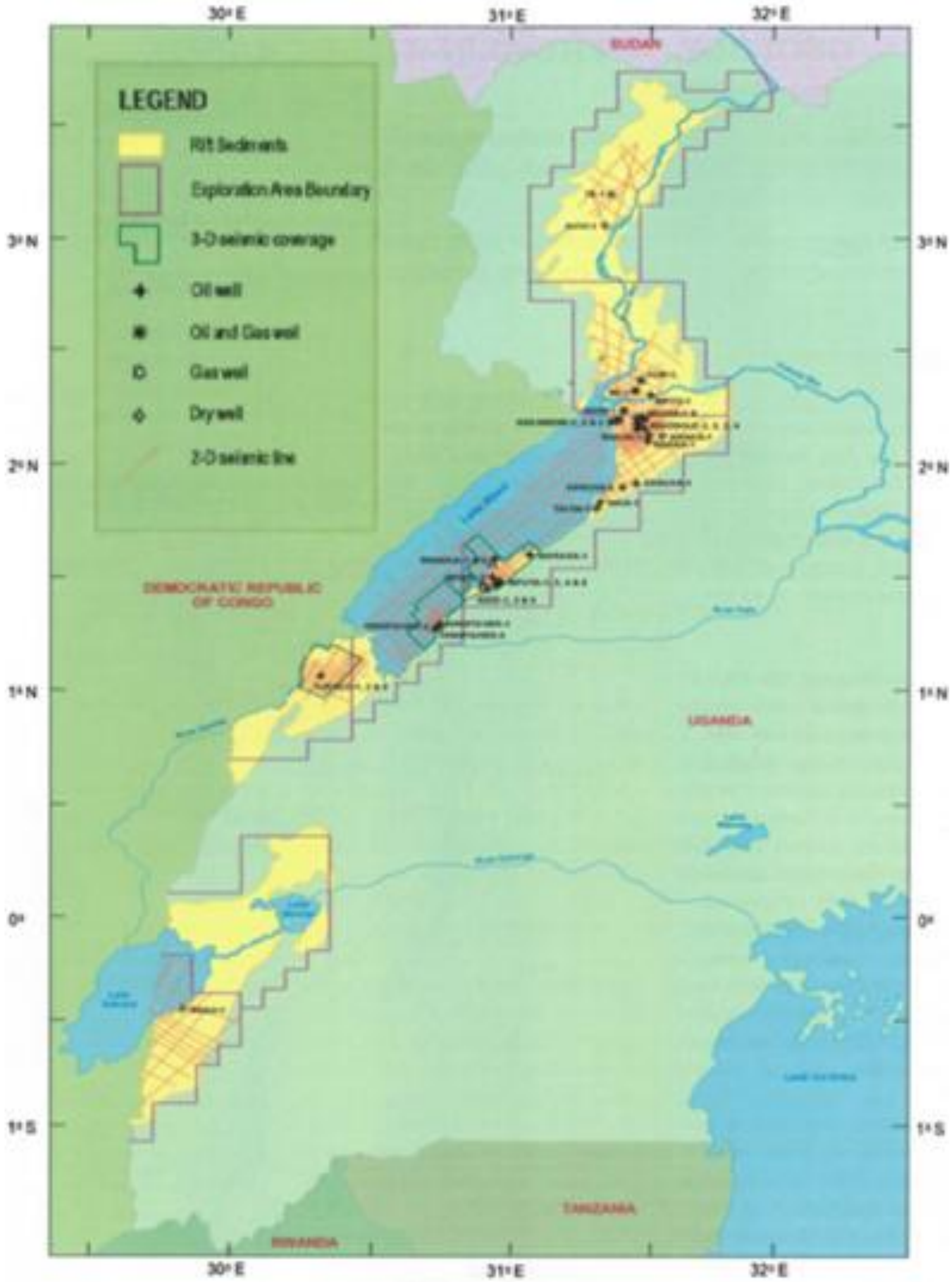
In managing energy security, information about petroleum products prices, quality, stock levels and stock changes are necessities. In this regard, the establishment of the National Petroleum Information System, monitoring international and domestic petroleum products prices, stocks and uses is a good practice.

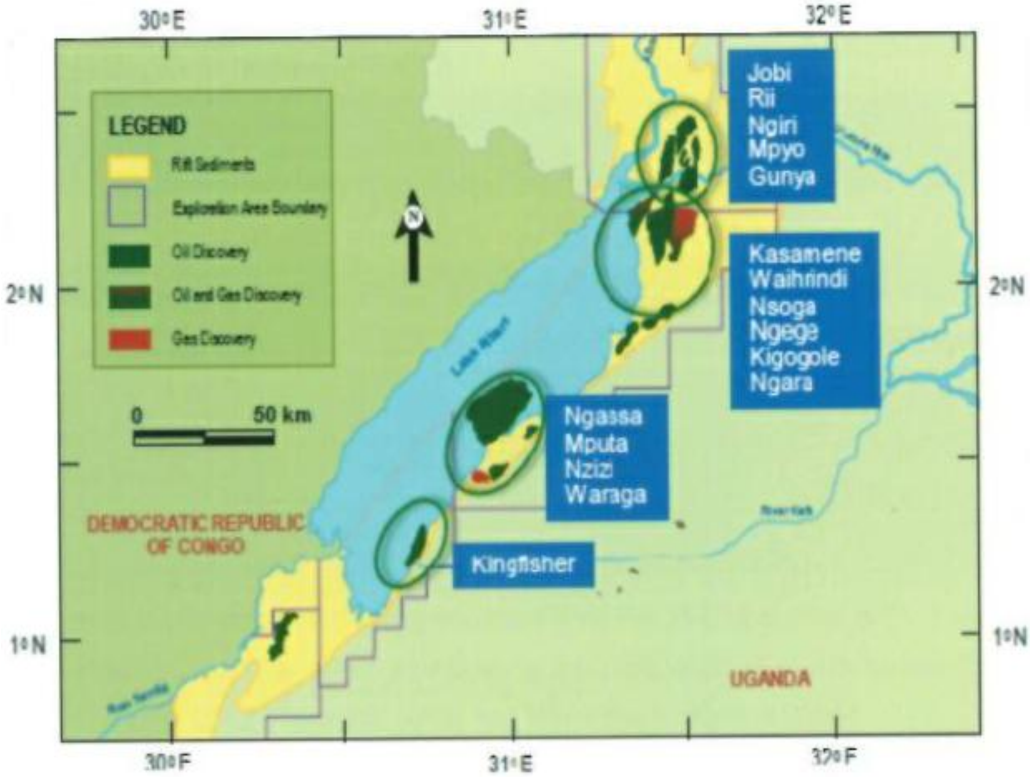
One major strategy of Uganda on fuel supply stability and security has been improving oil pipeline infrastructure with Kenya, through the Kenya-Uganda Oil Pipeline Extension project, proposed to be largely (75%) financed through private capital. Oil discovery in Uganda has affected the project, due to the interest in seeing reverse fuel flows through the infrastructure. Implementing the project will strengthen the infrastructure needed for energy security, and will contribute to enhancing both Uganda and Kenya energy security capacity.

The future options of energy security management in Uganda will involve at least three additional developments in the energy sector: the discovery and recovery of oil and gas; fuel diversification through biofuels and the possible role of nuclear energy.

Discovery and development of oil and gas: the discovery of oil in Uganda is a game changer, for energy security in the country, in member countries of the EAC and potentially in South Sudan, putting Uganda in the energy map of the sub-region. From 2002-2011, a total of 39 oil wells were drilled (see Fig. 92, 1st panel), and 36 wells showed signs of hydrocarbons, and 16 discoveries of oil and gas (see Fig 92, 2nd panel) are announced (Petroleum Exploration and Production Department, 2011).

Figure 92 Wells drilled in the Albertine Graben (panel 1) and discoveries (panel 2).





Source: Ministry of Energy and Mineral Development of Uganda, Petroleum Exploration and Production Department, 2011.

Estimates put the stock tank oil initially in place (STOIIP) at 2.5 billion barrels (bbls) with recoverable reserves of 729 million bbls at an assessed 30% recovery rate, with prospective discoveries of up to 4.2 bbls (see Table 43). The proven reserves are nearly equivalent to the proven oil reserves found in South Sudan.

Table 43: Discovered and prospective oil deposits of Uganda.

Exploration Area	Discovered STOIIP (mmbbls)	Prospective STOIIP (mmbbls)	Total STOIIP (mmbbls)
1	1,719	3,196	4,915
2	457	-	457
3A	387	1,006	1,393
Total STOIIP	2,563	4,202	6,765
Recoverable (at 30%)	729	1,261	1,290

Source: Ministry of Energy and Mineral Development, Uganda. 2010. "Refining Opportunities in Uganda."

In addition, a 12 BCF (billion standard cubic feet) gas reserve is estimated. These deposit assessments are so far conducted based on 40% exploration of the total area. These oil and gas finds are significant, and have much potential to help enhance sub-regional energy security. This optimism is enhanced by the position of the Government to refine oil products in Uganda. The commercialization strategy has considered the options of exporting crude oil as a commodity, local refining, inducing petro-chemical industry and conversion of fuel to thermal power generation. To sort through the feasibility of these choices, the Government

commissioned a study in 2010 to determine the feasibility of a large-scale refinery operation in Uganda. The study, completed in 2011, found that "an oil refinery in the country to supply the Ugandan and regional markets than constructing a pipeline to export crude oil in the medium term" as a preferred and feasible option (Ministry of Energy and Mineral Development, 2012).

Furthermore, the discovered oil is *waxy*, meaning it will not flow through a pipeline below temperatures of 40 ^{o}C. This will require the pipeline to be heated all through, adding substantial cost to the crude oil. This chemical characteristic is another reason for some to advocate for local refining and efficient multi-product liquids production without resorting to expensive and well suited export pipeline infrastructure.

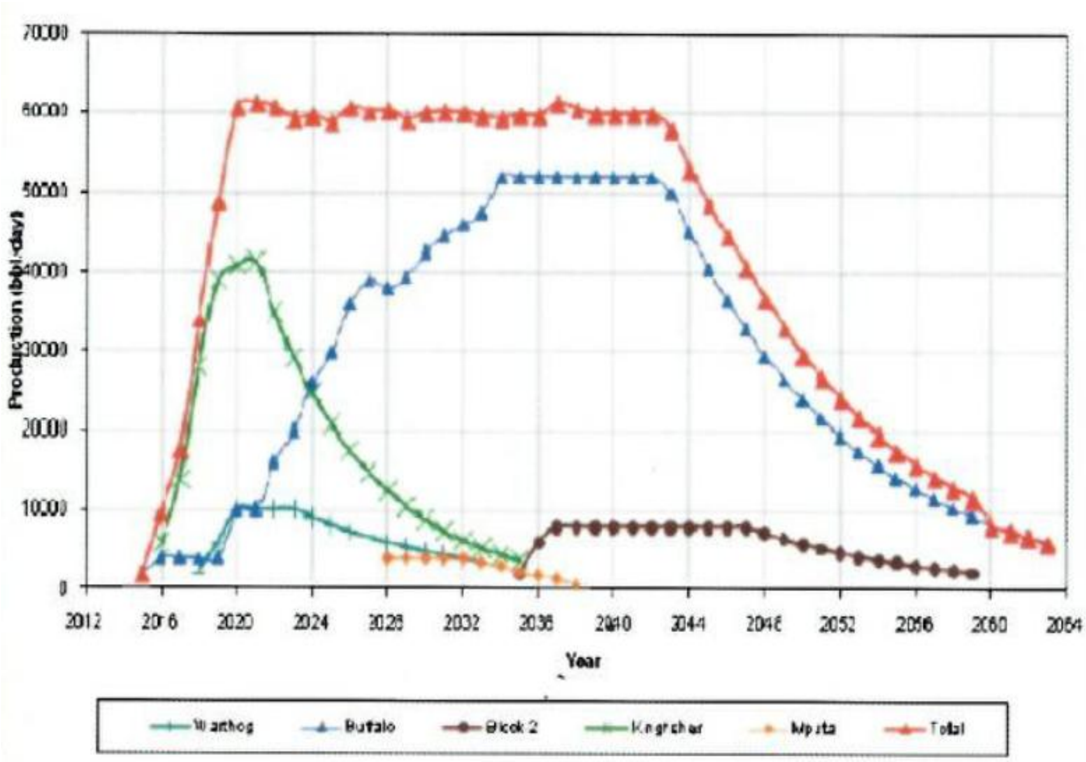
The overall oil resource development plan includes a short-term strategy of diverting the 200 or so bbls/day test production for use potentially in cement production, and with enough supplies, also to support thermal power generation. Medium-term plans involve putting in place refinery capacity in phases, starting possibly with a 20,000 bbls/day capacity, eventually growing it to meet regional demand. The prevailing view, based on the feasibility study, is that a refinery supporting a production of 60,000 bbls/day is possible for 20 years, and a capacity of 120,000 bbls/day with majority of the prospects is achievable (see production/refining profile by crude oil input capacity in Fig. 93).[30] If implemented, the refined production capacity will have the effect of enhancing energy security in Uganda and at least in the EAC and South Sudan. *Uganda's strategy of developing its oil resources with the regional market in mind is demonstrably a good practice; a practice energy policymakers and experts would prefer to see in Tanzania's gas sector.*

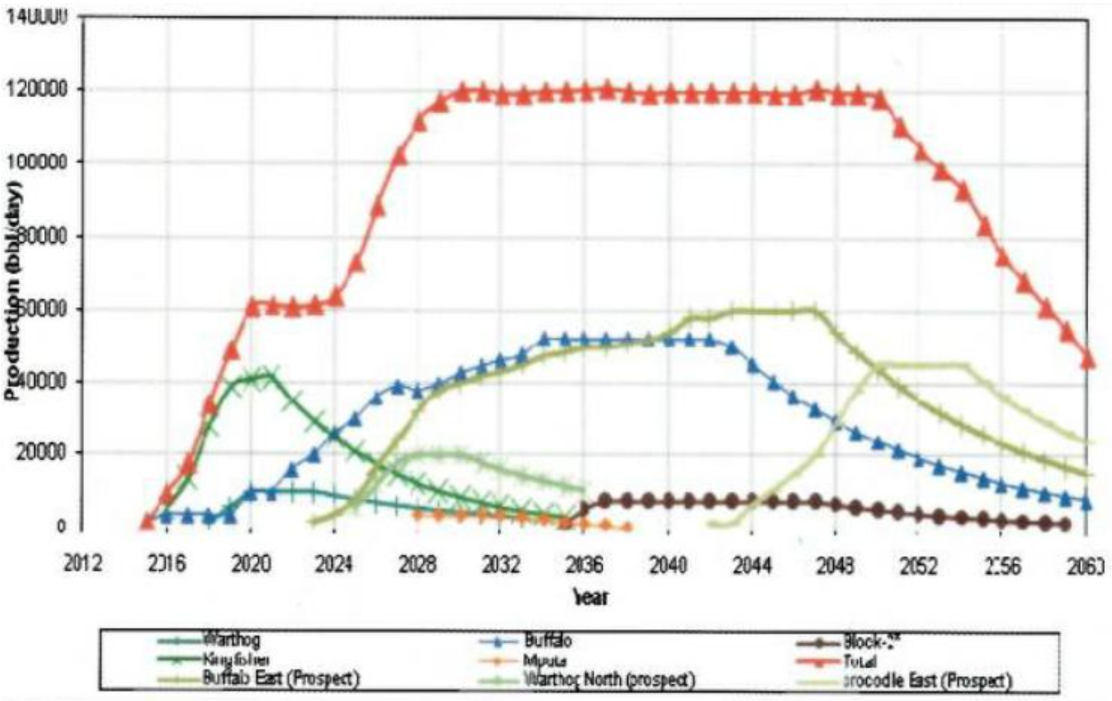
Nuclear energy: another option to enhancing energy security in Uganda is the peaceful application of nuclear energy. The institutional and legal framework for atomic energy has taken shape in 2008, with the Atomic Energy Act and establishment of the Atomic Energy Council, with a mandate of regulating and monitoring nuclear technology utilization and safety. The regulatory framework is laid through the Atomic Energy Regulations of 2011. Moreover, Uganda has developed the Country Programme Framework (2009-2013) in collaboration with the International Atomic Energy Agency (IAEA), for energy and other applications. The Ministry of Energy and Mineral Development (2012) states the prevailing view on the future of nuclear energy in Uganda as follows:

> Nuclear power can significantly contribute to national development. In view of the increasing energy needs and urgent environmental concerns relate dto power production using fossil fuels, …, nuclear power will play an important role in the future energy mix. The Ministry is therefore considering nuclear energy as part of the future energy mix.

Figure 93: Production profile for 60,000 bpd (panel 1) and 120,000 bpd (panel 2) refinery.

[30] Based on Ministry of Energy and Mineral Development, "Oil Refining Opportunities in Uganda", report with no specified date.





Source: Ministry of Energy and Mineral Development of Uganda, “Refining Opportunities in Uganda.” Unspecified date.

Biofuels: Uganda produces nearly 200,000 tons of sugar canes, generating 80,000 tons of molasses waste, with potential to produce million liters of alcohol per year, based on a conversion factor of a ton of molasses to 320 liters of ethanol (Ministry of Energy and Mineral Development, 2012). Ethanol and biodiesel production capabilities from other sources are also significant. The establishment of a Biofuels Program is encouraging, but much remains to be done to displace imported petroleum based on a diversified and locally resourced biofuels development.

4.4.4.2 Energy Security – Lessons from Uganda

Review of the overall energy security profile of Uganda offer valuable lessons for member States in the Eastern Africa sub-region, including the following.

- *Strategic petroleum reserve and short-term supply disruptions*: the importance of strategic reserves as management scheme to mitigate the impact of short-term petroleum supply disruptions is evident. The experience of Uganda in the Kenyan post-election violence and termination of oil supplies has made that quite clear. The strategic reserve of Jinja had to go through transfer to private sector management, to be refurbished and restocked. Insufficient strategic reserve continues to pose risk of potential disruptions. The case of Uganda has demonstrated that strategic reserves will have to be part of the short-term energy security strategy, and putting in place adequate infrastructure and stock will continue to be vital to shielding the economy from the impacts of unmitigated disruptions.

- *Fuel supply infrastructure and route diversification*: for land locked countries such as Uganda, Rwanda, Burundi, South Sudan and Ethiopia energy import infrastructure and fuel supply routes are vital considerations. Efforts to increase the capacity of the oil pipeline between Kenya and Uganda, with future plans to incorporate Rwanda and Burundi are steps in the right direction. While the delay of investment in capacity enhancement, through PPP, is understandable given oil discoveries in Uganda, joint collaboration and efforts on energy infrastructure investment offer a good example for enhancing energy security through a bilateral approach. Uganda has taken further steps to put incentives in place to encourage diversification of routes to include a balanced share of trucking through Tanzania, thus offering it a level of mitigated risk through route diversification. The strategy can appeal to landlocked countries excessively depending on one route, such as Ethiopia's reliance on Djibouti and South Sudan's reliance on Kenya.

- *Product adulteration and quality assurance*: petroleum product adulteration is lucrative, especially in markets where regulation is lax and enforcement is sparse. Uganda has instituted a Fuel Marking and Quality Monitoring program, along with mandated biocode for imported petroleum to tackle smuggling. These institutional and policy responses are worth looking at for countries considering measures to tackle smuggling and adulteration. However, the lack of necessary budgetary resources to implement these initiatives has resulted in limited effectiveness. The additional lesson is that innovative product adulteration and quality monitoring programs will need to be well resourced and enforced to reduce the problem to end users and enhance system reliability.

- *Information system*: in managing energy security, information is key to bring valuable analysis and data to decision-makers to make informed decisions. Uganda has instituted the National Petroleum Information System in 2011 to monitor global and local prices, stock levels and quality. The absence of real-time information will hamper measures to effectively respond to potential supply disruptions, and efforts to avert them. To member States considering development of an information system on petroleum, and other energy sector data, Uganda offers a best practice initiative to consider.

- *Oil sector development, refinery and regional strategy*: crude oil is a high-demand commodity with value everywhere. The disciplined approach of Uganda to give priority to local industrial development around petro-chemicals, invigorating development of

refinery capacity to enhance energy security locally, putting in place strategies to tap test well oil output and gas for thermal electricity and cement factory and a long-term plan to boost refining capacity to serve the regional market is indeed a best practice of domestic energy resource development policy with regional energy security enhancement benefits. The development of the natural gas sector in Tanzania, crude oil and potential new discoveries in South Sudan, crude oil potential recovery in Kenya and other potential oil and gas discoveries and development in the sub-region can give the Uganda model and feasible strategy a good look by considering existing markets in the sub-region.

- *Nuclear energy mix in the future*: whether or not nuclear energy should be in the mix of future energy planning is an active debate in the sub-region, particularly in relation to uranium discoveries and planned mining in Tanzania and Madagascar. Similar to Kenya, Uganda has put forth a nuclear energy policy and a regulatory framework, as well as institutional partnership with IAEA, laying the ground work for energy and other civilian use of nuclear technology. Nuclear energy is not yet in the short to medium range planning in majority of the sub-regional States, but future efforts of broadened energy sector development may consider the potential application of nuclear energy, which would start with laying the requisite policy, regulatory and institutional frameworks. Uganda offers a case example in navigating the policy, regulatory and institutional issues, along with Kenya, around nuclear energy.

5 GOVERNANCE OF TRANS-BOUNDARY WATER RESOURCES FOR HYDROPOWER DEVELOPMENT IN EASTERN AFRICA

5.1 WATER RESOURCES AND ENERGY DEVELOPMENT IN EASTERN AFRICA

One of the biggest challenges facing sub-Saharan Africa is generating sufficient power to unlock its economic potential. Presently, food insecurity continues to prevail with millions of people struggling to survive the relentless hunger and poverty for the last several decades. While the continent is blessed with natural resources, several factors contribute to the food insecurity and limited agricultural productivity. The most critical ones are the ever increasing population and the associated water and energy demands exacerbated by changing weather patterns and climate change. Water is a vital strategic natural resource for all economies mainly in food production, domestic use, and in the production of renewable energy. Development and management of this resource is thus a necessary condition for sustainable development for Sub-Saharan Africa's economies and for meeting the Millennium Development Goals (MDGs). Attaining food security by raising agricultural productivity will inevitably involve increases in energy inputs for water supply and management, plant nutrients, and agro-processing, to provide community lighting and drinking water, and for cultivation.

Energy security and access challenges are the main issues to address in terms of the developmental agenda of Africa for the attainment of the MDGs. The Eastern Africa sub-region has a huge bodies of water to co-manage (from Lake Victoria and Tana to several numbers of rivers and streams that flow across and between the borders of the countries) with the potential for competition and conflict, exacerbated by a growing population and increased demand for water use in hydropower energy production for development of their economies.

Presently, the Eastern Africa sub-region has an energy shortage problem that has proved to be costly to the region's economy and sustainable development goals. Efforts to develop the economy across the sub-region are being stifled by this lack of reliable energy. This is in spite of the fact that the region has significant number of perennial rivers with the potential to generate more than enough energy for the sub-region and beyond. The low levels of energy access, heavy dependence on biomass for energy, low *per capita* energy consumption and the lack of adequate energy infrastructure are some of the main energy challenges.

For the sub-region, an energy transition would be characterized by a move from the present levels of subsistence energy usage based on human labor and fuel wood resources, to a situation where household services and farming activities use a range of sustainable and diversified energy sources. Obvious benefits are greater resilience in the production system, higher productivity, improved efficiency and higher incomes to farmers. Environmental degradation, driven primarily by poverty, would be minimized.

The underlying themes that need to be stressed in for increasing energy access are country-led efforts, regional projects and strengthened partnerships. The emphasis should be

electricity growth, powering sustainable development and meeting basic needs. In order to achieve these goals, an effective governance of the resources with improved institutional performance within the sub-region is a necessity. More deliberative water governance is thus needed for informed trans-boundary negotiations.

Given the increasing demand for clean, reliable and affordable energy, the role of hydropower is gaining importance, particularly as a means to reduce poverty and attain sustainable development. Hydropower could be used to not only provide electricity access but can also effectively contribute to regional cooperation and development through the judicious and optimal allocation of increasingly scarce water resources. Hydropower has a great role to play in solving Africa's energy security and access challenges. Hydropower encompasses a number of complex issues including economic, social and environmental ones that should be addressed through considerate application of lessons learnt and best practices and through a triple bottom line approach to achieve sustainability.

The Eastern Africa sub-region has a number of rivers with excellent potential for hydropower development. The hydropower resources in sub-Saharan countries account for about 12% of the world's hydropower potential, but only 17.6% of these resources had been harnessed - one of the world's lowest figures (FAO, 2008). The continent has a technically exploitable capability of 1,888 TWh/yr of which 41% (or 774 TWh/yr) is in one country, the D. R. Congo, thanks to the mighty Congo River. Ethiopia, with its highlands, has a technically exploitable capacity of 260 TWh/yr and Cameroon 115 TWh/yr. Madagascar also has substantial potential capacity at 180 TWh/yr. In terms of installed capacity (Fig. 94), Egypt, with its famous Aswan Dam, leads with 2 810 MW, followed by the D. R. Congo (2,440 MW) and Mozambique (2,180 MW), while Mozambique (11 548 GWh) and Egypt (11 450 GWh) are the leading producers of hydroelectricity (1999 generation data) (WEC, 2003). Figure 94 shows estimates of the hydropower potential for the continent.

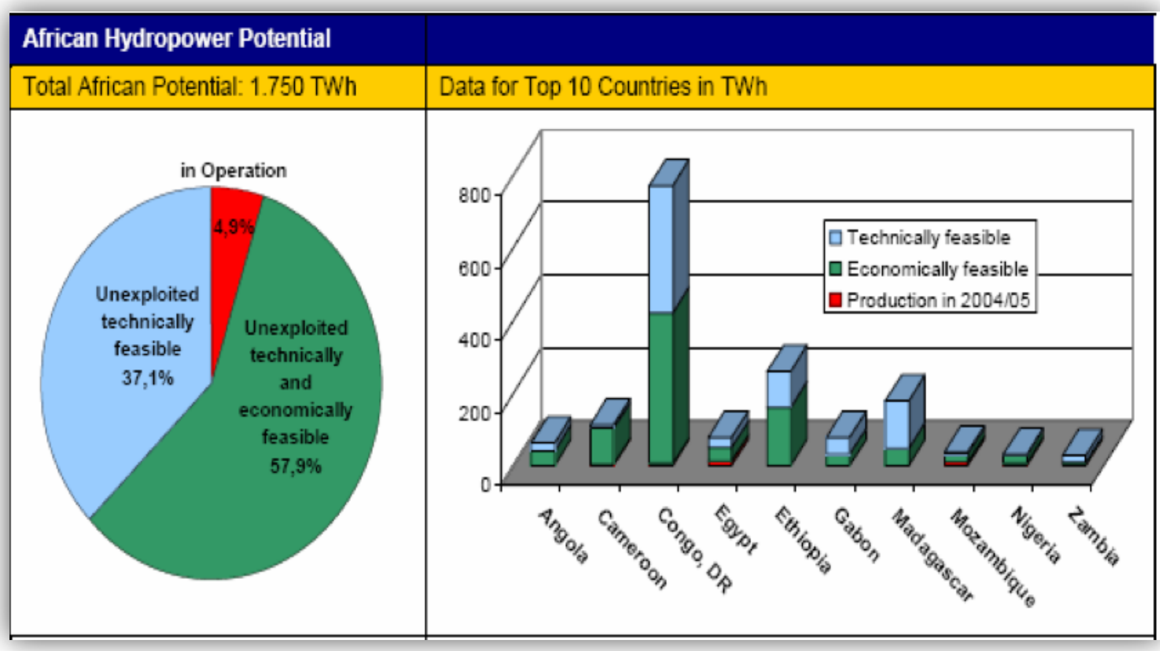
The current geographic distribution of hydropower in Africa demonstrates the following pattern: North Africa (23%), West Africa (25%) and South/Central/Eastern Africa (51%). Despite this potential, which is enough to meet all the electricity needs of the continent, only a small fraction has been exploited and Africa has one of the lowest electricity utilization rates in the world. Presently, 20% of this potential has been harnessed.

In the Eastern Africa sub-region, as mentioned earlier, a number of countries have faced power shortages that have caused power supply rationing. The origin of the crisis is the decrease of water levels in rivers and lakes that are feeding the hydropower plants and lack of investment in power generation. Countries in the sub-region have responded to the challenges by embarking on aggressive measures in the production as well as transmission of energy, interconnecting countries and sharing available capacity. The creation of the Eastern Africa Power Pool (EAPP) in 2005 is one of the major steps undertaken in this regard.

Hydropower has long been the pillar of Eastern Africa's energy production capabilities. Indeed, the majority of electricity produced in the sub-region comes from hydropower, and it is expected to provide 79% of East Africa's total new additional generation capacity (REEP, 2010). However, environmental and institutional challenges to harnessing the region's hydropower production potential remain, including drought, carbon

issues relating to reservoirs, the need for capital investment, a lack of technical expertise in formulating energy plans and feasible projects, and perhaps a focus on large-scale projects.

Figure 94: Africa's hydropower potential.



Source: FAO, 2008.+

On the other hand, hydro projects have benefitted, and can continue to benefit, from private sector investment and foreign donors. Eastern African countries are an attractive area for such investment; the region has maintained a fast growth trajectory despite experiencing severe droughts and famine. The region registered 5.8% GDP growth in 2011, and 6% in 2010 (UNECA, 2012). Indeed, much of Uganda's growth came from increased Foreign Direct Investment (FDI) in its energy sector (UNECA, 2012). Furthermore, Africa's hydroelectricity production costs are the lowest in the world.[31]

5.2 MAJOR SUB-REGIONAL WATER SYSTEMS AND HYDROPOWER DEVELOPMENT IN EASTERN AFRICA

5.2.1 Nile River and Hydropower Development

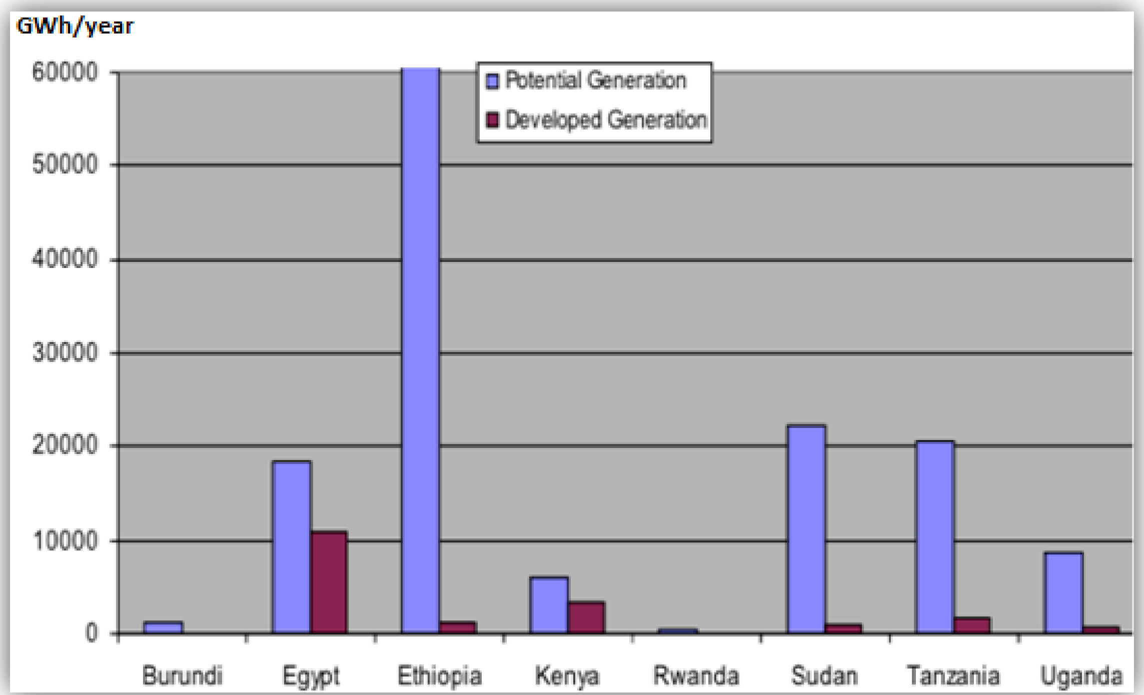
The Nile, the world's longest river, flows for 6,850 Km, and covers ten countries: Burundi, the D.R. Congo, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, the Sudan, Tanzania and Uganda. The Nile, due to its length and climatic variety, is one of the most complex river systems in the world. Its main sources are the Blue Nile, which arises from Lake Tana in Ethiopia, and the White Nile, which arises from Lake Victoria in Uganda. Some countries, such as Burundi, Rwanda, Uganda, Sudan and Egypt are highly-dependent on the river, while for others, such as D.R. Congo the Nile's water constitutes only a small part of their resources. Egypt and the Sudan use the Nile's water mainly for agriculture purposes; 80% of water in Egypt is directed to this sector. The Nile is not only a water reserve for its riparian States, it is also a fundamental waterway. In the Sudan, it is the only practicable way to navigate across

[31] See (www.worldenergy.org, 2007).

regions during the flood season from May to November. Nile water is also used for production of hydroelectric power, especially in Ethiopia (Sinnona, 2007).

If all the Nile Basin Countries are taken into account, their hydropower potential is estimated at 140,000 MW. The D.R. Congo alone is considered to have a potential of 100,000 MW, with approximately is 40,000 MW concentrated in the INGA complex from the Congo River; Ethiopia has a hydropower potential of 45,000 MW. Figure 95 shows the energy from hydropower for the Nile basin countries, excluding D.R. Congo.

Figure 95: Energy generation potential and realized for the Nile basin countries.



Source: Kanangire, 2008.

While the sub-regional hydropower potential is considerable, especially for D.R. Congo and Ethiopia, the current approach is that each country is attempting to develop its hydropower resources autonomously. Whereas they face challenges for collaboration, there are examples of countries jointly building hydropower plants such as Burundi, Rwanda and D.R. Congo on the Ruzizi through collaborated, despite the challenges.

With regards to small hydropower developments, which are of importance to rural power supply, while most of the countries have recognized their role, particularly for rural electrification through small/mini hydropower development, progress has been limited. The reasons cited mostly are lack of access to relevant technologies and limited financial resources.

The central water and energy management challenge for the Nile River Basin, as in many other river basins throughout the world, is sustainability of water supply in the context of population growth, recurring drought and increasing competition for water. The issues get complicated as a result of global climate change. As a result, the demand for the Nile water is expected to increase significantly. Some of the basin states, such as Ethiopia, Kenya,

Tanzania and Uganda have already experienced critical water shortages due to extreme events such as recurring droughts. Shortage of water occurs when the needed amount of quality water is not available at the right time and place of need. Shortage due to drought represents physical shortage. On the other hand shortage can happen due to contamination of the available water. In this case the water can become degraded to an extent it is not safe for human consumption. Considering a threshold value of 1000 cu m per person per year, it is projected that some of the Nile Basin countries: Burundi, Rwanda, Egypt, Ethiopia and Kenya will be considered as water "scarce" by 2025. This is based on a continuous population growth of the basin. If the present trend continues, water shortage is likely to materialize and impacting socio-economic development and increasing the potential for water conflict (Yitayew and Melesse, 2010). The main strain on the Nile water resource comes from Egypt's unilateral development of new areas such as the Toshca project to expand irrigated areas to establish claims for prior appropriation rights. Equally, Ethiopia's unilateral decision to build the Renaissance Dam is a challenge for water governance.

The historical hydro-climatology studies show the variability in flow of the Nile both in time and space. Unless there is a way to regulate this flow condition, it is difficult to plan a meaningful sustainable water resources and energy development program. This is particularly true when one consider hydropower development. It is also apparent that in a basin as big as the Nile, a concerted effort to gather data to forecast the hydrologic and climatologic variables is absolutely necessary. Effective Nile water governance must consider integrated basin-wide hydraulic cooperation in parallel with the rest of the effort to bring the riparian countries to work together with a shared vision of benefiting socio-economically and politically.

Until recently, most of the agreements on the Nile Basin were made either between colonizers or bilateral agreement between the Sudan and Egypt. The 1990s has been one where substantial effort has been invested by the riparian States themselves and by the donor agencies to develop confidence and vision for the future which is based on cooperation, consideration for the environment and the efficient use of water. Despite the intense pressure for cooperation driven by demographics, sustainable development needs, water and food security, economic integration and climate change, there is no reliable established framework for governance of the water and energy resource of the Nile basin to attain the shared vision of benefiting socio-economically and politically that is accepted by all the riparian countries. The present challenge for cooperation stems from conflicting agricultural water demands mainly from the Eastern Nile countries. All have yet to agree on equitable and reasonable use of the water.

5.2.2 The Congo River and Hydropower Development

The Congo River is the ninth largest river in the world at 3,100 km. It originates in Zambia, flows north into Lake Bangwelu and then Lake Mweru. The Luvua flows north out of Lake Mweru and joins the Lualabu, which is a major tributary of the Congo. The Congo flows southeast into the Atlantic Ocean. It has the highest potential for hydropower of any river in the world. The basin contains 30% of the fresh surface water in Africa, and the discharge at Kinshasa and Brazzaville is 1,269 km^3/y (UNECA, 2000). There are many tributaries on both sides of the Equator, tehrefore the rainy season alternates in different parts of the basin, providing a fairly constant yearly flow in the Congo.

Figure 96: The water basin of D.R. Congo.

The Congo River basin is the second largest in the world with an area of 3.7 million km^2. Nine countries make the Congo River basin: the D. R. Congo , the Central African Republic, Angola, the Republic of Congo, Tanzania, Zambia, Cameroon, Burundi and Rwanda. Approximately 29 million people live in the basin, which includes 250 indigenous groups. It has diverse and dynamic ecological systems with many unique plants and animals.

The Congo River has tremendous potential to provide electricity, and in terms of ecological and power wealth, as well as its rain forests, is rated second in the world after the Amazon (Fairley, 2010). Since its tributaries are on both sides of the equator, the Congo is swamped with rain water in all seasons. This consistent flow translates into a hydropower potential that knows no equal in scale, concentrating at a natural pinch point 225 km upstream from Kinshasa. The Congo River drops some 102 meters over a distance of 15 km within the valley. Total flows range from a low of 30,000 m^3/s in the dry season from June until September to up to 55,000 m^3/s at the peak of the wet season in November. Two channel diversion power projects, Inga I and II, take a portion of the flow off the main channel and divert it 9 km through a canal to the hydroelectric plants. After powering the turbines the water rejoins the main channel (Fairley, 2010).

The Inga valley 250km west of Kinshasa is the site of the most important hydroelectric projects and proposals in all of Africa. The existing installation already power Kinshasa and western D.R. Congo and provide critical export revenue, and expansions could see the site develop into a clean energy provider of global importance. These developments however will not be without localized impacts and risks which need to be mitigated.

Inga I was built in 1972 and Inga II in 1982, and have a design capacity of 351 MW and 1,424 MW, respectively. Nevertheless, due to old installations and lack of maintenance, the output is now considerably reduced. An internationally funded $US 500 million rehabilitation project is in progress to restore some of that capacity to over 70% and to modernize the generating facility, the distribution network and the electricity authority SNEL (Société Nationale d'Electricité) (UNEP, 2012).

In 2002, there was an attempt to obtain more power from Inga through international cooperation. A major new project, Inga III, is at the design level with a proposed total capacity of 3.5 to 5 GW. High voltage lines are intended to transmit the power generated to Zambia, Zimbabwe, South Africa and the Republic of Congo (Brazzaville). Much of the anticipated project cost (up to US$8 to 10 billion) faces tough technical choices including that of optimal design (IRENA, 2012).

The Grand Inga project is at the feasibility stage and plans are to generate 39 GW, which is the largest energy-generating project ever-built. The project is expected to cost as much as US$ 80 billion and significant amounts of electricity could be exported. The D.R. Congo and South Africa have signed a Memorandum of Understanding to establish partnership between the two countries of the development of Grand Inga.

5.3 GOVERNANCE OF TRANS-BOUNDARY WATER RESOURCES IN EASTER AFRICA FOR HYDROPOWER DEVELOPMENT: CHALLENGES AND OPPORTUNITIES

5.3.1 The African Context

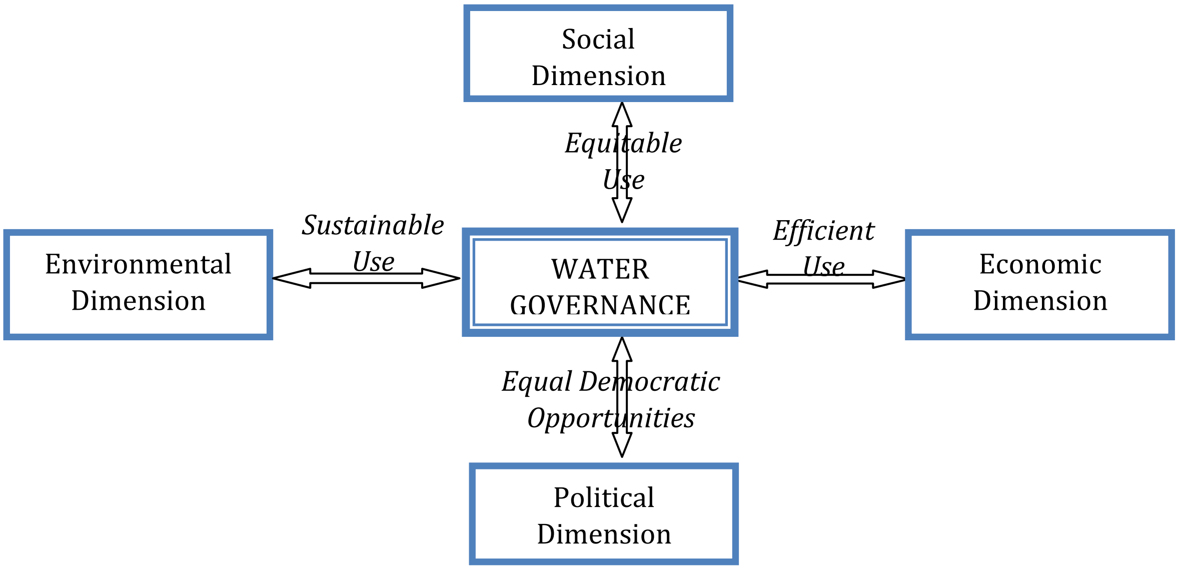
Optimum management of water resources to meet the MDGs requires effective governance of the resource especially, along with transnational lakes and river basins. Water governance refers to the different political, social and administrative mechanisms that must be in place to develop and manage water resources and the delivery of water services at different levels of society. It is the framework of political, social, economic and legal structures within which societies choose and accept to manage their water-related affairs. Efficient water governance requires transparency and accountability, participatory mechanisms appropriate to regional realities, needs and wishes and respect for the law and contractual obligations set for the region.

The social dimension of water governance deals with equitable use of water resources while the economic dimension draws attention to the efficient use of water resources and the role of water in overall economic growth. The political empowerment dimension addresses granting water stakeholders and citizens at large equal democratic opportunities to influence and monitor political processes and outcomes. The environmental sustainability dimension shows that improved governance allows for enhanced sustainable

use of water resources and ecosystem integrity. Figure 97 illustrates the relationships of these dimensions of water governance.

Water governance capacity also reflects a society's level of competence to implement effective water arrangements through policies, laws, institutions, regulations and compliance mechanisms. Without a clear policy, it is difficult to develop a coherent system of laws. Without a clearly established legal structure, it is difficult for institutions to know how to operate. Without effective institutions, compliance and enforcement are likely to be lax (Iza and Stein, 2009). This is particularly true when dealing with water as a transnational resource that is to be shared for sustainable development of a region, such as Eastern Africa.

Figure 97: Different dimensions of water governance.



Source: http://www.watergovernance.org/why.

While water governance is a complex subject that needs an extensive treatment, the focus on water governance in this report is in the context of energy production. Good water governance along trans-boundary lakes and river basins is a necessary while not sufficient prerequisite for achieving the MDGs. Equitable governance of water resources implies finding a balance between citizens' needs, and the demands from stakeholders in the agricultural, industrial, and other fields. While water is considered a national resource by governments, it is not demarcated by borders that are political by nature. By connecting people and creating interdependence among local users from different countries, trans-boundary rivers and lakes pose governance challenges and can become a source of tension at the political level. Trans-boundary water resources hold considerable potential for conflict and escalation, but also offer a variety of different possibilities for transnational cooperation.

In the 1980s and 1990s, concerns were greatly raised about water shortages-related conflicts in various regions given the rising consumption of water and the asymmetrical power relations between riparian countries. A much-cited example was conflict among the riparian countries along the Nile. The relations between the riparian countries of Southern Africa were likewise seen as a potential source of conflict. However, these somber

predictions have not materialized. The UNDP Human Development Report (2006)[32] affirms that water could foster conflicts, but more frequently it has been a bridge to cooperation. Indeed, experience shows that trans-boundary water resources are far more likely to serve as the motor of trans-boundary cooperation than of violent conflict between nations. Since the end of the apartheid regime in South Africa, it is precisely Southern Africa – a region with an exceptional number of trans-boundary rivers – that has a number of positive developments to show in this regard. Also in other sub-regions, Africa's heads of State and government have opted for a cooperative management that has been affirmed in many declarations and bi- and multilateral agreements.

Trans-boundary water resources management in Africa is addressed in various international documents with guideline characters; including the G8 Africa Action Plan, the New Partnership for Africa's Development (NEPAD) Action Plan, and the Abuja Declaration of the African Ministers Council on Water (AMCOW). These efforts also have reference to the work of the UN Secretary-General's Advisory Board on Water and Sanitation and the International Water for Life Decade proclaimed by the UN General Assembly (2005–2015).

Trans-boundary water resources management provides for governance of water resources shared between two or more riparian neighboring countries. Issues of differing and elastic political agendas and competition for scarce water resources complicate the governance approach. The Nile Basin with 10 riparian countries and complex upstream/downstream issues is one such example. In the South African Development Community (SADC) alone, there are 13 trans-boundary rivers shared by two or more riparian states. As many local, national and international stakeholders are involved, Trans-boundary Water Resources Management (TWRM) cannot be conducted purely on a state-by state basis. Multi-national dialogue and negotiations are the basis of wide-ranging agreements between riparian states. The need for cooperation and information sharing is an essential element. This can be facilitated by the creation of trans-boundary-basin institutions or agreements – such as the Congo-Oubangui-Sangha International Basin Commission (CICOS), the still-born Zambezi Basin Commission, or the Nile Basin Initiative – established to monitor the policies of riparian states and ensure equitable utilization of water resources, create development strategies and monitor the implementation of national Integrated Water Resource Management (IWRM) plans. In most cases, however, such institutions have faced severe challenges impeding their ability to get off the ground (Schmeier, 2010).

Governance of trans-boundary water resources in riparian countries along the Nile present both challenges and opportunities. While at the national-level different institutions have been created to settle disputes over water allocation, at the regional-level institutional structure with authority to enforce water agreements are rather absent.

While progress made with regards to conventions is commendable, a sustainable regional framework is absent. Governments also have preference for bilateral agreements to settle disputes over trans-boundary water resources. Internationally, there exist two multilateral agreements, the UNECE "Convention on the protection and use of trans-boundary watercourse and international lakes", signed in Helsinki in 1992 and in force from

[32] UNDP Human Development report. 2006. Beyond scarcity: power, poverty and the global water crisis.

1996, and the UN "Convention on the Law of the Non-Navigational Uses of International Watercourses", adopted in 1997, but still not in force (Sinnona, 2007).

5.3.2 The Political Economy of the Nile and Implications for Water Governance

Trans-boundary water management is mainly a political process. This is the reason why cooperation and conflicts on water resources are determined by asymmetries in power among riparian states. It is not without good reason that the example of the Nile is often cited in the popular discourse on "water wars." Egypt is wholly dependent on the waters of the Nile for its economic development, and hence it has declared a secure supply of water from the areas beyond its border to be a vital national security interest. In the past there have been repeated conflicts between Egypt and the upstream Nile riparian states over the allocation of the waters of the Nile, and these conflicts have even led to threats of war in times of particular stress (i.e. in periods of drought). It is important to point out that while there are ten riparian countries, only three of these are in the most critical position for peaceful, cooperative sharing of Nile water—Ethiopia as the primary supplier, and Egypt and Sudan as the dominant consumers.

Among riparian states, Egypt has the highest Nile water share, subject to water management of the upstream riparian states. In 1979 it was declared that at the beginning of 2000 Egypt would have faced a water deficit of 4 billion m3 due to its alarming population growth (one million every nine months) and agricultural water uses. Still in 1990s, Lake Nasser, because of the high evaporation, could not meet the population's water demand, thus 50% of food was imported from abroad (Swain, 1997). These occurrences caused high internal instability and a strong political and economic dependence on other countries' policies, threatening Egyptian national security. In order to face these political problems, Egyptian diplomacy has strongly promoted water allocation based on old treaties, basically attempting to maintain the *status quo*. North and South Sudan (secession with the referendum of 9th of January 2011), as well, are strongly dependent on the river.

After the Second World War, with independence of riparian states, the river became the scenario for power games and disputes related to the Cold War. In 1956, when the Sudan obtained independence, it requested a renegotiation of the 1929 Water Agreements with Egypt. Sudan accepted the Aswan High Dam construction by Egypt, in exchange for sharing the water of the dam. The two countries signed in 1959 Nile water agreements to allocate the resource and to share costs and benefits of future projects on the river. From then on, cooperation between the Sudan and Egypt more or less continued (Sinnona, 2007).

The Hydromet Agreement was signed in 1967, originally among Egypt, Kenya, Tanzania, Uganda and the Sudan with the collaboration of the United Nations Development Programme and the World Meteorological Organization, and later joined by Rwanda, Burundi, D.R. Congo and Ethiopia, increasing cooperation. Hydromet lasted for 25 years, terminating in 1992. The same year the water resource ministers from Egypt, the Sudan, Rwanda, Tanzania, Uganda and D.R. Congo created a new organization, the Technical Committee for the Promotion of the Development and Environmental Protection of the Nile Basin (TECCONILE). The rest of the four riparian states participated as observers. In February 1999, the Nile Basin Initiative (NBI) was launched by all riparian countries, except Eritrea. In September 1999, the NBI Secretariat replaced TECCONILE in Entebbe, Uganda. The NBI is considered a transitional arrangement until the member countries agree on a

permanent Nile River Basin Commission for sustainable development of the river basin (Sinnona, 2007).

This positive development is a good indication that the constellation outlined above also offers incentives for international cooperation. Decision makers throughout the world, and precisely in Africa, have come to recognize in principle that trans-boundary waters call for cooperative trans-boundary management. This has found expression in numerous bi- and multilateral declarations and agreements on individual water bodies as well as in framework agreements that lay down general principles governing the management of trans-boundary river basins.

Cooperation is often extended to other benefits. The UNDP Report (2006) claims that more than 40% of transnational water treaties include provisions on financial investments, energy commerce and peace negotiations. This approach could facilitate agreements, because it provides governments national justifications and it promotes financial flows, capable of opening cooperation on a variety of matters. Moreover, it offers a bargaining power to weaker states that could grant something in return to an equitable water management. Trans-national cooperation is influenced by asymmetries in power. In this framework, trans-national relations for the management of common water resource become a matter of interactions, more than a pure problem of conflict or cooperation. *Conflicts and cooperation coexist in situations where a resource is shared.*

5.3.3 Public Participation in Water Governance

In many respects, civil society participation in water resources management and water supply and sanitation is the key to successful sector governance, encompassing management, quality service provision and sustainability. This has been recognized in the Dublin-Rio principles, which are clear in their statements that water development and management should be based on a participatory approach, involving users, planners, policy-makers at all levels and that women play a central part in the provision, management and safeguarding of water. This calls for a sharing and balance between stakeholders (both top-down and bottom-up) in their planning and management. It has also been recognized that service provision functions should be delegated to the "lowest appropriate level" at which stakeholders involved in management need to be identified, resourced and mobilized. It follows that in the water sector, far more than most, the beneficiary needs to be involved at all stages of the project cycle from monitoring and needs identification right through maintenance and basin and system management.

In order to manage water equitably, governments must solicit stakeholders' involvement. Involvement of stakeholders at the trans-boundary scale is key in order to ensure adaptive water management (Kranz and Mostert, 2010). Principle 10 of the 1992 Rio Declaration on Environment and Development affirms that environmental issues are best handled with the participation of all concerned citizens. The Declaration exhorts nations to facilitate public participation through methods to increase transparency, participatory decision-making and accountability. The International Association for Public Participation (IAP2) defines public participation as "any process that involves the public in problem solving or decision making and uses public input to make better decision". As mentioned by Kranz and Mostert (2010), there is public participation when the involvement is direct. This

form excludes elections, that are a form of indirect involvement, and it includes financial contributions. Inadequate public participation, or even worse, the exclusion of people in decisions that affect their welfare, often lead to a violation of basic human rights and possibly to public protests and obstruction to the implementation of decisions (*idem*). "Ending global thirst depends upon providing the public with a voice in water resource decisions that directly affect them" (*idem*).

5.4 THE CONGO RIVER: CHALLENGES AND OPPORTUNITIES FOR EFFICIENT USE

In 2002, the D.R. Congo was just beginning its post-conflict phase from its five years instability during which Mobutu Sese Seko was overthrown in 1997. Mobutu Sese Seko had dominated the country for thirty years. Congolese rebel leader Laurent Kabila unseated Mobutu with help from Rwanda and Uganda, but conflict ensued the following year involving Rwanda and Uganda. Forces from Angola, Namibia and Zimbabwe also intervened, turning the D.R. Congo into a regional battleground until 2002 when Joseph Kabila was appointed president in 2001 following his father's assassination, and secured a peace deal that brought some stability and spurred an international effort to rebuild D.R. Congo's infrastructure.

The D.R. Congo government identified restoration of its war-ravaged electrical system as an early priority for national recovery. The World Bank intervened to support the rehabilitation of the power stations installed under Mobutu to generate electricity from the water flowing into the Inga Dams. The original 1972 station known as Inga 1 was completely dysfunctional and Inga 2, added in 1982, was badly neglected. The transmission lines to distribute their power within the D.R. Congo and export customers as far away as South Africa were also neglected. Power output was barely a third of Inga 1 and 2's original capacity, according to the World Bank.

An African program was also created to realize Inga's further potential under the encouragement of the African Union and its New Partnership for Africa's Development (NEPAD). A key goal was to interconnect Africa's power systems as a means to expand access to electricity and reduce its cost. The proposed Grand Inga Dam, which is to be constructed in western D. R. Congo will build on the existing dams, Inga I and Inga II, and a yet to be constructed Inga III. It has been proclaimed that upon construction, 500 million of Africa's 900 million people currently without electricity will be able to benefit.

5.5 BEST PRACTICES IN GOVERNANCE OF WATER RESOURCES

The Mekong River Commission (MRC), an inter-governmental agency that works directly with the governments of Cambodia, Laos, Thailand and Viet Nam, established under the 1995 Agreement on Cooperation for the Sustainable Development of the Mekong Basin, provides one of the most highly developed examples of an international river basin organization founded to facilitate trans-boundary water cooperation. Currently the MRC Secretariat administers a range of joint programmes, including: the Basin Development Plan; the Water Utilisation Programme; the Environment Programme; the Flood Management and Mitigation Programme; the Fisheries Programme; the Agriculture, Irrigation and Forestry

Programme; the navigation Programme; the Hydropower Programme; the Information and Knowledge Management Programme; and the Integrated Capacity Building Programme.

As one of the world's largest and most complex efforts at TWRM, the Nile Basin Initiative (NBI) could be considered as best practice as its objective is to develop water resources in a sustainable and equitable way, and to ensure efficient water management and optimal use of the Nile's water resources. Major achievements have been to facilitate cooperative action, build confidence and capacity in riparian states, and pursue cooperative development opportunities.

In the SADC Region, the SADC Water Protocol was prepared in 1995 to encourage the establishment of appropriate institutions for monitoring and ensuring equitable utilization and strategizing for water resources development. The Protocol also provides for essential data and information exchange between riparian states. Progress has been made in forging agreements in some shared basins, such as the Zambezi, Orange-Senqu and Incomati basins, and some water monitoring networks have been established that are now providing information to riparian states. Efforts to get the Zambezi Watercourse Commission (ZAMCOM) up and running five years after an agreement was signed by seven of eight riparian states to do so continue to be bogged down by political disputes.

> *Civil Society Participation in Practice*: Burkina Faso, Senegal and South Africa use decentralization approaches to ensure the enhanced participation of target communities in program design and implementation and come closest to what could be defined as best practice. Benefiting from decentralization and democratic systems that avail responsive representation and local governments, these approaches center on participatory planning in the development of Local Development Plans (LDPs) and, commensurate with them, Local Water and Sanitation Plans (LWSPs). The LDPs and LWSPs constitute a useful framework for sector planning that is based on community and community organization participation. They successfully integrate community involvement and local government ratification with regional and national planning and budgeting processes.

5.6 WAYS FORWARD FOR EASTERN AFRICA

River water does not stop at administrative or political boundaries, so the best way to develop, use, protect and manage water resources is by forging cooperation between all the countries within the natural geographical and hydrological unit of the river basin. The interests of both upstream and downstream countries has to be considered in a transparent, responsible and comprehensive manner.

Trans-boundary water resources represent a matter in which water governance is complicated by issues of politics and competition for scarce resources between two or more countries. Trans-boundary Water Resource Management (TWRM) cannot be conducted purely on a state-to-state basis, since many other stakeholders from the local to the international level typically need to be involved. Furthermore, weak legal and regulatory frameworks, a lack of basin-wide institutional arrangements for joint development and

management of trans-boundary water resources, poor water resources information systems, poor financing and a lack of stakeholder participation also affect the success of TWRM.

Two basic principles considered prerequisites for good water governance are transparency and accountability, which are closely related to one another within the context of governance systems. For instance, transparency necessitates strong sector performance monitoring systems, which will enhance accountability for the use of resources by service providers. Decentralization provides an opportunity for the introduction of transparency and accountability measures, but also introduces threats to the same if community and civil society voices are not well articulated.

Moreover, corruption in the water sector results from a lack of transparency and accountability. Corrupt practices are endemic to most institutions and transactions in Africa, leading to increased costs to users for service provision. With regards to civil society participation in sector governance, the involvement of all users in the process of developing appropriate policies and regulations for water resources management and use is essential for effective water sector governance. Participation of civil society and the permanent mechanisms that will enable it are essential in every aspect of governance, from project and program selection and planning, to budgeting, policy and regulation. This not only improves sustainability of services, but also improves transparency, accountability and regulatory enforcement.

The ongoing changes in the world economy and the shift from geopolitics to globalization are being complemented by a move away from special treatment for individual countries in mitigating their systemic development failures and structural weakness to accelerate their integration into the world economy. This is expected to help manage common problems, which stem from rapid global integration. Regional energy cooperation and integration offer one of the most promising and cost-efficient options for Africa, Eastern Africa in particular, to further develop their energy sectors, in order to gain the environmental, social and economic benefits from a more efficient use of resources. Four major benefits are associated with regional energy integration: improved security of supply; better economic efficiency; enhanced environmental quality; and development of renewable resources. It can enhance peace and stability. Historically, the first two factors have been the driving forces behind power interconnections and regional trading. However, with the increasing concern and awareness of the need to integrate environmental considerations in development planning, power interconnections are being considered as a means to develop alternative clean or more environmentally sound energy resources.

The way forward, one Eastern Africa states should consider, is to establish effective water governance based on the principles of equity and efficiency in water use and energy resources production and distribution. The countries in the sub-region need to formulate, establish and implement water and energy policies with appropriate legislative and institutional frameworks. There has to be clearly defined roles of governments, civil society and the private sector in terms of their responsibilities regarding ownership, management and administration of the water and energy resources. Transnational dialogue and co-ordination, conflict resolution, price regulation and subsidies must be clearly defined and agreed upon by all parties. Also, the sub-region has to focus on benefit-sharing rather than

water-sharing, multilateralism instead of unilateralism and enhancing more cooperative approaches. Establishing effective water governance and the NBI legal and institutional framework agreement with full consideration of the hydro-politics of the region is urgently needed if the countries are to overcome their differences and attain a sustainable water and energy development.

6 ENERGY TCHNOLOGY AND ENERGY ACCESS IN EASTERN AFRICA

6.1 INTRODUCTION

Science, Technology and Innovation (STI) is an often misunderstood concept but one definition which is apt is: finance creates technology and technology creates innovation which, in turn, creates financial benefits. However, in a broader sense it is widely accepted that STI is intrinsic and vital to a country's development, regardless of its prevailing level of development. Science and technology has become an undisputable element of development in any country.

Technological innovations have brought many transformations in society. One of the main causes of the rapid, profound and overall changes that humanity has experienced in the last three decades is the closer and organic relationship between scientific development, technological improvements and their application in the production, distribution and consumption of goods and services. In the world economy, there is a globalization of markets, characterized by an increasing competition leading to new technologies generated based on scientific advances.

Energy is widely recognized as an essential prerequisite for economic growth and sustainable development, including the achievement of the MDGs. Without access to modern energy and the services it can provide, people are deprived of the opportunities to engage in income-generating activities and in improving their living standards. Technologies can and must play an integral role in transforming the energy system. The incorporation of these technologies to the production system allows to reduce costs, improve quality, save energy and scarce raw materials as well as to increase the productivity of the labor force. Innovation and technology in energy the energy sector are integral parts, with knowledge applied to the production of goods or services in different forms: physical machinery; production processes; software and tacit knowledge help improve the energy system. With the acceptance of the importance of STI as a key component of sustainable development, the acquisition, adaptation and deployment of ICT, including in the energy sector, have received a growing attention.

Energy technologies play a crucial role in expanding energy access,, which in the future will come from diversified energy sources, including technology-supported renewable energy solutions. How STI, adapted and/or indigenously generated, facilitate expanded energy access and help reduce energy insecurity is among the key technology policy priorities in the energy sector. A framework for STI management in the energy sector in Eastern Africa is therefore a crucial consideration within the energy access and security agenda. .

6.2 ENERGY TECHNOLOGIES AND ENERGY SERVICES

Energy technologies offer a potential for diversification in energy supply, thus strengthening energy security by broadening the energy generation portfolio used within a country and can play an important and cost-effective role in rural electrification, particularly

in areas that are costly to connect to existing grid systems. Energy technologies have the potential to contribute to: reduce dependence on imported petroleum fuels; expand energy access in economically viable ways; improves indoor health; medium and large-scale renewable energy technologies supported employment growth; and broader socioeconomic improvements.

Innovation and technology in the energy sector offer opportunity to reach to the majority of the sub-region's population, especially the rural communities and the urban poor. Technologies like solar panels and wind turbines require many parts and services to develop projects, install and run them in the most efficient way, creating collateral economic opportunities. Renewable energy generation options such as wind, small hydropower bagasse-based cogeneration and geothermal help reduce adverse local, regional and global environmental impacts of increased reliance on conventional energy options. In 2008, about 18% of global energy consumption came from renewable (Zobaa and Bose, 2011). Wind power installed capacity grew at 30% worldwide in 2009: at 158 GW and cumulative global PV installations exceeds 21 GW. Africa has massive hydro-power capacity, 9,000 MW of geothermal (hot water and steam based) potential (Karekezi and Kithyoma, 2003), abundant biomass and significant solar and wind potential. Proper integration and application of innovation and technology in the energy sector can help release these renewables potential into expanded access and enhanced energy security.

In Eastern African countries, innovation and technologies are characterised by small systems, as governments often invest substantially more in conventional large-scale energy sources rather than in renewable energy sources (RES). However, distributing, installing, operating and maintaining RETs in rural areas have the potential for substantial power generation and expanding economic opportunities.

Renewable energy technologies (RETs) are diverse technologies that convert renewable energy sources into usable energy in the form of electricity, heat and fuel. A number of RETs offer viable potential and options for both off-grid and mini-grid solutions for energy access in rural areas (see Table 44).

These technologies leverage local resources and can often be sited close to load centers, reducing the need for costly grid extension (UN Foundation, 2012) and helping to lessen the need to import expensive diesel fuel. Aside from renewable energy technologies' commercial benefits, these technologies enhance energy security by decreasing dependency on fossil fuel imports, provide a number of benefits: improve human health, greater energy security, provide environmental services, and promote forest conservation. Their introduction also helps initiate gender- sensitive dialogue in local communities (SGP, 2011).

The wide range of renewable energy applications is shown in Table 45, ranging from lighting and refrigeration, communications, cooking, heating and cooling, industrial uses and agricultural applications. These services can be supported by renewable energy technologies such as solar thermal, solar cookers, solar pumps, mini hydro, wind energy, biogas, biomass gasifiers and mini-grid applications. The scale at which these technologies can be integrated to offer energy services differ. These technology options offer three category of options to expand energy access (see Box 1).

Table 44: Renewable energy sources in Eastern Africa.

	Wind	Solar	Hydro	Biomass	Geothermal	Ocean
Burundi	Medium	High	High	Medium	Unknown	N/A
Comoros	Medium	High	High	Unknown	High	Unknown
Djibouti	Medium	High	Unknown	Unknown	High	N/A
D.R. Congo	High	High	High	High	High	Medium
Eritrea	High	High	Unknown	Low	Medium	N/A
Ethiopia	High	High	High	High	High	N/A
Kenya	High	High	High	Medium	High	N/A
Madagascar	High	High	High	Medium	Low	High
Rwanda	High	High	Medium	Low	High	N/A
Seychelles	N/A	High	N/A	N/A	N/A	N/A
Somalia	High	High	High	Unknown	Unknown	High
South Sudan	N/A	N/A	N/A	N/A	N/A	N/A
Tanzania	High	High	High	High	High	N/A
Uganda	Medium	High	High	Medium	High	N/A

Box 1: Options for extending electricity access.

Grid extension. Extension of existing transmission and distribution infrastructure to connect additional communities. This is most feasible in or near urban areas or in otherwise sufficiently dense communities.

Mini-grid. Local low-voltage grids fed by multiple small-scale energy sources and are often run by a village co-operative or an individual entrepreneur.

Off-grid. Decentralised power-generation, via SHS or other small-scale options. This is usually the only realistic option for remote rural locations, where populations are not concentrated enough or are too poor to afford the previous two options

Source: IRENA.

In the Eastern Africa sub-region, targets to increase renewable energy are set in many countries to expand the integration of technologies to address energy challenges. Uganda targets integration of renewable energy to 61% of total energy consumption by 2017, through the development of 188 MW small-scale hydro electricity, biomass and geothermal capacity, the use of 30,000 solar water heaters and 100,000 biogas digesters. Ethiopia is looking at expansion of its energy capacity by 760 MW from wind power, 450 MW from geothermal and 5,600 MW from hydro power. Kenya focuses on doubling installed renewable energy capacity by 2012, and integrating 5,000 MW additional capacity from geothermal by 2030 (see Table 46 as an example to compare the target with current status). Rwanda is targeting a 90% of renewable integration in electricity generation by 2012, and 42 MW small hydro capacity by 2015. Djibouti is targeting a 30% solar energy-based rural electrification by 2017. Similarly Eritrea aims a 50% electricity generation from wind, while Madagascar is aiming a 54% final energy coming from renewables by 2020, and 75% of electricity generation from renewable by 2020. In Seychelles, the plan is a 5% electricity generation from renewable by 2020 and increasing it to 15% by 2030. Burundi similarly targets 2.1% of final energy to come from renewable by 2020. These policy prioritization of renewable energy integration into the energy portfolio will require accelerated technology adaptation and local innovation.

Table 45: Current power capacity in Kenya.

Sources	Installed Capacity (MW)	Capacity % Share
Hydro	763.3	50%
Thermal	527.5	34%
Geothermal	198	13%
Cogeneration	26	2%
Wind	5.45	0.4%
Isolated grid	14.6	1%
Total	1,529	100%

6.3 RENEWABLE ENERGY OPTIONS IN EASTERN AFRICA

The adoption and diffusion of energy technologies are influenced by a set of micro, meso and macro factors. At the macro level, the global agenda of Sustainable Energy for All (SEFA) is on key policy prioritization of the energy agenda which calls for doubling the use of renewable energy globally. It also sets expansion of energy access to all by 2030. The SEFA initiative will pave the way for countries to set ambitious targets and receive technical and financial assistance in pursuing universal energy access. Uganda is one of the first countries to participate in the SEFA framework, and has already developed a country SEFA strategy that aligns its universal access goal by 2030, close to its original target of 2034. Such ambitious initiatives will induce rapid integration and diffusion of energy technologies,

particularly off-grid applications. Global energy innovation and technological improvements, at small and large-scale, in all areas of energy services (motive, cooking, electricity, etc) will also be a factor in determining the pace at which such technologies will be globally diffused.

At the meso level, energy technology adoption and diffusion are determined by a set of country factors, including the nature of regulation, policies, markets, values and behavior (see Fig. 98). Renewable energy policies and strategies are in place in the sub-region, such as in Kenya, Uganda, Rwanda, Ethiopia and Tanzania, some including feed-in tariff, power purchase agreements and fiscal incentives to put in place strong incentives for rapid energy technology diffusion. Markets also play a role on how successful technology diffusion will be. Particularly on the demand side, a set of consumer attitudes towards untested new technology, the relative price of traditional fuels compared with improved technology based energy supplies, the initial cost of technology adoption, and other factors are important considerations. The collective valuation of risk, and risk-taking or risk-averse behavior can also play a role in technology diffusion.

At the micro level, the options available to households and their economic values are also important. In Eritrea, for example, the meager forest resources have increased wood and charcoal prices, and encouraged the use of alternative fuels for cooking (in urban areas including electricity). The options available to households, and the gradual value of options will have impact on the pathways of technology adoption. Niche markets and technologies in niche markets and the extent to which local innovation have access to such niche markets are also technology challenges at the micro level.

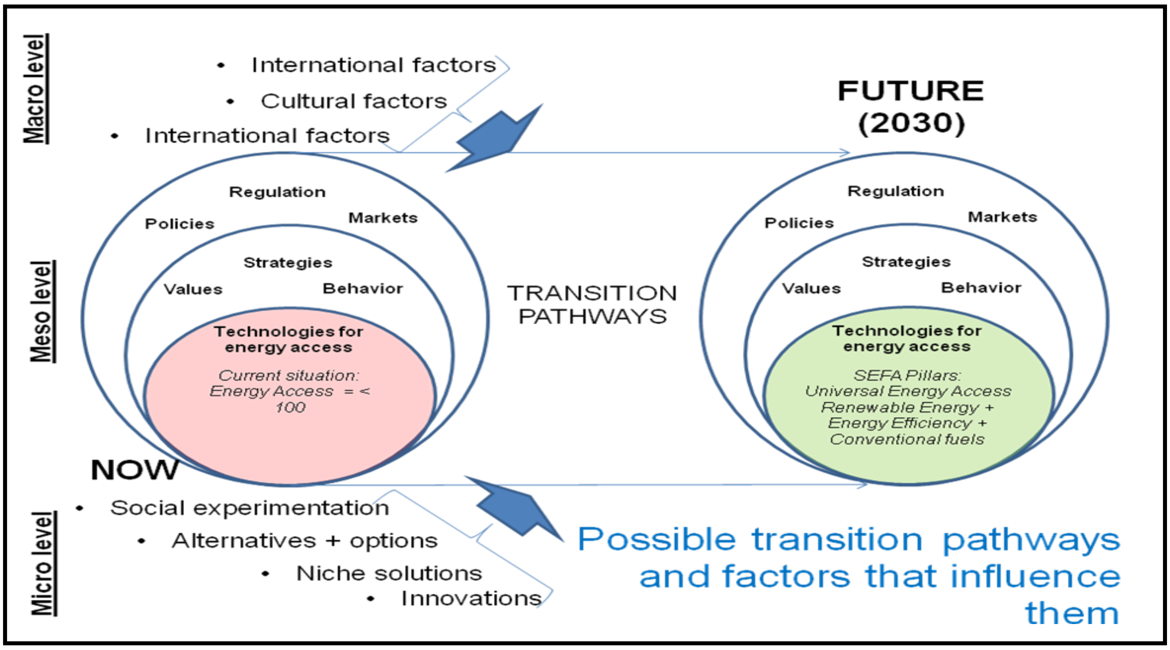
Table 46: Application of renewable energy technologies.

	Lighting /Refrigeration (Homes, stores, schools, street lights, vaccine storage)	Communications (TVs, radios, phones, Internet)	Cooking (Homes, commercial stoves)	Heating /cooling (Hot water, crop drying, etc.)	Process power (Small industry)	Water pumping (Agriculture, drinking water)
SHS	√	√			√	
Pico-scale SPV	√	√				
Solar thermal				√		
Solar cookers			√			
SPV pumps						√
Small hydro	√	√				
Small wind		√			√	√
Mechanical wind pumps						√
Household-scale biogas digester	√	√	√	√		

Biomass gasifier	√	√		√	
Mini-grid/hybrid	√	√		√	√
ICS			√		

Source: Adapted from REN21, 2011..

Figure 98: Global, sub-regional and country energy transition pathways and impact on energy technologies adaption, innovation and dissemination.



Source: SEFA workshop, May 2012, Africa Climate Policy Center.

Within these macro, meso and micro systems that filter technology adoption rate and pace, a set of renewable energy technologies offer promising potential to harness sub-regional green energy potential into actual integration in the energy portfolio and end use.

Hydropower: Hydropower has long been the pillar of East Africa's energy generation potential. The region has many permanent rivers (presence of the River Nile, numerous river basins and a vast coastline) and a large share of electricity generated in the region comes from hydropower. Small hydropower is often categorized into mini and micro hydro, referring to the harnessing of power from water at a small-scale (capacity of less than 10MW) (see Table 47). Small hydro has the advantage of multiple uses: energy generation, irrigation and water supply. It is also a technology well suited to rural areas outside the central grid system. With a potential of more than 6,000 megawatts (MW), mini hydropower could supply electricity needs at peak demand.

Table 47: Classification of hydropower by size

Type	Capacity	Description
Large-hydro	Above 100 MW	Usually feeding into a large electricity grid
Medium hydro	From10MW to100MW	Usually feeding a grid
Small-hydro	From 1 MW to 10 MW	Usually feeding into a grid
Mini-hydro	Above 100 kW but below 1 MW	Either standalone schemes or often feeding into mini-grid
Micro-hydro	From 10 kW to 100 kW	Isolated micro-grid. Usually provided power for a small

		community or rural industry in remote areas away from the grid
Pico-hydro	From a few hundred watts up to 10 kW	Suitable for isolated operation. Provide power for few specific users.

In Kenya, for example, around 50 % of all generated electricity hails from mostly large hydro schemes. An example of micro hydro's contribution in rural communities is the Tungu-Kabri Micro-hydro Power Project. A joint development by Practical Action East Africa and the Kenyan Ministry of Energy, and funded by the United Nations Development Programme (UNDP), the 18KW project benefits 200 households in the Mbuiru village river community (Quirke, 2012). The facility is believed to alleviate deforestation, diesel for milling and kerosene for lighting. Uganda and Rwanda have programmes in place specifically to encourage private sector sponsorship of such projects, with Uganda injecting an extra 30 MW into the grid through this scheme.

Table 48: Select initiatives on small hydropower in the Eastern Africa sub-region.

Location	Project	Implementer	Description	Important component
East Africa	Greening the tea industry	UNEP/GEF	Small hydro plants at tea factories, including rural electrification component	Linking rural electrification with existing industrial activity
Kenya	Tungu-Kabiri hydro project	Practical Action / UNDP/GEF-SGP	Community owned system to power micro enterprises centre	Legislative framework prohibited connection of households
Rwanda	Energizing Development	GTZ	Support to private sector to develop hydro plants	Need to incorporate requirements of financial sector
	Rural energy development in Rwanda	UNIDO	Rural energy development	Learning-by-doing project – increased role of private sector in construction and O&M
Tanzania	Kinko Village hydro, Lushoto	UNIDO/ MoEM/ TANESCO/ TaTEDO	Establishment of village hydro scheme	Integration of productive uses (grain milling and ICT centre)
Uganda	Kisiizi Hospital hydropower	Kisiizi Hospital Power Limited	300 kW cross flow turbine serving hospital and local community	Hospital as anchor client

Source: International Water Power and Dam Construction, October 2011.

Solar Energy: The Sun daily provides about 10,000 times more energy to the Earth than we consume. Solar has by far the largest renewable resource potential in Africa, with high-quality solar resources available in most places, except in the equatorial rainforest areas. The number of SHS deployed in developing countries now surpasses 3.6 million. There is large technical potential for concentrating solar power (CSP) and solar photovoltaic (PV) technologies (converting the sun's energy into electrical energy) in the region, and even under conservative assumptions it could meet a significant part of the energy demand by 2050 with proper integration of solar innovative technologies. Concentrating solar power (CSP) technologies use mirrors to reflect and concentrate sunlight onto receivers that collect solar energy and convert it to heat. This thermal energy can then be used to produce electricity via a steam turbine or heat engine that drives a generator. Smaller CSP systems can be located directly where power is needed. For example, single dish/engine systems can produce 3 to 25 kilowatts of power and are well suited for distributed applications. The CSP plants are expected to generate 25% of global electricity demands by 2050. However, the cost of solar electricity is too high; R&D is focused on reducing cost and increasing efficiency.

A photovoltaic (PV), or solar electric system, is made up of several photovoltaic solar cells. An individual PV cell is usually small, typically producing about 1 or 2 watts of power. To boost the power output of PV cells, they are connected together to form larger units called modules. Modules, in turn, can be connected to form even larger units called arrays, which can be interconnected to produce more power, and so on. In this way, PV systems can be built to meet almost any electric power need, small or large.

Solar energy is now utilized at various levels: small scale - household level for lighting, cooking, water heaters and solar architecture houses; medium-scale appliances: water heating in hotels and irrigation; and industrial scale: used for pre-heating boiler water for industrial use and power generation, detoxification, municipal water heating, telecommunications, and, more recently, transportation (solar cars).

Solar water systems of different capacity are available in the market, including 50 to 450 litres capacity. Solar water heating, a variation of solar thermal technology, has become popular with Kenyan home owners. There are over 75,000 solar water heaters in use in Kenya, and the number is growing.[33] In fact, Nairobi ranks first in Eastern Africa in terms of application fo solar water heating.

*Indigo System***:** Aziri Technologies introduced a technology that combines solar and mobile phone technology, enabling solar electricity to be delivered as a service using the scratch cards payment system. According to Azuri Technologies, in Kenya, a scratch-card costs $1.40 and allows for 8 hours of fume-free lighting for two rooms and mobile phone charging for a week. The company further stipulates that customers are able to grow their Indigo system over time to deliver lighting, media, communications and information, enabling families to access progressively more electricity and ultimately reach full home electrification. It also claims that the technology can cut a family's weekly energy expenses by 50 percent. Indigo is introduced in Kenya, Malawi, Zambia and South Sudan.

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[33] See Powerpoint Systems Limited at http://www.powerpoint.co.ke/solar_heaters.html.

Lighting Up the Idjwi Clinic in the Democratic Republic of Congo : WE CARE Solar designs cost-effective, portable solar suitcases that power critical lighting, mobile communication and medical devices in low-resource areas without reliable electricity. By equipping off-grid medical clinics with solar power for medical and surgical lighting, walkie-talkies and essential medical devices, WE CARE Solar states that its technology facilitates timely and appropriate emergency care, reducing maternal and infant morbidity and mortality, and improving the quality of care in Africa, Haiti, and other regions.

Table 49: Investment, transmission and distribution cost of solar technologies and their price range.

	Investment cost (US$/kW)	Capacity factor	Electricity price (US cents/ kWh)	Transmission, distribution cost (US cents/kWh)
Solar PV grid connected (85% PR)	3,000-4,000	0.2	24-37	3-7
Solar PN no battery	3,500-4,500	0.2	30-47	-
Solar PV with battery (2.4 kWh/kW)2	5,000-6,000	0.2	45-65	-
CSP grid connected no storage (90% PR)	5,500	0.3-0.4	35-47	3-7
CSP grid connected 8 hrs storage (90% PR)	8,500	0.5-0.7	31-43	3-7
Biomass co-combustion in coal-fired power plant	1,250	0.75	5-9	3-7
Geothermal (high quality resource)	5,000	0.8	14	3-7

Wind Energy:. The U.S. Department of Energy's National Renewable Energy Laboratory defines small wind turbines as those with 100 kW capacity or less. REN21 further distinguishes household wind turbines as anything from 0.1 to 3 kW in capacity. Wind energy technologies use the energy in wind for practical purposes such as generating electricity, charging batteries, pumping water and in agricultural applications such as grinding grains and cereals. Most wind energy technologies are applicable as stand-alone solutions, including connected to the grid, or in combination with other technologies, such as solar.. For utility-scale application of wind energy, a series of wind turbines on a *wind farm* are built to generate power to feed to the grid. According to the World Wind Energy

Association (WWEA), at the end of 2010, more than 656 000 small wind units with a capacity of 443 MW were installed worldwide.

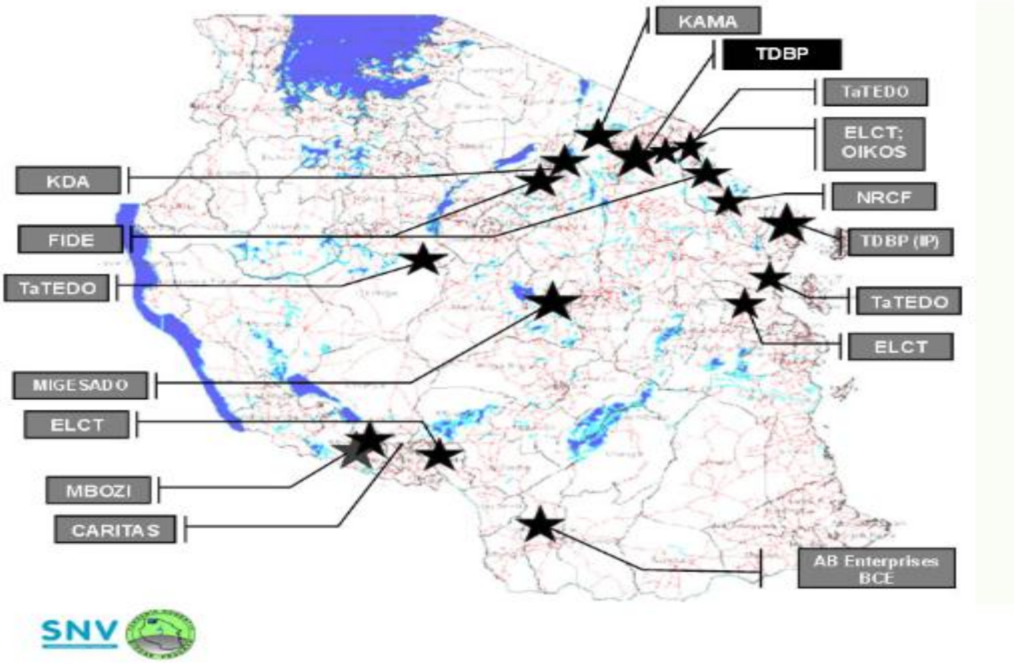
Wind energy is still at its infancy in Eastern Africa, though application fo such technology is taking shape in Ethiopia, Uganda, Tanzania and Kenya. Until now it is mainly used in the traditional fields of water pumping, but this is changing with installation of some 365 giant wind turbines around Lake Turkana in northern Kenya, with a planned power output capacity of upto 300 MW, nearly a quarter of current generation capacity. By proportion, this is one of the highest in the world. Similarly, Ethiopia's Ashegoda Wind Farm project, with 83 utility-sclae wind terbines, plans to bring 120 MW to the grid in northern Ethiopia, later in 2012 or in 2013 at the cost of US$ 300 million. Its ADama I wind far is expected to bring 51 MW capacity at the cost of US$ 117 million, financed through loan from China. Tanzania has announced plans to generate at least 100 MW from two wind farms projects in the central Singida region, which will constitute more than 10% of the country's current generation capacity.

Biogas and Biomass: Biogas technology generates combustible gas from digesters that utilize anaerobic digestion of biomas. The technology is widely used globally. A biogas plant (or digester) can generable combestible gas from such sources as waste, animal manure, plant residue, waste from agro industry and slaughterhouses. There are examples of application of this technology throughout the sub-region. In Kenya, application of units averaging 3-15 m^3 are on the rise, partly through the promotion by the Ministry of Energy through its Energy Centers. In Rwanda, the Kigali Institute of Science, Technology and Management implemented a biogas project at the Cyangugu Central Prison, with a capacity of generating 275 m^3 daily. The program is also expanded to the Kigoma Prison. Technicians are also trained and a number of biogas businesses are emerging. For these advances, Rwanda has received the Ashden Award for Sustainable Energy in 2005.

In Ethiopia, the National Biogas Program, under the Ethiopian Rural Energy Development and Promotion Center (EREDPC) launched a national strategy in 2008 stipulating the delivery of over 1 million domestic biogas installation in Tigray, Amhara, Oromia and Southern Nations and Nationalities regions, trying to utilize agricultural waste and manure, with capacity ranging from 4-10 m^3 (EREDPC, 2008). The International NGO SNV and the Ethiopian Government also plan the construction of 14,000 biogas plants in 2013.

Biogas application is also on the rise in Uganda. The Uganda Domestic Biogass Program built 583 plants in 2010 and over 560 in 2011, with a plant to build over 20,000 plants by 2013. Small scale applications using Jastropha by-products is operational in Madagascar. In Tanzania, the Tanzania Domestic Biogas Program (TDBP) spearheads the installation of biogas units. Through multiple implementing partners, biogas units are installed in multiple locations Tanzania (see Fig. 99).

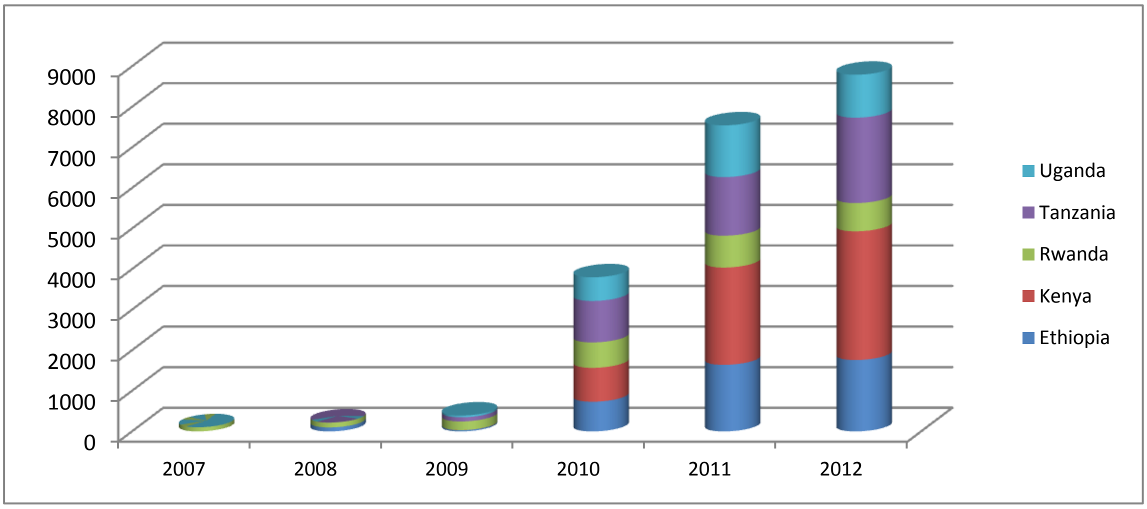
Figure 99: 2011 Biogas implementation location and partners, Tazania.



Source: Tanzania Domestic Biogas Program, http://www.biogas-tanzania.org/index.php/tdbp/about/category/coverage_map/.

The trend of biogas units installation in select countries in Eastern Africa (see Fig. 100) shows that Rwanda is an early implementing country, sustaining progress through 2012. In Kenya, Ethiopia, Tanzania and Uganda, biogas installation has progressed considerably since 2010.

Figure 100: Biogas installation trend in select Eastern Africa countries: 2007-2012.



Source: Africa biogas statistics at https://sites.google.com/site/biogas4all/documents.

There is need for African-based innovation in locally adoptable and efficient biogas unit development. While experience of biomass-based electricity production is a reality in Africa, particularly in countries with well-established sugarcane processing industries where biogas is used to produce power and heat, scientific and technological research is still required in the area of household and large-scale application of biogas technologies through indigenous technologies.

Peaceful applications of Nuclear Energy: Nuclear energy provides stability,

efficient and reliable power, at low cost. Despite the recent nuclear disaster in Japan at the Fukushima Daiichi plant, Nuclear technology is mature and proven and some African countries are aspiring to tap into this technology. Uganda has set an ambiguous energy production target to see nuclear energy become part of its national grid by 2050 in order to reduce the country's electricity deficit. Uganda could see its first nuclear power station as early as 2018 (Wakabi, 2010). Kenya has similarly expressed interest in nuclear energy. The Government of Kenya established the Nuclear Electricity Project Committee (NEPC) in November 2010 to spearhead a nuclear energy roadmap for Kenya to enhance generation of affordable and reliable electricity. The future energy policy option for Kenya includes a nuclear component (see Table 50). Nuclear energy is likely to be part of the future options agenda in the sub-region.

Table 50: Kenya's anticipated 2031 electricity generation portfolio.

Technology	Capacity (MW)	Percentage of total
Geothermal	5,530	26
Nuclear	4,000	19
Coal	2,720	13
GT-NG	2,340	11
MSD	1,955	9
Import	2,000	9
Wind	2,036	9
Hydro	1,039	5
Total	**21,620**	**100**

Source: Nuclear Electricity Project Committee (NEPC).

6.4 ICT AND ENERGY

Technological innovations have brought many transformations on society. However, with the advent of climate change, the next transformation to society may be driven by environmental considerations and the need to reduce energy consumption. Determining the contribution of ICT to global energy use is complex and difficult. Energy access is critical for the use of popular applications such as mobiles phones, radio and internet. In measuring the energy demands of ICT equipment, it is complex to determine the direct and indirect impact ICT on the overall energy demand of a country. To identify the indirect effects of ICT energy use, one must consider: energy demand over the life cycle of equipment, the energy for producing, distributing and refurbishing and/or recycling of equipment; efficiency

improvements as a result of the ICT; structural changes within the economy such as material saving and substation; and economic growth due to enhanced productivity effects.[34]

In general, there are two approaches to evaluating the effects of ICT on energy demand. A microeconomic approach focuses on the impact of ICT on specific services and the implication fo these specific services on the energy intensity. The macroeconomic approach focuses on the impact of ICT on economic performance, and the energy intensity of the whole economy over time. Most of the case studies to date investigate one of the following fields: manufacturing or technical processes; building automation and intelligent homes; traffic management; and e-economy with e-commerce, e-work, e-learning and e-governance. The domain of manufacturing and technical processes is the only one in which most studies agree that ICT substantially reduces energy input.[35]

Energy use in buildings can potentially be reduced. In single family houses, 'intelligent systems' tend to lead to an increase in energy services and therefore to increases in energy demand (Aebischer and Huser, 2000, 2003). Energy is also wasted in traffic jams where ICT can support efficient transportation system.

6.5 CONSTRAINTS ON ENERGY TECHNOLOGY AND INNOVATION

Creating links between knowledge generation and enterprises is a challenge. Particularly in countries where technology and innovation support infrastructure is inadequate, development and integration of innovation with business enterprises can be constrained. South Africa is currently creating a Technology and Innovation Agency to promote innovation and integrate technology into its economy, partly through the identification of gaps and linking sectors where resources can be shared. Innovative energy technologies are relatively new and are largely small-scale technologies that do not require large amounts of capital. They are also relatively less sophisticated where industry could be developed around these technologies. They are ideal for countries with limited technical and innovative expertise.

Most of the challenges facing energy technologies exploitation are not specific for one technology but generic for all types of energy technologies. General constraints for access to innovative energy technologies include: the absence of clear policies to promote energy technologies; financial shortfalls for R&D; lack of conducive environment for resource mobilization from the private sector; lack of awareness about renewable energy technologies (RET); and lack of long-term framework for consumers of renewable energy to receive products at affordable prices and in a sustainable manner. Sampath (2010) identifies further the constraints to technology and innovation in developing countries (see Box 2).

Box 2: Constraints on technology and innovation in developing countries.

[34] See Bernard Aebischer on "ICT and Energy: Some Methodological Issues." Available at http://ercim-news.ercim.eu/en79/special/ict-and-energy-some-methodological-issues.

[35] Also see Bernard Aebischer on "ICT and Energy: Some Methodological Issues." Available at http://ercim-news.ercim.eu/en79/ special/ict-and-energy-some-methodological-issues

The main constraints on technology and innovation capacities in developing countries can be categorized as follows:

(a) Lack of local capacity to absorb and use knowledge, primarily determined by the availability of human skills locally and the institutional capacity of the system to provide the basis for innovative activity within any of the four knowledge domains identified in the previous section. In the absence of this, access to knowledge remains at best just access to information, since the actors lack the capacity to build further upon it.

(b) Lack of well-developed institutional frameworks to forge second-best responses to innovation issues, which manifests in the form of high transaction costs to conduct innovation activities. Institutional frameworks that are either incomplete or do not clearly specify the roles and responsibilities of various actors often result in organizations being set up with overlapping competencies and duplication of, or gaps in, roles and responsibilities.

(c) Lack of resources in the general innovation environment, which includes lack of physical and knowledge infrastructure, as well as financial instruments for reducing innovation risks. Innovation processes are associated with their own range of technological and market-related uncertainties, but at the same time innovation outcomes can vary when the same activities are conducted by diverse groups of individuals in different contexts whose levels of "imagination and accuracy" differ. This largely explains the varying performances of firms and sectors (Archibugi and Michie, 1997). In resource-constrained developing countries, there are few, if any, institutions that reduce market-related uncertainties and promote innovation.

(d) Lack of a supportive public sector that has the human and financial capacity to conduct relevant basic and applied research and industrial R&D. This constraint can have very different consequences for different sectors. In sectors that require the involvement of publicly funded research, such as pharmaceuticals, agriculture and new technologies, an efficient and well-endowed public sector is a prerequisite for innovation.

(e) Lack of a thriving private sector that can uptake results of industrial R&D conducted in public sector organizations is a common constraint on innovation in developing countries.

(f) Lack of collaborative linkages that allow mobility of ideas and human capital between firms and organizations alike. Competing agendas of organizations involved in STI, lack of a collaborative culture amongst academics and industry practitioners, lack of incentives that reward collaborative conduct, and lack of discernable benefits of collaborative linkages within the system, all contribute to poor or no collaborations, and therefore to the absence of interactive learning.

(g) Lack of policy competence in developing countries is perhaps as complex a phenomenon as the lack of innovation capability itself. Governments, by their actions as well as inactions, make technology choices for national development. They should be able to identify market failures and opportunities, make strategic choices, translate them into policies and ensure effective implementation of those policies.

Source: UNCTAD, based on Gehl Sampath (2010).

Beyond innovation and energy technology development, there are barriers to dissemination of new technology and energy products. In the context of rural areas, Deutch Bank identifies the following (see Table 51).

Table 51: Potential barriers of RETs deployment in rural areas.

Market Customer	Constraints
Legal issues, regulations and administrative barriers	Lack of information about potential markets/customer needs and preferences
	Consumers lack awareness of RET products and their benefits
Remoteness, Physical infrastructures	Lack of land title or title uncertainties, which can limit ability to sign contracts
	Lack of regulatory predictability and long term vision concerning rural electrification strategies and planning
	Approval processes for RET projects may take a considerable amount of time
	Unfair competition from conventional energy sources (subsidies)
	Import tariffs increase cost RETs and could make them prohibitively expensive
Skills and training	Difficult to recruit and retain staff with adequate technical skills to install , maintain and repair RETs
	Limited business skill (literacy, book-keeping, computer-related)
	Customers lack information/skills needed to properly operate RETs
Cost and access to financial services	Up-front costs can be high compared cash flows
	Lack of access to credit)for entrepreneurs and end users); local banks need experience and greater awareness of how to finance RETs
	Customers do not have access to financial services to make payments (bank accounts)
Supply Chains and services Delivery Channels	Insufficient development of supply chains
	Retail and logistics services are limited low-income communities
	Geographical mismatch of sources and centre of energy consumption
	Private companies face high costs of going to rural areas, often preferring donor contracts and capital cities
Performance of	Power quality products can undetermine reputation of RETs and

the RETs	diminish customer trust
	If promised economic (payback period, etc.) fails to materialize, customer trust may suffer
Gender	The fact that men are responsible of household investment in many rural developing regions but not for lighting and cooking energy often hinders investment in RET

Source: Deutch Bank, 2011.

6.6 THE WAY FORWARD

The Eastern Africa sub-region requires a revolution in energy technology innovation and adoption to meet the profound economic, environmental and social challenges energy poses in the 21st century. The G8 Summit in Heiligendamm (Germany 6-8 June 2007) Declaration states the aim to promote major emerging and developing economic participation in international technology partnerships in the energy sector and to scale-up national, regional and international research and innovation activities. It is evident that without an energy policy based on technology-supported sustainability, Africa and other developing countries may not achieve strong sustainable development outcomes. Collaboration on science and technology within a South-South framework and with technology and innovation robust countries is an ideal partnership for the sub-region to develop and obtain the necessary capacity to boost indigenous energy technologies capacity that will allow sustainable economic growth. Having a Europe-Africa energy partnership would respond to the challenges identified at the G8 Summit addressing energy security, climate protection, development and the achievements of the MDGs.

Based on these considerations, the following recommendations are put forth for policymakers, decision-makers and stakeholders in the Eastern Africa sub-Region to consider:

- Establishment of science and technology policies;
- Strengthening innovation systems through innovation policy frameworks;
- Accelerating energy innovation and public research, development and demonstration;
- Developing human capital to support indigenous energy technologies development;
- Promotion of appropriate (environmentally sound) energy technologies for mechanized agriculture, water pumping, agro-processing, educational, health facilities, and in other sectors;
- Enhancing the ; utilization of indigenous and renewable energy sources and technologies;
- Capacity building in terms of skills for managing appropriate energy technologies;

- Information and awareness creation on the available options in increasing energy services;
- Encouraging firms to develop and share technology;
- Encouraging private sector participation in technology diffusion;
- Better linkages between the research and enterprise in specific sectors of energy.

7 ENERGY ACCESS, ENERGY SECURITY AND THE ENVIRONMENT IN THE EASTERN AFRICA SUB-REGION

7.1 BACKGROUND

Sustainable energy development is an important consideration in the policy making process aiming at alleviating poverty and generating socio-economic development. Access to energy, through energy development, translates into access to basic services such as healthcare and education, and along with energy security, it plays a critical role in meeting the MDGs. This is particularly the case in the Eastern Africa sub-region where populations have the *lowest access to electricity* due to primarily lack of infrastructure, translating into prohibitive costs of connection to the grid and high consumer fees.

The energy access condition is dire in rural areas leading to an excessive proportion of use of solid biomass by 80-90% of the population such as wood and charcoal, deterrent to the environment (deforestation, soil erosion) and contributing to climate change. The social and economic impacts, including for women and girls who have to walk long distances to fetch wood and experiencing loss of time for education, are significant. Furthermore, the use of solid fuels (eg. wood, charcoal, dung, waste) for indoor cooking represents a health hazard for women and girls[36].

Eastern African countries are highly dependent on imports of fossil fuel sources (oil, coal and gas) for thermal power generation, commercial and industrial uses and transport, impacting energy security and increasing vulnerability to energy price shocks (see Fig. 101). The rise in vehicles on the road (and resulting greenhouse gas emissions (GHG)), rising competition for limited, and non-renewable, fossil fuels, new oil discoveries in the Eastern Africa and potential environmental impacts, such as the Turkana region in Kenya, and the overall balance between energy development and environmental management remain notable concerns. .

[36]The World Health Organization (WHO) estimates that worldwide 2.5 million women and young children die prematurely each year from inhaling fumes from traditional cooking stoves using biomass.

Diversification of energy supplies, with more use of indigenous renewable energy sources, is seen part of the strategy to energy sector development. Within this framework, a sustainable and secure energy has four characteristics: *available* (reliable quantity over the long-term); *accessible* (existing appropriate infrastructure, low impact risks of extreme events); *utilizable* (sound quality, affordable prices and functional market structures) and *stable* (not affected by potential conflicts over resources among others). The rapid and continuous increase of energy prices over the last decade has shown the strong linkages between energy access, affordable supplies, climate change, and development.

Dependency on unsustainable and inefficient energy forms potentially endangers environmental sustainability and vulnerability of populations (OCHA, 2010). The choices in energy generation have impacts on the environment, but the state of the environment and climate change also influence the energy sector. The impacts of climate change in the energy system, for example, are not restricted to the supply side as final energy can be influenced by variations in temperature and rainfall patterns. Higher temperatures in Eastern Africa located in the tropical belt will imply a higher demand for cooling, increasing demand for electricity. Climate change can also affect the water and electricity demand in industries and agriculture for irrigation purposes (Schaeffer, et al., 2012). Climate change impacts emanating from deforestation and desertification (wood cutting and charcoal production) lead to higher rainfall variability and thus compromising the refilling of reservoirs for hydropower generation. This in turn increases their siltation and erosion requiring costly maintenance operations.

Figure 101: Reliance on imported fossil Fuels.

Source: International Energy Statistics, 2008.

The negative impacts of the current energy patterns on the health and wellbeing of the environment in Eastern Africa will need to enter energy policy frameworks. Existing dynamics and close synergies among and between water, forest, agriculture and climate change will need to be considered in the overall analysis of barriers, challenges and opportunities of sustainable energy development.

With a view to attaining energy sector development, policy makers will need to devise different scenarios over the medium (energy mix packages) and long-term considering the two key criteria of sustainability and cost-effectiveness from socio-economic and environmental angles while taking into account:

(1) linkages between energy development, environmental degradation and climate change (Fig. 102) and the need to tap into existing climate change related funding mechanisms to support a paradigm shift in energy;

(2) intertwined issues of energy security and food security;

(3) the considerable potential of renewable energy in building an energy mix and diversified sources of supply (i.e. second generation of biofuels, sustainable bioenergy);

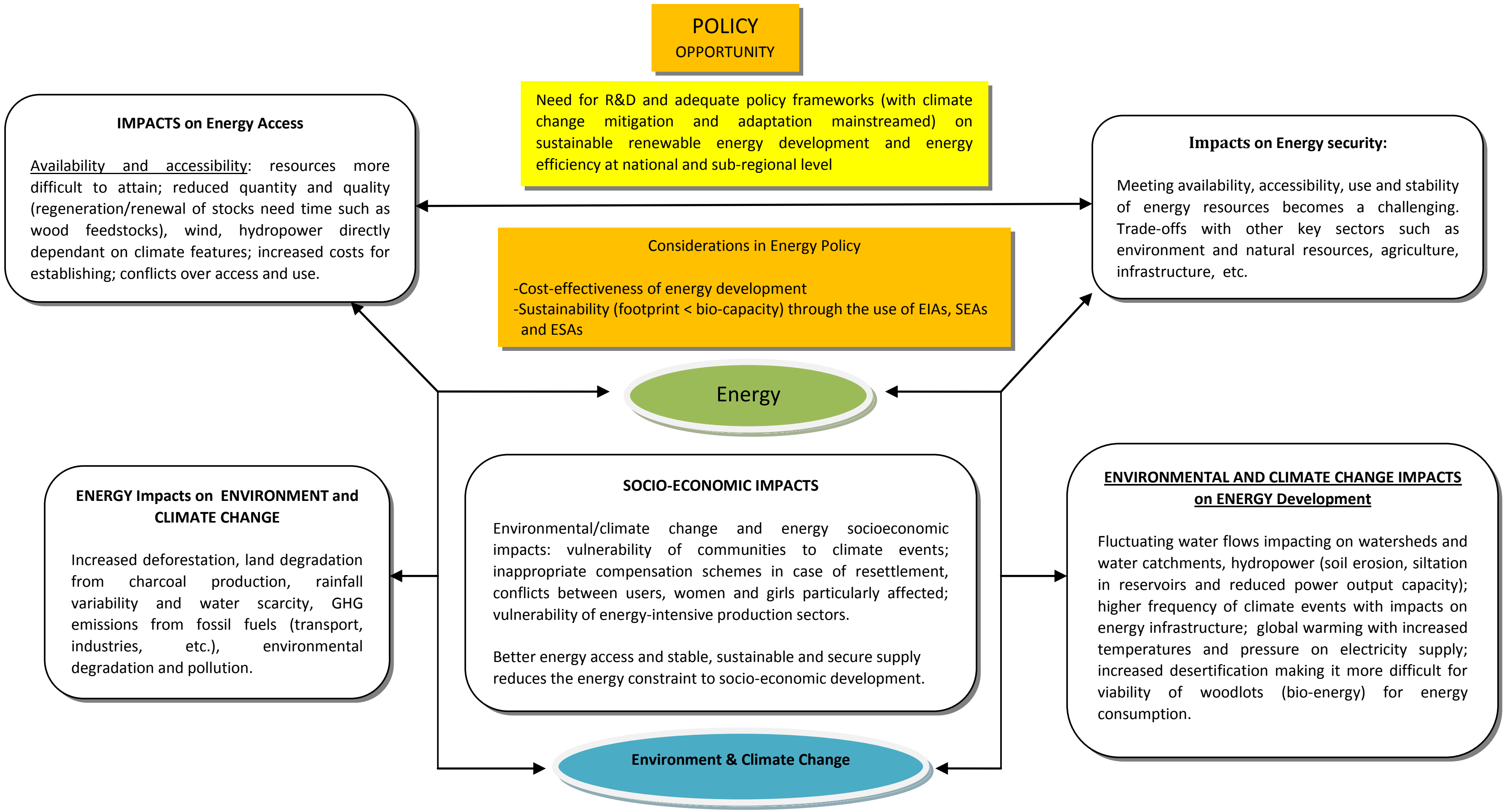
(4) the need for inter-sectoral dialogue at institutional level to pace mainstreaming of the nexus energy-agriculture-environment-climate change in policy frameworks at national and sub-regional levels;

(5) the role of research and development as well as local innovation, national and sub-regional standards in promoting energy efficiency (improved cookstoves, enhanced technologies to increase access to affordable alternative sources - lighting in rural areas);

(6) the importance of primary data collection and analysis (based on agreed upon definitions and indicators) and the consolidation of national and sub-regional comprehensive and user-friendly databases specially targeting policy makers and experts.

The next decade may see "an energy revolution" to address increased energy demand and anchor continuous economic growth in Eastern Africa. The energy sector requires an in-depth analysis of key access and security goals that consider sustainability, taking into account trade-offs between economic, social and environmental benefits in the short and long-term.

Figure 102: Linkages between energy development, environment and climate change and related impacts in the Eastern Africa sub-Region.



Source: Author elaboration.

7.2 THE ECOLOGICAL FOOTPRINT, BIO-CAPACITY AND ENERGY DEVELOPMENT

Ecosystems provide provisioning services (eg. food, medicine, timber and fiber), regulating services (eg. water filtration, waste decomposition, climate regulation and crop pollination), supporting services (eg. nutrient cycling, photosynthesis and soil formation) and cultural services (eg. enriching, recreational, aesthetic and spiritual). Without access to land, clean water, adequate food, fuel and materials, vulnerable people cannot break out of the poverty trap and prosper. There is growing consensus that to avoid serious consequences, global warming change has to be below 1.5 degrees Celsius, requiring greenhouse gas emissions to fall, and be cut by at least 80% globally by 2050 (from 1990 levels).

Box 3: Ecological footprint and bio-capacity.

The Ecological Footprint tracks humanity's demands on the biosphere by comprising humanity's consumption against the Earth's regenerative capacity or bio-capacity. It does this by calculating the area required to produce the resources people consume, the area occupied by infrastructure, and the area of forest required for sequestering CO2 not absorbed by the ocean (see Galli et al. 2007; Kitzes et al., 2009 and Wackernagel et al., 2002).The largest component of the ecological footprint is the carbon footprint (55%). Bio-capacity quantifies nature's capacity to produce renewable resources, provide land for built-up areas and provide waste absorption services such as carbon uptake. Bio-capacity acts as an ecological benchmark against which the Ecological Footprint can be compared. Both the Ecological Footprint and bio-capacity are expressed in a common unit called a global hectare, where 1 gha represents a biologically productive hectare with world average productivity. In 2008, the Earth's total bio-capacity was 12 billion gha or 1.8 gha per person, while humanity's ecological footprint was 18.2 billion gh or 2.7 gha per person. This discrepancy means it would take 1.5 years for the Earth to fully regenerate the renewable resources that people used in one year. Population size affects the available bio-capacity as well as income level. Low income countries have on average a smaller footprint today than they had in 1961-a reduction of 0.01 gha per person. However, rapid population growth in these countries (4.3 times since 1961) has led to an overall 323 % increase in the total Ecological Footprint of low-income countries since 1961. The Living Planet Index tracks trends in a large number of populations of species in much the same way that a stock market index tracks the value of a set of shares or a retail price index tracks the cost of a basket of consumer goods. This index has declined by 60% in low-income countries: while everyone depends ultimately on the biodiversity that provides ecosystem services and natural assets, the impact of environmental degradation is felt most directly by the world's poorest people, particularly by rural populations and forest and coastal communities.

Source: Living Planet Report (WWF, 2012).

The global energy sector plays a key role towards this end. It is responsible for around two-thirds of global GHG, an amount that is increasing at a faster rate than for any other sector. Coal is the most carbon-intensive fuel and the single largest source of global GHG. Embracing renewable energy, along with ambitious energy-saving measures are viewed viable pathways to achieve the rapid emissions reductions needed (WWF, 2012). The loss of ecological services from forests and other ecosystems will also have economic implications. A recent report suggests that by 2030, the world may need to spend more than Euros 200 billion a year on adaptation measures (Parry, et al., 2009).

Table 52: Gha per person, 2008.

Country	Total Ecological Fooprint	Total bio-capacity
Burundi	0.85	0.45
DRC	0.76	3.10
Eritrea	0.66	1.47
Ethiopia	1.13	0.65
Kenya	0.95	0.53
Madagascar	1.16	2.92
Rwanda	0.71	0.52
Somalia	1.44	1.36
Tanzania	1.19	1.02
Uganda	1.57	0.81

Source: Living Planet Report, (WWF, 2012)..

Out of the analyzed countries in Eastern Africa, Burundi, Ethiopia, Kenya, Rwanda and Tanzania seem to exhaust their natural resources faster than what their ecosystems can provide/regenerate in renewable resources form over a given period of time. The more this trend will accelerate due to pressure of population growth and accelerated urbanization, the more these countries will face serious challenges in meeting their resource demand starting with energy, in a sustainable way. In the case of D.R. Congo, the Congo Basin ecosystem still provides a vast reservoir of untapped resources, hence the highest positive ratio in the sub-region. When selecting energy development options, sustainable energy solutions require particular attention.

7.3 SUSTAINABILITY CONSIDERATIONS IN THE ENERGY SECTOR

7.3.1 7.3.1. The Case of Fossil Fuels

Eastern Africa stands on the cusp of an oil-driven energy sector growth. In January 2009, Heritage Oil, in partnership with Tullow Oil, announced that exploration on concessions in the Lake Albert Basin in Uganda contained over 2 billion barrels in reserves, far outstripping the commercial viability threshold. The Lake Albert find has enhanced foreign investor confidence in Eastern Africa's energy potential, while for Uganda, it promises to boost its economy. However, the site is part of the Albertine Graben ecosystem, worldwide known for its richness in flora and fauna and it is expected that oil developments can have potential impacts on this unique environment[37].

Lessons can be drawn from the Ogoni land in the Niger Delta in Nigeria. The 2011 UNEP assessment underlines that oil exploration and production projects may have impacts on the natural environment long before any oil is actually produced (land survey, land clearance for seismic lines, establishment of seismic and drilling camps, site preparation, infrastructure construction, drilling for oil (even when the effort is unsuccessful) and development of transportation infrastructure). Once a facility begins operating, other issues have to be dealt with, such as spills caused during oil production and the disposal of water (often salty and known as 'produced water') and flaring of gas ('produced gas') generated alongside the oil. All these activities and their effects leave an environmental footprint as shown in Box 3.

[37] It is hoped that oil related concerns will be further addressed in the recently developed Environmental Monitoring Plan for the Albertine Graben (AGEMP) in collaboration with the Environmental Information Network.

Box 4: UNEP findings in Ogoniland (impacts of oil production in the Niger Delta)

Ogoniland is a region covering some 1,000 km^2 in the south-east of the Niger Delta basin (the largest river delta in Africa) and has a population of close to 832,000 people. Oil exploration in Ogoniland commenced in the 1950s and extensive production facilities were established during the following three decades. These operations were handled by Shell Petroleum Development Company (Nigeria) Ltd (SPDC), a joint venture between the Nigerian National Petroleum Company (NNPC), Shell International, Elf and Agip. The oil industry's environmental awareness and standards in the 1960s were very different and lower compared to those of the present day. This impact was exacerbated by the Nigerian Civil War (known widely as the Biafran War) in the late 1960s, during which oil industry infrastructure was targeted and a number of facilities were damaged, with consequent spillage of oil and widespread pollution. The conflict within the region, however, was not resolved in a peaceful manner. As a consequence of the ensuing violence, oil exploration and production activities in Ogoniland ceased in 1993. While no oil production has taken place in Ogoniland since 1993, the facilities themselves have never been decommissioned. Some oil pipelines carrying oil produced in other parts of Nigeria still pass through Ogoniland but these are not being maintained adequately. Consequently, the infrastructure has gradually deteriorated, through exposure to natural processes, but also as a result of criminal damage, causing further pollution and exacerbating the environmental footprint.

Following preparatory consultations, UNEP presented a proposal to the Nigerian Government in January 2007 for a two-phase project: (1) a comprehensive Environmental Assessment of Ogoniland, and (2) an environmental clean-up to follow, based on the assessment and subsequent planning and decisions. The assessment completed in 2011 found that overlapping authorities and responsibilities between ministries and a lack of resources within key agencies has serious implications for environmental management on the ground, including enforcement. The report concludes that pollution of soil by petroleum hydrocarbons in Ogoniland is extensive in land areas, sediments and swampland. Oil pollution in many intertidal creeks has left mangroves denuded of leaves and stems, leaving roots coated in a bitumen-like substance sometimes 1cm or more thick. Mangroves are spawning areas for fish and nurseries for juvenile fish and the extensive pollution of these areas is impacting the fish life-cycle. The wetlands around Ogoniland are highly degraded and facing disintegration. The Ogoni community is exposed to petroleum hydrocarbons in outdoor air and drinking water, sometimes at elevated concentrations. They are also exposed through dermal contacts from contaminated soil, sediments and surface water. key legislation is internally inconsistent with regard to one of the most important criteria for oil spill and contaminated site management – specifically the criteria which trigger remediation or indicate its closure (called the 'intervention' and 'target' values respectively. A combination of approaches will therefore need to be considered, ranging from active intervention for cleaning the top soil and replanting mangrove to passive monitoring of natural regeneration. Practical action at the regulatory, operational and monitoring levels is also proposed.

Source: UNEP Environmental Assessment of Ogoniland (2011).

However, national economies being heavily dependent on fossil fuels to cover energy needs, it will take some time for a paradigm shift to operate in terms of their substitution by other sustainable and cost-effective sources of energy. The implementation of a transition phase promoting an energy mix will enable a progressive and gradual process towards reducing this dependency on fossil fuels through the mainstreaming of renewable energy sources. Current oil exploration projects in the sub-region are subject to Environmental Impact Assessments (EIAs) (eg. Madagascar, D.R. Congo, Uganda and Kenya).[38] However, for

[38] Environmental Impact Assessment (EIA) is a process that can be used to improve decision-making and ensure that development options under consideration are environmentally, socially and economically sound and sustainable. It is concerned with identifying, predicting and evaluating the foreseeable impacts, both beneficial and adverse, of proposed development activities, alternatives and mitigating measures, and aims to eliminate or minimize negative impacts and optimize positive impacts.

EIAs to be operational, Monitoring and Evaluation tools for environmental protection, they need to follow some principles related to process transparency and consistency, absence of conflicts of interests, sound governance and genuine commitment to implementation of mitigation measures by private companies be met. Madagascar and Rwanda have developed guidelines for the use and application of Strategic Environment Assessments (SEAs) targeting mainstreaming of environment in policies, programmes and plans (Madagascar applied SEAs to the oil sector). Rwanda went forward by linking EIAs, SEAs and Environmental Security Assessments (ESAs) analyzing impacts of identified sectoral interventions on vulnerability of populations and ecosystems services. These instruments appropriately implemented in the context of clear and open inter-institutional collaboration can prove efficient and effective in addressing environmental impacts of energy interventions at all levels.

7.3.1.1 Road Transport: A Sector with Growing Fossil Fuels Demand

The sub-region has witnessed a steady increase in the number of all types of road vehicles (see Table 53 in EAC) linked to continued economic growth. Most registered vehicles are imported and second-hand and therefore bigger consumers of oil/diesel than more recent models. About 60% of all motorized transport (excluding three wheelers and motorcycles) in the sub-region are private vehicles; slightly more than 20% are public passer vehicles; while less than 10%t are trucks. Tanzania's share in the vehicle population over the six year period has overtaken that of Kenya. In 2005, Tanzania and Kenya accounted for 31.6 percent and 47.6% of the vehicle population, respectively. By 2010, the ratios stood at 60.7% and 35.8%, respectively. This could be attributed to, among others, the different regimes on the age limit of vehicles imported.

7.3.2 Sustainability: the Case of Nuclear Energy

Some countries in the world (eg. Japan, Germany) are planning to phase out their nuclear programme following the Fukushima Dayichi accident in 2011. Nuclear energy is a high-level technology which requires a solid operational framework, evaluated and endorsed by the International Atomic Energy Agency (IAEA) to guarantee sufficient safeguards. Contrary to other sources of energy which have limited and localized damage areas, nuclear incidents can lead to consequential outcomes at wider geographic area. Environment impacts during the operation of nuclear plants are minimal compared to use of fossil fuels but become significant during decommissioning of the plants. UNEP has identified decommissioning of nuclear plants as an emerging key topic for the coming years in its Annual Year Book 2012. Further research findings could feed back into a sub-regional discussion on the topic.

Table 53: Access to road transport facilities/services, motorized transport by type, number.

Indicator	State	2005	2006	2007	2008	2009	2010
Trucks	Burundi	-	-	-	-	-	-
	Tanzania	7, 178	-	43, 811	51, 477	59, 066	64, 790
	Uganda	18, 684	20, 496	23, 323	28, 501	33, 425	-
	Kenya	66, 472	35, 838	42, 654	51, 445	60, 365	67, 668
	Rwanda	2, 100	2, 351	2, 784	3, 054	3, 319	3, 595
	East Africa	-	-	-	-	-	-
Private Vehicles	Burundi	-	-	-	-	-	-
	Tanzania	163, 244	-	364, 234	456, 236	599, 796	472, 907
	Uganda	123, 267	128, 558	142, 463	155, 063	163, 176	-

	Kenya	329, 068	167, 563	219, 041	271, 457	323, 106	383, 799
	Rwanda	23, 772	26, 210	30, 420	34, 956	38, 454	41, 124
	East Africa	-	-	-	-	-	-
Passenger Vehicles	Burundi	-	-	-	-	-	-
	Tanzania	132, 081	173, 315	199, 021	231, 440	273, 377	317, 929
	Uganda	28, 436	32, 863	40, 471	50, 472	63, 789	-
	Kenya	60, 109	31, 578	35, 830	42, 279	47, 819	52, 683
	Rwanda	3, 549	3, 846	4, 117	4, 880	5, 125	5, 380
	East Africa	-	-	-	-	-	-
3 Wheelers	Burundi	-	-	-	-	-	-
	Tanzania	369	639	1, 098	2, 406	4, 531	6, 556
	Uganda	-	-	-	-	-	-
	Kenya	869	1, 944	3, 016	3, 720	4, 583	6, 104
	Rwanda	-	-	-	-	-	-
	East Africa	-	-	-	-	-	-
Motorcycles	Burundi	-	-	-	-	-	-
	Tanzania	31, 006	47, 888	76, 282	121, 710	207, 460	323, 192
	Uganda	108, 207	133, 985	176, 516	236, 452	292, 263	-
	Kenya	57, 465	29, 572	45, 865	97, 277	188, 428	305, 694
	Rwanda	11, 653	15, 224	20, 598	28, 416	33, 121	38, 521
	East Africa	-	-	-	-	-	-

Source: EAC Partner States.

7.4 LINKING ENERGY ACCESS AND SECURITY: PROMOTION OF RENEWABLE ENERGY AND ENERGY EFFICIENCY

Renewable energy is any form of energy from solar, geophysical or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use. The theoretical potential of renewable energy is much greater than all of the energy that is used by all the economies on Earth. The challenge is to capture it and utilize it to provide desired energy services in a cost-effective manner (REN 21).

The Eastern Africa sub-region is significantly endowed with a wide range of renewable energy resources, including hydro-power, geothermal, biomass, solar, wind, and other renewables, most of which are currently under-exploited. Member States can opt for an alternative path to the 'business as usual' scenario by prioritizing fulfillment of their renewable energy potential. This approach will support the development of green economies anchored into green growth diagnostics and implementation of equitable solutions, in phasing out for example inefficient use of traditional biomass and pursue alternatives such as improved cookstoves. There is an urgent need for policy makers to recognize the potential role of renewable energy in meeting the energy challenges of the sub-region and assume an integrated and coordinated approach at a sub-regional level to scale-up the deployment of renewable energy technologies.

Table 54: Sources of electricity production (GWh)

	D.R. Congo	Eritrea	Ethiopia	Kenya	Tanzania
Oil	6	293	508	3029	42
Coal & peat	-	-	-	-	125

Gas	29	-	-	-	1677
Biofuels	-	-	-	321	-
Waste	-	-	-	-	-
Nuclear	-	-	-	-	-
Hydro	7795		3583	2170	2734
Geothermal	-	-	15	1339	-
Solar PV	-	2	-	-	-
Solar thermal	-	-	-	-	-
Wind	-	-	-	16	-
Tide	-	-	-	-	-
Other sources	-	-	-	-	-
Total	7830	295	4106	6885	4628

Source: IEA, 2009.

The share of renewable energy in electricity generation remains marginal in some countries of the sub-region (Eritrea 1 %, Seychelles 0% - REN 21). Other countries have a sizable renewable energy share such as Madagascar (25% ADER 2012, REN 21 has a different data - 57%), Tanzania (59% EIA, 46% REN 21), Uganda (54% REN 21) and Kenya (56% EIA; 66%, REN 21). Countries such as D.R. Congo (99%, EIA) and Ethiopia (88% - average between REN 21, 2012 and EIA 2009) produce almost all their electricity from hydro. Tanzania is amongst the few countries in Africa endowed with abundant energy resources namely: biomass, electricity, natural gas, coal, solar, wind, geothermal, nuclear (from uranium), tidal and wave power that could meet the national energy demand on sustainable basis if wisely planned and used.

Kenya’s energy mix is somewhat diversified. In September 2011, the Governing Bodies of the Climate Investment Funds (CIF) endorsed Kenya's investment plan for funding under its Scaling Up of Renewable Energy Program in Low Income Countries (SREP). Developed under the leadership of the Kenyan Government with support from the African Development Bank (AfDB), World Bank Group and inputs from private sector, civil society and community representatives, Kenya has produced a plan outlining development of its multiple renewable energy resources to enhance energy security, improve access to electricity, reduce the cost of supply, and bring substantial economic, social, and environmental co-benefits to local communities. Economic and financial, along with technical and human capacity, constraints have hindered Kenya's ability to take full advantage of its natural energy resources, which include geothermal, solar, wind, biomass and biogas. While Kenya has made important institutional and policy reforms to its energy sector, SREP concessional financing, estimated at about USUS 50 million, will help absorb high start-up costs and other risks and catalyze financing from the private sector and other sources to help bring Kenya's renewable energy market up to scale.

Kenya is one of three African nations to pilot SREP; the others being Mali and Ethiopia. With just 2% rural access to electricity but enormous potential for hydro, geothermal and solar energy generation, Ethiopia was also selected to become a SREP pilot. SREP aims to scale-up the deployment of renewable energy solutions and expand their markets in the world's poorest countries. It is a program under the CIFs, a USUS 6.5 billion financing instrument designed to channel scaled up climate change financing to developing countries through multinational banks like the AfDB.

Electric power based on renewable energy sources is a fundamental enabler of green growth, powering green cities, industrial operations, and crop irrigation. More than 85% of GHG emissions in Ethiopia come from forestry (37%) and agriculture (50%). Ethiopia is endowed with ample natural resources to meet these demands and already generates 90% of its electricity from renewable sources. It has a master plan to exploit its vast potential for hydro, geothermal, solar, and wind power to increase supply capacity fivefold over the next five years –and then to double it again, to 67 TWh, by 2030, and achieve zero emissions even sooner. Furthermore, due to the expected impact of energy-saving measures, Ethiopia foresees having a surplus of clean power, which it could export. In 2030, such exports could replace up to 19 Mt CO_2e per year of neighboring countries' generation from fossil fuels while contributing positively to Ethiopia's trade balance (national source).

7.5 BIOMASS: FIRST SOURCE OF ENERGY IN THE SUB-REGION

Traditional biomass energy refers to solid biomass, including agricultural residues, animal dung, forest products, and gathered fuel wood, that are combusted in inefficient, and normally polluting open fires, stoves, or furnaces to provide heat energy for cooking, comfort, and small-scale agricultural and industrial processing, typically in rural areas of developing countries.

Nearly half the world's population and about 81% of Sub-Saharan African (SSA) households rely on wood-based biomass energy (fuelwood and charcoal) for cooking. This proportion is much higher in Eastern Africa with 83% of the population relying on traditional biomass for cooking in Kenya, 94% in Tanzania, 94% in D.R. Congo and 93 % in Ethiopia (REN 21, 2012). This degree of reliance is far greater than in any other region of the world and will remain at high levels (or even grow) over the next few decades because: (a) electricity is still not considered as a suitable alternative given high costs of equipment and use; (b) rapid population growth; and (c) accelerated urbanization. The number of wood-based biomass energy consumers in Sub-Saharan Africa will reach almost one billion by 2030 (IEA, 2010). The economic value of the charcoal industry in Sub-Saharan Africa may exceed US$12 billion by 2030, employing almost 12 million people (AFREA, 2011).

Wood-based biomass consumption is occurring in both rural and urban areas (fuelwood, predominantly used by rural population and traditionally characterized by subsistence collection, and charcoal, the major cooking fuel for urban population and with associated commercialization and value-chain involving many stakeholders). This preference is essentially motivated by: (a) availability of wood (though the distance to forests and woodlands increases year after year and negatively reflects back on sale prices; for example up to 200 kms to servce Kinshasa); (b) affordability compared to other modern sources (though retail prices of charcoal have doubled in the last five years in most countries, for example from US$ 15-20 to US$ 50-60 for a bag of 50kgs in Kinshasa; US$ 15 for a bag of 50kgs in Addis Ababa; Euros 5 for a bag of 50 kgs in Madagascar); (c) simplicity of use (cultural features are key in traditional ways of cooking, easy to transport, distribute and store).

The sector remains informal with unclear regulations though its estimated total annual value can exceed agriculture crops for export (World Bank, 2009). The sector also provides employment and income. In Kenya, it is estimated that about 700,000 people work

in the sector (Sepp, 2008a) for a total annual income estimated at US$450 million, equal to the country's tea industry (World Bank, 2007). In Uganda, around 200,000 people permanently earn money from charcoal (World Bank, 2007). Another study for Uganda found that if households are involved in charcoal production, it reduces their likelihood of falling below a poverty line by approximately 14% (Khundi et al., 2010). In Rwanda, where 95% (national source) of the population rely on solid wood-based fuels, the charcoal sector is estimated to account for an annual volume of US$77 million (van der Plas, 2008). In D.R. Congo, the charcoal sector employs 270,000 people for an annual income between USUS 75 and 100 million for Kinshasa (country report). The case of the charcoal sector in Tanzania described in Box 3 further illustrates existing similar trends in other neighboring countries.

Box 5: Charcoal sector in Tanzania.

The contribution of Tanzania's charcoal sector to employment, rural livelihoods, and the wider economy is estimated to be of US$650 million per year, providing income to 300,000 people in both urban and rural areas. The economic contribution of the charcoal sector for Dar es Salaam alone exceeds the coffee and tea sectors. National and local governments are estimated to lose about US$100 million per year due to their failure to effectively regulate the charcoal sector.

Charcoal is generally unsustainably harvested from dry (or miombo) woodlands within a catchment area that extends up to 200 kilometers from urban energy markets. An average annual loss of forest area of about 100,000–125,000 hectares can be attributed to the charcoal sector. Total annual charcoal consumption in Tanzania is estimated at 1 million tons. The annual supply of wood needed for this is estimated at 30 million cubic meters. To produce charcoal it is estimated that as many as 160,000 earth kilns are used each year, or 438 per day.

The production of charcoal is often a byproduct of other economic activities, such as the clearance of land for agriculture. About half of the total charcoal produced in Tanzania supplies the Dar es Salaam energy market, estimated at around 1,500 tons each day. Given the projected rapid expansion of Dar es Salaam's urban population over the next two decades, it is estimated that this figure could rise to around 3,300 tons per day by 2030. Assuming that the current unsustainable charcoal harvesting and production methods continue unchecked, deforestation rates can only be expected to increase proportionately. As a result, natural woodland cover within the districts surrounding Dar es Salaam can be expected to almost disappear over the next decade.

Source: World Bank, 2009.

Table 55 shows that all countries in the sub-region have considerably increased their production of woodfuels (essentially in rural areas) and charcoal (in urban areas) in the last decade. Burundi has almost doubled its woodfuel consumption (+81.6% increase) whereas Eritrea cut it by half and Seychelles by one fourth (as a result of the implementation of environmental protection measures). With respect to charcoal production, Madagascar (+85,3%), Somalia (+49,2%) and D.R. Congo (+41,5%) are those which have recorded the largest increase during the 2000-2010 period, closely linked to political instability and lack of proper policy frameworks as well as monitoring. Production of charcoal seems to have stabilized in Burundi and Rwanda (which has put into place several forest rehabilitation, reforestation and afforestation programmes). Figures 103 and 104 show that Ethiopia and D.R. Congo are the largest producers of woodfuels and charcoal in terms of quantities in the sub-region (as per FAO data). The very low figure of charcoal production provided for Kenya (2005 and 2010) seems to be questionable in the light of the International Energy Agency

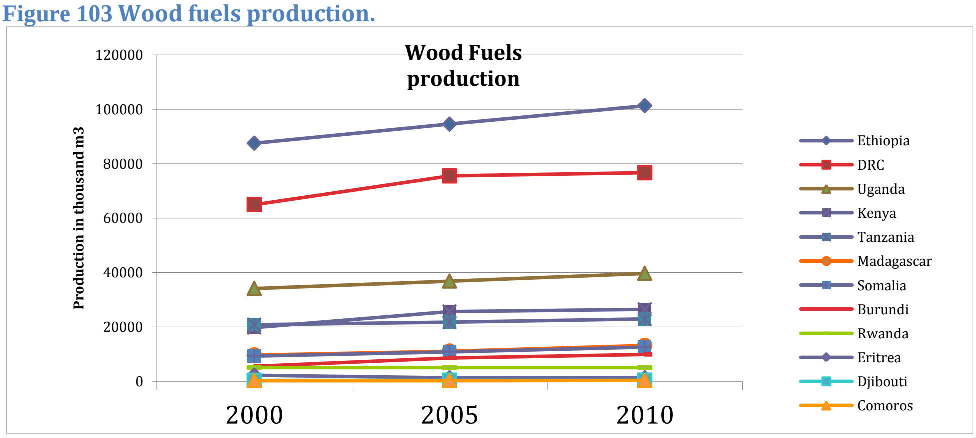
(IEA) own figure of around 3,109,000 tons which would place Kenya as top producer in the sub-region before Ethiopia (where IEA is indicating a much lower figure than FAO).

Table 55: Wood fuels and charcoal production in Eastern Africa.

Countries	Wood fuels[1] (1000 m3)				Charcoal[2] (1000 tons)			
	2000	2005	2010	Trend (2000-2010)	2000	2005	2010	Trend (2000-2010)
Burundi	5 420	8 542	9 846	+81,6%	60	60	60	0%
Comoros	201	232	266	+32,3%	29	34	40	+37,9%
Djibouti	293	325	356	+21,5%	39	43	48	+23,1%
D.R. Congo	64 903	75 446	76 602	+18%	1 431	1 704	2 025	+41,5%
D.R. Congo*							728	
Eritrea	2 224	1 264	1 264	-43,2%	146	163	183	+25,3%
Eritrea*							135	
Ethiopia	87 471	94 481	101 274	+15,8%	2 908	3 304	3 734	+28,4%
Ethiopia*							1 232	
Kenya	19 658	25 600	26 400	+34,3%	641	18	18	-97,2%
Kenya*							3 109	
Madagascar	9 637	11 055	13 100	+35,9%	645	910	1 195	+85,3%
Rwanda	5 000	5 000	5 000	0%	48	48	48	0%
Seychelles	4	3	3	-25%	-	-	-	-
Somalia	9 228	10 803	12 532	+35,8%	651	797	971	+49,2%
South Sudan	-	-	-	-	-	-	-	-
Tanzania	20 787	21 712	22 836	+9,9%	1 165	1 372	1 609	+38,1%
Tanzania*							1 569	
Uganda	34 090	36 797	39 636	+16,3%	713	814	931	+30,6%
Totals	258 916	291 260	309 115	+19,4%	8 476	9 267	10 862	+28,2%

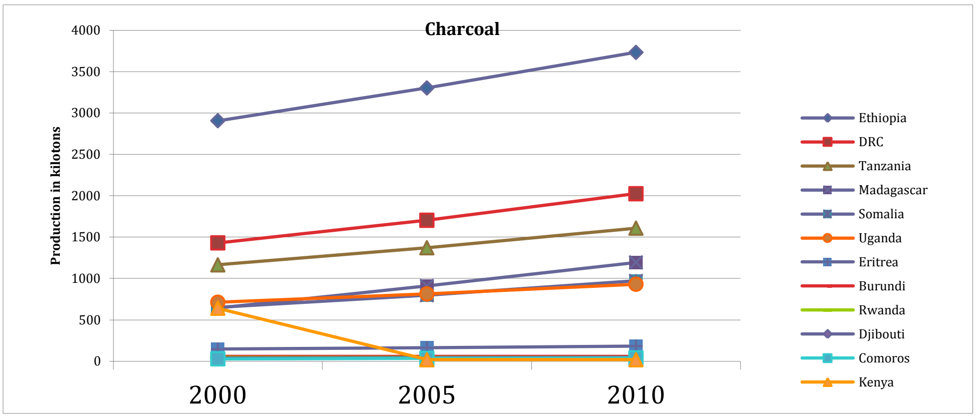
Source: FAO STAT, FAO website: http://faostat3.fao.org/home/index.html#COMPARE
Wood from main stem and branches, other than logs, used as energy source.
[2] Wood carbonized by partial combustion or application of heat from an external source.
*IEA, 2010.

Figure 103 Wood fuels production.



Source: FAO STAT.

Figure 104: Charcoal Production.



Source: FAO STAT.

7.5.1 Biomass: Data Challenges

The discrepancy in figures raises the issue of data quality, relevance and reliability. Several agencies and institutions (World Bank, FAO, IEA among others) obtain different data based on the methodology used, definitions of items and criteria for analysis. Some will use estimates and aggregates rather than actual/sectoral figures; others will only provide data for selected countries, leading to results that may not match each other as well as national figures, hence making the overall exercise of comparative analysis difficult for policy makers and experts. Woodfuels are likely to remain a major energy source and a determining environmental and development issue in Africa in the mid-term to the longer term. Therefore, a relevant effort aiming at improving knowledge on woodfuel demand and supply, as well as on its economic and social role, should clearly be undertaken in the future, particularly through sustainable and systematic data collection, compilation and analysis processes, with a unified approach and with the involvement of the major international organizations in this field.

7.5.2 Charcoal Production and Forest Degradation

Wood for charcoal production is mainly harvested from natural forests under de facto open-access management regimes often leading to significant forest degradation and—when coupled with other land-use changes—to permanent deforestation. Harvesting wood from natural forests for charcoal production occurs mainly in three ways: (a) as a by-product of some other wood extraction, (b) when forests are converted to other land-uses, including shift and burn agriculture, or (c) when wood is removed specifically for charcoal production. 400,000 ha of forest are lost to charcoal production every year in D.R. Congo alone (70 million m^3 forest wood per year), 100,000 ha per year in Madagascar (reduced by half since the implementation of a national environmental action plan in early 2000).

Data referring to forest cover and deforestation need to be considered and further interpreted with caution and scrutiny since related definitions may imply different local realities based on origin of data sources. Different definitions of forests depending on

identified institutions (UN Convention on Biological Diversity-CBD, FAO) exist reflecting the diversity of forests and forest ecosystems as well as the diversity of human approaches to forests. CBD defines primary forest a forest that has never been logged and has developed following natural disturbances and under natural processes, regardless of its age. It is referred to "direct human disturbance" as the intentional clearing of forest by any means (including fire) to manage or alter them for human use. Also included as primary, are forests that are used inconsequentially by indigenous and local communities living traditional lifestyles relevant for the conservation and sustainable use of biological diversity.

Table 56: Forest cover* in Eastern African countries.

Country	Forest area (%) (2000)	Forest area (%) (2005)	Forest area (%) (2010)
Burundi	7.7	7.0	6.7
Comoros	4.3	2.7	1.6
Djibouti	0.3	0.3	0.3
D.R. Congo	69.4	68.7	68
Eritrea	15.6	15.4	15.2
Ethiopia	13.7	13.0	12.3
Kenya	6.3	6.2	6.1
Madagascar	22.6	22.1	21.6
Rwanda	13.9	15.6	17.6
Seychelles	89	89.1	89.1
Somalia	12	11.4	10.8
South Sudan	-	-	-
Tanzania	42.3	40.0	37.7
Uganda	19.4	17.2	15

Source: World Bank.

* Forest area is land under natural or planted stands of trees of at least 5 meters in situ, whether productive or not, and excludes tree stands in agricultural production systems (for example, in fruit plantations and agroforestry systems) and trees in urban parks and gardens.

Table 57: Forest characteristics in Eastern Africa.

Country/area	Primary Forest		Other naturally regenerated forest			Planted Forest		
	1000 ha	% of forest area	1000 ha	% of forest area	% of which introduced species	1000 ha	% of forest area	% of which introduced species
Burundi	40	23	63	37	-	69	40	100
Comoros	0	0	2	67	0	1	33	100
Djibouti	0	0	6	100	-	0	0	-
DRC	-	-	-	-	-	59	Ns	-
Eritrea	0	0	1,498	98	0	34	2	90
Ethiopia	0	0	11,785	96	-	511	4	-
Kenya	654	19	2,616	75	-	197	6	100
Madagascar	3,036	24	9,102	73	-	415	3	100
Rwanda	7	2	55	13	-	373	86	-
Seychelles	2	5	34	83	-	5	12	-
Somalia	0	0	6,744	100	-	3	Ns	-
South Sudan	-	-	-	-	-	-	-	-
Tanzania	0	0	33,188	99	-	240	1	-
Uganda	0	0	2937	98	-	51	2	100

Source: FAO Global Forest Resources Assessment (2010).
Ns: not significant
FAO Note: a reported 0 for primary forest may be due to lack of data rather than a complete lack of primary forest.

A secondary forest for CBD is a forest that has been logged and has recovered naturally or artificially. It is important to underline that "not all secondary forests provide the same value to sustaining biological diversity, or goods and services, as did primary forest in the same location". A plantation forest may be afforested land or a secondary forest established by planting or direct seeding. FAO uses more often the term of "natural forest" (in lieu of primary forest) referring to a forest composed of indigenous trees and not classified as forest plantation. 'Forests' in general for FAO include natural forests and forest plantations.

This is the reason why overall forest cover related data do not fully reflect disparities between different types of forests and may convey a mixed impression about the real health of forests and associated biodiversity. Secondary forest including other naturally regenerated forest, planted forest and other woodland will never substitute to primary or natural forests ecosystems. Fauna and flora species are unique to them and are most often irreversibly affected impacting on the overall sustainability of remnant forest patches and other key resources such as land and water. Informal and formal internal country assessments often reveal that actual covers' sizes are much smaller than those shown in data and also rapidly evolving due to increased urbanization pressure and population growth.

At the exception of Djibouti and Seychelles who record a stable forest area over the last decade due to a quite insignificant forest cover for the former country and stringent forest conservation programmes for the latter one, and Rwanda which is the only country in the sub-region to have increased its cover through forest rehabilitation and sustainable land management projects (for example in Gishwati and Bugesera), all other countries have seen their forest cover reduced. Comoros has lost more than two thirds of its forest cover (from 4,3% to 1,6%), exacerbating the risk of losing it completely in the next five years (this would translate into dramatic impacts on the overall resilience to climate and other shocks of the small island developing state increasing the vulnerability of the population) (Table 56).

Except for Madagascar and Kenya, most countries in the sub-region have lost their primary forests (even though considering that actual lack of data may have influenced figures, Table 57 and Figure 105). Though several countries have embarked in ambitious forest rehabilitation and tree planting programmes (Eritrea, Ethiopia, Madagascar, Rwanda, Tanzania and Uganda), as shown in Table 56 and Figure 105 the overall forest cover in the sub-region has decreased by 9-10% in the last decade. This implies that afforestation and reforestation efforts at national level were insufficient to offset the continued disappearance of primary forest mostly encroached upon for slash and burn agriculture, grazing land, commercial logging and used for charcoal production resulting in additional carbon emissions. Other studies[39] show that forests were particularly hard hit near protected areas (46% of East Africa's National Parks having lost forest cover in the last decades). Just outside of protected areas, forests were particularly vulnerable, with buffer zones losing forest at an even faster pace. As per Figure 105, D.R. Congo, Madagascar, Tanzania and Ethiopia seem to have the largest forest reserves. D.R. Congo hosts the second largest forest ecosystem in the world after the Amazon (6% of world rain forests). Forest covers 125 million ha (half of the country's surface) and represents 47% of the total African forest cover.

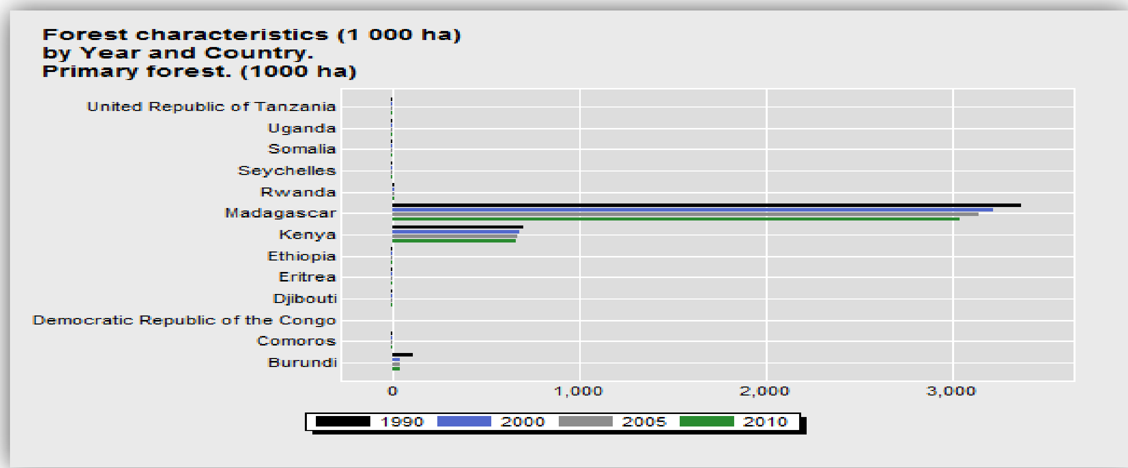
7.5.3 Policy Options for Promoting Sustainable Biomass Energy Development

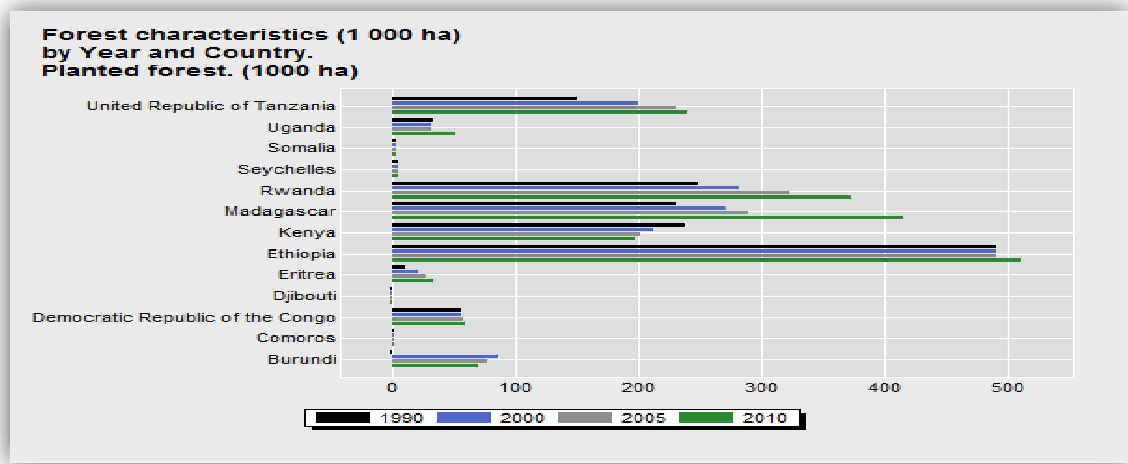
With increasing economic development, the demand for energy is increasing as well and consumers depend on a broader portfolio of energy sources to satisfy growing energy needs. Switching away from wood-based energy will not necessarily be only a matter of improving the economic situation of consumers. In fact, if the price of alternative fuels continues to rise and supply remains erratic, households have little incentive to switch away from biomass energy. Given the often erratic and unreliable income streams to urban households, small quantities of fuel is bought with the cash available even if an ex-post analysis of total fuel expenses per month reveals higher expenses for charcoal compared to alternative fuel, such as LPG. Due to the complexity of the energy decision, a doubling of typical incomes would only reduce the number of those depending on biomass energy for cooking by 16% (World Bank, 2011, forthcoming).

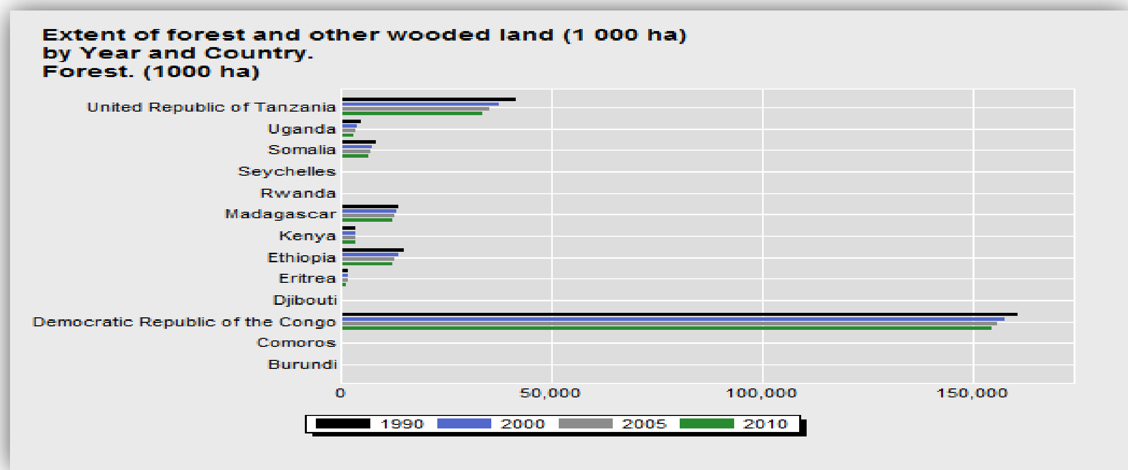
Though being the most important source of energy in rural and urban areas of Eastern Africa, wood-based biomass energy has been politically neglected. The charcoal trade is characterized by very weak governance, law enforcement, and other regulatory capacity. Despite its important interactions with development, environment and social welfare, there have only been a few attempts in Africa to include wood-based biomass as a basic sector in planning processes. Further emphasis needs to be put on the promotion of fuel switching, the introduction of fuel-efficient charcoal stoves, improved charcoal production kilns, and afforestation/reforestation measures designed to increase the supply of woody biomass. Increased kiln efficiency would play an important role in achieving a reduction of overall wood quantities needed for charcoal production, while the promotion of fuel switching would mainly buffer against a further increase in demand due to an increase in population.

Figure 105: Forest characteristics (primary forest, planted forest, extent of forest and other woodland) – FRA 201.

[39] Pfeifer M, Burgess ND, Swetnam RD, Platts PJ, Willcock S, et al. (2012) Protected Areas: Mixed Success in Conserving East Africa's Evergreen Forests. PLoS ONE 7(6): e39337. doi:10.1371/journal.pone.0039337.







Such ambition is seriously hampered by the scarcity, limited scope and poor quality of existing data, despite several past efforts to improve wood-based biomass information systems. These shortcomings make it difficult to undertake relevant impact studies of woodfuels and charcoal use on environment in general and on forestry resources in particular, thus the need for energy and forest planning and forecasting studies. With a

rapidly changing context for wood-based biomass energy in sub-Saharan Africa, policy makers need reliable baseline data to design appropriate measures (Sepp, 2008). Such data include population growth, urbanization dynamics and consumers' fuel switching behavior. The collection and management of data along the biomass value chain provides an excellent entry-point for shaping sound policies. Such efforts help stakeholders add knowledge, innovation capital and technology at each step in the chain.

Unsustainable charcoal use is increasingly seen as rooted in more systemic, site-specific deficits related to land tenure, fiscal[40] and incentive policies, urban energy markets and misallocation of forests and crop-land— problems that occur along the entire charcoal production chain. The three main factors affecting the transition to modern fuels are convenience, price and reliability of supplies.

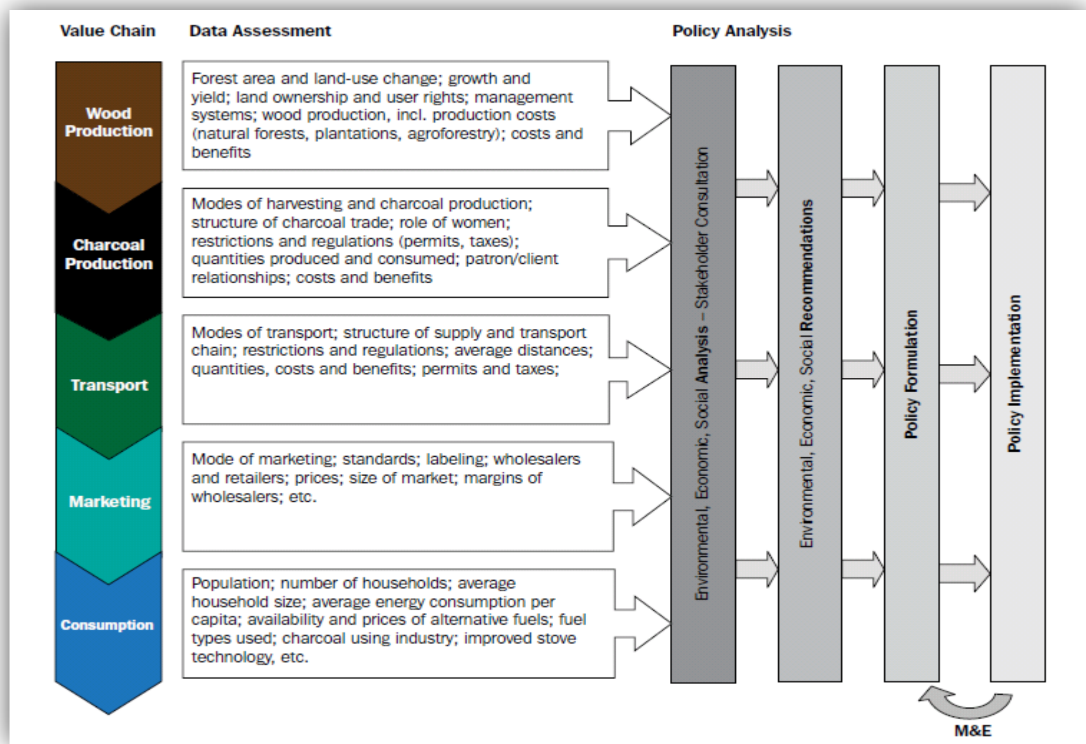
Three broad policy options can be utilized to promote sustainable wood production for charcoal:

(a) Using the full potential of sustainable harvests from natural forests through decentralized forest management approaches involving local stakeholders;
(b) increasing sustainable wood supply through tree-plantations; and
(c) increasing incentives of trees-outside-forests, for example through agro-forestry systems.

Forest management plans need to be simple and short and developed in a participatory fashion, so as to remain accessible for communities. The following principles would need to be further embedded: first, no natural forest area should be converted to plantations and second, even for degraded natural forests it is preferable to improve production through enrichment planting rather than full conversion to plantations or woodlots. Plantations should also provide direct pecuniary benefits to rural households in order to divert pressures from primary/natural forests. One of the main reasons for rural households to engage in unsustainable charcoal production is their need for cash income, which is almost exclusively provided by the charcoal business (AFREA, 2011). Figure 106 presents a framework for developing and evaluating various policy options that address the charcoal challenge (Sepp, 2008).

Figure 106: Charcoal value chain.

[40] Differential taxation of fuelwood is a means by which governments can introduce fiscal incentives to traders to use the fuelwood markets rather than obtain their supplies in an uncontrolled fashion from natural woodlands. The tax, collected by the government, is placed on resources taken from open woodlands and is designed to: (a) discourage traders from buying fuelwood extracted from natural woodlands; and (b) encourage the extraction of more distant fuelwood resources over those closer to the urban areas. Tax for sustainably produced fuelwood would be lower or abolished to encourage traders to buy it, and perhaps lower government administration costs if untaxed (AFREA 2011).



Source: AFREA, 2011.

7.5.4 Promotion of Improved Cookstoves for Enhanced Energy Efficiency

At present, some sources estimate that cooking with traditional biomass fuels contributes about 18% of current global GHG emissions when forest degradation and deforestation is included (SEI, 2008). Most countries in Eastern Africa have already promoted the development of improved cookstoves in the framework of the charcoal value chain, aimed at reducing in-door pollution, quantities of charcoal produced and GHG emissions, in the framework of country climate resilient green economy strategies. Challenges remain in their design, quality and technical standards and need to be addressed through research and development; monitoring and evaluation (M&E) mechanisms; subsidies and grants; awareness raising, business development, and consumer research; adapting cookstoves and programs to country contexts; and taking account of consumer preferences and behavior.

Madagascar has an ambitious and effective innovation and research programme focusing on the design and fabrication of improved cookstoves-*fatapers* (using rice balls technology for example), which are locally patented (the main challenge remaining on the high annual patents' fees that need to be paid). The population usually opts for them though some initial reluctance (adaptation to new design, cooking time assessment) based on affordability and practicality. In Uganda, a joint venture of private companies aims to provide low-income communities with access to energy-efficient household cookstoves; at an estimated cost of US$ 20 million, this represents one of the largest carbon-finance commitments made to clean cookstoves in the sector's history (REN 21). In D.R. Congo, three million improved cookstoves (*mbambula*) were distributed to the population and the Government has engaged into field tours to Rwanda which is well ahead in the sector, with

more than 50% of all households owning improved cookstoves (REN 21) through an Improved Stove Programme.

Ethiopia went through thorough assessments on linkages between wood-based biomass consumption and GHG (a rise in GHG emissions from current 24 Mt CO2e to 41 Mt CO_2e in 2030). As part of the proposed actions, the replacement of open fires and rudimentary stoves for cooking and baking with stoves that need only half as much fuelwood or stoves that use other fuels holds an estimated 20% of Ethiopia's total potential for emission reduction, or about 50 Mt CO_2 annually in 2030. The Government has plans to deploy 9 million more efficient stoves by 2015 corresponding to savings of US$ 270 million in opportunity costs for fuelwood, increasing rural household income by 10%. It would also create many more jobs in making stoves. Using better stoves would not only save energy, hence reducing emissions, but would also reduce severe health risks from smoke inhalation ("black carbon"). The government has identified the following targets: by 2030, fuelwood-efficient stoves for 80% rural population/5% urban (both cooking and baking); LPG stoves: 0%/5%; biogas stoves: 5%/1%; electric stoves: 5%/61% (both cooking and baking). Regarding efficiency improvement, the Ethiopian Ministry of Water and Energy estimates the following potential savings: fuelwood-efficient stoves: 50% (average for both cooking and baking); LPG stoves: 100% (cooking only); Biogas stoves: 100% (cooking only); Electric stoves: 100% (cooking and baking). The effect of overall reduced degradation will result in an abatement potential of 1.6 t CO_2/stove/year.

An ongoing project in Kenya, which is jointly implemented with GIZ and the Ministries of Energy, Agriculture and Education has disseminated approximately 850,000 stoves since it was established in 2005, and provides an example of state-promoted sustainable heating and cooking solutions. Producing cookstoves can provide business opportunities for many entrepreneurs, while other operations— such as formalizing the charcoal sector and creating fuelwood markets—can bring a range of income generating benefits. In Kenya, reports suggest that on average, 337 improved cookstoves were produced each month per producer, who earned an average monthly income of US$120-US$240 (GIZ, 2009). Moreover, fuel, time and money savings can also be a factor for some businesses such as restaurants that would be able to take advantage of newer technologies. For example, households can save an estimated half-ton of fuelwood each year if they own one of the new generation of improved stoves, which substantially affects their income (Adkins et al., 2010).

Countries making charcoal and biomass energy production more sustainable can rely on further support provided by existing initiatives such as the World Bank funded Biomass Energy Initiative for Africa (BEIA) initiated in 2009. The BEIA tests promising approaches to deal with biomass energy that can potentially be incorporated into the World Bank's lending portfolio. It provides small grants to African NGOs, research institutions, universities and private enterprises—selected via a proposal review process—to undertake pilot activities related to the development of biomass energy in Sub-Saharan Africa. The program aims to fund innovative ways to address fundamental problems facing Africa's biomass energy sector. Support focuses on five themes: 1. Enabling market conditions for high-quality and high-performance modern cookstoves (creating the conditions that ease the commercialization of cleaner, more efficient cookstoves to replace traditional biomass-based cookstoves); 2. Modernizing the charcoal industry (improving environmental sustainability and energy efficiency of charcoaling and end use); 3. Demonstrating the feasibility of social

biofuels (using small-scale biofuels production systems that supply a local market fuels for cooking, lighting, and power generation); 4. Increasing power capacity with bioelectricity (using biomass to fuel power generation for off-grid or add-on capacity); and 5. Strengthening leadership in biomass energy (promoting higher-level training for technical and professional leaders).

Box 6: Cookingstoves and standards.

Traditional stoves refer to either open fires or stoves constructed by artisans or household members that are not energy efficient and have poor combustion features. Improved cookstoves are used in the historical sense for stoves installed in "legacy" programs, usually with a firebox and chimney, but without standards and with poor quality control. Advanced biomass cookstoves refer to the more recent manufactured stoves, based on higher levels of technical research; these stoves are generally more expensive and are based on higher, but as yet not well-defined, standards that include safety, efficiency, emissions, and durability; among others, they might include wood, charcoal, pellet, and gasifier stoves. Finally, the effective improved cookstoves, cheaper but close in performance to advanced biomass cookstoves, are assembled on-site by qualified installers adhering to standards. Unsuccessful past programs were often based on cookstoves that performed well in the laboratory or when first installed, but then deteriorated quickly, often breaking down within a year. Failure was due, in part, to a lack of standards and quality control. In addition, many past programs had short-term financing and were supply driven, with little attention paid to stove design, market development, or the consumer research needed for long-term business growth. The advanced biomass cookstoves are manufactured in factories or workshops, undergo rigorous consumer testing before public introduction, and pay attention to performance. Many of these cookstoves have been supported by a consortium of established private-sector organizations and donors.

The lack of an international agreement on standards has made it challenging for stove manufacturers, distributors, investors as well as users to rate the quality and efficiency of cook stoves in different markets. Because improved stoves are not necessarily significantly cleaner, safer, or more efficient, having a set of standards in place that clearly defines how technology impacts fuel use, emissions, durability and safety will allow consumers to make more informed choices, spur manufacturers to build higher quality stoves, and increase the level of overall investment in the sector. Standards are particularly important because they provide policymakers, donors, investors, stove experts, and program managers with a credible basis for comparing stove performance and safety and provide experts with a common set of terms for communicating and understanding stove performance. Furthermore, standards can give stove makers affirmation of product quality, let users know they are making a worthwhile investment, and drive industry innovation (GACC 2012). Standards and certification for stove performance and testing methods need to be further developed. Cookstoves should be certified as safe, reliable, efficient, and clean burning. Definition of respective roles of governments, nongovernmental organizations, microfinance organizations, and the private sector in programs to promote advanced biomass and effective improved cookstoves will be required. The provision of clean and affordable household energy is an integral part of scaling up energy access for the poor. The social and economic consequences of reducing the hours that women spend collecting biomass fuel, improving their health, and freeing up their time for more beneficial activities might well result in raising the living standards of an entire generation of children and households. Finally, at the global and regional levels, advanced cookstoves could contribute to a reduction in greenhouse gases and other climate forcers attributed to biomass burning.

Source: BEIA, World Bank, 2011.

The recently launched Global Alliance for Clean Cookstoves (GACC)[41] under the United Nations Foundation (2010) has provided an umbrella for many organizations and institutions to work synergistically toward bringing household energy and advanced biomass cookstoves back on the policy agenda of international development agencies and donors. The World Bank has also joined the GACC, as have a number of country governments and other partners. The GACC is a public-private initiative that aims to save lives, improve livelihoods, empower women and combat climate change by creating a thriving global market for clean and efficient household cooking solutions.

7.5.5 Alternative Biomass Energy

7.5.5.1 Biogas

Household biogas is considered a clean and affordable substitute for traditional biomass fuels, and even for kerosene in case of lighting. Through a composting process, bio-digesters produce methane that can be used for cooking and lighting. Other benefits include improving agricultural productivity and household sanitation. Partnerships may provide a supporting context to further advocate the idea of biogas energy generation, facilitate knowledge exchange—especially with other regions where biogas has already been mainstreamed. For example, the Africa Biogas Partnership Programme (ABPP), created by SNV and HIVOS, aims at constructing 70,000 biogas plants in Ethiopia, Kenya, Tanzania, Uganda, Senegal and Burkina Faso, providing about half a million people access to a sustainable source of energy by 2013. Estimates suggest that Rwanda could have 100,000 installations, Ethiopia 1.1 million, and Kenya 320,000 (Winrock, 2007). In Rwanda, the National Domestic Biogas Programme (NDBP), with technical and institutional support from the Dutch (SNV) and German (GIZ) development agencies, aims to install at least 15,000 biogas digesters in rural households owning 2–3 cows; a total of 1,846 digesters were installed by the end of 2011 (REN 21).

In Eastern Africa, most sugar-producing countries generate power and heat with bagasse-based combined heat and power (CHP) plants. Grid connected bagasse CHP plants exist in Kenya, Tanzania, and Uganda. However, despite Africa's enormous biomass resource potential, biomass power generation has remained extremely low until recently. Biomass power plants are now planned in Rwanda and plans for an 11.5 MW biomass power plant in Kenya were announced in early 2012 (REN 21).

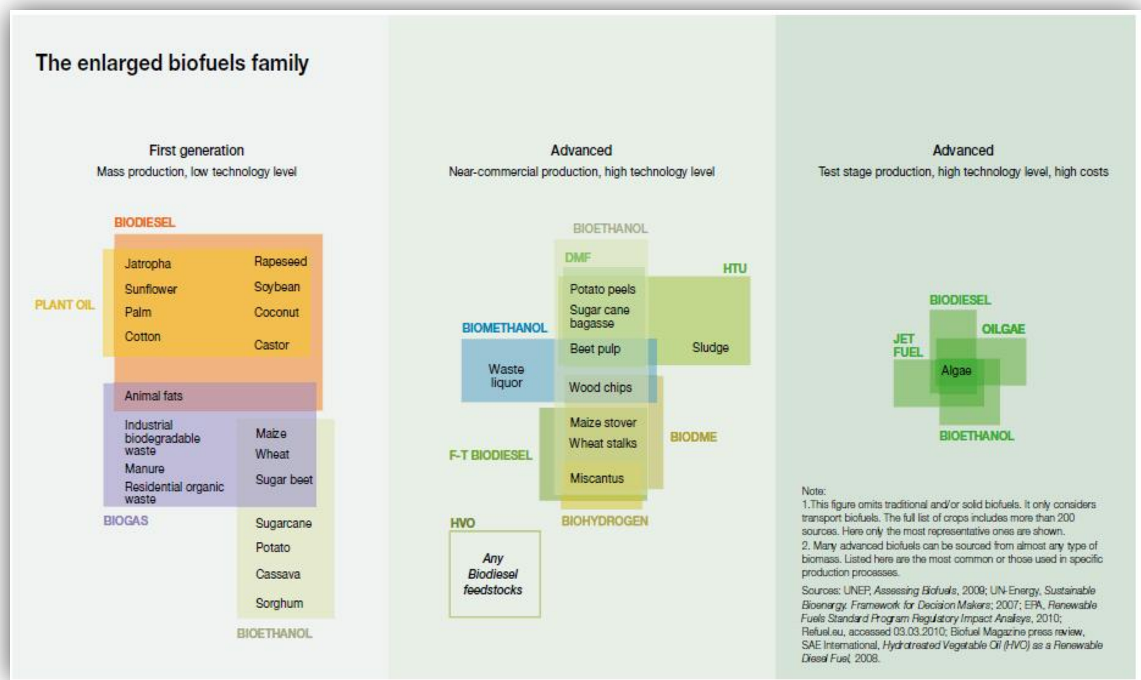
7.5.5.2 Biofuels

First-generation biofuels, those derived from starches, sugar, soy, animal fats, palm and vegetable oil-have won wide popular support. But because some of these crops require a tremendous amount of land, scientists worry that forested areas will be cut down or burned to make way for agricultural expansion. Some of these crops also have a low energy return. Soy and rapeseed, for instance produce only 500 to 1,000 liters of biodiesel per hectare, according to the University of California at Los Aangeles' Institute of the Environment and Sustainability, meaning the life-cycle production and transport emissions in some cases exceed those of traditional fossil fuels. But experts are still hopeful about second-generation biofuels, those derived from woody crops, agricultural residues, waste and inedible crops, like stems and switch grass (Figure 107). It turns out they are often both better for the

[41] www.cleancookstoves.org.

environment and more fuel efficient than the first-generation biofuels. Though a few first-generation crops-sugarcane, sugar beet and sweet sorghum-perform well environmentally, sugar cane is the most economically competitive among these. Liquid biofuels are vulnerable to the effects of changes in climate variables, like temperature, rainfall, as well as CO_2 levels, on crops used as raw materials to produce ethanol and biodiesel. This process directly affects many key factors of agriculture, like crop yield, agricultural distribution zones, incidence of pests and the availability of lands suitable for growing some crops.

Figure 107: The enlarged biofuels family.



Source: UNEP Grid Arendal 2012

Biofuel production is still marginal in most Eastern African countries due to initial concerns and failures around the first generation of biofuels and heated debate about negative impacts on food security and the environment. Only a few of them such as Ethiopia and Kenya among others have strategies to develop biofuel production and consumption.

7.6 THE NEXUS BETWEEN ENERGY SECURITY AND FOOD SECURITY

Agriculture, livestock and fisheries are the major economic sectors for countries in the sub-region as well as the sole livelihoods for their population. However, numerous constraints including low investment in agriculture, price fluctuations and recurrent extreme weather events among others compromise the farmers' capacity to supply an increasing food demand. About 80% of the population of the sub-region lives in rural areas and though an accelerated urbanization rate is changing this picture. Despite agriculture accounting for 70% of the labor force in the Eastern African sub-region, its contribution to GDPs remains low.

Energy security and food security are intertwined socio-economic issues which are essential to social and environmental security. They share similar characteristics and trends, face linked challenges and opportunities, and require well coordinated, connected and integrated policy interventions that are also harmonized at sub-regional level. Rural electrification is a top priority on the political agenda of Eastern African countries. Tanzania is amongst the few countries which have reached their planned target and increased the rate of rural electrification from 2.5% in 2007 to 14% in 2011 (REN 21, 2012). Mechanization efforts as well as on-going development of fully fledged regional commodity chains including promotion of agribusiness through processing will require sustained supply of energy to plants, and equipments.

Land resource is at the core of the energy and food security nexus. "Land is becoming an increasingly globalised commodity, fuelled by rising demand for food and agrofuels, for minerals, for tourism, and for ecosystem services including carbon sequestration. Resource-poor land users are facing increased competition for land with other land users, national elites and global investors"[42]. Insecure land tenure systems have led to unequal control over land and inequitable access to land resources fuelling tensions between land user groups as well as severe conflicts over different land uses thus constraining farmer innovation and investment in agriculture. This situation aggravates poverty through serious impacts upon food security, environmental sustainability and social security. The last couple of years have seen a steady increase in demands by local (both private and state) and international investors for land for large scale farming of food crops to meet food security and for biofuel crops to meet global renewable energy demands. The latest analytical report on Transnational Land Deals for Agriculture in the Global South based on the Land Matrix Database[43] shows that Eastern Africa ranks first in term of land deals projects (1/3 of all reported projects). Ethiopia, Tanzania, Madagascar and D.R. Congo are among countries concentrating the major number of land acquisitions. Food and biofuels production (Jatropha) account for the majority of large-scale land acquisitions (mainly from China and South Korea).

Bio-energy constitutes a further challenge to the agricultural sector, representing the largest source of new demand for agricultural commodities in recent years. Production of biofuels, particularly ethanol and bio-diesel for use in the transport sector, has tripled since 2000 and is projected to double again within the next decade. Fischer et al. (2007) find that expansion of first generation biofuels is likely to continue to compete with food production for land and water resources, with potentially significant negative impacts on food insecurity. However, second generation biofuel development could decrease competition for arable land use from biofuels, indicating the importance of research and development in this area (Fischer et al. 2007; Kahn and Zaks 2009), (FAO, 2009)[44].

Development in the bio-fuel sub-sector provides both opportunities and challenges to sustainable agricultural development and food security in Africa. Increases in production in response to high oil prices means substantial income for farmers, but the sustainability of

[42] ILC, *Increasing commercial pressure on land: Building a coordinated response*, 2009 (www.landcoalition.org)

[43] Land Matrix Partnership (CDE, CIRAD, GIGA, GIZ, ILC), Authors: Anseeuw, W.; Boche, M.; Breu, T.; Giger, M.; Lay, J.; Messerli, P.; Nolte, K. (April 2012),

[44] "Food Security and Agricultural Mitigation in Developing Countries: Options for Capturing Synergies"

this income could be highly uncertain in view of the extreme volatility of oil prices. Furthermore, increased bio-fuel production often means reduced production and supply of food crops. Governments and farmers often face a tough choice in terms of adopting one or the other option and require technical capacity support to inform their decisions.

Biofuels pose several environmental and social risks. Concerns are being raised about the potential risks and trade-offs of developing biofuels that include, among other things, food security, biodiversity loss, competition for land and water resources, the use of genetically modified organisms, greenhouse gas emissions, soil erosion and other soil degradation, water contamination, human health impacts, labour conditions, and rights of children. The environmental, social and other costs of biofuels, including lifecycle GHG emissions, can be significant without safeguards and vary according to several factors including feedstock, land use changes and refining processes. In general, ethanol made from corn has higher associated environmental impacts than ethanol made from sugar cane.

7.7 POLICY OPTIONS

7.7.1 Biofuels

To be truly a part of the green economy, biofuels need to comply with a set of safeguards along the entire production chain. Bioenergy development strategies will need to integrate safeguards at all levels, from policy to investments and the project itself. Conducive policy instruments could include research and development, blending targets, tax benefits, smart subsidies and loan guarantees. These policies should be developed considering the cross-sectoral nature of biofuels and the need to comply with agreed sustainability criteria and resource availability. Biofuels are context–specific, and replicating success stories is complex. As a first step, the development of biofuels should initially be prioritized on ensuring energy access for the local market and to international markets once local capacities and sustainability standards are in place.

Feedstock availability and sustainability are central to the success of the biofuels industry. As such, there is need to closely assess Eastern Africa's feedstock production capacities and comply with emerging global sustainability guidelines. As such, efforts to develop biofuels should initially focus on the use of existing agricultural waste and then gradually shift towards expansion of existing agricultural systems once agreed sustainability guidelines are in place.

Biofuels in Ethiopia[45]

Over 300,000 ha were allocated to investors in biofuels in 2008 in Ethiopia, with over 80% of these developments occurring in arable lands, forest lands and woodlands. Many more companies were requesting for more lands for further expansion of biofuel production in and around their current production sites. Several other national and foreign investors had obtained investment licenses for the development of biofuels from the Federal Investment Commission. The land requirements amounted to 1.65 million hectares (requirements for obtaining permits for biofuels production are minimal). The Ethiopian Biofuels Development

[45] MELCA Mahiber (2008)

and Utilization Strategy in place tried to address some of the environmental and social issues but failed to put Environmental Impact Assessment as a mandatory process for new and expanding biofuels projects. In addition, no proper land inventory (and suitability for biofuel production and definition of 'marginal lands' for small-scale energy crops production) and linkages to food security strategies as well as the development of a monitoring and evaluation system had been undertaken.

7.7.2 Hydropower

The Inga River in D.R. Congo holds great potential for hydropower generation in Africa estimated at 40,000 MW. In fact, DRC alone accounts for over 50% of Africa's hydropower potential. However, only 3% of this potential is being currently used (almost electricity in the country is currently produced by hydro), an on-going review of the country energy policy provides further emphasis to the development hydropower and has identified 300 hydro sites essentially for small-hydro. Small Hydropower systems (SHPs, less than 10MW) can supply energy to remote communities and catalyze development in such communities and in comparison to large hydropower systems require significantly lower capital costs.

Other countries with a considerable hydropower potential include Ethiopia, Madagascar, Kenya and Tanzania. In Kenya, more than half of the electricity supply is produced by hydroelectric dams built in the Tana River basin and on the Turkwel; the rest is mainly produced by fossil fuel thermal power plants and geothermal utilities.

Madagascar is planning to phase out all thermal plants in rural areas (which currently generate 75% of all electricity – the remaining 25% being produced by hydro, biomass, wind and solar) and replace them with small-hydro and other sources of renewable energies. The costs of installed kW are for thermal: US$ 650-850; wind: US$ 1800-2200; hydro: US$ 1900-2500; biomass: US$ 1900-2200 (the lower costs of installation for thermal production but high costs over long-term running explained the preference for this type of energy). The country also wishes to increase three-fold the current connection rate of 5% in rural areas by end of 2013 through 83 hydro plants and further emphasis on other renewable energies (wind, solar and biomass)[46].

Hydropower infrastructure has potentially significant environmental and social impacts. Attention must be paid to downstream flows as peaking operations can impact on natural habitats and human use of rivers. Through smart choices of locations, designs and operating regimes such impacts can be avoided, minimized mitigated or compensated in accordance with existing internationally agreed sustainability criteria. Hydropower generation depends directly on the availability of water resources, hence an increased vulnerability to climate change impacts on the hydrological cycle. Environmental and social management plans will be needed to address identified issues and adopt remedial measures.

The Gibe III dam in southern Ethiopia is a controversial project and a good case study illustrating the real dynamics and trade-offs between energy development and socio-economic-environmental impacts. The impacts arise from the formulation and

[46] Agency for Development of Rural Electrification (ADER), 2012.

implementation of energy projects, their ownership and thorough consideration of short-term and long-term socio-economic-environmental changes. “friends of Lake Turkana” (a Kenyan-based NGO) indicates that the project may dry up Kenya’s Lake Turkana, the world’s largest desert lake and impact half a million people in the two countries. The plan is to dam the Omo River which flows into Lake Turkana, in order to provide electricity for more than 200 million people in five countries. The dam project, the highest in Africa, has already been delayed and is now scheduled to start operating in 2014. The sugar cane and cotton plantations down the Omoriver are monocultures which require large amounts of water. That means less water remains for the river and environmentalists warn that many plants and animals could become extinct. Among the organizations funding Gibe III at the start of the project was the World Bank (WB). However, citing a lack of transparency, it withdrew its support. In July 2012, the WB decided to finance a 1,000 km-long (621 miles) power cable from Ethiopia to Kenya. Facing protests from the opponents to the plan, the WB indicated that 44 power plants feed the Ethiopian electricity network and, with it, the power line to Kenya, without any specific link to the Gibe III dam. They did an analysis showing that even if Gibe III was not built, the interconnection would still be viable (with power available for the national grid as well as for export to Kenya). Among the critics of the project, Human Rights Watch (HRW) voices their concern about this new development indicating that the WB is not willing to apply the safeguards, the policies that are meant to ensure against human rights abuses. It will take some more time and mediation before the two visions reconcile (the one of the Ethiopian government and the World Bank arguing that the new power transmission line will bring urgently needed power to countries in the region and the one of opponents for whom the price is too high, if it includes driving people from their homes and damaging the environment)[47]. It will also require thorough assessment of all social, economic and environmental impacts taking into time-bound criteria of cost-effectiveness and sustainability.

The global energy sector uses vast amounts of water for power generation, accounting for an estimated 8% of all freshwater withdrawals and much higher rates in some countries. There are already signs that water scarcity may be constraining energy production in many parts of the world. The lifecycle water consumption of renewable energy varies widely depending on technology types, manufacturing processes and operational contexts. In certain cases, the water use of wet-cooled CSP, biomass and geothermal power plants can be comparable to traditional thermal power, while biofuels processing can be highly water intensive: corn ethanol from irrigated crops requires vastly more water than standard oil refining.

The expansion of hydropower production must take into account the potential for significant evaporative water losses from the regional watershed as well as the environmental impacts associated with altering natural water flows and siltation patterns. Water consumption through evaporation from dams cannot necessarily be directly associated with energy production given that dams often serve multiple purposes, including flood control, water storage and recreation, in addition to electricity generation. As many nations seek to increase the share of renewables in their national energy portfolios, they will need to evaluate the water impacts of these technology commitments. However, with the

[47]http://ethioinfo.wordpress.com/2012/08/18/world-bank-under-fire-over-ethiopian-dam/

appropriate selection and deployment of renewable energy systems, it should be possible to meet the goals of providing clean energy and mitigating greenhouse gas emissions without placing undue burdens on regional water systems.

7.7.3 Geothermal

Geothermal electric capacity is growing at around 5% each year. Geothermal energy is an untapped renewable energy source that is abundantly present in the East African Rift Valley, a geothermal hot-spot that spans eleven countries. It has a potential of generating up to 14,000 MW. However, only few countries such as Kenya have used it commercially. As of today, Kenya has installed up to 127 MW, amounting to about 17% of the national power supply, followed by Ethiopia with a 7 MW installation. Plans to use potential of geothermal energy in Uganda, Tanzania, Djibouti and Eritrea are at different stages (REN 21, WWF 2011, national sources).

The AfDB is working closely with Kenya to prepare one of the first projects in the SREP investment plan: a geothermal plant in Menengai aimed at producing 400 MW of its 1,650 MW potential by 2015. This will improve power reliability and stability and reduce system losses on the national grid. It will also avail additional capacity that will facilitate grid extension to other areas. This is the first geothermal field being developed solely by Kenya's newly established Geothermal Development Company (GDC), which is responsible for the country's scale-up in geothermal development. In terms of the unit generation cost, geothermal is the most cost effective of Kenya's renewable energy sources. It is also not affected by drought and climatic variability, has limited environmental impacts and the highest availability factor at about 95 percent, (indigenous and readily available in Kenya, i.e. an estimated potential of over 7,000 MW spread over 14 prospective sites). Kenya seeks to develop about 5,000 MW of electricity from geothermal by 2030[48].

As the geothermal power market continues to broaden, a significant acceleration in the rate of deployment is expected, with advanced technologies allowing for development of geothermal power projects in new countries. Drought in East Africa has renewed interest in geothermal electricity to improve reliability in a region dependent predominantly on hydropower. The high cost of exploration has dampened the growth rate in the region, but plans are progressing for significant growth in the East African Rift Valley.

Geothermal steam of hot water used for generating electricity contains toxic compounds, but closed loop systems can prevent these from escaping. In fact, because geothermal need healthy water catchment areas, they may actually strengthen efforts to conserve surrounding ecosystems.

7.7.4 Solar

Solar energy provides light, heat and electricity. Photovoltaic (PV) cells, which convert sunlight directly into electricity, can be integrated into devices or buildings. Eastern Africa has great potential for concentrated solar thermal power generation. Solar PV Pico systems (SPS) and solar home systems (SHS) are two of the most popular lighting solutions. However, in spite of some incentive programs, the majority of the population still cannot afford PV panels simply because of their cost. Mini-grids based on PV and hybrid systems

[48] www.climateinvestmentsfunds.org

(including small hydro and wind) are gaining popularity in villages that are sufficiently dense and well-off, due to their economies of scale and to the demand for electrical services beyond lighting, including communications, space cooling and refrigerators, and motive services (such as water pumping and irrigation).

Kenya has some of the highest documented installed capacities of solar PV systems that stand at over 3,600 kWp and one of the largest solar PV system in sub-Saharan Africa (0.5 MW). More than 220,000 solar PV systems and 140,000 m^2 of solar thermal systems for heating and drying are also installed across the country. In 2011, a Kenyan-Dutch joint venture opened the first PV production facility in Naivasha, Kenya, supplying the East African market with PV panels in the range of 30–125 Wp. While most projects have been for off-grid applications, there are also examples of using renewables to provide grid-connected electrification. Throughout Eastern Africa, the Dutch-German-Norwegian partnership Energising Development is supporting market development of solar PV systems of various sizes (particularly in Burundi, Ethiopia and Uganda) and small-scale hydropower plants (in Ethiopia, Rwanda and Uganda). The partnership is being implemented by the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) and NL Agency in the form of bilateral government projects (REN 21).

Climate change can affect solar energy resources by changing atmospheric water vapor content, cloudiness and cloud characteristics, which affects atmospheric transmissivity. This can have effects on electricity generation from photovoltaic and concentrated solar power (CSP) arrays.

7.7.5 Wind

Eastern Africa still lags behind and the development of wind energy projects is primarily constrained by lack of precise information about wind potential. Different technologies are available: off-shore wind energy and on-shore small wind turbines for electricity generation. The Lake Turkana Wind Power project (LTWP) is poised to provide 300 MW of clean power to Kenya's national electricity grid using the latest wind turbine technology (upon full commissioning in 2014) satisfying up to 17% of Kenya's total installed power[49].

The availability and reliability of wind power depend on weather and climate conditions. The energy density in the wind is determined by the global energy balance and the atmospheric motion that results from it. The main mechanisms by which global climate change impacts wind energy endowments are shifts in the geographical distribution and the variability of wind speed. Environmental impacts include noise and aesthetic pollution, as well as increased avian and bat mortality.

7.8 POLICY INTERVENTIONS

Coherent, consistent and conducive policy and regulatory frameworks are central to the successful dissemination of renewable energy in Eastern Africa. A clear direction and leadership from the governments in the form policies and regulations is much needed. Policy

[49] See further details here http://ltwp.co.ke/.

and regulatory frameworks can offer space for the private sector to operate effectively and expand their investments in the development and use of renewable energy.

Several national and international policies have so far been used to promote the use of renewable energy technologies and it is clear that policy successes are likely to be achieved when used in combination and adapted to the local, regional or national condition. Based on these experiences, policies to be considered for implementation at the national level are: regulation measures (i.e., performance standards, equipment standards, etc); subsidies and financial incentives (feed-in tariffs, rebates, grants, loans, production incentives, government purchasing agreements, insurance) that are targeted and have a clear sunset clause; voluntary agreements (e.g. between government and private sector).

At regional and sub-regional levels, policy measures that have been successful and can be considered for development in Africa include focused use emission targets and trading systems, technology co-operation and financial systems (ODA, FDI, commercial bank loans). In selecting appropriate policy options, it is important that these policy options be evaluated for their environmental impacts and cost effectiveness, distributional aspects, institutional feasibility,; and suitability to the local context. In addition, renewable energy policy development should be well integrated into policies of other sectors. Poverty reduction strategies and well-coordinated through a consistent, coherent and transparent inter-institutional dialogue. Eastern African countries can tap into the Africa-European Union Energy Partnership (AEEP) further described in Box 7.

7.9 ENERGY AND CLIMATE CHANGE: FUNDING MECHANISMS FOR RENEWABLE ENERGY POLICY AND GREEN GROWTH

Africa is particularly vulnerable to the expected impacts of global warming though being the less significant source of GHG emissions from energy and industrial activities in the world. Global warming threatens the fragile balance of the planet's ecosystems and could consign a quarter of all species to extinction[50]. The main drivers of GHG emissions as well as their assumed impacts in the sub-region are mainly the increase in cropland and in the cutting of fuelwood to meet the needs of a growing population.

[50] http://www.nature.com/nnature/journal/v427/n690/abs/nature02121.html

Box 7: The Africa-EU Energy Partnership (AEEP) (2011)

The Africa-EU Energy Partnership (AEEP) is a long-term framework for structured political dialogue and cooperation between Africa and the EU on energy issues of strategic importance, reflecting African and European needs. The objective of the AEEP is improved access to reliable, secure, affordable, cost-effective, climate friendly and sustainable energy services for both continents, with a special focus on achieving the MDGs in Africa. In order to achieve it, the AEEP will focus its efforts on concrete, realistic, visible targets to be attained by 2020, as agreed by the First High Level Meeting of the AEEP held in Vienna on 14–15 September 2010. Specific initiatives will focus on the following priority areas: (a) energy access; (b) energy security; (c) renewable energy and energy efficiency; (d) institutional capacity building; and (e) scaling-up investment.

The above-mentioned meeting endorsed the following political targets to be achieved by 2020:

Energy access: as a contribution to the African objective of achieving a continent wide rate of access to modern and sustainable energy of around 50%, which means additional 250 million people, Africa and the EU will take joint action to:

- bring access to modern and sustainable energy services to at least an additional 100 million Africans, focusing on sustainable models: to provide energy for basic services (health, education, water, communication); to power productive activities; and to provide safe and sustainable energy services to households.

Energy security:

- doubling the capacity of cross border electricity interconnections, both within Africa and between Africa and Europe, thus increasing trade in electricity while ensuring adequate levels of generation capacity; doubling the use of natural gas in Africa, as well as doubling African gas exports to Europe, by building natural gas infrastructure.

Renewable energy and energy efficiency:

- building 10,000 MW of new hydropower facilities taking into consideration social and environmental standards;

- building at least 5,000 MW of wind power capacity;

- building 500 MW of all forms of solar energy capacity; and

- tripling the capacity of other renewables, such as geothermal, and modern biomass;

- improving energy efficiency in Africa in all sectors, starting with the electricity sector, in support of Africa's continental, regional and sectoral targets.

7.9.1 UN-REDD, REDD+, FCPC and FIP[51]

The UN-REDD Programme is the United Nations collaborative initiative on Reducing Emissions from Deforestation and forest Degradation (REDD) in developing countries. The Programme was launched in 2008 and builds on the convening role and technical expertise of the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP). The UN-REDD Programme supports nationally-led REDD+ processes and promotes the informed and meaningful involvement of all stakeholders, including Indigenous Peoples and

[51] www.un-redd.org

other forest-dependent communities, in national and international REDD+ implementation. The Programme supports national REDD+ readiness efforts in 46 partner countries spanning Africa, Asia-Pacific and Latin America, in two ways: (i) direct support to the design and implementation of UN-REDD National Programmes; and (ii) complementary support to national REDD+ action (REDD+ preparedness strategies) through common approaches, analyses, methodologies, tools, data and best practices developed through the UN-REDD Global Programme. By July 2012, total funding for these two streams of support to countries totaled US$ 117.6 million.

Deforestation and forest degradation through agricultural expansion, conversion to pastureland, infrastructure development, destructive logging, fires, etc. account for nearly 20% of global GHG, more than the entire global transportation sector and second to the energy sector. REDD is an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested land and invest in low-carbon paths to sustainable development. Most REDD strategies developed by Eastern African countries contain actions to make the extraction of wood-based fuel sustainable, helping them achieve low-carbon growth while simultaneously satisfying the basic energy needs of rapidly growing populations. Voluntary markets have, in many instances, shown a preference for forestry credits (Chenost et al., 2010).

REDD+ goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. Protecting forests because of their critical role in mitigating climate change and in meeting sustainable development goals remains a priority. The internationally-backed climate mitigation scheme that pays developing countries to reduce emissions from deforestation and degradation, or REDD+, is moving forward-but slowly. REDD+ is a performance-based mechanism and developing countries will receive financial support contingent on achieving emissions reductions. Going forward, international donors will need to support forest-rich nations as they build their capacity to measure, report and verify (MRV) their carbon emissions-vital to demonstrating impact.

Principles for intervention of REDD+ and related mechanisms are further redefined following climate meetings (in the framework of the UN Framework Convention on Climate Change (UNFCCC)) and are thus subject to continuous evolution to ensure optimal alignment with country needs. Furthermore, experts agree on the need to develop a consistent approach to the concept of "carbon rights" in national REDD+ regimes. *Country Forest carbon regimes* will need to be built upon the existing legal regimes in relevant areas such as forestry and environmental management.

The Forest Carbon Partnership Facility (FCPF) seeks to build the capacity of developing countries in subtropical and tropical regions to reduce emissions from deforestation and forest degradation and to prepare them to take advantage of the incentive mechanisms that are currently under development. As part of their *Readiness Preparation Proposals* ("R-PPs") under REDD+, each of these countries has acknowledged the importance of clarifying issues arising from forest carbon ownership and governance (Kenya, Tanzania, the D. R. Congo and Ethiopia).

Kenya's proposed REDD+ readiness strategy is to test appropriate benefit-sharing arrangements and private sector involvement. Ethiopia has decided to focus its strategy on identification of forest use rights (given that insecurity of land tenure provides little incentive for sustainable management and conservation of forested land). It also emphasizes the need for capacity building in several areas around forest governance and the development of an appropriate MRV system. The Tanzanian strategy highlights that the existing land, forestry and environmental law in Tanzania provides a starting point for establishing forest carbon ownership, though challenges posed by overlapping and/or unregistered claims to land that need to be addressed as part of tenure reform (which may be further supported through the existing Norway-Tanzania Forest Climate Change partnership).

D.R. Congo is already involved in REDD+ (UN-REDD and FIP) and could provide an example of how regional initiatives for forest conservation can be integrated within a country's national framework, if efforts to develop a collaborative MRV system in the Congo Basin prove successful. Centralized approaches that are consistent with existing laws may offer a good starting point, particularly when structured as central guidance that allows for regional implementation. Existing issues with complex or insecure tenure arrangements will also potentially delay or frustrate the development of a consistent approach to forest carbon in a country.

Another important mechanism for the sub-region is the Forest Investment Programme (FIP), a targeted programme of the Strategic Climate Fund (SCF), which is one of the two funds within the framework of the Climate Investment Funds. The FIP supports developing country efforts to reduce deforestation and forest degradation and promote sustainable forest management that leads to emissions reductions and enhancement of forest carbon stocks (REDD+). Channeled through the Multilateral Development Banks (MDBs) grants and near-zero interest credits, FIP financing complements large-scale investments and leverages additional resources, including from the private sector to: promote forest mitigation efforts, including protection of forest ecosystem services; provide support outside the forest sector to reduce pressure on forests; help countries strengthen institutional capacity, forest governance and forest-related knowledge; mainstream climate resilience considerations and contribute to biodiversity conservation, protection of the rights of indigenous peoples and local communities, and poverty reduction through rural livelihoods enhancements. The FIP of D.R. Congo is further described in Box 7.

7.9.2 The Clean Development Mechanism (CDM): Opportunities for Eastern Africa

Under the Clean Development Mechanism (CDM), emission reduction projects in developing countries can earn certified emission reduction credits. These saleable credits can be used by industrialized countries to meet a part of their emission reduction targets under the Kyoto Protocol. The CDM was quite criticized for its complex procedures, low number of registered African projects and lack of national capacity in developing CDM eligible projects. As early as 2006, Parties to the Kyoto Protocol recognized the importance of a balanced regional distribution of CDM projects and welcomed the establishment of the Nairobi Framework, which brings together UN and regional organizations to support equitable access to the mechanism. In light of the benefits that the CDM can bring to less developed regions, the Nairobi Framework partners and others began funding technical support and capacity-

Box 8: D.R. Congo Forest Investment Programme (FIP)

The Democratic Republic of Congo (DRC) has a forest cover of approximately 1.5 million km^2 out of a national territory of 2.3 million km^2, and a population estimated at 60 million inhabitants. It is amongst the top ten countries in terms of loss of forest cover (measured on an annual basis), with an estimated deforestation of around 400 000 ha per annum over the period 2000-2010. Such deforestation is concentrated around "hotspots" located mainly around the large cities of the country, as well as in the densely populated areas on the edge of the large forest massif of the central basin. Household-scale slash and burn agriculture and exploitation of wood in the form for fuelwood (including charcoal) and timber appear to be the major drivers of deforestation and forest degradation in DRC. They reflect the very strong dependence of the rural and urban populations on forest resources, caused in part by the collapse of the physical and socio-economic infrastructures.

The FIP in DRC will support a number of key activities for the participation of the local communities, in particular land tenure security, micro-zoning, small-scale afforestation, support to small enterprises (charcoal production, energy-efficient stoves), and community forestry. In this context, the FIP (i) complements the Forest and Nature Conservation Project (US$64 million WB) which already finances land use zoning (micro and macro) and community forestry activities in three provinces (Bandundu, Equateur and Province Orientale), and (ii) establishes a direct link with the dedicated mechanism for Indigenous Peoples and local communities, in particular by improving land tenure security and by strengthening the capacity of indigenous communities. Other significant partnerships and possible sources of co-financing or synergies are to be announced, notably the REDD pilot projects (Congo Basin Forest Fund and private funds), the Forest and Biodiversity (PBF) project of the GIZ, the CARPE project of USAID, as well as many other initiatives supported by the main sponsors (the UK, Japan, EU, etc). Committing the private sector to REDD+ in DRC will require the establishment of sophisticated financial mechanisms and the intervention of stakeholders and tailor-made structures.

The interventions to be financed by the FIP in DRC are expected to generate measurable results in terms of reduced emissions for which the country will seek compensation through a performance-based mechanism (such as the FCPF Carbon Fund, bilateral deals or the carbon market). These emission reductions payments will ensure the long-term sustainability of the various activities proposed, especially those with a long-term nature, such as reforestation and support for community forestry, including capacity building for the creation of Small and Medium Enterprises. Hence, the FIP Investment Plan can be seen as an attempt to form a link between REDD Preparation and future performance-based payments for Emission Reductions.

The FIP in DRC will be based on the REDD+ Readiness process, in which the country is firmly engaged since January 2009 under the leadership of the Ministry of the Environment, Nature conservation and Tourism, and in partnership with the United Nations REDD (UN-REDD) program and the Forest Carbon Partnership Facility (FCPF) managed by the World Bank. In order to ensure inter-sectoral and multi-stakeholder coordination and participation, institutional arrangements for the REDD process were established, including a National REDD Committee and an Inter-ministerial REDD Committee along with the structure of day-to-day management of the process, the National REDD Coordination. These structures lead the development of an implementation framework for REDD+, including, in particular: (i) participatory development of the national REDD+ strategy; (ii) stakeholder consultation mechanisms; (iii) safeguard mechanisms (definition of socio-environmental standards and implementation of a Strategic Environmental and Social Assessment, which will help design an Environmental and Social Management Framework); (iv) reporting and control mechanisms (national authorization procedures for REDD+ projects, establishment of a national registry for all REDD+ initiatives, establishment of a national Measurement, Reporting and Verification system); and (v) mechanisms for financial management (national REDD+ fund and mechanisms for REDD+ related benefit sharing). The FIP thus fits within an ongoing national REDD+ process and provides a first source of substantial financing, making it possible for DRC to gradually enter into an investment phase. With that, the country expects to (i) build the structural conditions for the deployment at a larger scale of the REDD+ strategy, and (ii) undertake the first sectoral transformational programs.

Source: extracted from country project document.

building programmes for the CDM, particularly in Africa[52]. Existing funding mechanisms are listed in Box 8. Given the continued importance of wood-based biomass energy in the sub-region, a sustainably designed and operated sector could significantly reduce GHG emissions and help launch low carbon-growth strategies. For example, if charcoal was sustainably produced it would be carbon neutral since this emitted carbon could be sequestered by trees that are planted. In this scenario, one ton of sustainable charcoal would offset one ton of non-sustainable charcoal or nine tons of carbon dioxide (GEF, 2010).

In Eastern Africa, and as per UNFCCC database, Kenya registered four CDM projects (mostly focusing on sustainable forest management, afforestation and reforestation); Rwanda has three registered projects (on energy) and several others under development; Madagascar registered two projects (on small-hydropower); Uganda registered five projects (sustainable forest management, afforestation and reforestation); and Tanzania, one project on energy.

Under the CDM, the Programme of Activities (PoA) concept was introduced at the UNFCCC meeting (COP11) in Montreal in 2005. It was developed for simplification of project registration procedures and for expanding the scope of project activities with the aim of allowing the least developing countries to increase their participation in the carbon market PoAs currently being developed across East Africa cover improved cook stoves, demand-side energy efficiency (efficient lighting, new appliances, industrial equipment such as boilers, motors, pumps and also fuel efficient vehicle), small-scale fuel switch measures and small-scale waste management activities, forestry plantations and renewable energy schemes such as hydro, geothermal solar PV and wind. As of July 2012, 325 CDM PoAs (18 projects in Africa, 2.9% of all other CDM projects) had reached the validation stage with 20 being fully registered on the UNFCCC website. PoAs provide a mechanism to create region wide carbon access programmes, so EAC member states could develop a regional PoA for improved cookstoves, hydro power or energy efficiency projects providing access to the carbon markets that would otherwise be impossible to achieve for projects in small countries (Uganda Carbon Bureau, 2012).

[52] The Nairobi Framework Partners are the United Nations Framework Convention on Climate Change, the United Nations Development Programme, the United Nations Environment Programme, the World Bank Group, the African Development Bank, the United Nations Conference on Trade and Development, and the United Nations Institute for Training and Research.

Box 9: CDM in Africa, finance and support.

AFRICAN CARBON SUPPORT PROGRAMME (ACSP) BY THE AFRICAN DEVELOPMENT BANK (AfDB)

ACSP supports potential CDM projects contained in the AfDB project portfolio by:

- Providing technical assistance to develop the CDM component of eligible projects
- Developing project idea notes (PINs) and PDDs for a few selected projects
- Securing funds to cover transaction costs for potential carbon credit buyers or other sources (e.g. UNFCCC Loan Scheme, ACAD)
- Offering capacity-building upon request to CDM Designated National Authorities (DNAs) and other national institutions in AfDB's regional member countries.

Applications can be submitted through the Energy, Environment and Climate Change Department (ONEC), country field offices or regional offices of the AfDB. The programme expires in December 2012, although it may be extended for a second phase.

Further information on ACSP is available at: http://www.afdb.org/en/topics-and-sectors/initiatives-partnerships/african-carbon-support-program/

CARBON FUND FOR AFRICA (FCA)

The Carbon Fund for Africa was announced at the Africa Carbon Forum in April 2012 and is an initiative of the West Africa Development Bank, Caisse des Dépôts and the French Development Agency Group "Proparco". It is currently under development.

Project developers are encouraged to submit project proposals through the following link where further information will be published as it becomes available at: http://www.cdcclimat-am.com/en.

AFRICAN BIOFUELS AND RENEWABLE ENERGY FUND (ABREF)

ABREF contributes to the development of the biofuel and renewable energy industry in Africa, and was initially focussed on the member countries of the Economic Community of West African States (ECOWAS).

The fund is managed by the African Biofuel and Renewable Energy Company (ABREC), which also offers technical assistance by preparing feasibility studies and engaging in capacity-building and technology transfer. It is open to all renewable energy projects in Africa, including those eligible under the CDM.

The following project types are covered by the fund:

- Biofuels
- Fuel-switching to biomass energy
- Hydro power
- Wind
- Methane leakage
- Capture of methane from landfills
- Forestry

Further information is available at: http://www.faber-abref.org/index_english.php

UNDP'S MILLENNIUM DEVELOPMENT GOALS (MDG) CARBON FACILITY (LDC SUPPORT)

The carbon facility of the United Nations Development Programme supports projects in countries with few or no CDM projects. It focusses on projects that strongly contribute to the MDGs in least developed countries, where it offers:

- Project development services
- Technical assistance for the approval process
- Assistance in monitoring and reporting during a project's first year of operation
- Finance support

Certain types of projects are excluded, such as geo-sequestration including enhanced oil recovery, electric power load shifting and capture and destruction of industrial gases.

Further information is available at: http://www.mdgcarbonfacility.org/

Carbon funds and initiatives under the umbrella of the World Bank Group

CARBON PARTNERSHIP FACILITY (POA SUPPORT)

The Carbon Partnership Facility (CPF) supports CDM Programme of Activities (PoA) by developing large scale emission reduction projects and purchasing the resulting CERs. In order to scale up carbon finance, the CPF collaborates with governments and market participants on investment programmes and sector-based interventions. These initiatives have to be consistent with low-carbon economic growth and the sustainable development priorities of developing countries. Further information is available at: http://cpf.wbcarbonfinance.org/cpf/

CARBON INITIATIVE FOR DEVELOPMENT (LDCS AND ACCESS TO ENERGY SUPPORT)

This fund was launched at the United Nations Climate Change Conference in December 2011 in Durban, South Africa. It aims to help low-income countries access sustainable financing for low-carbon investments through carbon markets. Its three components are the Readiness Fund, the Financing Fund and the Carbon Fund, which together support capacity-building, methodology and project development. In addition, the initiative helps with up-front financing and purchases carbon credits generated by the supported projects.

Further information is available at: http://wbcarbonfinance.org/Router.cfm?Page=CIDEV&FID=65997&ItemID=65997&ft=About

BIOCARBON FUND (AFFORESTATION AND REFORESTATION SUPPORT)

Phase 3 of this fund was also launched in Durban in December 2011 with the aim of increasing the number of projects that sequester or conserve carbon in forests and landscapes, such as REDD (reducing emissions from deforestation and forest degradation) and afforestation and reforestation CDM projects.

Further information is available at:
http://wbcarbonfinance.org/Router.cfm?Page=CIDEV&ItemID=65997&FID=65997

FINANCIAL SUPPORT FOR PUBLIC SECTOR PROJECTS (NOT EXCLUSIVELY CDM RELATED)

The World Bank's country offices provide support for public sector projects. Contact details are available at: http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/0,,pagePK:180619~theSitePK:136917,00.html

FINANCIAL SUPPORT FOR PRIVATE SECTOR PROJECTS (NOT EXCLUSIVELY CDM RELATED)

The International Finance Corporation provides support to private sector projects. An overview of the various programmes, as well as contact details for IFC's regional and country offices, is available at: http://www.ifc.org

TRAINING SEMINARS ON THE CDM

World Bank Institute holds training seminars for identified stakeholders. It also offers online seminars that are open to the public. Further information is available at:
http://einstitute.worldbank.org/ei/CourseTheme

An overview of financial options for climate action in developing countries in general is available at: http://www.climatefinanceoptions.org

In addition, there are national programmes for the purchase of CERs, some of which also include early-stage support for CDM projects. For example:

GERMANY'S KfW CARBON FUND (PoA support): The KfW Carbon Fund serves as a platform for CDM projects and offers:

- Financial support for Programme of Activities (PoA) in least developed countries through the PoA Support Centre Germany.
- Early investment finance for PoA through a newly established PoA foundation

Information on all initiatives is available at the Carbon Fund homepage at: http://www.kfw.de/carbonfund.

UNFCCC'S LOAN SCHEME FOR COUNTRIES WITH FEWER THAN 10 REGISTERED CDM PROJECTS

This loan scheme was established by the secretariat of the United Nations Framework Convention on Climate Change at the request of the Parties to the Kyoto Protocol. It provides zero per cent interest loans to cover the following expenses associated with CDM projects:

- Development of project design document (PDD)
- Validation of the PDD by a Designated Operational Entity (DOE)
- Verification by a DOE of the first issuance of Certified Emission Reductions (CERs)

Projects applying for this loan must have a high probability of getting registered with the UNFCCC and generate at least 7,500 CERs per year for projects in Least Developed Countries (LDCs), and 15,000 CERs per year in non-LDCs. The project documentation must be developed by an experienced CDM consultant and the loan must not "crowd out" other funding sources like donor funding or funding by an already identified buyer of CERs from the project.

Further details on the application procedure and the selection requirements are available at: http://www.cdmloanscheme.org.

AFRICA CARBON ASSET DEVELOPMENT INITIATIVE (ACAD)

Launched in 2009 to kick-start the African carbon market, ACAD supports potential CDM projects with:

- Targeted grants for early stage costs
- Technical assistance for local project developers
- Carbon finance training for local financial institutions

ACAD aims to support highly replicable demonstration projects by reducing the early-stage investment risks associated with African carbon projects. Afforestation and reforestation projects are excluded.

This is an initiative of the United Nations Environment Programme (UNEP) and Standard Bank and is funded by the German government. Further information, including application guidelines, is available at: http://www.acadfacility.org.

Source: UNFCC, 2012.

8 ENERGY INFRASTRUCTURE GAPS AND ENERGY TRADE IN THE EASTERN AFRICA SUB-REGION

The African continent's energy profile is characterized by abundant energy resources in oil, gas, coal and especially hydro potential –but which are unevenly distributed across the continent, complicating energy development and distribution for most countries. There are underexploited energy resources and under-served demand. In comparison with the rest of the world, Africa has 15% of world population but only 3% of primary energy consumption. Access rates to basic energy services, especially in Sub-Saharan Africa (SSA), are low where access rates are barely 31%, thereby throttling socio-economic development. The energy market is fragmented and there is low capacity to mobilize financing for investment, especially from private sources, due to low country and utility creditworthiness and high political risks. Africa has limited generation capacity (only 125 GW of capacity in all Africa). Power transmission system is limited (only 89,000 km for the entire continent); and so are gas and petroleum product pipeline systems.

8.1 POWER SYSTEMS

8.1.1 Power Generation

As depicted in Table 58, Africa has the lowest electricity capacity per capita in the world (123 MW/million population), as compared with 3,600 for Asia, 515 for Latin America and 1,078 for Eastern Europe and Central Asia. Orvrika Rosnes and Haakon Vennemo (2008)[53] stated that nowhere in the world is the gap between available energy resources and access to electricity greater than in sub-Saharan Africa. They indicated that whereas sub-Saharan Africa as a whole was rich in oil, gas and hydropower potential, 76% of the population lacked access to electricity, with coverage particularly low in rural areas.

Table 58: Generation capacity per capita and per unit GDP, Africa and rest of the world

Continent	Capacity per capita (MW/million population)	Capacity per unit of GDP (MW/billion unit of GDP)
Africa	123	106
Asia	3,600	121
Latin America	515	60
Eastern Europe/Central Asia	1,078	144

Source: PIDA Study by SNC LAVALIN International Inc. in association with PARSONS BRINCKERHOFF (May 2011).

The situation in Eastern Africa is not any different from the above general picture of sub-Saharan Africa and Africa as a whole. Power generation, transmission and distribution infrastructure in the majority of the sub-regional countries is currently inadequate, leading to low access averaging around 23%.

[53] Powering Up: Costing Power Infrastructure Investment Needs in Southern and Eastern Africa – World Bank Africa Infrastructure Country Diagnostic Paper No. 61813

Economic recovery and growth in several of the Eastern Africa sub-regional countries is curtailed by lack of adequate supply of power to drive industries. The condition is worse when it comes to meeting domestic electricity needs of the population. Power supply shortages and poor infrastructure often result in several hours, or days, of power outages. Needless to say rural communities in most of the countries have little or no access to electricity. The comparison between Africa and other continents highlight the low levels of installed power generation capacity per capita, and per unit of GDP, clearly pointing to a case of under-investment in Africa in terms of power generation infrastructure.

Among the East African Power Pool (EAPP)/ East African Community (EAC) sub-region, there are plans to expand generation capacities by the year 2030, as depicted in Table 58. The last column of this table shows countries with highest potential to generate surpluses, which they can trade with the sub-region. Ethiopia has one of the highest potential for surplus electricity generation. Egypt and Sudan are factored-in as they belong to the EAPP.

Table 59: Present and potential generation resources of EAPP/EAC countries.

Country	Existing Capacity 2012 (MW)	Additional 2013-2030 (MW)	Total 2030 (MW)	Peak Demand 2030 (MW)	Potential Surplus 2030 (MW)
Burundi	49	422	470	385	86
Djibouti	123	187	310	198	112
East DRC	74	1,117	1,191	179	1,012
Egypt	25,879	46,570	72,449	69,909	2,540
Ethiopia	2,179	13,617	15,796	8,464	7,332
Kenya	2,051	6,288	8,339	7,795	544
Rwanda	103	411	514	484	30
Sudan[54]	3,951	11,310	15,261	11,054	4,207
Tanzania	1,205	4,881	6,086	3,770	2,316
Uganda	822	2,531	3,353	1,898	1,455
Total with Egypt	36,436	87,334	123,769	104,136	19,633
Total minus Egypt	10,557	40,764	51,320	34,227	17,093

Source: EAPP/EAC Regional Power System Master Plan Study.

[54] Disaggregated figure for South Sudan not available.

8.1.2 *Power Transmission*

Power transmission systems in the sub-region are primarily country focused and tend not to be interconnected; and not designed to facilitate regional energy trade and to enhance energy access and security. It is therefore an imperative that future power generation and transmission plans in the sub-region should take into account the aspect of regional cooperation and integration, in order to take advantage of scale economies and the comparative advantages of the various countries. In this regard, the efforts of the East African Power Pool and the Regional Economic Communities (RECs), along with close collaboration with member States, are instrumental.

Energy transmission and distribution losses in most of the sub-regional countries are currently in the region of 20-25%. As a greater portion of energy losses are attributable to poor transmission and distribution systems, the high loss rates are clear indication of the need for the countries in the sub-region to upgrade their power transmission systems and infrastructure.

8.1.3 *Sub-Regional Power Interconnection*

Whereas there are bilateral power exchange agreements, power exchange has been hampered by either supply deficits or inadequate infrastructure to facilitate regional power trade. As a consequence, regional interconnectivity is rather limited. Existing power interconnections include:

- DRC, Burundi, and Rwanda interconnected from a jointly developed hydro power station Ruzizi I, (capacity 45 MW) operated by a joint utility (Societe d'Electricite des Pays des Grand Lacs (SINELAC));
- Kenya – Tanzania interconnection;
- Kenya – Uganda interconnection;
- Ethiopia – Djibouti interconnection;
- Ethiopia – Sudan interconnection.

Within the EAPP/EAC framework, however, a number of power interconnection projects are under development, bearing interconnection results during the next 5 to 10 years (see Table 60). As will be seen later, investments associated with the regional interconnectivity projects are substantial. However, a regional energy infrastructure would significantly expanding electricity access through interconnection-supported trade.

8.2 NATURAL GAS AND PETROLEUM PIPELINE INFRASTRUCTURE

8.2.1 *Natural Gas Pipeline Infrastructure*

The African continent's main regional gas pipeline network is in North Africa, where gas is being exported from Algeria and Libya via Morocco to southern Europe. Regional gas pipeline systems also exist in southern Africa between Mozambique and South Africa as well as in West Africa between Nigeria and Ghana, with spur connections to Benin and Togo. There are currently no gas pipelines in the Eastern Africa sub-region. A recent discovery of large gas deposits in Tanzania is, however, bound to alter the gas infrastructure shortfall in the sub-region. Kenya has also reported gas finds in its north eastern coastline near Somalia. The development of gas pipeline systems will depend on markets to be supplied, as at the moment there is virtually no intra-regional trade in oil and gas. But significant discoveries

and development of gas resources in the sub-region opens the potential to develop intra-regional gas trade.

8.2.2 Oil Products Pipeline Infrastructure

Existing regional or continental petroleum products pipelines in Africa are very limited, with most of the existing petroleum products pipelines serving national markets. Within the Eastern Africa sub-region, Kenya has an internal products pipeline distribution system, which links the port of Mombasa and its refinery to Nairobi. The system extends through two further pipelines to Eldoret and Kisumu. Plans were underway to extend the Kenya oil pipeline system from Eldoret to Kampala in Uganda and subsequently to Rwanda and beyond. The execution of this project has however been delayed by several factors and recent geopolitical events. The recent discoveries of oil in Uganda and Kenya, as well as the conflict between Sudan and South Sudan have further complicated matters, requiring a total rethink of the oil pipeline infrastructure network in Eastern Africa.

Tanzania is proposing the construction of an oil refinery and a 1,200 km long pipeline from Dar es Salaam to Mwanza on the southern shores of Lake Victoria. If the pipeline project is successful, it could be extended to Uganda, Burundi and Rwanda. There exists a crude oil pipeline between Dar es Salaam (Tanzania) to Ndola (Zambia). The Zambian Government has recently commissioned a study to examine upgrading options. In the case of Southern Sudan, the pipeline network runs from the oil fields in the south to the Port Sudan on the Red Sea. Recent misunderstandings between the newly independent State of South Sudan with the Sudan have led to renewed interest to pursue an alternative export pipeline(s) to Kenyan port of Lamu and/or the Djibouti port. The agreement signed on September 27, 2012 by Sudan and South Sudan in Addis Ababa to resolve their dispute and return to oil flow through the Sudan pipeline has left uncertainty as to how vigorously South Sudan will continue to pursue alternative export routes.

Within the EAC, oil transportation used to be predominantly through a combination of pipeline and rail. The collapse of the rail system has led to diversion of heavy loads, including oil products, to the road subsector leading to the growth in the trucking industry, but with severe consequences on road infrastructure network. Fuel tankers are particularly heavy and contribute significantly to road pavement damage. Moreover, attempts to regulate axle load limits to prevent overloading have so far not been quite successful. Furthermore, road accidents involving fuel tankers have led to heavy losses of life and property, as well as damages to road surfaces as a result of oil spillages.

The performance of the rail sector has continued to deteriorate despite privatization of rail services through concessions. It is proving to be difficult for the rail concessionaires to invest in both the provision and maintenance of rail track, in addition to running services that equally require heavy investments in rolling stock and motive power. The policy of vertically integrated concessions where the concessionaire is involved in both track maintenance and running rail services needs to be reviewed. Without substantial improvement in rail services and the expansion of the pipeline network in the sub-region, the road infrastructure network will not be adequate to ensure energy security. The discovery of commercial quantities of oil and gas in countries of the sub-region offers a great opportunity for planners and policy

makers to consider the optimal modal mix for the exploitation and marketing of the products. Indeed the development of rail infrastructure, such as the much talked about standard gauge

Table 60: EAPP/EAC on-going interconnection projects.

From	To	Length (km)	Type AC/DC	Capacity (MW)	Earliest Year in Operation	Status	Comments
Tanzania	Kenya	260km	400kV-AC	1520	2015	Ongoing. Feasibility Study, detailed design and tender documents preparation	Bidding for line construction was to commence at and of 2011
Rusumo	Rwanda	115km	220kV-AC	320	2015	Feasibility Study Completed	Lines associated with the Rusumo Falls Hydro Power Plant connecting the project to the grids of Tanzania, Rwanda and Burundi
Rusumo	Burundi	158km	220kV-AC	280	2015		
Rusumo	Tanzania	98km	220kV-AC	N.A.	2015		
Ethiopia	Kenya	1120km	500kV-DC	2,000	2016	Design and Tender documents 2011	New design study with highly optimistic completion of phase I (1000MW) by 2013 and phase II upgrade to 2,000MW by 2019
Ethiopia	Sudan	570km	500kV-AC 4 lines	1,600x2	Phase I 2020, Phase II, 2025	Feasibility study completed	
Egypt	Sudan	1,665km	600kV-DC	2,000	2016	Feasibility Study completed	
Uganda	Kenya	254km	220kV-AC	300	2014	Under Construction	Line runs from Lessos substation in Kenya to Bujagali substation in Uganda, duplicating the existing 132kV line
Uganda	Rwanda	172km	220kV-AC	250	2014	Detailed design and tender documents preparation, 2011	Line runs from Mbarara to Mirama Hills (Uganda/Rwanda border), to Birembo/Kigali, Rwanda
Rwanda	D. R. C	68km	220kV-AC	370	2014	Under Construction	Line between new substation at Kibuye Methane Gas Plant in Rwanda and Goma in DRC, completing the loop around Lake Kivu

D.R.C	Burundi	105km	220kV-AC	330	2014	Feasibility and detailed design and tender documents preparation started 2011	Line from future substation Kamanyola/Ruzizi III to Bujumbura, Burundi
Burundi	Rwanda		220kV-AC	330	2016	Feasibility update, 2011	Line from Rwegura in Burundi to Kigoma, Rwanda. Previous Feasibility Study had recommended 110kV line. Update to re-examine proposed 220kV option and rerouting to feed intermediate locations

Source: EAPP/EAC Regional Power System Master Plan Study.

railway from Mombasa to the land-locked countries is unlikely to be realized unless it is linked with the exploitation of mineral resources, including oil and gas.

8.2.3 Refineries and Storage Infrastructure

The main refinery in Eastern Africa is the Kenya Petroleum Refinery Ltd situated in Mombasa, Kenya. It has the capacity to refine 70,000 barrels (11,000 cubic meters) of crude per day. The refinery is currently jointly owned by the Government of Kenya (50%) and Essar Energy Overseas Ltd (50%). Previously there was a refinery in Dar es Salaam with a capacity of 17,000 barrels per day, but it was closed in 2000 due to high costs of small scale operations. Madagascar also has a refinery, Solina Refinery jointly owned by Galana and the Madagascar government. It has capacity to refine 14,000 barrels a day. The other refinery which has been serving Sudan and South Sudan is the Khartoum Refinery Company Ltd, with capacity to refine 100,000 barrels a day. It is jointly owned by the Sudan Government and China National Petroleum and Gas Corporation.

Meanwhile, Uganda is pressing ahead with plans for an oil refinery following the discovery of commercially viable quantities of oil in the Lake Albert region (2.5 billion barrels of crude oil so far confirmed, 2012). The feasibility study recommended a phased approach. Initial plan entails building a facility to process 20,000 barrels a day at an estimated cost of US$600 million. This would then be expanded to a facility that can process 60,000 barrels per day under public private partnership arrangement, which may comprise the Government of Uganda, China National Offshore Oil Corporation (CNOOC) and TOTAL.

Uganda's determination to put up a refinery is, however, reported to be facing criticism and skepticism from donors, civil society groups and international oil companies. Donors argue that a world class refinery in a landlocked country like Uganda with undiversified crude supply will face commercial challenges. They further argue that even a small-scale refinery tailored to Uganda's domestic needs will diminish the scale economies of export infrastructure without necessarily reducing domestic fuel prices and that there will be temptation to imbed hidden fuel subsidies within a domestic refinery entity. International oil companies meanwhile are using the reported oil discoveries in Kenya to de-campaign Uganda's refinery project. The companies prefer exporting the crude oil through pipeline to Mombasa Port to the global market.

Uganda's response to the above arguments is premised on value addition and on building additional capacity to strengthen the EAC region. Uganda argues that more discoveries in Kenya, Tanzania, Burundi and Rwanda will provide feedstock to both the Hoima and Mombasa refineries and make them competitive. The EAC region's current total demand for oil is estimated at 164,000 barrels per day. Mombasa refinery has capacity to process 70,000 barrels a day. The arguments for and against Uganda's oil refinery brings into focus the need for regional cooperation in developing a regional refinery and pipeline network.

With regard to oil storage infrastructure, most countries would like to develop facilities that can hold upto three months oil reserve, which is a costly undertaking. Holding strategic reserves could mitigate the effects of oil prices on the economies of the region. In this regard, more cost savings could be possible if countries collaborated in developing regional storage and distribution facilities to mitigate the current inefficiencies in petroleum

products procurement and distribution. At the continental level, African ministers responsible for hydrocarbons have proposed the establishment of an African Petroleum Fund. It can be taken that such a concept could be applicable at the regional level through development of proper policy and framework. This would entail establishing a strategic framework for cooperation in regional oil procurement, utilization of refineries, storage and distribution facilities as well as the development of necessary infrastructure.

8.3 PLANNING FOR GROWING ENERGY DEMAND IN THE EASTERN AFRICA SUB-REGION

8.3.1 Demand and Accessibility of Electricity

Countries in the Eastern Africa region (EAPP/EAC) are targeting energy access rate of 62% by the year 2030, which is projected to rise to 68% by the year 2040[55]. Similarly, country-specific energy access targets and the global Sustainable Energy For All (SEFA) target of universal access by 2030 are expected to result in robust growth in energy demand. Table 61 depicts the planned energy access of the EAPP/EAC region in comparison with other Power Pools in Africa. With broader acceptance and implementation of the SEFA framework, the access targets are even more aggressive.

Table 61: Energy access target rates for the different regions of Africa: 2010-2040.

Region	2010	2020	2030	2040
COMLEC	96%	96%	97%	97%
WAPP	44%	58%	65%	67%
SAPP	24%	41%	58%	63%
CAPP	20%	37%	54%	63%
EAPP	36%	49%	62%	68%
AFRICA	39%	54%	64%	69%

Meanwhile the EAPP/EAC Regional Power System Master Plan Study has forecast electricity demands as shown in Table 62**.** Most of the countries in the sub-region will have annual average growth rate (AAGR) of demand in excess of 10% during the 2010-2040 period. In order to meet such demand, countries will either have to invest heavily in power generation (if they have the potential) or import the required power from other countries that can generate surpluses. Worthy of mention is the specific case of the newly independent state of South Sudan. The proposed Action Plan for the electric power sector has six key components for the decade ahead:

[55] Programme for Development of Infrastructure in Africa (PIDA) study by SOFRECO.

(i) To meet existing and projected demand for electric power, undertake a major program of expansion in generation capacity from about 50 MW at the present time to about 580 MW by 2025;

(ii) Expand the national transmission and distribution grid to link all ten state capitals and link the South Sudan grid to those of Ethiopia, Kenya and Uganda;

(iii) Expand access to electricity to provide 75% of urban households with access to electricity from the national grid by 2025, compared with only 5% at present;

(iv) Complete a major restructuring of the South Sudan Electricity Corporation (SSEC) to convert it into a fully-fledged, and financially sound, state enterprise that has the capacity to enter into take-or-pay contracts with private suppliers of electric power;

(v) Strengthen the enabling environment for private investment in power generation and attract private investors to operate as independent power producers (IPPs) within South Sudan; and

(vi) Strengthen the existing regulatory arrangements for the electric power sector. Even with this expansion program average consumption of electricity in South Sudan increases from a current low of 25 kWh to about140 kWh per person per year by 2020.

Part of the reason for this continued low level per capita consumption is that extending the national grid to reach large numbers of rural household in sparsely populated and more remote areas will be costly. The Action Plan therefore calls for a substantial expansion of off-grid arrangements for the supply of energy to these rural households. The total cost of the proposed program for electric power and rural energy during 2011-2020 is $2.3 billion, with an additional $180 million to be spent on extension of the national network and the rural energy program during 2021-2025. The proposal is to mobilize about $870 million of private capital for the expansion of generation capacity, with the government and international donor community providing the balance of the required funding.

Table 62: Electricity peak demand forecasts (base case), 2010 – 2038 for EAPP/EAC (MW).

Country	2010	2015	2020	2025	2030	2038	AAGR
Burundi	30	57	81	102	120	146	13.8%
Djibouti	62	79	103	136	179	276	6.7%
East DRC	62	79	103	136	179	276	6.7%
Egypt	22,911	31,489	42,286	55,043	69,794	96,495	11.5%
Ethiopia	881	1,364	2,040	2,946	4,134	6,794	24.0%
Kenya	1,082	1,485	2,019	2,676	3,501	5,145	13.4%
Rwanda	53	74	98	125	156	213	10.8%

Sudan	1,357	2,582	4,465	7,196	11,054	19,827	48.6%
Tanzania	767	1,064	1,458	1,921	2,509	3,608	13.2%
Uganda	596	816	1,091	1,470	1,898	2,650	12.3%
Total	27,801	40,089	53,704	71,751	93,524	135,430	

Source: Adopted from EAPP/EAC Regional Power System Master Plan Study.

8.3.2 Demand for Oil and Gas Products in the Sub-Region

8.3.2.1 Oil Consumption

The global financial crisis, which led to a fall in global oil consumption of 1.5% between 2008 and 2009, appears to have had little impact on oil consumption in the Eastern Africa region. Consumption of petroleum products grew from 80.4 million barrels in 2007 to 86.7 million barrels in 2009. There was further rise in consumption in 2010, which reached 95.5 million barrels before dipping slightly to 93.2 million barrels in 2011, representing a decline of about 2.4 per cent (see Table 63). It is, however, expected that demand for petroleum products in the sub-region will continue to grow in line with projected economic growth.

Table 63: Average Daily Consumption of Petroleum Products ('000 bpd).

Country	2005	2006	2007	2008	2009	2010	2011
Burundi	2.6	2.6	2.4	1.3	2.6	3	2.3
Comoros	0.8	0.8	1.0	1.0	1.0	1	1.0
DR Congo	11.6	11.3	13.0	11.5	12.0	13	10.2
Djibouti	11.7	11.5	11.2	8.0	12.0	12	12.5
Eritrea	4.9	4.9	4.5	2.7	5.0	5.4	4.5
Ethiopia	29.8	33.7	37.3	47.0	45.0	47	49.1
Kenya	65.8	73.2	73.1	67.8	74.0	78	79.4
Madagascar	16.7	16.6	16.5	13.7	21.0	20.6	17.5
Rwanda	5.5	5.6	5.1	5.1	5.0	6	5.2
Seychelles	5.7	5.9	6.3	6.9	7.0	8	7.8
Somalia	4.9	5.1	5.8	5.5	6.0	5	5.7
South Sudan	N.A	N.A	N.A	N.A	N.A	N.A	N.A
Tanzania	26.8	28.1	30.3	32.7	34.0	38	43.3
Uganda	11.4	12.9	13.9	24.0	13.0	14.7	16.9

Total (000 bpd)	193.3	212.2	220.4	237.2	237.6	261.7	255.4
Annual Total (million barrels)	70.6	77.5	80.4	86.6	86.7	95.5	93.2

Source: Compiled from US Energy Information Administration (International Energy Statistics).

A sizeable amount of the GDP of countries in the EA region is spent on oil consumption. This is likely to be due to increasing demand and the rise in world oil prices. Consumption of oil by EAC countries between 2000 and 2009 is shown in Table 64.

Table 64: Annual oil consumption by EAC countries (2000-2009), US$ million.

Year	Burundi	% of GDP	Rwanda	% of GDP	Kenya	% of GDP	Tanzania	% of GDP	Uganda	% of GDP
2000	35.8	6.4	70.5	4.0	771.6	6.0	219.6	2.3	116.2	1.9
2001	31.7	4.9	59.3	3.5	588.4	4.5	214.7	2.2	107.8	1.7
2002	32.3	4.9	60.1	3.5	584.3	4.5	248.1	2.6	113.4	1.7
2003	37.3	6.9	68.5	4.5	697.2	5.0	298.5	3.2	137.5	2.1
2004	44.7	7.1	85.9	5.7	984.2	7.1	412.4	4.3	180.7	2.4
2005	60.5	8.6	126.0	7.5	1508.3	9.7	613.3	5.7	261.0	3.1
2006	67.9	7.7	149.1	8.3	1940.6	11.2	744.7	7.2	341.6	3.9
2007	67.6	7.9	147.0	7.5	2094.2	10.6	867.3	7.7	398.4	4.0
2008	92.7	11.1	185.4	5.0	2670.2	13.6	1186.7	9.6	496.9	4.5
2009	61.3	4.6	118.1	3.1	1746.5	9.7	802.4	6.7	306.8	3.2
10 Year Average		7.0%		5.3%		8.2%		5.2%		2.9%

Source: US Energy Information Administration and BP Industry Statistics, June 2012 and EAC Secretariat.

8.3.2.2 Natural Gas Consumption

With the exception of Tanzania and Rwanda where gas is used in electricity generation, in the rest of the sub-region gas is used mainly for domestic purposes. The use of gas by urban households is rising, particularly as electricity and charcoal prices rise. Due to deforestation in the region, wood fuel is becoming scarce and charcoal has increasingly become expensive. Africa's natural gas domestic consumption grew from 34.6 billion cubic meters (bcm) in 2000 to 115.2 bcm in 2011; that is an average growth of 6.2% per annum[56].

[56] Energy Data Yearbook 2012: www.enerdata.net

8.4 ENERGY INFRASTRUCTURE INVESTMENT NEEDS IN THE EASTERN AFRICA SUB-REGION

8.4.1 Investment to Expand Access and to Meet Increasing Power demand

As depicted in Table 60, countries in the EAPP/EAC region seek to achieve energy access of 68% by 2040. Orvika and Haakon (2008) established that to raise access to 35% by the year 2015 in the EAPP countries, would require raising existing power generation capacity by 11%. They projected demand for power in this region to grow by 7% per annum to reach the level of 170 terawatt hours (TWh) by 2015. They reckoned that for the EAPP region, annualized capital investment costs toward generation capacity expansion would be 2 to 3 per cent of GDP. In addition, US$2.4 billion per year would be needed to develop transmission and distribution networks, and that about 40 per cent of this amount would be spent in rural areas.

The Programme for Infrastructure Development in Africa (PIDA) anticipates that EAPP's demand will increase by a moderate 6.5% per annum and access rate will increase substantially from 36% to 68% between 2010 and 2040, over the PIDA period, requiring an investment of US$ 44 billion in access over that period. The list of generation projects identified in the EAPP/EAC Regional PSMP & Grid Code Study are shown in Table 65.

Table 65: List of identified regional generation projects.

Country	Plant Name	Type	Installed Capacity (MW)	Date
Eastern D.R. Congo	RUZIZI III	Hydro	145	2024
	RUZIZI IV	Hydro	287	2027
	Mandaya	Hydro	2,000	2031
Ethiopia	Gibe III	Hydro	1,870	2013
	Gibe IV	Hydro	1,468	2016
	Karadobi	Hydro	1,600	2036
Rwanda	Kivu I	Methane	100	2013
	Kivu II	Methane	200	2033
Tanzania	Stieglers Gorge (I, II, III)	Hydro	1,200	2020;2023;2026
	Karuma	Hydro	700	2016
Uganda	Ayago	Hydro	550	2023
	Murchison Falls	Hydro	750	2032

Source: EAPP/EAC Regional PSMP & Grid Code Study (May 2011).

8.4.2 Regional Power Trade

The countries in the Eastern Africa sub-region have different endowments in terms of power generation potential, as well as cost, creating the necessary arbitrage for power trading in the sub-region. Trading with neighboring countries facilitates the development of cheapest forms of energy resources in the sub-region, potentially reducing cost of electricity member States within the trading regime. Stimulating the development of hydropower in countries with the comparative advantage, while expanding regional trade in energy, for example, would lower generation costs in the long run, reduce carbon emission from generating plants and insulate countries from hikes in the price of fossil fuels[57]. Whereas regional power trade would initially entail significant infrastructure costs to develop the missing cross-border transmission capacity, benefits of building them are substantial. Orvika and Haakon pointed out that the existence of regional connectors would make it possible to shave 5-6 percent off annualized power system costs. For the EAPP region, they reckoned that the savings could be in the order of US$ 1 billion per year. It is therefore encouraging to note the EAPP/EAC Regional Power System Master Plan and Grid Code Study (2011) has selected a number of interconnection projects as shown in Table 66.

Table 66: EAPP/EAC schedule of selected interconnection projects.

Name of Project	From	To	Voltage	Capacity	Invest	Year in-operation	
				MW	US$M	RGP_RIP	NGP_RIP
TZ-KY_4S	Tanzania	Kenya	400kv-AC	1520	117.0	2015	2015
TZ-UG_2S	Tanzania	Uganda	220kv-AC	700	30.4	2015	2023
TZ-RW_2S	Tanzania	Rwanda	220kv-AC	320	37.6	2015	2015
TZ-BR_2S	Tanzania	Burundi	220kv-AC	280	47.9	2015	2015
ET-KY_5dS	Ethiopia	Kenya	500kv-DC	2000	845.3	2016	2016
ET-SD_5S1	Ethiopia	Sudan	500kv-AC	1600	255.4	2016	2016
ET-SD_5S2	Ethiopia	Sudan	500kv-AC	1600	255.4	2016	2016
EG-SD_6dS	Egypt	Sudan	600kv-DC	2000	1,033.9	2016	2016
UG-RW_2G1	Uganda	Rwanda	220kv-AC	520	51.3	2016	OUT
ET-KY_5dG1	Ethiopia	Kenya	500kv-DC	2000	845.3	OUT	2020
ET-SD_5G1	Ethiopia	Sudan	500kv-AC	1600	255.4	2020	2020
EG-SD_6dG1	Egypt	Sudan	600kv-DC	2000	1,033.9	2020	2020
UG-KY_2G1	Uganda	Kenya	220kv-AC	440	71.0	OUT	2023
ET-SD_5G2	Ethiopia	Sudan	500kv-AC	1600	255.4	2025	2025

[57] Some countries rely on imported fuel to generate electricity

EG-SD-6dG2	Egypt	Sudan	600kv-DC	2000	1,033.9	2025	2025
	N.B:	RGD – Regional Generation Plan					
		NGP – National Generation Plan					

Source: EAPP/EAC Regional PSMP & Grid Code Study (May 2011).

8.4.3 Investment in Oil and Gas Pipeline Infrastructure

8.4.3.1 Kenya Oil Pipeline

The Kenya oil pipeline, initially linking Nairobi with the Mombasa Port (450km) has been in operation since 1978. The Western Kenya Pipeline Extension (WKPE), which runs from Nairobi to Nakuru and Eldoret, was commissioned in 1994. As a result of regional economic growth, the pipeline has experienced capacity constraints. The short-term solution was to install additional pumping stations to increase the rate of flow. Subsequently, however, it was found necessary to enhance capacity through installation of additional or wider pipes. In this regard the WKPE was expanded from 8-inch to 14-inch pipeline with a flow rate of 378 cubic meters per hour. In a similar manner, there is need to enhance pipeline capacity from Mombasa to Nairobi by installing a parallel line to the existing one. Plans are underway to do just that and tenders were issued for detailed engineering design for the new pipeline.

8.4.3.2 Kenya-Uganda Oil Pipeline Extension

The project to extend the pipeline to Uganda from Eldoret in Kenya had been planned on the basis of a public-private partnership (PPP). Each of the two governments was to take 12.5% of the shares, leaving the 75% to the strategic private investor. However, the project stalled due to the recent political events in Libya since the strategic partner selected happened to be from Libya. The discovery of oil in Uganda has also affected the project. The Eldoret to Kampala extension was meant to be a unidirectional line from Kenya into Uganda and yet the latter may need a pipeline to export oil products in the opposite direction. Uganda is considering the development of a 230km refined fuel products oil pipeline from Hoima to Kampala, with the expectation that it would eventually be linked to Kenya's Mombasa-Eldoret pipeline. Thus, need has therefore arisen to reappraise the project, which is likely to result in a different set-up, costing and financing arrangements.

8.4.3.3 South Sudan Oil Pipeline

South Sudan plans to build a pipeline to Kenya, or Djibouti, to reduce dependency on the Sudan route to the Red Sea port. Although necessary feasibility and engineering design

studies have not been undertaken, preliminary estimates indicate a cost of US$ 3 billion and above for such a pipeline.

8.4.3.4 Tanzania Oil and Gas Pipelines

Tanzania already has a gas pipeline from connecting Songo Songo Island with Dar es Salaam. Following further discovery of an estimated 3 trillion cubic feet of gas off Tanzania's southern Indian Ocean coast, the government plans to begin construction of a natural gas pipeline project from Mtwara to Dar es Salaam. China has offered a loan of US$1.2 billion to finance the construction. In addition, a feasibility study was completed for a gas pipeline to run from Ubungu in Dar es Salaam though Tanga to Vipingo in Mombasa. The study report was submitted to the project stakeholders for consideration.

In April 2007, the Tanzania Government signed implementation agreements with a US-based firm Noor Oil and Industry Technology (NOIT) for the construction of Dar es Salaam-Mwnza-Kigoma pipeline and oil refinery. The two projects have however not taken off due to reported failure on the part of NOIT to adhere to the agreements that were stipulated in the contract. It was reported (Tanzania Daily News, 14 August 2012) that the Tanzania Government was reviewing the project.

8.5 FINANCING MECHANISMS

It would appear that Official Development Aid (ODA) funding of energy projects in Africa is limited. Nevertheless there are still a number of possible infrastructure financing mechanisms to consider.

8.5.1 Domestic Resource Mobilization

Domestic resource mobilization takes many forms, with the most common one being the establishment of an Infrastructure Fund or Energy Fund. Countries that are reported to have explored and/or utilized this option are Ethiopia, Kenya and Uganda. The other domestically mobilized resource that could be used to finance energy infrastructure are the Pension Funds. In many countries, the National Social Security Funds are holding billions of dollars in the form of workers savings, which could be used for infrastructure development, provided that credible loan arrangements are entered into so as not to put the pension funds at risk of misappropriation.

8.5.2 Public-Private Partnerships

Perhaps the most common and preferred financing mechanism is the public-private partnerships where publicly owned utilities partner with a strategic private investor in power generation, transmission and distribution. This model works better when power generation, transmission and distribution are run by separate entities. This allows Independent Power Producers (IPPs) to invest in power generation and then sell the power to the distribution company. Uganda is an example where this model is currently in application.

8.5.3 Regional/Cross-border Integrative Projects

Regional or inter-state cross-border projects involving two or more countries tend to be attractive to funding by multilateral funding agencies, such as the World Bank, International Finance Corporation (IFC), African Development Bank (AfDB) and others. There are however challenges during implementation arising from different national laws and regulations. Such challenges could be overcome by adopting common regional investment regulations, norms and practices.

8.6 POLICY CONSIDERATIONS IN ENERGY INFRASTRUCTURE DEVELOPMENT IN THE EASTERN AFRICA SUB-REGION

8.6.1 Regional Energy Policy based on AU Continental Vision

The AU energy vision stipulated since 2000 and reaffirmed by the Africa's Ministers in charge of energy in the Maputo Declaration of November 5, 2010 calls for: "Integration of the continent and to enhance access to modern energy services for the majority of the African population". This is to be achieved through the following objectives:

- Developing major regional and continental hydro power projects;
- Implementing high capacity oil refineries and oil pipelines projects; and
- Developing renewable energy resources.

In view of the foregoing, it is imperative that countries in the sub-region enhance regional cooperation in pursuit of the above objectives. It is encouraging to note that in the case of hydro power generation there is joint planning within the EAPP/EAC framework. There is need to do likewise in the case of oil refineries and pipelines.

8.6.2 Coordinated Development of Optimum Regional Networks

Countries in the sub-region have different endowments in energy resources. Development of an optimal regional network would enable the development of the cheapest sources of energy facilitated through regional energy trade. The optimal regional energy network would reduce costs and enhance access. In addition, a strategic framework for cooperation in regional oil procurement, utilization of refineries, storage and distribution facilities, as well as the development of necessary infrastructure is necessary. In this regard, appropriate regional protocols and implementation frameworks and strategies are crucial.

8.6.3 Renewable Energy Policy

Eastern Africa countries should adopt policies that encourage investment in renewable energy sources. Similar recommendation is passed in the Energy Development and the Environment section of this report.

8.6.4 Technological Considerations

There are two basic issues relating to technology. The first concerns the small generation plants in Africa, which tend to be costly per kW installed. Broader collaboration

and development/adoption of appropriate technologies will be crucial. The other consideration relates to the reduction of greenhouse gases. The Clean Development Mechanism (CDM) under the Kyoto Protocol allows industrialized countries that have made a commitment to reduce greenhouse gases to invest in projects that reduce emission in developing countries. A policy to encourage such investments in the sub-region would bear some fruit. More policy discussion is offered in the Technology section of this report.

8.6.5 Financing/Investment Policies and Strategies

Various financing mechanisms were already explored under ***section 3.4*** above. In several countries, however, appropriate policies and regulatory frameworks are still lacking. There will be need for such policies and regulatory mechanisms to be put in place to encourage broader investment in the energy sector.

- Therefore, based on the above, the following key policy pathways are recommended:
- Adopt and implement the AU Continental Energy Vision
- Enhance collaboration in the development of regional power generation and transmission systems
- Harmonize investment codes and regulations to encourage investment in cross-border projects
- Adopt a strategic framework for cooperation in regional oil procurement, utilization of refineries, storage and distribution facilities, as well as the development of necessary infrastructure is necessary
- Collaborate sub-regionally in the development of oil and gas pipelines and regional refinery projects
- Adopt strategies to counter the negative effects of low country and utility credit worthiness ratings and the perceived political risks

9 MITIGATING THE ENERGY CONSTRAINT ON ECONOMIC TRANSFORMATION IN THE EASTERN AFRICA SUB-REGION

9.1 INTRODUCTION

Energy has a profound influence on economic and human development. Access to modern reliable and affordable energy services plays a critical role in achieving meaningful sustainable development. It contributes not only to economic growth and household incomes, but also to the improved quality of life that comes with better education and health services. Without adequate access to modern, commercial energy, developing countries can be trapped in a vicious circle of poverty and underdevelopment.

The Eastern Africa sub-region is endowed with a variety of energy resources requisite for sustainable development. These energy resources, which are widely distributed throughout the sub-region include hydro, wind, biomass, solar, geothermal, peat and fossil fuels. Despite the enormous potential, the sub-region's energy sector remains largely undeveloped and is characterized by extremely low levels of modern energy access, low per capita consumption and heavy reliance on biomass energy, which accounts for over 85 % of total energy consumption across the sub-region. Access to electricity in rural areas is meagre. Furthermore, increasing energy demand due to population and economic growth, the impact of drought on hydroelectric generation, volatility of energy prices, low quality of energy services and institutional and human capacity have created a challenge to energy access and security in the sub-region.

The Eastern Africa sub-region is the fastest growing in Africa, and features countries growing at rates favorable internationally. As a result, millions have been lifted out of poverty, and economic transformation is taking shape. As a result, Ethiopia, Kenya, Rwanda and Uganda, among others, are aspiring to middle-income status within a decade or so. Economic optimism is widespread, both among policy makers and the sub-regional population. Recent reports of the social and economic condition of the region show increasing intra sub-region trade, growing foreign direct investment (FDI), greater investment in the energy sector (in energy resources endowed countries), increasing trade with China and other emerging economies and GDP growth at a favorable pace. Sustaining these gains and achieving broad-based socioeconomic transformation is one central agenda in the sub-region.

Energy, as much a source of growth it has been in Ethiopia, South Sudan and Tanzania, is also a critical constraint that can limit the potential of economic transformation in the sub-region. The region depends nearly entirely on imported oil, drawing much needed hard currency away from domestic development finance. Limited and unreliable electricity supply, and integration of costly technologies into the energy portfolio, is introducing systemic risk of rising power cost, and the vast dependence of populations in the sub-region on biomass is limiting opportunities in

energy-dependent small and large-scale industries, particularly in rural areas. As a result, figuring out how to expand energy production, and largely inclusive distribution, and supply of adequate, quality and affordable energy is one priority in the socioeconomic transformation agenda. In essence, energy security is an economic security agenda, and structural transformation is an agenda that has to be supported by reduced constraints in the energy sector.

9.2 ENERGY ACCESS AND ECONOMIC DEVELOPMENT

Countries in the sub-region have been fighting poverty and underdevelopment for years. Factors contributing to persistent poverty include conflict, deficient infrastructure, poor access to capital, governance and insufficient institutional capacity (IMF, 2008). For the last two decades, sustained growth, job creation and poverty alleviation have been priority development goals, and these goals can be supported through implementation of broad-based socio-economic development policies.

Historically, achievement of these goals has occurred with a corresponding increase in energy use (Jakobsson, 2007). Energy impacts all sectors of the economy and thus access to adequate and reliable energy supplies is central to economic growth. Securing higher living standards implies high rates of economic development. Reliable and affordable energy is a needed to power industry, increase agricultural productivity and boost GDP, to electrify rural areas, and improve quality of life. Thus, availability and reliability of cost-effective energy supplies impact directly many aspects of a country's social and economic development.

It is critical that energy access and supply should not a stumbling block in the way of realizing national potentials. Unfortunately, in the East African sub-region, energy poverty is one of the biggest obstacles to sustainable economic growth and development, hindering efforts to reach the poverty reduction and related MDGs. Power is by far Africa's largest infrastructure challenge, with countries facing regular power shortages and devoting valuable resources to emergency generation. Reliable and accessible electricity supply has emerged as a major bottleneck.

Recent empirical studies on the energy consumption–economic growth relationship for countries includes Jumbe (2004), Wolde-Rufael (2006), Akinlo (2008), Odhiambo (2009), Kahsai et.al. (2011) and Nando et al. (2012). They found some form of relationships between energy consumption and economic growth. Furthermore, an IEA study shows that energy consumption is positively related to wealth, while a lack thereof is correlated with people living on less than $2/day (IEA, 2004), providing support for the hypothesis that inadequate energy services impede from achieving their development goals. A study by Chien and Hu (2007) on the effects of renewable energy on GDP for 116 economies also reveals that renewable energy indirectly stimulates GDP through the channel of increasing capital formation. Accordingly, investment in renewable energy might result in the development and expansion of businesses and thus effectively stimulate employment growth and increase earnings.

In the sub-region, energy poverty is more prominent than in any other regions due to the low level of per capita income, high level of poverty and the low access to modern energy. For the sub-region and sub-Saharan Africa at large, countries have the lowest access to electricity in the world (Legros et al., 2009), also demonstrated in Table 67 by urban and rural areas.

Table 67: Percentage of population with access to Electricity.

Country	National	Year	Rural	Year	Urban	Year
Burundi	2.8	2006	0.1	2006	25.6	2006
Comoros	40.1	2004				
Congo (DR)	11.1	2008	25	2008	4	2008
Djibouti	49.7	2004	10.2	2004	56.9	2004
Eritrea	32	2008	5	2008	86	2008
Ethiopia	15.3	2008	2	2008	80	2008
Kenya	15	2008	5	2008	51.3	2008
Madagascar	19	2008	5	2008	53	2008
Rwanda	4.8	2005	1.3	2005	25.1	2005
Seychelles	96	2002				
Tanzania	11.5	2008	2	2008	39	2008
Uganda	9	2008	4	2008	42.5	2008

Source: UNDP/WHO 2009.

Therefore, it is imperative that to sustain the gains in socioeconomic development and transformation underway in the Eastern Africa sub-region, the energy constraint to it in terms of low level of access will require to be alleviated.

9.3 ENERGY SECURITY AND ECONOMIC GROWTH

Energy security is a complex theme that relates to the reliability, resilience and sustainability of energy supplies. For policy makers, energy security concerns vary widely and include: the stability of fossil fuel prices; the long-term availability of energy resources; the impact of energy production on the local and global environment

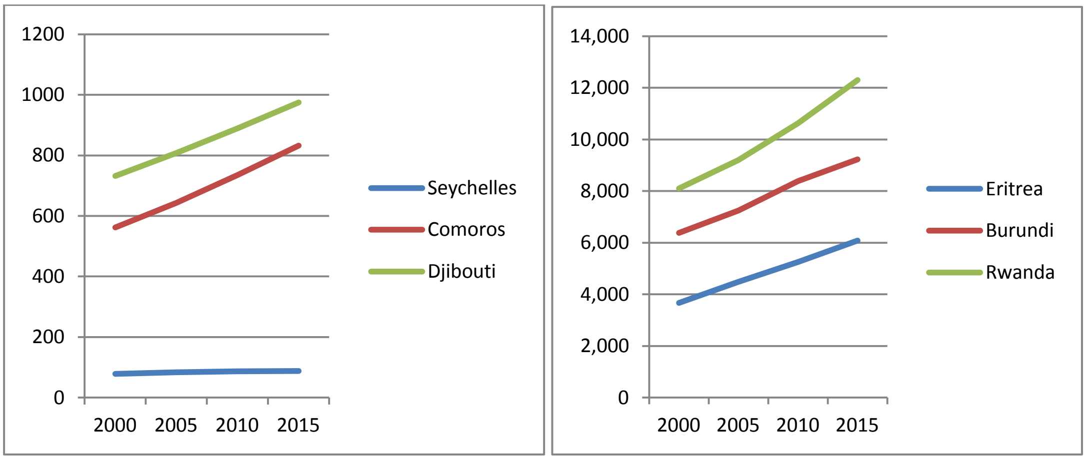
and the susceptibility of energy infrastructure to acts of violence and natural disasters. Further, the availability and reliability of cost-effective energy supplies impact directly many aspects of a country's social and economic development, including poverty alleviation, private sector modernization and balance of trade. Energy security underlies a nation's ability to supply reliable and affordable energy to meet the energy demand and to promote sustainable development.

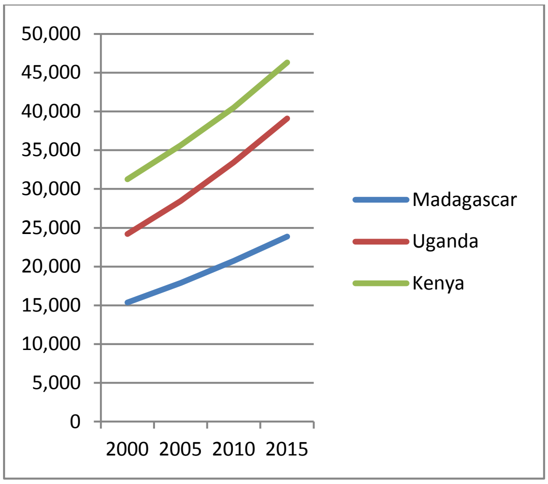
Countries in Eastern Africa have the potential to deliver sufficient energy to meet their current and future energy demands by exploiting more fully the mix of hydrocarbons and renewable energy resources at their disposal. For example, South Sudan is a producer of oil, Kenya and Uganda have announced discovery of oil, and Uganda is in resource development phase, Tanzania is in development phase of its significant gas find, Ethiopia and D.R. Congo are among the countries with the highest potential for hydroelectric power generation and trade, and the potential to generate electricity from geothermal, solar and wind energy resources are widespread. However, increasing energy demand due to population and economic growth, the impact of drought on hydroelectric generation, volatility of energy prices, low quality of energy services and insufficient institutional human capacity have created challenges to energy security in the sub-region.

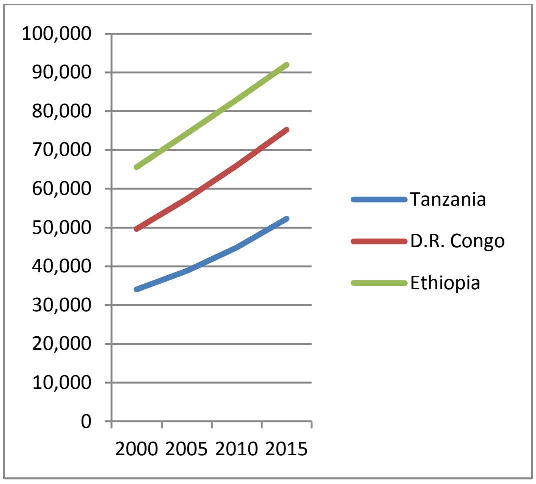
9.3.1 Increasing Energy Demand and Energy Services

Energy consumption within the sub-region is expected to increase significantly during the coming years. This increase will be triggered mainly by the current low level of energy consumption (3% of world average consumption), rapid population growth (see Fig. 108) and the expansion of the economies of the region. With growing demand comes more pressure on how to provide a secure and reliable energy services at affordable price for current and future needs. For example, in Kenya the rate of electricity services has not been able to keep with the population and economic growths (Kiva, 2008). In 2007/08 Kenya's reserve capacity was 3% compared to the required safety margin of 15% (KPLC, 2007). The lack of adequate reserve to meet the growing demand led to load shedding of electricity services in 2009. A similar situation is experienced in Ethiopia, Rwanda, Tanzania and Uganda.

Figure 108: Actual and projected population growth in the Eastern Africa sub-Region.







The key challenge is how to meet the need and obligation to deliver secure and affordable energy services to rural remote areas and the poorest segments of the population and continue to provide reliable services to existing customers and growing demand from the traditional economic sectors. To meet this challenge, a practical and long term plan must be in place to address the issue of national energy portfolio, energy price affordability and demands for expansion of energy infrastructure, conjointly with economic development and transformation strategies.

9.3.2 Natural Disasters, Emergency Generation, Energy Security and Economic Impacts

Natural disasters such as earthquakes and extreme weather events (hurricanes, drought, forest fires and floods) represent a threat to achieving and maintaining a secure energy infrastructure. These events can damage the energy production and distribution infrastructure at national and local level, that ultimately influence the socio-economic development of impacted countries. For example, drought has seriously reduced the power available to hydro-dependent countries in Eastern Africa. In the sub-region, an estimated average of 67% of electricity net generation comes from hydroelectric power. Drought-induced reduction in hydropower generation has become a persistent feature in Kenya, Rwanda, Tanzania and Uganda[58] . The common response to these crises is to switch to thermal power at a high cost to meet the shortfall power supply. At least 750 megawatts of emergency generation are operating in sub-Saharan Africa, which for some countries constitute a large proportion of their national installed capacity.

[58]Burund, Ethiopia and D.R. Congo also face the same challenge with negative impacts to their economy.

Box 10: Emergency generation – cases in the Eastern Africa sub-Region.

Rwanda

With a significant drop in its internal capacity to produce electricity from its hydropower, Rwanda experienced widespread and sustained load shedding in 2004 and subsequent years. It was compelled to install diesel generators to compensate for the electricity shortfall. Starting from 2004, thermal electricity constituted 30 percent of the country's power generation in 2005, and 56 percent in 2006. Operation of these generators cost Rwanda up to US $65,000 per day (UNEP, 2006). These events had immediate economic costs for the country. Electricity rates doubled in 2004-05, from 7 to 14 US cents/kWh, and rose again in 2005-06 to 22 US cents/kWh. Rwanda continues to face expensive electricity as a result (GoR, 2010).

Uganda

Between 2004 and 2006, the reduction in water levels at Lake Victoria resulted in reduction in hydro-power generation by 50 MW and led to the adjustment of the GDP growth rate from 6.2% to 4.9% (Baanabe, 2008). The government was compelled to add thermal energy into its energy mix to fill the gap. This led to 100% electricity price increase (216.9 in 2005 to 426.10 Ugandan Shilling in 2006-2008) and it also induced businesses to purchase back-up diesel generators.

Tanzania

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 capacity was reduced by 25%. The resultant cumulative loss was variously estimated to be about 1-1.5% of the total GDP (Karekezi and Kithyoma, 2005).

in Tanzania to 3.29% of GDP in Uganda. When the shortage in hydroelectric power supply coincides with escalating oil prices, countries and end users are faced with high energy bills which have a serious negative effect on the economy. Paying for emergency leases absorbs significant budgetary resources, reducing the funds for longer-term domestic development finance.

Table 68: Impact of emergency power generation on GDP.

Country	Year	Contract Duration (year(s))	Emergency Capacity	% of Total Installed Capacity	Estimated Annual Cost % of GDP	Drought Related?
Kenya	2006	1	100	8.3	1.45	Yes
Rwanda	2005	2	15	48.4	1.84	Yes
Tanzania	2006	2	180	20.4	0.96	Yes
Uganda	2006	2	100	41.7	3.29	Yes

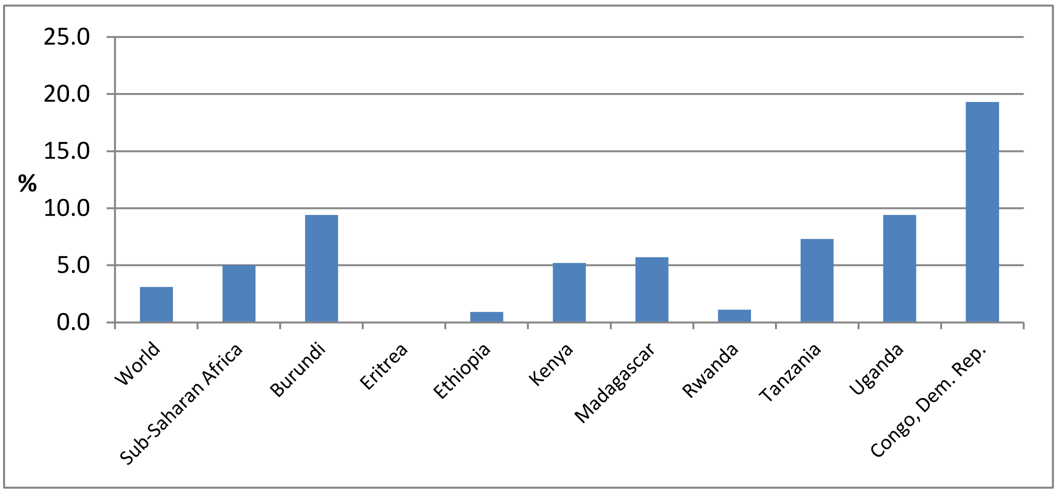
Source: Eberhard et al, 2008

9.3.3 Energy Services Disruption and Economic Impacts

The cost of energy services disruptions due to electricity outage is another major constraint to economic performance and long-term transformation. African manufacturing enterprises experience power outages on average 56 days per year. As a result, firms lose 6% of sales revenues; in the informal sector, where back-up generation is limited, losses can be as high as 20%, and the overall economic costs of power outages can rise to 1–2% of GDP (Khennas, 2012). As shown in Fig. 109, in

Eastern Africa, annual sales revenue loss of firms due to electrical outage is one of the (D.R. Congo 19.3%, Uganda and Burundi 9.4% and Tanzania 7.3%). Electricity constraint is identified as a major obstacle for doing business (49.2% of firms in sub-Saharan Africa compared with 39.2% world average, based on World Bank Enterprise Survey).

Figure 109. Losses due to electrical outages (% of annual sale of firms).



Source: Enterprise Survey database, the World Bank.

9.3.4 Oil Price Volatility and Economic Impacts

Conceptually, the current high and volatile oil prices, combined with increasing oil import dependence of countries in the sub-region poses a concern to sustaining the pace of economic development. The rising oil prices could lead to decreases in output and consumption, worsening the net foreign asset position and affecting business, consumers and government budget. The rise worsens the trade balance, as discussed in the Energy Security assessment of the sub-region earlier in this report, lead to a higher current account deficits and a deterioration of net foreign asset positions. At the same time, it can decrease private disposable income, corporate profitability and reduce domestic aggregate demand. The impact also depends whether or not the government decides to pass the price increase to consumers, structural flexibility of the economy and access to international capital markets, monetary policy, the shock’s expected persistence and the rate of depreciation of the exchange rate among others. These in turn can influence the extent to which rising oil prices raise inflationary pressures that necessitates a monetary tightening that could in turn lead to slow economic growth.

The adverse economic impact of higher oil prices on oil-importing developing countries is generally more severe than developed countries. This is because their economies are relatively more dependent on imported oil and increasingly energy-intensive, and because energy is used less efficiently. According to IEA (2004), on average, oil-importing developing countries use more than double the oil to produce a unit of economic output as do Organization for Economic Cooperation and Development (OECD) countries. Developing countries are also less able to manage the financial pressure they face by higher oil-import costs. It is estimated that the loss of GDP averages 0.8% in Asia and 1.6% in highly indebted poor countries (HIPC) in the

year following a $10 oil-price increase. There are fewer studies on the impact of high oil prices on African economies compared with other continents. However, specific studies have been conducted on the effects in Kenya (Semboja, 1994), Nigeria (Ayadiet al., 2000; Ayadi, 2005), Mali (Kpodar, 2006), Mozambique (Coady and Newhouse, 2005), South African Region (Nkomo, 2006) and Ghana (Coady et al., 2006). The loss of GDP in the sub-Saharan African countries was estimated to be between 3% (IEA, 2004) and 6% (Bouakez and Vencatachellum, 2007). The finding of Bouakez and Vencatachellum (2007) is quite interesting. It indicates that a doubling of the price of oil on world markets with complete pass through to oil consumers would lead to a 6% contraction in the first year. If that country were to adopt a no-pass through strategy, output would not be significantly affected but its budget deficit would increase by 6%. Both ways, whether it follows a pass through strategy or not, the macro-economic stability of the country is affected.

In Eastern Africa, this volatility represents a significant threat to energy security and economic resiliency. Fossil fuels provide approximately 14% of the regional energy supply, 27% of electricity net generation and 100% of the fuel used in the transportation sector. In countries such as Comoros, Eritrea and Seychelles, close to 100% of electricity net generation depends on fossil fuel. Furthermore, it is difficult to solving sectoral challenges, such as the chronic food insecurity in the sub-region, without introducing modern agricultural machinery and drip irrigation which adds to the existing demand for fossil fuels. *The interconnections between energy security and economic transformation would therefore need careful examination and management strategy.*

9.3.5 Conflict-related Power Threats

The sub-region has a long history of armed conflicts that threats its infrastructure and puts into jeopardy its economic development. For example, war has seriously damaged critical infrastructure in the D.R. Congo, Eritrea, Ethiopia, Somalia and South Sudan. Obviously, countries in conflict perform worse in the development of infrastructure than do countries at peace (Yepes, Pierce and Foster, 2008).

9.4 POLICY OPTIONS TO REDUCING ENERGY CONSTRAINTS TO ECONOMIC TRANSFORMATION IN THE EASTERN AFRICA SUB-REGION

9.4.1 Within-Country Strategies

The sections on *energy access, energy security, governance of trans-boundary water resources, technology and innovation and the environment* have passed country-specific policy recommendations that can also serve as reducing the energy constraint to economic transformation. The following recommendations are offered in relation to economic transformation.

9.4.1.1 Enhancing Energy Efficiency

The sub-region can go a long way in enhancing energy efficient regions, as the average energy intensity (GDP per unit of energy) in Africa of 13,352 is much higher than the global average of 9803 (EIA, 2012). This is 36% above world average which indicates the amount of energy input in production processes wasted that could have been saved for other productive activities. Energy saving reduces strain on generation expansion demand. There are great potential and opportunities in energy efficiency and it needs prioritizing in the strategy for sustainable energy development and constraint alleviation.

9.4.1.2 Joint Economic and Energy Planning

Economic transformation planning has a wide range of anchoring strategies and policy targets. Given the level of influence the energy sector has on the overall economy, and due to the energy input implications for ambitious economic development plans, a joint economic and energy sector planning is quite crucial. Economic transformation requires vast amounts of energy to be available. For example, middle income countries, on average, have 80% population electricity access, compared with 23% in the Eastern Africa sub-region. An ambitious economic transformation agenda to enter middle income status in the sub-region would therefore require an equally ambitious energy access transformation, which necessitates joint economic and energy planning.

9.4.1.3 Shielding the Economy from Energy Insecurity Impacts

Economic transformation can be constrained by energy insecurity, stemming from sustainability of biomass-based energy supply and the availability, quality and affordability of electricity supply. More importantly, petroleum import dependence and disruption management policies and schemes in-country determine the nature of impact on the economy. Efforts at energy diversification and maintenance of strategic reserves would certainly help, so would an information management system that would provide policymakers timely and accurate analysis and information on the risk of energy disruption for timely management decisions that can deter potential spillover effects of energy on the economy.

9.4.2 Sub-Regional Strategies

A sub-regional framework is advantageous for many reasons. It helps bring a whole serious of high-potential energy sources for development, enabling the alleviation of the energy constraint throughout the sub-regional economy. With proper infrastructure development and trade, the sub-regional average cost of energy supply can be reduced while enhancing supply constraints. Moreover, a regional framework can help pool investment resources together to develop an otherwise costly project. One example is the development plan of Inga III power project in D.R. Congo that is pooling financial resources from countries in the Southern Africa Power Pool (SAPP), particularly South Africa.

On petroleum products, a regional framework on strategic reserves, procurement, distribution infrastructure and coordinate policy response are effective possibilities. Political will of regional governments and policy makers will be required to help building an effective response to the energy constraint to economic development.

CONCLUSION

From basic aspects of everyday life, such as lighting and cooking, to the intricate economic production systems, energy has become an indispensable input. It is widely recognized that achievement of the MDGs and broader social transformation necessitates the availability of modern, affordable and reliable energy, and increasingly needed from cleaner and sustainable energy sources. Despite the strong linkages between energy sector development and socioeconomic transformation, Eastern Africa is one of the few sub-regions with poor energy access. As the sub-region continues to enjoy robust economic growth, sustaining the momentum will require taming energy problems: poor availability of energy; poor population energy access levels; unreliable and insufficient quality energy; generation, transmission and distribution inefficiencies; insufficient policy, institutional and human capacity in the energy sector; energy market structural barriers; limited private sector participation; energy planning lags and emergency generation and others. As part of the overall effort to reduce transaction costs and structural constraints on economic transformation in Eastern Africa, alleviating the energy challenges to growth constitutes a major step. Moreover, the excessive reliance on imported energy, particularly petroleum, has exacerbated energy security in the sub-region, with severe impacts on member States' macroeconomy, including balance of payments impacts. Management of energy security risks to the economy continues to be part of the structural constraints to economic transformation.

Despite numerous challenges in the energy sector of Eastern Africa, opportunities abound. Member States are endowed with significant clean energy resources, development potential of trans-boundary hydropower systems is ripe, energy trade is barely leveraged in the sub-region, private sector participation and capital infusion is a real possibility, and institutional and policy reforms can address the pent-up demand for rapid energy development. Discovery of oil and gas resources in the sub-region, and growing interest in biofuel development also offer pathways to meeting energy insecurity through regional frameworks. These, and other opportunities, constitute the possibility of an *energy transformation and revolution* in the sub-region.

Recognizing that energy access and security are indispensable to economic transformation, member States of the Eastern Africa sub-region are advised to consider: strong commitment to energy sector development consistent with their socioeconomic development aspirations; increasing private sector engagement, and private-public partnerships to enhance investment resources in the energy sector;

pursuing regional opportunities to engage in energy trade and benefit from lower energy costs and economies of scale; pursue renewable energy initiatives aggressively; commit to energy access sub-regional and country targets and strive to achieve Sustainable Energy for All objectives by 2030; strengthen energy planning while synergizing with economic planning; institute and stock strategic reserves of petroleum to lower the economic costs of energy disruptions while developing partnerships for a regional procurement framework; strengthen regional cooperation on development of strategic energy resources such as oil and gas; engage in exchange of information and experiences pertaining to enhancing energy access and security and ultimately addressing the energy constraint to resilient economic transformation through workable strategies implemented in the Eastern Africa sub-region and beyond.

This report offers a sub-regional picture on energy access and security, reviews case studies from select member States to highlight lessons on energy access and security, looks at the environmental, trans-boundary energy resources, infrastructure and trade, technology and energy and economic performance issues at length. Policymakers, decision-makers and energy sector stakeholders may find it useful as they deliberate, advocate and implement programs and strategies that will collectively enhance the state of energy access and security. The United Nations Economic Commission for Africa (UNECA), including its Sub-Regional Office for Eastern Africa (SRO-EA), will continue to engage policymakers and energy sector stakeholders, particularly in the regional dimension of energy sector development, to simultaneously encourage regional integration, a central objective that will be enhanced by regional energy integration.

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