


Energy Access and Security in Eastern Africa

Status and Enhancement Pathways

United Nations
Economic Commission for Africa

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Energy Access and Security in Eastern Africa

Status and Enhancement Pathways

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Preface and Acknowledgements

The report offers a detailed overview of the state of energy access and energy security in countries of the Eastern Africa subregion. In reviewing the current state of energy access and energy access gaps relative to the numerous policy initiatives, the report recognizes the importance of energy in supporting the ongoing economic growth and social development of the region, and takes account of the multitude of energy policy initiatives at global, regional and State levels. The report considers the "middle-income" economic policy targets of a number of States in the region, and analyses the energy access requirements of these States accordingly. The report outlines in further detail the issues of energy technologies, infrastructure, energy resources governance, energy development and environmental considerations in assessing their potential impact on energy enhancement initiatives and programmes. The different country experiences and specific country challenges in enhancing energy access are illustrated in the case studies of Ethiopia, South Sudan, Tanzania and Uganda.

Recognizing the need of energy security for sustained socioeconomic development, the report also considers the state of energy security in countries of the Eastern Africa subregion in the broader context of security of supply of oil, biomass and electricity. Energy security challenges from a regional and country perspective are assessed on the basis of a number of energy security assessment methodologies. Key policy recommendations are outlined for enhancing energy security in the short and long-term at country and regional levels.

The report was prepared by Yohannes G. Hailu, Energy Expert and Economic Affairs Officer at the United Nations Economic Commission for Africa (UNECA), Subregional Office for Eastern Africa (SRO-EA), under the guidance and leadership of Mr. Antonio Pedro, Director of UNECA, SRO-EA, and supervision of Mr. Soteri Gatera, former Cluster Leader, Special Initiatives Cluster of SRO-EA. We acknowledge the contributions of chapters of the report from: Ms. Marit Kitaw (SRO-EA) and Prof. Muluneh Yetayew (University of Arizona, Tucson) on Transboundary Water Resources Governance for Energy Development; Ms. Daya Bragante (SRO-EA) on Energy and Environment; Mr. Mactar Seck (SRO-EA) on Energy Technology and Innovation; Mr. Godfrey Oniango (formerly at SRO-EA) on Infrastructure; and Dr. Mulugeta S. Kahsai (Virginia State University) on Energy Constraint and Economic Transformation.

A draft version of this report received valuable feedback from experts participating in the 2013 meeting of ECA Intergovernmental Committee of Experts (ICE) held in Kampala from 18 to 22 February. We are grateful for the internal peer review by colleagues from SRO-EA and to external reviewers, including experts at ICE, whose comments have improved the quality of the report.

Executive Summary

The 2011 *World Energy Outlook* indicates that globally over 1.3 billion people lack access to electricity and 2.7 billion lack clean cooking facilities, concentrated largely (95 per cent) in Africa and developing Asia, with 84 per cent in rural areas. The International Energy Agency (IEA) states that even with investments of $14 billion per year between 2010 and 2030 for 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 would need to be invested from 2010 to 2030 to achieve universal access to modern energy, with the bulk of the investment going to Africa.

In most countries of the Eastern Africa subregion more than 90 per cent of the population are reliant on biomass compared with developing Asian countries (54 per cent), Latin American countries (19 per cent) and the Middle East (0 per cent). Electricity access rates range from 1 per cent in the new State of South Sudan (leaving 9.3 million people without access), 9 per cent in the Democratic Republic of Congo (DRC) (nearly 60 million without access) to 12 per cent in Uganda (more than 27 million people without access), 14 per cent in Tanzania (nearly 38 million without access), 18 per cent in Kenya (more than 32 million without access) and 22.5 per cent in Ethiopia (nearly 64.5 million without access). Africa, and particularly the Eastern Africa subregion, 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, the affordability and reliability concerns related to electricity supply and rising petroleum consumption in the Eastern Africa subregion have also raised concerns about energy security. In terms of percentage changes in forest cover based on forest resources, using 1990 as a base reference, a stock decline of nearly 20 per cent has been observed in Ethiopia, Somalia and Tanzania, nearly 40 per cent in Uganda and Burundi, and 75 per cent in the Comoros. Between 4 and 8 per cent of forest stock declines are seen in DRC, Eritrea, Kenya and Madagascar. In DRC, while a 4 per cent decline seems marginal, given the size of the stock which was 160 million hectares in 1990 and 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, with forest resource recovery of 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 DRC; 2.8 million hectares in Ethiopia; and between 1.3 million and 1.7 million hectares in Madagascar, Somalia and Uganda. The state of forest resources and biomass energy production capacity in the Eastern Africa subregion is sliding 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.

With regard to the impact on energy security from the electricity subsector, it should be noted that the generation of electricity in the Eastern Africa subregion was predominantly hydroelectricity. Insufficient energy planning and growing energy demand have obliged the region to make some technology choices resulting in thermal generation, which has been increasing overtime as a contribution to total electricity generation. The shift in energy conversion technology to thermal options in the subregion has energy security implications. Africa's proportion of global petroleum consumption has gradually increased from around 3.25 per cent to about 4 per cent over the last decade. In the same period, the Eastern African subregional proportion of Africa's petroleum consumption increased from about 8 per cent to close to 10 per cent. Though the proportions seem to have increased only gradually, the comparison of absolute consumption levels of petroleum from 2000-2011 shows that while consumption at the continental level increased by slightly more than 40 per cent, the rise in the Eastern African subregion was 67 per cent. This constitutes a significant increase in exposure to global energy markets and to sources of energy insecurity. A decade-by-decade analysis of the price shifts reveals that oil prices were already declining before the 1970s oil crisis, only to increase by nearly 3,000 per cent in the 1980s. They receded in the 1990s, and increased slightly from 1990 to 2000. In the 2000s, though the price hike was not as detrimental as the 1970-1980 decade, it nonetheless broke from norm and increased sharply, by nearly 170 per cent. Dominant growth prospects in China, India, Brazil and Russia (BRICs) and global growth in per capita income are likely to put further pressure on energy prices, which will have energy security impacts on fuel importing countries.

The World Summit on Sustainable Development in 2002 highlighted the role of energy, and through the Johannesburg Plan of Implementation emphasized the importance, including the aspect of energy when promoting development and reducing poverty. The 2012 conference of the United Nations Rio+20 stated that since 1992, the global energy crisis had aggravated the lack of progress in sustainable development, particularly in developing countries, and urged countries to address the challenges posed by access to sustainable modern energy services. The Conference further outlined that energy was a crucial component in development, as access to modern energy contributed to poverty reduction, improvement of health and provision of basic human needs, thereby making "reliable, affordable, economically viable and socially and environmentally acceptable energy" crucial in developing countries. The United Nations Secretary-General, Mr. Ban Ki-moon, declared that he had made Sustainable Energy for All a top priority because it was central to all aspects of sustainable development.

Though there are numerous challenges in the energy sector of Eastern Africa, there are also abundant opportunities. Member States are endowed with significant clean energy resources and development potentials in transboundary hydropower systems. Though energy trade is barely leveraged in the subregion, possibilities exist for private sector participation and capital infusion, and institutional and policy reforms can address the pent-up demand for rapid energy development. Discovery of oil and gas resources in the subregion, and growing interest in biofuel development also offer pathways to dealing with energy insecurity through regional frameworks. These, and other opportunities, constitute the possibility of an energy transformation and revolution in the subregion.

Given that energy access and security are indispensable to economic transformation, member States of the Eastern Africa subregion are advised to consider: (a) making a strong commitment to energy sector development consistent with their socioeconomic development aspirations; (b) increasing private sector participation, and private-public partnerships to enhance investment resources in the energy sector; (c) pursuing regional opportunities to engage in energy trade and benefit from lower energy costs and economies of scale; (d) undertaking renewable energy initiatives; (e) committing to the attainment of subregional and country targets set for energy access and striving to achieve the Sustainable Energy for All objectives by 2030; (f) strengthening energy planning while synergizing with economic planning; (g) instituting and stocking strategic reserves of petroleum to lower the economic costs of energy disruptions and developing partnerships for a regional procurement framework; (h) strengthening regional cooperation on the development of strategic energy resources such as oil and gas; (i) engaging in exchange of information and experiences to enhance energy access and security; and (j) addressing the issue of energy constraint which impedes economic transformation, through workable strategies implemented in the Eastern Africa subregion and beyond.

The report provides a subregional picture of energy access and security, reviews case studies from some selected member States to highlight lessons on energy access and security, looks at the environmental, transboundary 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 programmes and strategies that will collectively enhance the state of energy access and security. The United Nations Economic Commission for Africa (UNECA), and its Subregional Office for Eastern Africa (SRO-EA), will continue to engage policymakers and energy sector stakeholders, particularly in the area of regional energy sector development, so as to encourage regional integration, another objective that could be enhanced through regional energy integration.

Acronyms

AAGR	Average growth rate
ADER	Madagascar 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	United Nations 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
DRC	Democratic Republic of Congo
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	United Nations 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 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 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 CO2e	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	United States Department of Energy 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 United Nations
SHS	Solar Home Systems
SINELAC	Société d'Electricité des Pays des Grand Lacs
SNEL	Société Nationale d'Électricité, Democratic Republic of 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 Programme in Low Income Countries
SRO-EA	ECA Subregional 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 Programme
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	Transboundary 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	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change
US$	United States Dollar
USAID	United States 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 the study is to inform energy policymakers, regulators, regional energy development partners, Regional Economic Communities (RECs) and energy stakeholders - at regional, national and local levels - about the state of energy access and security in the 14[1] Eastern African States. It is also to highlight existing barriers to enhancing energy access and security in the subregion, and the regional and country opportunities and pathways to improving energy access and security.

The report further aims to deepen the policy discussion among stakeholders by raising key issues related to energy access and security in the subregion, measuring and evaluating in-depth the state of energy access and security and suggesting possible pathways to enhance access and security, including regional frameworks. This is to increase greater awareness about the issues and encourage consideration of policy opportunities to enhance energy access and security in the subregion and in each member State.

1.2 Scope of the report

Eastern Africa comprises 14 countries. The study offers a subregional analysis on energy access and security. This analysis is supplemented by a review of cases studies from Ethiopia, Tanzania, Uganda and South Sudan. The case study of Ethiopia will provide an example of the role of countries with energy potential, yet faced with internal energy development constraints, regarding the enhancement of subregional energy access and security.

The case study of South Sudan will enable a discussion of challenges a new State with energy potential but low access faces. The case studies of Uganda and Tanzania will feature the role of energy-constrained countries which have newly found potential,

1 The Eastern African subregion referred to in this report comprises: Burundi, Comoros, Democratic Republic of Congo, Djibouti, Ethiopia, Eritrea, Kenya, Madagascar, Rwanda, Seychelles, Somalia, South Sudan, Tanzania and Uganda.

and the impact of energy development in the gas and oil sector on subregional energy access and security.

The study therefore focuses on providing a subregional analysis and overview of energy access and security, followed by case assessments of selected countries. The country case studies are based on missions undertaken to the countries, and consultations conducted with the respective ministries of energy, petroleum/hydrocarbon, rural electrification agencies, energy regulatory agencies, energy access institutions and development partners. The subregional and country specific discussions are based on the socioeconomic transformation agenda in the subregion, and how reducing energy constraints will support such transformative visions. There is a particular focus on the stated goal of some member States, which is to reach "middle-income" status within about a decade, and along with 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 complex issues are explored in this report.

To meet Millennium Development Goals (MDGs) by 2015, it will be necessary to extend access to clean energy to 395 million more people, and clean cooking facilities to over 1 billion people worldwide.

1.3 Energy access

1.3.1 The global energy access challenge

For decades, access to modern forms of energy has been a structural constraint to socioeconomic development in the developing world, thus recently, energy access has become a part of the global policy priority agenda. This policy prioritization seems to be informed by the realization that the achievement of development milestones are linked 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 extend access to clean energy to 395 million more people, and clean cooking facilities to over 1 billion people worldwide. This will perhaps require an additional investment of $41 billion per year between 2010 and 2015 (WEO, 2010).

$48 billion per year would need to be invested from 2010 to 2030 to achieve universal access to modern energy.

Globally, over 1.3 billion people lack access to electricity, and 2.7 billion lack clean cooking facilities, concentrated largely (95 per cent) in Africa and developing Asia, particularly (84 per cent) in rural areas (WEO, 2011). The IEA states that even with an investment of $14 billion per year between 2010 and 2030 for 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 would need to be invested from 2010 to 2030 to achieve universal access to modern energy, with the bulk 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 per cent 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 per cent of rural population lack access to electricity, compared with 56 per cent in urban areas, in developing countries, while 27 per cent of urban residents have access to modern fuels, compared with 3 per cent of the population in rural areas. About 70 per cent of the population in developing countries relies on wood and its by-products as main cooking fuel. Furthermore, the use of improved cooking stoves is minimal, at about 4 per cent in sub-Saharan Africa.

Energy access is indeed a global challenge and a closer look at the regional disparities on access to energy reveals that a greater part of the energy access problem is concentrated in less developed countries, particularly in Africa and the southern parts of Asia (see Figure 1). The structure of the global access disparity is captured by Figure 1. Regarding access to electricity, while there are quite high levels in parts of south Asia, sub-Saharan Africa, excluding South Africa, has a low access to electricity in urban and more so in rural areas. The picture is similar for access to modern fuels, where sub-Saharan Africa has lower levels, compared with other regions of the world.

While access to modern fuels in Africa is slightly better, compared with the least developed countries, access to electricity, particularly in rural areas, is however much lower compared with the average for the least developed countries (see Figure 2). In essence, the global energy access challenge is intrinsically tied, to a large extent, to what happens to energy sector development in Africa. Changing the global energy access profile will involve improving rapidly the energy profile of Africa, addressing key structural and policy constraints and improving the economic development context within which energy access solutions will be sought.

In essence, the global energy access challenge is intrinsically tied, to a large extent, to what happens to energy sector development in Africa. Changing the global energy access profile will involve improving rapidly the energy profile of Africa, addressing key structural and policy constraints and improving the economic development context within which energy access solutions will be sought.

The global energy access challenge is also reflected in the energy sources portfolio, and the degree to which access to modern forms of energy is constrained. In least developed countries, cooking fuels are mainly sourced from wood (73 per cent) and charcoal (11 per cent), with minimal access to gas (7 per cent) and electricity (1 per cent)(see Figure 3). In sub-Saharan Africa, cooking sources of energy are similarly sourced from wood (69 per cent) and charcoal (11 per cent), with minimal, but slightly higher sources from kerosene (7 per cent) and electricity (6 per cent). 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 constitutes a profound structural challenge.

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

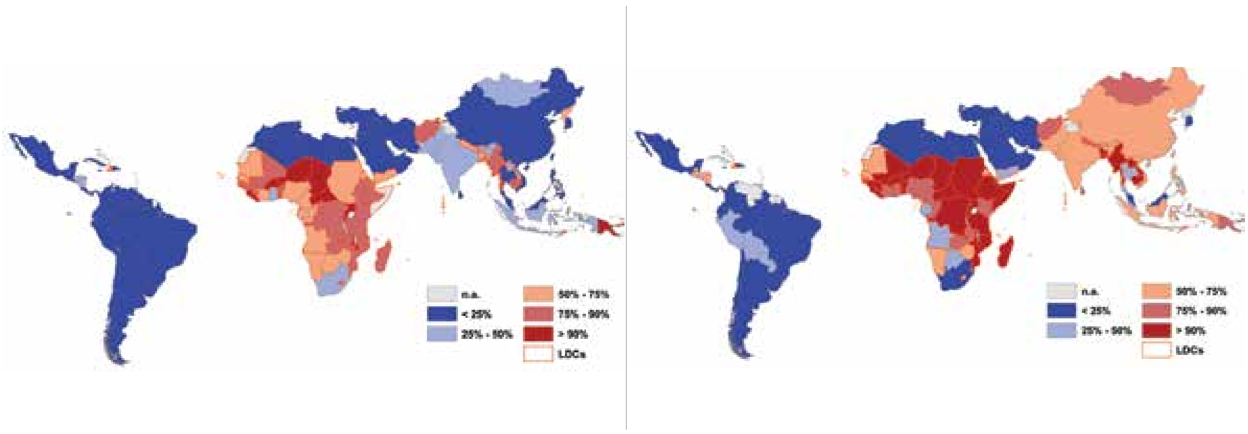
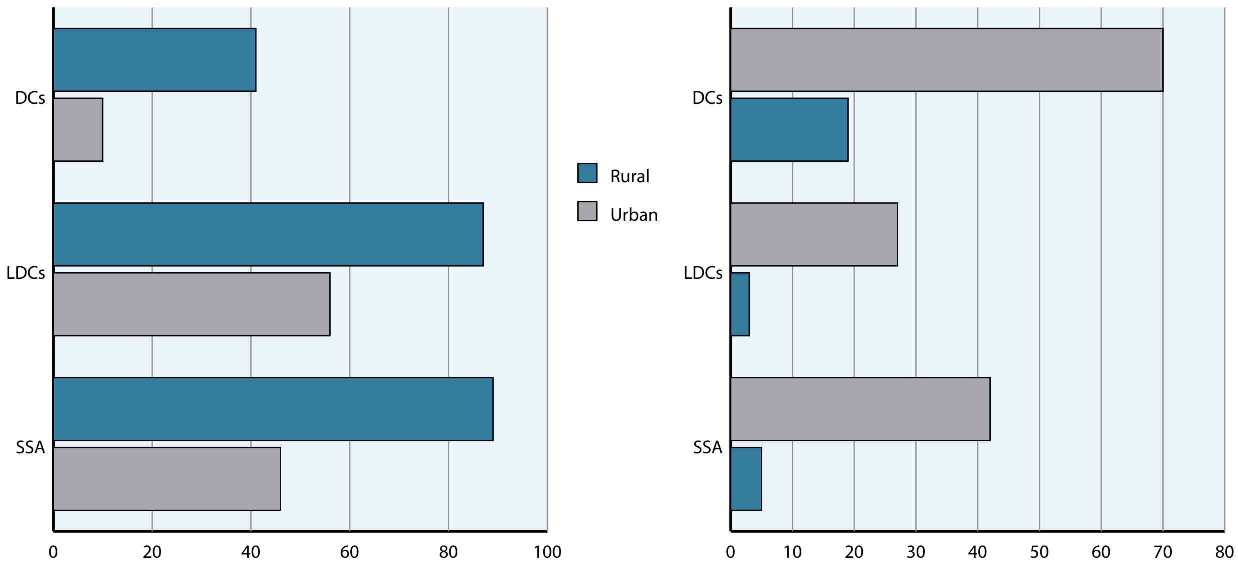
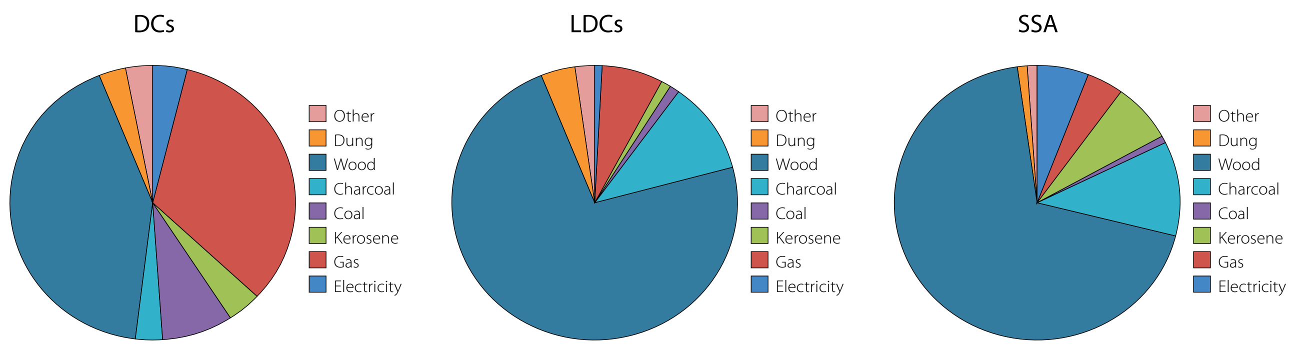


Figure 2: Percentage of population without electricity (panel 1) and with access to modern fuels (panel 2) – urban and rural regional variation



Sources: Adapted from WHO, UNDP (2009).

Figure 3: Percentage 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 subregion

Africa is a continent under transformation, featuring favourable GDP growth rates in the last decade and at an 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 to 7 per cent between 2012 and 2015. The infamous declaration of Africa as the hopeless continent by the *Economist* magazine has been replaced in recent issues with hopeful and bullish economic prospects. The IMF (2012) report on Regional Economic Outlook in Africa 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 the continent.

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 per cent (WEO, 2011), but with significant disparity between urban (89 per cent) and rural (46 per cent) areas

(WHO, UNDP, 2009). The focus on sub-Saharan Africa on its own in discussing the energy challenge is mainly because there are better access rates in Northern Africa. Access rates in the Northern African countries; Morocco (97 per cent), Algeria (99.3 per cent), Tunisia (99.5), Egypt (99.6) and Libya (99.8 per cent) (see Fig. 4), attest to the structural nature of the energy access problem in Africa, thus the focus on sub-Saharan Africa. The following factors may explain the disparity in achieved energy access levels, and the type of energy portfolio chosen: limited biomass resources in Northern Africa; favourable policy environment; level of economic development; climatic conditions; and endowment of vast energy resources.

An estimated 657 million people (65 per cent) in Africa rely on biomass for cooking, about 74 per cent in sub-Saharan Africa, and only 3 per cent in Northern Africa.

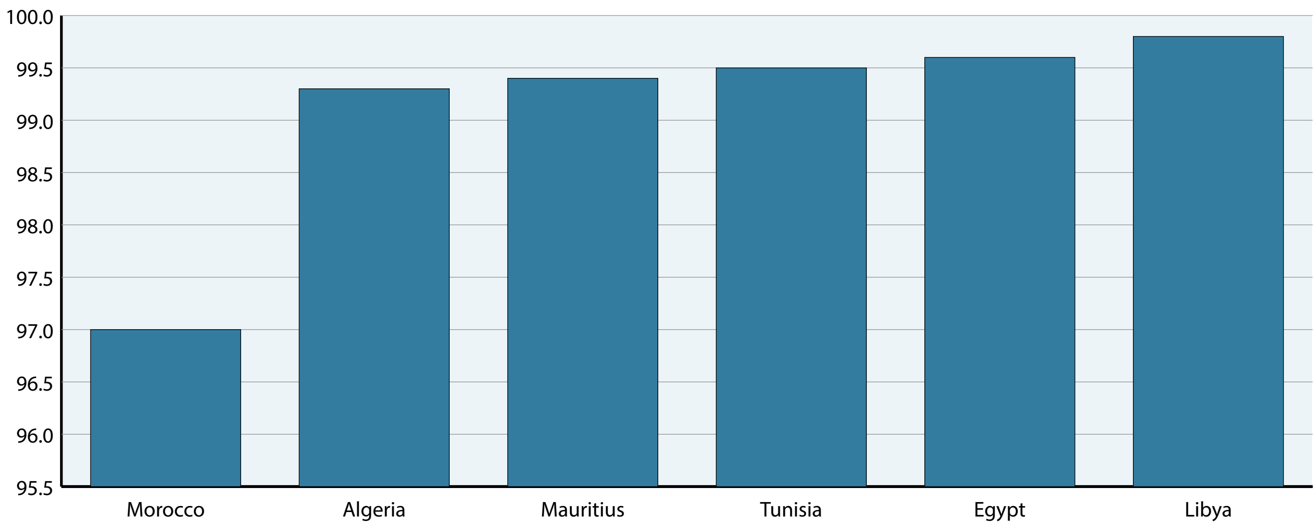
Access to modern energy for household cooking is also limited in Africa, with an unsustainably large and growing population relying directly on biomass. An estimated 657 million people (65 per cent) in Africa rely on biomass for cooking, about 74 per cent in sub-Saharan Africa, and only 3 per cent in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

If sub-Saharan Africa poses a formidable challenge in solving the energy access problem, Eastern Africa is a particular concern. Electricity access rate ranges from just 1 per cent in the new State of South Sudan (leaving 9.3 million people without access), to 9 per cent in DRC (nearly 60 million people without access), 12 per cent in Uganda (more than 27 million people without access), 14 per cent in Tanzania (nearly 38 million people without access), 18 per cent in Kenya (more than 32 million people without access) and 22.5 per cent in Ethiopia (nearly 64.5 million people without access) (see Table 2).

If sub-Saharan Africa poses a formidable challenge in solving the energy access problem, Eastern Africa is a particular concern.

While these access figures are comparable to those of some African countries, such as Malawi (9 per cent) and Zambia (18.8 per cent), they trail behind countries such as Zimbabwe, Senegal, Botswana, Côte d'Ivoire, Cameroon, Nigeria, Ghana and Mauritius

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



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

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

	Relying on traditional use of biomass for cooking	
	Population (million)	Percentage of Population
Africa	657	65%
Nigeria	104	67%
Ethiopia	77	93%
DRC	62	94%
Tanzania	41	94%
Kenya	33	83%
Rest of 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.

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

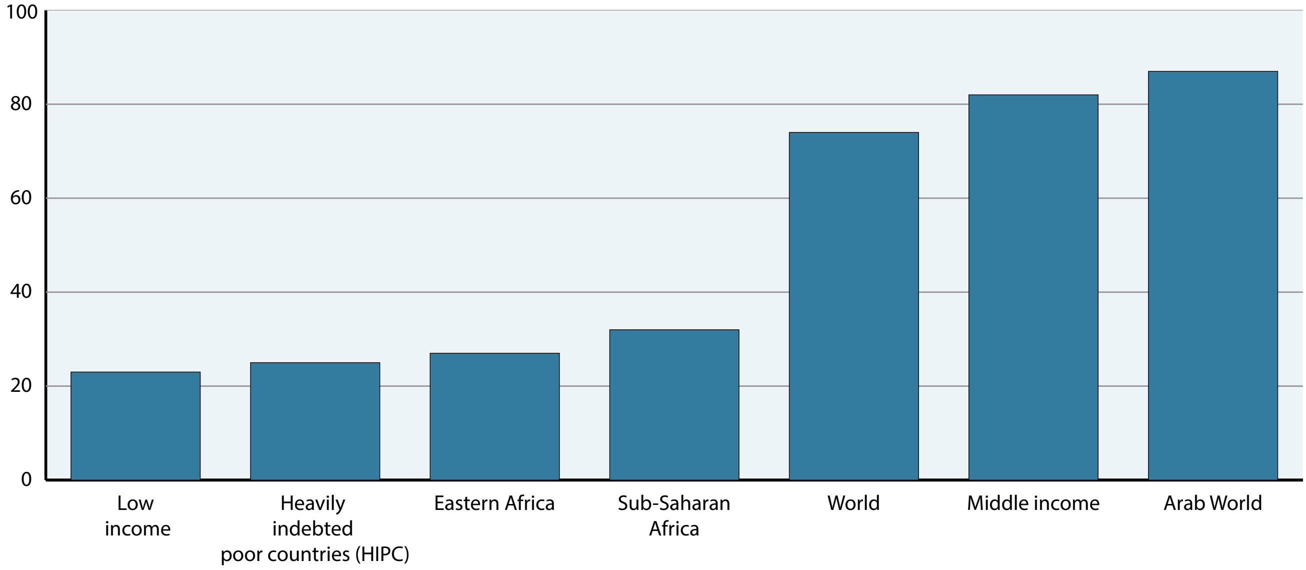
Country	Electrification rate (%)	Population without electricity (millions)	Country	Electrification rate (%)	Population without electricity (millions)
Select Eastern Africa Countries			Angola	26.2	13.7
South Sudan	1	9.3	Namibia	34.0	1.4
Uganda	12.0	27.0	Sudan	35.9	27.1
DRC	11.1	58.7	Gabon	36.7	0.9
Tanzania	13.9	37.7	Congo	37.1	2.3
Kenya	16.1	33.4	Zimbabwe	41.5	7.3
Ethiopia	22.5	64.5	Senegal	42.0	7.3
Madagascar	19.0	15.9	Botswana	45.4	1.1
Eritrea	32.0	3.4	Côte d'Ivoire	47.3	11.1
Selected Sub-Saharan African 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
Zambia	18.8	10.5			
Benin	24.8	6.7	**Sub-Sahara**	**30.5**	**585.2**

Source: Adapted from WEO data, 2011.

where access rates are above 40 per cent. Eastern African countries also under perform in energy access (at around 27 per cent) compared with the sub-Saharan average of 30.5 per cent. The peculiarly low levels of energy access in the region may be due to: (a) limited development of vast clean energy resources in the region; (b) energy infrastructure inadequacy; (c) limited investment in energy generation capacity for a prolonged period of time; (d) low income levels[2]; (e) nature of energy policy reform; and (f) market organization. If urgent solutions to rapid expansion of energy access are needed globally, they are more so in the Eastern Africa subregion.

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

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



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

Comparing energy access in Eastern Africa with other regions gives a better perspective of the picture. In particular, comparison with access rates in middle-income countries with over 80 per cent (see Figure 5) is worth taking note of, as one central goal in the economic development agenda of Eastern African countries is the transition to middle-income status. There is ample optimism as economic growth in Eastern African member States demonstrated a strong performance, bringing middle-income status within policy sight; but if energy development does not take on an accelerated pace, this economic agenda is likely to face an energy road block.

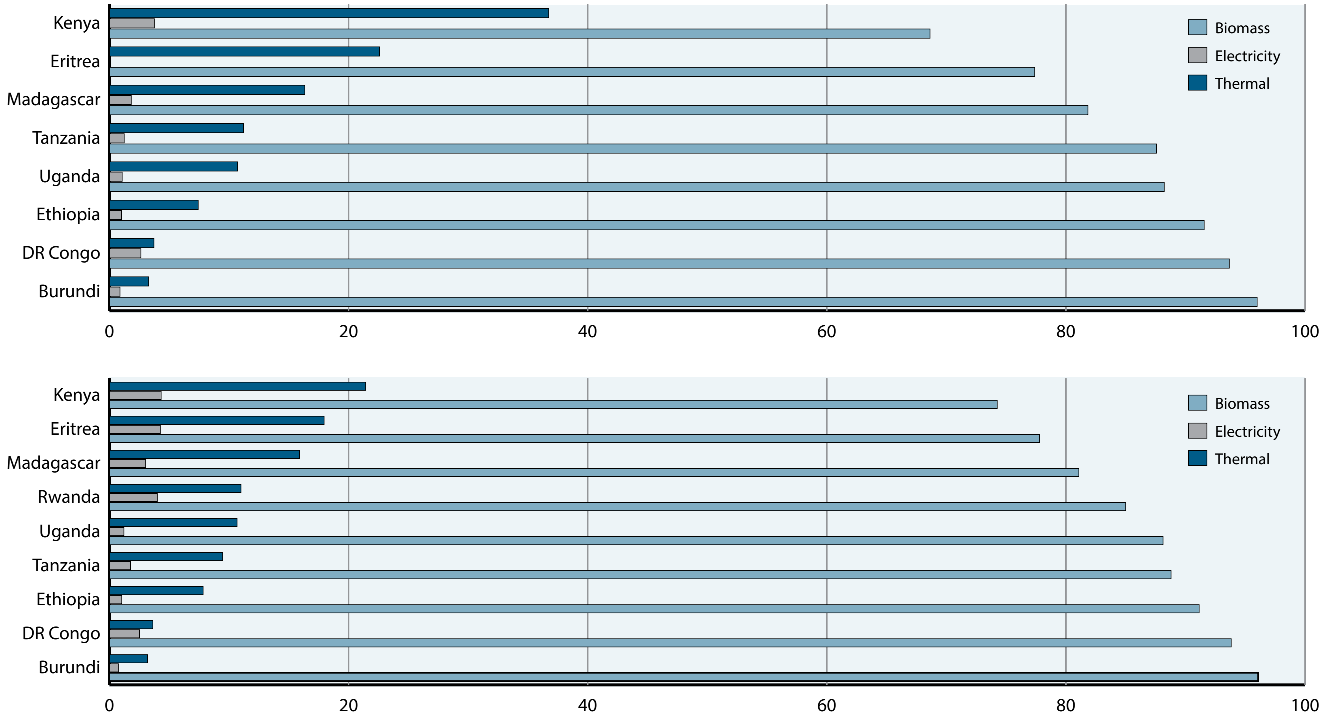
There is ample optimism as economic growth in Eastern African member States demonstrated a strong performance, bringing middle-income status within policy sight; but if energy development does not take on an accelerated pace, this economic agenda is likely to face an energy road block.

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

It is worth noting that in countries with relatively lower levels of biomass dependence, biomass energy is replaced with thermal sources of energy for electricity, as demonstrated by high levels of thermal usage in Kenya and Eritrea. This has energy security implications, since thermal sources of energy are mostly imported into the Eastern Africa subregion. The energy security context is a topic that will be discussed in later sections.

A growing concern is the status quo of continued dependence on biomass for energy, with limited efforts towards a transition to modern energy sources. The demand for wood in the Eastern Africa subregion is increasing, while the resource base is declining. Comparison of demand and supply in the subregion demonstrates that a large part of the region has either a low or high deficit, particularly in urban areas (see Figure 7). This complicates finding a solution to the energy problem, which requires a fast move towards energy transition while sustainably managing the biomass resources of the subregion.

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



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

1.3.3 Why energy access matters in the Eastern Africa subregion?

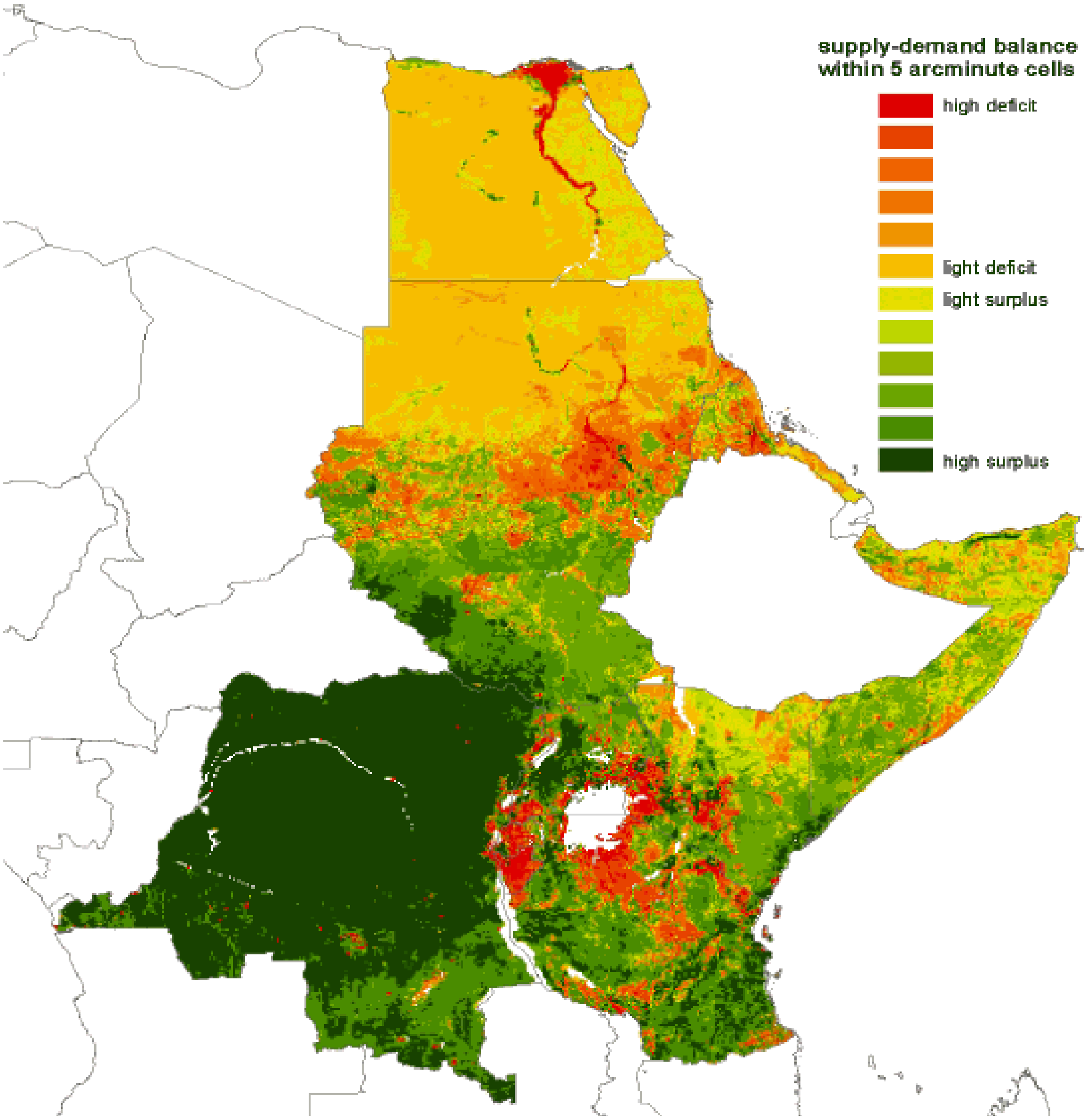
Pondering on the simple question of "why energy access," is often overlooked, since energy has become mundane, and the services it provides is widespread in many parts of the world, although millions still live without it. Beyond providing basic services such as lighting and power to energy end uses, access to energy is redefining economic and social progress, which is a facet of transformation that is 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 important because the development and proper functioning of present day societies, which include their social affairs, economic exchange, information sharing, provision of public services and the overall quality of life depend on the availability and reliable supply of energy.

Energy access is important because the development and proper functioning of present day societies, which include their social affairs, economic exchange, information sharing, provision of public services and the overall quality of life depend on the availability and reliable supply of energy. Availability of energy has become central to global, regional and local systems and as such, its expansion and secure supply has long become a core goal of States. The United Nations Rio+20 Outcome of Conference stated that since 1992, insufficient progress in sustainable development had been 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 was a crucial component to development, since access to modern energy contributed to poverty reduction, improvement of health, and provision of basic human needs, making "reliable, affordable, economically viable and socially and environmentally acceptable energy" crucial for 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

Figure 7: Firewood demand and supply 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.

economic development. The reasons for this observation are many. At the microlevel, the productive use of energy is tied to economic empowerment and poverty alleviation. Access to energy helps stimulate the development of microenterprises, 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 macrolevel, energy is tied to development due to its direct input in production (Apergis and Payne, 2009) and indirectly complementing labour and capital inputs (Toman and Jemelkova, 2003). Therefore, energy consumption and economic growth are interlinked. Based on a study during the 1980-2005 period in the COMESA region, Nando, and others (2010) concluded that the long-run relationship between energy and GDP in the region showed a strong relationship, and that they tended to go together.

A look at economic development and energy consumption globally reveals a similar trend, leading to a similar conclusion. A comparison of GDP per capita and primary energy consumption per capita, shown in Figure 8, indicates a strong and direct relationship between energy and economic growth. This implies that economic growth requires access to increasing levels of energy, and therefore, lack of 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 root in many parts of Eastern Africa, sustaining it with proper development of and accessibility to affordable energy is quite important.

Economic growth requires access to increasing levels of energy, and therefore, lack of access to energy can act as a constraint to economic growth and poverty alleviation.

Energy accessibility is also crucial and goes beyond economic growth considerations, to broader social development. At the microlevel, the existing heavy reliance on biomass and limited transition to modern energy sources has social costs, such as 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 due to health complications resulting from inhalation of smoke from biomass burning (see Figure 9). This health impact is largely felt by women.

Moreover, with declining forest resources, the cost of fetching firewood and other biomass has increased significantly, requiring more time being spent on wood energy collection, time that could otherwise have been spent on other productive uses. A study of this issue in Tanzania by Modi, and others (2005) reveals that females spend around 250 hours 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 the reduced likelihood of school attendance, particularly for girls. Energy services therefore play a significant role in social development and improvement in living conditions, where they allow community-level delivery of social services, such as health, education, potable water and agricultural extension which would enable even the poorest to benefit from such services (the Energy and Resource Institute, 2007).

At the macrolevel, the human capital development of countries, in health, education and other indicators is closely related to the level of energy consumption (see Figure

Figure 8: Energy consumption and GDP per capita

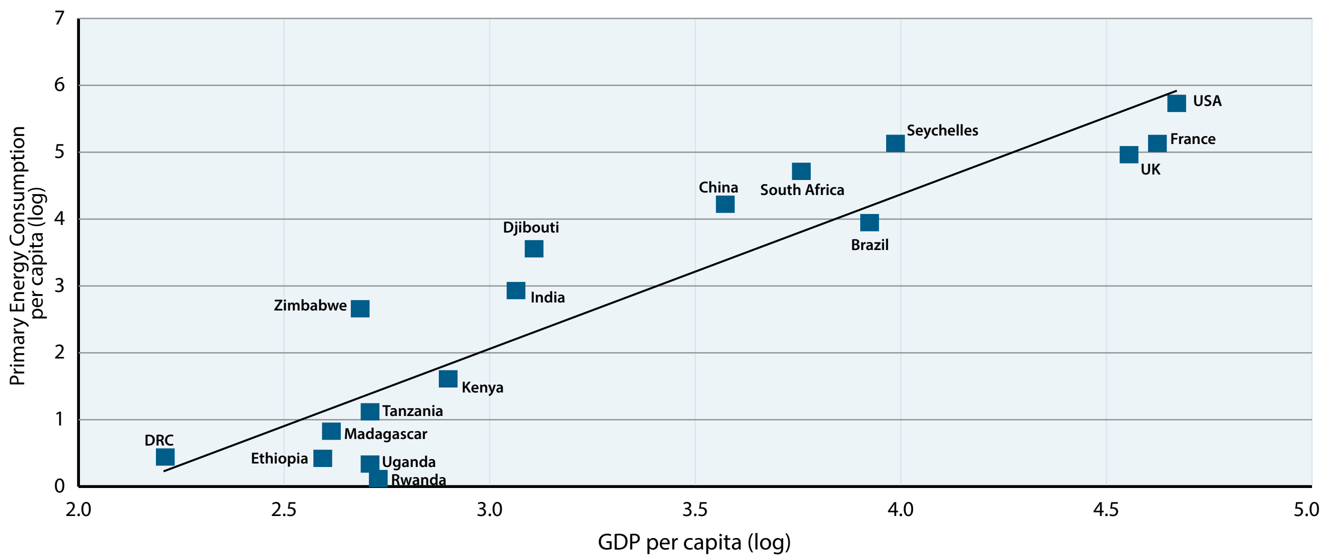
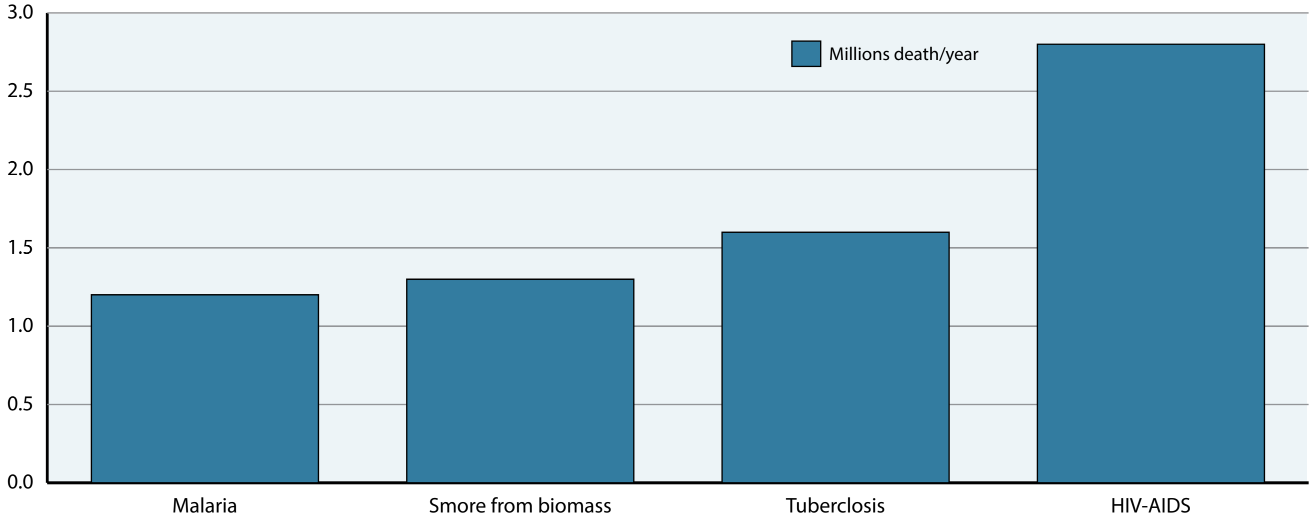


Figure 9: The health impact of traditional biomass use



Source: IEA estimates based on WHO data.

10). Countries with lower levels of energy consumption show lower levels of human capital development.

Since the provision of quality public services, such as health, education and clean water 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 and others 2005, Nussbaumer, and others 2011).

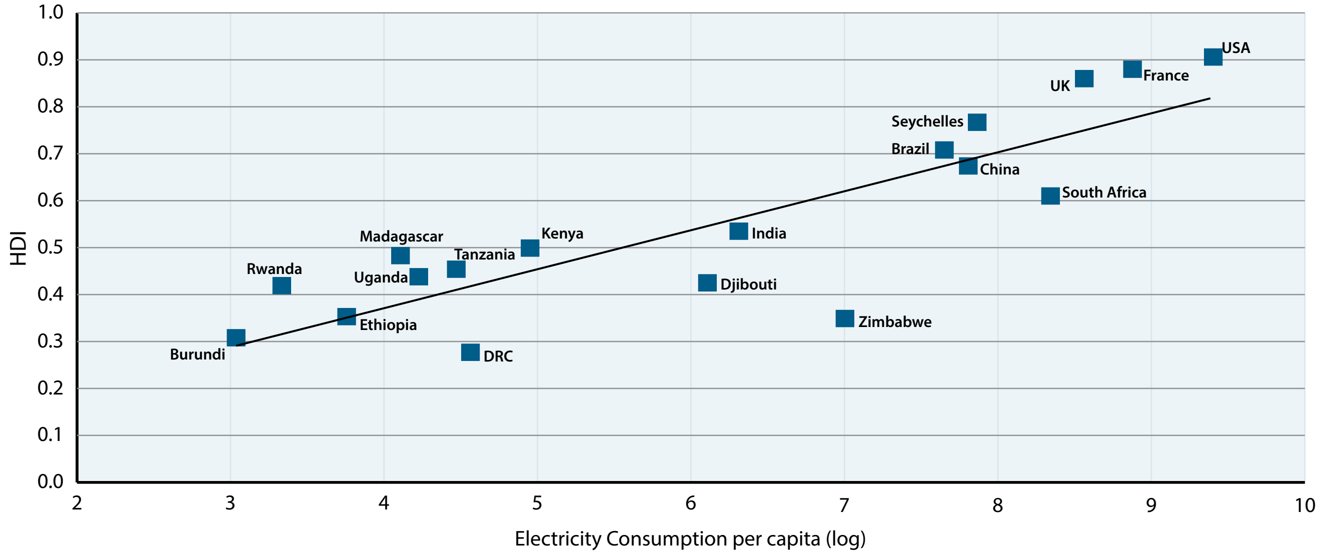
1.3.4 The global and subregional energy access agenda

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), have resulted in inadequate energy access and constrained productive end uses, with negative implications for socio-economic development. To address the energy challenge, global efforts are spearheaded, particularly in line with the global consensus on promoting and grounding sustainable development, or even a green economy. The fundamental challenge remains shifting the energy system towards a more efficient, broadly accessible, affordable and sustainable path while supporting broad-based development, in this case sustainable development. Steering the energy system in this strategic direction requires a concerted effort in prioritizing energy, and particularly energy access, at the global level, and setting key visions and strategies to be implemented at regional, subregional and country levels.

The fundamental challenge remains shifting the energy system towards a more efficient, broadly accessible, affordable and sustainable path while supporting broad-based development, in this case sustainable development.

Elevating the energy agenda at the global level was a result of preceding efforts. The Commission on Sustainable Development has recognized the role of energy in sustainable development, particularly at the eleventh 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 highlighted the role of energy, and through the Johannesburg Plan of Implementation solidified the importance of

Figure 10: Energy consumption and human development index (HDI)



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 extending 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 EAC strategy has ambitious goals of: access to modern cooking energy for 50 per cent of biomass users; access to reliable electricity for all urban and peri-urban poor; access to energy for all schools, clinics, hospitals and community centres; and access to mechanical power for productive use for all communities.

The Johannesburg agenda promoted the international consensus on the importance of access to energy, and broader movement in Africa, partly supported by the Regional Energy for Poverty Programme (REPP) of UNDP (UNDP, 2007). The development of regional power pools in Africa built momentum on the energy access agenda on the continent by charting action plans to implement the energy agenda. Regional Economic Communities (RECs), such as ECOWAS[3] in West Africa (developed a white paper on a regional strategy adopted by Heads of State of the 15 member States); CEMAC[4] in Central Africa (since the Brazzaville gathering in 2005 of the Energy Ministers of CEMAC, an 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).

The EAC strategy has ambitious goals of: (a) access to modern cooking energy for 50 per cent of biomass users; (b) access to reliable electricity for all urban and peri-urban

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.

poor; (c) access to energy for all schools, clinics, hospitals and community centres; and (d) 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 the promotion of suitable business models were anchored as national intervention opportunities.

These ambitious regional energy visions and strategies are also spearheaded at the continental level, by the promotion of the energy agenda through NEPAD. The NEPAD continental vision advocates for increasing access to reliable and affordable energy supply for 35 per cent of the population by 2015 and access to modern energy for cooking to 50 per cent of the population. The vision and goals also call for: (i) improving the cost of energy supply to enable economic growth of 6 per cent per annum; (ii) improving the distribution of unevenly distributed energy resources; (iii) enhancing renewable energy development; (iv) reversing the negative impact of traditional biomass reliance on the environment; (v) integrating energy infrastructure; and (vi) reforming and harmonizing regulations and legislations.

The NEPAD continental vision advocates for increasing access to reliable and affordable energy supply for 35 per cent of the population by 2015 and access to modern energy for cooking to 50 per cent of the population.

From the global to the regional and subregional levels, a broader consensus is achieved at the policy level on the relevance of dealing with the energy access challenge head-on to gather 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 United Nations Secretary-General, Mr. Ban Ki-moon, declared that he made Sustainable Energy for All a top priority because it was central to all aspects of sustainable development. As the debate on a post-2015 development agenda has intensified at the United Nations, among member States and development stakeholders, the issue of access to energy may enter the post-2015 agenda, directly or indirectly.

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 subregional levels, Mr. Ban Ki-moon launched an ambitious global vision for energy access, targeting major achievements by 2030, at the opening of the United Nations General Assembly in September 2011. The year 2012 was named "Year of Sustainable Energy for All" to promote the energy access global vision. The core tenets of the SEFA vision are: (a) ensuring universal access to modern energy services by 2030; (b) doubling the portion of renewable energy in the global energy mix; and (c) doubling global rate of

The core tenets of the SEFA vision are: ensuring universal access to modern energy services by 2030; doubling the portion of renewable energy in the global energy mix; and doubling global rate of improvement in energy efficiency.

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 fire-wood 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 reduce waterborne 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 Millennium Development Goals.

Figure 11: The SEFA agenda and development

	Ensuring universal Energy Access	Doubling the share of Renewable Energy	Doubling the rate of improvement in Energy Efficiency
Achieving the three objectives of Sustainable Energy for All...			
... makes many development goals possible	▪ Improved health improved agricultural productivity ▪ Empowerment of women ▪ Business and employment creation ▪ Economic development ▪ Achievement of the Millennium Development Goals	▪ Affordable energy even where grid does not reach ▪ New opportunities for small entrepreneurs ▪ Decreased variability in energy costs ▪ Energy security and reduced import bills ▪ Reduced environmental impacts	▪ Lighting / appliances that require less power ▪ Fossil fuel resources used more effectively ▪ Reduced energy costs for consumers ▪ Redistribution of electricity that now is wasted or lost ▪ More reliable electricity systems

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

improvement in energy efficiency. These three goals are related to development objectives (see Figure 11).

It has been realized that to achieve these objectives, business as usual will not deliver these results. Instead, four enabling action areas are recommended: (i) energy planning and policies at all levels; (ii) business model and technology innovations; (iii) finance and risk management; and (iv) 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 speak, are expected to accelerate the path towards SEFA targets globally. Many developing countries have expressed interest in participating in the SEFA initiative (The United Nations Secretary-General's High-level Group on SEFA, 2012), with Ghana developing a national energy plan and programme of action, and Uganda, developing a national strategy for SEFA. The agenda of energy access has become the centre of global policy, and it is expected that much progress will follow.

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

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

1.4 Energy security

1.4.1 The global energy security challenge

An embargo from OPEC countries after the Arab-Israeli wars of the late 1960s (the Six Day War) and the early 1970s (Yom Kippur War), resulted in a quadruple price hike, and made the global economy descend into recession between 1973 and 1975. The consequences of the recession, which were sluggish economic growth in the 1970s and inflation (or stagflation), were far-reaching and caused economic and social damage.

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 telecommute
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 technology innovation	Develop innovative payment approaches to reduce consumer resistance to high upfront 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.

Since the oil embargo and price hike, energy security, particularly availability and affordability of crude oil, has dominated global energy security and the 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 on oil led to the creation of the International Energy Agency (IEA) in 1974, with the initial central goal of "helping countries coordinate 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 the cooperation of OPEC in oil market stability and with 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.

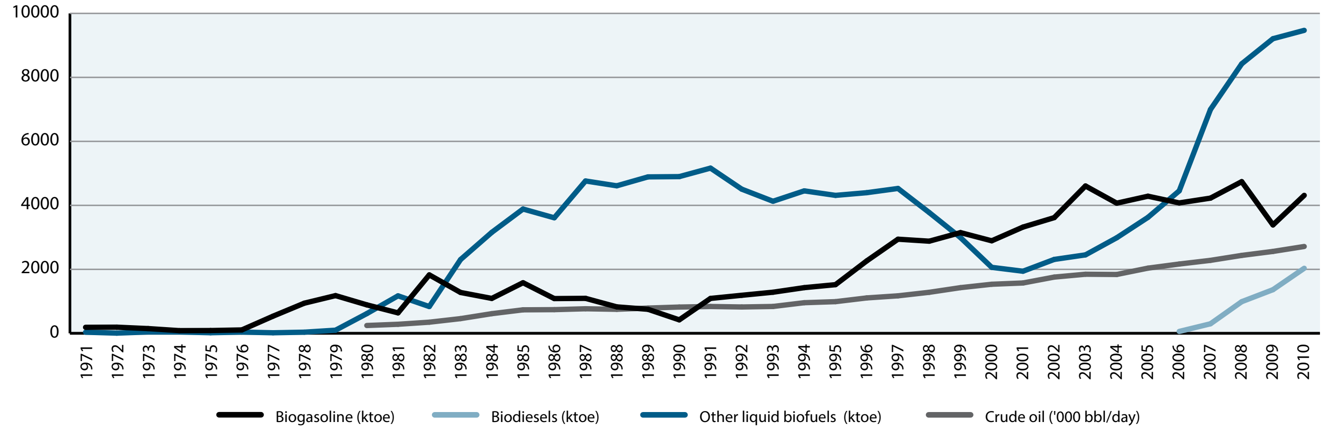
Countries that did not participate in the IEA framework pursued their own energy security strategies. For example, the successful Brazilian model of diversification after the global oil shock brought indigenous sources of energy, particularly in the transportation sector, into greater play in Brazilian society. Review of data from 1971 (pre-crisis) to

2010 on biofuels production in Brazil (see Figure 12) reveals that Biogasoline and other liquid biofuels increased sharply in the post-crisis period, largely to the concerted fuel diversification strategy pursued.

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

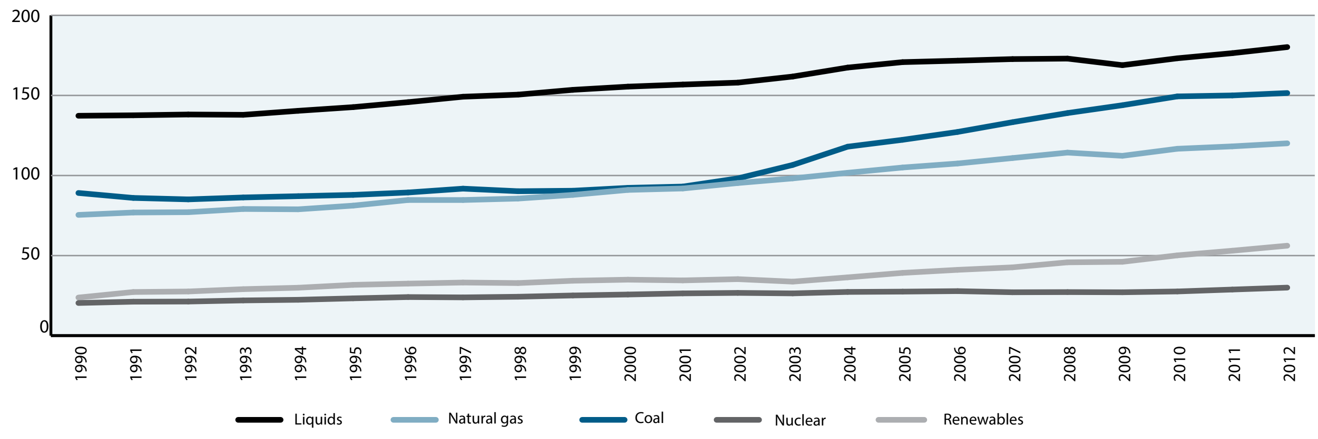
While the oil crisis in the 1970s spurred the formulation of policy and regulatory reform and new management schemes to stabilize energy markets locally, the resurgence of rapid price increases in energy commodities has raised concern about the state of global energy security. This concern is well placed, since price shifts associated with increased consumption can cause macroeconomic impacts that can be far-reaching. Consumption of liquids, natural gas and coal as well as renewables has surged globally (see Figure 13). The pressure on demand for energy sources has led to sharp increases in energy prices in recent years.

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



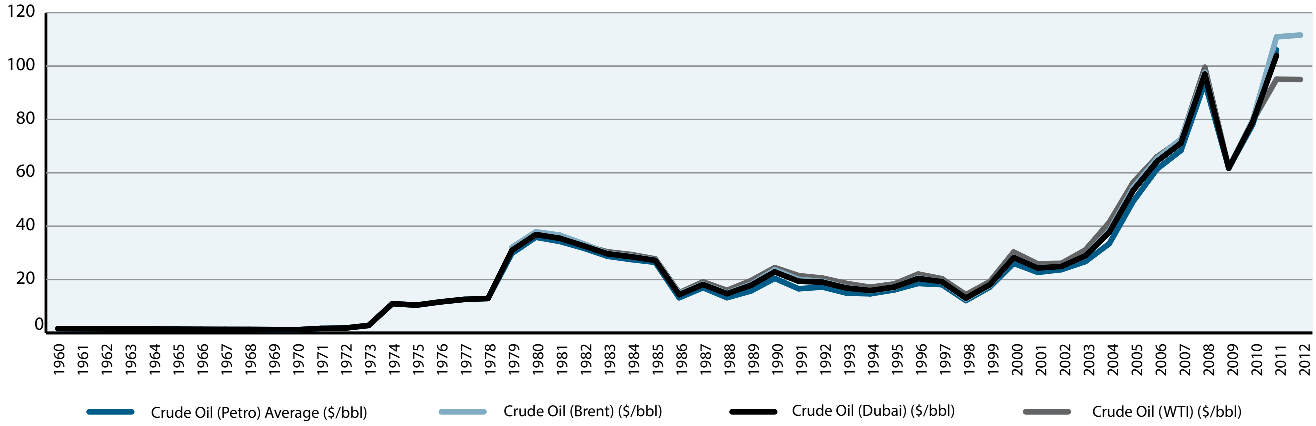
Source: Based on data from IEA. Crude oil data source is US EIA.

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

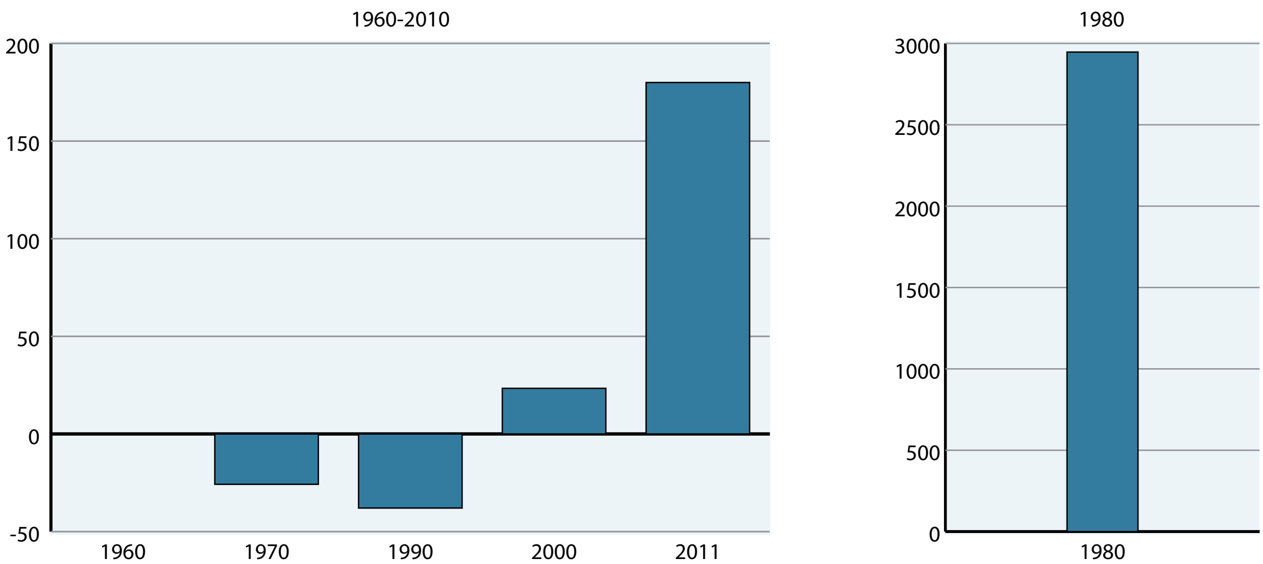


Source: World Bank Commodity Price Data (Pink Sheet) 1960-2011, and US Energy Administration for 2012 data.

Note: With the exception of Crude Oil (Petro) average, all prices are in US dollars at 2005 value.

The price of crude oil (Petro, Brent, Dubai and WTI[7]) increased gradually until 2000 (bar the oil crisis of the 1970s and 1980s), and particularly since 2008 when prices per barrel were in excess of $80, it became a norm, with subsequent years exceeding $100/bbl (see Figure 14). This phenomenon of price volatility and surge reduces energy affordability, which is a tenet of energy security. The burden on the global economy, particularly the economy of developing countries is palpable. A decade-by-decade analysis of the price shifts reveals that oil prices were indeed declining before the 1970s oil crisis, only to increase by nearly 3,000 per cent in the 1980s, recede in the 1990s, and slightly increase from 1990 to 2000. In the 2000s, though the price hike has not been as detrimental to economies as in the 1970-1980 decade, there has been a departure from the norm with a sharp increase of nearly 170 per cent (see Figure 15).

Figure 15: Percentage change in crude oil prices by decade

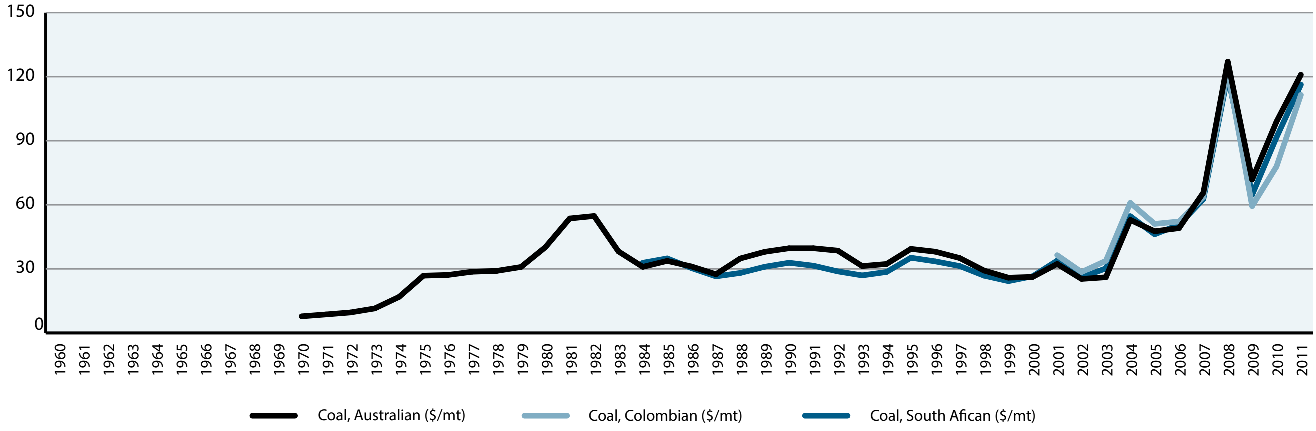


Source: World Bank Commodity Price Data (Pink Sheet) 1960-2010.

Note: 1960 is the initial reference period for 1970 values, therefore showing starting point value.

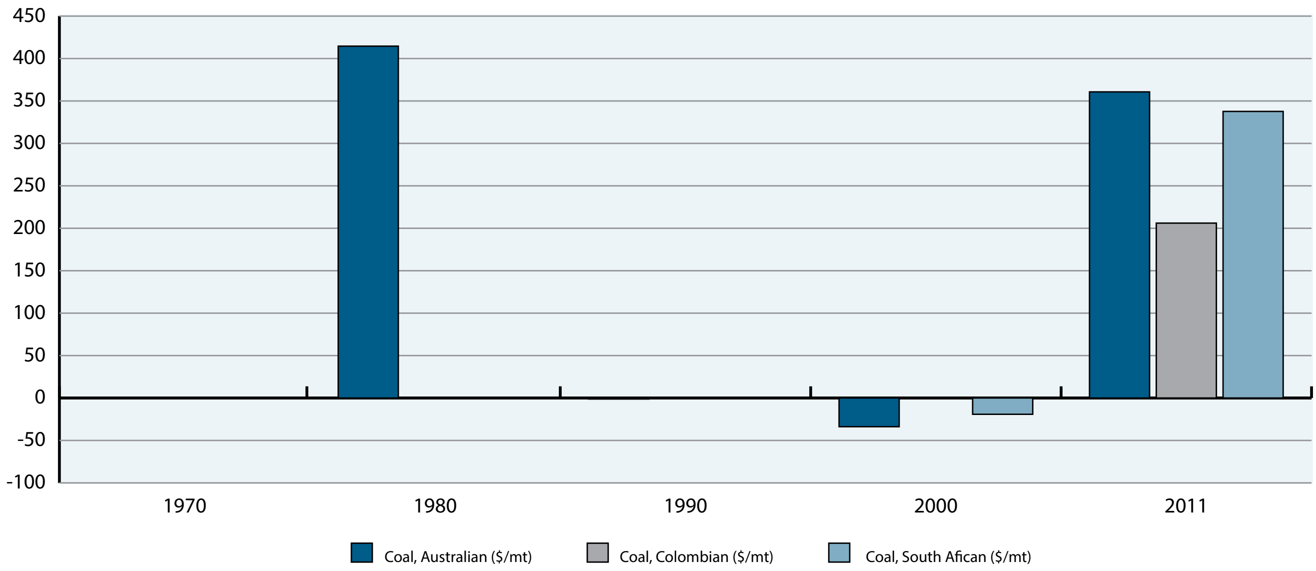
7 WTI is the West Texas Intermediate crude oil.

Figure 16: Coal price trends



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

Figure 17: Percentage change in coal prices by decade



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

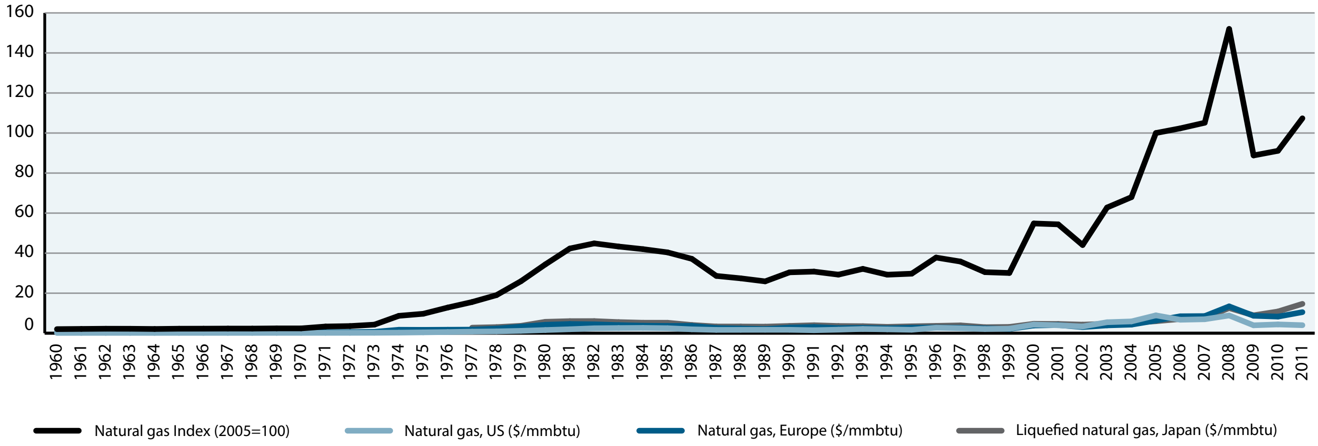
Note: 1970 is the initial reference period for 1980 values, therefore showing starting point value. Data for Colombian coal prices available from 2001-2011; the value shown is comparison from 2001-2011. The data for South African coal is available from 1984-2011. Comparison for 1980-1990 period is based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

Volatility and price surge in global energy markets pose serious energy security and economic stability challenges to countries, particularly in the developing world.

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 influence prices. After a relatively long stable period in the coal market till the early 2000s, post-recession (2008) prices for Australian, Colombian and South African coal have surged sharply (see Figure 16).

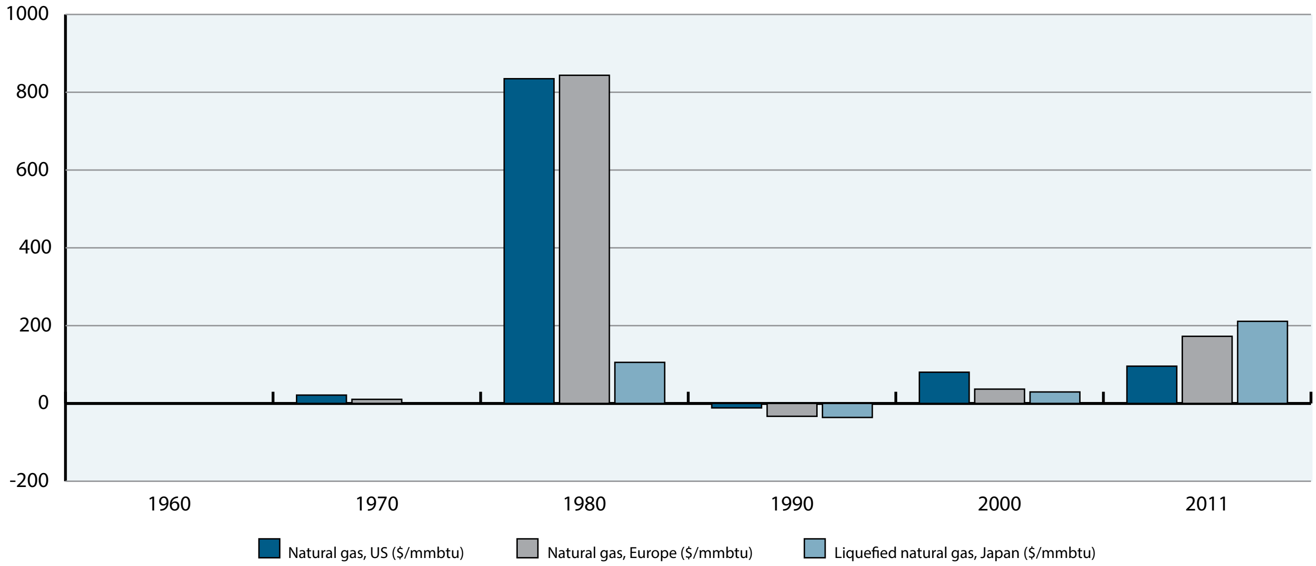
A decade-by-decade look at coal prices demonstrates that the oil crisis of the 1970s also led to Australian coal price increases in the decade ending 1980 by over 400 per cent. Coal prices have stabilized and declined ever since, until the 2000-2011 period, when prices for Australian, Colombian and South African coal surged by 361 per cent, 206 per cent and 338 per cent, respectively (see Figure 17). The challenge for economies that may not rely on coal but on imported liquids is that prices seem to pass from one energy commodity market to another, largely due to speculation.

Figure 18: Natural gas price trends



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

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 on 1977-1980 data. Comparison for the last period is from 2000-2011.

There has also been a momentum in the natural gas market in the last decade, due to climate change and environmental concerns in the use of coal, regarding 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, has shown a significant surge since 2005 (see Figure 18).

Volatility and price surge in global energy markets pose serious energy security and economic stability challenges to countries, particularly in the developing world.

A decade-by-decade analysis of the price trends reveals that apart from the 1970-1980 price hike of over 830 per cent (see Figure 19), prices actually went down in the 1980-1990 decade. Prices surged again in the 1990-2000 decade, mainly in the United States natural gas market, followed by a sharper increase in the 2000-2011 period, particularly in the LNG market in Japan.

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

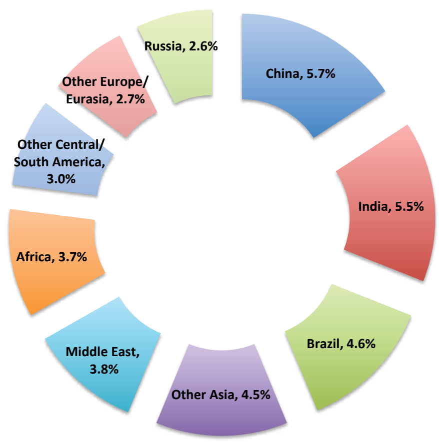
1.4.2 The new sources of global energy insecurity

Long-term structural changes are introducing a new dynamics in the global energy market, and one such factor is a structural shift in the origin of global growth.

Traditional sources of energy insecurity, stemming from supply and demand, speculation, market dependence, political instability, diversity of supply sources and other factors are widely discussed in energy security literature (see for example IEA, 2007; Toman, 2002; Jenny, 2007; Scheepers and others, 2007; Jansen and others, 2004; Awerbuch, 2006; Frondel and Schmidt, 2008; Grubb and others, 2006). Long-term structural changes are however introducing a new dynamics in the global energy market, and 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] countries. The growth rate projection from 2008 to 2035 (see Figure 20) shows robust global economic increase over the next three decades. Africa is peaking, at what seems to be a conservative growth projection of 3.7 per cent; the Middle East 3.8 per cent; Central and South America 3 per cent; and much of Asia 4.5 per cent; among others. The global economy is in an expansion mode, increasing the global demand for energy commodities, particularly hydrocarbons.

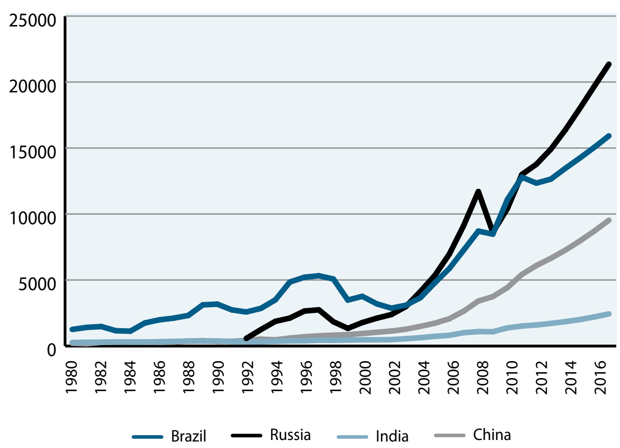
Dominant growth prospects are expected in BRICs (see Figure 20). Except for Russia (projected to grow at 2.6 per cent till 2035), the BRIC countries are projected to experience more than 4.6 per cent rates till the mid 2030s. Global growth is accompanied by a rise in income per capita. Personal incomes, particularly in Russia, Brazil and China are expected to increase quite sharply, 2 to 5 times by 2017 from levels in 2000 (see Figure 21). Growth in GDP and personal income will put added pressure on energy markets, with likely upward price responses 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 to which BRICs are net importers or exporters of oil (Bhar and Nikolova, 2009).

Figure 20: Projected growth: 2008-2035



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

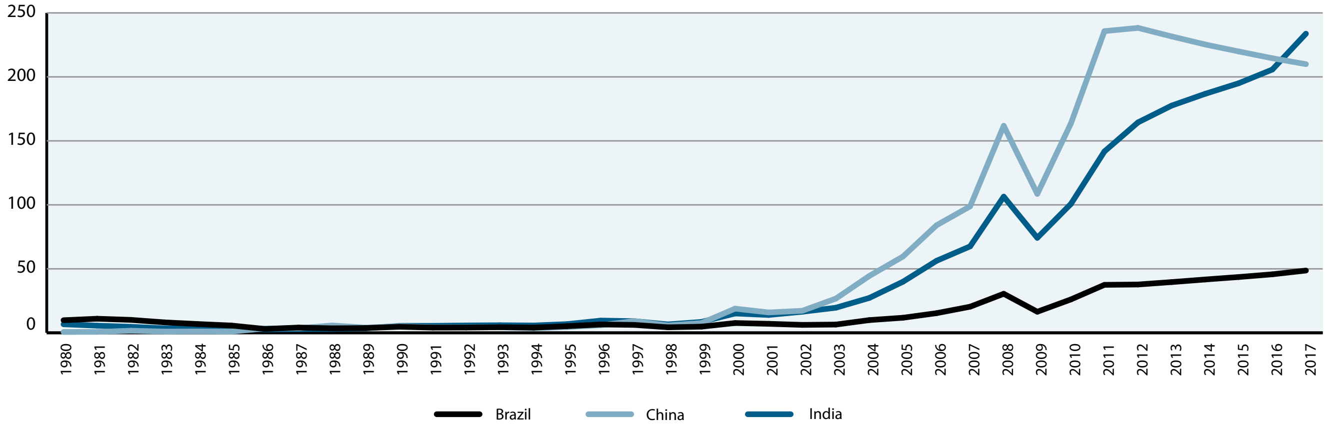
Figure 21: GDP per capita in BRICs: 1980-2017



Source: Based on IMF, World Economic Outlook data.

8 BRIC refers to Brazil, Russia, India and China, countries with fast growing economies.

Figure 22: Oil import bills for Brazil, China and India (in billion US$)



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

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

While Bhar and Nikolova (2009) advise that the impact of BRICs on global energy prices is dependent on their net trading position, indications are that BRICs are increasing their presence in global energy markets. The total import bill for China, India and Brazil (Russia is a net exporter of energy) from 2000-2012 reveals that their oil import bill increased by 54 per cent, 215 per cent and 164 per cent respectively, between 2000 and 2005. In the 2006-2012 period the oil import bill for China, India and Brazil further grew by 146 per cent, 183 per cent and 192 per cent, respectively. This surge in oil imports is projected to increase rapidly in the foreseeable future (see Figure 22), increasing the competition for existing oil supplies and contracts, raising pressure on energy commodity prices in the futures market, and increasing pressure on short-term energy prices, thus affecting global energy security. Regarding developing countries, they are likely to incur rising energy import bills, thus drawing on resources that could have been used for other productive activities.

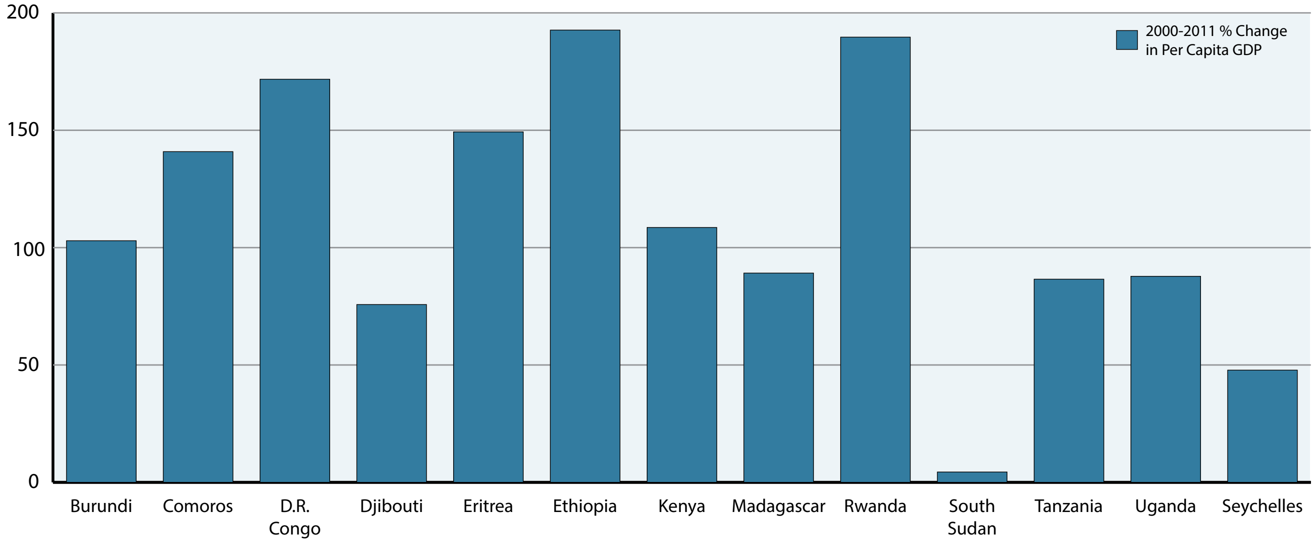
1.4.3 Energy security in Eastern Africa

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

Developing countries are likely to incur rising energy import bills, thus drawing on resources that could have been used for other productive activities.

GDP projections by the IMF about the global economy, in the *World Economic Outlook*, offer progressive assessment for the subregion up to 2017. In both small and island states as well as in large states, GDP is expected to rise significantly, and particularly so in Burundi, Eritrea, Ethiopia, Kenya, Rwanda and Tanzania, though the entire region is expected to see a rise (see Figure 24). Sustaining the economic momentum through

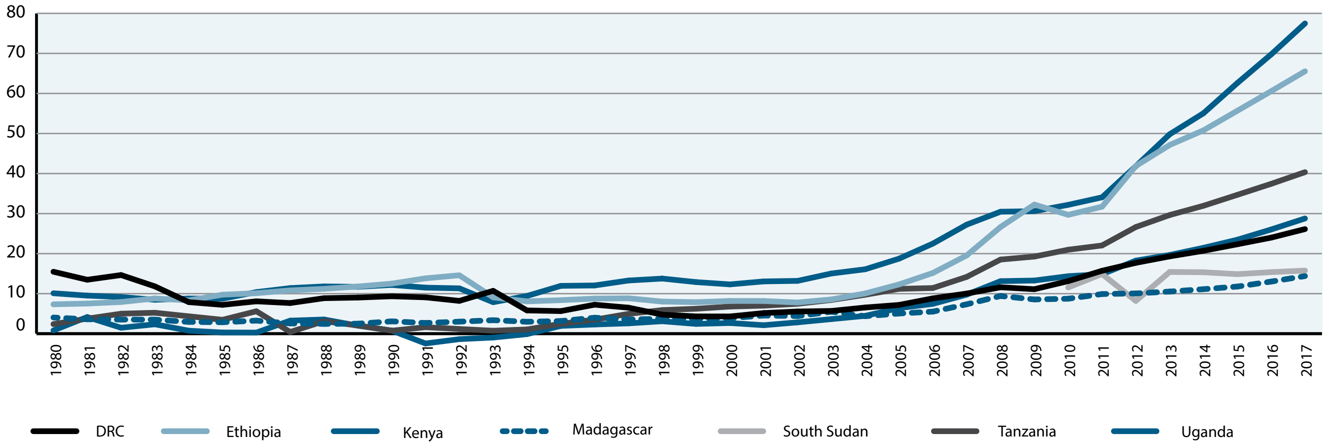
Figure 23: Per capita GDP growth in Eastern African subregion member States: 2000-2011

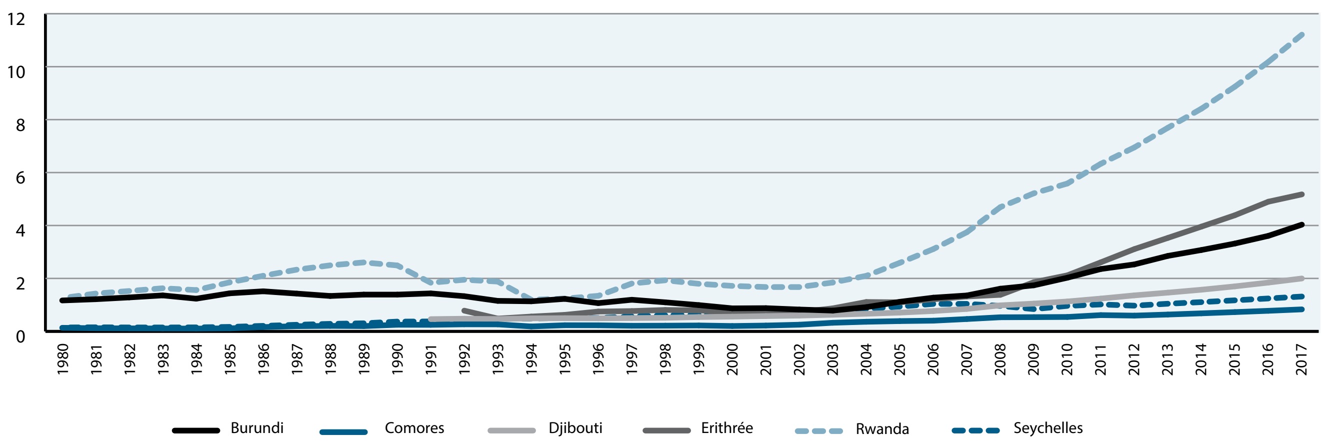


Source: Based on IMF, World Economic Outlook data.

Note: South Sudan growth rate is computed from 2010-2011.

Figure 24: Real GDP (in billion US$) of Eastern Africa subregion member States: 1980-2017





Source: Based on IMF, World Economic Outlook data.

energy security is likely to enter the policy debate as robust growth will require increase in supply of energy input. A number of factors can affect the projected scenario, including global energy prices till 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 major petroleum requirements, the region is exposed to global energy market shocks to the maximum. Shielding economic gains from these shocks in the future will require a regional focus and strategy.

Since all member States import their major petroleum requirements, the region is exposed to global energy market shocks to the maximum. Shielding economic gains from these shocks in the future will require a regional focus and strategy.

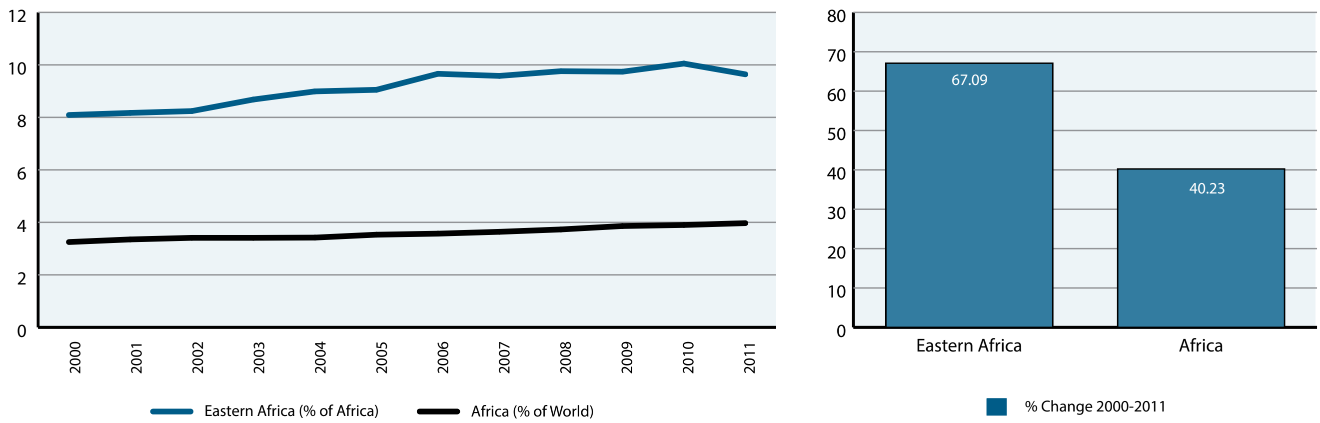
Petroleum consumption is already surging in the Eastern Africa subregion. The global share of petroleum consumption in Africa has gradually increased from around 3.25 per cent to about 4 per cent over a decade (see Figure 25). In the same period, the share of the Eastern African subregion in Africa's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

To identify the source of increase in petroleum consumption in the Eastern Africa subregion, a country-by-country trend analysis will be informative. Three observations can be made about petroleum consumption patterns in the Eastern Africa subregion. First, comparing countries with smaller economies with those with relatively large populations and economies (see Figure 26), shows that much of the subregional increase in petroleum consumption did not come from smaller economies, such as Somalia, Burundi, Rwanda, Djibouti and Eritrea. The increase came from Island States and larger economies, such as the Comoros, Madagascar, Uganda, Ethiopia and Tanzania. Second, as a result of this, large economies and Island States in the subregion are more exposed to international market risks and the impact thereof. 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.

Consumption at the continental level increased by slightly more than 40 per cent, the rise in the Eastern African subregion was 67 per cent. This constitutes a significant increase in exposure to global energy markets.

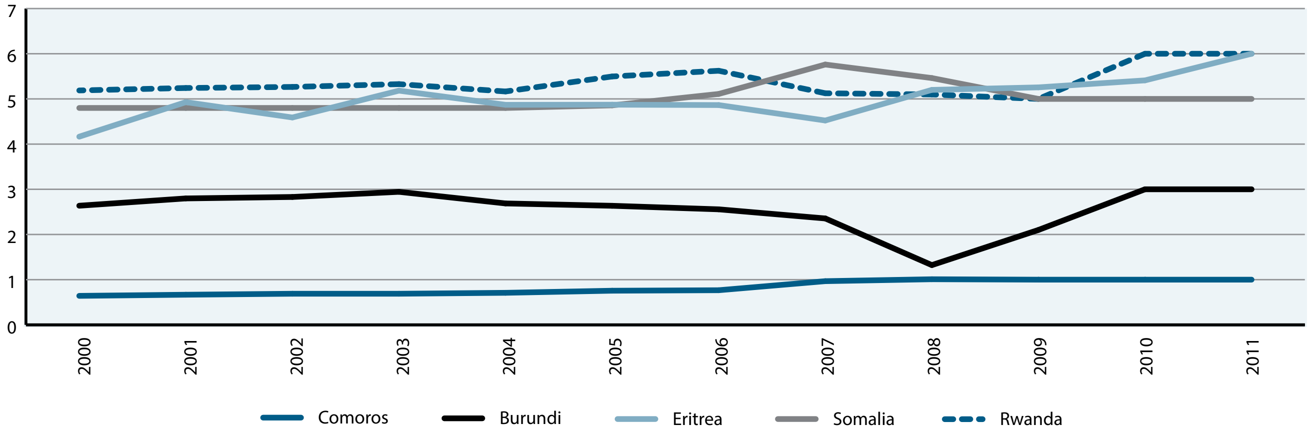
Comparison of percentage changes in petroleum consumption from 2000-2010 supports these propositions. The Island States of the Comoros and Madagascar saw consumption increases of 56 per cent and 98 per cent, respectively. Larger economies such as Uganda, Ethiopia and Tanzania saw increases in the range of 75 per cent, 94 per cent and 166 per cent, respectively (see Figure 27). Smaller economies saw changes in the range of 4.2

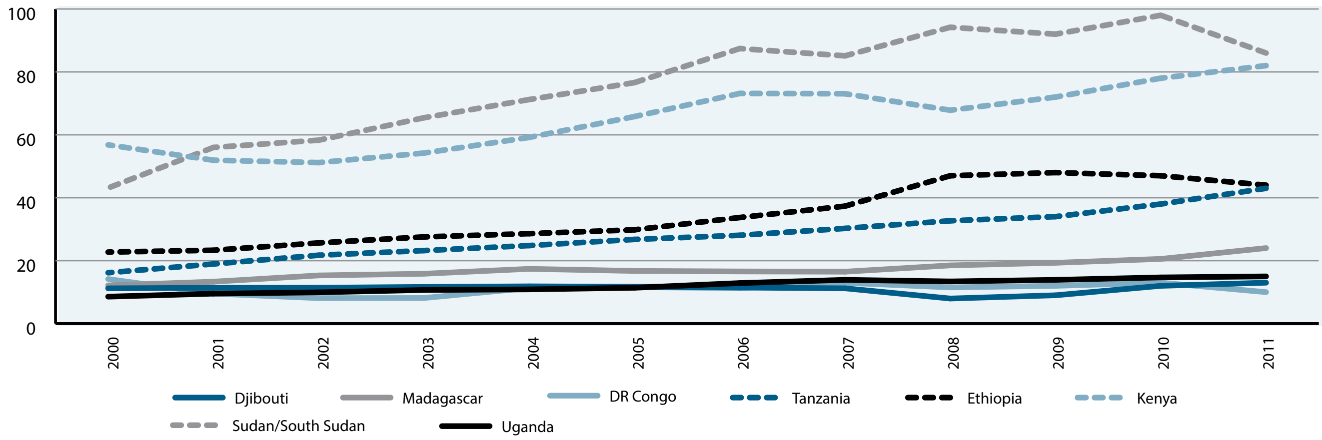
Figure 25: Petroleum consumption shares of Africa and the Eastern Africa subregion and consumption percentage changes: 2000-2011



Source: Based on data from US EIA.

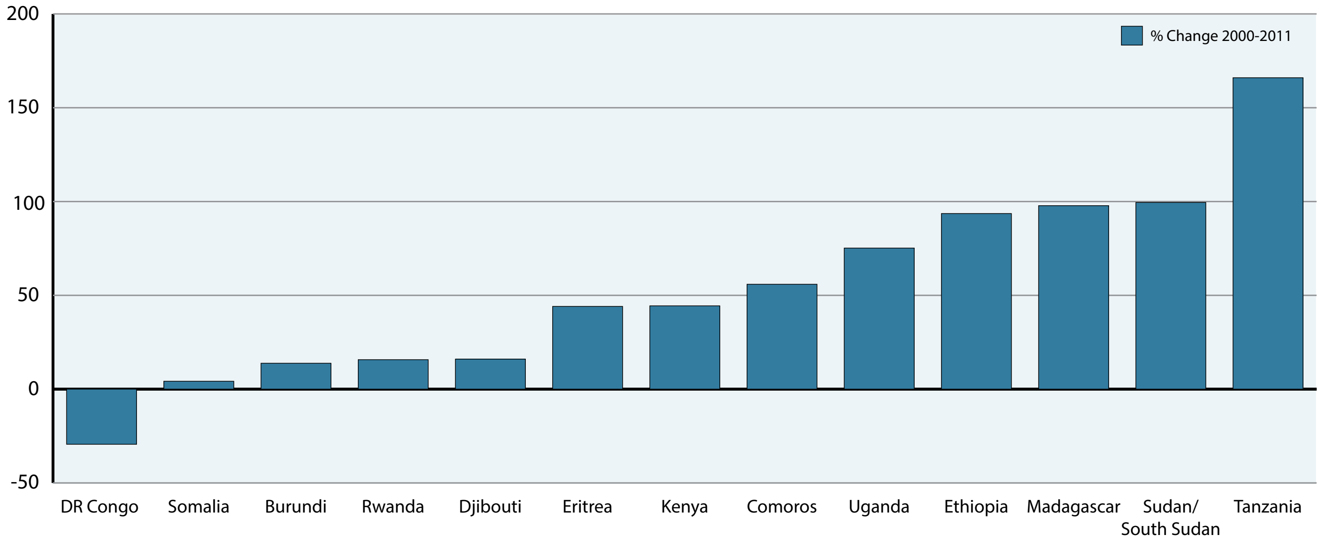
Figure 26: Petroleum consumption in thousands bbl/day: 2000-2011





Source: Based on IMF, World Economic Outlook data.

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



Source: Based on data from US EIA.

per cent in Somalia, 14 per cent in Burundi and 16 per cent in Rwanda and Djibouti, which are modest for a decade change.

1.4.4 Why energy security matters in the Eastern Africa subregion?

Energy security is better understood when viewed beyond oil supply and inclusive of electric generation and distribution as well as the use of bioenergy sources, from traditional and processed biomass. Biomass is mainly resourced locally, and is generated partly by biological processes that respond to long-term harvest and environmental regeneration patterns. Electricity generation from clean energy sources, such as hydro, is based on hydrological patterns, related to climate change risks and drought. Dependence on imported energy poses a serious risk as many of the factors that determine its supply and price are outside the control of importing states. In this context, the discussion in this section will focus on the latter, and return to the biomass and electricity components in the next chapter.

Increases in oil prices in recent years (post 2008) have led to a drift in current account balances of subregional member States.

The nexus between energy and economic and social development has been discussed in earlier sections. The argument is that the achievement of the MDGs relies partly on the availability and accessibility of modern forms of energy, and energy security can also be considered 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 the economic development taking root in the Eastern Africa subregion. Disruption can also hamper proper functioning of the socioeconomic system, and lack of affordability can withhold economic activities, particularly in energy intensive industries. Energy security is therefore a component of economic stability.

The most direct impact of dependence on imported oil is price hikes in global markets. Comparison of oil import values and current account balance for countries in the subregion (see Figure 28) demonstrates the importance of energy security. Increases in oil prices in recent years (post 2008) have led to a drift in current account balances of subregional member States as seen from trend. The observation is consistent throughout the region, except in Eritrea (trend reversed due to contributions of mining sector revenues from gold). Increased negative balances in the current account is likely to lead to a drawdown of foreign reserves, or an increase in public debt to finance imports, both posing a risk to sustained robust economic growth in the region.

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

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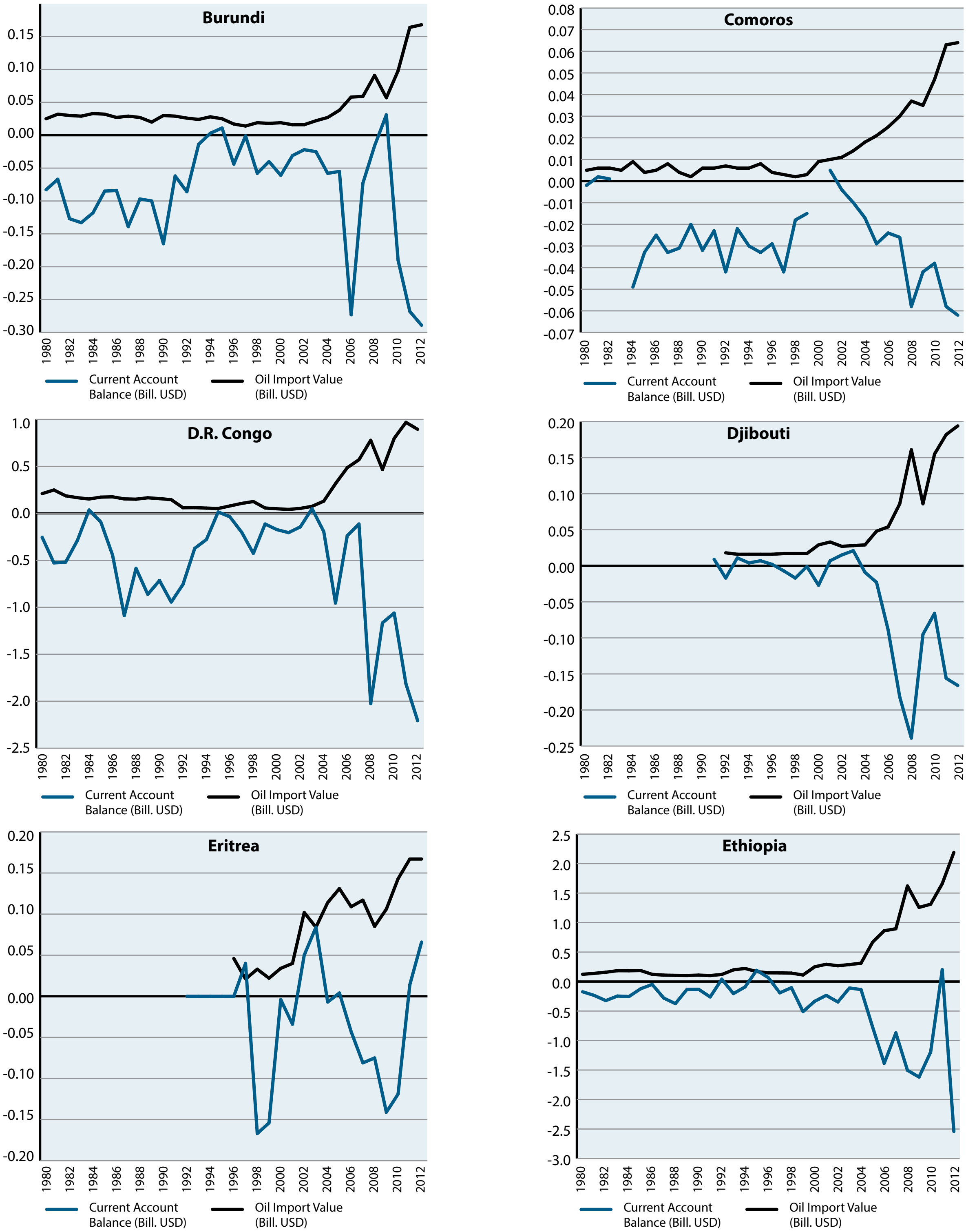
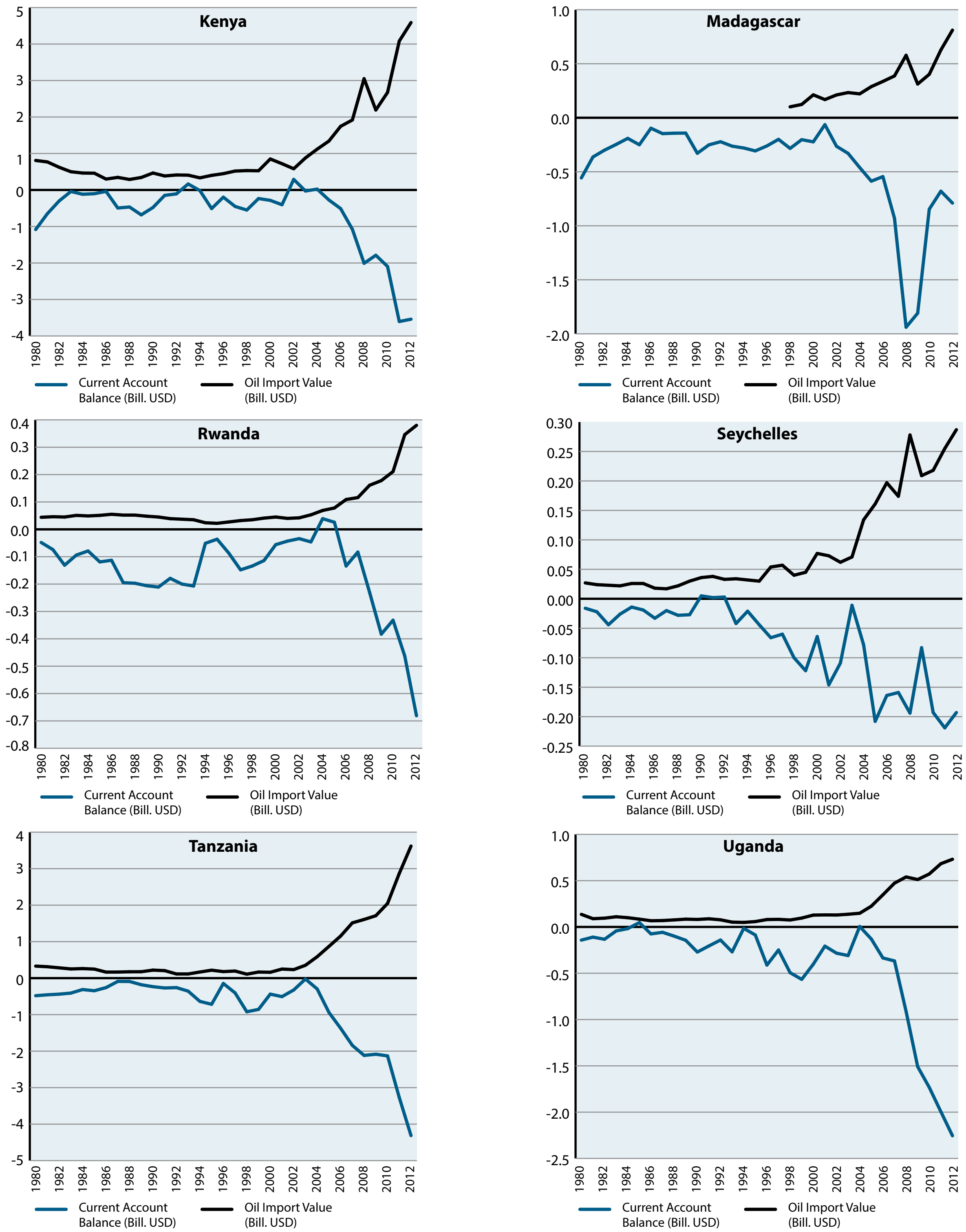
Figure 28: Oil import values and current account balances in Eastern Africa subregional member States, in billion US$: 1980-2011





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

Measuring the Status of Energy Access in the Eastern Africa Subregion and Potential Monitoring Frameworks

2

2.1 Measuring energy access

A proper measurement and monitoring mechanism is needed to trace energy access goals to determine the degree to which they are pursued and implemented. That in itself depends on what is meant by energy access. There is no globally accepted definition for energy access, nor is there a 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 is important.

The United Nations 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-being. 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…" (United Nations Secretary-General High-Level Group on SEFA, 2012b). From these statements, the idea that emerges is that energy access is related to access from a 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.

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 focus on access to electricity and cookstoves, with a long-term progression to increasing the level of energy consumption to some regional standard. Access to electricity and cookstoves is therefore 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 definition emphasizes on households and 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 one, access to basic human energy needs, that is, 50-100 kwh/person/year and 50-100 kgoe of modern fuel is deemed necessary. In stage two, access to productive uses of energy is required. In stage three, access to energy usage of 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.

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.

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 according to a set of measures that define policy setting and implementation strategies. For example, Ethiopia promotes a definition of energy access that focuses on 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 whether to connect to it or not. Access is therefore defined as giving households in a community the ability to connect if they choose so, and not necessarily the number of household connections. In much of the Eastern Africa subregion, energy access is defined as the number of households with connection to electricity on-grid or off-grid, and to clean cooking devices, though the economic use of energy is also emphasized. In Uganda however, energy access is considered in conjunction with the economic strategy to revitalize the agricultural sector, and in DRC energy is considered 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 with the goal of enhancing energy access to achieve a target will succeed by using 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 and business cycles among others. These indicators sufficiently inform decisionmakers 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 policymakers 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 the measurement and monitoring framework to support decisionmakers in the translation of the energy access goal and targets into reality.

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 enhancing it seems a natural transition. There is already momentum in the energy literature giving valuable insights. Bazilian, and others (2010) reviewed energy sector indicators and observed that they were: single metric indicators; series of single indicators (dashboard); or composite indices that summarized 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 a 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. The United Nations 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 ease to acquire data can make these indicators appealing. Foster, and others (2000) propose a measurement regime around energy poverty. The study advises that the number of households below the fuel poverty line can be determined by establishing a fuel poverty line. 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 to utilize it repeatedly 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 – the 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 the measurement of multiple dimensions of energy deprivation, including access to basic appliances and cooking facilities. While these complex indicators require a 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 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): (a) availability of data on a continual basis; (b) degree to which the indicators are statistically sound; (c) ability to compare across different political units (for example countries); (d) validation of the method; (e) cost of utilizing the indicator for analysis; (f) the degree to which urban and rural access are differentiated; (g) degree to which policy and regulatory improvements are accounted for; and (h) political acceptability. Considering these potential criteria, a selection of a measurement and monitoring indicator(s) can support decisionmakers to monitor progress towards ambitious energy access targets.

2.3 The role of energy access targets

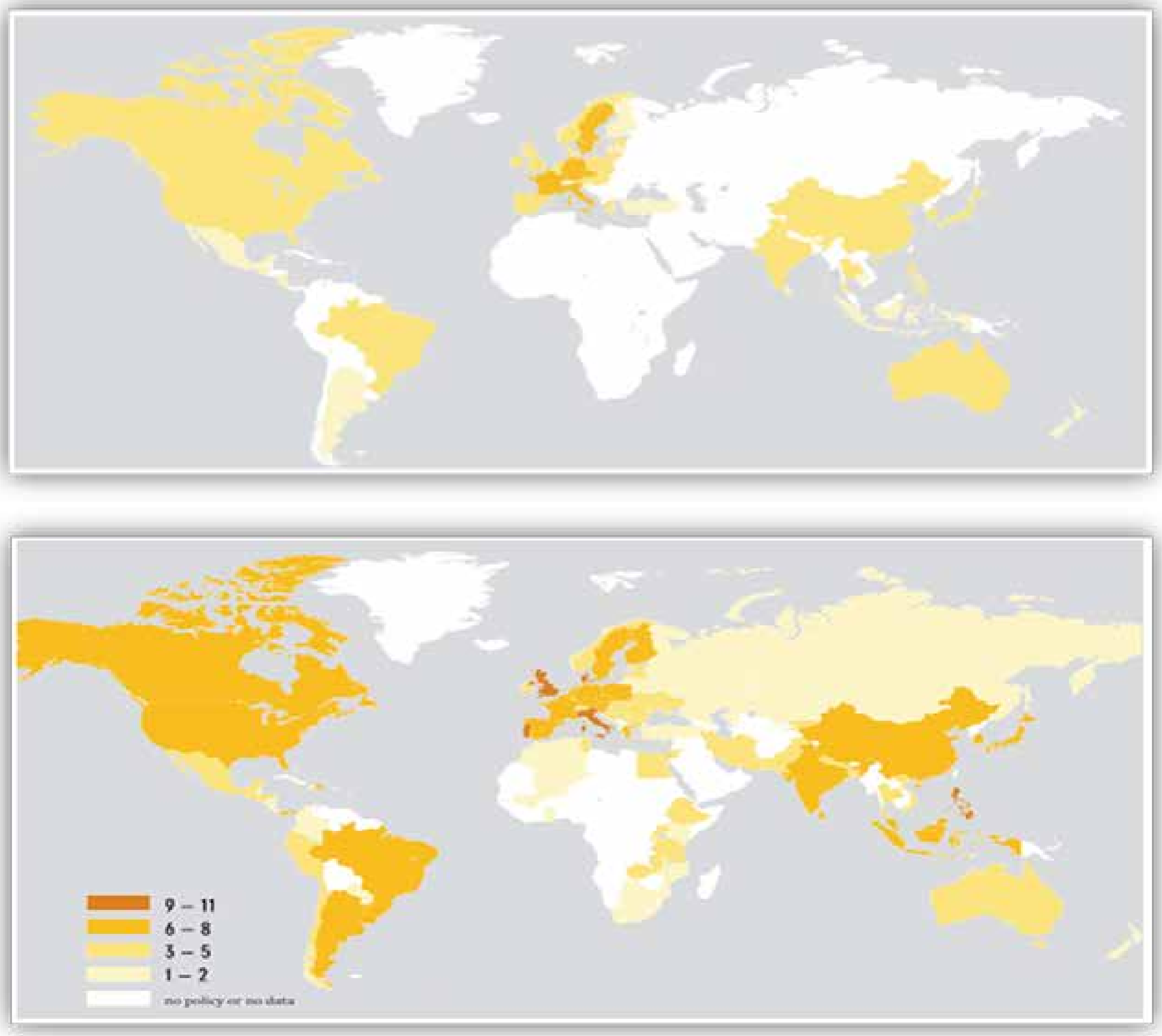
Measuring and monitoring energy access requires a policy preset: the existence of an energy policy, vision or strategy that lays down a clear target. Targets offer the finish-line on the basis of which interim progress can be measured and monitored. Energy access targets in the Eastern Africa subregion are complemented by continental and intracountry 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 per cent to 35 per cent within 20 years.
- Improving energy reliability and lowering its cost to sustain a 6 per cent economic growth.
- Reducing the environmental impact of traditional biomass use.
- Integrating grid and gas pipeline infrastructure to facilitate cross-border energy trade.
- Harmonizing 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.

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).

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

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

- Access to modern cooking energy for 50 per cent of biomass users.
- Access to energy for all schools, clinics, hospitals and community centres.

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% 15%	2020 2030
Uganda	54%	61%	2017

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

- Access to energy services for 100 per cent of urban and peri-urban residents.

- Access to mechanical power for 100 per cent of communities for productive use.

Comparison of particularly renewable energy policy evolution, with the potential to enhance access, in 2005 and 2011 shows that Africa, and particularly the Eastern Africa subregion, has made progress in that the subregion has introduced new policy tools to expand access, particularly in Ethiopia, Uganda, Rwanda and Burundi.

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 Figure 29) shows that Africa, and particularly the Eastern Africa subregion, has made progress in that the subregion has introduced 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 intracountry 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.

Benchmarks for energy access in the Eastern Africa subregion are more dynamic, given the setting of benchmarks in intracountry policy environments. For example, Ethiopia has set a 75 per cent electricity access by 2015, from the current level of 45 per cent.[9] Rwanda also targets a 70 per cent access rate by 2017.[10] Tanzania has set a target for rural electrification of 30 per cent of the population by 2015, from the current level of 2 per cent. South Sudan has set a 70-80 per cent target for electrification.[11] On the aspect of transportation fuel, Ethiopia remains the only country in the subregion with a biofuel blending mandate (E10) through the experimental programme in Addis Ababa, with plans to extend it to more cities.

Small and Island States have taken the lead in setting policy goals to scaleup renewable energy integration into the electricity system.

Energy sector targets do not only relate 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 subregion 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 scaleup renewable energy integration into the electricity system. The plan of Rwanda is among the most ambitious, targeting 90 per cent share of electricity production to come from renewables, and to achieve it initially by 2012.

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

9 Articulation of Ethiopia 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.

10 See http://www.mininfra.gov.rw/index.php?id=88&tx_ttnews[tt_news]=34&cHash=76786f8e21177530e9df931c700ac7c4.

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

50 per cent renewable energy in the electricity production portfolio is expected to come from wind energy. Ethiopia targets wind energy (770 MW by 2014), hydroelectricity (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, and expected to bring in 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 encouraging. Given the multiple layers of targets for energy access from continental, subregional and country levels, coordination and harmonization will be key in measuring and monitoring effectively progress towards established targets.

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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 per cent of households already owned improved cookstoves by 2008, with more 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 distributed in Benin, Burkina Faso, Burundi, Ethiopia, Kenya, Senegal, and Uganda since 2009 with support from GIZ of Germany; … the ongoing project in Kenya, which is jointly implemented with the Ministries of Energy, Agriculture, and Education, has distributed 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 per cent 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 $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, by providing at least 15,000 biogas digesters to rural households with cows.

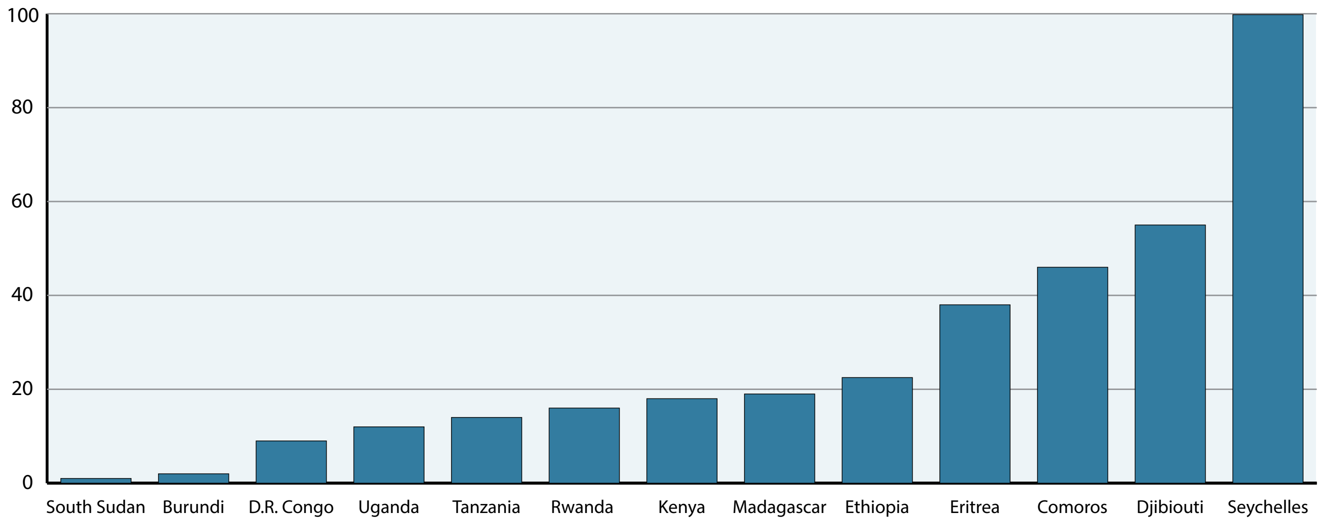
A number of Eastern African member States have set energy access targets at different levels and target years, prioritized the integration of renewable energy into the electricity generation portfolio, and set fuel source targets as a pathway to meet the renewable energy targets. Dissemination of improved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

The level of energy access in member States of the Eastern Africa subregion is generally quite low, ranging from 1 per cent in South Sudan, 2 per cent in Burundi, 9 per cent in DRC, 12 per cent in Uganda and to relatively better performance in Comoros (46 per cent), Djibouti (55 per cent) and Seychelles (99.8 per cent).

2.4 The state of energy access in Eastern Africa

The level of energy access in member States of the Eastern Africa subregion is generally quite low, ranging from 1 per cent in South Sudan, 2 per cent in Burundi, 9 per cent in DRC, 12 per cent in Uganda and to relatively better performance in Comoros (46 per cent), Djibouti (55 per cent) and Seychelles (99.8 per cent) (see Figure 30). In most of the member States, electricity access rates are below 20 per cent, with large urban-rural gaps. Rural electricity access is in single digit in many of the member States. Comparison of access gaps within the Eastern Africa regional average, with the average for sub-Saharan Africa, middle-income countries and the universal access target reveal the depth of the energy access challenge in the subregion.

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



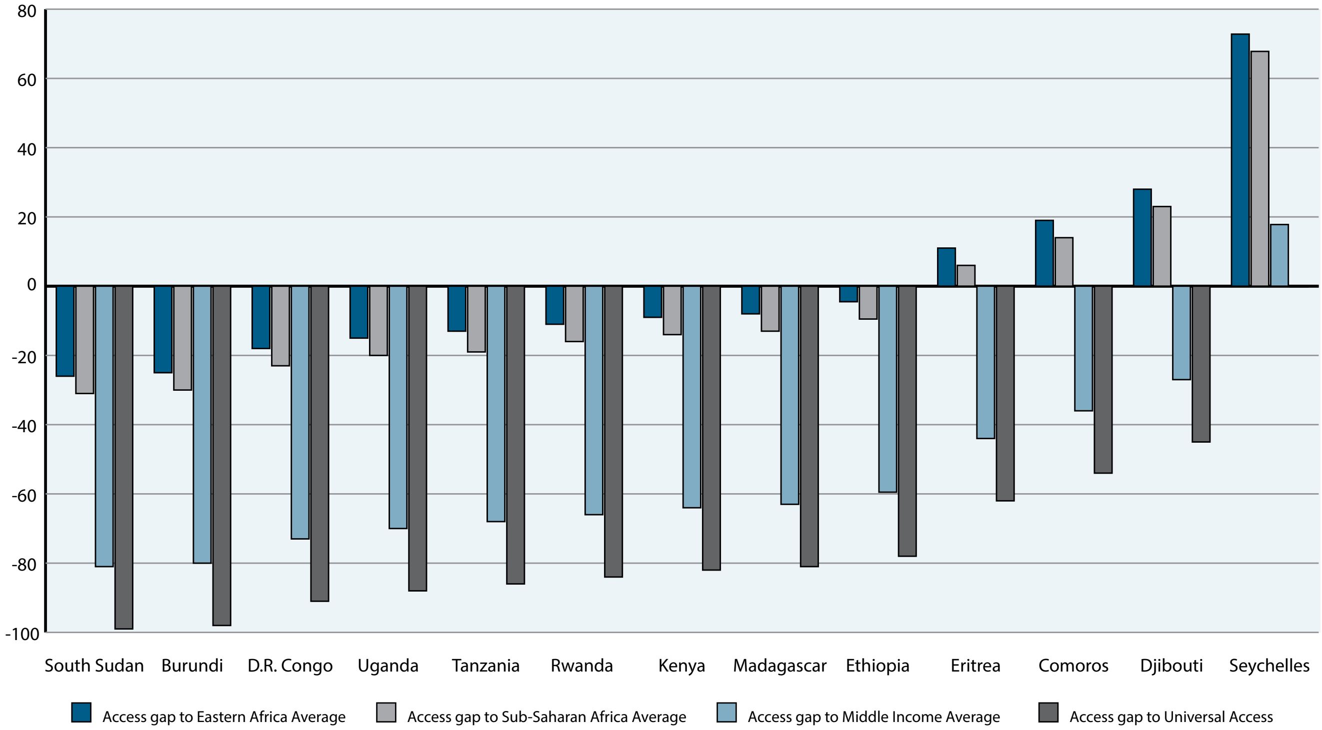
Sources: Data from country missions (South Sudan, DRC (2011 data), Uganda, Tanzania (from Joint Energy Sector Review report), Madagascar and Ethiopia, updated data based on official presentation at UNECA, SRO-EA 17th ICE meeting (Burundi, Eritrea and Seychelles), African Development Bank (Djibouti 2010 Ethiopia-Djibouti Power Interconnection Project report) and Rwanda (2012 Rwanda Energy Sector Review and Action Plan report)), REN21 (18 per cent access rate in 2013) for Kenya and IRENA and Reegle.info for Comoros.

Comparison within the subregion can help identify member States with comparative intensity regarding the access challenge. Comparison with sub-Saharan countries provides a profile of energy access in the subregion 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 countries 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 Figure 31. The assessment includes 13 of the 14 member States, leaving out Somalia due to lack of access data.

The intensity of the gap between subregional and country access is largest in South Sudan (down by 26 per cent), Burundi (down by 26 per cent), Uganda (down by 15 per cent) and DRC (down by 18 per cent). Tanzania, Rwanda, Kenya, Madagascar and Ethiopia have gaps of 13 per cent, 11 per cent, 9 per cent, 8 per cent and 4.5 per cent, respectively.

Within the Eastern Africa subregion, the average electricity access level is about 27 per cent, mainly due to the high access rate in Seychelles (99.8 per cent). The subregional average without Seychelles drops to just 21 per cent. Out of the 13 countries depicted in Figure31, 4 have electricity access rates above the subregional average of 27 per cent: Eritrea (up 11 per cent), Comoros (up 19 per cent), Djibouti (up 28 per cent) and Seychelles (up 72.8 per cent). Subregional access rates tend to be higher in coastal small States and Island States. The relatively small population that is reachable through the gird could be one reason, and 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 (electricity trade with Ethiopia has now improved per unit cost), Eritrea and Seychelles, and to a similar level in the Comoros, barring the slight contribution from hydropower. On the contrary, in 9 of the 13 countries in the analysis, access levels are below the subregional average. The intensity of the gap between subregional and country access is largest in South Sudan (down by 26 per cent), Burundi (down by 26 per cent), Uganda (down by 15 per cent) and DRC (down by 18 per cent). Tanzania, Rwanda, Kenya, Madagascar and Ethiopia have gaps of 13 per cent, 11 per cent, 9 per cent, 8 per cent and 4.5 per cent, respectively. Countries with access gaps within the subregional average are those with vast hydropower potential (DRC and Ethiopia), small landlocked countries (Burundi and Rwanda), countries with oil and gas potential

Figure 31: Assessment of the electricity access gap in Eastern African countries relative to subregional, sub-Saharan, middle-income and "universal access" levels



(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 per cent, slightly higher than the Eastern African subregional average (27 per cent). The Comoros, Djibouti, Eritrea and Seychelles have electricity access levels significantly above the sub-Saharan average. The rest of the member States in the subregion under perform compared with the sub-Saharan level, by a margin ranging from 31 per cent to 9.5 per cent. This reveals the degree to which the subregion faces an alarming energy access challenge.

A number of subregional member States aim to make a transition to middle-income status as a medium- to long-term economic development objective. The transformation will require rapid expansion of energy capacity to sustain economic growth to the middle-income post. Middle-income countries, on average, have an electricity access rate of 82 per cent. With the exception of Seychelles (up 17.8%), all other member States have significant access deficit from the middle-income level. The deficit is 80 per cent and above in South Sudan and Burundi, in the range of 70 per cent and above in Uganda and DRC, between 60 per cent and 70 per cent in Tanzania, Kenya, Rwanda, Madagascar and Ethiopia, and between 27 per cent and 44 per cent in Eritrea, Comoros and Djibouti.

All member States in the subregion have gaps compared to "universal access," of course, with targets to be met by 2030, not 2013. But the current gap is reflective - it is in the range of 45 per cent to 99 per cent, but Seychelles has a deficit of just 0.2 per cent. The energy access challenge in the subregion is massive, requiring far-reaching vision, implementation strategy and regional cooperation.

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2.5 The structure of low energy access in Eastern Africa

Formulating strategies to expand energy access will require a consideration of the underlying causes of poor access levels in the Eastern African subregion. Energy access challenges have several similarities in the subregion, and in the wider African and international context. The root causes for the level of achieved energy access are based on the demand and supply sides of the energy system in a country, as well as the institutions, policies and regulatory bodies that govern their management.

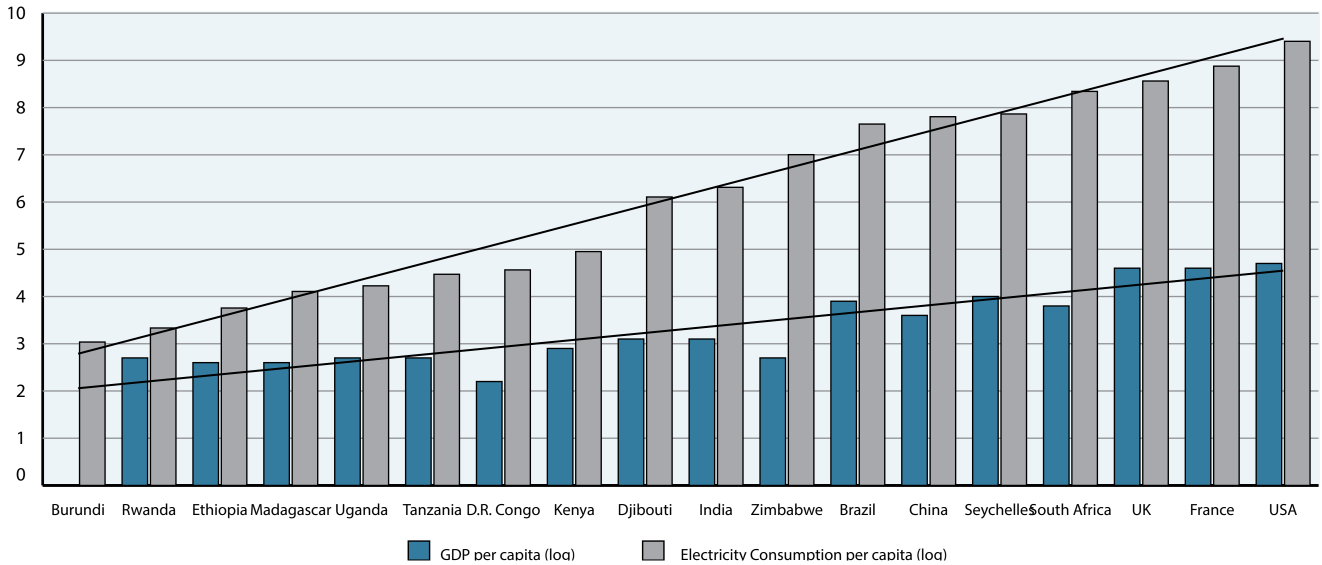
2.5.1 Demand side constraints

The energy access challenge in the subregion is massive, requiring far-reaching vision, implementation strategy and regional cooperation.

Income, effective demand and access levels: the demand for modern forms of energy is dependent on the level of income of consumers. It is intuitive to expect that as income levels increase overtime, the level of demand for modern forms of energy also increases. The willingness to pay for modern energy is therefore income sensitive. A study by KIPPRA (2010) based on interviews of 6,346 households in Kenya demonstrated that the willingness to pay per kWh/month for households in urban areas was KSh132.41 (~$1.6), compared with KSh88.84 (~$1.1) for rural areas and KSh35.45 (~$0.44) for low income households. Leach's (1992) energy ladder hypothesis ascertains that switching to modern energy services for cooking, lighting and electrical appliances is dependent on the level of income, which changes overtime. The implication of this hypothesis is that at the lower income level, consumption of biomass and charcoal are predominant, and switching to electricity, LPG, fossil fuels and appliances come with income shifting to higher brackets (Masera, and others, 2000, Heltberg, 2005). The speed of transition to modern energy services will be dependent on relative affordability, which in turn relate to income (IEA, 2004).

This relationship between income levels and electricity consumption is obvious in the Eastern Africa subregion, as shown in Figure 32, where countries at relatively higher levels of income per capita exhibit higher per capita electricity consumption. This pattern

Figure 32: 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.

is further demonstrated in countries outside the subregion. The low level of income, on the demand side, is therefore a key deterrent in accessing electricity.

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

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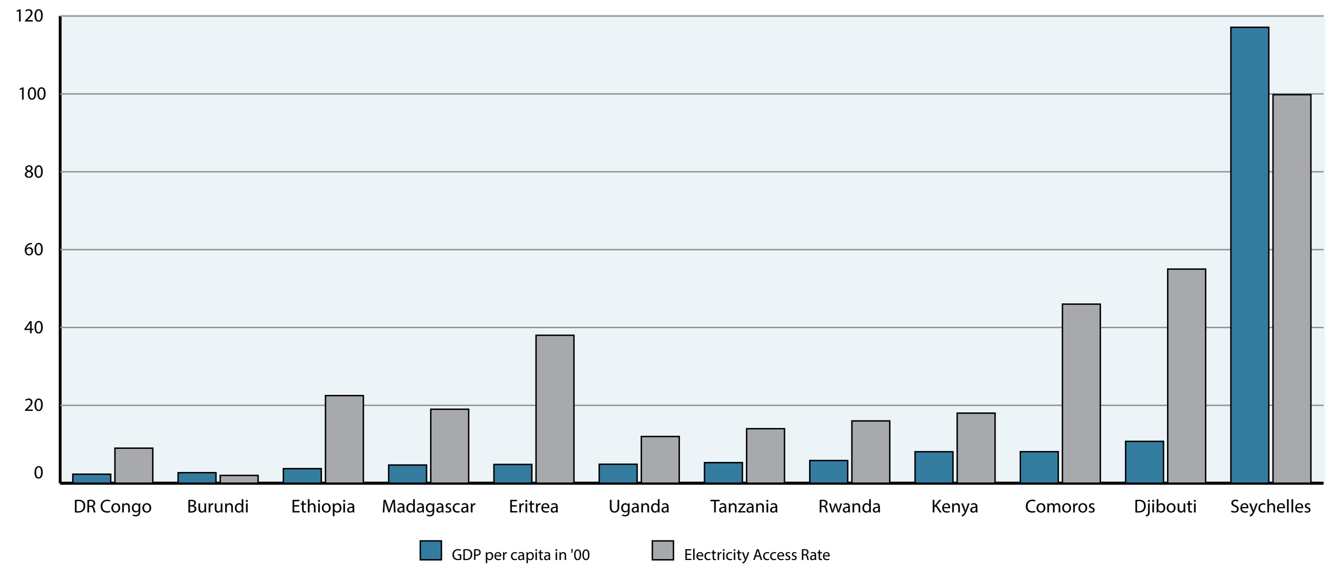
Despite these strong linkages for policymakers to leverage, Mekonnen and Kohlin (2008) warn that higher income levels do not necessarily lead to rapid increase in the use of modern energy services. By using the case of urban Ethiopia, they argue that urban residents, even with rising income levels, may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

Sticky preferences and attitudes: switching to energy technologies, and accessing modern forms of energy, instead of traditional ones, is confronted by the challenges of culture, attitudes and preferences. Consumers often prefer energy sources they have come to rely on and used for a long time, and thus show resistance to switching. Murphy (2001) demonstrated that in 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

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



Source: World Bank national accounts data.

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 to 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 networks poses access challenges, given the limited diffusion of off-grid energy systems in many parts of the Eastern Africa subregion. Illegal settlements and land-use patterns pose legal and physical barriers to the urban poor. Illegal tenancy arrangements (often unrecognized by utilities and city administration) and settlements away from the national grid pose difficulties in the face of demand (Fall, and others 2008; Dhingra, and others, 2008). In progressive energy programmes, the attempt to provide energy access to the urban poor and slum residents pose cost difficulties, such as attempting to deliver energy from grids that could be as far as 30 kms away, and the need for higher upfront costs that can limit access expansion to the urban poor. The high infrastructure and connection cost for 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 programmes attempt to deal with the lack of physical accessibility of grid-based power to rural residents, United Nations

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.

Habitat (2009) notes that slum electrification programmes are often not prioritized and mainstreamed into national policies and programmes.

Targeted subsidy, price support programmes 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 subregion. Though costly, these policy efforts reduce the actual price of energy to households, increasing access and consumer welfare. However, these programmes often come at a considerable cost to governments and utility companies. 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 decided to no longer grant such huge subsidies. The Electricity Regulatory Authority (ERA) as a result announced the rise in what consumers pay from Shs 385.6 to Shs 524.5 per unit, a rise in what commercial users pay from 358.6 to Shs 487.6 per unit, a rise in what 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 expected to finance the other hydroeclectic projects, including the Karuma Hydro Power project. The challenge of keeping electricity rates affordable as well as keeping the system financially sustainable is an ongoing challenge in the sector.

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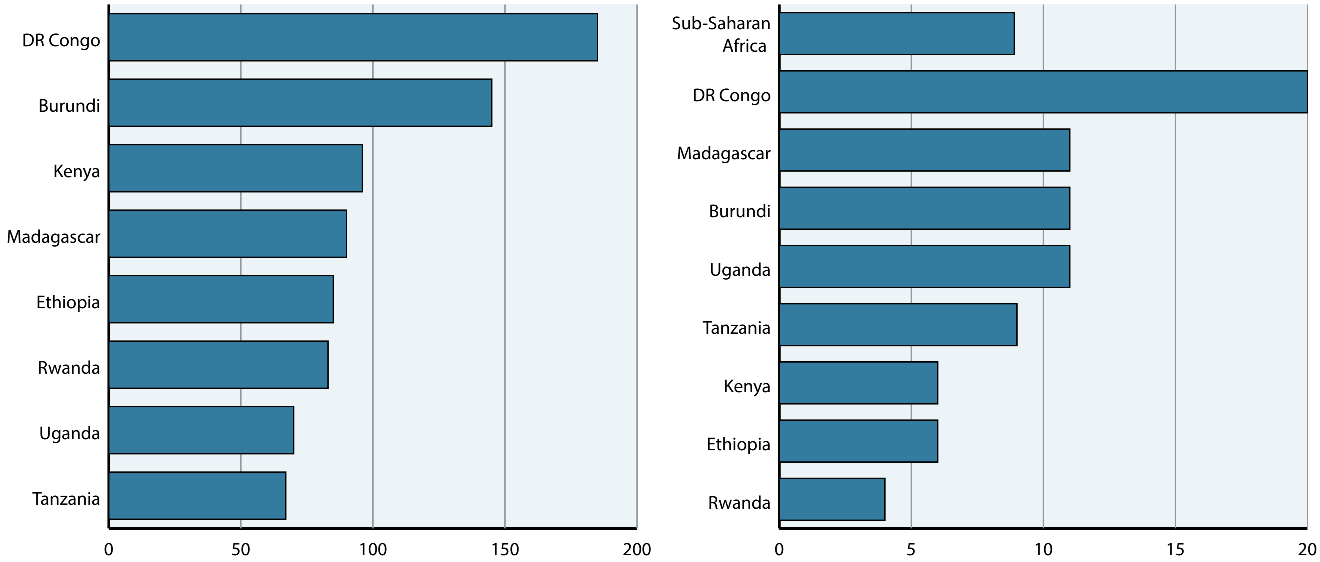
Moreover, electricity subsidies that reduce the tariff to consumers largely benefit those who are already connected, and may not benefit the population that have not yet accessed it, demonstrated by Eastern and Southern Africa experiences (Hosier and Kipondya, 1993; Dube, 2003; Kebede, 2006[12]) and from Asian experience (Shelar, and others, 2007). Since consumers already connected to access modern energy are at a relatively higher level of income, most of the subsidy schemes, if untargeted, goes to them, with limited impact on population access rates. One model programme is from South Africa, where subsidies are targeted at poor households who are provided access to 20-50 kWh of energy per month for free, beyond which they are expected to pay (UNDP, 2010).

The utilization of improved cookstoves and energy efficient appliances by households is also constrained by affordability factors in the Eastern Africa subregion. Karekezi, and others (2008) state that accessibility to cleaner energy sources are impeded by taxes on imported kerosene stoves, reaching as high as 51 per cent of the value which prices the majority of households out. Karekezi and Kithyoma (2002) also note that the cost of clean energy technologies, reaching 131 per cent to 363 per cent of per capita GNP in Eastern Africa, and given 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 overtime. The reliability of the energy system can be determined 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 selected countries in the Eastern Africa subregion is depicted in Figure 35. While most recent data on outages is not available for most of the subregional countries, the indicative measures in Figure 35 demonstrate that outages, in terms of number of days per year, are anywhere between 65 and 185. The number of outages per month range

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

Figure 35: Power outage days per year (panel 1) and number of electrical outages in a typical month (panel 2) in selected countries in the Eastern Africa subregion



Source: Based on data fromWorld Bank Enterprise Survey.

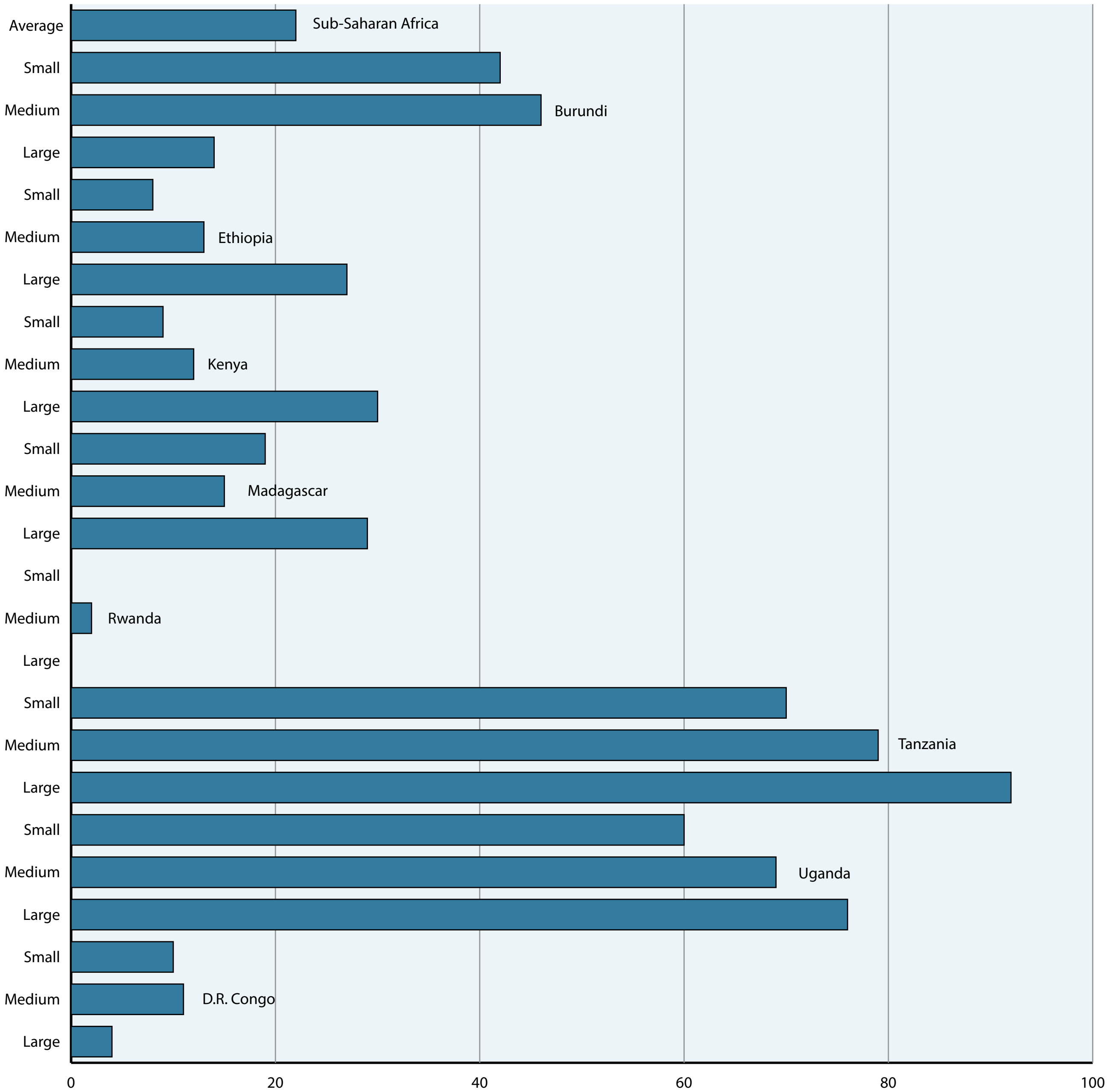
Note: Data is for the following years: DRC (2010); Madagascar (2009); Uganda (2006); Burundi (2006); Tanzania (2006); Kenya (2007); Ethiopia (2011) and Rwanda (2011).

Power quality is particularly a challenge to industry, where costly appliances and technology can be damaged by irregular and poor quality power supply.

from less than 5 in Rwanda to close to 20 in DRC. Such systemic and frequent power outages discourage reliance of consumers on the grid, and encourage household and business investments to turn to alternative energy supplies. Power outages in Eastern Africa exceed even sub-Saharan averages by significant margins. The quality of power is also a related problem, and as such, 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.

The industrial demand for consistent and reliable energy is affected by the power interruption challenge. Based on World Bank Enterprise Survey data, Figure 36 depicts the share of electricity and the constraint to business identified in a sample of countries. The data enables a look at the energy constraint to industry in three industrial classes: small (5-19 employees); medium (20-99 employees); and large (more than 100 employees) enterprises. In Uganda and Tanzania small, medium and large enterprises have identified electricity as accounting for 60 to 90 per cent of their business challenges, even considering issues of crime and theft, customs and trade regulation, available human capital, labour regulations, political instability, corruption, business licensing and permits, access to land and finance, and transportation. The scale of the energy problem in industry is quite sizeable in these countries. In Burundi, small and medium enterprises consider energy as accounting for over 40 per cent of their business operation challenges, though large enterprises see energy accounting for about 16 per cent of their business constraints. In Ethiopia, Kenya and Madagascar, large enterprises consider energy as accounting for over 20 per cent of their business challenge, though small and medium enterprises put the constraint at a relatively lower level. In DRC 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 (%)

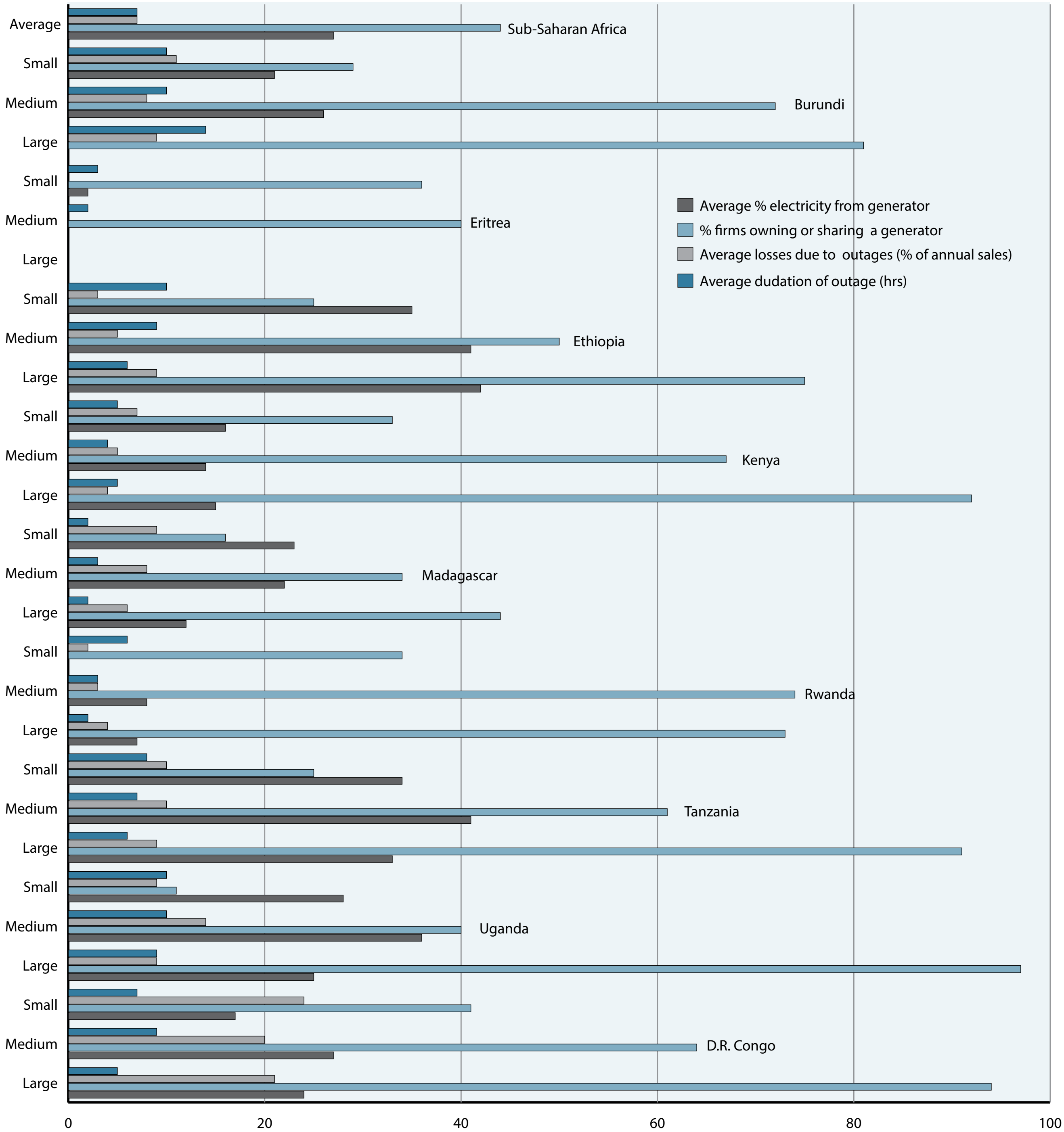


Source: Based on data from World Bank Enterprise Survey.

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, Figure 37 demonstrates the share of enterprises that own or share generators as a backup and self-generation system. Compared to the sub-Saharan average of 44 per cent, the share of large enterprises who own or share generators is 81 per cent in Burundi, 75 per cent in Ethiopia, 92 per cent in Kenya, 44 per cent in Madagascar, 73 per cent in Rwanda, 91 per cent in Tanzania, 97 per cent in Uganda and 94 per cent in DRC. 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 subregion 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: DRC (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 subregion is due to existing low power generation capacity. In looking at the structure of energy production and consumption in the subregion (see Table 6), the share of thermal and electricity production and consumption are low compared with energy generated

Table 6: Energy balances in Eastern Africa, 2009

Country	Total energy Production (%)			Final consumption (%)		
	Thermal	Electricity	Biomass	Thermal	Electricity	Biomass
Burundi	3.28	0.88	95.99	3.18	0.74	96.07
DRC	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
Eastern Africa	14.00	1.55	85.61	11.23	2.54	86.23

Source: United Nations Statistics, Energy Balances and Electricity Profiles, 2009; Rwanda related data is from National Energy Policy and Strategy, Rwanda 2011.
Note: Eastern Africa average does not include the Comoros, Djibouti, Seychelles, Somalia and South Sudan due to lack of data.

from biomass. In much of the subregion, the share of electricity in final consumption is below 5 per cent, and thermal ranges from 3.18 per cent in Burundi to a high of 21.43 per cent in Kenya. The structure of energy production and consumption demonstrates the low contribution of electricity to final consumption, partly due to low levels of generation.

In much of the subregion, the share of electricity in final consumption is below 5 per cent, and thermal ranges from 3.18 per cent in Burundi to a high of 21.43 per cent in Kenya. The structure of energy production and consumption demonstrates the low contribution of electricity to final consumption, partly due to low levels of generation.

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

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

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Transmission and distribution: despite low electricity generation capacity in the Eastern Africa subregion, which poses a supply constraint, further power shedding from transmission and distribution lower the available generated power for end users. Transmission and distribution losses are quite high in the subregion. For example, Tanzania transmission and distribution loss is in excess of 20 per cent of generated electricity, with 15 per cent or more coming from technical and non-technical (theft and misuse – see announcement from TANESCO to deal with the problem on page 47) losses. In the DRC, losses are estimated at between 20 and 30 per cent, with significant illegal connections. In Uganda, transmission and distribution losses are also quite high, distribution losses alone accounting for 38 per cent of generated electricity, which in recent years declined to 29 per cent (see Figure 40). Such high levels of transmission and distribution losses reduce the available energy, curtailing effective supply.

Investments are increasing in the subregion for interconnections and transmission and distribution upgrade to reduce losses. Some of these projects include: the DRC, Burundi and Rwanda interconnection from a shared hydropower station Ruzizi II; inter-State connections between Uganda and Rwanda (to be commissioned in 2014), Tanzania and

Figure 38: Subregional distribution of energy consumption per person

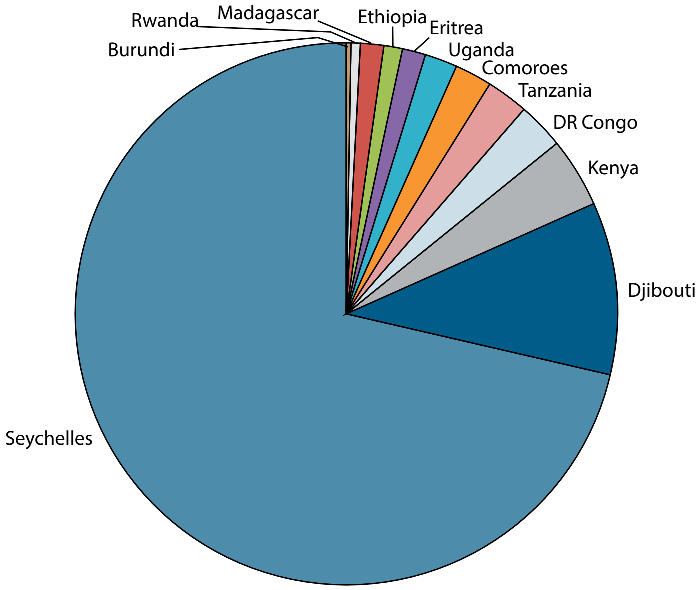
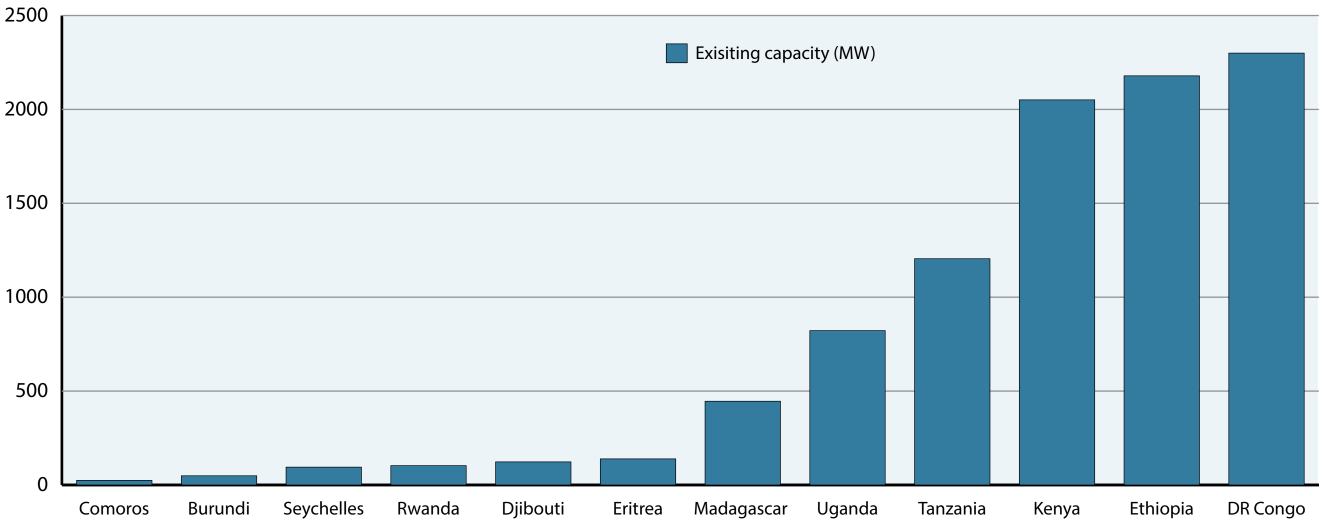


Figure 39: Existing generation capacity of countries in the Eastern African subregion



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.

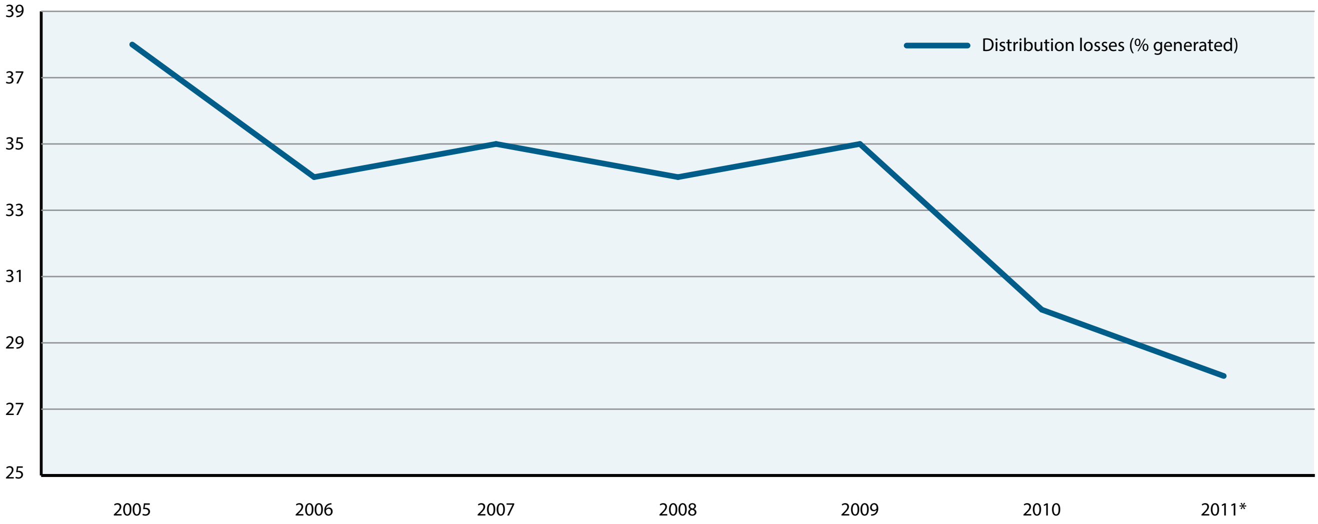
Uganda, Kenya and Tanzania (2015), Ethiopia and Djibouti (commissioned in 2011), Ethiopia and the Sudan, Ethiopia and Kenya (2013), the Kenya-Uganda interconnection (2014), the Ethiopia-Sudan-Egypt connection (feasibility study completed), Rwanda and Burundi (2014), Uganda and Rwanda (2014) and other intracountry projects.[13]

Intracountry investments in transmission and distribution networks are expected to drive system power losses down. Current and planned transmission networks are indicated for Tanzania, Uganda and Eritrea. The Tanzania grid expands to Kenya and Zambia, the Uganda grid to Kenya, Rwanda, Tanzania and DRC, and the Eritrean grid to the Sudan.

Energy Planning and Technology Choice: energy sector development has not received adequate attention for most of the period between1980 and 2000 in many subregional

13 See EAC Regional Power System Master Plan for details.

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 know 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.

countries. Comparison of the total existing capacity with the capacity expansion since 2000 (see Table 7) demonstrates that investments were for the most part 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 has been met with growing demand for more energy, driving most of the subregion into emergency generation. In the 2000s, Kenya, Rwanda, Tanzania and Uganda, for example, have added 51 per cent, 45 per cent, 68 per cent and 52 per cent to their total capacity, respectively.

Since 2000, the lagging generation capacity development has been met with growing demand for more energy, driving most of the subregion into emergency generation.

The emergency generation scheme has forced subregional 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 was substantial, costing subregional countries between 0.96 and 3.29 per cent of GDP (see Table 8). In the case of Rwanda and Uganda, by 2005 and 2006, emergency generation had already accounted for over

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

40 per cent of total power supply, largely from thermal technology options, which were more expensive.

The emergency generation scheme has forced subregional 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 was substantial, costing subregional countries between 0.96 and 3.29 per cent of GDP.

A detailed look at Table 9 demonstrates the generation capacity expansion path of selected subregional countries, the energy planning and investment path, the timing of capacity expansion and the technology choice for capacity development since the beginning of the 2000s.

In each of the cases, new capacity addition has come mostly from generation sources that are quite costly (thermal sources) but have the advantage of a lower project gestation period from investment to commissioning. 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, available and reliable electricity.

Solvency of public utilities: as aforementioned, the subregion has numerous challenges on the supply side of electricity, ranging from limited generation capacity, significant transmission and distribution losses, emergency generation to the rise of thermal

Table 7: Electricity generation capacity enhancement: emergency expansion

Electricity Generation Planning in Select Subregional 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	-

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 and others (2008).

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

Plant	Installed Capacity (MW)	Plant Factor	Year on Power
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).

technology in the generation portfolio. In subregional countries public utilities companies operating the transmission and distribution network, and in some cases the whole chain from generation to distribution, 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 company in Madagascar, is under a similar challenge, and although 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 driven JIRAMA to financial insolvency. In DRC, the public utility company, SNEL, operates from generation to transmission and distribution, and this company too has faced financial insolvency. Finance-strapped utility companies are less likely to invest in grid improvement and quality service delivery, and unable to reinvest in generation capacity expansion.

In much of the subregion, where energy sector reform has taken shape, regulated tariffs with rising generation cost due to rapid integration of thermal technologies, have left utilities companies ill-equipped to plan for capacity expansion. In Uganda, regulators have already removed part of the subsidy which were to keep tariffs low, leading by some estimates to a 42 per cent 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 utility companies) and keeping rates low to enhance socioeconomic development on cheaper energy. This wedge is likely to continue in the foreseeable future.

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 utility companies) and keeping rates low to enhance socioeconomic development on cheaper energy.

Energy trade and enhanced electricity supply: energy trade, given the energy potential of the subregion, is low, mainly due to constrained generation capacity in subregional member States and the limited interconnection among them, but the trend is changing. Table 10 demonstrates potential energy trade in the near future in selected member States of subregions. 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.

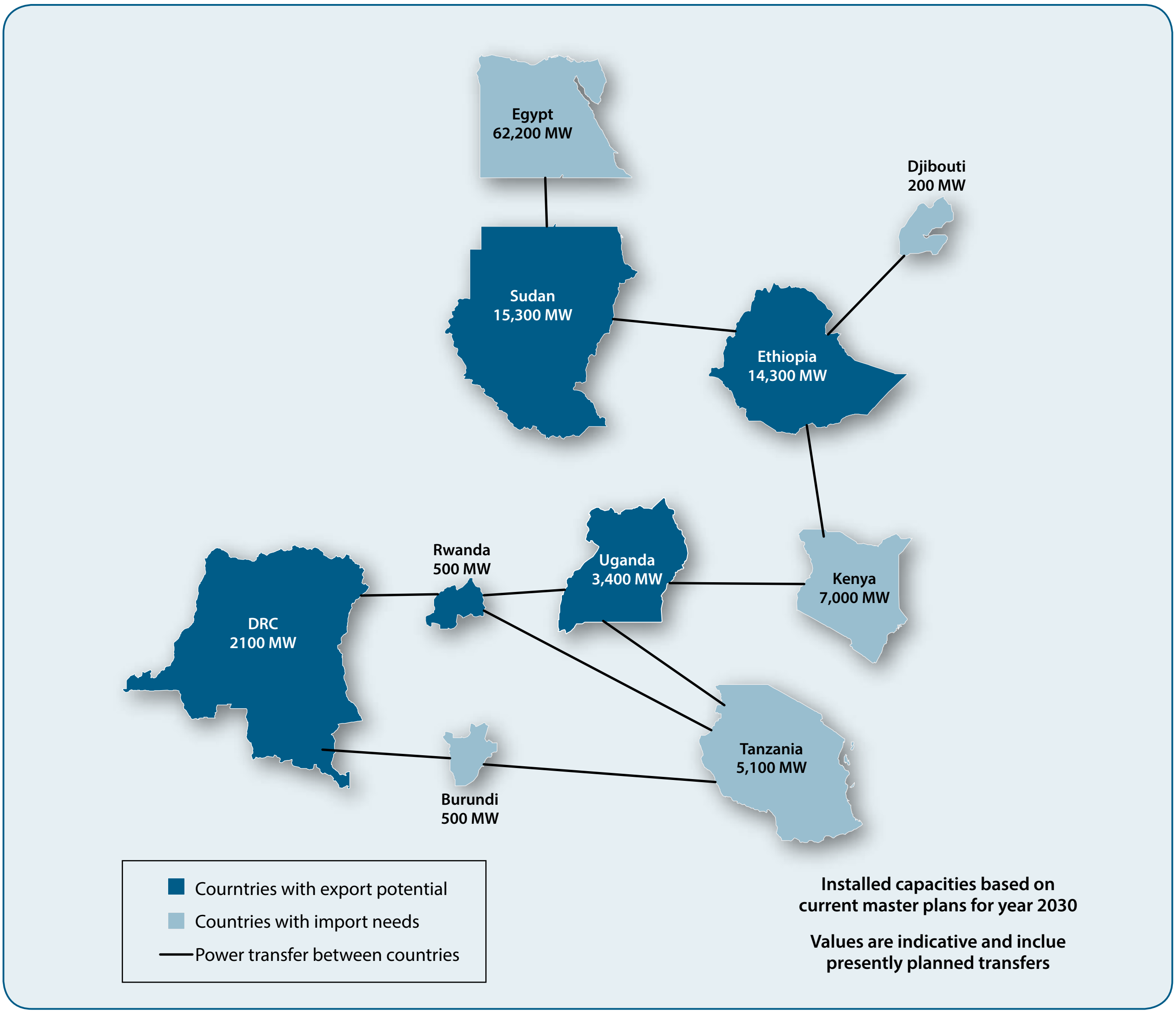
The long-term potential trade scenario is depicted in Figure 42. Egypt, Djibouti, Kenya, Tanzania, Burundi and South Sudan are energy import destinations, to be fed largely from the enhanced export capacity of Ethiopia, DRC, Rwanda and Uganda. Subregional

Table 10: Anticipated electricity trade in selected countries in the Eastern Africa subregion

Projected Energy Trade in Selected subregional Countries			
Country	**Import/Sharing Scheme**	**Import Country**	**Trading/sharing Year**
Burundi	Lake Kivu gas plant 2 = 66.7 MW	-	
	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
Rwanda	Kivu gas plant 2 = 66.7 MW		2015
	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).

Figure 42: Long-term electricity trade scenario in the Eastern Africa subregion



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

Subregional electricity trade and joint investment ventures have a promising potential to vastly expand electricity supply in the subregion.

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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 subregion, but trade potentials and greater attention to indigenous energy resources development by member States constitute a positive shift on the supply side.

Monitoring the Status of Energy Security in the Eastern Africa Subregion and Monitoring Frameworks

3

3.1 Measuring energy security

Energy security has become a global challenge in an interdependent global economic system, which is reliant on the growing consumption of energy, with underlying uneven distribution of energy resources. 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 significantly.

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

Geopolitical events also influence 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 Spring uprising, the Iran-United States confrontation over the Strait of Hormuz, are a few of the recent geopolitical tensions that had direct bearing on energy insecurity. The continuing instability in the Arab world and central Asia continues 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, and others, 2007; Stern, 2002). Reduction 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, as well as potential sources of energy insecurity, governments have little analytical support to supplement expert judgment in properly evaluating energy security challenges (Lefévre, 2010).

Energy insecurity refers to the physical disruption in the supply of energy sources and price/affordability shifts in energy commodities overtime.

What policymakers mean by energy security is an important consideration. Scheepers, and others (2007) articulate energy security as a 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, and others (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 years 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 of energy to more economic interpretations, Boni and Toman (1996) identify energy security as the loss of economic welfare that may result from a change in the price or availability of energy, which is reflected in energy imports and energy price volatility. Lefévre (2010) puts forth a similar definition. Since shortages of energy reflect on prices and their short-term fluctuation (Toman, 2002), energy security has moved from consideration of only physical supply to definitions 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 impact of energy insecurity is often far-reaching, particularly in countries where energy security management policies and mechanisms are inadequate.

The European Commission (2001) targets long-term energy security by ensuring the uninterrupted physical availability of energy products in the market at affordable prices to consumers, for the well-being of citizens and the functioning of the economy. Similarly, the IEA (2007a) elucidates energy security 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 insecurity refers to the physical disruption in the supply of energy sources and price/affordability shifts in energy commodities 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. That is, 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 enforcement practices. In places like the Eastern Africa subregion 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

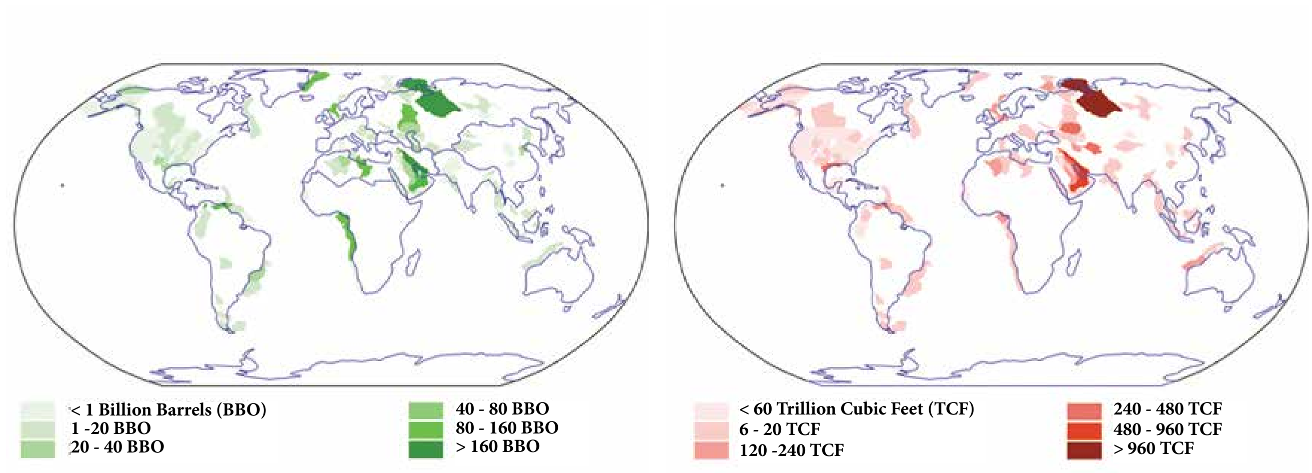
Tracing and monitoring the state of energy security requires developing and adapting indicators and indices, similar to the indicators to measure the performance of the economy, improvements in education and health, the state of governance improvements, the state of environmental health, the state of social progress among other indicators. 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 make 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 price shifts that can alter the affordability of energy supplies. Regarding the physical disruption aspect of energy security, particularly imported hydrocarbons, a set of indicators are developed to assess the vulnerability of countries to short-term disruptions of supply.

Geological availability of resources and supply risks: there are concerns about continuous long-term supply of oil in particular, especially by advocates of the peak oil phenomena.[14] Such concerns have led to the examination of the extraction potential of known geological hydrocarbon resources. In 2000, the United States Geological Survey conducted a global assessment of oil and gas resources and their extraction potential (see Figure 43). This assessment is widely viewed to offer an optimistic view of the global state of oil and gas. Focusing on peak oil arguments, some have criticized these estimates as optimistic (Greene, and others 2005). In the case of Eastern Africa, oil and gas resource finds since 2000 have significantly expanded the potential of hydrocarbons

Figure 43: Global petroleum and natural gas resources



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

14 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.

in the subregion. The rate of reserve drawdown, due to extraction, at current global consumption levels, is taken as one aggregate of an 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 so as not to rely solely on this measure. As a result, its use as a policy-relevant indicator seems limited.

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, and others, 2003), and net energy imports. The concentration of oil and gas resources in selected regions and countries of the world (62 per cent of oil in the Middle East and 56 per cent of gas in Russia, Iran and Qatar) obliges the majority of countries to have some level of import dependence, with the risk highest in countries that are totally dependent on imported hydrocarbons.

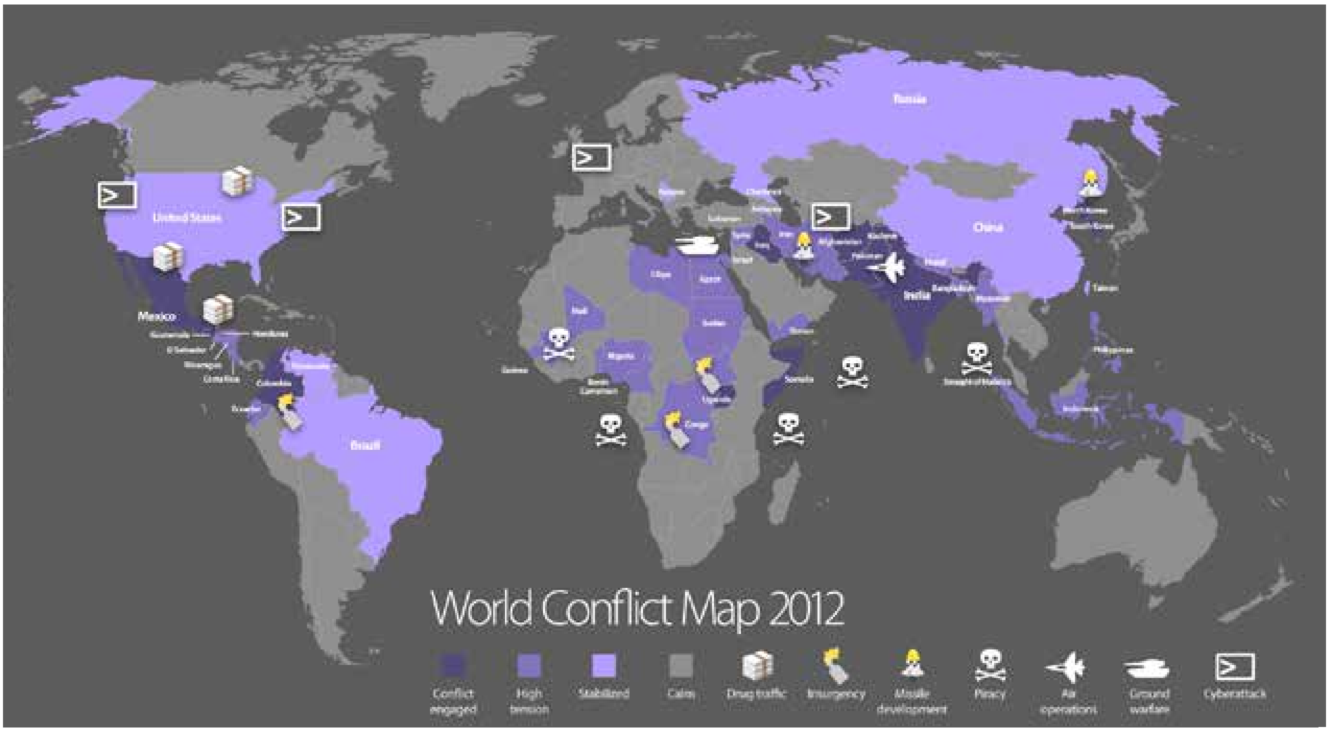
Diversity of import sources and political stability: diversity is a proven risk management strategy. The concentration of oil and gas supply in a few countries in the world is likely to lead to a concentration, and not a diversity, of import sources for energy import-dependent countries. However, the 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 Figure 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 Human Development Index (HDI), arguing that it encompasses indicators that can be proxy for long-term sociopolitical stability in a country. The IEA utilizes the World Bank 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.

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. The immediate impact of the price of these energy sources on the global economy and on consumers, and the ease of access to available data has made this indicator prevalent amongst energy experts and useful to decision makers and also to the general public.

Energy-dependence of economy: a set of indicators are also widely used 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

Figure 44: Global wars and conflicts in 2012



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

imports, and the share of oil utilized in the transportation sector.[15] Energy-intensive economies where a large quantity of the imported oil goes to inelastic industries poses a high risk regarding the impact of supply disruption on the economy.

Biomass sustainable supply: in economies where the share of biomass is still quite high as a share of total energy provision (that is above 65 per cent, reaching 95 per cent in the Eastern Africa subregion), 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, dashboard 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 the application of the principal components method. The IEA *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).

15 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.

3.2.2 Advanced energy security measurement and monitoring

The single, or dashboard, 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 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, and others (2007) offer two comprehensive energy security assessment indicators based on short-term disruption risks in the energy system, and energy 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), applied in energy security assessment of countries, such as Ireland and more recently the IEA Clean Coal Center long-term coal security assessment (see Loschel, and others, 2010).

The energy system 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.

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

Risk factors indicate 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

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

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

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, which employ outdated or less reliable technology and are mismanaged, increase the risk of domestic supply disruption.

In the case of domestic biomass production, which accounts for a large share of primary energy source in the Eastern Africa subregion, 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. Where there is 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 outright blackouts, severely putting a constraint on energy security. The recent blackout in India which put millions of consumers and producers out of service, largely due to power usage beyond the regional allocated quota is one such example. In the Eastern Africa subregion, policy, operation, technological and investment and upgrade challenges to many of the power plants have long been a source of energy insecurity.

In the Eastern Africa subregion, policy, operation, technological and investment and upgrade challenges to many of the power plants 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 accidents. Inland import routes also pose challenges of infrastructure capacity, maintenance, safety and affordability, particularly to landlocked countries. The quality of domestic energy infrastructure, including roads 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 for vulnerable countries, the greater 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; reserve; and locked-in capacities.

Emergency stocks offer a short-term mitigation effect should any of the risk factors materialize. Strategic reserves set-up, drawdown and injection to markets are governed by response mechanisms based on 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 wood and charcoal production are predominantly artisanal, and often lack coordinated production and distribution management on a large-scale, strategic reserve options are quite limited.

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.

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

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

Strategic reserves are supplemented by demand restraint measures in times of disruptions. A demand restraint could be the rationing of remaining supplies equitably, while markets stabilize and prices take their natural course 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. Regarding electricity in particular, the technological capacity of power plants to switch to alternative power generation sources is a mitigation strategy factor. Excessive reliance in one source, such as hydro, which can be affected by severe drought and water shortage, could have a drastic impact on power output where there is 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.

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 neighbouring and regional power sources, or from local reserve generation capacity, which is also the case for refineries. For gas production, additional production capacity and what remains in the distribution pipeline constitute part of the domestic reserve capacity. Locked-in production offers added flexibility in the use of more 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.

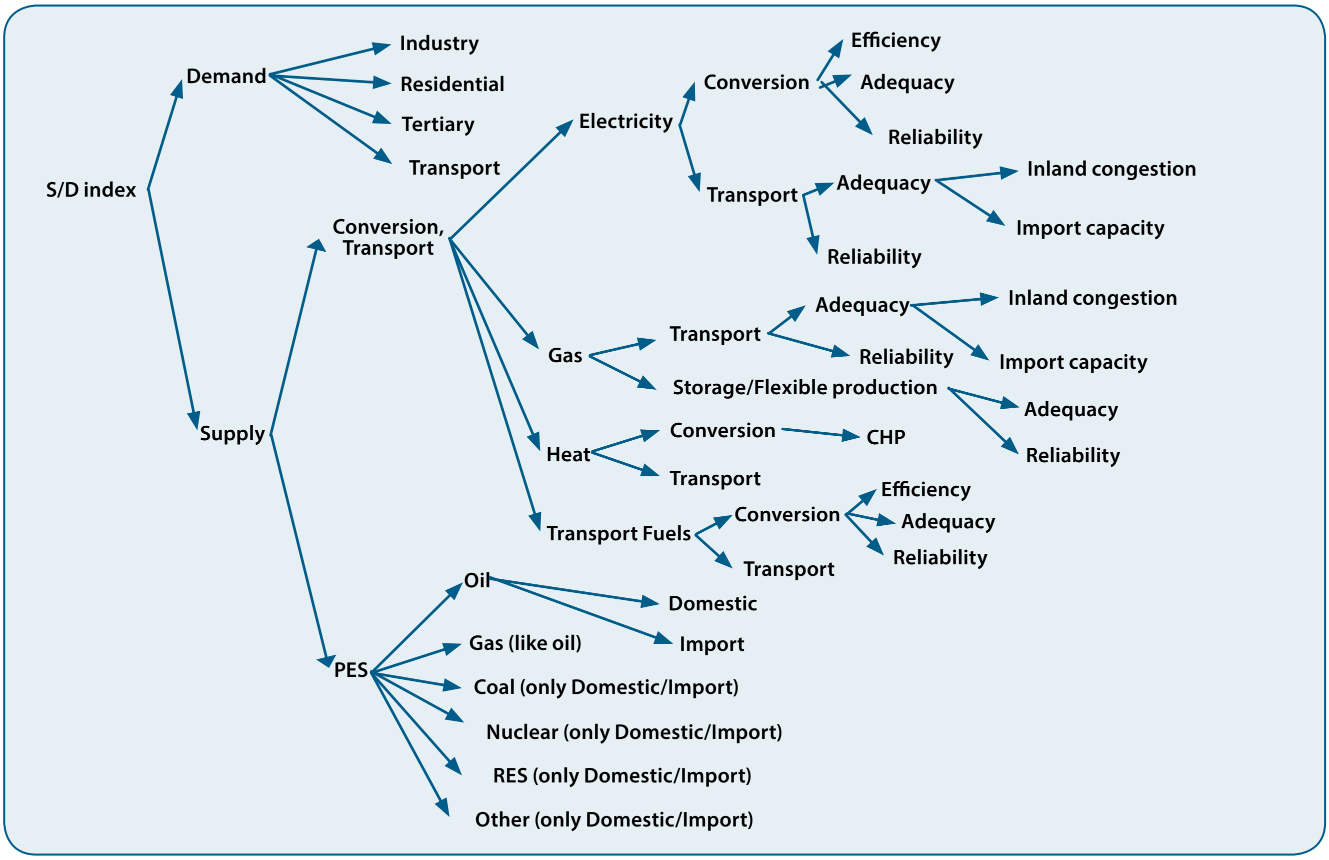
The Supply-Demand Index: the crisis capabilities index focuses on the sources of short-term energy insecurity and how to manage them to reduce their impact. Energy security, however, has long-term implications in that the entire energy system can shift to a more insecure or secure path based on choices taken and the 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 has often been assessed primarily from 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 from 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 in industry, efficiency in 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.

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 over a period of time in the entire energy system.

On the supply side, as shown in Figure 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 conversion 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 over a period of 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 subregion

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

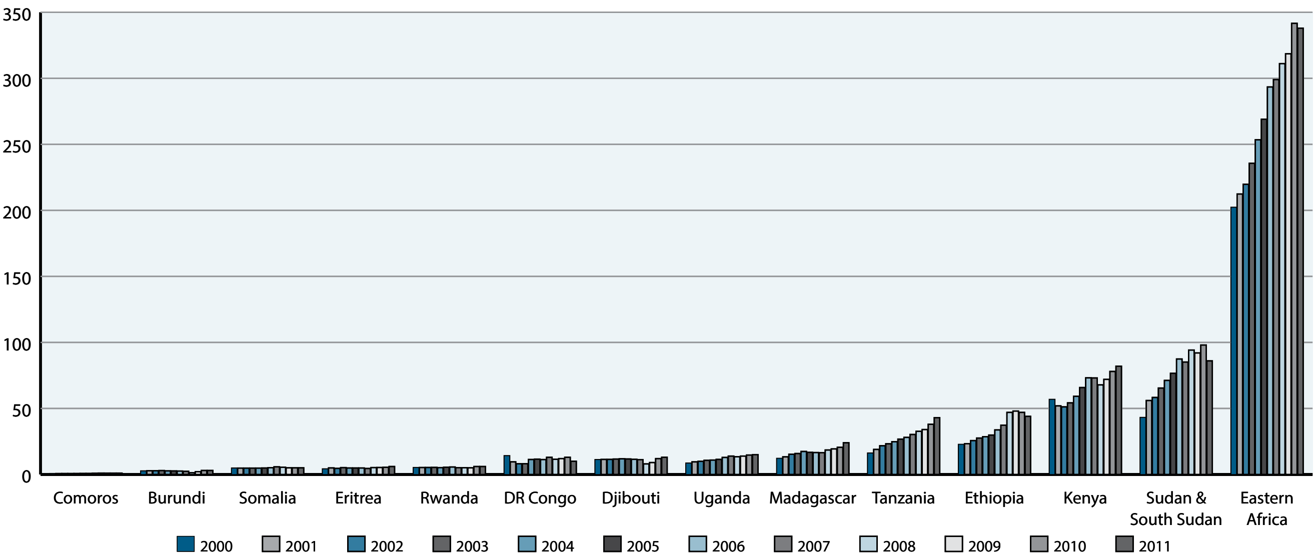
3.3.1 Petroleum import dependence and energy security in Eastern Africa subregion

Larger economies such as Kenya, Ethiopia and Tanzania saw steeper increases in petroleum consumption. The subregion 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.

The consumption of petroleum products in the Eastern Africa subregion has grown significantly over the last decade (see Figure 46). Larger economies such as Kenya, Ethiopia and Tanzania saw steeper increases in petroleum consumption. The subregion 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.

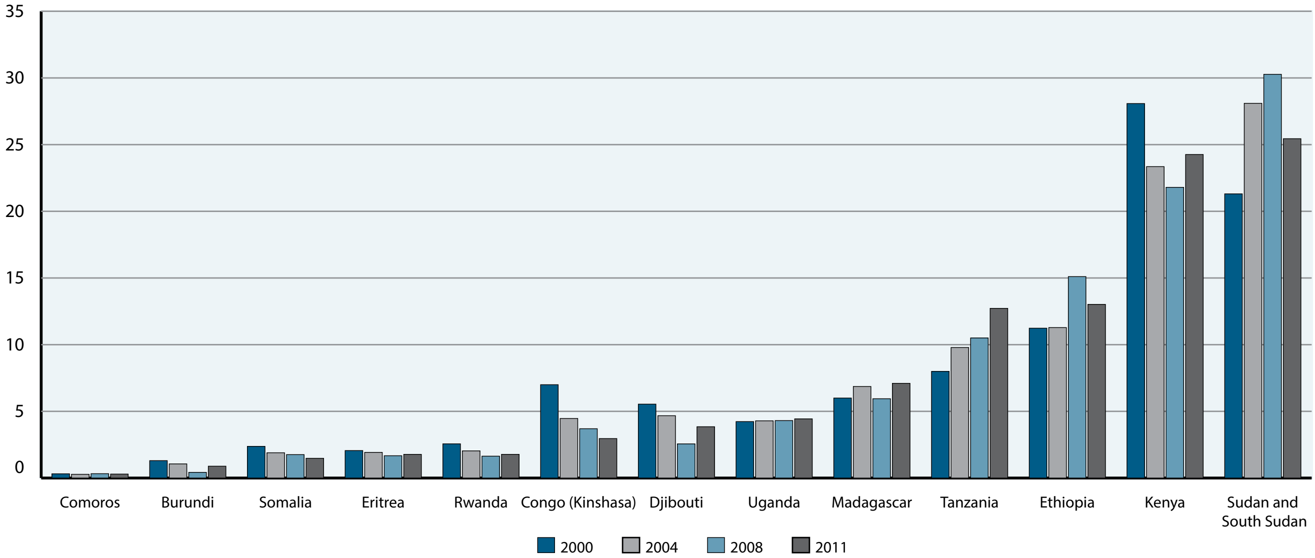
Within the subregion, the share of subregional consumption declined: the Comoros (0.02 per cent), Burundi (0.42 per cent), Eritrea (0.28 per cent), Somalia (0.89 per cent), Rwanda (0.79 per cent), Djibouti (1.69 per cent), DRC (4.04 per cent) and Kenya (3.82 per cent) between 2000 and 2001. The subregional share increased in: Uganda (0.2 per cent), Madagascar (1.1 per cent), Ethiopia (1.78 per cent), Tanzania (4.73 per cent) and Sudan/South Sudan (4.13 per cent). Despite these variations, the exclusive reliance of member States on imported fuel, at an 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 in the region. But until these new found resources are properly integrated into the domestic and subregional energy markets, the current exclusive reliance on imported petroleum is cause for specific concern.

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



Source: Based on data from IEA.

Figure 47: Countries' share of subregional petroleum consumption



The level of petroleum import dependence is considered low if it is below 15 per cent, medium in the 40 to 65 per cent range, and high, above 85 per cent. With the exception of Kenya, which is 70 per cent reliant on imported motor gasoline, 50 per cent reliant on imported kerosene type jet fuel and 75 per cent reliant on imported diesel (due to domestic refining capacity), all the remaining countries in the subregion rely totally on imported oil products (see Table 13). In the case of South Sudan, crude oil production and refining capacity at refineries in Khartoum brought about energy independence regarding motor gasoline, and significantly alleviated kerosene type jet fuel and diesel import dependence, at 37 per cent and 16 per cent, 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 subregion.

The state of oil import dependence in the subregion is extreme, at 100 per cent, exposing States and their economies to the vagaries of global oil markets.

Table 13:Degrees of refined oils import dependence (%) in the Eastern Africa subregion

	Motor Gasoline	Aviation Gasoline	Kerosene Type Jet Fuel	Gas/Diesel
DRC	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

The state of oil import dependence in the subregion is therefore very serious, at 100 per cent, exposing States and their economies to the vagaries of global oil markets.

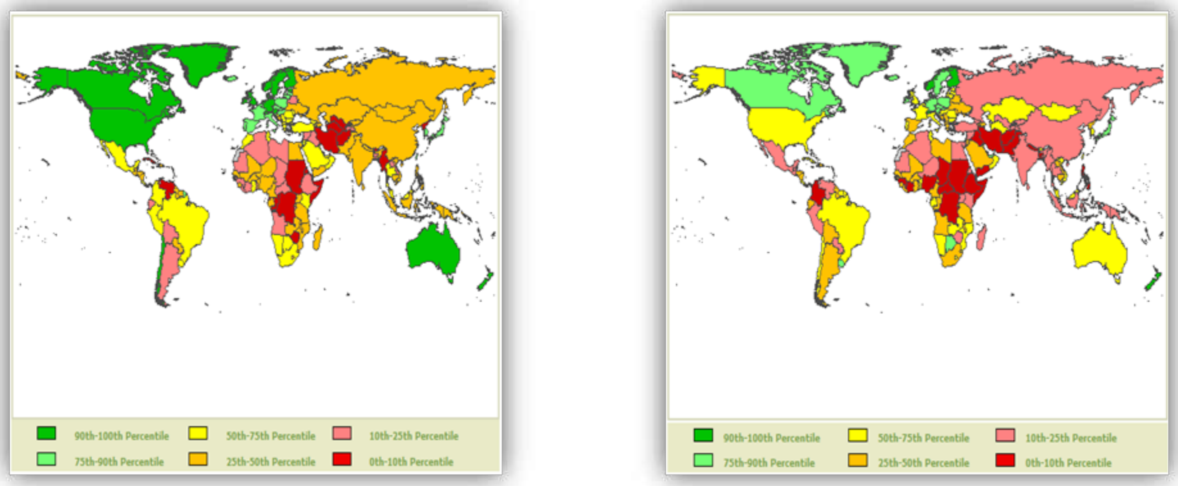
3.3.2 Oil market volatility and political instability in oil-exporting countries

Excessive import dependence poses two immediate risks: oil market volatility and political instability in oil-exporting countries, and additional political risks for landlocked countries emanating from fuel routing States. The political risk from 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", rising tension in the Strait of Hormuz as a result of confrontations about the nuclear programme of Iran, and conflicts between Sudan and South Sudan. The World Bank puts forth two indicators of governance that are often used 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 and 25 percentile globally (see Figure 48), making the region politically risky as a source for continued petroleum supply. Any political instability in oil-exporting countries, given the almost total subregional reliance on imported fuels, will result in a maximum energy security exposure for member States, and their economies.

Any political instability in oil-exporting countries, given the almost total subregional reliance on imported fuels, will result in a maximum energy security exposure for member States, and their economies.

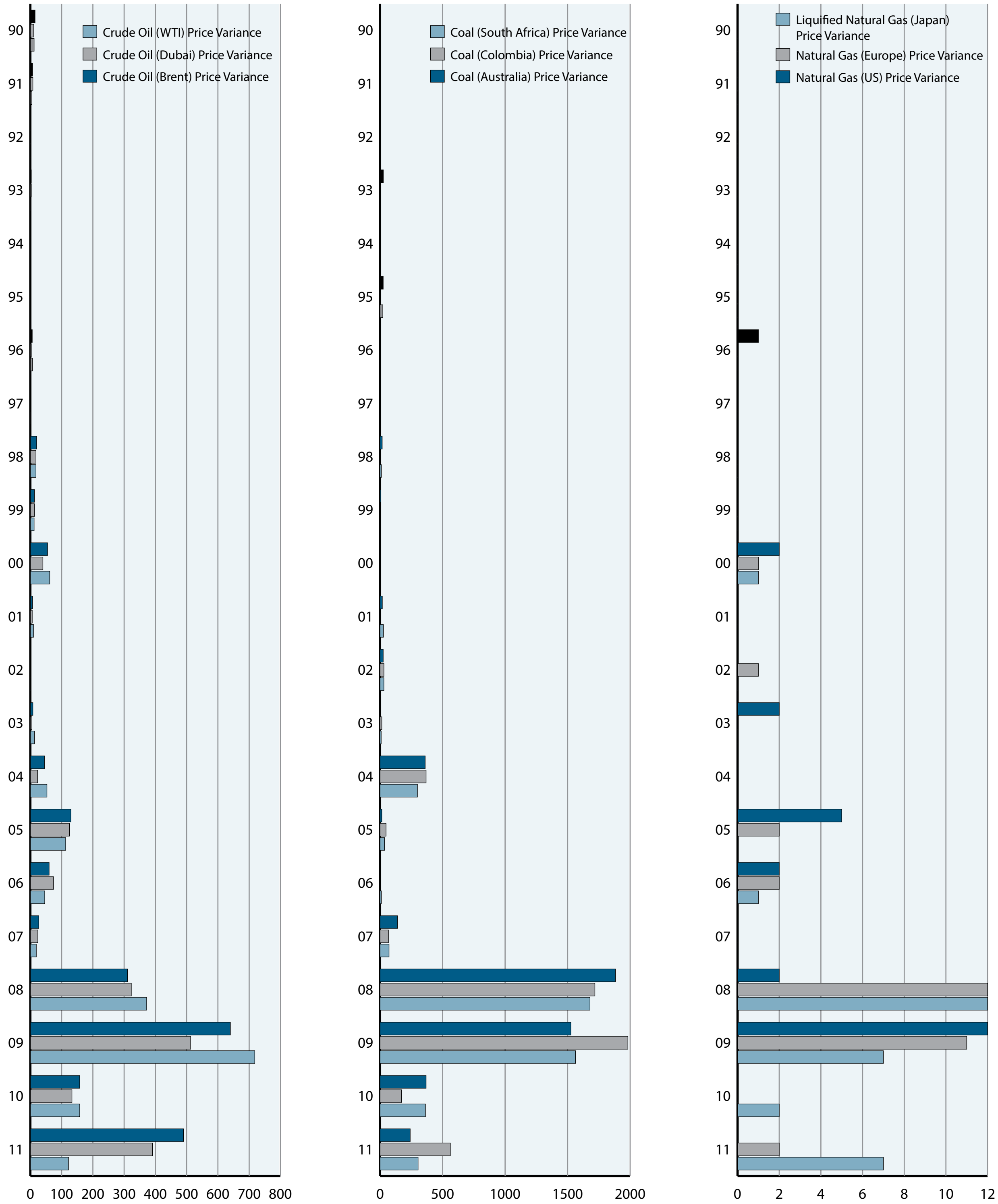
The second immediate concern for member States is market risk resulting from unmitigated volatility in the oil market. Factors that have shifted the structure of oil market volatility in ways not seen in previous decades are: (a) emergence of the rapidly expanding BRICs economies (see Figures 20, 21) with growing oil import demand (see Figure 22); (b) concerns about supply shortages; (c) stability concerns in the Middle East, North Africa and the Arabian Sea; (d) population growth and rising per capita income; and (e) rampant speculation in oil commodities. In the estimated year-to-year price volatility for crude oil, coal and natural gas prices from 1990-2011 (see Figure 49), energy price volatility were mostly stable from 1990to 2004, with temporary volatility spikes of limited amplitude. From 2005 to2011, energy price volatility took a structural shift, with sharp

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.

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



volatility particularly in 2008 and 2009, and a resurgence of volatility again in 2011. The brunt of this market volatility, particularly in upswing 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 Figure 23).

3.3.3 Expenditure on oil imports and economy oil vulnerability (Oil Vulnerability Index)

The level 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 scarce foreign exchange reserves could have been used instead for development financing. The oil import bill for 2000-2012 shows increases throughout the member States, but sharp increases in Tanzania, DRC, Burundi, Ethiopia, Rwanda, Eritrea, the Comoros and Djibouti (see Figure 50). The rise in oil import expenditure is far more than the rate of GDP growth in the subregion, putting a strain on resources.

To give an idea of this situation, the percentage change in oil import bill in the last decade is depicted in Figure 51. The slowest growth in the subregion in public spending on imported oil was in Seychelles, which grew by an estimated 273 per cent and Madagascar by 283 per cent! Import bills grew 4.4 and 4.7 fold in Kenya and Uganda, 5 times in Djibouti, more than 6 times in the Comoros and Eritrea, between 7 and close to 8 fold in Rwanda, Ethiopia and Burundi, and by a whopping 17 times in the DRC and 21 times in Tanzania! The result has been a subregional rise in current account deficits (see Figure 28).

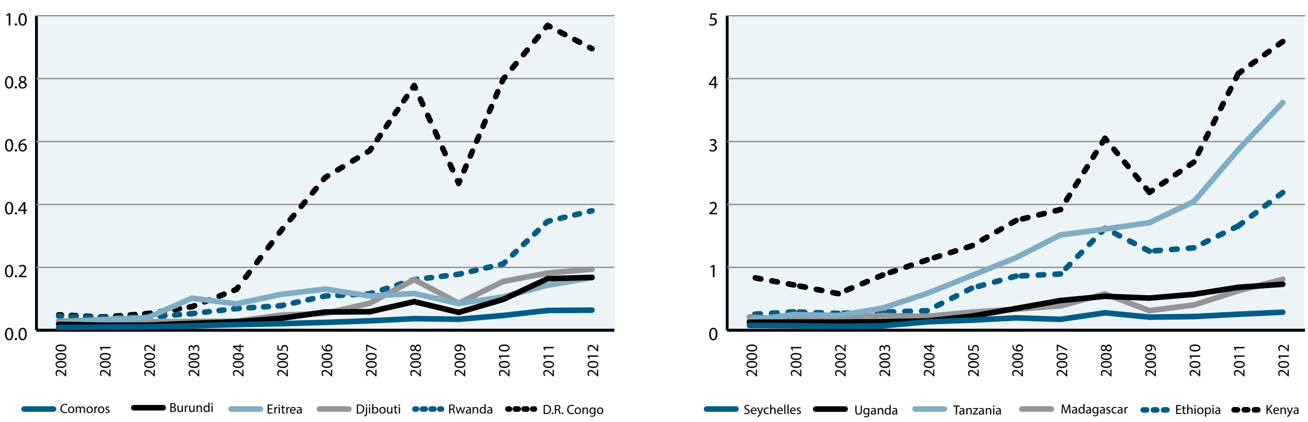
The slowest growth in the subregion in public spending on imported oil was in Seychelles, which grew by an estimated 273 per cent and Madagascar by 283 per cent! Import bills grew 4.4 and 4.7 fold in Kenya and Uganda, 5 times in Djibouti, more than 6 times in the Comoros and Eritrea, between 7 and close to 8 fold in Rwanda, Ethiopia and Burundi, and by a whopping 17 times in the DRC and 21 times in Tanzania! The result has been a subregional rise in current account deficits.

The rapid rise in public expenditure on imported oil in a decade, by a margin of 273 per cent to 2,148 per cent, demonstrates the state of growing energy insecurity in the Eastern Africa subregion.

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 subregion, the GDP share of oil import bills has increased, and the slope of increase overtime is significant (see Figure 52). The subregion is devoting a growing share of its GDP to fuel imports, not only transferring wealth to oil-producing countries, but continuing to expose their economies to energy insecurity impacts.

The change in oil import share of GDP from 2000 to 2012 (see Figure 53) similarly demonstrates the energy security challenge of member States. The GDP share increased from a low of 48 per cent in Madagascar, to between 100-200 per cent in Rwanda, Seychelles,

Figure 50: Oil import bills, in billion US$: 2000-2012



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

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

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

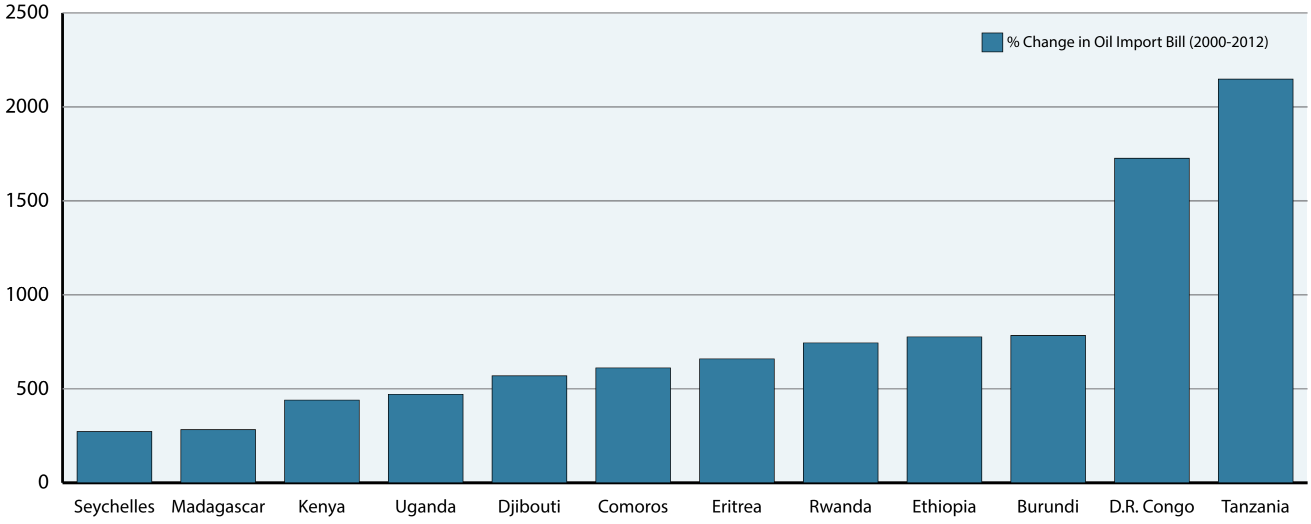
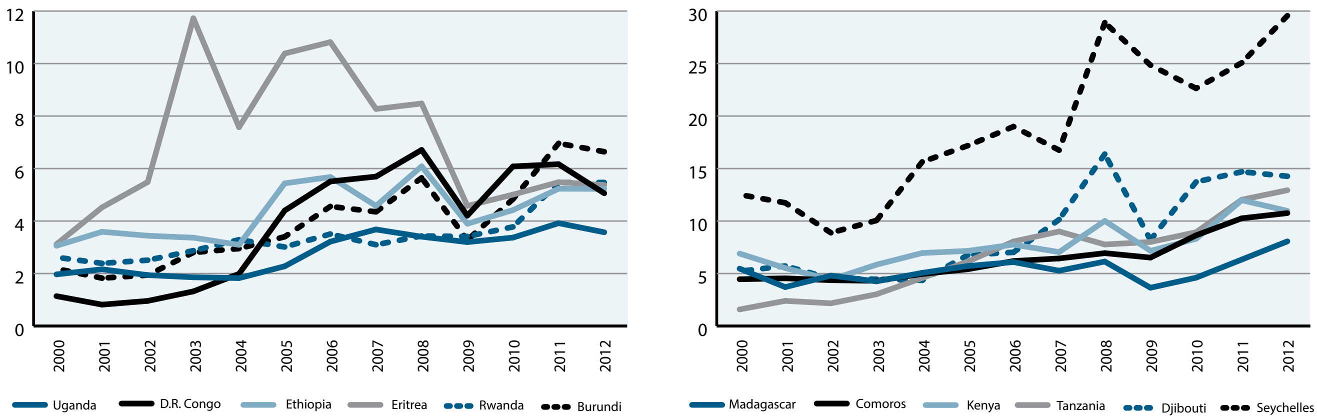


Figure 52: Oil import bills as a share of GDP (oil vulnerability index)



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

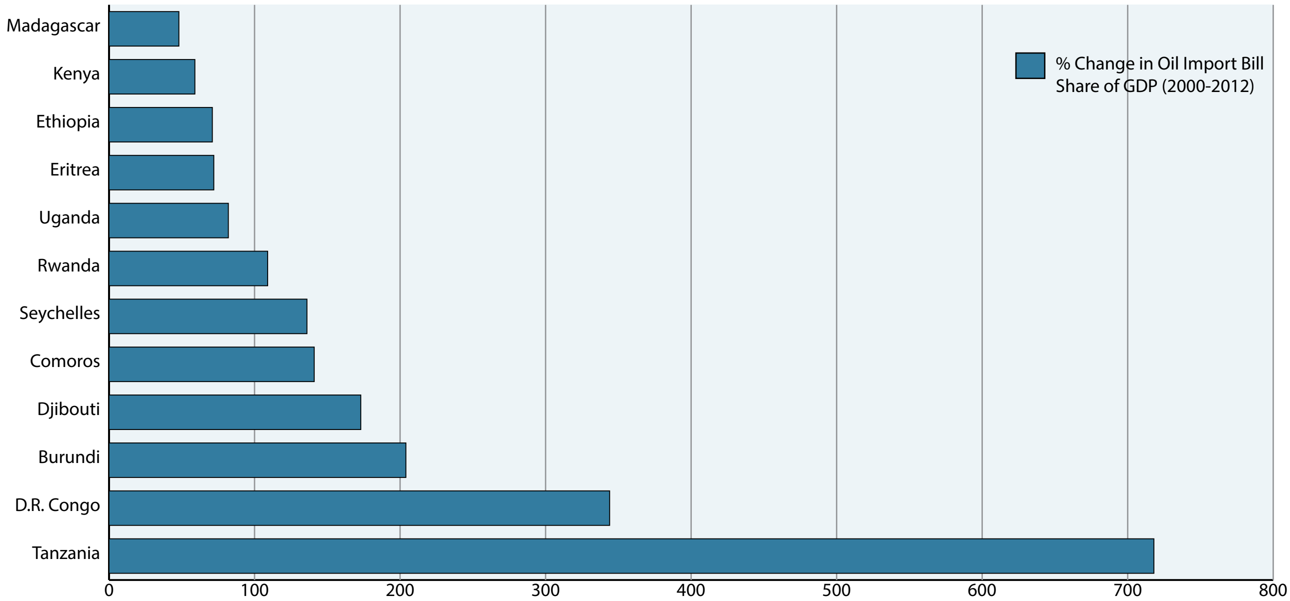
the Comoros, Djibouti and Burundi. In DRC and Tanzania, the increase was 344 per cent and 718 per cent, respectively. From these figures, energy security vulnerability has increased throughout the subregion, in small, large and Island States.

Significant improvements in energy intensity are seen in 2008, compared with 2001, in Uganda, DRC, Djibouti and Rwanda. In these countries, the GDP value added per unit of energy input has increased.

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 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 Figure 54. Review of energy intensity from 2000 to 2008 shows that for most countries in the subregion, energy intensity has remained more or less the same, or shown marginal changes. However, significant improvements in energy intensity are seen in 2008, compared with 2001, in Uganda, DRC, Djibouti and Rwanda. In these countries, the GDP value added per unit of energy input has increased. In most of the subregion, however, energy intensities have remained more or less the same, maintaining a similar level of

Figure 53: Percentage change of oil import bills as a share of GDP (2000-2012)

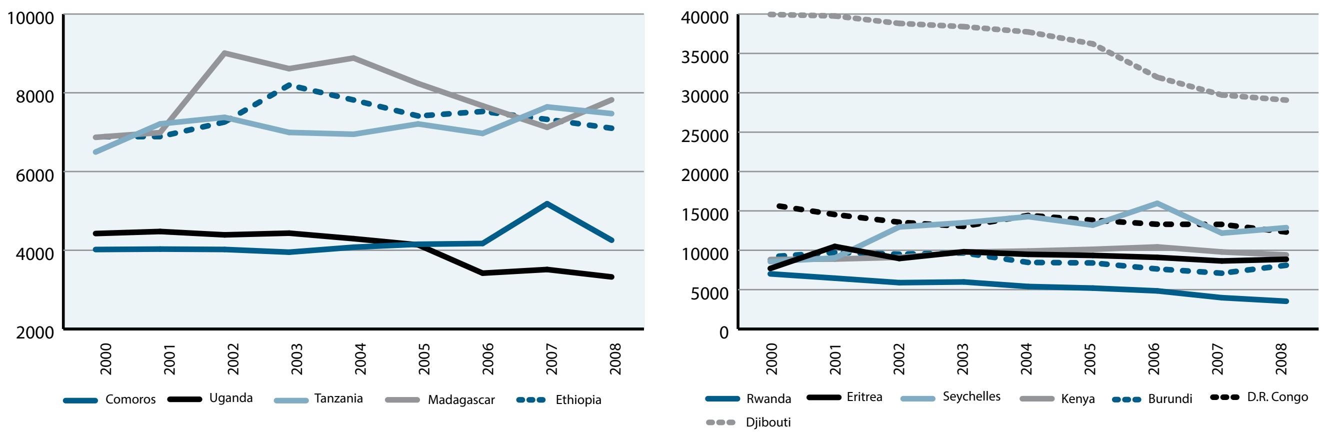


energy input per unit of GDP generated, and therefore limited progress in aggregate energy efficiency per unit of growth generated.

The consumption of oil by sector indicates the nature of flexibility on the use of imported fuel, or its drawdown when necessary. The higher the share of imported oil consumption in the transportation sector, the greater is the risk for energy insecurity. The transportation sector is known to have inelastic fuel demand, as there are no available feasible switching alternatives in the subregion (with the exception of the experimental biofuel programme in Addis Ababa). The sectoral distribution of oil products consumption (see Figure 55) shows variation across countries.

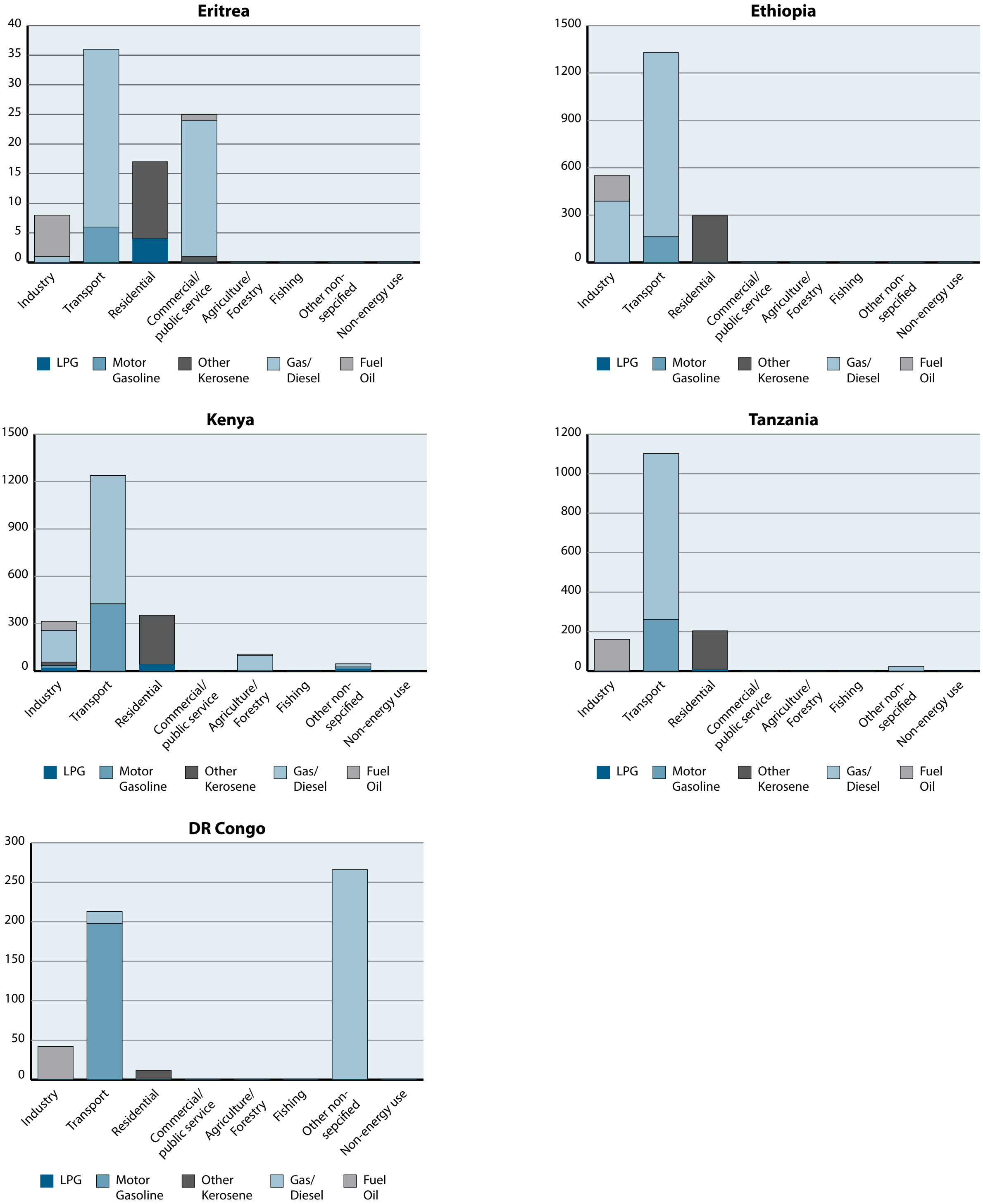
In Ethiopia, diesel is primarily used in the transportation sector, with significant use in industry, and kerosene largely utilized in the residential sector. The transportation sector locks a large share of oil use in Ethiopia, increasing vulnerability to energy insecurity but the industrial sector has switching alternatives in the long-run. Similarly, in Eritrea, the transportation sector is a major sector for diesel consumption, but the share allocated

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



Source: Based on data from the US EIA.

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 subregion.

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. The transportation sector absorbs a large share of diesel and motor gasoil in Kenya and Tanzania as well, with similar implications to energy security. The domestic refinery capacity of Kenya mitigates this vulnerability in that it replaces imported refined fuel. The DRC is a unique case, in that transportation is largely reliant on motor gasoil, and almost the entire diesel is used in other non-specified sectors. The exposure to inflexible fuel use is in motor gasoil product.

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

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3.3.5 Energy crisis management capability

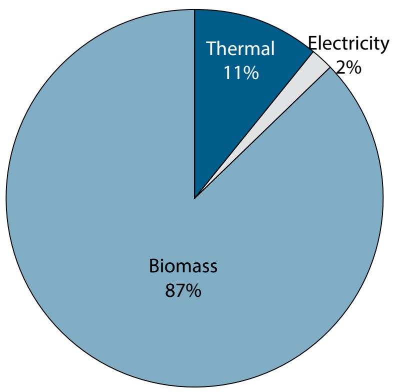
The energy crisis management capacity of a country depends on risk factors, some of which were discussed in previous sections, and in the mitigation capacity. The risk factors relate to: production capacity of primary energy; energy conversion capacity through power plants; refineries; improved cookstoves;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

3.3.5.1 Production capacity risks

Production capacity risk relates to oil, gas, coal, renewable energy and biomass production. With the exception of South Sudan, limited oil production activities in DRC, and the emerging gas production activity in Tanzania, the Eastern Africa subregion relies on biomass and imported energy for a large share of primary energy supply. About 87 per cent of primary energy source in the subregion is biomass, 11 per cent from thermal energy largely depending on imported fuels and just 2 per cent sourced from electricity. Therefore, the production capacity side will depend mainly on the management of biomass resources, until there is sufficient transition of the energy system to modern fuels. The domestic production capacity of thermal energy sources is rather limited, and currently will not alter substantially the structure of energy security risks. However, efforts to increase local primary energy supply from discovered resources can make a long-term difference.

The capacity to sustain biomass energy supply in the subregion, particularly wood and charcoal, is already a concern, recognizing that household energy security, particularly for the poor, will be severely undermined. Assessment of the state of forest resources in the subregion reveals major concerns, as forest resources show signs of unsustainable and rapid decline (see Figure 57). In Tanzania, DRC, Ethiopia, Uganda, Somalia and Madagascar, forest resources have shown a noticeable decline. The only country in the

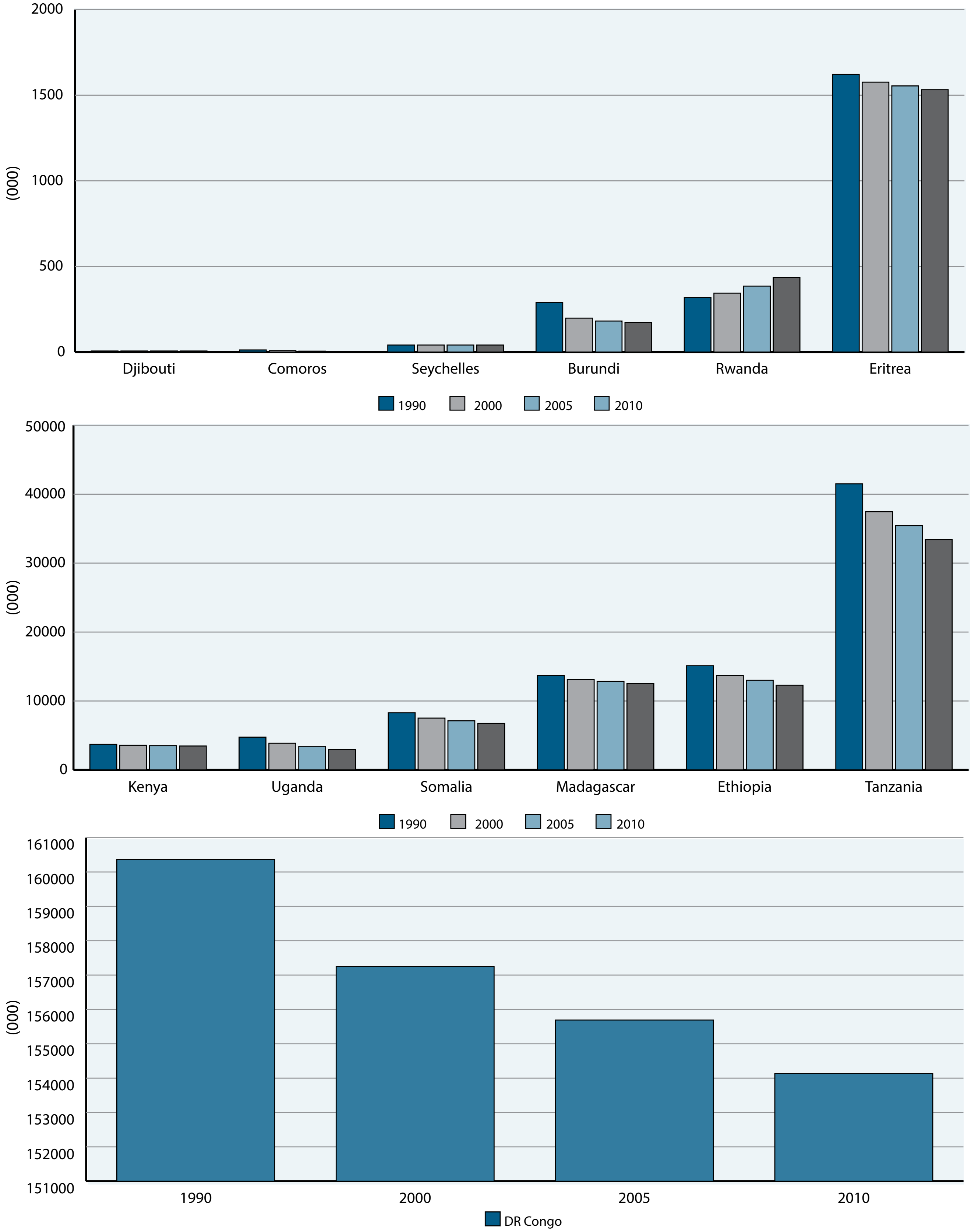
Figure 56: Energy balance of the Eastern Africa subregion, 2009



Source: UN Statistics, Energy Balances and Electricity Profiles, IEA2009.

Note: East Africa average doesnot include the Comoros, Djibouti, Seychelles, and Somalia because of lack of data.

Figure 57: Forest covers change in the Eastern Africa subregion (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 per cent stock decline is observed in Somalia, Ethiopia and Tanzania, nearly 40 per cent decline in Uganda and Burundi, and 75 per cent decline in the Comoros.

subregion with successful forest resource recovery is Rwanda, followed by no noticeable change in Djibouti and Seychelles, where the local climate is not conducive to forests.

In terms of percentage changes in forest cover based on 1990 forest resources as a base reference, nearly 20 per cent stock decline is observed in Somalia, Ethiopia and Tanzania, nearly 40 per cent decline in Uganda and Burundi, and 75 per cent decline in the Comoros (see Figure. 51). Between 4 and 8 per cent forest stock declines are observed in Madagascar, Kenya, Eritrea and DRC. In the DRC, while a 4 per cent decline seems marginal, given the size of the stock of 160 million hectares in 1990, one of the largest in the world, the magnitude of deforestation is quite high. Rwanda is the only country managing its forest resources quite well, showing forest resource recovery of 117,000 hectares between 1990 and 2010.

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

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

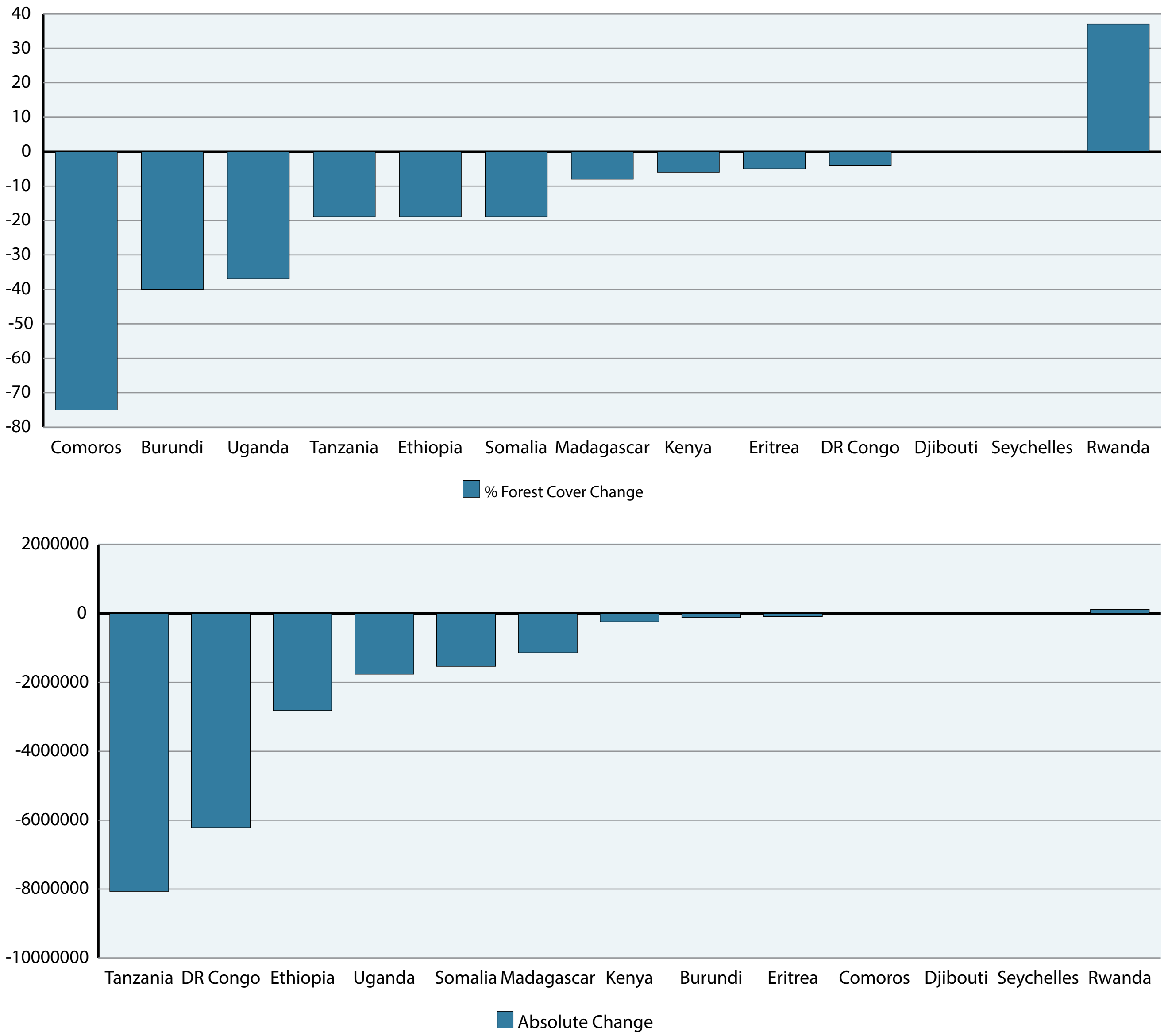
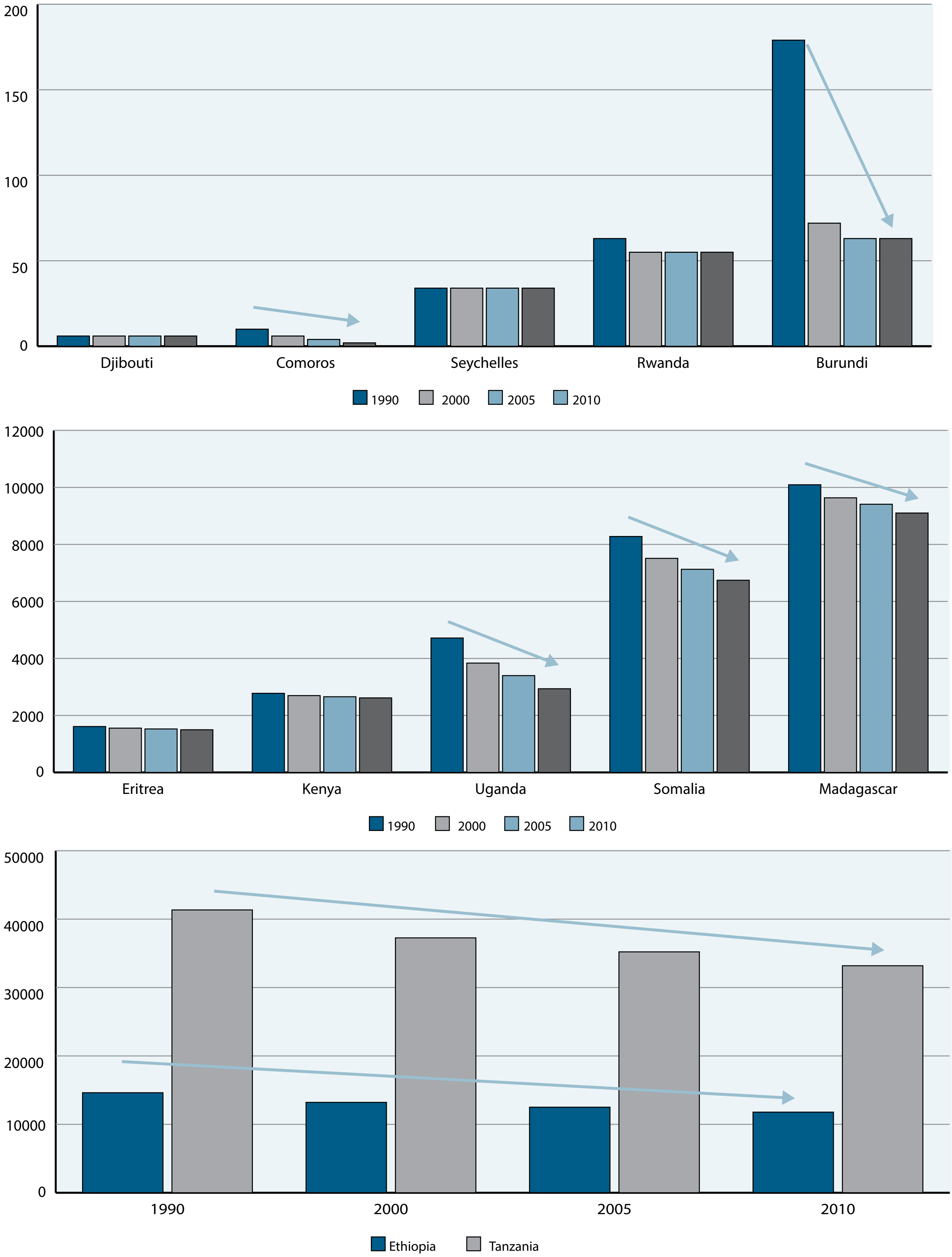
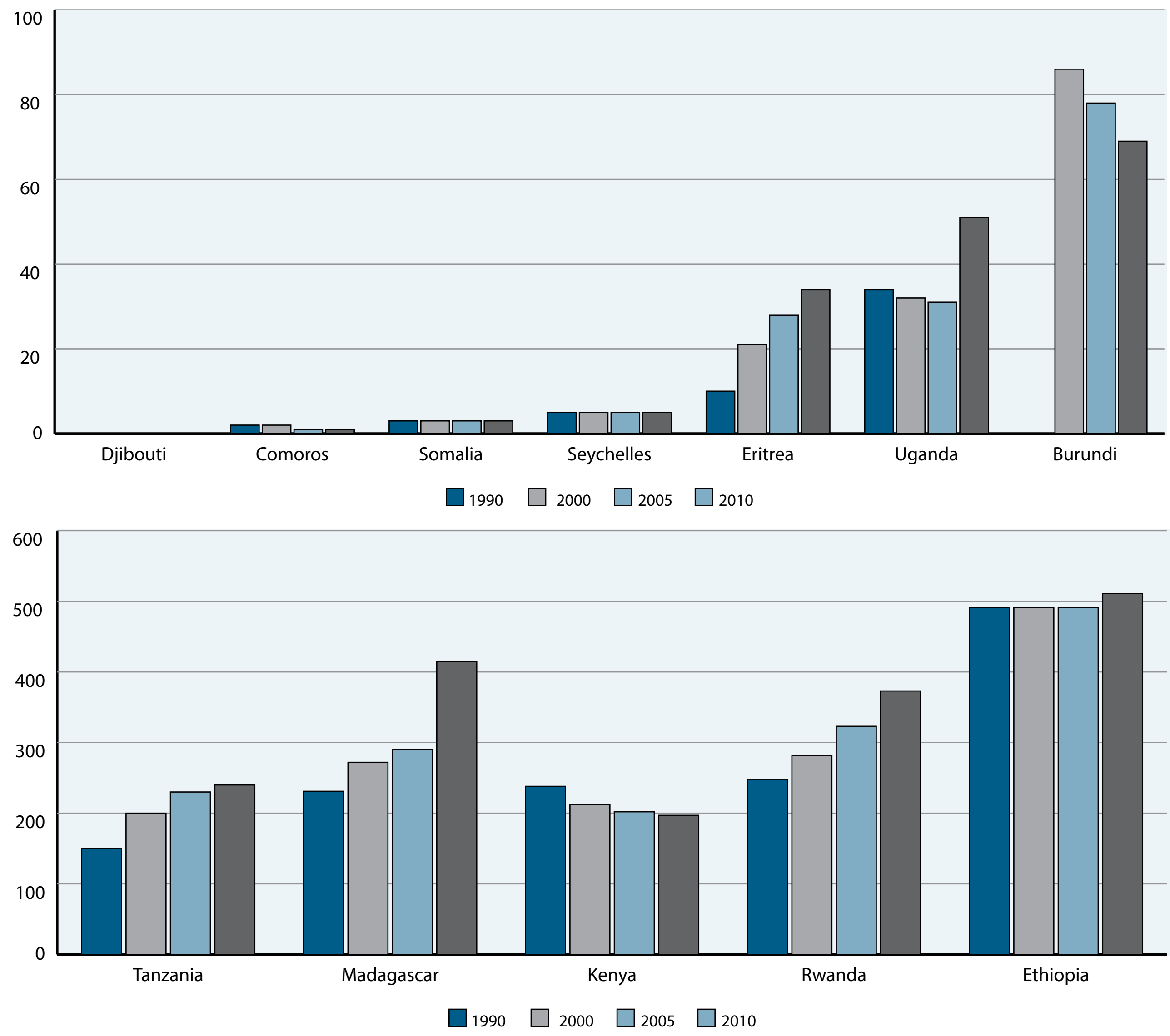


Figure 59: Naturally regenerated forest (in '000 hectares): 1990-2010.



Source: Based on data from FAO Forestry Department.

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



Source: Based on data from FAO Forestry Department.

The state of forest resources and biomass energy production capacity in the Eastern Africa subregion is sliding towards greater insecurity, with the 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, following current trends, is likely to worsen.

Forest losses were highest in Tanzania, with more than 8 million hectares of forest lost; over 6.2 million hectares in DRC; 2.8 million hectares in Ethiopia; and between 1.3 million and 1.7 million hectares in Madagascar, Somalia and Uganda.

Mitigation of deforestation can come from the natural regeneration capacity of the forest resource and from reforestation programmes. Trends in the natural regeneration capacity of forests in the subregion (see Figure 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.

Reforestation efforts to limit further stock decline are common throughout the sub-region. Even though reforestation efforts slowed in 2000, compared with 1990, in Burundi, the Comoros and Kenya, improvements were observed in Uganda, Tanzania and Madagascar, with sustained large increases in Eritrea and Rwanda (see Figure 60).

The scale of reforestation, in view of limited natural regeneration, is in no way sufficient to replace stock drawdown, but encouraging reforestation efforts are being undertaken in the subregion.

The structure of primary energy supply from biomass is breaking down – with limited regeneration capacity of the forest stock and insufficient replantation efforts, the current rate of stock drawdown, given the 87 per cent reliance on it, will impact household energy security in the Eastern Africa subregion negatively.

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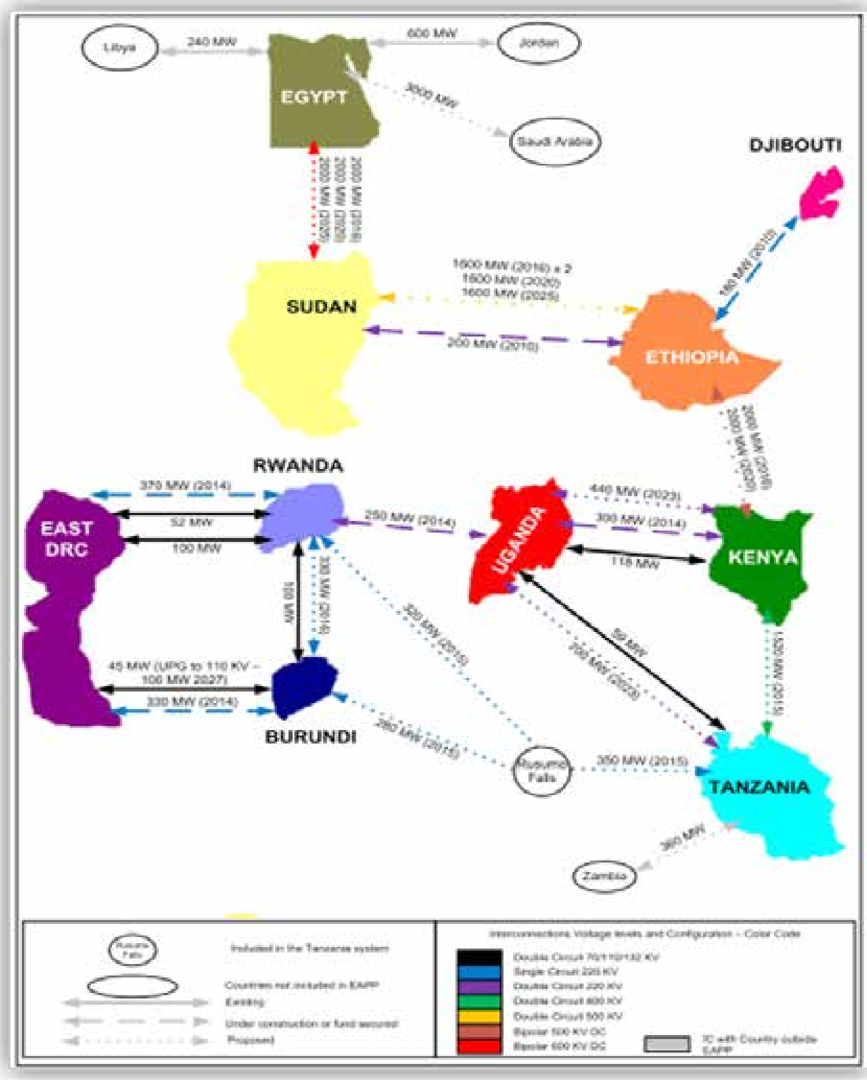
3.3.5.2 Energy conversion capacity through power plants

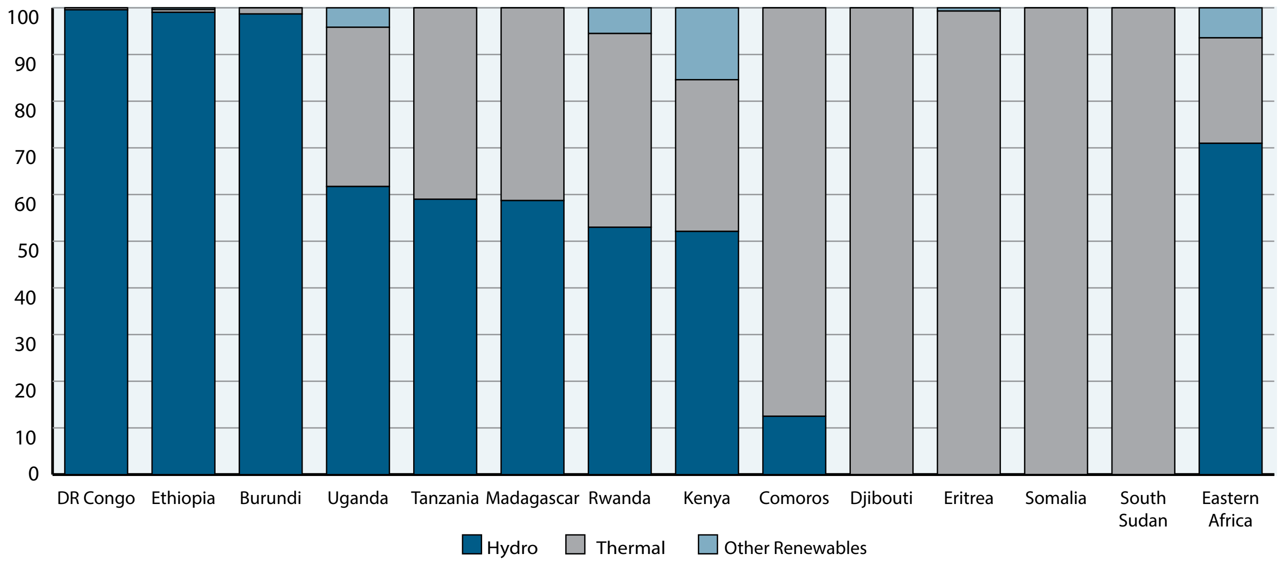
In discussing energy access challenges, the demand and supply side constraints to energy conversion were identified. The power conversion challenges in the energy sector of the Eastern Africa subregion are epitomized by: (a) frequent power outages (see Figure 29); (b) energy constraint to businesses (Figure 30); (c) self-generation by households and

Figure 61: Future regional grid interconnection and trade scenario



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

Figure 62: Share of thermal generation in total electricity supply



Source: Energy Information Administration, 2010 international energy data, with adjustments based on recent country data.

businesses outside the national grid (Figure 31); (d) limited power generation capacity (Figure 33); (e) high power distribution losses (Figure 34); (f) minimal transmission interconnection (Figure 35); and (g) 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 subregion (Table 9), and anticipated expanded regional grid interconnection schemes (Figure 61) will help enhance energy conversion capacities; and access to energy locally and regionally will improve on electricity crisis management.

Refinery operations in Eritrea, DRC and Tanzania have closed down, leaving Kenya as the only Member State with significant refining operations, along with limited refining operations in Madagascar. Consequently, the share of Eastern Africa subregion total refinery capacity as a share of Africa's capacity has declined.

It is noteworthy to draw attention to the technology shift in electricity conversion. The legacy of electricity in the Eastern Africa subregion was predominantly hydroelectricity. Insufficient 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 Figure 62, energy conversion in the region, in terms of technology, comes entirely from thermal generation in South Sudan, Somalia, Seychelles, Djibouti[16], and almost entirely from thermal generation in Eritrea and the Comoros. The thermal generation share of Madagascar, Rwanda, Kenya and Uganda are also sizable.

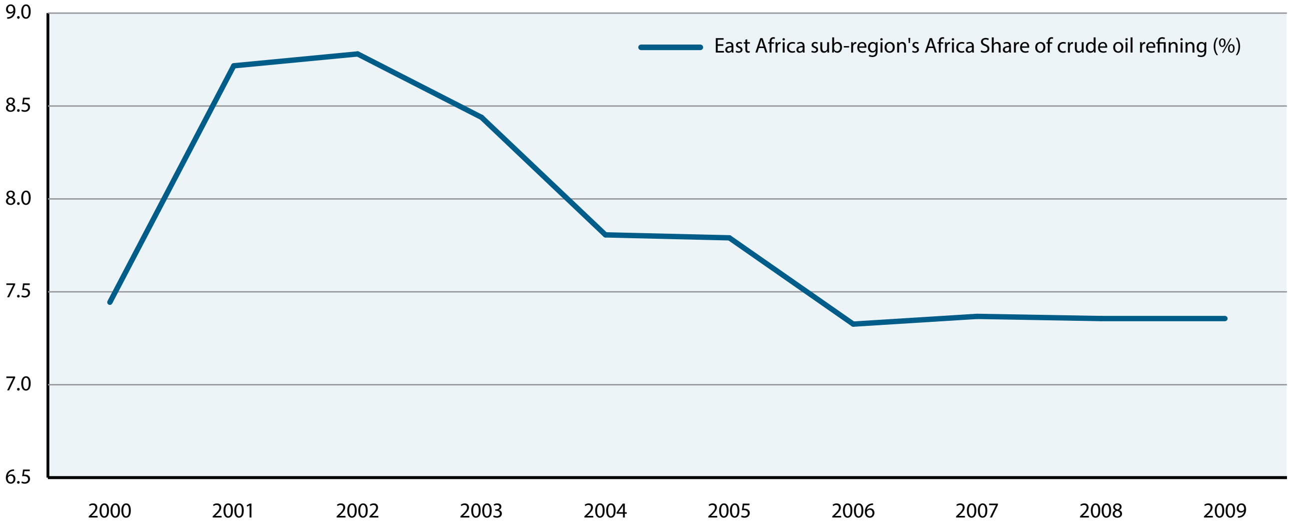
The shift in energy conversion technology of the subregion to thermal options has energy security implications: generation is becoming increasingly based on imported fuel, which has increased energy insecurity and reduced the energy crisis management capability of member States.

3.3.5.3 Oil refinery and natural gas distribution capacity

The capacity to refine crude oil provides a form of crisis management capacity by increasing domestic output of refined oil products. The level of refinery operations in the Eastern Africa subregion has actually declined. Refinery operations in Eritrea,

16 The electricity profile of Djibouti changed with resumption of hydropower imports from Ethiopia in recent years.

Figure 63: Eastern Africa subregion share of Africa's oil refining capacity: 2000-2009



Source: Based on data from the US EIA.

DRC and Tanzania have closed down, leaving Kenya as the only member State with significant refining operations, along with limited refining operations in Madagascar. Consequently, the share of Eastern Africa subregion total refinery capacity as a share of Africa's capacity has declined from close to 8.8 per cent in 2001 to below 7.5 per cent by 2006 and remained at that level till 2009 (see Figure 63). New efforts to increase investment in the oil refining industry in Kenya, and the possibility of refining South Sudan crude oil offer new hopes for the region in mitigating energy insecurity. The most promising and heated debate is in Uganda, where the government has a long-term plan to refine the country's crude oil found at Lake Albert. The government plan envisages to first of all start refining crude oil locally at 20,000 bbl/day, and gradually increasing the capacity to 60,000 bbl/day and beyond to meet regional demand for refined oil products. Disputes regarding refining or exporting the crude oil have not yet been resolved with oil companies.

The Uganda ambitious plan will alter the energy security profile of the country, and has the potential, if the regional-focused refinery plan is implemented, to reduce energy insecurity in the EAC countries and in South Sudan.

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The Tanzania natural gas find, the largest in the region, also has the potential to alter the nature of energy security in the subregion. Natural gas pipeline infrastructure schemes in Tanzania to transport the gas offshore 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 subregional natural gas distribution potential of Tanzania will face constraints from economic and contract negotiations.

The Tanzania natural gas find, the largest in the region, also has the potential to alter the nature of energy security in the subregion.

Natural gas extraction in Tanzania is currently linked with investment interests 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 a longer distance can shift Tanzanian natural gas to export markets, away from subregional consumers. This concern is strengthened by contracts entered into between the Republic of Tanzania and gas exploring and extracting companies, *Industry experts believe that price disparities, LNG production capacity and cheaper cost of transporting natural gas over a longer distance can shift Tanzanian natural gas to export markets, away from subregional consumers.*

such as BG Tanzania, according to which it is believed 5 to15 per cent of the gas finds are likely to be committed to the domestic market, and the rest sent to overseas markets.

While current natural gas contracts offer great opportunities for Tanzania to improve energy security through the use of LPG and gas-fired power plants, and boost its economy from natural gas proceeds, the subregional energy security mitigation benefit of Tanzanian natural gas remains in doubt apart from the potential of some connection to the electricity sector of Kenya.

3.3.5.4 Energy imports transportation

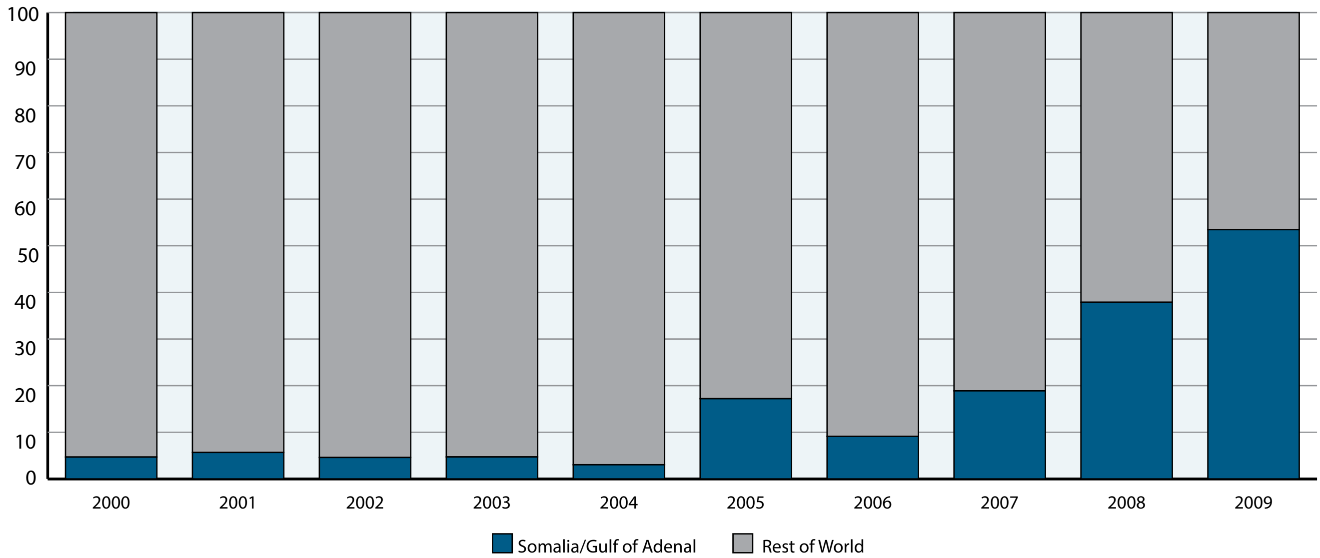
Exposure to energy import risks from import corridor safety is another risk factor affecting the energy crisis management capability in the area of sea transportation safety and the added risk for land transportation through third countries for landlocked States. Land transportation for landlocked countries in the EAC countries has been without problems to a large extent, facing no major sustained disruption due to political instability. However, the risk level was demonstrated during the post-election violence in Kenya after the 2007 presidential elections which halted land transportation and disrupted fuel deliveries through pipelines. Uganda has attempted to diversify to the Tanzanian road transportation route to deal with such risks by offering a subsidy of USh 150/litre of fuel routed through the Southern Corridor. Restrictions on road transport in Tanzania, such as limits on the wheel capacity of trucks, remain a concern to Uganda. Similarly, Rwanda and Burundi are affected by their landlocked status. There are plans to expand oil pipeline infrastructure to Rwanda to mitigate such inland transportation risks.

While current natural gas contracts offer great opportunities for Tanzania to improve energy security through the use of LPG and gas-fired power plants, and boost its economy from natural gas proceeds, the subregional energy security mitigation benefit of Tanzanian natural gas remains in doubt apart from the potential of some connection to the electricity sector of Kenya.

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 considered, in addition to the improved road connection with Uganda, partly funded by the United States government.

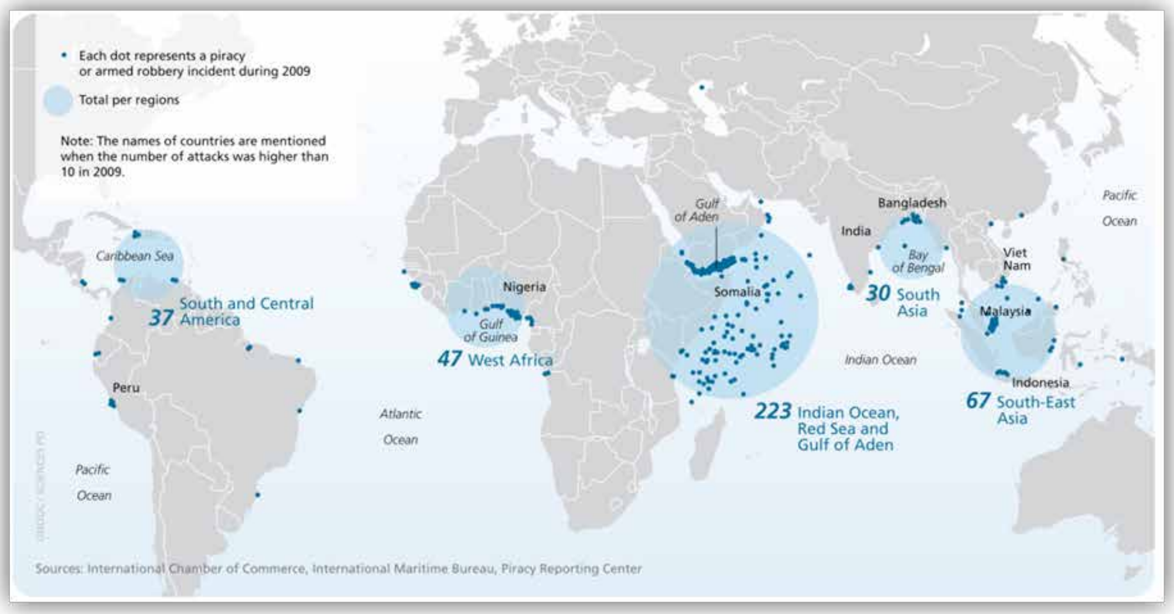
Ethiopia is also affected by road transportation. Its dispute with Eritrea has led to the shutdown of road transportation routes to all port cities in Eritrea since 1998. Since then, the use of the Assab oil refinery in Eritrea has also been terminated (the refinery

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.

stopped operating in 1997/1998). This has forced Ethiopia to rely on the Djibouti route. The railway connection between Djibouti and Addis Ababa has also been ruled out for oil transportation due to the narrow width of the rail lines which are inadequate 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 are in the offing, which should alleviate some of the inland tracking challenges.

The incidence of piracy activity in the Gulf of Aden, compared to global total incidents, has increased from 4.7 per cent in 2000 to 17.2 per cent by 2005, reaching 53.4 per cent in 2009.

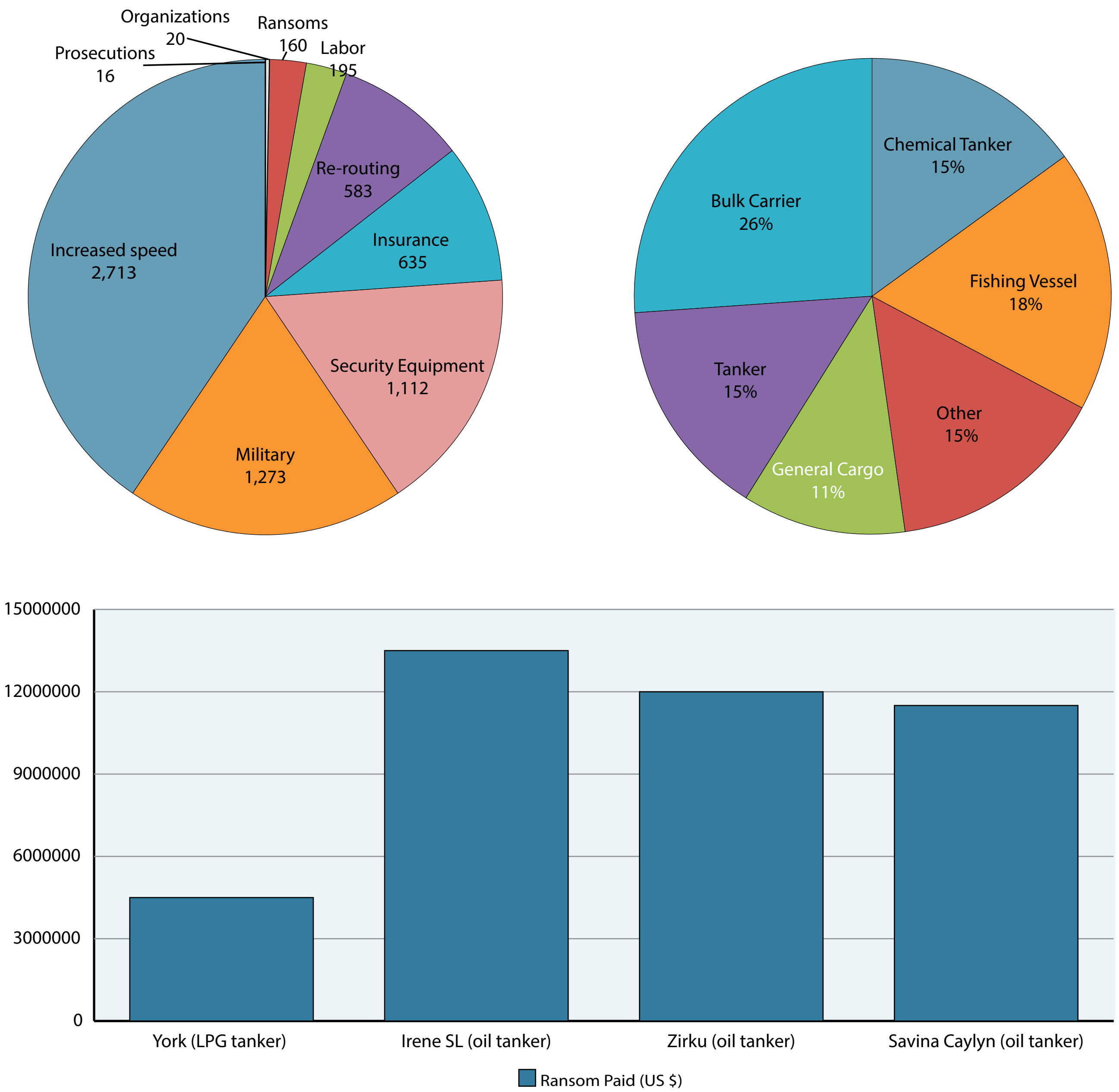
Transportation of fuel import is impacted particularly by the surge of piracy activities in the Red Sea and Indian Ocean as a result of the crisis in Somalia. The incidence of piracy activity in the Gulf of Aden, compared to global total incidents, has increased from 4.7 per cent in 2000 to 17.2 per cent by 2005, reaching 53.4 per cent in 2009 (see Figure 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 the elevation of the risk to physical disruption. Seizure of oil tankers by Somali pirates has caused fuel supply disruptions in Kenya and Uganda, and threatened deliveries to the 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 in the Gulf of Aden, but the risk from piracy 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 Figure 65).

The economic impacts of piracy could reach $6.6 to $6.9 billion per year.

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 the energy security of the Eastern Africa subregion, due to unsafe sea transport routes for imported fuels and rising cost of insuring shipments.

The economic impacts of piracy are significant. The One Earth Future Foundation, in its 2011 report on the economic cost of the Somali piracy crisis estimated that the cost for 2011 could reach $6.6 to $6.9 billion. Increasing the speed of ships to prevent pirates capturing them costs $2.7 billion in 2011. Military presence to guard against

Figure 66: The cost allocation of Somali piracy (in million $), the share of vessels affected and sample ransom paid, 2011



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

piracy incurred an estimated cost of $1.3 billion as well as insurance premiums of $635 million (see Figure 66). In successful piracy captures, 15 per cent of the cases involved oil tankers, which is almost 1 in 9. The ransoms are equally exorbitant, reaching $160 million in 2011. Extortions from carriers differ, but can reach as high as $13.5 million, as was the case with the Irene SL oil tanker (see Figure 66).

The total economic cost of Somali piracy reached close to $7 billion in 2011, including 635 million insurance premium costs, involving 15 per cent of oil tankers. The significant change in geographic coverage, involving nearly 1 in 9 oil tankers and the prevalence of attack has incurred greater fuel import cost for the Eastern Africa subregion, thus undercutting affordability, and posing greater physical disruption risk, which implies unsafe sea fuel transportation.

The energy crisis management capacity of a country, beyond the risk factors mentioned, is also dependent on 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 as a result of the materialisation of any of the risk factors. The resiliency of the energy security status of a country, in such situations, depends on built-in mitigation strategies, frameworks and effectiveness of implementation. Maintaining a strategic reserve, or emergency fuel stock, is one effective mitigation mechanism. A strategic reserve policy and implementation is in place in 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 it to the 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 as well as a lack of a mitigation policy, regarding strategic reserves, have heightened the state of energy insecurity in South Sudan.

Eritrea has drawn on its strategic reserves, leading to fuel rationing and frequent interruptions of electricity supply. Ethiopia has a 3 month fuel stocking practice, which puts it at par with international best practice. But strategic stocks are drawn on up to one month's supply, largely due to financial difficulties of restocking in fuels in its 13 or so strategic reserves. The decision of government to revise and announce regulated fuel prices at the end of each month, thereby asking operators to pay if price revisions are upward, and creating windfall gains for remaining stock at the end of the month, but failing to compensate distribution operators when government revises prices down, thus exposing them to losses on unsold fuel stock has led to unintended, but noticeable speculation. This system of pricing and windfall extraction with no loss compensation introduces artificial fuel shortages towards the end of the month. Some have also delayed receivership of oil shipments in Djibouti, waiting for the new prices in order to determine shipment schedules. Stock drawdown due to financial challenges and systemic speculation are introducing challenges to managing short-term fuel supply security.

In Tanzania, the requirement is two weeks of stock to be held by private operators, which is already significantly lower than international best practice. In addition, the lack of effective regulation given that the private sector keeps 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

Table 14: Strategic reserve policy and implementation in selected countries

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

Source: Country mission and secondary data, 2012.

crisis in Kenya, when fuel supplies were temporarily cut off, causing short-term fuel disruption since Uganda had no effective strategic reserves. Investment in an expanded strategic reserve system is under consideration in Uganda.

The practice of energy security in biomass requires a further look at, as well as designing proper frameworks to manage its continual supply with a disruption management scheme.

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

3.3.5.6 Demand restraints

Demand restraints assist in mitigating widespread fuel shortages. Rationing is the most commonly used approach in demand restraint in times of energy shortages. In the Eastern Africa subregion, demand restraints are often used to deal with fuel supply disruptions. In recent years, the subregion has been exposed to numerous fuel 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 resort to fuel rationing. Uganda also saw fuel shortages in 2010, due to the devaluation of the Shilling, delays at the Mombasa port, Nairobi-Eldoret pipeline constraints and rising global oil price, resulting in price increases from Shs10,000 for 4.5 litres down to 3 litres.[17] Uganda also faces other sources of supply disruptions, such as the Kenya three-axle rule that reduced the amount of fuel trucks could carry on the road, the Mombasa-Eldoret pipeline condition and other delays in clearing shipments. Timing of oil procurement can also introduce risks, such as that of July 2008 when oil companies procured at higher prices, though prices subsequently came down but then the stock had been acquired at high prices (Kojima, and others, 2010).

In Rwanda, similar fuel rationing was immediately started following post-election violence in Kenya, due to disruptions in fuel supply from the port of Mombasa, resulting in a 10 litre petrol cap allocation for small cars and a 20 litre cap for SUVs. It has also engaged Tanzanian authorities to facilitate the routing of fuel trucks through Tanzania for 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 per cent for diesel and 78 per cent for petrol[18]. The Rwanda coordinated response was well targeted, and the then Minister of Commerce, Mr. Protais Mitalli, gave an assurance to markets by stating, "there should not be panic. There are adequate fuel reserves to take the country through the crisis, but contracts are currently on to have the first delivery of four million litres of fuel to be on standby."[19] Similar shortages were experienced in Burundi, resulting in fuel rationing.

Burundi 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. The Company's bank accounts were later frozen. Since the company supplied 50 per cent of the fuel in Burundi, supply shortages were quickly felt, necessitating smuggling of fuel from Rwanda in the Ngozi Province, and resulting in fuel price hikes, and in the case of the town of Rumenge it almost doubled.[20]

17 See Adrew Nkurunziza's article in *The Monitor*, April 16, 2010.
18 See Eddie Mugaaya's article in *Sunday Times*, December 21, 2008.
19 Ibid.
20 See Jean Pierre Nkunzimana's article in *NewVision*, Uganda daily newspaper, August 28, 2007.

Eritrea also faced fuel supply disruptions in 2004 when fuel rationing was imposed. Eritrea later banned the sale of petrol to the public, conserving it for "essential uses." Petrol prices went up 40 per cent and diesel 25 per cent. Rationing continued till 2005, and for the most part through to 2012. Public services and development programmes are given priority in the supply of petrol. There were fuel shortages and rationing in Ethiopia in 2006, as a result of the timing of transportation and distribution of fuel stocks.

The cities of Dire Dawa, Jimma and Addis Ababa experienced disruptions, which were resolved by replenishment of supplies. 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, distributors are requested to pay the windfall gains to government on their remaining stock. However, when prices are revised downwards, government payout to compensate for losses on remaining stock is not a common practice. This has led to rife speculation, and delays in taking stock from the port of Djibouti till prices are known, to mitigate windfall losses. These responses often cause temporary fuel shortages, particularly in Addis Ababa.

Demand restraints in times of fuel and electricity shortages are common in the subregion, but in the case of fuels these are not often sufficiently supplemented by strategic reserve stock releases.

Shortages in electricity are handled in a similar manner, 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 have Uganda and Eritrea. Demand restraints in times of fuel and electricity shortages are common in the subregion, but in the case of fuels these are not often sufficiently supplemented by strategic reserve stock releases.

3.3.5.7 Reserve capacity

Existence of a sizeable reserve capacity in the energy system can help mitigate the impact of short-term energy disruptions. Dependence on imported fuel in the subregion, and the absence of local production of fuels, limit the capacity of keeping reserves to manage fuel shortages. Kenya is the only country in the subregion with a refinery, making it possible to refine fuel locally and supply it, thereby reducing imports by sizeable margins. The limits on existing capacity to import and distribute fuel quickly through pipelines and road transportation present challenges. In the electricity sector, there is often limited power, and power shortage is the norm. The fact that the subregion is poorly interconnected limits the potential of electricity imports to deal with peak demand shortfalls. Expanding reserve capacity in electricity and fuel stocking and transportation will assist in managing short-term energy disruptions.

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 Ethiopia, fuel switching in the transportation sector is through policy and programme and this is where the only fuel blending mandate in the subregion is exercised. The plan, which is an experimental programme in Addis Ababa, requires a 10 per cent ethanol blending, with a plan to raise it to 20 per cent by 2015. New sugar factories have been opened, generating more supplies of ethanol, potentially meeting higher blending mandates. A blending factory has been setup in Sululta, just outside Addis Ababa, to produce standardized blended fuel. By 2010, 314,000 tons of ethanol was produced, with a goal to increase production to 2.2 million tons by 2015. About 2.5 million hectare of land has been set aside for biofuels, for both local consumption and exports. The Ethiopia blending programme is the only one in the subregion that puts in place a tangible plan to switch fuel, and reduce imports. The claim is that the programme is saving the country $20 million in fuel import bills.

Regarding the electricity sector in the subregion, fuel switching is either in the planning or implementation stage. Tanzania has successfully expanded the share of its indigenous gas resources in electricity generation, and plans to expand the 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 under consideration in Kenya and Tanzania. Fuel switching for cooking is also widely practised in Rwanda where 50 per cent of households already had improved stoves by 2008, with a plan to increase coverage to 100 per cent by 2012. Through its national Domestic Biogas Programme, it aims to install at least 15,000 biogas digesters in rural households which own two or three cows by 2011, and expand biogas services to public institutions such as schools, hospitals and the prisons.

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

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Governance of Transboundary Water Resources for Hydropower Development in Eastern Africa

4

4.1 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, there is food insecurity and millions of people have been struggling to survive relentless hunger and poverty over the past several decades. Though the continent is blessed with natural resources, several factors contribute to 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 and for agro-processing.

Energy security and access challenges are the main issues to address in the developmental agenda of Africa for the attainment of the MDGs. The Eastern Africa subregion has huge water bodies 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. This has the potential for creating 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 subregion has an energy shortage problem that has proved to be costly to the region's economy and sustainable development goals. Efforts to develop the economies in the subregion are being stifled by this lack of reliable energy. This is in spite of the fact that the region has a significant number of perennial rivers with the potential to generate more than enough energy for the subregion 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.

An energy transition in the subregion would involve a move from the present levels of subsistence energy usage based on human labour and fuelwood resources, to a situation where household services and farming activities use a range of sustainable and diversified energy sources. The obvious benefits would be greater resilience in the production system, higher productivity, improved efficiency and higher incomes to farmers. Furthermore, environmental degradation, resulting primarily from poverty, would be minimized.

The underlying themes that need to be stressed for increasing energy access are country-led efforts, regional projects and strengthened partnerships. The emphasis should be on an increase in electricity generation, to power sustainable development and meet basic needs. In order to achieve these goals, there is the need for an effective management of resources with improved institutional performance within the subregion. There is also a need for more deliberations on the management of water to inform transboundary negotiations.

The hydropower resources in sub-Saharan countries account for about 12 per cent of the world's hydropower potential, but only 17.6 per cent of these resources have been harnessed - one of the world's lowest figures.

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 not only to provide electricity access but also to contribute effectively 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 the considerate application of lessons learned and best practices and also through a triple bottom line approach to achieve sustainability.

The Eastern Africa subregion has a number of rivers with excellent potential for hydropower development. The hydropower resources in sub-Saharan countries account for about 12 per cent of the world's hydropower potential, but only 17.6 per cent of these resources have been harnessed - one of the world's lowest figures (FAO, 2008). The continent has a technically exploitable capability of 1,888 TWh/yr, 41 per cent (or 774 TWh/yr) of which is in one country, DRC, 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 a substantial potential capacity of180 TWh/yr. In terms of installed capacity (Figure 67), Egypt, with its famous Aswan Dam, leads with 2 810 MW, followed by DRC (2,440 MW) and Mozambique (2,180 MW). Meanwhile, Mozambique (11,548 GWh) and Egypt (11,450 GWh) are the leading producers of hydroelectricity (1999 generation data) (WEC, 2003). Figure 67 shows estimates of the hydropower potential of the continent.

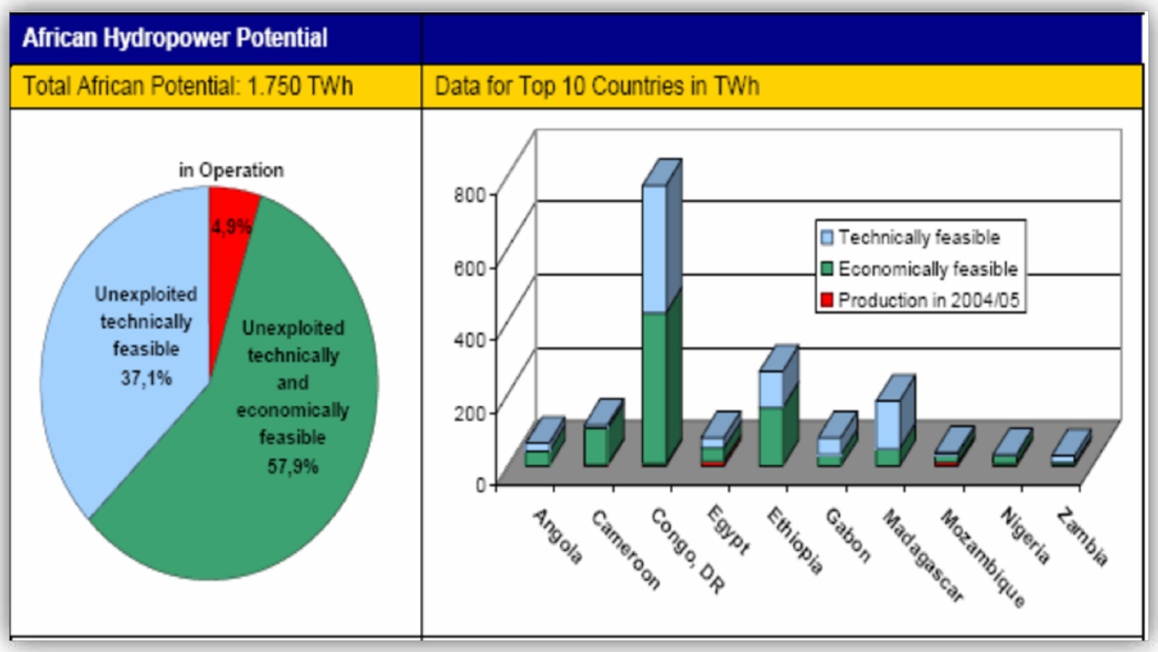
The current geographic distribution of hydropower in Africa demonstrates the following pattern: North Africa (23 per cent), West Africa (25 per cent) and South/Central/Eastern Africa (51 per cent). Despite this potential, which is enough to meet all the electricity needs of the continent, only a small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

In the Eastern Africa subregion, as mentioned earlier, a number of countries have faced power shortages that have led to power supply rationing. The origin of the crisis is the decrease in water levels in rivers and lakes that are feeding the hydropower plants and the lack of investment in power generation. Countries in the subregion 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 taken in this regard.

Hydropower has long been the pillar of Eastern Africa's energy production capabilities. The majority of electricity produced in the subregion comes from hydropower, and it is expected to provide 79 per cent of the total of East Africa's new additional generation capacity (REEP, 2010). However, there are environmental and institutional challenges to harnessing the region's hydropower production potential, 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.

On the other hand, hydro projects have benefited, and could continue to benefit, from private sector investment and foreign donors. Eastern African countries are an attractive destination for such investments; the region has maintained a fast growth trajectory despite experiencing severe droughts and famine. The region registered a 5.8 per cent GDP growth in 2011, and 6 per cent in 2010 (UNECA, 2012). In effect, much of growth of Uganda 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.[21]

Figure 67: Africa's hydropower potential



Source: FAO, 2008.

21 See (www.worldenergy.org, 2007).

4.2 Major subregional water systems and hydropower development in Eastern Africa

4.2.1 Nile River and hydropower development

The Nile, the world's longest river, is 6,850 Kilometres long, and covers eleven countries: Burundi, DRC, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, the Sudan, South Africa, Tanzania and Uganda.

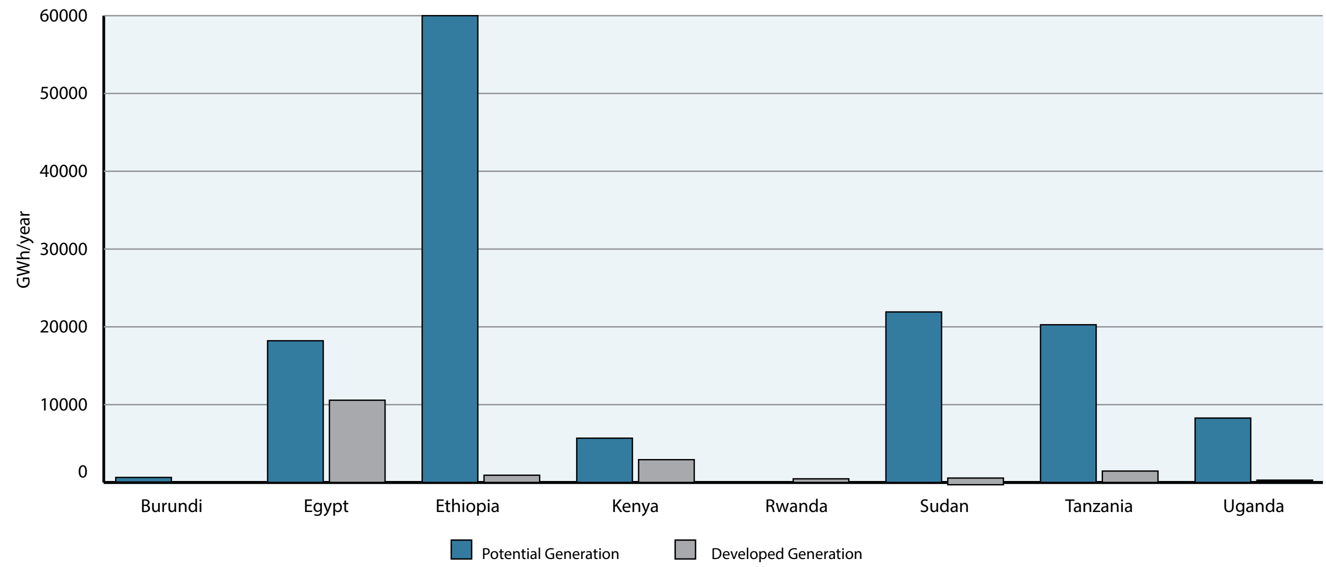
The Nile, the world's longest river, is 6,850 Kilometres long, and covers eleven countries: Burundi, DRC, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, the Sudan, South Sudan, Tanzania and Uganda. The Nile, due to its length and climatic variety, is one of the most complex river systems in the world. Its main sources are the Blue Nile, which takes its source from Lake Tana in Ethiopia, and the White Nile, which takes its source 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 DRC the Nile water constitutes only a small part of their resources. Egypt and the Sudan use the Nile water mainly for agricultural purposes; 80 per cent 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 regions during the flood season from May to November. The Nile water is also used for the production of hydroelectric power, especially in Ethiopia (Sinnona, 2007).

The hydropower potential of all the Nile Basin Countries put together is estimated at140,000 MW.

The hydropower potential of all the Nile Basin Countries put together is estimated at140,000 MW. The DRC alone is considered to have a potential of 100,000 MW, with approximately 40,000MW concentrated in the INGA complex from the Congo River; Ethiopia has a hydropower potential of 45,000 MW. Figure 68 shows the energy from hydropower of the Nile basin countries, excluding DRC.

Though the hydropower potential in the subregion is considerable, especially in DRC and Ethiopia, the current approach is that each country is attempting to develop its hydropower resources on its own. Even though there are challenges in collaboration, there are examples of countries building hydropower plants jointly, such as Burundi, Rwanda and DRC on the Ruzizi through collaboration, despite the challenges.

Figure 68: Energy generation potential and developed of the Nile basin countries



Source: Kanangire, 2008.

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

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

The main strain on the Nile water resource is from the unilateral development of new areas in Egypt such as the Toshca project to expand irrigated areas to claim prior appropriation rights. Likewise, the unilateral decision by Ethiopia to build the Renaissance Dam is a challenge for water governance.

Some of the states in the Nile basin, such as Ethiopia, Kenya, Tanzania and Uganda have already experienced critical water shortages due to extreme conditions 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, and shortage due to drought represents physical shortage. On the other hand, there can be a shortage as a result of contamination of the available water. In this case the water can become degraded to an extent that 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 the continuous population growth in the basin. If the present trend continues, there is likely to be a water shortage which will impact socioeconomic development and increase the potential for water conflict (Yitayew and Melesse, 2010). The main strain on the Nile water resource is from the unilateral development of new areas in Egypt such as the Toshca project to expand irrigated areas to claim prior appropriation rights. Likewise, the unilateral decision by Ethiopia to build the Renaissance Dam is a challenge for water governance.

Historical hydroclimatology studies show the variability in flow of the Nile both in time and space. Unless there is a way to regulate the condition of this flow, it will be difficult to plan any meaningful sustainable water resources and energy development programme. This is particularly the case regarding hydropower development. It is also obvious 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. For the effective governance of the Nile water there is the need for an integrated basin-wide hydraulic cooperation as well as other efforts to bring the riparian countries to work together towards the shared vision of benefiting socioeconomically and politically.

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Until recently, most of the agreements on the Nile Basin were made either between colonialists (except Ethiopia) or bilateral agreement between the Sudan and Egypt. It was in the 1990s that there were substantial efforts made by the riparian States themselves and by the donor agencies to develop confidence and a vision for the future based on cooperation, consideration for the environment and the efficient use of water. Despite the intense pressure for cooperation due to demographics, sustainable development needs, water and food security, economic integration and climate change, there is no reliable established framework accepted by all the riparian countries for governance of the water and energy resources of the Nile basin towards attaining the shared vision of benefiting socioeconomically and politically. The present challenge for cooperation stems from conflicting agricultural water demands mainly from the

Eastern Nile countries, which are all yet to agree on the equitable and reasonable use of the water.

4.2.2 The Congo River and hydropower development

The Congo River is the ninth largest river in the world at 3,100 kilometres long. 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 and flows southeast into the Atlantic Ocean. The Congo is the river with the highest potential for hydropower in the world. The basin contains 30 per cent of the fresh surface water in Africa, and the discharge at Kinshasa and Brazzaville is 1,269 km^3/year (UNECA, 2000). There are many tributaries on both sides of the Equator, and so the rainy season alternates in different parts of the basin, providing a fairly constant yearly flow into the Congo.

The Congo River basin is the second largest in the world with an area of 3.7 million km^2. Nine countries make up the Congo River basin: DRC, the Central African Republic, Angola, the Republic of Congo, Tanzania, Zambia, Cameroon, Burundi and Rwanda.

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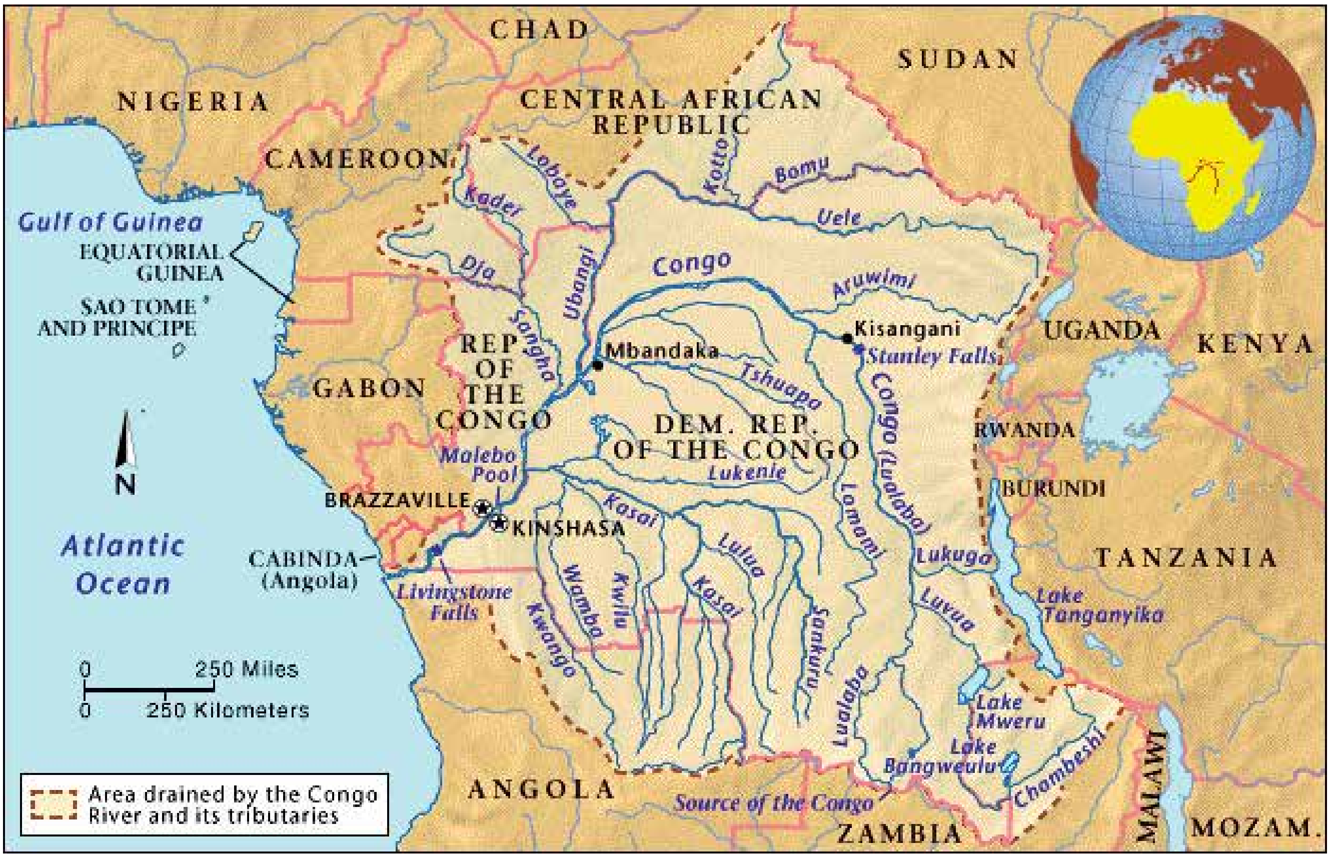
The Congo River has a tremendous potential to provide electricity, as well as ecological wealth and power, and with its rain forests, is rated second in the world after the

Figure 69: The Congo River basin



Source: http://piperbasenji.blogspot.com/2012/10/the-congo-river.html.

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 is incomparable in scale, concentrating at a natural pinch point 225 km upstream from Kinshasa. The Congo River descends at about 102 meter 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, 250 km west of Kinshasa is the site of the most important hydroelectric projects and proposals in all of Africa. The existing installations already power Kinshasa and western DRC and provide critical export revenue, and expansions could see the site develop into a clean energy provider of global importance. These developments however will result in localized impacts and risks which will need to be mitigated.

Inga I was built in 1972 and Inga II in 1982, and have a design capacity of 351MW and 1,424 MW, respectively. Nevertheless, due to the age of the installations and the lack of maintenance, the output is now considerably reduced. An internationally funded rehabilitation project at a cost of $500 million is in progress to restore some of the capacity to over 70 per cent 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 will transmit the power generated to Zambia, Zimbabwe, South Africa and the Republic of Congo (Brazzaville). Most of the anticipated project cost ($8 to 10 billion) faces tough technical choices including that of optimal design (IRENA, 2012).

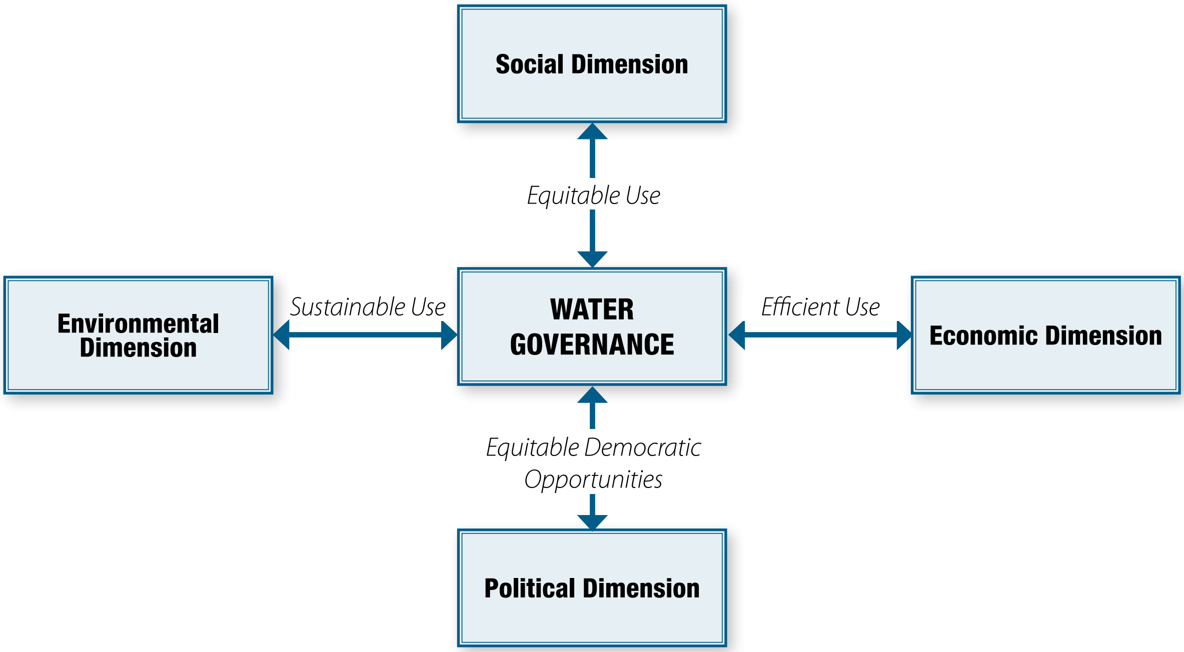
The Grand Inga project is at the feasibility stage and expected to generate 39 GW, which is the largest energy generating project ever built. The project is expected to cost as much as $80 billion and significant amounts of electricity could be exported. DRC and South Africa have signed a Memorandum of Understanding to establish partnership between them for the development of Grand Inga.

4.3 Governance of transboundary water resources in Eastern Africa for hydropower development: challenges and opportunities

4.3.1 The African context

The optimum management of water resources to meet the MDGs requires effective governance of the resource especially, along 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

Figure 70: Different dimensions of water governance



Source: http://www.watergovernance.org/why.

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 the 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 70 illustrates the relationships between these dimensions of water governance.

Water governance capacity also reflects a society's level of competence in implementing 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, and 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 the sustainable development of a region, such as Eastern Africa.

While water governance is a complex subject that needs extensive treatment, the focus on water governance in this report is in the context of energy production. Good water governance along transboundary lakes and river basins though necessary, is not a 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 in nature. By connecting people and creating interdependence among local users from different countries, transboundary rivers and lakes pose governance challenges and can become a source of tension at the political level. Transboundary water resources are a considerable potential for conflict and escalation of conflict, and also offer a variety of different possibilities for transnational cooperation.

Transboundary water resources are a considerable potential for conflict and escalation of conflict, and also offer a variety of different possibilities for transnational cooperation.

In the 1980s and 1990s, great concerns were raised about conflicts relating to water shortages in various regions, given the rising consumption of water and the asymmetrical power relations between riparian countries. An example often cited 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 sombre predictions have not materialized. The UNDP Human Development Report (2006)[22] affirms that water could generate conflicts, but more frequently it has been a bridge to cooperation. Indeed, experience shows that transboundary water resources are far more likely to serve as the source of transboundary cooperation than of violent conflict between nations. Since the end of the apartheid regime in South Africa, it is specifically Southern Africa – a region with an exceptional number of transboundary rivers – that has had a number of positive developments to show in this regard. In other subregions as well, Africa's Heads of State and Government have opted for cooperative management that has been affirmed in many declarations and bi- and multilateral agreements.

Transboundary water resources management in Africa is addressed in various international documents with guidelines; 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 refer to the work of the United Nations Secretary-General Advisory Board on Water and Sanitation and the International Water for Life Decade proclaimed by the United Nations General Assembly (2005–2015).

Equitable governance of water resources implies finding a balance between citizens' needs, and the demands from stakeholders in the agricultural, industrial and other sectors.

Transboundary water resources management involves the governance of water resources shared between two or more riparian neighbouring countries. Issues of differing and elastic political agendas and competition for scarce water resources complicate the governance approach. The Nile Basin with 11 riparian countries and complex upstream/downstream issues is one such example. In the South African Development Community (SADC) alone, there are 13 transboundary rivers shared by two or more riparian states. Since many local, national and international stakeholders are involved, Transboundary Water Resources Management (TWRM) cannot be carried out purely on a state-by-state basis.

Multinational 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 transboundary basin institutions or agreements – such as the Congo-Oubangui-Sangha International Basin Commission (CICOS), the stillborn 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).

22 UNDP Human Development report 2006. Beyondscarcity: power, poverty and the global water crisis.

Governance of transboundary 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 structures with the authority to enforce water agreements are absent.

While progress made with regard to conventions is commendable, a sustainable regional framework is absent. Governments also have a preference for bilateral agreements to settle disputes over transboundary water resources. Internationally, there exist two multilateral agreements, the UNECE "Convention on the protection and use of transboundary watercourse and international lakes", signed in Helsinki in 1992 and in force from 1996, and the United Nations "Convention on the Law of the Non-Navigational Uses of International Watercourses", adopted in 1997, but still not in force (Sinnona, 2007).

Governance of transboundary 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 structures with the authority to enforce water agreements are absent.

4.3.2 The political economy of the Nile and implications for water governance

Transboundary water management is mainly a political process, which is the reason why cooperation and conflicts on water resources are determined by asymmetries in power among riparian states. It is with 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 Nile as 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 (that is, in periods of drought). It is important to point out that though there are eleven riparian countries, only three of them are critically involved in issues regarding peaceful, cooperative sharing of Nile water—Ethiopia as the primary supplier, and Egypt and the Sudan as the major consumers.

Among riparian states, Egypt has the highest share of the Nile water, subject to water management of the upstream riparian states. In 1979 it was declared that at the beginning of 2000 Egypt would face a water deficit of 4 billion m3 due to its alarming population growth (one million every nine months) and agricultural water usage. In the 1990s, Lake Nasser could not meet the population's water demand because of the high evaporation, thus 50 per cent 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 deal with 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 after the referendum of 9 January 2011) are also strongly dependent on the river.

After the Second World War, and the independence of riparian states, the river became the scenario for power games and disputes relating to the Cold War. In 1956, when the Sudan obtained independence, it requested a renegotiation of the 1929 Water Agreements with Egypt. The Sudan accepted the Aswan High Dam construction by Egypt, in exchange for sharing the water of the dam. In 1959 the two countries signed agreements regarding the Nile water, to allocate the resource and share costs and benefits of future projects on the river. From then on, cooperation between the Sudan and Egypt has somewhat continued (Sinnona, 2007).

The Hydromet Agreement was signed in 1967, originally between 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, DRC and Ethiopia, thus increasing cooperation. Hydromet lasted for 25 years, terminating in 1992. In the same year the water resource ministers from Egypt, the Sudan, Rwanda, Tanzania, Uganda and DRC created a new organization, the Technical Committee for the Promotion of the Development and Environmental Protection of the Nile Basin (TECCONILE). The remaining 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 the sustainable development of the river basin (Sinnona, 2007).

More than 40 per cent of transnational water treaties include provisions on financial investments, energy commerce and peace negotiations. This approach could facilitate agreements, because it provides governments with national justifications and promotes financial flows, capable of opening cooperation on a variety of matters.

This development is positive and an 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 transboundary waters require cooperative transboundary 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 transboundary river basins.

Cooperation is often extended to other areas of benefits. According to a UNDP Report (2006), more than 40 per cent of transnational water treaties include provisions on financial investments, energy commerce and peace negotiations. This approach could facilitate agreements, because it provides governments with national justifications and promotes financial flows, capable of opening cooperation on a variety of matters. Moreover, it offers a bargaining power to weaker states that could contribute something in return for equitable water management. Transnational cooperation is influenced by asymmetries in power. Within this framework, transnational relations regarding the management of a common water resource become a matter of interactions, rather than a mere issue of conflict or cooperation. Conflicts and cooperation coexist in situations where a resource is shared.

4.3.3 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 acknowledged in the Dublin-Rio principles, which make it clear in their statements that water development and management should be based on a participatory approach, involving users, planners, policymakers 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, more so than in most others, the beneficiary needs to be involved at all stages of the project cycle, from monitoring and needs identification right through to maintenance and basin and system management.

In order to manage water equitably, governments must solicit stakeholders' involvement. Involvement of stakeholders on the transboundary scale is key in ensuring 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 by instituting measures 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 principle excludes elections, that are a form of indirect involvement, and includes financial contributions. Inadequate public participation, or even worse, the exclusion of people in decisions that affect their welfare, often leads 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*).

4.4 The Congo River: challenges and opportunities for efficient use

In 2002, DRC was just beginning its post-conflict phase from five years of 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 a conflict ensued the following year involving Rwanda and Uganda. Forces from Angola, Namibia and Zimbabwe also intervened, turning the DRC into a regional battle ground until 2002 after Joseph Kabila had been appointed president in 2001, following his father's assassination. He secured a peace deal that brought some stability and an international effort to rebuild DRC infrastructure.

The DRC government identified restoration of its war-ravaged electrical system as an initial 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 extremely neglected. The transmission lines to distribute power from the dams within the DRC and export power to customers as far away as South Africa had also been neglected. Power output was barely a third of the original capacity of Inga 1 and 2's, according to the World Bank.

An African programme was also initiated to further enhance the potential of Inga, with 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 expanding access to electricity and reducing its cost. The proposed Grand Inga Dam, which is to be constructed in western DRC will be built near the existing dams, Inga I and Inga II, and the yet to be constructed Inga III. It has been estimated that after construction, 500 million of Africa's 900 million people currently without electricity will be able to benefit from it.

4.5 Best practices in governance of water resources

The Mekong River Commission (MRC), an intergovernmental 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 transboundary water cooperation. Currently, the MRC Secretariat administers a range of joint programmes, including: the Basin Development Plan; the Water Utilization 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.

The NBI could be considered as a best practice since its objective is to develop water resources in a sustainable and equitable manner, and to ensure efficient water management and optimal use of the Nile's water resources. Some of the major achievements have been to facilitate cooperative action, build confidence and capacity in riparian states, and pursue cooperative development opportunities.

As one of the world's largest and most complex efforts at TWRM, the NBI could be considered as a best practice since its objective is to develop water resources in a sustainable and equitable manner, and to ensure efficient water management and optimal use of the Nile's water resources. Some of the 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 which are now providing information to riparian states. Attempts to get the Zambezi Watercourse Commission (ZAMCOM) up and running five years after an agreement was signed by seven of eight riparian states continue to be frustrated 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 programme design and implementation, and come closest to what could be defined as a best practice. These approaches which benefit from decentralization and democratic systems and include responsive representation and local governments, center on participatory planning in the development of Local Development Plans (LDPs) and, complement them with 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, and successfully integrate community involvement and local government plans with regional and national planning and budgeting processes.

4.6 Way forward for Eastern Africa

Transparency and accountability, which are closely related, are two basic principles considered prerequisites for good water governance within the context of governance systems.

River water does not stop at administrative or political boundaries, so the best way to develop, use, protect and manage water resources is to forge cooperation between all the countries within the natural geographical and hydrological unit of the river basin. The interests of both upstream and downstream countries have to be considered in a transparent, responsible and comprehensive manner.

Transboundary water resources create issues whereby water governance is complicated by matters of politics and competition for scarce resources between two or more countries. TWRM cannot be conducted purely on a state-to-state basis, since many other stakeholders from the local to the international level also need to be involved. Furthermore, the success of TWRM is also affected by weak legal and regulatory frameworks, a lack of basin-wide institutional arrangements for joint development and management of transboundary water resources, poor water resources information systems, poor financing and a lack of stakeholder participation.

Transparency and accountability, which are closely related, are two basic principles considered prerequisites for good water governance 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.

Regional energy cooperation and integration offer one of the most promising and cost-efficient options for Africa, particularly Eastern Africa, to further develop their energy sectors, in order to gain the environmental, social and economic benefits from a more efficient use of resources.

Moreover, corruption in the water sector results from a lack of transparency and accountability. Corrupt practices are endemic in most institutions and transactions in Africa, leading to increased costs to users for service provision. Regarding 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 this participation are essential in every aspect of governance, from project and programme selection and planning, to budgeting, policy and regulation. This not only improves sustainability of services, but also improves transparency, accountability and regulatory enforcement.

Regional energy cooperation and integration offer one of the most promising and cost-efficient options for Africa, particularly Eastern Africa, 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 also 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 considered as a means to develop alternative clean or more environmentally sound energy resources.

Eastern Africa states should consider the establishment of effective water governance systems based on the principles of equity and efficiency in water use and energy resources production and distribution.

As the way forward, Eastern Africa states should consider the establishment of effective water governance systems based on the principles of equity and efficiency in water use and energy resources production and distribution. The countries in the subregion need to formulate, establish and implement water and energy policies with appropriate legislative and institutional frameworks. There have to be clearly defined roles for governments, civil society and the private sector regarding their responsibilities in the areas of ownership, management and administration of the water and energy resources. Transnational dialogue and coordination, conflict resolution, price regulation and subsidies must be clearly defined and agreed upon by all parties. Moreover, the subregion should consider multilateralism instead of unilateralism as well as the enhancement of more cooperative approaches. If the countries are to overcome their differences and attain sustainable water and energy development, then the establishment of an effective water governance system and of the NBI legal and institutional framework agreement with full consideration of the hydropolitics of the region is urgently needed.

The subregion should consider multilateralism instead of unilateralism as well as the enhancement of more cooperative approaches.

Energy Access, Energy Security and The Environment in the Eastern Africa Subregion

5

5.1 Background

Sustainable energy development is an important consideration in the policy making process aimed at alleviating poverty and achieving socioeconomic development. Access to energy, through energy development, translates into access to basic services such as healthcare and education, and together with energy security, plays a critical role in meeting the MDGs. This is particularly the case in the Eastern Africa subregion where populations have the lowest level of access to electricity due primarily to lack of infrastructure, resulting in prohibitive costs of connection to the grid and high consumer fees.

The lack of access to energy is very serious in rural areas and has led to an excessive use of solid biomass such as wood and charcoal, by 80 to 90 per cent of the population. This is detrimental to the environment (deforestation, soil erosion) and contributes to climate change. The social and economic impacts, which include women and girls having to walk long distances to fetch wood, thereby resulting in loss of time for education, are significant. Furthermore, the use of solid fuels (for example wood, charcoal, dung, waste) for indoor cooking creates a health hazard for women and girls[23].

Eastern African countries are highly dependent on the importation of fossil fuel (oil, coal and gas) for thermal power generation, commercial and industrial uses and transport, thus impacting energy security and increasing vulnerability to energy price shocks (see Figure 71). Notable concerns are the increase in vehicles on the roads, resulting in 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 case in the Turkana region in Kenya, and the overall balance between energy development and environmental management.

The diversification of energy supplies and the use of more indigenous renewable energy sources are regarded as part of the strategy for energy sector development. Within this

23 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.

framework, sustainable and secure energy has four characteristics: availability (reliable quantity over the long-term); accessibility (existing appropriate infrastructure, low impact risks from extreme conditions); utilization (sound quality, affordable prices and functional market structures) and stability (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 and development.

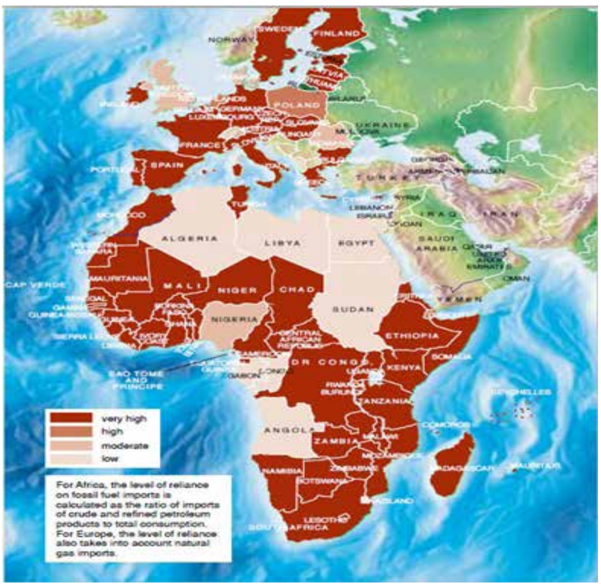
The dependency on unsustainable and inefficient energy forms potentially endangers environmental sustainability and increases the vulnerability of populations (OCHA, 2010). The choices in energy generation have impacts on the environment, but the state of the environment and climate change also influence the energy sector. The impacts of climate change on the energy system, for example, are not restricted to the supply side since the form of energy can also be influenced by variations in temperature and rainfall patterns. Higher temperatures in the parts of Eastern Africa located in the tropical belt imply a higher demand for cooling, increasing the demand for electricity. Climate change can also affect the water and electricity demand in industries and agriculture for irrigation purposes (Schaeffer, and others, 2012). Climate change impacts resulting from deforestation and desertification (wood cutting and charcoal production) lead to higher rainfall, thus affecting negatively the refilling of reservoirs for hydropower generation. This in turn increases siltation and erosion which require costly maintenance operations.

The dependency on unsustainable and inefficient energy forms potentially endangers environmental sustainability and increases the vulnerability of populations.

The negative impacts of the current energy patterns on the environment in Eastern Africa will need to be taken into consideration in the formulation of energy policy frameworks. Existing dynamics and close synergies among and between water, forest, agriculture and climate change will also need to be considered in the overall analysis of barriers and challenges to, and opportunities for sustainable energy development.

With a view to attaining energy sector development, policymakers 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 socioeconomic and environmental angles while taking into account the following:

Figure 71: Reliance on imported fossil Fuels



Source: International Energy Statistics, 2008.

1) linkages between energy development, environmental degradation and climate change (Figure 72) and the need to tap into existing climate change related funding mechanisms to support a paradigm shift in energy;

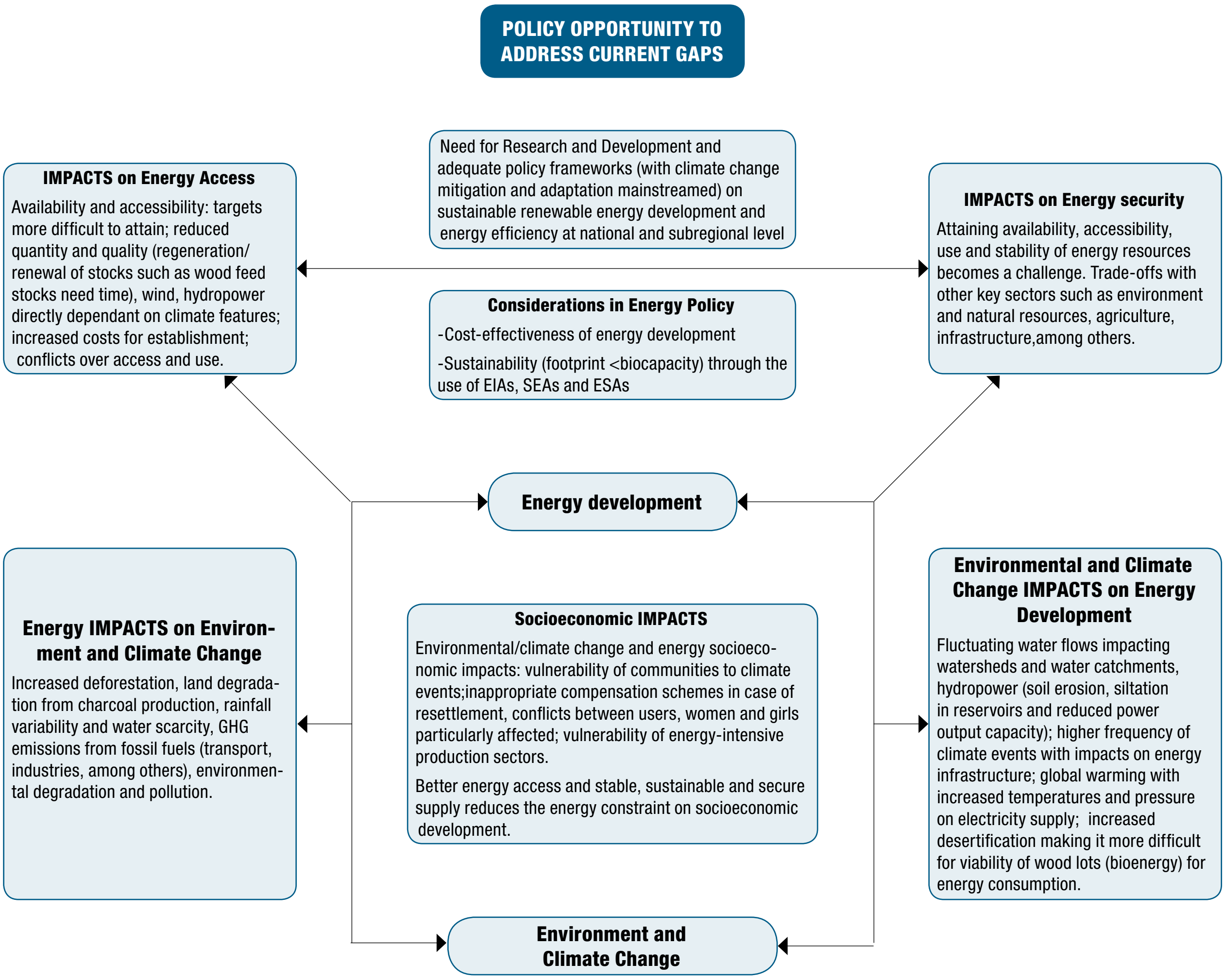
2) intertwined issues of energy security and food security;

3) the considerable potential of renewable energy in building an energy mix and diversified sources of supply (that is, second generation of biofuels, sustainable bioenergy);

4) the need for intersectoral dialogue at institutional level to mainstream the energy-agriculture-environment-climate change nexus in policy frameworks at national and subregional levels;

5) the role of research and development as well as local innovation, national and subregional standards in promoting energy efficiency (improved cookstoves, enhanced technologies to increase access to affordable alternative sources - lighting in rural areas);

Figure 72: Linkages between energy development, environment and climate change and related impacts in the Eastern Africa subregion



Source: Author formulation.

6) the importance of primary data collection and analysis (based on agreed upon definitions and indicators) and the consolidation of national and subregional comprehensive and user-friendly databases specially targeting policymakers 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 take into consideration sustainability, taking into account trade-offs between economic, social and environmental benefits in the short- and long-term.

5.2 The ecological footprint, biocapacity and energy development

Ecosystems provide items (food, medicine, timber and fiber), regulating services (water filtration, waste decomposition, climate regulation and crop pollination), supporting services (nutrient cycling, photosynthesis and soil formation) and cultural services (enriching, recreational, aesthetic and spiritual). Without access to land, clean water, adequate food, fuel and materials, vulnerable people cannot break out of the poverty cycle and prosper. There is a 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 per cent globally by 2050 (from 1990 levels).

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 as viable pathways to achieving the rapid emissions reductions needed (WWF,

Box 1: Ecological footprint and biocapacity

The Ecological Footprint tracks humanity's demands on the biosphere by comparing humanity's consumption with the Earth's regenerative capacity or biocapacity. 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 and others, 2007; Kitzes and others, 2009 and Wackernagel and others, 2002). The largest component of the ecological footprint is the carbon footprint (55 per cent). Biocapacity quantifies nature's capacity to produce renewable resources, provide land for built-up areas and provide waste absorption services such as carbon uptake. Biocapacity acts as an ecological benchmark against which the Ecological Footprint can be compared. Both the Ecological Footprint and biocapacity 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 biocapacity was 12 billion gha or 1.8 gha per person, while humanity's ecological footprint was 18.2 billion gha 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 biocapacity 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 per cent 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 per cent 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).

Table 15: Gha per person, 2008

Country	Total Ecological Footprint	Total biocapacity
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).

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 200 billion euros a year on adaptation measures (Parry, and others, 2009).

From the analysis done on countries in Eastern Africa, Burundi, Ethiopia, Kenya, Rwanda and Tanzania appear 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 increases due to pressure from population growth and accelerated urbanization, the more these countries will face serious challenges in meeting their resource demand starting with energy, in a sustainable manner. In the case of DRC, the Congo Basin ecosystem still provides a vast reservoir of untapped resources, hence the highest positive ratio in the subregion. When selecting energy development options, sustainable energy solutions require particular attention.

5.3 Sustainability considerations in the energy sector

5.3.1 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 revealed that it contained over 2 billion barrels in reserves, far outstripping the commercial viability threshold. In Lake Albert, there is an 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, known worldwide for its richness in flora and fauna and it is expected that oil developments could have potential impacts on this unique environment[24].

Lessons can be drawn from the Ogoni land in the Niger Delta in Nigeria. The 2011 UNEP assessment states that oil exploration and production projects may have impacts on the natural environment long before any oil is actually produced (land survey, land

24 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 2: UNEP findings in Ogoniland (impacts of oil production in the Niger Delta)

Ogoniland is a region covering some 1,000 km2 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, andalso 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 butthe extensive pollution of these areas is impacting the fish lifecycle. 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 to these 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).

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 2.

However, since national economies are heavily dependent on fossil fuels to provide their energy needs, it will take some time to adopt a paradigm shift comprising substitution with other sustainable and cost-effective sources of energy. The implementation of a transition phase which promotes an energy mix will enable a progressive and gradual process towards reducing this dependency on fossil fuels by focusing on renewable energy sources. Current oil exploration projects in the subregion are subject to Environmental Impact Assessments (EIAs) (for example

Madagascar, DRC, Uganda and Kenya).[25] However, for EIAs to be operational as Monitoring and Evaluation tools for environmental protection, they need to follow some principles relating to process transparency and consistency, absence of conflicts of interests, sound governance and genuine commitment to implementation of mitigation measures by private companies. 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 a step forward by linking EIAs, SEAs and Environmental Security Assessments (ESAs), analysing 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 the environmental impacts of energy interventions at all levels.

5.3.1.1 Road transport: a sector with growing fossil fuels demand

The subregion has witnessed a steady increase in the number of all types of vehicles on the roads (see Table 16), due to continued economic growth. Most registered vehicles are imported and second-hand and therefore bigger consumers of petrol/diesel than the more recent models. About 60 per cent of all motorized transport (excluding three wheelers and motorcycles) in the subregion are private vehicles; slightly more than 20 per cent are public passenger vehicles; while less than 10 per cent are trucks. The share of Tanzania in 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 per cent, respectively of the vehicle population. By 2010, the percentages stood at 60.7 per cent and 35.8 per cent, respectively. This could be attributed to, among others, the different regimes on the age limit of vehicles imported.

About 60 per cent of all motorized transport (excluding three wheelers and motorcycles) in the subregion are private vehicles; slightly more than 20 per cent are public passenger vehicles; while less than 10 per cent are trucks. The share of Tanzania in vehicle population over the six year period has overtaken that of Kenya.

5.3.2 Sustainability: the case of nuclear energy

Some countries in the world such as Japan and Germany are planning to phase out their nuclear programme following the Fukushima Dayichi accident in 2011. Nuclear energy is 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 over a 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 in the years ahead in its Annual Year Book 2012. Further research findings could constitute the basis for a subregional discussion on the topic.

25 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 involves 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.

Table 16: 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.

5.4 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 subregion is significantly endowed with a wide range of renewable energy resources, including hydropower, geothermal, biomass, solar, wind, and other renewables, most of which are currently underexploited. Member States could 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 based on green growth diagnostics and implementation of equitable solutions, to phase out for example, inefficient use of traditional biomass and pursue alternatives

Table 17: Sources of electricity production (GWh)

	DRC	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.

such as improved cookstoves. There is an urgent need for policymakers to recognize the potential role of renewable energy in meeting the energy challenges of the subregion and to take on an integrated and coordinated approach at subregional level to scaleup the deployment of renewable energy technologies.

The share of renewable energy in electricity generation remains marginal in some countries of the subregion (Eritrea 1 per cent, Seychelles 0 per cent - REN 21). Other countries have a sizable renewable energy share such as Madagascar (25 per cent ADER 2012, REN 21 has a different data - 57 per cent), Tanzania (59 per cent EIA, 46 per cent REN 21), Uganda (54 per cent REN 21) and Kenya (56 per cent EIA, 66 per cent, REN 21). Countries such as DRC (99 per cent, EIA) and Ethiopia (88 per cent -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.

The energy mix of Kenya is somewhat diversified. In September 2011, the governing bodies of the Climate Investment Funds (CIF) endorsed the Kenya investment plan for funding under its Scaling Up of Renewable Energy Programme in Low-Income Countries (SREP). Developed under the leadership of the Kenyan Government with support from the African Development Bank (AfDB), the World Bank Group and inputs from the private sector, civil society and community representatives, Kenya has produced a plan outlining the 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, financial, technical as well as human capacity constraints have hindered the ability of Kenya to take full advantage of its natural energy resources, which include geothermal, solar, wind, biomass and biogas. Though Kenya has made important institutional and policy reforms to its energy sector, SREP concessional financing, estimated at about $50 million, will help absorb high start-up costs and other risks, and catalyze financing from the private sector and other sources to help scale up the renewable energy market of Kenya.

Kenya is one of three African nations to pilot SREP; the others are Mali and Ethiopia. With just 2 per cent rural access to electricity but enormous potential for hydro, geothermal and solar energy generation, Ethiopia was also selected to become part of a pilot SREP. SREP aims to scaleup the implementation of renewable energy solutions and expand their markets in the world's poorest countries. It is a programme under the CIFs, a $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 per cent of GHG emissions in Ethiopia come from forestry (37 per cent) and agriculture (50 per cent). Ethiopia is endowed with ample natural resources to meet these demands and already generates 90 per cent 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 to 67 TWh by 2030, and achieve zero emissions even sooner. Furthermore, due to the expected impact of energy-saving measures, Ethiopia foresees generating a surplus of clean power, which it could export. In 2030, such exports could replace up to 19 Mt CO_2e per year of what neighbouring countries generate from fossil fuels, while contributing positively to the trade balance of Ethiopia (national source).

5.5 Biomass: first source of energy in the subregion

The number of wood-based biomass energy consumers in sub-Saharan Africa will reach almost 1 billion by 2030.

Traditional biomass energy refers to solid biomass, including agricultural residues, animal dung, forest products, and gathered fuelwood, that are usually combusted in inefficient, and 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 per cent 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 where 83 per cent of the population rely on traditional biomass for cooking in Kenya, 94 per cent in Tanzania, 94 per cent in DRC and 93 per cent in Ethiopia (REN 21, 2012). This level 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 1 billion by 2030 (IEA, 2010). The economic value of the charcoal industry in sub-Saharan Africa may exceed $12 billion by 2030, employing almost 12 million people (AFREA, 2011).

Wood-based biomass usage is in both rural and urban areas- fuelwood, predominantly used by rural populations and traditionally obtained by subsistence collection, and charcoal, the major cooking fuel for urban populations and with the associated commercialization and value chain involving many stakeholders. This preference is essentially motivated by: (i) availability of wood (though the distance to forests and woodlands increases year after year and negatively reflects on sale prices; for example up to 200 kms to service Kinshasa); (ii) affordability compared to other modern sources (though retail

Box 3. Charcoal sector in Tanzania

The contribution of the Tanzania charcoal sector to employment, rural livelihoods, and the wider economy is estimated to be $650 million per year, providing income to 300,000 people in both urban and rural areas. The economic contribution of the charcoal sector to Dar es Salaam alone exceeds the coffee and tea sectors. National and local governments are estimated to lose about $100 million per year due to their failure to effectively regulate the charcoal sector.

Charcoal is generally produced from dry (or miombo) woodlands which are unsustainably harvested 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 could 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 metres. 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 by-product 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 about1,500 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 about 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.

prices of charcoal have doubled in the last five years in most countries, for example from $15-20 to $50-60 for a bag of 50 kgs in Kinshasa; $15 for a bag of 50 kgs in Addis Ababa; Euros 5 for a bag of 50 kgs in Madagascar); (iii) simplicity in use (cultural features are key in traditional ways of cooking, easy to transport, distribute and store).

Though the charcoal sector remains informal with unclear regulations, its estimated total annual value could exceed agricultural crops for export.

Though the sector remains informal with unclear regulations, its estimated total annual value could exceed agricultural 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 $450 million, equal to the country's tea industry (World Bank, 2007). In Uganda, about 200,000 people permanently earn money from charcoal (World Bank, 2007). Another study for Uganda found that if households were involved in charcoal production, it would reduce their likelihood of falling below the poverty line by approximately 14 per cent (Khundi and others, 2010). In Rwanda, where 95 per cent (national source) of the population rely on solid wood-based fuels, the charcoal sector is estimated to account for an annual volume of $77 million (Van der Plas, 2008). In DRC, the charcoal sector employs 270,000 people for an annual income of between $75 and $100 million for Kinshasa (country report). The situation of the charcoal sector in Tanzania described in Box 3 further illustrates existing similar trends in other neighbouring countries.

Regarding charcoal production, Madagascar (over 85.3 per cent), Somalia (over 49.2 per cent) and DRC (over 41.5 per cent) are the countries that have recorded the largest increase during the 2000-2010 period.

Table 18 shows that all countries in the subregion 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 (over 81.6 per cent increase) whereas Eritrea cut it by half and Seychelles by one quarter (as a result of the implementation of environmental protection measures). Regarding charcoal production, Madagascar (over 85.3 per cent), Somalia (over 49.2 per cent) and DRC (over 41.5 per cent) are the countries that have recorded the largest increase during the 2000-2010 period, and this is due 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 have put in place several forest rehabilitation, reforestation

Table 18: Woodfuels and charcoal production in Eastern Africa

Countries	Woodfuels[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%
DRC	64,903	75,446	76,602	+18%	1,431	1,704	2,025	+41.5%
DRC*							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

1 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.*

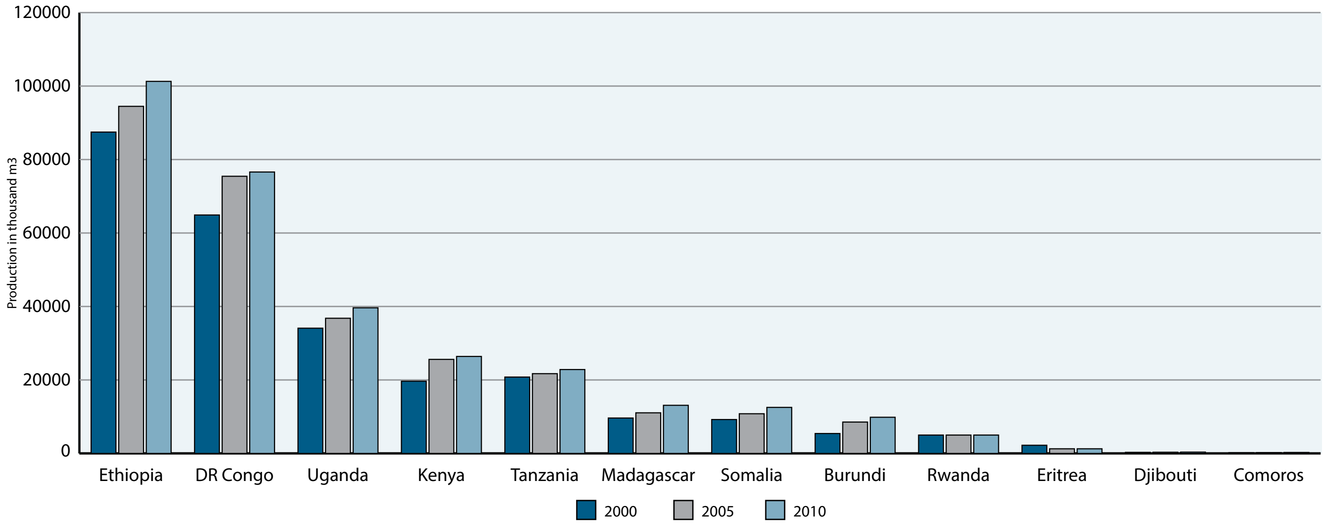
and afforestation programmes). Figures 73 and 74 show that Ethiopia and DRC are the largest producers of woodfuels and charcoal in the subregion by quantity (FAO data). The very low figure for charcoal production provided for Kenya (2005 and 2010) seems to be questionable in the light of the International Energy Agency (IEA) figure of about 3,109,000 tons which would place Kenya as the top producer in the subregion before Ethiopia (where IEA provides a figure much lower than FAO).

5.5.1 Biomass: Data challenges

There should be a concerted effort aimed at improving knowledge on woodfuel demand and supply, as well as its economic and social role.

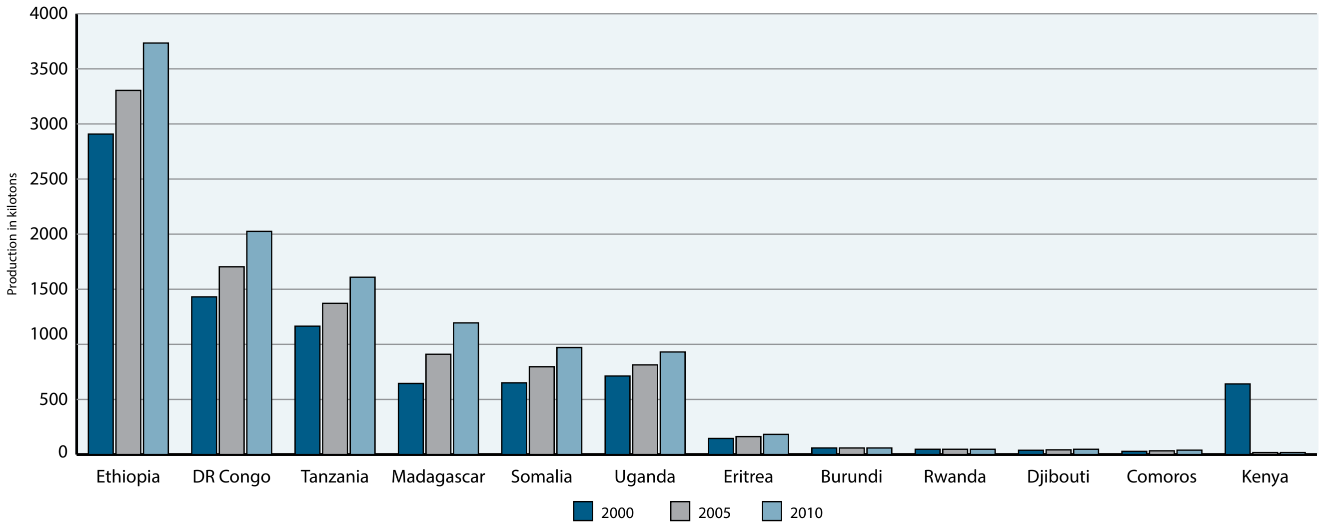
The discrepancy in figures raises the issue of data quality, relevance and reliability. Several agencies and institutions (World Bank, FAO and IEA, among others) obtain different data based on the methodology used, definitions of items and criteria for analysis. Some use estimates and aggregates rather than actual/sectoral figures; others 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 policymakers and experts. Woodfuels are likely to remain a major energy source and a determining environmental and development issue in Africa in the midterm to the longer term. There should therefore be a concerted effort aimed at improving knowledge on woodfuel demand and supply, as well as its economic and social role. This should definitely 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.

Figure 73: Woodfuels production



Source: FAO STAT.

Figure 74: Charcoal Production



Source: FAO STAT.

5.5.2 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 in conjunction 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. Four hundred thousand ha of forest are lost to charcoal production every year in DRC 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

Table 19: 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
DRC	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 20: 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.

realities based on origin of data sources. Different definitions of forests depending on identified institutions (United Nations 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 a primary forest as a forest that has never been logged and has developed according to natural disturbances and under natural processes, regardless of its age. "Direct human disturbance" refers to 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.

A secondary forest according to 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 primary forests do in the same location". A plantation forest may be afforested land or a secondary forest established by planting or direct seeding. FAO more often uses the term "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.

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 logging used for charcoal production.

This is the reason why data relating to overall forest cover 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 forests including other naturally regenerated forests, planted forests and other woodland will never revert 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 sizes of covers are much smaller than those shown in data and also rapidly changing as a result of increased pressure from urbanization and population growth.

With the exception of Djibouti and Seychelles who recorded a stable forest area over the last decade as a result of an existence of quite an insignificant forest cover for the former and stringent forest conservation programmes for the latter, and Rwanda which is the only country in the subregion to have increased its cover through forest rehabilitation and sustainable land management projects (for example in Gishwati and Bugesera), all other countries have had their forest cover reduced. The Comoros has lost more than two thirds of its forest cover (from 4.3 per cent to 1.6 per cent), exacerbating the risk of losing it completely within the next five years (this would translate into dramatic impacts on the overall resilience to climate and other shocks for the small island developing state, thereby increasing the vulnerability of the population) (Table 19).

DRC has the second largest forest ecosystem in the world after the Amazon (6 per cent of world's rain forests). Forest covers 125 million ha (half of the country's surface) and represents 47 per cent of the total African forest cover.

With the exception of Madagascar and Kenya, most countries in the subregion have lost their primary forests (even with the consideration that actual lack of data may have influenced figures, Table 20 and Figure 75). Though several countries have embarked on ambitious forest rehabilitation and tree planting programmes (Eritrea, Ethiopia, Madagascar, Rwanda, Tanzania and Uganda), as shown in Table 19 and Figure 75, the overall forest cover in the subregion has decreased by 9 to 10 per cent 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 logging used for charcoal production, resulting in additional carbon emissions. Other studies[26] show that forests were particularly hard hit near protected areas (46 per cent 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 forests at an even faster pace. As per Figure 75, DRC, Madagascar, Tanzania and Ethiopia seem to have the largest forest reserves. DRC has the second largest forest ecosystem in the world after the Amazon (6 per cent of world's rain forests). Forest covers 125 million ha (half of the country's surface) and represents 47 per cent of the total African forest cover.

26 Pfeifer M, Burgess ND, Swetnam RD, Platts PJ, Willcock S, and others (2012) Protected Areas: Mixed Success in Conserving East Africa's Evergreen Forests. PLoS ONE 7(6): e39337. doi:10.1371/journal.pone.0039337.

5.5.3 Policy options for promoting sustainable biomass energy development

With increasing economic development, the demand for energy is also on the rise and consumers depend on a broader portfolio of energy sources to satisfy growing energy needs. Switching away from wood-based energy will not necessarily mean improving the economic situation of consumers. In effect, if the price of alternative fuels continues to rise and supply remains erratic, households have little incentive to switch 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 analysis of previous total fuel expenses per month reveals higher expenses for charcoal compared to alternative fuel, such as LPG. Due to the complexity of the decision on energy choices, a doubling of typical incomes would only reduce the number of those depending on biomass energy for cooking by 16 per cent (World Bank, 2011, forthcoming).

Due to the complexity of the decision on energy choices, a doubling of typical incomes would only reduce the number of those depending on biomass energy for cooking by 16 per cent.

Though wood-based biomass energy is the most important source of energy in the rural and urban areas of Eastern Africa, it 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 in overall wood quantities needed for charcoal production, while the promotion of fuel switching would mainly act as a buffer against a further increase in demand due to an increase in population.

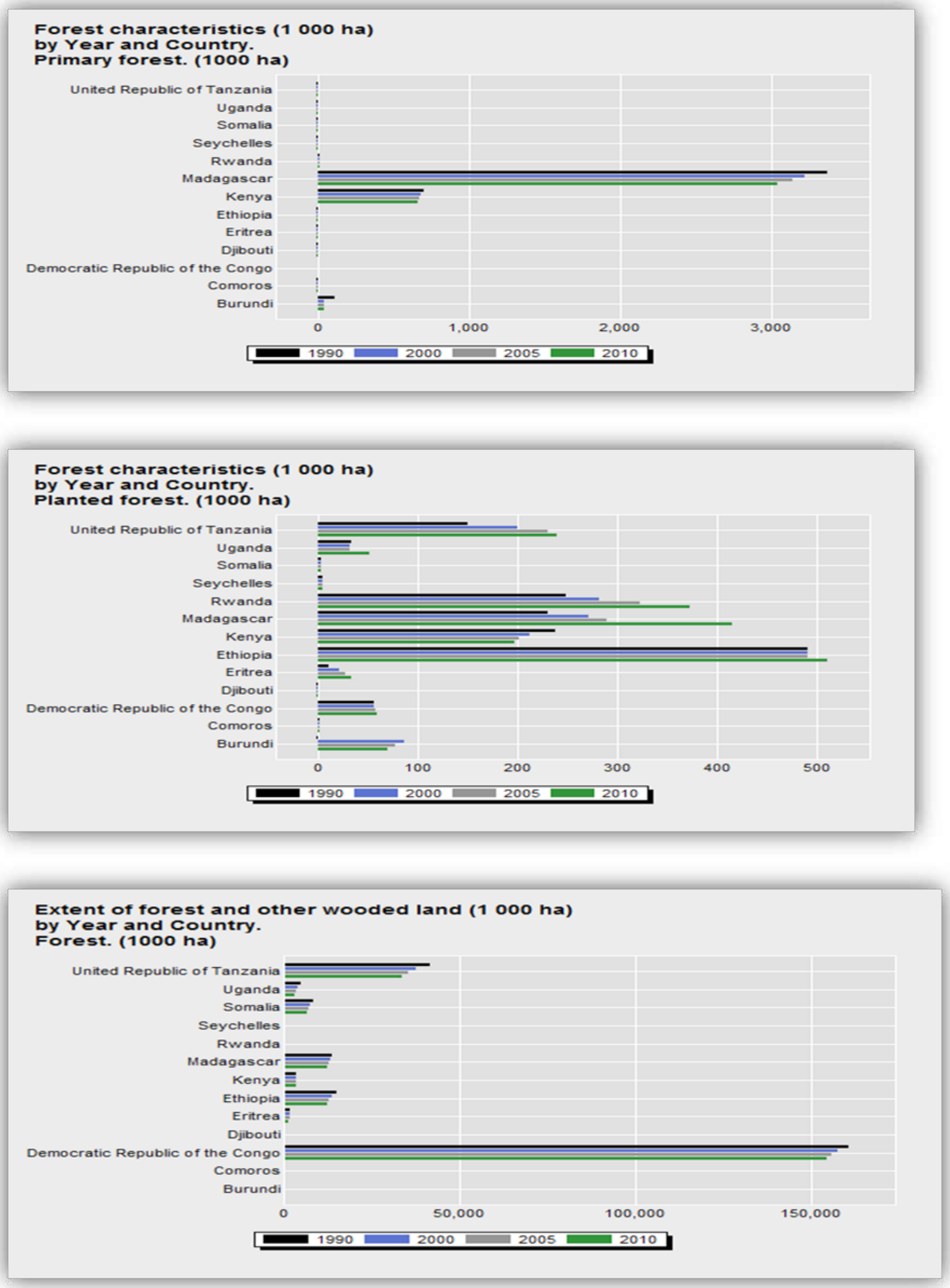
This ambition is seriously hampered by the scarcity, limited scope and poor quality of existing data, despite several past efforts to improve wood-based biomass information systems. These shortcomings make it difficult to undertake the relevant studies on the impact of woodfuels and charcoal use on the environment in general and on forestry resources in particular, thus the need for energy and forest planning and forecasting studies. Given the rapidly changing situation of wood-based biomass energy in sub-Saharan Africa, policymakers need reliable baseline data to design appropriate measures (Sepp, 2008). Such data include population growth, urbanization dynamics and consumers' fuel switching behaviour. 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.

The collection and management of data along the biomass value chain provides an excellent entry point for shaping sound policies.

Unsustainable charcoal use is increasingly seen as rooted in more systemic, site-specific weaknesses relating to land tenure, fiscal[27] and incentive policies, urban energy markets and misallocation of forests and cropland— problems that occur along the entire

27 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 manner from natural woodlands. The tax collected by the government, is used to replace resources taken from open woodlands and designed to: (a) discourage traders from buying fuelwood extracted from natural woodlands; and (b) encourage the extraction of fuelwood resources from a distance further than fromcloser 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).

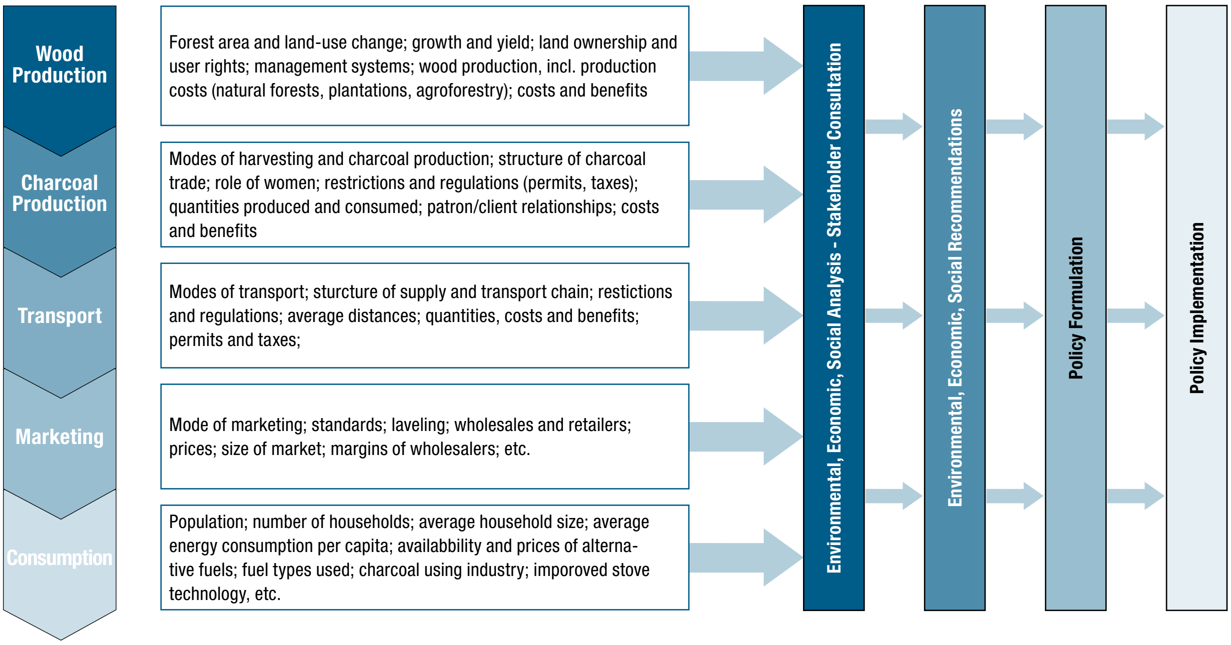
Figure 75: Forest characteristics (primary forest, planted forest, extent of forest and other wood-land) –FRA 2010



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:

Figure 76: Charcoal value chain



Source: AFREA, 2011.

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 for trees outside forests, for example through agroforestry systems.

Forest management plans need to be simple and short and developed in a participatory manner, so as to remain accessible to communities. The following principles would need to be further embedded: first, natural forest area should be protected from conversion 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 engaging in unsustainable charcoal production is the need for cash income, which is almost exclusively provided by the charcoal business (AFREA, 2011). Figure 76 presents a framework for developing and evaluating various policy options that address the charcoal challenge (Sepp, 2008).

5.5.4 Promotion of improved cookstoves for enhanced energy efficiency

At present, some sources estimate that cooking with traditional biomass fuels contributes about 18 per cent of current global GHG emissions when forest degradation and deforestation are included (SEI, 2008). Most countries in Eastern Africa have already promoted the development of improved cookstoves in the area of the charcoal value chain, aimed at reducing indoor pollution, quantities of charcoal produced and GHG emissions, in line with the 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 and E) mechanisms; subsidies and grants; awareness raising, business development, and consumer research; adapting cookstoves and programmes to country contexts; and taking into account consumer preferences and behaviour.

In Uganda, a joint venture of private companies aims at providing low-income communities with access to energy-efficient household cookstoves; at an estimated cost of $20 million. This represents one of the largest carbon-finance commitments made to clean cookstoves in the sector's history.

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 remains the high annual patent fees that need to be paid). The population usually opts for them though there was some initial reluctance (adaptation to a new design, cooking time assessment) based on affordability and practicality. In Uganda, a joint venture of private companies aims at providing low-income communities with access to energy-efficient household cookstoves; at an estimated cost of $20 million, this represents one of the largest carbon-finance commitments made to clean cookstoves in the sector's history (REN 21). In DRC, 3 million improved cookstoves (*mbambula*) were distributed to the population and the Government has undertaken field tours to Rwanda which is well ahead in the sector, with more than 50 per cent of all households possessing improved cookstoves (REN 21) through an Improved Stove Programme.

Ethiopia plans to distribute 9 million more efficient stoves by 2015, corresponding to savings of $270 million in opportunity costs for fuelwood, thus increasing rural household income by 10 per cent.

Ethiopia went through thorough assessments on linkages between wood-based biomass consumption and GHG (a rise in GHG emissions from the 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 would mean an estimated 20 per cent for Ethiopia of the total potential for emission reduction, or about 50 Mt CO_2 annually in 2030. The Government has plans to distribute 9 million more efficient stoves by 2015, corresponding to savings of $270 million in opportunity costs for fuelwood, thus increasing rural household income by 10 per cent. Many more jobs would also be created through the production of the 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 set the following targets: by 2030, use of fuelwood-efficient stoves by 80 per cent of rural population/5 per cent of urban population (for both cooking and baking); LPG stoves: 0 per cent/5 per cent; biogas stoves: 5 per cent/1 per cent; electric stoves: 5 per cent/61 per cent (for both cooking and baking). Regarding improvement in efficiency, the Ethiopian Ministry of Water and Energy estimates the following potential savings: fuelwood-efficient stoves: 50 per cent (average for both cooking and baking); LPG stoves: 100 per cent (cooking only); Biogas stoves: 100 per cent (cooking only); Electric stoves: 100 per cent (cooking and baking). The effect of overall reduced degradation will result in a potential abatement of 1.6 t CO_2/stove/year.

In Kenya, 337 improved cookstoves were produced each month per producer, who earned an average monthly income of $120-$240.

An ongoing project in Kenya, which is jointly implemented with GIZ and the Ministries of Energy, Agriculture and Education, has distributed 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 $120-$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,

Box 4: 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" programmes, 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. hese 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 programmes 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. Since 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 programme 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, enable users to 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, non-governmental organizations, microfinance organizations, and the private sector in programmes 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, which improves their health, and free 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 forces attributed to biomass burning.

Source: BEIA, World Bank, 2011.

households could save an estimated half-ton of fuelwood each year if they owned one of the new generation improved stoves, which substantially affects their income (Adkins and others, 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. BEIA tests promising approaches to deal with biomass energy that can potentially be incorporated into the World Bank 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 programme aims at funding innovative ways to address fundamental problems facing Africa's biomass energy sector. Support focuses on five themes: (a) 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); (b) modernizing the charcoal industry (improving environmental sustainability and energy efficiency of producing charcoal and its end use); (c) demonstrating the feasibility of social biofuels (using small-scale biofuel production systems that supply a local market fuels for cooking, lighting, and power generation); (d) increasing power capacity with bioelectricity (using biomass to fuel power generation for off-grid or add-on capacity); and (e)strengthening leadership in biomass energy (promoting higher level training for technical and professional leaders).

The recently launched Global Alliance for Clean Cookstoves (GACC)[28] 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 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.

The Africa Biogas Partnership Programme (ABPP) 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.

5.5.5 Alternative biomass energy

5.5.5.1. Biogas

Household biogas is considered a clean and affordable substitute for traditional biomass fuels, and even for kerosene in the case of lighting. Through a composting process, biodigesters 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 that own 2 to 3 cows; a total of 1,846 digesters were installed by the end of 2011 (REN 21).

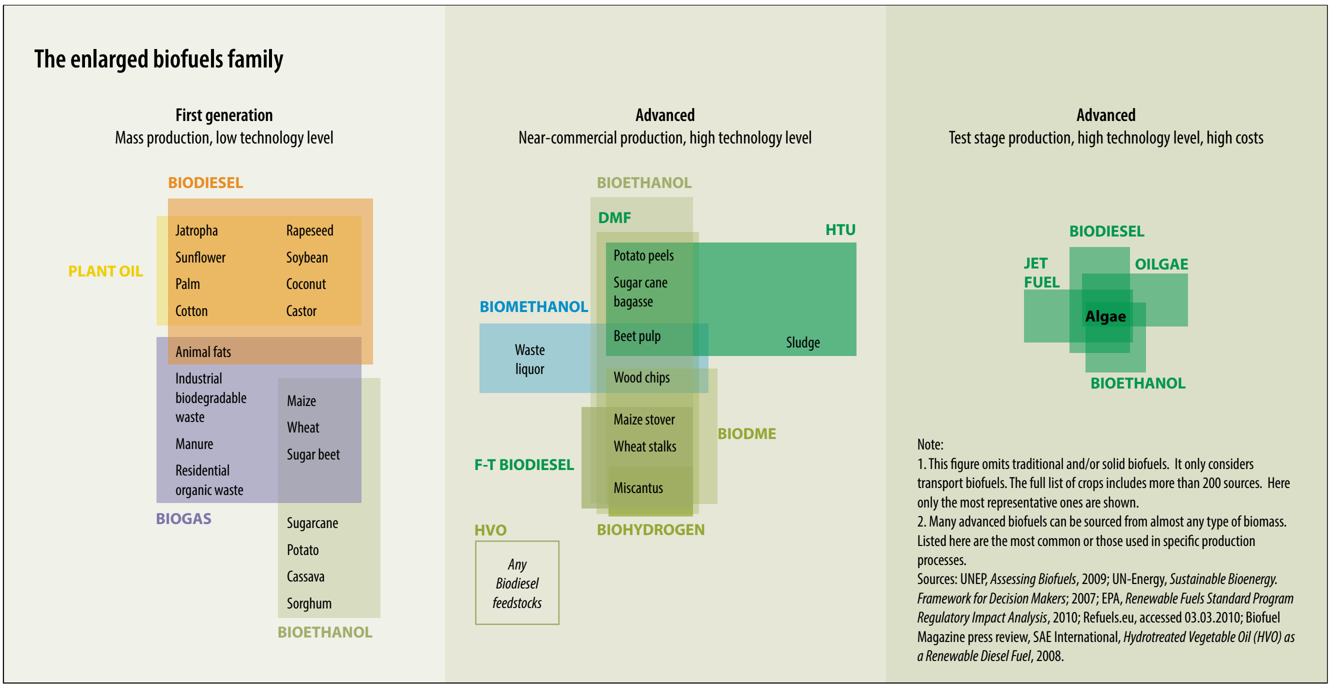
In Eastern Africa, most sugar-producing countries generate power and heat with bagasse-based combined heat and power (CHP) plants. Grid connected bagasse CHP plants exist in Kenya, Tanzania, and Uganda. However, despite Africa's enormous biomass resource potential, biomass power generation has remained extremely low until recently. Plans are now underway for biomass power plants in Rwanda and for an 11.5 MW biomass power plant in Kenya which were announced in early 2012 (REN 21).

5.5.5.2 Biofuels

First-generation biofuels, those derived from starches, sugar, soy, animal fats, and palm and vegetable oil have won wide popular support. But given that 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 rape seed, for instance produce only 500 to 1,000 litres of biodiesel per hectare, according to the University of California at the Los Angeles

28 www.cleancookstoves.org.

Figure 77: The enlarged biofuels family



Source: UNEP Grid Arendal 2012

Institute of the Environment and Sustainability, meaning the lifecycle production and transport emissions in some cases exceed those of traditional fossil fuels.

Experts are however still hopeful about second-generation biofuels, those derived from woody crops, agricultural residues, waste and inedible crops, like stems and switch grass (Figure 77). These often turn out to be both better for the 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 them. 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.

Biofuel production is still marginal in most Eastern African countries due to initial concerns and failures about the first generation of biofuels and the heated debate about the 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.

Biofuel production is still marginal in most Eastern African countries due to initial concerns and failures about the first generation of biofuels and the heated debate about the 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.

5.6 The nexus between energy security and food security

Agriculture, livestock and fisheries are the major economic sectors for countries in the subregion as well as the sole livelihoods for their populations. However, numerous constraints including low investment in agriculture, price fluctuations and recurrent extreme weather events, among others, compromise the capacity of farmers to supply the increasing demand for food. About 80 per cent of the population in the subregion lives in rural areas, though an accelerated urbanization rate is changing this picture. Despite agriculture accounting for 70 per cent of the labour force in the Eastern African sub-region, its contribution to GDPs remains low.

Energy security and food security are intertwined socioeconomic issues which are essential to social and environmental security. They share similar characteristics and trends, face similar challenges and opportunities, and require well-coordinated, well-connected and integrated policy interventions that are also harmonized at subregional 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 set target and increased the rate of rural electrification from 2.5 per cent in 2007 to 14 per cent in 2011 (REN 21, 2012). Mechanization efforts as well as ongoing development of fully fledged regional commodity chains, including the promotion of agribusiness through processing will require the sustained supply of energy to plants, and equipments.

Ethiopia, Tanzania, Madagascar and DRC are among countries with a high number of land acquisitions. Food and biofuels production (Jatropha) account for the bulk of large-scale land acquisitions.

Land resource is at the core of the energy and food security nexus. "Land is becoming an increasingly globalized commodity, due to the rising demand for food and agrofuels, minerals, tourism, and ecosystem services, including carbon sequestration. Resource-poor land users are facing increased competition for land from other land users, national elites and global investors"[29]. Insecure land-tenure systems have led to unequal control over land and inequitable access to land resources, fuelling tensions between land user groups and creating serious conflicts over different land uses, thus constraining farmer innovation and investment in agriculture. This situation aggravates poverty due to its 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[30] shows that Eastern Africa ranks first in the area of land deals projects (1/3 of all reported projects). Ethiopia, Tanzania, Madagascar and DRC are among countries with a high number of land acquisitions. Food and biofuels production (Jatropha) account for the bulk of large-scale land acquisitions (mainly from China and South Korea).

Bioenergy 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 biodiesel for use in the transport sector, has tripled since 2000 and is projected to double again within the next decade. Fischer and others (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 security. 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 and others 2007; Kahn and Zaks 2009; FAO, 2009[31]).

Development in the biofuel subsector entails both opportunities and challenges to sustainable agricultural development and food security in Africa. Increases in production

29 ILC, *Increasing commercial pressure on land: Building a coordinated response*, 2009 (www.landcoalition.org)

30 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),

31 "Food Security and Agricultural Mitigation in Developing Countries: Options for Capturing Synergies"

in response to high oil prices means substantial income for farmers, but the sustainability of this income could be highly uncertain in view of the extreme volatility of oil prices. Furthermore, increased biofuel production often means reduced production and supply of food crops. Governments and farmers often face a tough choice regarding the adoption of 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 forms of 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.

5.7 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 of policies and regulations is greatly needed. Policy 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. Further discussion on energy technologies and pertinent recommendations, is provided in the next chapter.

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: regulatory measures (that is, performance standards, equipment standards, among others); 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; and voluntary agreements (for example between government and the private sector).

At regional and subregional levels, policy measures that have been successful and can be considered for development in Africa include focused use emission targets and trading systems, technology cooperation 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, aspects regarding distribution, institutional feasibility, and suitability to the local context. In addition, renewable energy policy development should be well integrated into policies of other sectors. Eastern African countries can tap into the Africa-European Union Energy Partnership (AEEP) further described in Box 7.

5.8 Energy, environment and climate change: funding mechanisms

Africa is particularly vulnerable to the expected impacts of global warming though it is the least 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[32]. The main drivers of GHG emissions as well as their assumed impacts in the subregion are mainly the increase in cropland and in the cutting of fuelwood to meet the needs of a growing population.

5.8.1 UN-REDD, REDD+, FCPC and FIP[33]

The UN-REDD Programme is the United Nations collaborative initiative on Reducing Emissions from Deforestation and forest Degradation (REDD) in developing countries.

Box 5: 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 this, the AEEP will concentrate 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 and 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) scalingup investment.

The above-mentioned meeting endorsed the following policy 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 about 50 per cent, which means an additional 250 million people, Africa and the European Union will act jointly 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 windpower 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.

32 http://www.nature.com/nnature/journal/v427/n690/abs/nature02121.html
33 www.un-redd.org

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 other forest-dependent communities, in national and international REDD+ implementation. The Programme supports national REDD+ readiness efforts in 46 partner countries across 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 $117.6 million.

REDD is an effort to create financial value from the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested land and invest in low-carbon projects that lead to sustainable development.

Deforestation and forest degradation through agricultural expansion, conversion to pastureland, infrastructure development, destructive logging, fires, among other things account for nearly 20 per cent of global GHG, more than the entire global transportation sector and second to the energy sector. REDD is an effort to create financial value from the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested land and invest in low-carbon projects that lead 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 and others, 2010).

REDD+ goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks.

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. In addition, international donors will need to support forest-rich nations as they build their capacity to measure, report and verify (MRV) their carbon emissions, which is vital to demonstrating the impact.

Principles for intervention of REDD+ and related mechanisms are further redefined following climate meetings (in the framework of the United Nations 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 build 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.

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, DRC and Ethiopia).

The proposed REDD+ readiness strategy of Kenya 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 of 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 there are challenges posed by overlapping and/or unregistered claims to land that need to be addressed as part of land tenure reform, which may be further supported through the existing Norway-Tanzania Forest Climate Change partnership.

DRC is already involved in REDD+ (UN-REDD and FIP) and could provide an example of how regional initiatives for forest conservation can be integrated in 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 subregion is the Forest Investment Programme (FIP), a targeted programme of the Strategic Climate Fund (SCF), which is one of the two funds of the Climate Investment Funds. The FIP supports the efforts of developing countries to reduce deforestation and forest degradation and promote sustainable forest management that leads to reductions of emissions and enhancement of forest carbon stocks (REDD+). Channelled through the Multilateral Development Banks (MDBs) grants and near-zero interest credits, FIP financing supplements large-scale investments and leverages additional resources, including those from the private sector to promote forest mitigation efforts, including the 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 DRC is further described in Box 7.

5.8.2 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. CDM was highly 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

Box 6: DRC Forest Investment Programme (FIP)

The Democratic Republic of Congo (DRC) has a forest cover of approximately 1.5 million km² out of a national territory of 2.3 million km², and a population estimated at 60 million inhabitants. It is amongst the top ten countries regarding 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 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 socioeconomic infrastructures.

The FIP in DRC will support a number of key activities for the participation of the local communities, in particular land tenure security, microzoning, small-scale afforestation, support to small enterprises (charcoal production, energy-efficient stoves), and community forestry. In this context, the FIP: (a) complements the Forest and Nature Conservation Project ($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 (b) establishes a direct link with the 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 (United Kingdom, Japan, European Union, among others). 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. The FIP Investment Plan can therefore be considered 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 has been 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) programme and the Forest Carbon Partnership Facility (FCPF) managed by the World Bank. In order to ensure intersectoral and multi-stakeholder coordination and participation, institutional arrangements for the REDD process were established, including a National REDD Committee and an Interministerial 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.

establishment of the Nairobi Framework, which brings together United Nations and regional organizations to support equitable access to the mechanism.

In the 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-building programmes for the CDM, particularly in Africa[34]. Existing funding mechanisms are listed in Box 8. Given the continued importance of wood-based biomass energy in the subregion, 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 developed 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 vehicles), 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 at July 2012, 325 CDM PoAs (18 projects in Africa, representing 2.9 per cent 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, hydropower or energy efficiency projects providing access to the carbon markets that would otherwise have been impossible to achieve for projects in small countries (Uganda Carbon Bureau, 2012).

34 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 7: 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 (for example UNFCCC Loan Scheme, ACAD)
- Offering capacity-building upon request to CDM Designated National Authorities (DNAs) and other national institutions in AfDB 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 focused 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
- Fuelswitching to biomass energy
- Hydropower
- Wind
- Methane leakage
- Capture of methane from landfills
- Forestry

Further information is available at: http://www.faber-abref.org/index_english.php

UNDP MILLENNIUM DEVELOPMENT GOALS (MDGs) CARBON FACILITY (LDC SUPPORT)

The carbon facility of the United Nations Development Programme supports projects in countries with few or no CDM projects. It focuses 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 upfront 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 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 Corporationprovides support to private sector projects. An overview of the various programmes, as well as contact details for IFC regional and country offices, is available at: http://www.ifc.org

TRAINING SEMINARS ON CDM

World Bank Instituteholds 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 earlystage 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 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.

Energy Technology and Energy Access in Eastern Africa

6

6.1 Introduction

Science, Technology and Innovation (STI) are often misunderstood concepts 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 are intrinsic and vital to a country's development, regardless of its prevailing level of development. Science and technology have become indisputable elements 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 and based on scientific advances.

Energy is widely recognized as an essential prerequisite for economic growth and sustainable development, as well as the achievement of the MDGs. Without access to modern forms of energy and the services it can provide, people are deprived of the opportunities to engage in income-generating activities and to improve their living standards. Technologies can and must play an integral role in transforming the energy system. The incorporation of these technologies into the production system enables the reduction of costs, improvement in quality, saving of energy and scarce raw materials as well as increasing productivity of the labour force. Innovation and technology in the energy sector are complementary and the know-how is used in the production of different goods and services: physical machinery; production processes; software and tacit knowledge, and so on. With the acceptance of the importance of STI as a key component of sustainable development, the acquisition, adaptation and deployment of ICT, also in the energy sector, have received 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 created, 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 in 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 also 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 reducing dependence on imported petroleum fuels; expanding energy access in economically viable ways; improving indoor health; medium and large-scale renewable energy technologies to support employment growth; and broader socioeconomic improvements.

Innovation and technology in the energy sector offer an opportunity for energy to reach the majority of the subregion's population, especially the rural communities and the urban poor.

Innovation and technology in the energy sector offer an opportunity for energy to reach the majority of the subregion's population, especially the rural communities and the urban poor. Technologies like solar panels and wind turbines require many parts and services to develop, install and run in the most efficient way, thus 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 per cent of global energy consumption came from renewable sources (Zobaa and Bose, 2011). Energy from wind power installed capacity grew by 30 per cent worldwide in 2009: at 158 GW and cumulative global PV installations exceeds 21 GW. Africa has massive hydropower 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 renewable potentials into expanded access and enhanced energy security.

In Eastern African countries, innovation and technologies are in the form of small systems, as governments often invest substantially more in conventional large-scale energy sources rather than in renewable energy sources (RES). However, installing, operating, distributing 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 21).

These technologies leverage local resources and can often be sited close to load centres, reducing the need for costly grid extension (United Nations Foundation, 2012) and helping to lessen the need to import expensive diesel fuel. Aside from the commercial benefits from renewable energy technologies, they enhance energy security by decreasing dependency on fossil fuel imports, and provide a number of other benefits such as improvement in human health, greater energy security, provision of environmental

Table 21: 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
DRC	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

services, and promotion of 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 23, ranging from lighting and refrigeration, communications, cooking, heating and cooling, to 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 categories of options to expand energy access (see Box 8).

In the Eastern Africa subregion, several countries set targets to increase renewable energy so as to expand the integration of technologies and to address energy challenges. Uganda has set a target of integration of renewable energy at 61 per cent of total energy consumption by 2017, through the development of 188 MW small-scale hydroelectricity, biomass and geothermal capacity, the use of 30,000 solar water heaters and 100,000 biogas digesters. Ethiopia is looking at the expansion of its energy capacity by 760 MW from windpower, 450 MW from geothermal and 5,600 MW from hydropower. Kenya focuses on doubling installed renewable energy capacity by 2012, and integrating 5,000 MW additional capacity from geothermal by 2030 (see Table 22 as an example to compare the target with current status). Rwanda is targeting a 90 per cent renewable integration in electricity generation by 2012, and 42 MW small hydro capacity by 2015. Djibouti is targeting a 30 per cent solar energy-based rural electrification by 2017. Similarly, Eritrea

Box 8: 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 often run by a village co-operative or an individual entrepreneur.

Off-grid. Decentralized 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.

Table 22: 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%

Source: "Nuclear Energy for Industrialization: A Case Study of Kenya's vision 2030." Presentation to the Dialogue Forum on "Long-term Prospects for Nuclear Energy in the Post-Fukushima Era" by Eng. Collins Juma, Director, Technical Affairs, Nuclear Electricity Project Committee of Kenya.

aims at 50 per cent electricity generation from wind, while Madagascar is aiming at 54 per cent of total energy coming from renewables by 2020, and 75 per cent of electricity generation from renewables by 2020. In Seychelles, the plan is a 5 per cent electricity generation from renewables by 2020, increasing it to 15 per cent by 2030. Burundi similarly targets 2.1 per cent of total energy to come from renewables by 2020. This policy prioritization of renewable energy integration into the energy portfolio will require accelerated technology adaptation and local innovation.

Uganda was 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 to 2030, close to its original target of 2034.

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 a 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 was 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 to 2030, close to its original target of 2034. Such ambitious initiatives will lead to rapid integration and diffusion of energy technologies, particularly off-grid applications. Global energy innovation and technological improvements, on a small- and large-scale, in all areas of energy services (locomotion, cooking and electricity, among others) 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 behaviour (see Figure 78). Renewable energy policies and strategies are in place in the subregion, in countries such as 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 in how successful technology diffusion will be. On the demand side in particular, 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 behaviour 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

Table 23: Application of renewable energy technologies

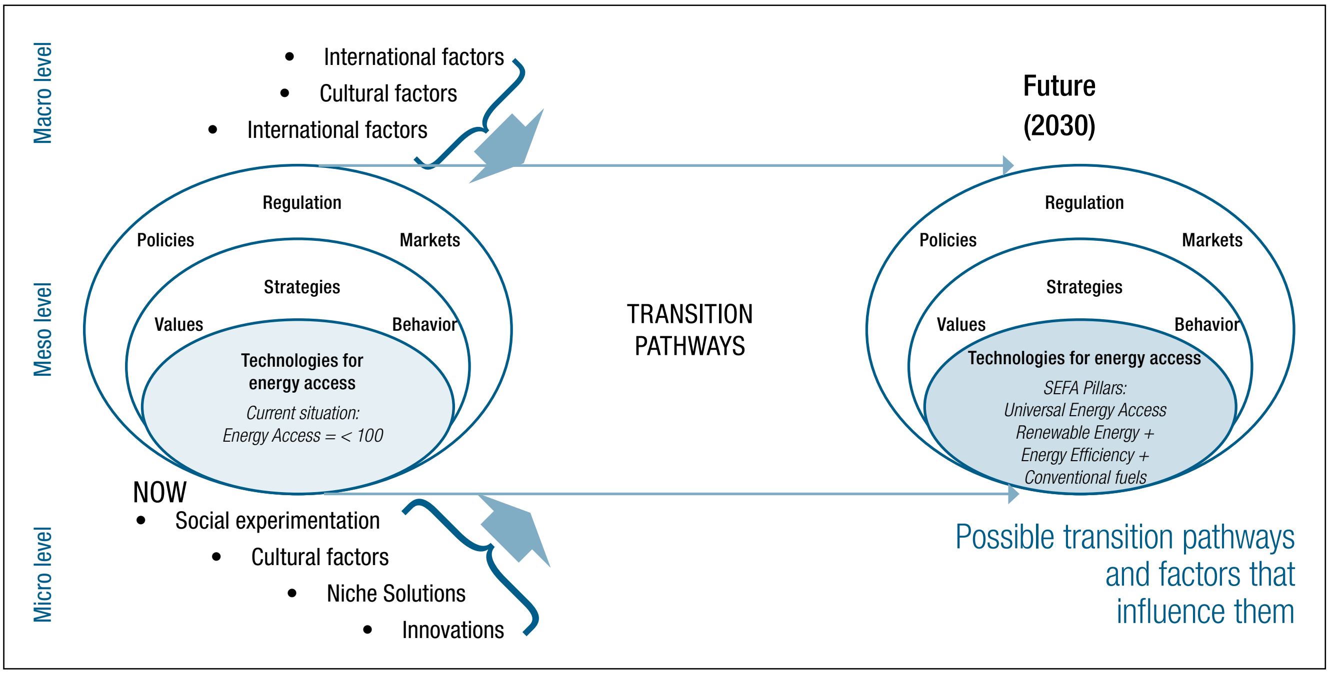
	Lighting /Refrigeration (Homes, stores, schools, street lights, vaccine storage)	Communications (TVs, radios, phones, Internet)	Cooking (Homes, commercial stoves)	Heating /cooling (Hot water, crop drying, among others)	Process power (Small industry)	Water pumping (Agriculture, drinking water)
SHS	√	√			√	
Pico-scale SPV	√	√				
Solar thermal				√		
Solar cookers			√			
SPV pumps						√
Small hydro	√	√				
Small wind		√			√	√
Mechanical wind pumps						√
Householdscale biogas digester	√	√	√	√		
Biomass gasifier	√	√			√	
Mini-grid/ hybrid	√	√			√	√
ICS			√			

Source: Adapted from REN21, 2011.

and charcoal prices, and encouraged the use of alternative fuels for cooking inurban areas, including electricity. The options available to households and the gradual value of options have an impact on the pathways of technology adoption. Niche markets and technologies in niche markets and the extent to which local innovation has access to such niche markets are also technology challenges at the micro level.

Within these macro, meso and micro systems that filter technology adoption rate and pace, a set of renewable energy technologies offers promising potential to harness

Figure 78: Global, subregional and country energy transition pathways and impact on energy technologies adoption, innovation and dissemination



Source: SEFA workshop, May 2012, Africa Climate Policy Center of UNECA.

Table 24: Classification of hydropower by size

Type	Capacity	Description
Large-hydro	Above 100 MW	Usually feeding into a large electricity grid
Medium hydro	From10MW to 100 MW	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 stand-alone schemes or often feeding into mini-grid
Micro-hydro	From 10 kW to 100 kW	Isolated micro-grid. Usually providing 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. Providing power for few specific users.

Source: Technical Brief of PRACTICAL ACTION organization on Micro-Hydro Power, available [online] at http://practicalaction.org/docs/technical_information_service/micro_hydro_power.pdf.

subregional green energy capacity and turn into actual integration in the energy portfolio and end use.

Within macro, meso and micro systems that filter technology adoption rate and pace, a set of renewable energy technologies offers promising potential to harness subregional green energy capacity and turn 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 (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 projects are often categorized into mini and micro hydro, referring to the harnessing of power from water on a small-scale (capacity of less than 10MW) (see Table 24). Small hydro has the advantage of multiple uses: energy generation, irrigation and water supply. It is also 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.

In Kenya, for example, around 50 per cent of all generated electricity is from mostly large hydro schemes. An example of the contribution of micro hydro 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 UNDP, a 18KW project which benefits 200 households in the Mbuiru village river community (Quirke, 2012). The facility is believed to alleviate deforestation, provide 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 25: Selected initiatives on small hydropower in the Eastern Africa subregion.

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 microenterprises 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 Operations and Management
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 provides daily, about 10,000 times more energy to the Earth than we consume. Solar energy 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 a 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 distribution. The CSP plants are expected to generate 25 per cent of global electricity demands by 2050. However, the cost of solar electricity is too high; research development is focused on reducing cost and increasing efficiency.

There are over 75,000 solar water heaters in use in Kenya, and the number is growing. In fact, Nairobi ranks first in Eastern Africa in the area of usage of solar water heating.

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: (a) small-scale - household level for lighting, cooking, water heaters and solar architecture houses; (b) medium-scale - appliances such as water heating in hotels and irrigation; and (c) 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 capacities are available on the market, from 50 to 450 litres. 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.[35] In fact, Nairobi ranks first in Eastern Africa in the area of usage of 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 states that customers are able to grow their Indigo system over time to deliver lighting, media, communications and information, enabling families to access increasingly 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 has been introduced in Kenya, Malawi, Zambia and South Sudan.

35 See Powerpoint Systems Limited at http://www.powerpoint.co.ke/solar_heaters.html.

Table 26: 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

Source: "Prospects for the African Power Sector: Scenarios and Strategies for Africa" report of IRENA.

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 lighting for medical and surgical purposes, 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.

The installation of some 365 giant wind turbines around Lake Turkana in northern Kenya, and a planned power output capacity of up to 300 MW, nearly a quarter of current generation capacity, has put Kenya on the global wind energy map.

Wind Energy: The U.S. Department of Energy National Renewable Energy Laboratory defines small wind turbines as those with a capacity of 100 kW or less. REN21 further defines household wind turbines as anything from 0.1 to 3 kW in capacity. Wind energy technologies use the energy in the wind for practical purposes such as generating electricity, charging batteries, pumping water and in agricultural processes such as grinding grains and cereals. Most wind energy technologies are applicable as stand-alone solutions, and 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.

The Ethiopia Ashegoda Wind Farm project, plans to add 120 MW to the grid in northern Ethiopia at the cost of $300 million. The Adama I wind farm is expected to produce a capacity of 51 MW at the cost of $117 million.

Wind energy is still at an infant stage in Eastern Africa, though application of such technology is taking shape in Ethiopia, Uganda, Tanzania and Kenya. Up until now it has been mainly used in the traditional fields of water pumping, but this is changing with the installation of some 365 giant wind turbines around Lake Turkana in northern Kenya, and a planned power output capacity of up to 300 MW, nearly a quarter of current generation capacity. By comparison, this is one of the highest in the world. Similarly, the Ethiopia Ashegoda Wind Farm project, with 83 utility-sclae wind turbines, plans to add 120 MW to the grid in northern Ethiopia, later in 2012 or in 2013 at the cost of $300 million. The Adama I wind farm is expected to produce a capacity of 51 MW at the cost of $117 million, financed through a loan from China. Tanzania has announced plans to generate at least 100 MW from two wind farm projects in the central Singida region, which will constitute more than 10 per cent of the country's current generation capacity.

Tanzania has announced plans to generate at least 100 MW from two wind farm projects in the central Singida region, which will constitute more than 10 per cent 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 combustible gas from sources such as waste, animal manure, plant residue, waste from agro-industry and slaughterhouses. There are examples of application of this technology throughout the subregion. In Kenya, the application of units averaging 3-15 m^3 are on the rise, partly due to 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 to generate 275 m^3 daily. The programme has also been extended to the Kigoma Prison. Technicians are also trained and a number of biogas businesses are emerging. For these advances, Rwanda received the Ashden Award for Sustainable Energy in 2005.

The trend in biogas units installation in selected countries in Eastern Africa shows that Rwanda started implementing biogas early, sustaining progress through to 2012. In Kenya, Ethiopia, Tanzania and Uganda, biogas installation has progressed considerably since 2010.

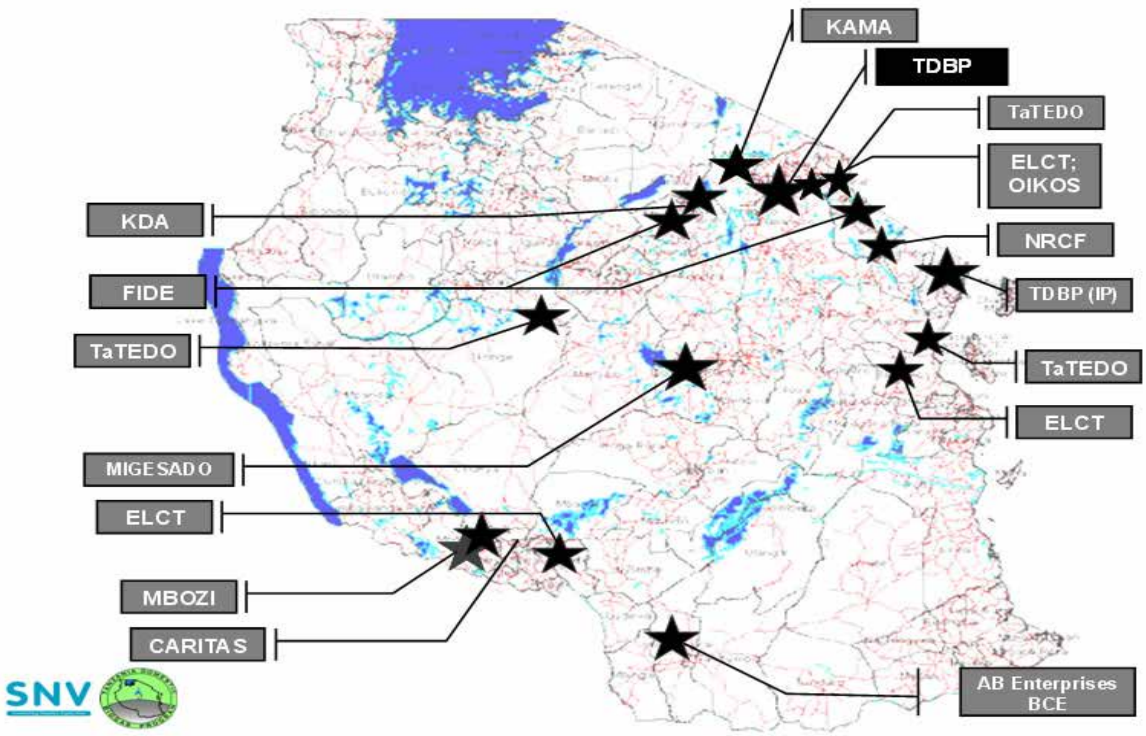
In Ethiopia, the National Biogas Programme, under the Ethiopian Rural Energy Development and Promotion Center (EREDPC) launched a national strategy in 2008 for the delivery of over 1 million domestic biogas installations in Tigray, Amhara, Oromia and Southern Nations and Nationalities regions, in a bid to utilize agricultural waste and manure, with a capacity ranging from 4-10 m^3 (EREDPC, 2008). The International NGO SNV and the Ethiopian Government also plan to construct 14,000 biogas plants in 2013.

The use of biogas is also on the rise in Uganda. The Uganda Domestic Biogass Programme built 583 plants in 2010 and over 560 in 2011, with plans to build over 20,000 plants by 2013. Small-scale applications using Jatropha by-products are operational in Madagascar. In Tanzania, the Tanzania Domestic Biogas Program (TDBP) spearheads the installation of biogas units, and with multiple implementing partners, biogas units are installed in multiple locations in the country (see Figure 79).

There is a need for African-based innovation in locally adoptable and efficient biogas unit development.

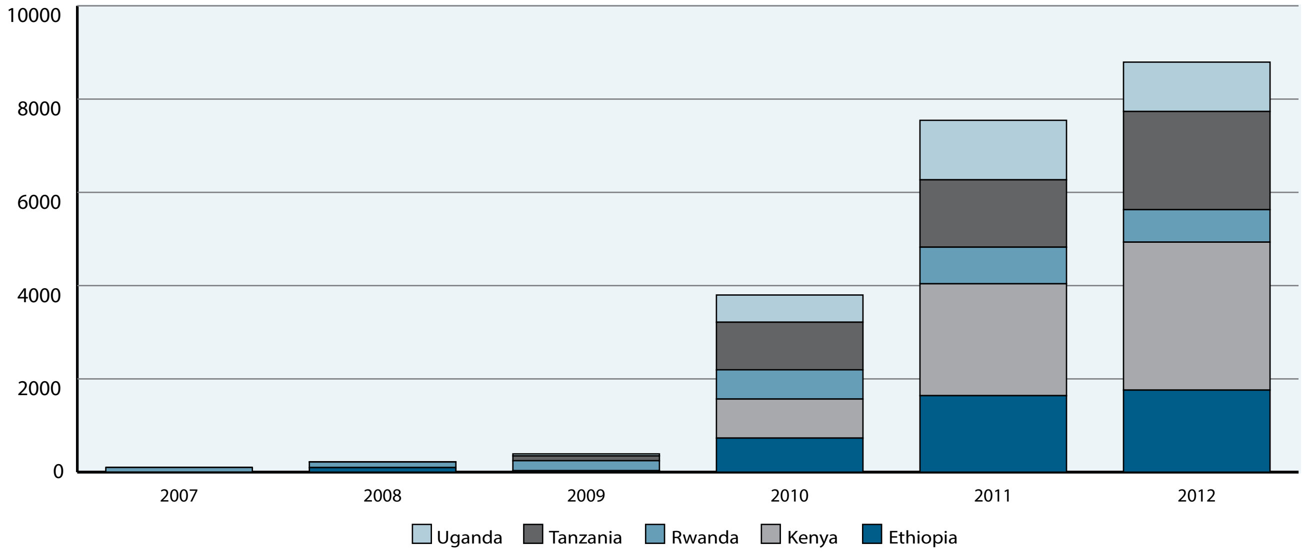
The trend in biogas units installation in selected countries in Eastern Africa (see Figure 80) shows that Rwanda started implementing biogas in the country early, sustaining progress through to 2012. In Kenya, Ethiopia, Tanzania and Uganda, biogas installation has progressed considerably since 2010.

Figure 79: 2011 Biogas implementation location and partners, Tanzania



Source: Tanzania Domestic Biogas Program, http://www.biogas-tanzania.org/index.php/tdbp/about/category/coverage_map/.

Figure 80: Biogas installation trend in select Eastern Africa countries: 2007-2012



Source: Africa biogas statistics at https://sites.google.com/site/biogas4all/documents.

There is a 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 sugar cane 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 has matured and been proven and some African countries are aspiring to tap into the technology. Uganda has set an ambitious energy production target, which is, to see nuclear energy become part of its national grid by 2050 in order to reduce the country's electricity deficit. Uganda could have its first nuclear power station as early as 2018 (Wakabi, 2010). Kenya has equally 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 the country, to enhance generation of affordable and reliable electricity. The future

Table 27: Anticipated 2031 electricity generation portfolio of Kenya

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).

energy policy option for Kenya includes a nuclear component (see Table 27). Nuclear energy is likely to be part of the options in the agenda of the subregion in the future.

6.4 ICT and energy

Technological innovations have brought many transformations in 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. The contribution of ICT to global energy use is complex and difficult to determine. Energy access is critical for the use of popular applications such as mobiles phones, radio and the internet. Since measuring the energy demands of ICT equipment is complex, determining the direct and indirect impact of ICT on the overall energy demand of a country is difficult. To identify the indirect effects of ICT on 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.[36]

The Eastern Africa subregion requires a revolution in energy technology innovation and adoption to meet the profound economic, environmental and social challenges energy poses in the 21st century.

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 of 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.[37]

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, and particularly in countries where technology and innovation support infrastructure is inadequate, the 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

36 See Bernard Aebischer in"ICT and Energy: Some Methodological Issues." Available at http://ercim-news.ercim.eu/en79/ special/ict-and-energy-some-methodological-issues.

37 Also see Bernard Aebischer in "ICT and Energy: Some Methodological Issues." Available at http://ercim-news.ercim.eu/en79/ special/ict-and-energy-some-methodological-issues

Box 9: Constraints on technology and innovation in developing countries

The main constraints on technology and innovation capacities in developing countries are 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 research and development. 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 research and development 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).

industry could be developed around these technologies. They are ideal for countries with limited technical and innovative expertise.

Collaboration in science and technology within a South-South framework, and particularly in technology and innovation with robust countries would constitute an ideal partnership for the subregion to enable it develop and obtain the necessary capacity to boost indigenous energy technologies capacity that will allow sustainable economic growth.

Most of the challenges facing the exploitation of energy technologies are not specific to one technology but generic for all types of energy technologies. General constraints for access to innovative energy technologies include: (a) absence of clear policies to promote energy technologies; (b) financial shortfalls for research and development; (c) lack of a conducive environment for resource mobilization from the private sector; (d) lack of awareness about renewable energy technologies (RET); and (e) lack of a long-term framework for consumers of renewable energy to receive products at affordable prices and in a sustainable manner. Sampath (2010) further identifies the constraints to technology and innovation in developing countries (see Box 9).

Beyond innovation and energy technology development, there are barriers to dissemination of new technology and energy products. In the rural areas, Deutch Bank identifies the following (see Table 28).

Table 28: 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 infrastructure	• 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 of RETs and could make them prohibitively expensive
Skills and training	• Difficulty in recruiting and retaining staff with adequate technical skills to install , maintain and repair RETs • Limited business skill (literacy, bookkeeping, computer-related) • Customers lack information/skills needed to properly operate RETs
Cost and access to financial services	• Upfront costs can be high compared to 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	• Inadequate development of supply chains • Retail and logistics services are limited in 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 the RETs	• Power quality products can undetermine reputation of RETs and diminish customer trust • If promised economic benefit (payback period, among others) fails to materialize, customer trust may suffer
Gender	• The fact that men are responsible for 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 subregion 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 of promoting major emerging and developing economic participation in international technology partnerships in the energy sector and to scaleup 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 in science and technology within a South-South framework, and particularly in technology and innovation with robust countries would constitute an ideal partnership for the subregion to enable it 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 and address energy security, climate protection, development and the achievements of the MDGs.

Based on these factors, the following recommendations are put forth for policymakers, decision makers and stakeholders in the Eastern Africa subregion to consider:

- Formulation 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;

- Promoting appropriate (environmentally sound) energy technologies for mechanized agriculture, water pumping, agro-processing, educational and health facilities, and for other sectors;
- Enhancing the utilization of indigenous and renewable energy sources and technologies;
- Capacity-building in the area 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 spreading technology; and
- Better linkages between research and enterprise in specific sectors of energy.

Energy Infrastructure Gaps and Energy Trade in the Eastern Africa Subregion

7

The African continent's energy profile is characterized by abundant energy resources in oil, gas, coal and especially hydro potential, but these are unevenly distributed across the continent, complicating energy development and distribution for most countries. There are under-exploited energy resources and unmet demands. In comparison with the rest of the world, Africa has 15 per cent of the world population but only 3 per cent of primary energy consumption. Access rates to basic energy services, especially in sub-Saharan Africa (SSA), are low, and access rates are barely 31 per cent, thereby throttling socioeconomic development. The energy market is fragmented and the capacity to mobilize financing for investment is low, especially from private sources, due to low country and utility credit worthiness and high political risks. Africa has limited generation capacity (only 125 GW of capacity in the whole of Africa). The power transmission system is limited (only 89,000 km for the entire continent); and so are gas and petroleum product pipeline systems.

7.1 Power systems

7.1.1 Power generation

As depicted in Table 29, Africa has the lowest electricity capacity per capita in the world (123 MW/million population), as compared to 3,600 for Asia, 515 for Latin America and 1,078 for Eastern Europe and Central Asia. Rosnes and Vennemo (2008)[38] 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 per cent of the population lacked access to electricity, with coverage particularly low in rural areas.

38 Powering Up: Costing Power Infrastructure Investment Needs in Southern and Eastern Africa – World Bank Africa Infrastructure Country Diagnostic Paper No. 61813.

Table 29: 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 no 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 subregional countries is currently inadequate, leading to low access at an average of about 27 per cent.

Economic growth in several of the Eastern Africa subregional countries is curtailed by lack of adequate supply of power to drive industries. The condition is dire when it comes to meeting the 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 highlights 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 the area of power generation infrastructure.

Among the countries of the East African Power Pool (EAPP)/ East African Community (EAC) subregion, there are plans to expand generation capacities by the year 2030, as depicted in Table 30. The last column of this table shows that some countries have a high potential to generate surpluses, which they can trade within the subregion. Ethiopia has one of the highest potentials for surplus electricity generation. Egypt and Sudan are included as members of the EAPP.

Table 30: 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*	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.

** Disaggregated figure for South Sudan not available.*

7.1.2 Power transmission

Power transmission systems in the subregion are primarily country focused and tend not to be interconnected. They are neither designed to facilitate regional energy trade nor to enhance energy access and security. It is therefore an imperative that future power generation and transmission plans in the subregion take into account the aspect of regional cooperation and integration, in order to take advantage of economies of scale 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), as well as the close collaboration with member States, are necessary.

Future power generation and transmission plans in the subregion take into account the aspect of regional cooperation and integration, in order to take advantage of economies of scale and the comparative advantages of the various countries.

Energy transmission and distribution losses in most of the subregional countries are currently in the region of 20 to 25 per cent. Since a greater portion of energy losses is attributable to poor transmission and distribution systems, the high loss rates are clear indication of the need for the countries in the subregion to upgrade their power transmission systems and infrastructure.

7.1.3 Subregional power interconnection

Though 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 hydropower station Ruzizi I, (capacity 45 MW) operated by a joint utility company (Société d'Electricité des Pays des Grand Lacs (SINELAC));
- Kenya – Tanzania interconnection;
- Kenya – Uganda interconnection;
- Ethiopia – Djibouti interconnection;
- Ethiopia – Sudan interconnection.

In line with the EAPP/EAC framework, however, a number of power interconnection projects are being developed, and expected to bear results within the next 5 to 10 years (see Table 31). As will be seen later, investments associated with the regional interconnectivity projects are substantial. Regional energy infrastructure would however significantly expand electricity access through trade supported by interconnection.

7.2 Natural gas and petroleum pipeline infrastructure

7.2.1 Natural gas pipeline infrastructure

The significant discoveries and development of gas resources in the subregion will open the potential to develop intra-regional gas trade.

The African continent's main regional gas pipeline network is in North Africa, where gas is 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 subregion. A recent discovery of large gas deposits in Tanzania is, however, bound to alter the gas infrastructure shortfall in the subregion. 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 intraregional trade in oil and gas. However, the significant discoveries and development of gas resources in the subregion will open the potential to develop intra-regional gas trade.

7.2.2 Oil products pipeline infrastructure

There are very limited regional or continental petroleum products pipelines in Africa, and most of the existing ones serve national markets. Within the Eastern Africa subregion, Kenya has an internal products pipeline distribution system, which links the port of Mombasa and its refinery to Nairobi. The system includes 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 due to 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.

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 is a crude oil pipeline between Dar es Salaam (Tanzania) and 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 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 alternative export pipeline(s) to the 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 the oil flowing through the Sudan pipeline has left some 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 growth in the trucking industry, but with consequences on the 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 resulted in heavy losses of life and property, as well as damage to road surfaces as a result of oil spillages.

The performance of the rail sector has continued to fall 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 subregion to supplement transportation, the road infrastructure network on its own will not be adequate to ensure energy security. The discovery of commercial quantities of oil and gas in countries of the subregion offers a great opportunity for planners and policymakers to consider the optimal modal mix for the exploitation and marketing of products. Indeed the development of rail infrastructure, such as the much talked about standard gauge railway from Mombasa to the landlocked countries is unlikely to be realized unless it is linked with the exploitation of mineral resources, including oil and gas.

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Table 31: EAPP/EAC ongoing 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
DRC	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.

7.2.3 Refineries and storage infrastructure

The main refinery in Eastern Africa is the Kenya Petroleum Refinery Limited 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 per cent) and Essar Energy Overseas Ltd (50 per cent). There was previously a refinery in Dar es Salaam with a capacity of 17,000 barrels per day, but it was closed down 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 the capacity to refine 14,000 barrels a day. The other refinery which has been serving Sudan and South Sudan is the Khartoum Refinery Company Limited, with the capacity to refine 100,000 barrels a day. It is jointly owned by the Sudan Government and China National Petroleum and Gas Corporation.

More cost savings would be possible if countries collaborated in developing regional storage and distribution facilities to mitigate the current inefficiencies in petroleum products procurement and distribution.

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). The feasibility study recommended a phased approach. The initial plan entails building a facility to process 20,000 barrels a day at an estimated cost of $600 million. This would then be expanded to a facility that can process 60,000 barrels per day under a public private partnership arrangement, which may comprise the Government of Uganda, China National Offshore Oil Corporation (CNOOC) and TOTAL.

The determination of Uganda 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 Ugandan domestic needs will diminish the economies of scale of export infrastructure without necessarily reducing domestic fuel prices and that there will be the temptation to imbed hidden fuel subsidies within a domestic refinery entity. International oil companies are meanwhile using the reported oil discoveries in Kenya to campaign against the Uganda refinery project. The companies prefer exporting the crude oil through pipelines to the port of Mombasa to the global market.

The Uganda 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 the region will provide feedstock to both the Hoima and Mombasa refineries and make them competitive. The EAC region current total demand for oil is estimated at 164,000 barrels per day. The Mombasa refinery has the capacity to process 70,000 barrels a day. The arguments for and against the Ugandan oil refinery project brings into focus the need for regional cooperation in developing a regional refinery and pipeline network.

Regarding oil storage infrastructure, most countries would like to develop facilities that can hold up to 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 would 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. Such a concept could be applicable at the regional level through the development of a 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 the necessary infrastructure.

7.3 Planning for growing energy demand in the Eastern Africa subregion

At the continental level, African ministers responsible for hydrocarbons have proposed the establishment of an African Petroleum Fund. Such a concept could be applicable at the regional level through the development of a proper policy and framework.

7.3.1 Demand and accessibility of electricity

Countries in the Eastern Africa region (EAPP/EAC) are targeting an energy access rate of 62 per cent by the year 2030, which is projected to rise to 68 per cent by the year 2040[39]. 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 32 depicts the planned energy access of the EAPP/EAC region compared with other Power Pools in Africa. Given the broader acceptance and implementation of the SEFA framework, the access targets will be even more aggressive.

Meanwhile the EAPP/EAC Regional Power System Master Plan Study has projected electricity demands as shown in Table 33**.** Most of the countries in the subregion will have annual average growth rates (AAGR) of demand in excess of 10 per cent during the 2010-2040 period. In order to meet such demands, countries will have to either 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:

i) Meet existing and projected demand for electric power by undertaking a major programme of expansion in generation capacity from about the current 50 MW 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 so as to provide 75 per cent of urban households with access to electricity from the national grid by 2025, compared with only 5 per cent at present;

Table 32: 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%

39 Programme for Development of Infrastructure in Africa (PIDA) study by SOFRECO.

Table 33: 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.

iv) Complete a major restructuring of the South Sudan Electricity Corporation (SSEC) to convert it into a fully-fledged, and financially sound, state enterprise with 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 programme, average consumption of electricity in South Sudan will increase 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 households 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 programme for electric power and rural energy for the 2011-2020 period will be $2.3 billion, with an additional $180 million to be spent on extension of the national network and the rural energy programme for the 2021-2025 period. The proposal is to mobilize about $870 million private capital for the expansion of the generation capacity, with the government and international donor community providing the balance of the required funding.

7.3.2. Demand for oil and gas products in the subregion

7.3.2.1. Oil consumption

The global financial crisis, which led to a fall of 1.5 per cent in global oil consumption 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 a 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 34). It is, however, expected that demand for petroleum products in the subregion will continue to grow in line with projected economic growth.

Table 34: 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
DRC	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 East Africa 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 35.

7.3.2.2 Natural gas consumption

With the exception of Tanzania and Rwanda where gas is used for electricity generation, in the rest of the subregion gas is used mainly for domestic purposes. The use of gas by urban households is rising, particularly as electricity and charcoal prices rise. As a result of deforestation in the region, woodfuel is becoming scarce and charcoal has become increasingly expensive. Africa's domestic consumption of natural gas 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 cent per annum[40].

Table 35: Annual oil consumption of 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.

40 Energy Data Yearbook 2012: www.enerdata.net

7.4 Energy infrastructure investment needs in the Eastern Africa subregion

7.4.1 Investment to expand access and to meet increasing power demand

$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.

As depicted in Table 33, countries in the EAPP/EAC region seek to achieve energy access of 68 per cent by 2040. Orvika and Haakon (2008) established that raising access to 35 per cent by the year 2015 in the EAPP countries would require raising existing power generation capacity by 11 per cent. They projected that demand for power in this region would grow by 7 per cent per annum to reach the level of 170 terawatt hours (TWh) by 2015. They reckoned that in the EAPP region, annualized capital investment costs toward generation capacity expansion would be 2 to 3 per cent of GDP. In addition, $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 demand will increase by a moderate 6.5 per cent per annum and access rate will increase substantially from 36 per cent to 68 per cent between 2010 and 2040, requiring an investment of $44 billion in access over that period. The list of generation projects identified in the EAPP/EAC Regional PSMP andGrid Code Study is shown in Table 36.

7.4.2 Regional power trade

PIDA anticipates that EAPP demand will increase by a moderate 6.5 per cent per annum and access rate will increase substantially from 36 per cent to 68 per cent between 2010 and 2040, requiring an investment of $44 billion in access over that period.

Countries in the Eastern Africa subregion have different endowments regarding power generation potential, as well as costs, thus creating the necessary arbitrage for power trading in the subregion. Trading with neighbouring countries facilitates the development of the cheapest forms of energy resources in the subregion, potentially reducing cost of electricity for member States within the trading regime. For example, stimulating the development of hydropower in countries with the comparative advantage, while expanding regional trade in energy, would lower generation costs in the long run, reduce carbon emission from generating plants and insulate countries from hikes in the

Table 36: List of identified regional generation projects

Country	Plant Name	Type	Installed Capacity (MW)	Date
Eastern DRC	RUZIZI III	Hydro	145	2024
	RUZIZI IV	Hydro	287	2027
Ethiopia	Mandaya	Hydro	2,000	2031
	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
Uganda	Karuma	Hydro	700	2016
	Ayago	Hydro	550	2023
	Murchison Falls	Hydro	750	2032

Source: EAPP/EAC Regional PSMP and Grid Code Study (May 2011).

price of fossil fuels[41]. Though regional trade in power would initially entail significant infrastructure costs to develop the missing cross-border transmission capacity, the benefits of building them are substantial. Orvika and Haakon (2008) pointed out that the existence of regional connectors would make it possible to shave 5 to 6 percent off annualized power system costs. For the EAPP region, they reckoned that the savings could be in the range of $1 billion per year. It is therefore encouraging to note that the EAPP/EAC Regional Power System Master Plan and Grid Code Study (2011) has selected a number of interconnection projects as shown in Table 37.

The existence of regional connectors would make it possible to shave 5 to 6 percent off annualized power system costs. For the EAPP region, the savings could be in the range of $1 billion per year.

7.4.3 Investment in oil and gas pipeline infrastructure

7.4.3.1 Kenya oil pipeline

The Kenya oil pipeline, initially linking Nairobi with the port of Mombasa (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, it became necessary to enhance capacity through installation of additional or wider pipes. In this regard the WKPE was expanded from an 8-inch to 14-inch pipeline with a flow rate of 378 cubic meters per hour. There is likewise the need to increase the 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.

Though regional trade in power would initially entail significant infrastructure costs to develop the missing cross-border transmission capacity, the benefits of building them are substantial.

Table 37: 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
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).

41 Some countries rely on imported fuel to generate electricity

7.4.3.2 Kenya-Uganda oil pipeline extension

The project to extend the pipeline to Uganda from Eldoret in Kenya had been planned through a public-private partnership (PPP). Each of the two governments was to take 12.5 per cent share, leaving the 75 per cent for the strategic private investor. However, the project stalled as a result of 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 the Kenya Mombasa-Eldoret pipeline. The need has therefore arisen to reappraise the project, which is likely to result in a different set-up, costing and financing arrangements.

7.4.3.3 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 $3 billion and above for such a pipeline.

7.4.3.4 Tanzania oil and gas pipelines

Tanzania already has a gas pipeline connecting Songo Songo Island and Dar es Salaam. Following further discovery of an estimated 3 trillion cubic feet of gas off the southern Indian Ocean coast of Tanzania, the government plans to begin the construction of a natural gas pipeline project from Mtwara to Dar es Salaam. China has offered a loan of $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 through 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 the 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 terms of the agreement stipulated in the contract. It was reported (Tanzania Daily News, 14 August 2012) that the Tanzanian Government was reviewing the project.

7.5 Financing mechanisms

It would appear that Official Development Aid (ODA) funding for energy projects in Africa is limited, but there are still a number of possible infrastructure financing mechanisms to consider.

7.5.1 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 from 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 the risk of misappropriation.

7.5.2 Public-Private Partnerships

Perhaps the most common and preferred financing mechanism is the public-private partnerships where publicly owned utilities companies 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 of a country where this model is currently in application.

Domestic resource mobilization takes many forms, with the most common one being the establishment of an Infrastructure Fund or Energy Fund.

7.5.3 Regional/cross-border integrative projects

Regional or inter-State cross-border projects involving two or more countries tend to attract funding from 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.

7.6 Policy considerations in energy infrastructure development in the Eastern Africa subregion

7.6.1 Regional energy policy based on the African Union continental vision

The Africa Union energy vision which was proposed in 2000 and reaffirmed by the Ministers of African countries in charge of energy, in the Maputo Declaration of 5 November 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 hydropower 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 subregion enhance regional cooperation in pursuit of the above objectives. It is encouraging to note that in the case of hydropower generation there is joint planning within the EAPP/EAC framework. There is the need to do likewise in the case of oil refineries and pipelines.

7.6.2 Coordinated development of optimum regional networks

Countries in the subregion 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 the necessary infrastructure is required. In this regard, appropriate regional protocols and implementation frameworks and strategies are crucial.

7.6.3 Renewable energy policy

Eastern Africa countries should adopt policies that encourage investment in renewable energy sources. A similar recommendation is made in the Energy Development and the Environment section of this report.

7.6.4 Technological considerations

There are two basic issues relating to technology. The first is about 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 is the reduction of greenhouse gases. The 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 subregion would bear some fruit. More policy discussion is offered in the Technology section of this report.

7.6.5 Financing/investment policies and strategies

Various financing mechanisms were already explored under section 7.5 above. In several countries, however, appropriate policies and regulatory frameworks are still lacking. There will be a need for such policies and regulatory mechanisms to be put in place to encourage broader investment in the energy sector. Based on the above, the following key policy pathways are recommended:

- Adopt and implement the Africa Union 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 the necessary infrastructure;

- Collaborate subregionally 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.

8

Mitigating the Energy Constraint on Economic Transformation in the Eastern Africa Subregion

8.1 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 an improved quality of life due to better education and health services. Without adequate access to modern, commercial energy, developing countries could be trapped in a vicious circle of poverty and underdevelopment.

The Eastern Africa subregion is endowed with a variety of energy resources requisite for sustainable development. These energy resources, which are widely distributed throughout the subregion include hydro, wind, biomass, solar, geothermal, peat and fossil fuels. Despite the enormous potential, the subregion'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 per cent of total energy consumption across the subregion. 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 subregion.

The Eastern Africa subregion is the fastest growing region in Africa, and features countries growing at rates favourable internationally. Consequently, millions have been lifted out of poverty, and economic transformation is taking shape. Ethiopia, Kenya, Rwanda and Uganda, among others, are therefore aspiring to middle-income status within a decade or so. Economic optimism is widespread, both among policymakers and the subregional population. Recent reports of the social and economic condition of the region show increasing intra subregion trade, growing foreign direct investment (FDI), greater investment in the energy sector (in energy resource endowed countries), increasing trade with China and other emerging economies and GDP growth at a favourable pace. One central agenda in the subregion is sustaining these gains and achieving broad-based socioeconomic transformation.

Though energy is a source of growth as seen in Ethiopia, South Sudan and Tanzania, it can also be a great constraint to the potential of economic transformation in the subregion. The region depends nearly entirely on imported oil, drawing much needed hard currency away from domestic development funds. Limited and unreliable electricity supply, and the integration of costly technologies into the energy portfolio, introduces the systemic risk of rising power cost. In addition, the great dependence of populations in the subregion on biomass limits opportunities in the energy-dependent small and large-scale industries, particularly in rural areas. Consequently, figuring out how to expand energy production, and widespread distribution, as well as the 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.

8.2 Energy access and economic development

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.

Countries in the subregion have been fighting poverty and underdevelopment for years. Factors contributing to persistent poverty include conflict, inadequate infrastructure, poor access to capital, governance and insufficient institutional capacity (IMF, 2008). In the last two decades, sustained growth, job creation and poverty alleviation have been priority development goals, and these goals can be achieved through the implementation of broad-based socioeconomic 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 needed to power industry, increase agricultural productivity and boost GDP, to provide electricity to rural areas, and improve the 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 important that energy access and supply does not become a stumbling block in the way of realizing national potentials. Unfortunately, in the East African subregion, 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 carried out on the energy consumption–economic growth relationship for countries includes those by Jumbe (2004), Wolde-Rufael (2006), Akinlo (2008), Odhiambo (2009), Kahsai and others (2011) and Nando and others (2012). They found some form of relationship between energy consumption and economic growth. Furthermore, an IEA study shows that energy consumption has a positive bearing on wealth, while a lack thereof is correlated with people living on less than $2/day (IEA, 2004). This supports the hypothesis that inadequate energy services impede the achievement of 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 by increasing capital formation. Accordingly, investment in renewable energy might

Table 38: 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				
D.R. Congo	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.

result in the development and expansion of businesses and thus effectively stimulate employment growth and increase in earnings.

In the subregion, 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. Countries in the subregion and sub-Saharan Africa at large,have the lowest access to electricity in the world (Legros and others, 2009). This is demonstrated in Table 38 according to urban and rural areas.

Therefore, it is imperative that to sustain the gains in socioeconomic development and transformation underway in the Eastern Africa subregion, the energy constraint, namely the low level of access, will have to be dealt with.

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8.3 Energy security and economic growth

Energy security is a complex theme and relates to the reliability, resilience and sustainability of energy supplies. For policymakers, 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.

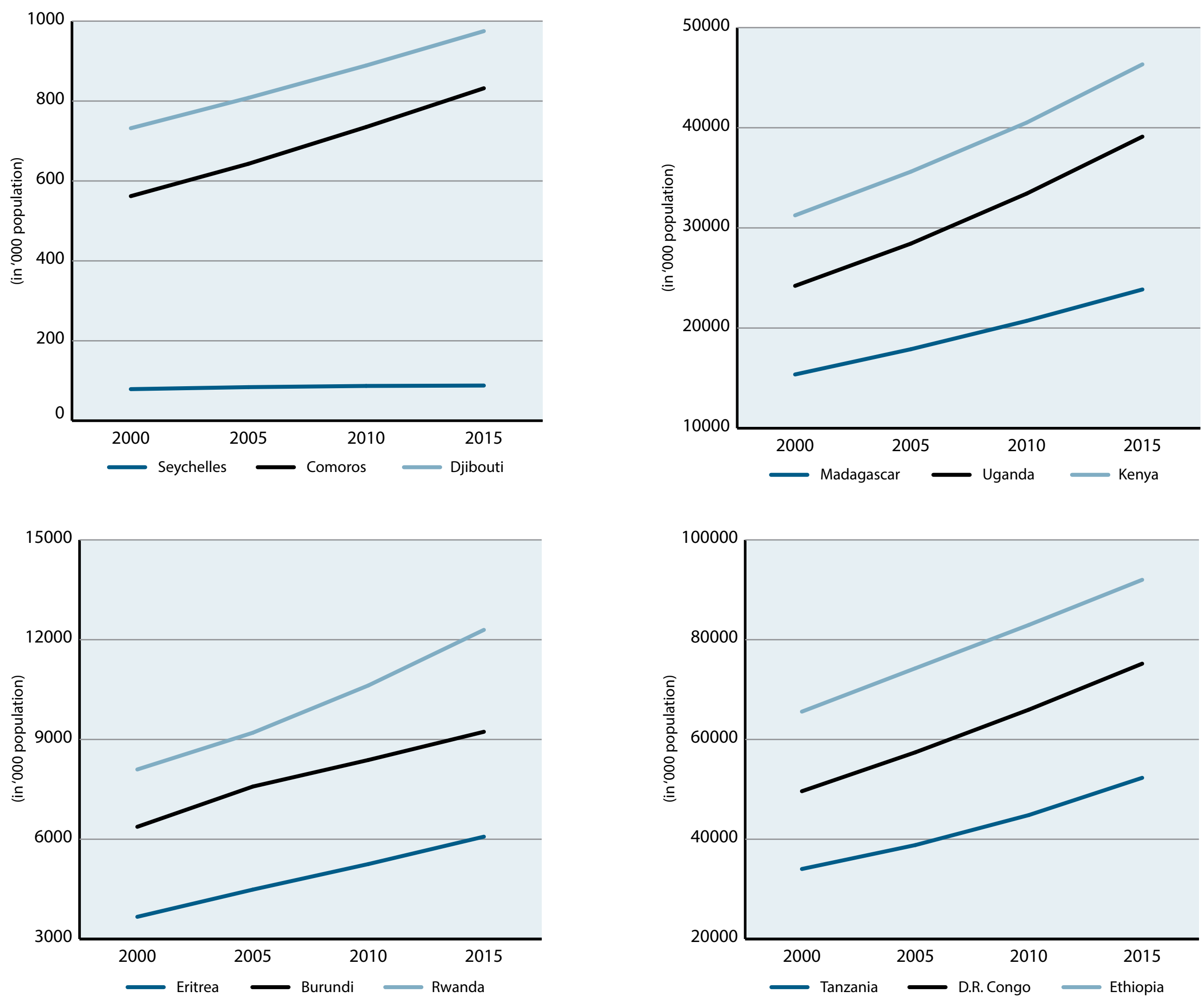
Countries in Eastern Africa have the potential to produce sufficient energy to meet their current and future energy demands by exploiting more fully the mix of hydrocarbons and renewable energy resources at their disposal. For example, South Sudan is a producer of oil, Kenya and Uganda have announced discoveries of oil, and Uganda is in the resource development phase, Tanzania is in the development phase of its significant gas find, Ethiopia and DRC 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 and human capacity have created challenges to energy security in the subregion.

8.3.1 Increasing energy demand and energy services

Energy consumption within the subregion is expected to increase significantly during the coming years. This increase will be triggered mainly by the current low level of energy consumption (3 per cent of world average consumption), rapid population growth (see Figure 81) and the expansion of the economies of the region. With growing demand comes more pressure on how to provide secure and reliable energy services at affordable price for current and future needs. For example, in Kenya the rate of provision of electricity services has not been able to keep up with the population and economic growth (Kiva, 2008). In 2007/08 the reserve capacity of Kenya was 3 per cent compared to the required safety margin of 15 per cent (KPLC, 2007). The lack of adequate reserves 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.

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

Figure 81: Actual and projected population growth in the Eastern Africa subregion



to continue to provide reliable services to existing customers and the growing demand from the traditional economic sectors. To meet this challenge, a practical and long-term plan must be put 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.

8.3.2 Natural disasters, emergency generation, energy security and economic impacts

Natural disasters such as earthquakes and extreme weather events (hurricanes, drought, forest fires and floods) are threats to achieving and maintaining secure energy infrastructure. These events can damage the energy production and distribution infrastructure at national and local levels, and ultimately influence the socioeconomic development of impacted countries. For example, drought has seriously reduced the power available to hydro-dependent countries in Eastern Africa. In the subregion, an estimated average of 67 per cent 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[42] . The common response to these crises is to switch to thermal power at a high cost, to meet the shortfall in 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.

Paying for emergency leases absorbs significant budgetary resources, reducing the funds for long-term domestic development finance.

Emergency generation is expensive and costs \$0.20–\$0.30 per kilowatt-hour (Eberhard and others, 2011). Table 39 shows the estimated GDP loss due to emergency power generation in four Eastern African countries. The loss ranges from 0.96 per cent of GDP in Tanzania to 3.29 per centof GDP in Uganda. When the shortage in hydroelectric power supply occurs at the same time as 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 long-term domestic development finance.

Box 10: Emergency generation – cases in the Eastern Africa subregion

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. From 2004, thermal electricity constituted 30 percent of the country's power generation, and in 2006 it was 56 percent. Operation of these generators cost Rwanda up to \$65,000 per day (IMF, 2008). These events had immediate economic costs for the country. Electricity rates doubled in 2004/5, from 7 to 14 US cents/kWh, and rose again in 2005/6 to 22 US cents/kWh. As a result of this, Rwanda continues to facea high cost of electricity (MININFRA, 2010).

Uganda
Between 2004 and 2006, the reduction in water levels at Lake Victoria resulted in reduction in hydropower generation by 50 MW and led to the adjustment of the GDP growth rate from 6.2 per cent to 4.9 per cent (Baanabe, 2008). The government was compelled to add thermal energy into its energy mix to fill the gap. This led to an electricity price increase of 100 per cent (216.9 in 2005 to 426.10 Ugandan Shilling in 2006-2008) and it also obliged businesses to purchase backup 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 hydropower generation and in the year 2000, the hydropower generation capacity was reduced by 25 per cent. The resultant cumulative loss was variously estimated to be about 1-1.5 per cent of the total GDP (Karekezi and Kithyoma, 2005).

42 Burundi, Ethiopia and DRC also face the same challenge, which impacts their economies negatively.

Table 39: 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 and others, 2008

8.3.3 Energy services disruption and economic impacts

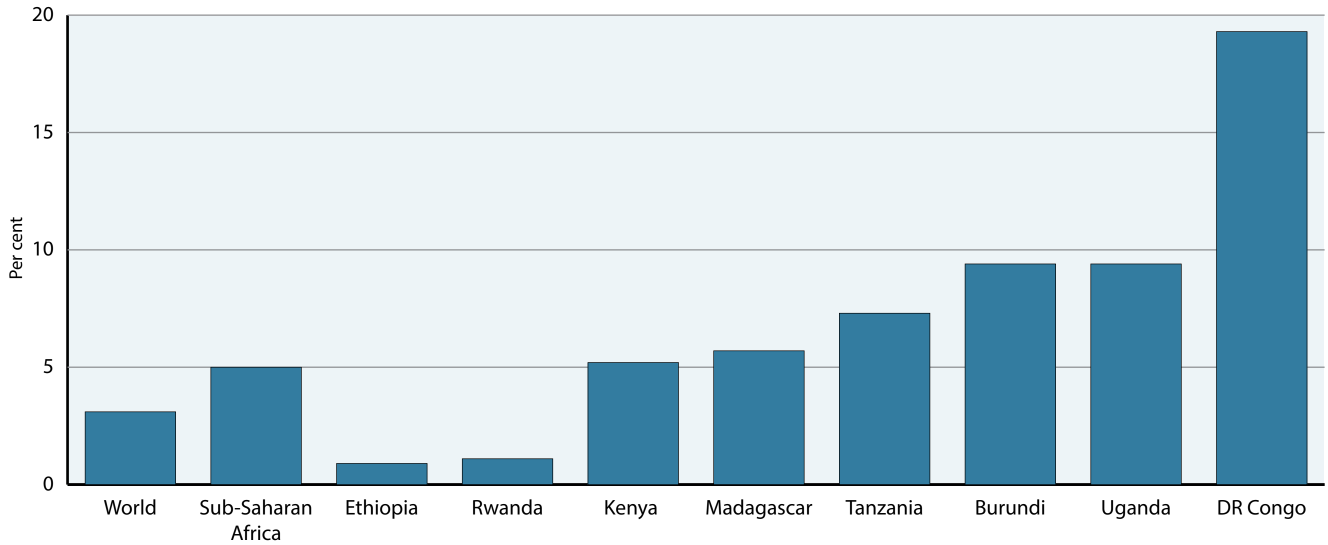
The cost of energy services disruptions due to electricity outage is another major constraint to economic performance and long-term transformation. African manufacturing enterprises experience power outages on an average of 56 days per year. As a result, firms lose 6 per cent of sales revenues; in the informal sector, where backup generation is limited, losses can be as high as 20 per cent, and the overall economic costs of power outages can rise to 1–2 per cent of GDP (Khennas, 2012). As shown in Figure 82, in Eastern Africa, annual sales revenue loss to firms due to electrical outage is one of the biggest problems (DRC 19.3 per cent, Uganda and Burundi 9.4 per cent and Tanzania 7.3 per cent). Power outage is identified as a major obstacle for doing business, affecting 49.2 per cent of firms in sub-Saharan Africa compared to 39.2 per cent of world average, based on World Bank Enterprise Survey.

Power outage is identified as a major obstacle for doing business, affecting 49.2 per cent of firms in sub-Saharan Africa compared to 39.2 per cent of world average.

8.3.4 Oil price volatility and economic impacts

The current high and volatile oil prices, combined with increasing oil import dependence of countries in the subregion pose an obstacle 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 the government budget. The rise worsens the trade balance, as discussed in the Energy Security assessment of the subregion earlier in this report, leading to higher current account deficits and a deterioration of net foreign asset positions. At the same time, it

Figure 82: Losses due to electrical outages (% of annual sale of firms)



Source: Enterprise Survey database, the World Bank.

can decrease private disposable income, corporate profitability and domestic aggregate demand. The impact also depends on whether or not the government decides to pass on 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 necessitate a monetary tightening that could in turn lead to slow economic growth.

On average, oil-importing developing countries use more than double the oil to produce a unit of economic output as do OECD countries.

The adverse economic impact of higher oil prices on oil-importing developing countries is generally more severe than on 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 per cent in Asia and 1.6 per cent 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 (Ayadi and others, 2000; Ayadi, 2005), Mali (Kpodar, 2006), Mozambique (Coady and Newhouse, 2005), South African Region (Nkomo, 2006) and Ghana (Coady and others, 2006). The loss of GDP in the sub-Saharan African countries was estimated to be between 3 per cent (IEA, 2004) and 6 per cent (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 the world markets with a complete pass onto oil consumers would lead to a 6 per cent contraction in the first year. If that country were to adopt a no-pass strategy, output would not be significantly affected but its budget deficit would increase by 6 per cent. Either way, whether it is passed onor not, the macroeconomic stability of the country is affected.

A doubling of the price of oil on the world markets with a complete pass onto oil consumers would lead to a 6 per cent contraction in the first year. If that country were to adopt a no-pass strategy, output would not be significantly affected but its budget deficit would increase by 6 per cent.

In Eastern Africa, this volatility is a significant threat to energy security and economic resiliency. Fossil fuels provide approximately 14 per cent of the regional energy supply, 27 per cent of electricity net generation and 100 per cent of the fuel used in the transportation sector. In countries such as the Comoros, Eritrea and Seychelles, close to 100 per cent of electricity net generation depends on fossil fuel. Furthermore, it is difficult to solve sectoral challenges, such as the chronic food insecurity in the subregion, 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 a careful examination and management strategy.

8.3.5 Conflict-related power threats

The subregion has a long history of armed conflicts that threaten its infrastructure and puts into jeopardy its economic development. For example, war has seriously damaged critical infrastructure in DRC, Eritrea, Ethiopia, Somalia and South Sudan. Obviously, countries in conflict perform worse in the development of infrastructure than those at peace (Yepes, Pierce and Foster, 2008).

8.4 Policy options to reducing energy constraints to economic transformation in the Eastern Africa subregion

8.4.1 Within-country strategies

The sections on energy access, energy security, governance of transboundary water resources, technology and innovation and the environment have passed country-specific policy recommendations that can also help to reduce the energy constraint to economic transformation. The following additional recommendations are offered in the context of economic transformation.

8.4.1.1 Enhancing energy efficiency

An ambitious economic transformation agenda to enter middle-income status in the subregion would require an equally ambitious energy access transformation, which necessitates joint economic and energy planning.

The subregion can go a long way in enhancing energy efficiency, since the average energy intensity (energy per unit of GDP) in Africa of 13,352 Btu is much higher than the global average of 9,803 Btu (EIA, 2012). This is 36 per cent above world average which indicates the amount of energy input in production processes that is wasted, but could have been saved for other productive activities. Saving energy reduces the demand for generation expansion. There are great potential and opportunities in energy efficiency which needs prioritizing in the strategy for sustainable energy development.

8.4.1.2 Joint economic and energy planning

Planning for economic transformation requires 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 the availability of vast amounts of energy. For example, middle-income countries, on average, have 80 per cent population electricity access, compared with 27 per cent in the Eastern Africa subregion. An ambitious economic transformation agenda to enter middle-income status in the subregion would therefore require an equally ambitious energy access transformation, which necessitates joint economic and energy planning.

8.4.1.3 Shielding the economy from energy insecurity impacts

Economic transformation can be constrained by energy insecurity, stemming from unsustainability of biomass-based energy supply and the availability, quality and affordability of electricity supply. More importantly, dependence on petroleum import and disruption in management policies and schemes in-country determine the nature of the 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 with timely and accurate analysis and information on the risk of energy disruption for timely management decisions that can deter potential spillover effects of energy insecurity on the economy.

8.4.2 Subregional strategies

A subregional framework is advantageous for many reasons. It helps to bring a whole series of high-potential energy sources for development, enabling the alleviation of the energy constraint throughout the subregional economy. With proper infrastructure development and trade, the subregional average cost of energy supply could be reduced while enhancing supply constraints. Moreover, a regional framework could help pool investment resources together to develop an otherwise costly project. One example is the development plan of Inga III power project in DRC that is pooling financial resources from countries in the Southern Africa Power Pool (SAPP), particularly South Africa.

A regional framework could help pool investment resources together to develop an otherwise costly project.

On petroleum products, a regional framework on strategic reserves, procurement, distribution infrastructure and a coordinated policy response are effective possibilities. The political will of regional governments and policymakers will be required to help build an effective response to the energy constraint to economic development.

Energy Access and Energy Security: Case Studies in the Eastern Africa Subregion

9

For a closer look at lessons on energy access and security, cases studies on four subregional countries are provided: South Sudan, Ethiopia, Tanzania and Uganda. The subregional analysis offered a broader evaluation of 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.

9.1 South Sudan

9.1.1 Background

Since 1956, when the Sudan became independent, the issue of South Sudan had been 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 ended in 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 9 July 2011, and was officially accepted shortly after into the United Nations and AU as an independent State.

The economy of South Sudan is dependent on the petroleum sector, where the export of crude oil accounts for nearly 98 per cent of State revenue. The agricultural and industrial sectors are yet to be built, and the 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 regional energy security strategy, as the only major crude oil-exporting country in the subregion (though DRC produces a much smaller amount of crude oil). As a landlocked country, the economy of South Sudan is closely linked to the economies of Uganda, Kenya and Ethiopia, and despite hostilities, to that of the Sudan as well.

Figure 83: Map of the Republic of South Sudan

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

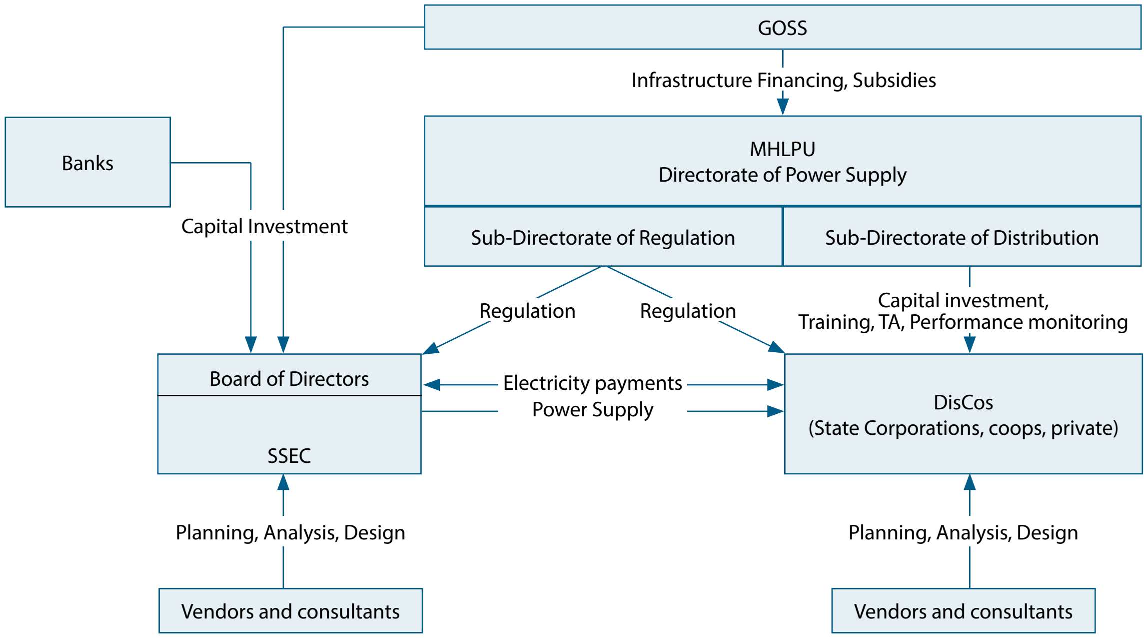
9.1.2 Energy institutions and policy

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 to the Ministry of Housing, Lands and Public Utilities (MHLPU), Ministry of Environment and the Ministry of Agriculture and Forestry. The Petroleum Bill has been passed by the National Assembly. The Electricity Bill of 2012 establishes the regulatory framework for the electricity subsector. 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 the 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 contains a provision that Independent Power Producers (IPPs) and non-governmental entities may develop and operate electricity generation plants. In addition, the Bill calls for the set-up of the Rural Electrification Committee from multiple Ministries, including Agriculture, Commerce and Rural Development. It also calls for the establishment of a Rural Electrification Fund, financed through National Assembly appropriations, levy on transmission of bulk purchase from generating stations and through donations, grants and loans.

The Electricity Bill of 2012 establishes the regulatory framework for the electricity subsector. 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.

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 subsector, 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 calls for prioritization for energy

Figure 84: Institutional framework for the energy sector of South Sudan



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

development. The policy recommends the establishment of an institutional framework for the electricity sector.

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.

The policy paper recognizes that generation of electricity from high-cost liquids results in economic costs 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, and the planning and management responsibility to the SSEC.

The rural electrification 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 services will be offered by "government-sponsored independently governed corporations, and by private independent power producers and energy companies".

9.1.3 The state of energy access and key lessons

9.1.3.1 The state of energy access

The rate of electricity access in South Sudan is 1 per cent, the lowest in the Eastern Africa subregion.

The rate of electricity access in South Sudan is 1 per cent, the lowest in the Eastern Africa subregion. The first power plant in South Sudan was initiated in 1936 (thermal) with the 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, and this continues to pose a structural constraint to socioeconomic activities in the country. Today, Central Equatorial (where the city of Juba is located), Western Bahr Al Gazal (where the city of Wau is located) and Upper Nile State (where the city of Malakal is located) have some level of access to electricity, but the rest of the country is without, or if at all it is negligible (see Table 40).

The South Sudan Development Plan (SSDP) foresees the expansion of the Juba capacity to 40 MW, and the addition of 5 MW to each State capital, along with distribution network expansion. All plans are under thermal generation.

During the six year transitional period before the referendum, 5 MW thermal capacity was added to Juba (2005), doubling it to 10 MW (2006), but 50 per cent of the capacity was lost in 2007 and 2008. Investment in 2009 saw the 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 which was 2.6 MW from 2005 – 2008, was increased to 4.8 MW during 2009-2010. In Wau, the installed capacity remained at 1.6 MW from 2005 to 2008, but had a capacity expansion in 2009 making it 3.6 MW. Out of the ten State capitals, three have basic access to electricity, and three more are planned. Consequently, the current generation portfolio in South Sudan is entirely thermal power. There are plans to add a 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 the Juba capacity to 40 MW, and the addition of 5 MW to each State capital, along with distribution network expansion. All plans are under thermal generation.

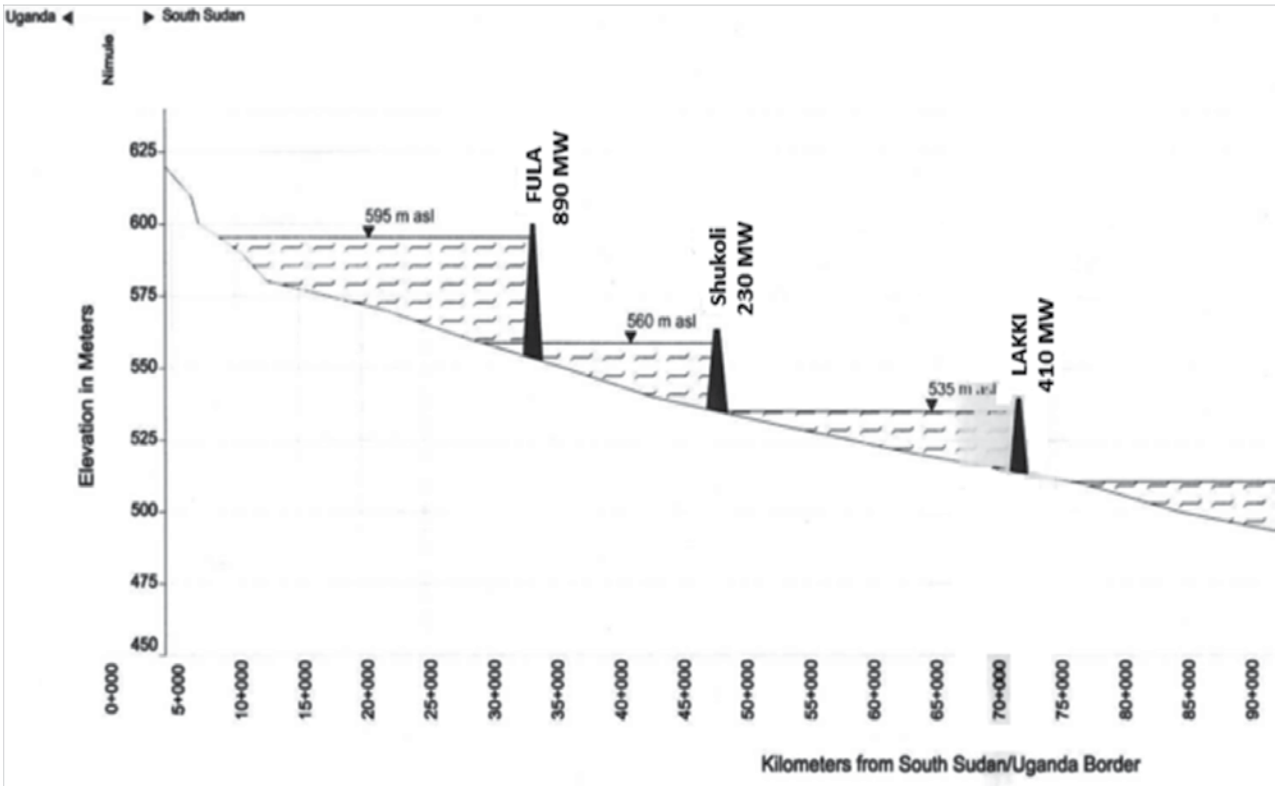
The Government is considering power import from the Ethiopian grid, in the short–term for Malakal, projected to be 50 MW, within three years. The possibility of utilizing crude oil for thermal generation is also under consideration, and likely to enter the generation portfolio in the short-term with the resumption of crude oil production in the South Sudan oil fields. The country also has an ambitious long-term plan to develop three hydroelectric plants along the Nile (see Figure 85). The first, Fula project, some 30-35

Table 40: 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.

Figure 85: Planned hydropower generation of South Sudan



Source: Ministry of Electricity and Dams, 2012.

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, and has the capacity to generate 230 MW. The third, Lakki project, has a capacity of 410 MW. If the development of these hydroelectric projects becomes a reality, they will bring significant improvement to the current capacity, from a clean energy resource. These hydroelectric projects on a transboundary river, the Nile, are likely to face challenges from upstream countries such as the Sudan and Egypt. For further discussion of developing transboundary water resources for hydroeclectric generation and governance challenges, see the related chapter in this report.

Given population growth and the demand from economic expansion, the power deficit is likely to remain a structural problem, calling for immediate expansion of capacity either through boosting domestic generation, and/or electricity imports.

It is clear that there is an immense 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 deficit exists in all 10 State capitals. The gap is largest in the three main state capitals of Juba, Malagal and Wau (see Table 41). Juba needs an immediate relief with supply of up to 40 MW of power, Malakal needs 12 MW, and Wau 13. The gap in most of the remaining state cities is estimated at 2 MW. Given population growth and the demand from economic expansion, the power deficit is likely to remain a structural problem, calling for immediate expansion of capacity either through boosting domestic generation, and/or electricity imports.

Installed capacity upgrade investment plans are already under consideration, so as to install power in excess of current demand. The plans would bring power supply at par with demand in Juba (with a 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 42), along with distribution network and network reinforcement investments.

Table 41: Supply and demand 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.

These investments will help relieve the pressure from short-term demand, and ensure increased access to electricity, but the challenge of expanding connections nationwide, including rural electrification, from the current meager level (see Table 43) to a much higher level of access will remain a major challenge and constraint to the economic revival of South Sudan. Large-scale investment ventures in the country will have to generate their own electricity, at least in the short-term, but integration of planned capacities can alleviate such constraints in the medium- to long-term.

Large-scale investment ventures in the country will have to generate their own electricity, at least in the short-term, but integration of planned capacities can alleviate such constraints in the medium- to long-term.

9.1.3.2 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 encountered energy constraint. The following are lessons from the South Sudan case study:

- **Energy shortages and deficits will call for an "all of the above" strategy for energy development**: electricity access in South Sudan is at 1 per cent, but there are high expectations among the citizenry of an independent State to see economic

Table 42: 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 43: Number of connected customers in South Sudan state capitals: 2005-2010

State capitals	2005	2006	2007	2008	2009	2010
Juba: Domestic Commercial Governmental			 4190 1214 243	 4521 1435 263	 5192 1808 278	 6288 2306 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.

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 highlighted the reality of the need to expand capacity massively. Confronted with this challenge, hydroelectric and other renewable sources are under consideration, but there are serious plans to establish crude oil powered power plants that utilize indigenous resources. This lesson is applicable to the subregion where the lack of energy planning and development for decades has left an energy deficit that can create 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 incorporate the abundant energy potential of the region – green energy.

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.

- **Subregional energy trade can offer relief and affordable energy supply**: expanding energy access in South Sudan, from the current 1 per cent 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 have led policymakers to consider energy trade, with Ethiopia. A Memorandum of Understanding (MoU) has now been reached between Ethiopia and South Sudan for the former to supply initially 50 MW of power to Malakal, with long-term plans to provide initially 100 MW to Juba. Energy trade, and its potential to bring low cost energy, is a possibility.

Without proper energy sector planning, future energy portfolios may not incorporate the abundant energy potential of the region – green energy.

- **Institutions and domestic financial mobilization do matter**: South Sudan has organized the energy sector by putting in place institutions to regulate and develop the sector. Aspects of generation, transmission and distribution are legally delineated, and institutionally overseen, so that no power generation and sale can take place without licensing, which are necessary steps for a new State. There are challenges with the administration of revenues (where not all revenue collected goes back to the energy sector), and not all energy consumers 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 the focus on increase of access in rural areas. The willingness of the State to devote budgetary and tax resources to fund rural electrification is a strategy that will enhance 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.

The willingness of the State to devote budgetary and tax resources to fund rural electrification is a strategy that will enhance expanded rural electricity access.

- **Within a massive power deficit in the system, off-grid energy solutions offer a realistic choice**: the existing level of meagre energy development in South Sudan had no national grid system, and the length of the existing lines was not adequate. This posed the challenge of either 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-term, 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 subregion, and the national grid 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 the private sector is invited to participate in power generation. South Sudan clearly asserts, through legislation, that energy infrastructure is a critical strategic asset of national importance, and as such the preserve of the Government of South Sudan, to be administered by the SSEC. The invitation of the private sector in generation is a potentially beneficial policy, but private public partnerships in the transmission and distribution aspects of the energy sector require broader subregional experience sharing and policy dialogue.

When energy access levels are low, as they are in most of the subregion, and the national grid is limited, off-grid energy access options offer a compelling alternative.

9.1.4 The state of energy security and key lessons

9.1.4.1 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, which is heavy oil with impurities and high acid content, posing storage difficulty but offering the advantage of lower sulphur content. Assessment of the remaining reserves of South Sudan shows that 45 per cent is Nile Blend and 55 per cent Dar Blend (see Table 44) distributed in different production sites (see Figure 86). Blocks 1a and 1b operated by Greater Pioneer Operating Company (GPOC), in Unity State, are the Nile Blend, with an estimated sulphur content of 0.06 per cent. Block 5A operated by SUDD Petroleum Operating Company (SPOC), in Unity State, is also the Nile Blend. Blocks 3 and 7 are operated by Dar Petroleum Operating Company (DPOC), in Upper Nile state, producing the Dar Blend with a sulphur content of 0.1 per cent.

Table 44: 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.

Table 45: Sales 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.

Sales data post independence show that export of the Nile blend is largely to Chinaoil (63 per cent), and Unipec (20 per cent) with Arcadia (17 per cent) sourcing the rest. Dar oil is largely sourced by Unipec, Chinaoil, Vitol and Petronile (see Table 45). The entire crude oil resource is for the export market, with no diversion to local and subregional markets. Lack of domestic refining capacity has contributed to total export.

The future production profile is increasingly dominated by Dar oil (see Figure 87). 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, the South Sudan production profile lasts in effect until 2025, with marginal production carrying through to 2035. Further explorations and new reserve finds will alter this production profile.

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, the South Sudan production profile lasts in effect until 2025, with marginal production carrying through to 2035. Further explorations and new reserve finds will alter this production profile.

South Sudan is an energy security paradox – the only country in the subregional with sizable crude oil production and export, but dependent on imported refined petroleum products, making it 100 per cent energy import dependent. The country has no active 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.

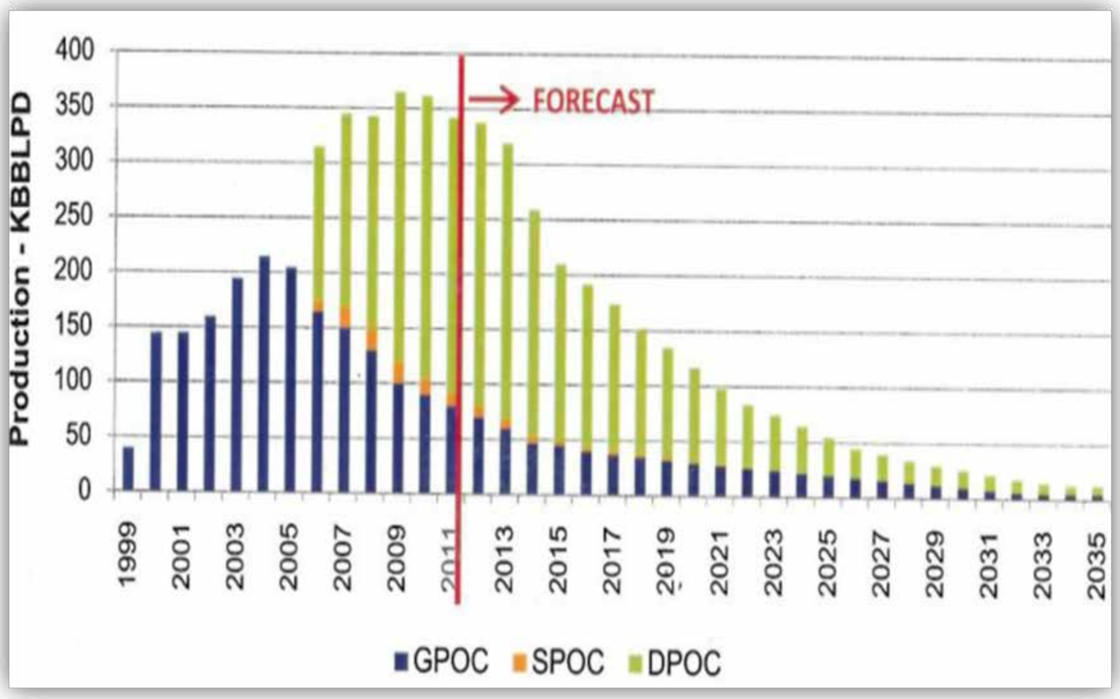
Recently, there were announcements of the development of a refining capacity. A memorandum of understanding was signed with a Russian oil giant for the construction of the Bentiu Oil Refinery. Teh Tangrial Oil Refinery in Melut is also another project under consideration. Nonetheless, the conflict with 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 state regarding energy security. Lack of energy security management schemes such as an energy security policy and framework and operationally strategic reserves has exposed the country to further energy security risks.

Figure 86: 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.

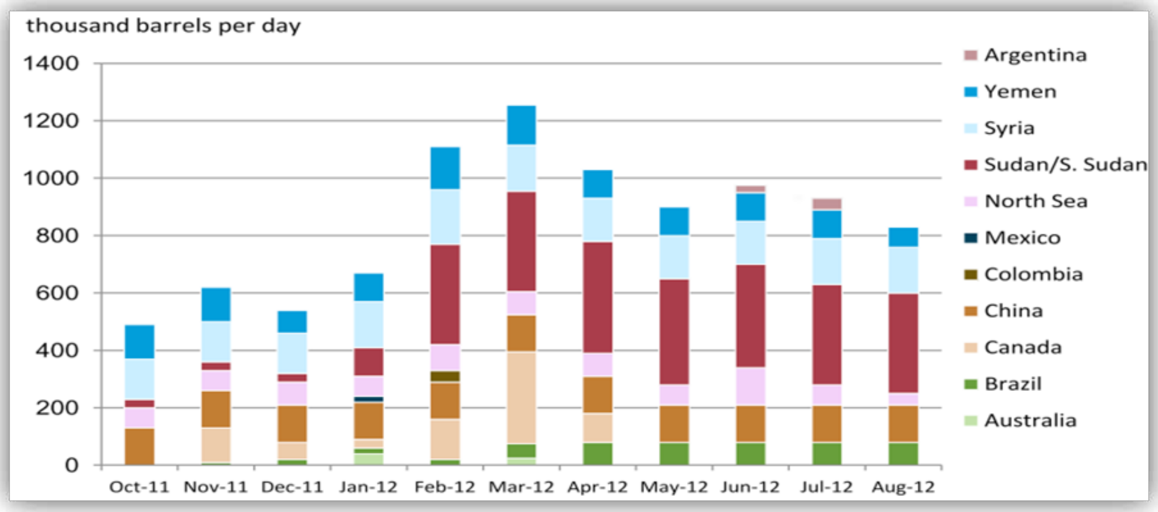
Figure 87: Crude oil production forecast, South Sudan



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

Note: KBBLPD = thousands of barrels per day.

Figure 88: Global crude oil supply disruptions in non-OPEC countries: Oct. 2011 – Aug. 2012

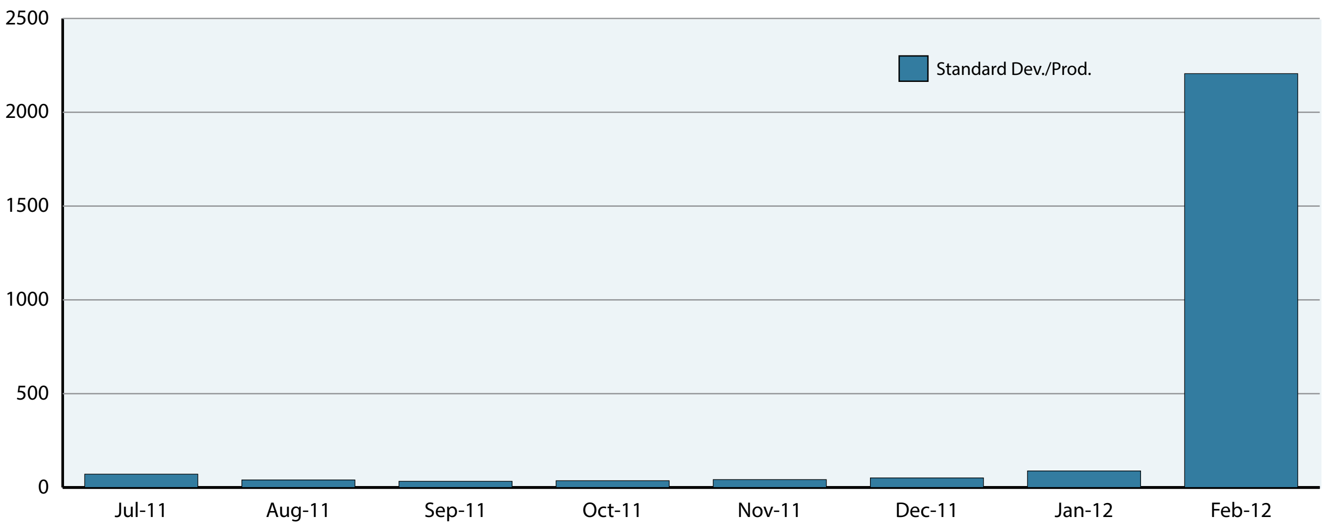


Source: US Energy Information Administration, 2012.

Not only is South Sudan vulnerable to supply disruptions in petroleum products, production interruptions and eventual shutdown of its oilfields have 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 Figure 88). The closure of the oilfield in South Sudan in February 2012 has been the largest cause of crude oil supply disruption.

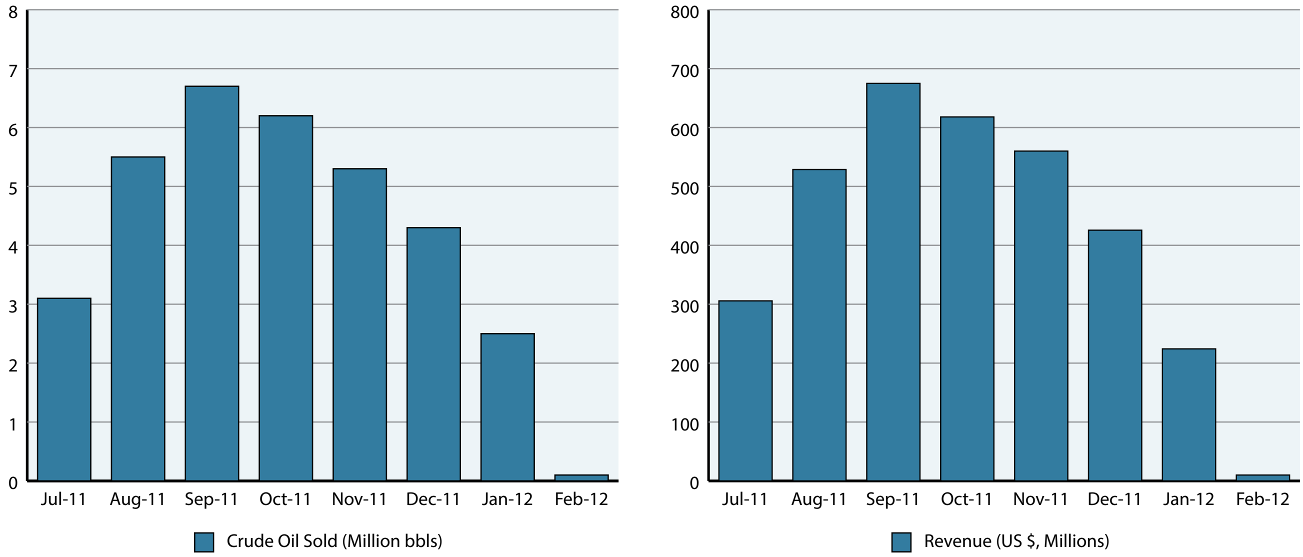
Crude oil producing countries are regarded as keeping a safe and secure flow of crude oil if the measure of their production standard deviation relative to the level of production is at 30 or lower. Since the independence of South Sudan, until January 2012, the production volatility was above 30, and reached 88 in January 2012 (see Figure 89). In February 2012, it topped to 2,206 due to the shutdown of production, increasing energy insecurity significantly, and imposing global energy security implications.

Figure 89: Energy security assessment based on crude oil production volatility



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

Figure 90: Production and sales volume of crude oil, June 2011-February 2012



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

The 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 $600 million in September and October, 2011, and nearly $200 million in January, 2012 just before the closure of the oilfields (see Figure 90).

9.1.4.2 Energy security –lessons from South Sudan

Effective institutional framework and operational transparency in crude oil export through pipelines between the Sudan and South Sudan remain crucial for their energy security.

- **Cross-border and internal conflict will undermine energy security**: at the advent of independence, South Sudan, faced insurmoutable challenges, mainly relating to conflict with neighbouring Sudan. The inability to resolve their differences over oil export through the northern pipeline and the breakdown of political engagements has led to severe energy security deterioration in the Sudan and South Sudan, extending to the global market. Subregional peace and security will remain one key determinant of the state of energy security in the subregion. Effective institutional framework and operational transparency in crude oil export through pipelines between the two countries remain crucial.

- **Discovery and development of crude oil resource without domestic refining capacity leads to energy security vulnerability**: the lack of refining capacity in South Sudan, or a framework agreement for a subregional refining capacity has left the country import dependent. The development of oilfields empowers countries through revenue generation that assists in domestic development finance. However, oil resource development involves domestic energy security challenges and also needs to be linked to regional opportunities, a lesson Uganda seems to have taken quiet well.

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

9.2 Ethiopia

9.2.1 Background

Ethiopia is one of the largest countries in the subregion, with an estimated population of nearly 90 million. Following decades of internal conflict to overthrow 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 the establishment of the Transitional Government of Ethiopia in 1991. In 1994, a new constitution was adopted with a bicameral legislature and a judiciary system that established the Federal Democratic Republic of Ethiopia. Elections have resumed since 1995.

The economy of Ethiopia is one of the fastest growing in the subregion. Between 2008 to 2011, the average growth rate was reported to be 10.4 per cent, growing at 11.2 per cent in 2008, 10 per cent in 2009, 10.4 per cent in 2010, 10 per cent in 2011 and a projected

Figure 91: Map of the Federal Democratic Republic of Ethiopia

Source: Nations Online Project.

Note: The map has not been updated to July 2011 to include South Sudan. For a map of South Sudan, see Figure 83. The map is representative, and not authoritative.

8.6 per cent in 2012 (ECA, SRO-EA, 2012)[43]. The source of the growth are improvements in the agricultural, construction and service sectors, exports and improved investment flows. Ethiopia also eyes the energy sector as a pole for its future growth, by aggressively developing its hydroelectric potential to meet the energy import needs of the subregion. A number of high-impact projects are already in the pipeline, expected to be brought into the energy system from the middle to the latter part of the decade.

9.2.2 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, growth in productivity, improvement in the standard of living, and agricultural, industrial and social services, the energy sector plays a key role."[44] 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 an energy policy for energy development, as well as for its supply and use."

The Energy Policy of Ethiopia recognizes that for a country's social and economic development, growth in productivity, improvement in the standard of living, and agricultural, industrial and social services, the energy sector plays a key role.

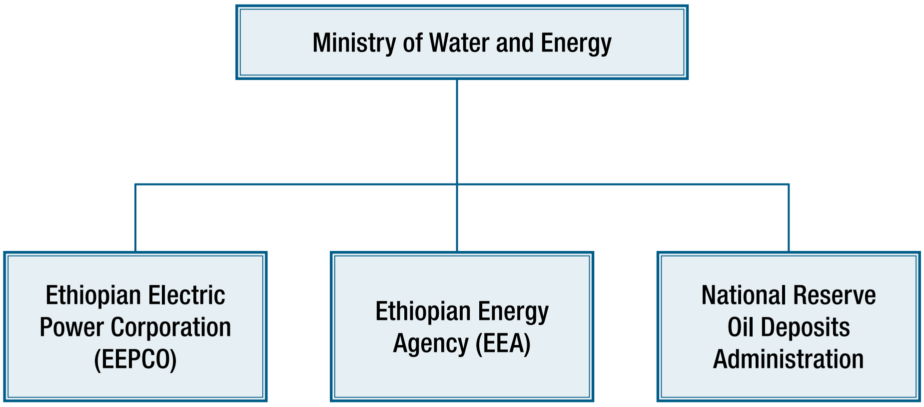
The energy policy states the following as key directions: (a) expanding hydroelectric power, particularly mini-hydropower, based on national economic and social needs; (b) encouraging exploration of oil, and development of natural gas; (c) expanding reforestation and agroforestry; (d) making efforts to ensure that all sectors of the economy have access to alternative energy; (e) enhancing, in all economic sectors, energy efficiency; (f) ensuring that energy development is sustainable and does not degrade the environment; (g) ensuring that energy development and supply is based on the principle of "self-sufficiency"; (h) encouraging and creating a conducive environment for private sector participation in energy development; (i) recognizing that energy shortage primarily affects women, so enhancing the role of women in energy supply and use, to save the time they spend on energy source gathering that could be better spent on development; (j) linking rural development with energy sector development; (k) promoting energy science and technology; and (l) 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 also made 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 it is believed will account key developments, including issues of energy security, access and the energy export strategy of the country.

The Ministry of Energy and Mines, which has subsequently been reorganized and renamed the Ministry of Water and Energy, has been given the primary role of monitoring, coordinating and implementing the tenets of the energy policy. The mandates and responsibilities include development, planning and management of water and energy resources, development of policies, strategies and programmes, development and

43 Economic Commission for Africa (UNECA), subregional 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.

44 Quote based on authors' translation of the *Amharic* version of the policy document.

Figure 92: Institutional framework of the energy sector in Ethiopia



implementation of laws and regulations, development of downstream petroleum operations and overseeing rural electrification (formerly the responsibility of the Ministry of Agriculture and Rural Development), promoting the development of alternative energy, setting standards for petroleum storage and distribution and determining the volume of petroleum reserves and ensuring maintenance (Ministry of Water and Energy, 2011)[45].

The institutional framework of the Ethiopian energy sector is based on a number of key institutions (see Figure 92). 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.

- *Ethiopian Electric Power Corporation (EEPCO):* formerly known as the Ethiopian Electric Power Corporation (EELPA), has since 1997, under Regulations No. 18/1997 been 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 per cent of electricity is from 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 licenses, setting tariffs and supervising the generation, distribution, sale and import/export of electricity, as well as in energy efficiency and conservation programmes.

- *National Reserve Oil Depots Administration (NRODA):* established by Proclamation No. 82/1997, its function is to maintain a reliable and sufficient national petroleum reserve for 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 Programme (which oversees universal electricity access activities), the Ethiopian Petroleum Enterprise (implementing fuel procurement and storage), Alternative Energy Technologies programme (conducting research into technology development and adoption), and Rural Electrification Programme (focused on

45 Ministry of Water and Energy, Energy Study and Development Follow-up Directorate. 2011. "Brief Note on the Ethiopian Energy Sector." Addis Ababa, Ethiopia.

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 for upstream hydrocarbon and geothermal resources exploration, and the Environment Protection Agency regulates environmental aspects of energy development, highlighting the need for inter-institutional collaboration.

9.2.3 The state of energy access and key lessons

9.2.3.1 The state of energy access

From the outset, it is important to state clearly that electricity access, including universal electricity access, is distinctly understood by policymakers 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 have access to electricity at that unit, and that all households in cities, towns and villages 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.

The hydropower potential of Ethiopia is estimated at between 30,000 to 40,000 MW with current exploitation at barely 3 per cent.

Ethiopia has embarked on an ambitious energy sector development strategy, largely focused on export markets in the subregion. The Government 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 that the population with service coverage increased from 16 per cent to 41 per cent. After the 2010 period, and the end of the preceding 5-year development plan, the Government introduced another plan for the 2011-2015 period, which it called the Growth and Transformation Plan (GTP). Regarding electricity access, the plan stipulates the following targets: (i) electricity population coverage to increase from 41 per cent to 100 per cent (universal access by 2015); (b) increasing electricity generation capacity from 2,000 MW to 8,000 MW; (c) reducing electricity distribution losses from 11.5 per cent to 5.6 per cent (close to international standard); (d) increasing connections from 2 million to 4 million; (e) increasing transmission lines from 126,038 kms to 258,038 kms; and (f) rebuilding distribution line from 450 kms to 8,130 kms. The plan is highy ambitious.

The strategy is based on the energy resources potential of Ethiopia, which are quite significant, and enable the formulation of an export-oriented development strategy (see Table 46). The hydropower potential of Ethiopia is estimated at between 30,000 to 40,000 MW (though some estimates put the economically affordable power estimate at 40 per cent (CESEN, 1986)), with current exploitation at barely 3 per cent. About 92 per cent of electricity supply in the country is from hydroelectricity.

Though currently not part of the Ethiopia 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 a potential of 4-6 kWh/m^2, particularly in northern Ethiopia) and wind energy (100,000 MW potential capacity) (see geographic distribution

Table 46: Indigenous energy resources potential of Ethiopia

Resource	Unit	Exploitable Reserve	Exploited	
			Amount	%
Hydropower	MW	30,000-40,000	~2,000	<3%
Solar/day	kWh/m2	4-6		~0%
Wind: power speed	MW m/s	100,000 > 7	120 MW Under construction	~0%
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 m3	113	-	0%
Coal	Million tons	300	-	0%
Oil shale	Million tons	253	-	0%

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

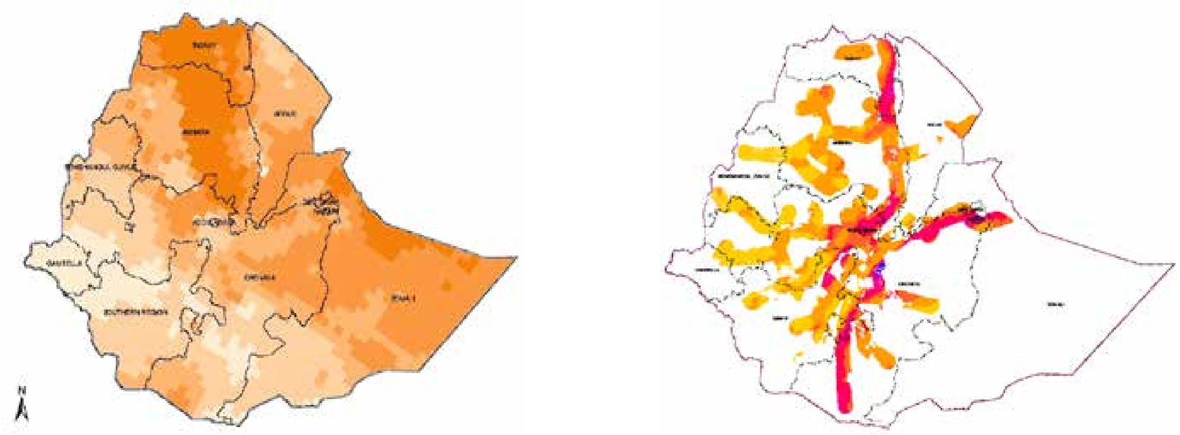
in Figure 93). Wind capacity is highest in Mekelle region (northern Ethiopia), Ashegoda, Harena and Aysha reaching a wind speed of 8 m/s, Adama and Gondar reaching 6.64 m/s and 6.07 m/s, and Harar, Debre Berhan and Sululta with 4m/s potential (GTZ-TERNA, 2005). An estimated 5,000 MW geothermal capacity along the East African Rift Valley of Ethiopia offers additional resource capacity, currently barely exploited.

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

Ethiopia also has an eye on its biofuel potential, particularly to replace imported fossil fuels. The Government has made available more than 3 million hectares of land to licensed developers.

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 generate 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 47). These projects are expected to raise the generation capacity from 2,000 MW to nearly 10,000

Figure 93: 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.

Table 47: 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 Conferenceon the Ethiopian Economy. Addis Ababa, Ethiopia.

As a result of pressure for 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 transboundary water resources outside the Nile water treaty.

MW. The Renaissance hydroelectric project (see Figure 94), with a generation capacity of 5,250 MW, will be the largest hydroelectric project in Africa, with a water storage capacity of 66 billion m^3. The tapping of the Nile River for such a project has drawn the attention of Nile upstream countries such as 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 strikes on such reservoirs. As a result of pressure for 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 transboundary water resources outside the Nile water treaty, which they believe unfairly allocates the major use of all of the water to the Sudan

Figure 94: Renaissance Grand Millennium Hydroelectric Power Project

Source: www.EEPCo.gov.et.

Table 48: 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.

and Egypt. For further discussion on transboundary water resources development for hydroelectricity, see the pertinent chapter in this report.

Solar energy development in Ethiopia is at around 6 MW, and much remains to be developed, but wind energy has developed relatively more quickly (see Table 48). The wind farm at Ashegoda, northern Ethiopia, has an installed capacity of 120 MW, the largest such farm in the country, and one of the largest in the subregion. The utility scale wind energy projects of Adama, Ayesh, Debre Berhan and Messebo are also examples of large-scale developments.

Green energy efforts are part of the overall goal to transform the country into a climate resilient green economy by 2025.

Geothermal energy, given its estimated potential of 5,000 MW, is currently marginally utilized in Ethiopia. The existing capacity is only 7.3 MW, through the Aluto Langano Geothermal development project. However, a number of feasible projects have been identified for potential development, including Aluto-Langano, Tendaho, Corbeti, Abaya, Tulu Moye and Dofan, potentially creating 440 MW of new capacity (see Table 49).

Bagasse energy, fuel based on the residual output of sugar factories, provides supplementary power in Ethiopia. The sugar factories of Metehara, Wenji and Fincha co-generate power for their consumption at an installed capacity of 9.9 MW, 9 MW and 7 MW, respectively. Combined with ethanol production (discussed under energy security of Ethiopia later) bagasse constitutes another source of renewable energy which is increasingly being integrated into the energy system.

The Alternative Energy Development Programme further aims at distributing 9.1 million improved cookstoves by 2015/16, as well as 300,000 solar lamps, 3,500 solar heaters and 10,000 solar cookers, 3,000 wind energy water pumps by 2015 and 65 small-scale hydroelectric generating plants (Ministry of Water and Energy, 2011). These green

Table 49: 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.

Table 50: 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 Scalingup Renewable Energy Programme (SREP). 2012. "Ethiopia Investment Plan." Addis Ababa, Ethiopia.

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). The energy sector development of Ethiopia is likely to change the capacity and composition of the generation portfolio up to 2030 (see Table 50), while the energy sector is expected to remain predominantly sourcing green energy.

The Djibouti-Ethiopia interconnection has already been implemented, with a planned export of 150 MW to Djibouti.

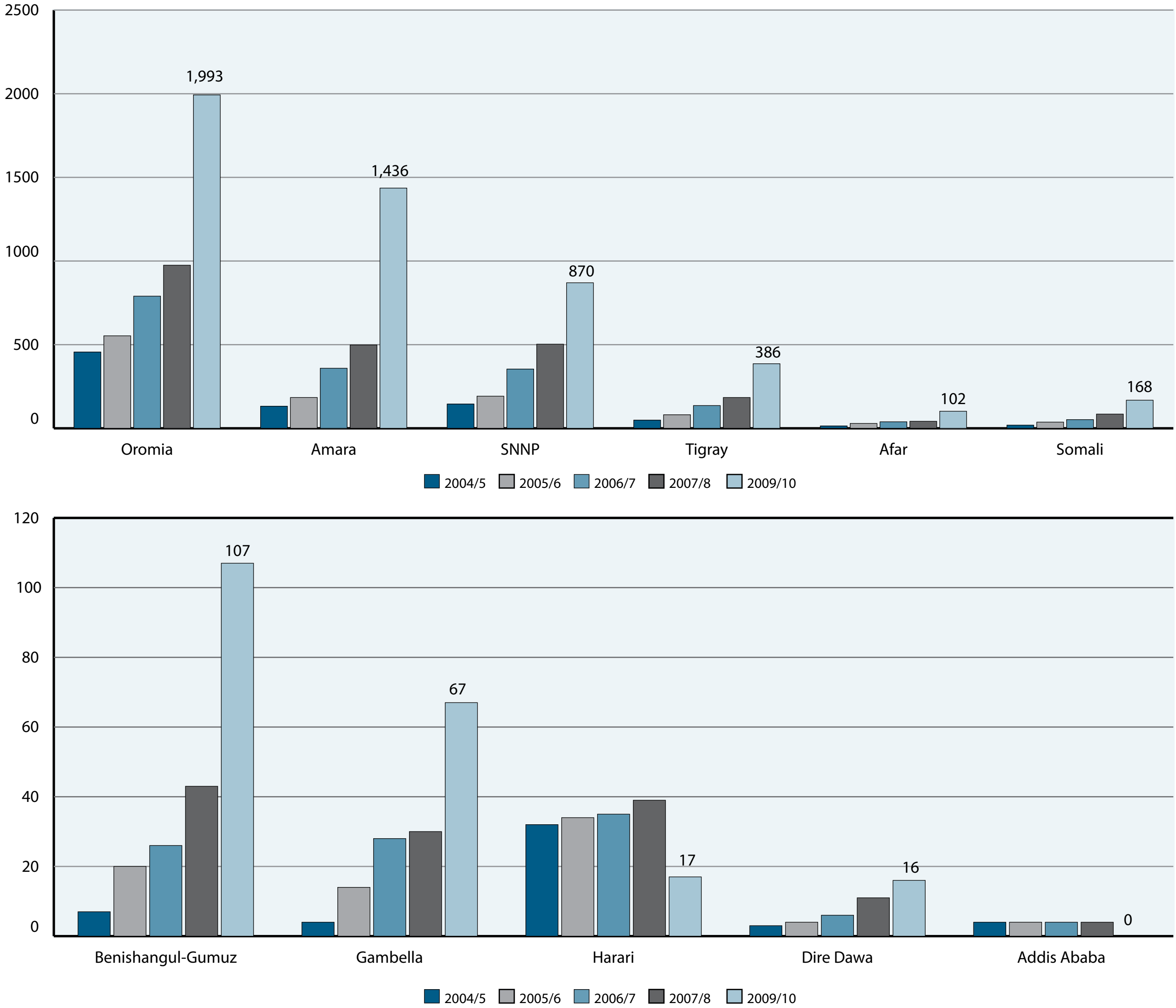
Significant expansion in the power capacity of Ethiopia is expected to lead to two outcomes: enhanced electricity access in the country and increased electricity export to regional markets. Regarding access to electricity, there had been significant expansion in electricity to towns and villages from 2004/5 to 2009/10 (see Figure 95). The number of towns and villages with electricity are highest in Oromia region (1,993 in 2009/10), Amara region (1,436) and Southern Nations, Nationalities and People (SNNP) region (870). The disparity according to region is largely due to the decision criteria utilized by the Universal Electricity Access Programme. The determination of which towns to supply with electricity 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.

The Ethiopia-Kenya interconnection, currently under construction, is expected to come to full service in 2016, potentially enabling Ethiopia to export 1,000 MW of electricity to Kenya.

Energy capacity development in the country also eyes export markets in the region. The Djibouti-Ethiopia interconnection has already been implemented, and Djibouti imports a significant amount of electricity from the Ethiopian grid. The plan aims to continue with a 150 MW export to Djibouti. The Ethiopia-Kenya interconnection, currently under construction, is expected 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, by exporting Ethiopian power further south to the Tanzanian market. The impact of the 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 in pursuing 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 the Egyptian market with an export potential of 3,400 MW by 2018 (see Figure 96).

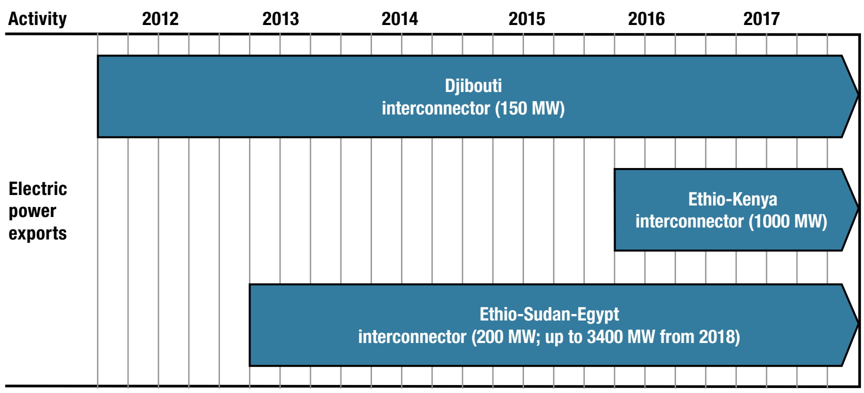
The Ethiopia-Sudan interconnection has already been finalized, and test power transfer is being conducted.

Figure 95: Number of towns and villages provided with electricity in Ethiopia: 2004/5-2009/10



Source: EEPCo, 2009.

Figure 96: Electricity export plan and implementation of Ethiopia



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

9.2.3.2 Energy access – lessons from Ethiopia

- **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 has led to substantial increase not only in energy capacity, but also in expansion of domestic use and exports. Ethiopia is continuing with the same plan, which could make it an energy export center for the subregion, and at the same time experience rapid capacity development. The lesson for the subregion is that an engaged and active government is key, one that prioritizes energy sector development and sets ambitious targets and undertakes aggressive implementation. The financing aspect of the engagement, particularly domestic resource mobilization, also offers collateral lessons.

There seems to be an 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.

- **Balancing energy access expansion with export offers optimal benefits**: energy policymakers are often advised that large-scale development of energy potential is only viable with an export component, to markets with better purchasing power to justify energy resource development. Consequently, there seems to be an 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 a beneficial outcome for the subregion**: Energy export will earn Ethiopia hard currency that can be reinvested into 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 landlocked countries. The subregion will benefit by reducing all barriers to energy trade.

- **Energy access will be accelerated through the introduction of supportive institutional arrangements**: domestic energy access in Ethiopia is institutionally supported. Apart from the traditional energy institutions there are also these: Rural Electrification Programme, Energy Technology Programme and Universal Access Programme. This added institutional capacity supports specific targets, such as ensuring universal access targets. To countries in the subregion with institutional gaps, the Ethiopian case study offers another perspective and an 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 supply with electricity in the Ethiopian case is partly based on 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 met. 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 springboard 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 subregion are using a similar approach.

- **How policymakers understand energy access makes a difference to household access**: the Ethiopia model of energy access expansion is not focused on households, but rather on towns and villages. Policymakers therefore estimate that once a village is connected to the grid, all households in the village are considered as having access. This leads to a different understanding of what universal access is, and Ethiopia has already declared that it will achieve that target by 2015. This is contrary to what the global effort to expand access at the household level means, which is ensuring actual, not potential, connection of households. In this regard, the Ethiopian model is likely to face two challenges. One is that economic development actually depends on households also having access to modern energy, thus 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 a potentially 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 subregion in terms of accelerated efforts for expanded access at the household level. Challenges of financing, initial connection cost, settlement patterns of households, intermittent income of rural households and the like are structural challenges for which countries in the subregion are exploring innovative solutions. In this regard, Ethiopia can examine these experiences in the subregion and expand its ambitious energy access programme to include households, in line with the global agenda of universal access for all (households) by 2030.

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 springboard for short- to medium-range energy access targets seems a model worth examining and considering.

9.2.4 The state of energy security and key lessons

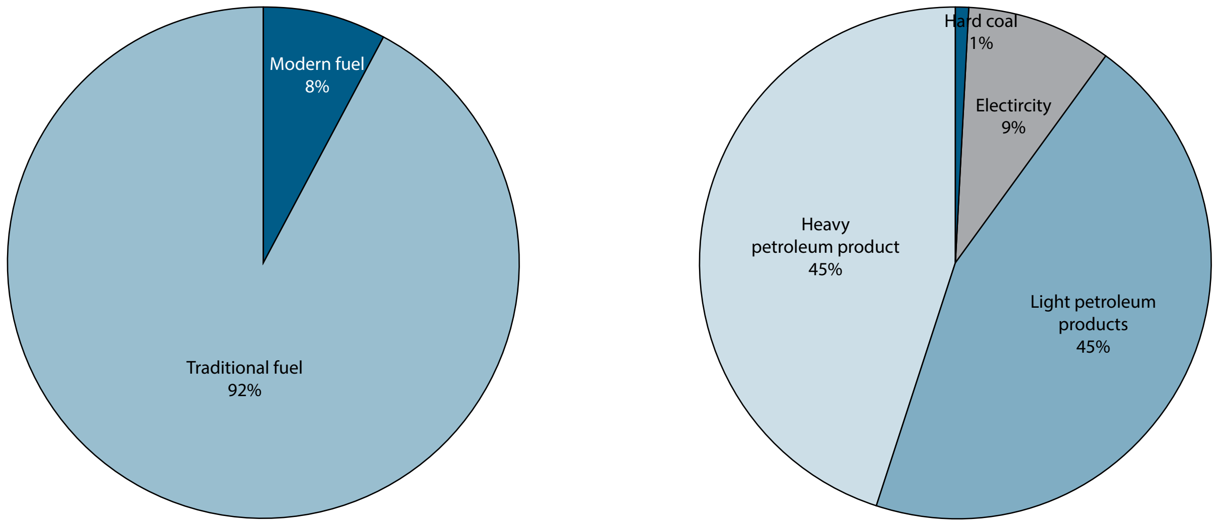
9.2.4.1 The state of energy security

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 like many of the countries in the Eastern Africa subregion, it is characterized by heavy reliance on traditional biomass (92 per cent) and barely on modern fuels (8 per cent) (see Figure 97). Much of the 8 per cent modern fuels utilized is imported, as electricity accounts for 9 per cent of the 8 per cent of modern energy usage. The remaining 90 per cent are in imported light and heavy petroleum products, and 1 per cent on imported hard coal.

Even though hydroelectric power expansion is quite significant, its share of total energy supply pales, and is still lower than the share of imported energy.

As a result of this, biomass accounts for a large share of total energy supply, followed by imported energy (see Figure 98). Even though hydroelectric power expansion is quite significant, 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 for recent efforts to integrate biofuels into the mix). The industrial and service sector demand a much lower level of the energy share. Therefore, from the energy security perspective, what happens to sustainable management of the biomass in the country, the trend in imported fuel dependence and progress in the electricity sector are areas to follow closely. In terms of biomass, detailed discussions are offered in the Environment and Energy Security Assessment chapters

Figure 97: Traditional and modern energy usage structure - Ethiopia

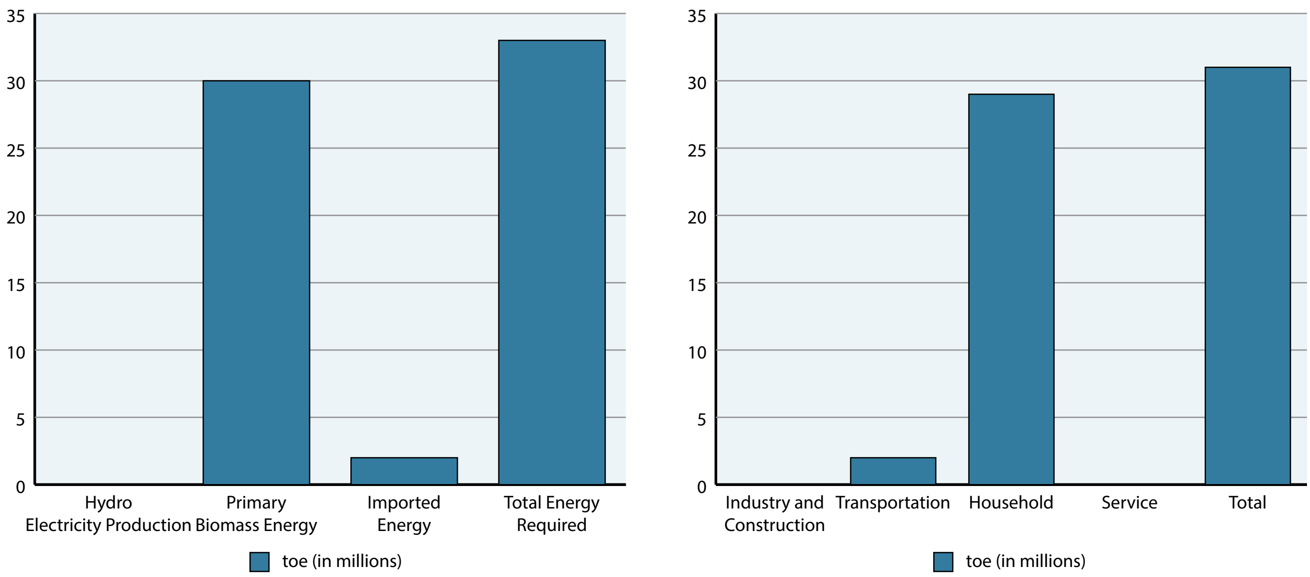


Source: Ministry of Water and Energy, Energy Balance and Statistics, 2011.

for the Eastern Africa subregion. Findings suggest that rapid decline in forest biostock 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 indigenous 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 by 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

Figure 98: Energy requirement and consumption by sector



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

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, though affordability is a key strength of the Ethiopian electricity sector, and an advantage to electricity consumers.

Most of the large-scale hydroelectric developments have generation cost profile of or below $0.045/kWh, except for Chemega Yeda (slightly above $0.05), Aleltu East (slightly above $0.065/kWh), Gojeb (around $0.075/kWh) and Aleltu West (slightly above $0.0825).

The levelized generation cost of electricity is $0.045 cents/kWh, the transmission cost is $0.007/kWh, and distribution cost is $0.014/kWh, putting the leveled cost of power supply for the period 2011-2015 at $0.067/kWh (Ministry of Water and Energy, 2012).[46] This makes Ethiopian power among the cheapest in the subregion. Electricity tariff to consumers was revised in 2006, partly due to concerns that the tariffs were inadequate to meet the cost of supply. The previous tariff structure had remained without revision for the 15 years leading to 2006. In 2006, a 22 per cent tariff hike was introduced, keeping it at $0.06/kWh (Ibid), with some variations according to the category of consumption (see Table 51). Due to inflation, some argue that the real tariff today is around $0.032/kWh. As a result, EEPCo has already submitted a request to the regulator, Ethiopian Electricity Agency (EEA) to revise the tariff and adjust it to system cost recovery level to ensure financial viability of EEPCo.

The risk of higher generation costs for the bulk of hydroelectric generation in the short- to medium-range is unlikely, ensuring continued affordability of Ethiopian power for domestic and export markets, hence offering an energy security buffer in Ethiopia and countries importing electricity from Ethiopia.

To evaluate the likelihood of lower cost electricity, hence affordability, including export to markets, continuing 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 or below $0.045/kWh, except for Chemega Yeda (slightly above $0.05), Aleltu East (slightly above $0.065/kWh), Gojeb (around $0.075/kWh) and Aleltu West (slightly above $0.0825) (see Figure 99). The bulk of capacity added will continue to remain at lower generation costs, with some projects introducing higher marginal costs. Thus, the risk of higher generation costs for the bulk of hydroelectric generation in the short- to medium-range is unlikely, ensuring continued affordability of Ethiopian power for domestic and export markets, hence offering an energy security buffer in Ethiopia and countries importing electricity from Ethiopia.

Table 51: Tariff structure from 2006 to present – Ethiopia

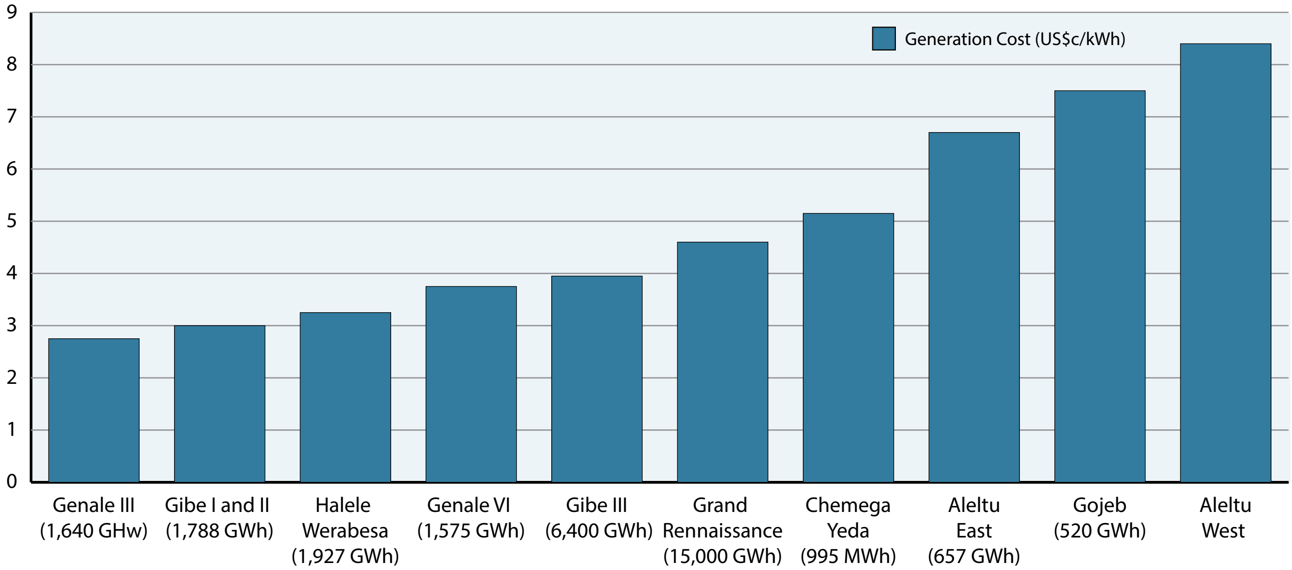
Tariff Category	Consumption (kWh/month)	Tariff Rate (Birr/kWh)
Domestic Equivalent Flat Rate		0.3897
First Block	First 50 kWh	0.2730
Second Block	Next 50 kWh	0.2921
Third Block	Next 100 kWh	0.4093
Fourth Block	Next 100 kWh	0.4508
Fifth Block	Next 100 kWh	0.4644
Sixth Block	Next 100 kWh	0.4820
Seventh 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 tothe dollar is 18.1597Birr per $as at December 20, 2012 (data from National Bank of Ethiopia).

46 Ministry of Water and Energy of Ethiopia and SREP, 2012."Ethiopia Investment Plant." Addis Ababa, Ethiopia.

Figure 99: Generation cost profile of future hydroelectric generation portfolio – Ethiopia



Source: EPPCo, Corporate Planning Department.

The risk to electricity supply domestically and to export markets is likely to come from weather and climate change related impacts. Ethiopia, along with hydroelectric producing countries in the subregion, have been repeatedly impacted by drought and the marked decline in the 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 subregion, adding a layer of safety, compared with less diversified watershed systems, such as the Congo river. However, climate change, especially in drought prone areas such as the Eastern Africa subregion, can have system-wide impacts that can hamper the security of supply of electricity in Ethiopia and its export markets.

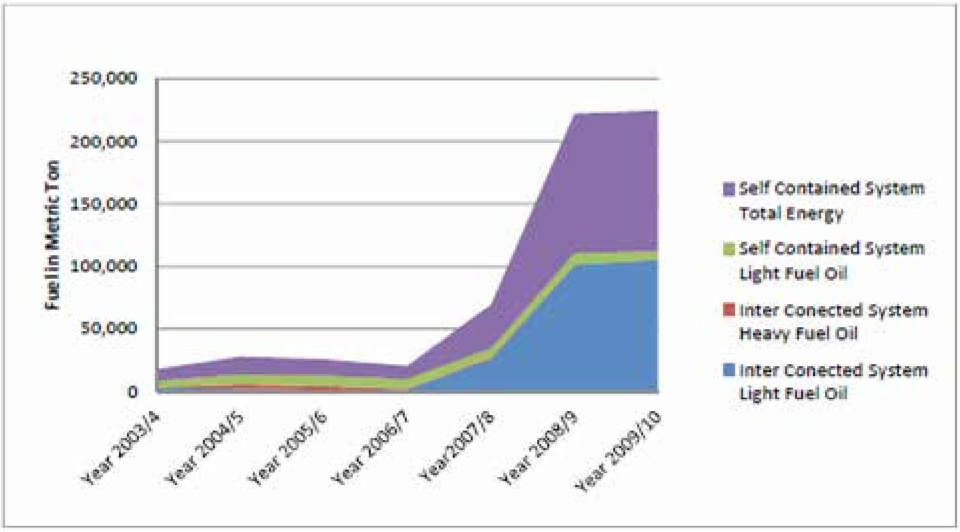
Climate change, especially in drought prone areas such as the Eastern Africa subregion, can have system-wide impacts that can hamper the security of supply of electricity in Ethiopia and its export markets.

The response of Ethiopia to drought in the recent past demonstrates this risk. Following the drought of 2006, and water shortages in subsequent years, emergency power generation using rental thermal units became common in much of the subregion, including Ethiopia. Using thermal fuel for generating electricity in both the self-contained system (SCS) and the interconnected system (ICS) increased (see Figure 100). Light fuel oil use in ICS increased sharply. Sustained drought conditions will therefore continue to pose energy security challenges in the electricity sector.

For export markets, the 14 per cent per year electricity demand growth in Ethiopia and the 15 per cent per year energy-intensive industries growth (Ministry of Water and Energy and SREP, 2012) could, 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, but could be fully mitigated if generation plans continue at full pace.

In the transportation sector, Ethiopia, just like the rest of the subregion, is fuel import dependent. Exposure to imported transportation fuel poses energy security challenges. The continuous supply of fuel and therefore energy security in the country faces numerous challenges.

Figure 100: Consumption of fuel for diesel power plants - Ethiopia



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

- **Import dependence**: the complete import dependence of the country on transport fuel stocks exposes the country to price shocks, which makes it necessary to spend 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 see the economic impacts of fuel imports).

- **Landlocked country**: as a landlocked country with no pipeline infrastructure, Ethiopia trucks transport fuel imports from the port of Djibouti, through an inadequate road infrastructure. Transporting fuel hundreds of kilometers adds significantly to the cost of fuel, particularly to the northern, western and southern parts of the country, further undermining affordability, 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 put further pressure on affordability.

- **Price regulation and speculative behaviour**: petroleum prices are regulated, and prices are revised at the end of each month. If the price, at the end of the month, is revised upwards, then there are windfall gains for distributors who still have unsold stock. The windfall gains are given to the Government. On the other hand, there are reports that if prices are reduced and there are 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 by Government, has introduced a series of temporary and artificial fuel shortages. Consequently, it is commonplace to see fuel shortages at the end of the month thus 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 at the distribution level

The lack of adequate enforcement at the distribution level continues to be a problem, since the profit motive, as well as lax enforcement, offer sufficient incentive for continued adulteration of petroleum products.

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- **Regional instability**: Ethiopia used to rely on the oil refinery in the port city of Assab, in Eritrea. The refinery used to refine fuel for supply to both Eritrea and Ethiopia. In 1997, disagreements over fees and questions about the feasibility of continued operation led Ethiopia to pull away from the use of the refinery, leading to a significant drawdown of needed refining capacity. Modernizing the refinery to meet the needs of both countries was being debated. When the Ethio-Eritrea border war broke out in May 1998, it completely severed potential access of Ethiopia to the refinery and the port facilities in Eritrea. Even though a legal decision has been made to resolve the demarcation of their boundaries (the declared source of the conflict), following the Organization of African Unity (OAU) brokered and the internationally endorsed Algiers Agreement that 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 the demarcation according to the final and binding decision and subsequent dialogue to normalize relations. The dispute continues to deny Ethiopia access to Eritrean alternative port facilities, 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 the termination of oil production, causing refining activities in Khartoum to be scaled down, resulting in cessation of fuel exports to Ethiopia. Mediation efforts by Ethiopia have led to an agreement, but there are concerns as to whether the parties will continue to abide by the agreements reached in Addis Ababa in September, 2012. Instability in Somalia has also led to rampant piracy, affecting maritime traffic, including traffic to Ethiopia. Subregional efforts to deal with the insecurity in Somalia have led to active military intervention. While piracy activities have been reduced considerably, following NATO anti-piracy activities in the Indian Ocean, the incidence of piracy nonetheless has continued to some extent. Regional instability impacts the energy security of Ethiopia. A broader subregional effort to ensure peace and security will be productive for all member States.

Regional instability impacts the energy security of Ethiopia. A broader subregional effort to ensure peace and security will be productive for 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 in the event of disruptions. The global rise in energy prices has made 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 used 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 programme seeks to: (a) obtain 195 million litres of ethanol by 2015; (b) obtain 1.6 billion litres of biodiesel; (c) earn $1 billion in foreign exchange from biofuel export; (d) increase the blending mandate to 25 per cent by using 64.4 million litres of bioethanol for blending; (e) enhance biodiesel and diesel blending to 20 per cent by using 621.6 million litres of biodiesel for blending; and (f) increase benefits from CDM programmes (Ministry of Water and Energy, 2011).

By 2008, a number of biofuel producers were already operating in the country (see Table 52), particularly in the Benishangul, Amara, Oromia and SNNPR regions. Foreign investment in Ethiopian land has grown rapidly, including investment in biofuel production. Some land deals are up to 100,000 ha and above, enabling large-scale operation. There are issues of conflict regarding land use, land rights protection, benefits for the community, technology transfer and others being actively raised and debated, but the country seems intent on making more land available to investors and integrating biofuels as part of the solution to import dependence on fossil foils.

Ethiopia operates the only fuel blending mandate in the subregion. The 5 per cent ethanol mixing mandate, E5, has been in operation in Addis Ababa for the past four years.

Ethanol production by sugar factories is also part of the sector development plan. Ethanol production from Fincha is expected to grow from 8 million litres in 2006/7 to 18.6 million litres by 2011/12. The target for Wenji/Shoa, is from 12.245 million in 2007/8 to 25.153 million litres by 2011/12. The targets for Methara and Tendaho are 24.48 million and 60.616 million litres, respectively by 2011/12 (see Table 53).

Ethiopia operates the only fuel blending mandate in the subregion. The 5 per cent ethanol mixing mandate, E5, has been in operation in Addis Ababa for the past four years. A blending factory in Sululta offers standardized blended fuel for consumption in the city. There are plans to encourage the importation of flexible fuel vehicles and to court Brazilian investment in biofuels and biofuel technology transfer. To fulfill this goal, 2.5 million hectares of land has been set aside for investment, with 100,000 hectares for invested targeted land. The internal study of the Ministry of Water and Energy shows

Table 52: Companies growing bioenergy 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 Environmental Impact Assessment and Biofuels.

Table 53: 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 Africa Regional Workshop on Biofuels, 28-29 June, Nairobi, Kenya.

that biofuels are land-intensive. A 5 per cent biodiesel production to displace diesel requires 50,000 hectares of land.[47]

Out of the total import of fuel, 93 per cent is [diesel (60%), jet fuel (18%), kerosene, furnace oil and others] and 7% is gasoline.[48] Therefore, the current mandate targets displacing 5 per cent of a 7 per cent slice of the total imported fuel, and there is a share of the 7 per cent consumed unblended outside Addis Ababa. Consequently, the impact of the current programme on energy security mitigation is minimal. However, large-scale expansion of the programme nationwide has the potential to cause fuel displacement effects. The Government claims that the current programme has already led to the saving of $20 million per year. Therefore, the benefits of a scaled up integration of biofuels will be sizeable.

The organization, operation and coordination of efforts through the production, processing and distribution in the value chain can offer valuable lessons to member States in the subregion with similar diversification strategies on bioenergy.

9.2.4.2 Energy security – lessons from Ethiopia

Diversification: intense efforts by Ethiopia to diversify its fuel mix by including indigenous biofuel resources are noteworthy. Large-scale experiments with biofuel programmes, encouragement of bioenergy investors, utilization of sugar factories to produce ethanol and expanded efforts in biodiesel use are all initial strategies of what seems to be a long-headed, Brazil-inspired, large-scale integration of bioenergy to replace imported liquids. The organization, operation and coordination of efforts through the production, processing and distribution in the value chain can offer valuable lessons to member States in the subregion with similar diversification strategies on bioenergy.

State intervention and investment: to enable effective diversification, the Ethiopian Government has introduced a mandate, E5 programme, with a plan to increase the 5 per cent mandate to the international best practice of 25 per cent. 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 become increasingly 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 for member States in the subregion.

Infrastructure: Ethiopia is considering various options to secure its fuel imports, including the construction of a new oil tanker compatible railway system to Djibouti, as well as the option of a pipeline connecting it to the Sudan (a plan not actively pursued at present). Ethiopia is also considering refining oil imported from South Sudan, and is party to the Lamu Port and Lamu South Sudan-Ethiopia Transport Corridor (LAPSSET) project, connecting it with Kenya. These infrastructure and energy access route diversification

47 Data based on information from the Ministry of Water and Energy.
48 Data based on information from the Ethiopian Petroleum Corporation.

programmes will enhance the energy security of the country. Landlocked countries in the subregion with limited access and routes can consider this strategy as an option.

Operational effectiveness and speculation: when it comes to strategic commodities such as petroleum, operational effectiveness does matter, and speculation management proves useful. The operational management of fuel stocks in Ethiopia has given rise 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 given to government, but where that does not apply, and prices are fixed lower than the previous month, exposing distributors to losses, no compensation is paid to them. This situation of a no windfall gain, but rather a potential loss causes distributors to manage the risk through speculation. As a result of this, temporary and artificial fuel shortages occur 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.

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Regulation and enforcement: adulteration of fuel products is a common problem in Ethiopia and the rest of the subregion, largely due to the lack of effective regulation and enforcement. The challenge is such that it requires a regulatory upgrade in the country. Adulteration of fuel affects the operation of vehicles and machines, 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, are required.

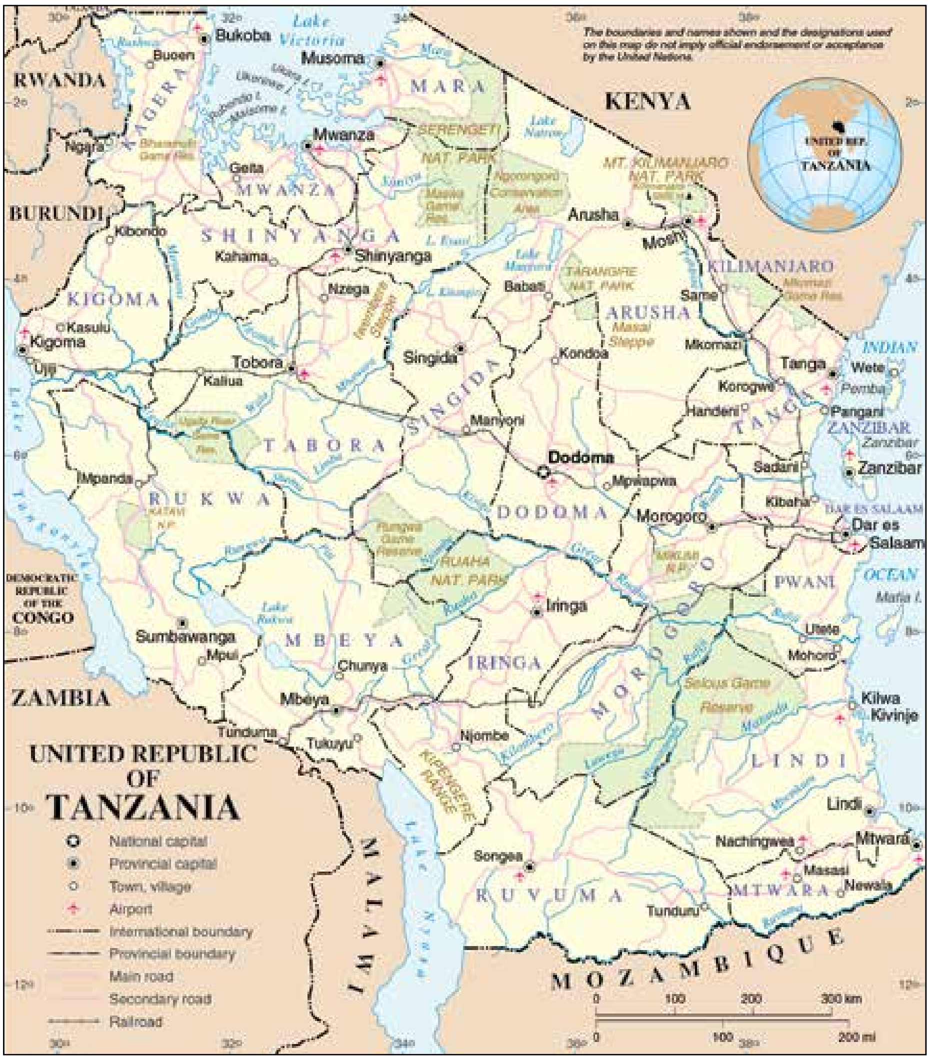
9.3 Tanzania

9.3.1 Background

The United Republic of Tanzania came into being in 1964, following the independence of Tanganyika (1961) and Zanzibar (1963). After 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 that of most African countries – reliant on agriculture, which accounts for nearly 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 offshore production plans will generate finance that support the building of 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 101: Map of the United Republic of Tanzania



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

9.3.2 Energy institutions and policy

Tanzania is endowed with energy resources, as 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 subregion, since 90 per cent of total energy consumption is generated from biomass, 8 per cent from petroleum products and barely 2 per cent 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, formulating strategies and laws for energy sector development, to contribute to the development of the economy. The Ministry states as its mission,"an effective institution contributing significantly to the acceleration of socioeconomic 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 play 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 in rural areas, the Rural Electricity Agency (REA) 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 per cent in 2005 to a 2010 target of 10 per cent. 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, was established in 1969, and operations resumed in 1973. TPDC is tasked with the promotion and support of petroleum development, including the exploration, development, production and distribution of oil and gas on 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 is currently engaged in the establishment of a public strategic petroleum reserves to manage short-term energy security on 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 Government 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 an Environment Facility (GEF) funded programme that run from 2008 through to 2012. The programme aims to, "improve the quality and efficiency of 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 expansion and renewable energy development in Tanzania."

Tanzania formulated its first National Energy Policy in 1992, which was subsequently revised in 2003 citing as reasons that both the energy sector and the overall economy had experienced structural change, and a revised policy consistent with these transformations was needed.

These energy sector institutions are guided by the energy policies of Tanzania. The country formulated its first National Energy Policy in 1992, which was subsequently revised in 2003 citing as reasons that both the energy sector and the overall economy had 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."[49] One hallmark of the 2003 policy revision is the focus on market mechanisms to transform the energy sector, believed to help achieve "an efficient energy sector with a balance between national and commercial interests." The revised energy policy is said to have taken into consideration the following:

> The need to have affordable and reliable energy supplies in the whole country; reforming the market to facilitate investment, expansion of services, efficient pricing mechanisms and other financial incentives; enhance utilization of

49 Emphasis in brackets added.

indigenous energy resources; account for the environment and increase energy efficiency and conservation.

The Tanzania national energy policy is one of the most comprehensive policies in the subregion, clearly articulating specific energy policy goals in different economic sectors, setting out energy access and energy security policy directions and actively encouraging regional trade and cooperation. In the transportation, manufacturing, mining, household, agricultural and IT sectors, it formulates, among others, the following energy policies:

The Tanzania national energy policy is one of the most comprehensive policies in the subregion, clearly articulating specific energy policy goals in different economic sectors, setting out energy access and energy security policy directions and actively encouraging regional trade and cooperation.

Transportation sector: promote energy efficiency; utilize more efficient modes and promote fuel switching from petroleum to other environmentally 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.

Household sector: encourage efficient technologies; encourage alternative sources of energy for cooking, heating, cooling, lighting and other services; regulate safety standards of household appliances.

Agricultural sector: ensure sufficient energy supply; encourage energy efficiency in irrigation and agro-processing; and encourage development of appropriate energy technologies for agriculture.

Tanzania is among the countries in the Eastern Africa subregion severely affected by energy shortages. The effort of the Government in the last few years in this regard focused on significantly boosting the generation capacity and meeting energy scarcity, while rationing existing supplies.

The National Energy Policy targets the following policy areas to enhance energy supply:

> Introducing competition to the electricity market as a principle, to attain efficiency; opening generation to both private (independent 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. The Tanzania 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 States with emphasis on future interconnections." It further calls for "collaboration in research, exchange of data, information and documentation."

With respect to petroleum and natural gas, which are 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 has also specific Acts to formalize and structure the energy sector, including 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.

The level of energy access in Tanzania is quite low, at just 14 per cent. 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 per cent.

9.3.3 The state of energy access and key lessons

9.3.3.1 The state of energy access

The level of energy access in Tanzania is quite low, at just 14 per cent 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 per cent. A baseline survey in 2011 showed access levels at 6.6 per cent, 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 to 15 per cent per annum, while generation is increasing at 6 per cent annually (Ministry of Energy and Minerals (Tanzania), 2011). Therefore, not only is current access level low, but energy demand for productive and household uses could pose a challenge to efforts to expand access of the population 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, by enhancing the generation capacity to 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 trends, power generation structure, distribution arrangements, 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, and normally with an available capacity of 991.5 MW, including imported energy (see Table 54).

Through the energy Medium Term Strategic Plan (2012/13-2015/16), the target is to increase power supply by 1,788 MW by 2015.

Out of the total generation capacity normally available, 56.68 per cent (or 562 MW) is from hydropower, generated at the Kidatu, Kihansi, Mtera, New Pangani Falls, Hale, Nyumba ya Mungu and Uwemba hydropower plants, connected to the national backbone grid. At Hale and Nyumba ya Mungu, power capacity is at half the installed capacity. Drought 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 constitutes 42.46 per cent 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 hydrogeneration have led to a legacy of increased thermal generation. A minimal amount of normally available power is imported from neighbouring

Table 54: 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.

Following the 2010/11 power shortage and load shedding, Parliament asked for an Emergency Power Plan (EPP) to generate supplementary power by the end of 2011, and a Technical Working Group under the Ministry of Energy and Mines rapidly prepared a plan within three weeks.

Zambia (3.5 MW), Uganda (3.7 MW) and Kenya (0.8 MW), constituting 0.8 per cent of total power supply. The role of the energy trade in energy access and the energy market in Tanzania is literally non-existent. TANESCO is the dominant utility corporation in the country operating vertically integrated generation, transmission, distribution and sale of electricity, providing nearly 96 per cent of the country's supply.

Following the 2010/11 power shortage and load shedding, Parliament asked for an Emergency Power Plan (EPP) to generate supplementary power by the end of 2011, and a Technical Working Group under the Ministry of Energy and Mines rapidly prepared a 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:

Table 55: 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.

(a) providing fuel for the 80 MW IPTL plant; (b) contracting 37 MW from Symbion (due to lack of fuel operated by JetA1 fuel); (c) contracting 205 MW from Symbion, bringing a fuel plant from abroad (on JetA1 fuel); (d) contracting 100 MW of diesel generation from Aggreko; and (e) installing a 150 MW fuel plant, operated by TANESCO (Joint Energy Sector Review, 2011). The power shortage emergency has pushed Tanzania into a major expansion of thermal generation at great costs. The final report of the Joint Energy Sector Review (2011) states that while Songas electricity costs $0.066/kWh, the thermal units cost ranges from $0.30/kWh to $0.43/kWh (see Table 55), a much higher cost. Consequently, the cost of the EPP from August 2011 to December 2012 was estimated at TZS 1.241 trillion, and financed through revenues (TZS 115 billion) and the rest raised from government guaranteed loans from local commercial banks.

The cost of the EPP from August 2011 to December 2012 was estimated at TZS 1.241 trillion, and financed through revenues.

Therefore, in the medium- to long-term, 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) an application for a tariff upgrade in 2010, which granted an 18.5 per cent increase, compared to the requested increase of 34.6 per cent.

A number of options are in the pipeline. The discovery and development of the gas resources of Tanzania is one feasible option being explored, along with other energy sources. In the future, the resources for energy generation in Tanzania 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 to2033 (Table 56), 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 to 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 and 2030, coal will bring in a significant capacity of 1,600 MW in addition to six hydro projects expected to produce 1,555 MW. The 2030 to 2033 period will continue to see expanded coal and LNG capacity, with some wind and biomass, and a 145 MW hydro capacity.

The future of the Tanzania 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.

The future of the Tanzania technology and generation mix will therefore 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 on the average cost of electricity in the long-run, and also on the security of electricity supply and system stability. Future energy needs of Tanzania are going to rely more on domestic resources of water and natural gas, some coal, wind and LNG, on enhancing

Table 56: 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.

energy security in electricity, but the rapid expansion of non-hydro options is likely to drive costs up, particularly fuels, and coal if some of the coal is imported.

Based on the observation of the capacity to be added between 2009 and 2033, 37.17 per cent, the largest share, will come from coal (see Table 57), followed by a 33.71 per cent new capacity coming from hydro. Therefore, the future energy generation portfolio will

Table 57: Capacity added through to 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.

see an integration of 1/3 hydropower in total added capacity. Natural gas, domestically sourced, will contribute to 11.54 per cent of added capacity, along with a 5.17 per cent capacity from petroleum products. LNG, wind and biomass will contribute 4.96 per cent, 1.29 per cent and 1.03 per cent, respectively. While energy trade and interconnection from 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 per cent of total capacity, the same capacity as the country plans to generate from expensive thermal generations.

While energy trade and interconnection from 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 per cent of total capacity, the same capacity as the country plans to generate from expensive thermal generations.

This has significant implication on 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 per cent of added capacity, affordability of electricity can be a game changer to energy access progress. Moreover, while an addition of 7,704 MW is quite significant from the existing capacity today, which is 1/7th, whether or not it will be sufficient to bring about universal access to electricity is another question that needs to be considered.

Tanzania has not yet committed to universal access to electricity by 2030, as the United Nations SEFA initiative encourages countries to do, but given the industrial and commercial demand growth in double digits per year, the possibility of a vast access expansion remains in question. 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 and other industrial and commercial activities is therefore going to tap part of the new capacity, taking electricity away from efforts to expand household connections, thus posing obvious trade-offs.

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 the existing capacity will be expected to be retired by 2033 is good news for Tanzania (see Table 58). Moreover, the fact that retired capacity will not include hydropower, but will include other relatively more expensive technologies is also a positive note.

The fact that only 1,158 MW of the existing capacity will be expected to be retired by 2033 is good news for Tanzania. Moreover, the fact that retired capacity will not include hydropower, but will include other relatively more expensive technologies is also a positive note.

The nuclear electricity option was not included in any capacity for the 2009 to 2033 Power Master Plan, but it is a demand that has been opened in the master plan. The plan 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

Table 58: 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.

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, thus the possibility that Tanzania may extract uranium commercially.

The nuclear electricity option was not included in any capacity for the 2009 to 2033 Power Master Plan, but it is a demand that has been opened in the master plan.

However, the Master Plan outlines the hurdles of technology, where medium-scale nuclear facilities are still under development (for example by Eskom for 170 MW capacity and China for a 195 MW prototype), uncertain cost, and the Government not yet having finalized policies on uranium and nuclear generation. Given the small- and medium-scale nuclear prototypes developed in the 2015 to 2020 period, and the potential policy advancement in times of peace and the 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 have been put forward, and to a limited extent in Uganda where medical and agricultural applications are undertaken on small scales, with a debate likely to open in the area of energy.

Finally, it is noteworthy to mention energy sector development and environmental challenges in Tanzania, and the implications to energy access. The Joint Energy Sector Review of 2011 notes that large-scale hydroelectricity projects face environmental challenges, such as the Malagarasi project (relocated to Rumakali) which derailed due to snail species, the Stiegler's Gorge (the largest such project) whose location was in a protected conservation area following the Algiers Protocol Heritage International, and requiring a 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 a 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 projects, fuel switching projects, biomass projects and Jatropha stove projects (see Table 59).

A proper balance between energy sector development, which needs expedited investment, and resource development, and sustainability and environmental management is in order, taking into account 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.

9.3.3.2 Energy access – lessons from Tanzania

The Tanzanian energy sector experiences present a number of lessons worth noting of by Eastern African subregion member States, which if followed could 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 a lot of the newly planned power projects will require coal, natural gas and hydro potential, resources which Tanzania is endowed with. While in general green energy development is an ideal goal, available local energy resources dictate the path of the energy sector development. The path is not necessarily green, or with lower environmental effects, but provides the much needed power from local resources. In fact, Tanzania has placed policy priority on expansion of energy capacity through the 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 subregional strategy, engaged policy dialogue, and development of trade frameworks. Efforts have so far largely been bilateral.

Recent efforts to put energy planning at the center of the energy policy in Tanzania are commendable, and efforts to shore up capacity by using a range of energy resource endowments in the country through policy and investment prioritization are notable best practices.

- **Energy planning, emergency generation and legal 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. 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 drought related hydropower shortfalls, leading to substantial load shedding, 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 the Tanzania generation portfolio in the short- to medium-term, posing legal costs. Recent efforts to put energy planning at the center of the energy policy in the country are commendable, and efforts to shore up capacity by using 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, which are aspects key to expanding energy access and security.

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

Table 59: 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 CO2/year	10 years	Operational
Singida Wind Electricity Project	Wind-e-Tanzania	Singida	60 MW and 70,000 t CO2/year	10 years	PIN approved
Sisal Waste Electricity Project	Katani Ltd	Hale -Tanga	5 MW and 44,087 t CO2/year	7 years	PIN approved
Improved Stoves	TaTEDO	Arusha and Kilimanjaro	36,000 t CO2/year	10 years	PIN approved
Arusha Biogas	CARMATEC	Arusha	3,728 t CO2/year	10 years	PIN approved
Mwenga Hydropower Project	Mwenga Hydro Ltd	Iringa	4 MW and 101,762 t CO2/year	7 years	PIN approved
Ruhudji Hydropower Project	Aldwych International Ltd	Iringa	1,980 GW and 1.21million t CO2/year	7 years	PIN approved
Mafia Biomass Electricity Project	Ng'ombeni Power Ltd	Mafia	1 MW and 66,580 t CO2/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 CO2/year	7 years	PIN approved
Mbeya Cement Fuel Switch Project	Mbeya Cement Company	Mbeya	50,343 t CO2/year	7 years	PIN in approved
Tanga Cement Fuel Switching	Tanga Cement Company	Tanga	17.5 MW and 84,673 t CO2/year	10 years	PIN in progress
Sagera Sisal Waste Biogas Project	Sagera Ltd	Tanga	4 MW and 50,912 t CO2/year	7 years	PIN in progress
Mtwara Energy Project	Artumas	Mtwara	40,000 t CO2/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 CO2/year	6 years	PDD not approved
Tanzania Jatropha Stove Project	Kiwia & Laustsen Ltd	Tanzania	45 MW and 40, 750 t CO2/year	10 years	PIN not approved

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

The potential contribution of the energy resource position of Tanzania in stabilizing domestic and subregional energy markets requires to be looked at further, particularly in an environment where energy access in the subregion is expected to increase rapidly in the coming two decades.

- **Underleveraged energy trade**: the Tanzania energy master plan through to 2033 reveals that of all the anticipated capacity, energy trade will constitute a little over 5 per cent import, with no export plans. Low-cost generation in countries like Ethiopia present notable opportunity for the subregion, 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 subregion. The potential contribution of the energy resource position of Tanzania in stabilizing domestic and subregional energy markets requires to be looked at further, particularly in an environment where energy access in the subregion is expected to increase rapidly in the coming two decades.

- **Renewable energy and electricity**: the Tanzania energy path will create considerable capacity in the coming two decades, but integrates a minimal amount of non-hydro renewable energy, mainly from wind which will account a little over 1 per cent of planned new capacity. Solar energy is barely taken into consideration in the master plan for the future, aside from rural electrification initiatives. In this regard, there should be a wider use of renewable energy sources in the medium- to long-term, particularly to expand access. To do so, there is the need for policy prioritization and the 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 however represent 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 has fallen short of liberalization efforts as seen in Uganda 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 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 subregion, has internal trade-offs and challenges. First, reforming the energy sector has allowed the private sector to come into the market, but though energy capacity is supplemented through new investments, most of the power generated is from thermal resources, which has a higher per unit cost, thus 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 tariffs, thereby 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 to TANESCO, ending up with tariffs that are not cost-effective, again pushing TANESCO to insolvency. Tariff regulation in a liberalized energy markets is an inherent challenge. The Tanzanian experience points to the need to look at the experiences of Uganda and Kenya regarding power sector liberalization, tariff 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 present in much of the Eastern Africa subregion.

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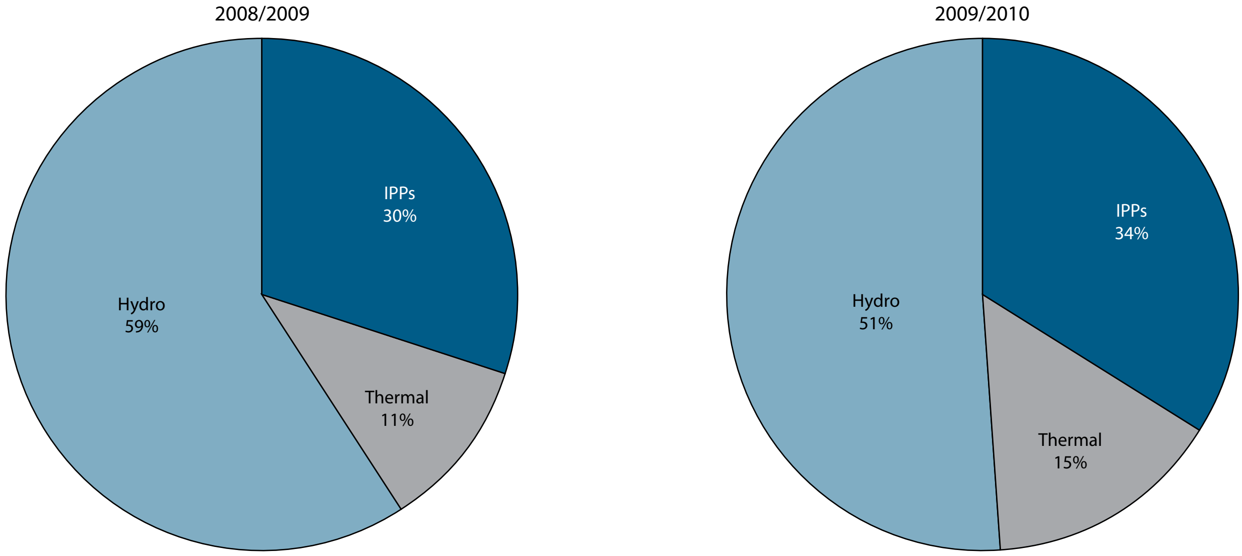
9.3.4 The state of energy security and key lessons

9.3.4.1 The state of energy security

Energy security in Tanzania can be viewed from the vantage point of oil and gas, and from electricity and biomass use (the latter is discussed in the environment chapter at length). With regard to electricity, short-, medium- and long-term challenges in the electricity sector and their implications for energy access in the country have been 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: (a) the Master Plan for electricity through to 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; (b) future expansion plans integrate fuels, albeit at around 5 per cent of newly installed capacity, but if current demand outpaces generation capacity enhancement, it is likely that fuel-based thermal energy will be part of the scenario, exposing the country to fuel-related energy security challenges; and (c) existing hydropower potential and the planned hydro capacity of 1/3 of the total through to 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 subsector. Looking at the evidence from 2008/9 to 2009/10 (just one

Figure 102: Transition of the Tanzanian generation mix: 2008/9 – 2009/10



Source: Based on data from EWURA, 2010.

year) reveals that the energy sector of Tanzania is going through rapid dynamics (see Figure 102). During this period, the share of hydroelectricity dropped by 8 per cent, which is replaced by IPP capacity enhancement of 4 per cent and thermal generation expansion of 4 per cent. This shift point to two facts: (i) the reliance on hydroelectricity will continue to create power shortage risks; and (ii) emergencies are likely to bring thermal generation back into the picture if there is insufficient reserve capacity from cheaper and cleaner energy sources.

Another determining factor in energy security in the electricity sector is infrastructure. Transmission and distribution losses are indicative of system resilience and efficiency. Transmission and distribution losses are estimated at 20 per cent in 2008, and 22.5 per cent in 2009, but the Master Plan for electricity foresees losses dropping to 13 per cent by 2033 (see Table 60). However, losses at or above 1/5th of the generated power are quite high, quite costly and may add to the pressure of raising tariff for consumers, thereby undermining energy affordability.

Moreover, at the institutional and market reform level, there are uncertainties. Though the effort by Tanzania to reform the energy sector and bring in private sector players is commendable, the reform remains confined to transmission and distribution largely within TANESCO, as well as much of the generation, and integrates the private sector mostly in the area of bringing in the needed capacity, mainly in the form of thermal power. The financial solvency difficulties faced by TANESCO will continue to pose energy security challenges, since a financially strapped utility company is unlikely to invest in system upgrade, infrastructure development and large-scale investment

Table 60: Transmission and distribution losses actual (2008, 2009) and estimated - 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.

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 reviews 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 subsector is undergoing a burgeoning and promising transformation. Petroleum exploration is being carried out by more than 25 companies, and at least 12 exploration blocks have been identified (see Figure 103). There are currently no oil discoveries in Tanzania, but exploration is ongoing. The country depends entirely on imported refined petroleum products, since it has no operating refinery. Energy crisis in both 2006 and 2010 led to the integration of the use of imported fuel for electricity, further undermining the state of energy security in the country. Reliance on the reserve capacity of petroleum distribution companies and the lack of a 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 the establishment of a public strategic reserve of petroleum, including an operational and oversight framework for it.

Petroleum stocks information is compiled twice a week, and when stock is low, the Ministry of Energy and Minerals and Tanzania Ports Authority are alerted to take necessary measures. Monitoring stock levels and communicating to agencies to deal with supply disruption are vital aspects of the short-term supply disruption management.

Despite these challenges, three best practices in quality management of short-term disruptions in the supply of petroleum products are worth taking note of.

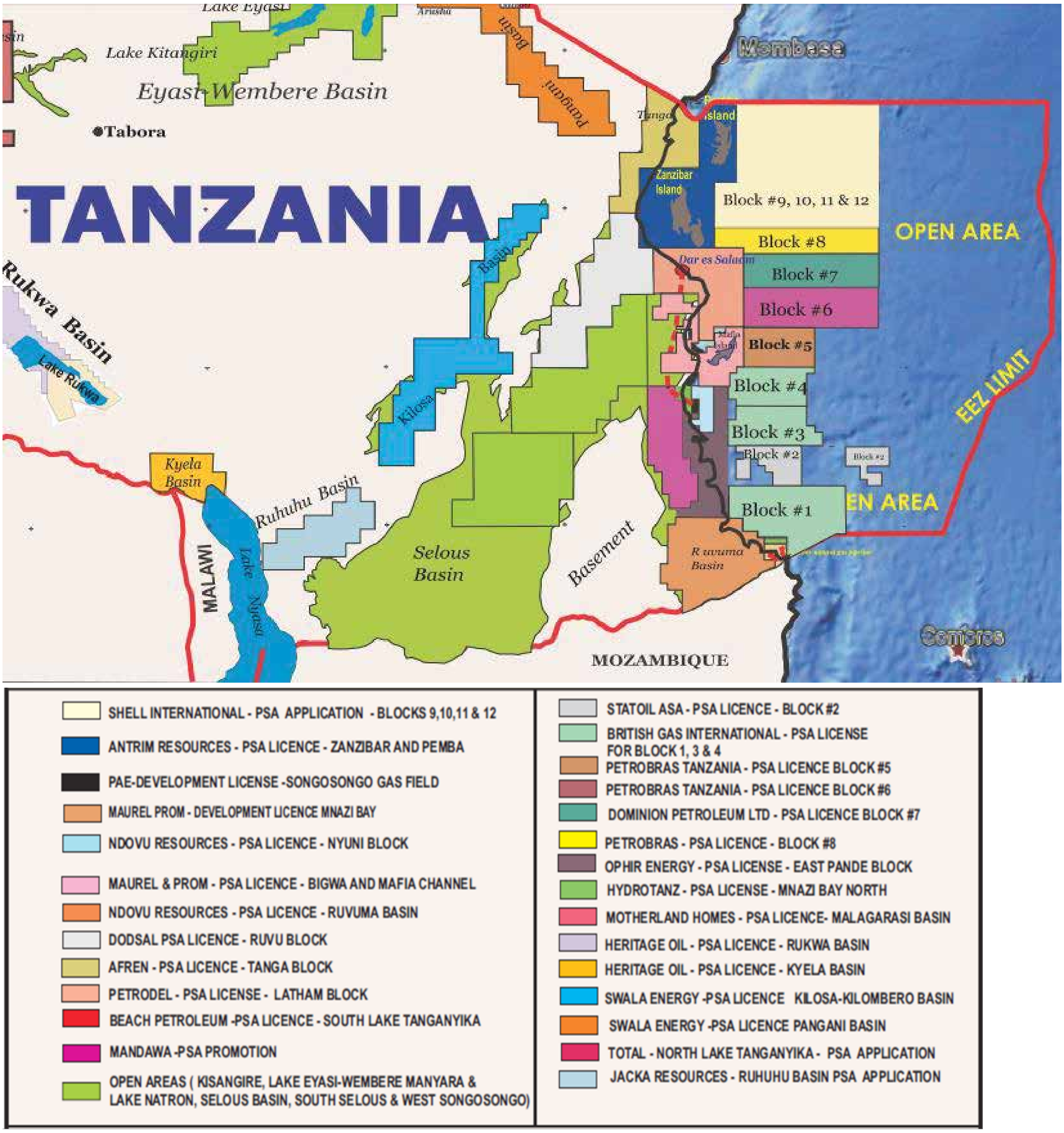
First, petroleum supply and domestic stocks are monitored through EWURA. Petroleum stocks information is compiled twice a week, and when stock is low, the Ministry of Energy and Minerals and Tanzania Ports Authority are alerted to take necessary measures (EWURA, 2010). The arrival of vessels is monitored for EWURA by SGS Superintendence Tanzania Limited. Monitoring stock levels and communicating to agencies to deal with supply disruption are vital aspects of the 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, 210 (48.6 per cent) of which 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 per cent of retail outlets, 29 per cent of depots and 55 per cent of tankers were carrying products that were not in line with the Tanzania Bureau of Standards specification (Ibid). As significant and worrying as substandard oil products are, the fact that the trend seems to be on the decline, based on quarterly and semi-annual inspection assessment, is encouraging (see Figure 104). However, more needs to be done to tackle the high level of product adulteration, which undermines availability of quality oil products. Regular sampling and monitoring of product for adulteration is nonetheless an example of a best practice to tackle the problem.

Bulk petroleum products procurement by petroleum marketing companies in Tanzania is important in reducing prices and managing supply in the short-run. Members States in the Eastern Africa subregion which have not instituted bulk procurement will benefit from such a practice.

Third, the practice of 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 Bill Procurement Rules and System Implementation Manual was prepared, and presented to the Ministry of Energy and Minerals to issue appropriate regulations (EWURA, 2010). These developments are steps in the right direction since they will

Figure 103: Tanzania oil exploration activity by Blocks

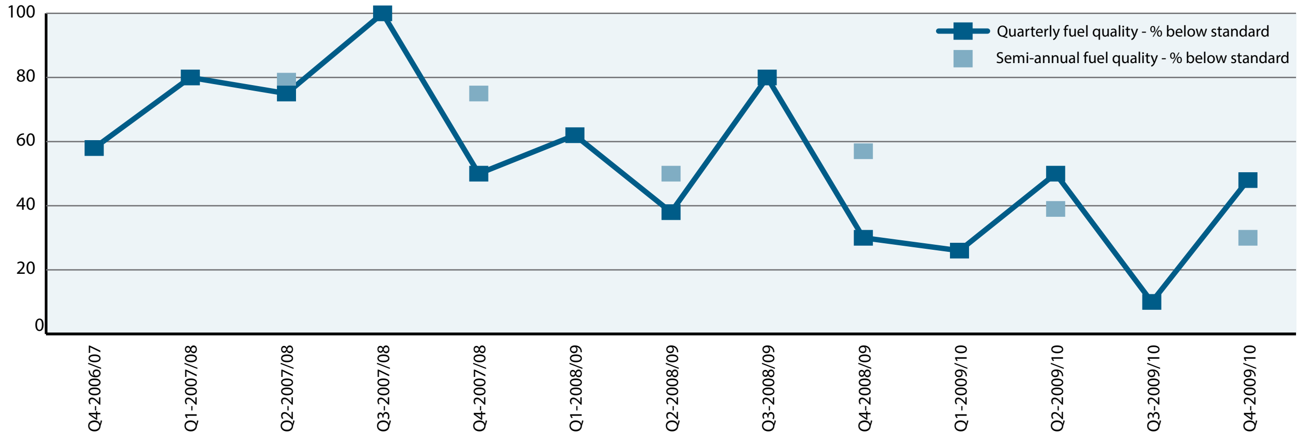


Source: Tanzania Petroleum Development Corporation.

bring about coordinated and bulk procurement that would afford better prices and coordinated supply. Members States in the Eastern Africa subregion which have not instituted bulk procurement will benefit from such a practice.

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

Figure 104: Oil quality at retail outlets percent of sample found below standard



Source: Based on data from EWURA 2010 Annual Report.

With regard to natural gas, remarkable discoveries have placed Tanzania on 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 to nearly 33 TCF of recoverable natural gas reserves, a point which led the Deputy Energy and Minerals Minister, Mr. George Simbachawene to declare at the oil and gas conference in Dar es Salaam in October 2012, that, "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 there are some 253 TCF of natural gas off the coasts of Tanzania, Kenya and Mozambique, increasing the prospects for more gas. Mozambique is also emerging as a major player in the gas industry, due to large finds in onshore fields. In Tanzania, BG Group, Ophir Energy, Royal Dutch Shell, Aminex Plc and Petrobras of Brazil are in the gas exploration and development business.

The economic benefits of natural gas use in Tanzania are already significant. During 2009/10, 21.73 billion standard cubic feet (BCF) of natural gas was consumed by thermal power generation plants, equivalent to 92.07 million litres of oil, generating $789.07 million savings.

The potential of the sizeable natural gas finds in Tanzania offer an opportunity to enhance energy security in the country, and in the subregion. Natural gas has already entered the electricity generation portfolio, and plans are to bring added capacity from gas-fired power plants. From 2004 through to 2013, at least 886 MW capacity of electricity was sourced from gas (see Table 61), with plans to generate additional capacity post-2013 (see Table 56). Natural gas will effectively enhance energy security by replacing other sources of fuel with domestic gas for electricity generation 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) of natural gas was consumed by thermal power generation plants, which is equivalent to 705.53 million litres of oil; and industry had consumed in the same year 3.78 BCF of natural gas, equivalent to 92.07 million litres of oil, generating $789.07 million savings in 2009/10 (EWURA, 2010). These gains are expected to increase as domestic gas replaces imported fuel in the generation portfolio.

Table 61: 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.

The role the development of the gas sector in Tanzania will play in the enhancement of energy security in the Eastern Africa subregion is however uncertain. Experiences from South Sudan and Uganda in oil sector development are indicative of what the gas industry in Tanzania can do. South Sudan exports its oil resources and imports refined petroleum, therefore commoditizing oil while the State faces energy security challenges from imported refined products. The country has now announced the setting up of two refineries to change this situation and enhance local energy security. In the case of Uganda, it is increasing the refining capacity beyond domestic demand to help meet regional demand for petroleum products, thereby potentially contributing to the enhancement of energy security in the subregion. The case of Tanzania can be informed by these experiences, where product-sharing agreements it enters into with oil and gas companies will certainly become a constraint. Indications are that after providing much of the domestic electricity, industrial and household demand, and perhaps exporting someto the subregion, through a 5-20 per cent 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 really fast. The subregion will need to engage with Tanzania to deal with systemic energy security challenges. Access to the gas in Tanzania, or to converted electricity export are possibilities that require further policy engagement at the subregional level.

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9.3.3.2 Energy security – lessons from Tanzania

Based on the experience of Tanzania in the electricity and oil and gas subsectors, the following lessons and best practices are worthy noting:

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

- **Bulk procurement***:* as with any other commodity, bulk purchase enables procuring products cheaper, as it offers a level of strength in negotiation and logistics management. Efforts by Tanzania 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 subregion can benefit from organizing the petroleum subsector in such a manner. A subregional 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 which requires urgent attention.

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- **Strategic reserve**: Tanzania relies on the private sector to maintain sufficient stock supplies, often at two 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 from this case is that private sector regulated stockpiles will not be sufficient to meet the short-term energy security of the country, and requires a supplementary, public stockpiling mechanism. Kenya has also taken steps to create a public strategic reserve, and Uganda is reviewing 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 centres and equally important is monitoring of quality. Product adulteration is endemic in the subregion, and the lack of monitoring and enforcement has made the adulteration challenge even more worrying. Tanzania has succeeded in cutting down on adulteration from nearly 80 per cent in 2007 to less than half the level by 2010 through frequent and random monitoring and enforcement of quality standards in depots, distribution centres and transportation tankers. The adulteration problem is still quite high, but the progress made thus far shows the importance of monitoring, regulation and enforcement in dealing with the adulteration challenge. Member States in the subregion can look at the Tanzanian experience, and other States in the subregion, to effectively tackle their product adulteration challenges to ensure not only petroleum supply at affordable prices, but also at acceptable quality.

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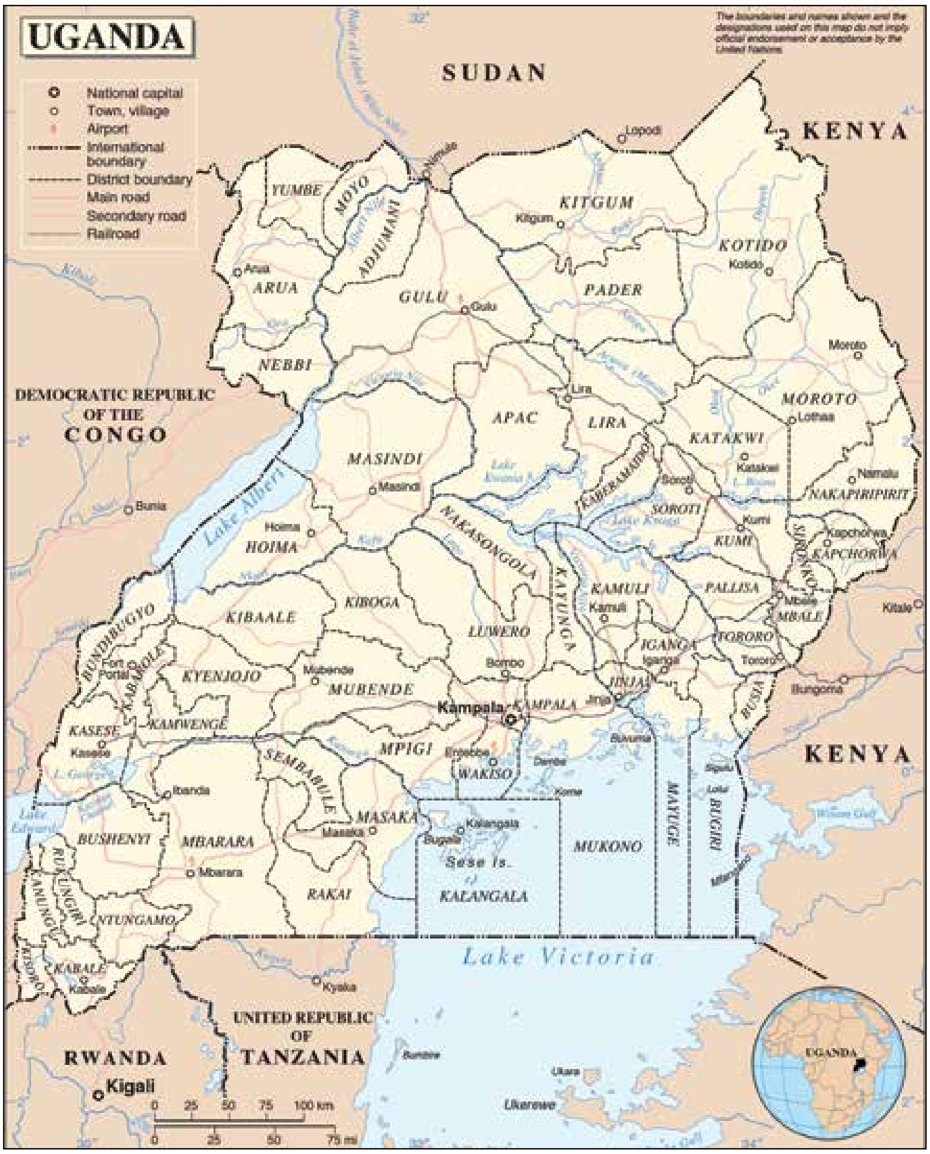
9.4 Uganda

9.4.1 Background

Uganda became an independent State in 1962, with Milton Obote as the Prime Minister. A year later, Uganda was declared a republic with the King of Buganda as President. This ceased as a result of the end of Buganda's autonomy and the ascendancy of Milton Obote as President in 1971. He returned as president in 1980. The advance of the National Resistance Army to the capital saw the ascendancy to power of President Yoweri

Figure 105: Map of the Republic of Uganda



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

K. Museveni in 1986. President Museveni introduced reforms, including restoration of traditional kings in 1993 and a constitutional provision to legalize political parties in 1995, leading to a 1996 presidential election win for him. Subsequent elections in 2006 and 2011 also saw a continuation of his presidency. Along with Kenya and Tanzania, Uganda renewed the East African Community (EAC) in 2001, supporting economic integration of the EAC.

The Ugandan economy depends on agriculture, as in much of the Eastern Africa subregion, particularly coffee exports. It however saw a gradual shift to an increasing role of the service sector. Its energy and minerals sectors are promising. In 2009, Heritage Oil (concessions later acquired by Tullow Oil) announced a major oil find in the country, establishing the country on the energy map of the subregion. The economy of Uganda has largely undergone privatization, including major reforms in its energy sector. Reform is widely believed to lead to the attraction of investments into the country and the 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 the raising of public funds through government securities.

9.4.2 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 aims "to meet the energy needs of the Ugandan population for social and economic development in an environmentally 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 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 is said to have taken note of the following energy sector challenges:

> Inadequate public 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 Uganda, adopted in 2002, is the guiding policy framework for the sector which aims "to meet the energy needs of the Ugandan population for social and economic development in an environmentally sustainable manner."

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

> Establish the availability, potential and demand of the various energy resources in the country; increase access to modern, affordable and reliable energy services; improve energy governance 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 affordable energy services for households and community-based services including water and sanitation, health, education, public lighting and communication.
>
> Industry: introduce energy efficiency measures to enhance industrial and commercial competitiveness.
>
> Transport: promote optimum and efficient utilization of petroleum fuels and substitutions.
>
> Agriculture: increase the use of modern energy in agriculture as a component of agricultural modernization.

The Energy Policy is supplemented 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 motivated by the fact that "a number of renewable energy technologies have become commercially viable and therefore need to be brought into the national energy supply mix." It is also 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, legal and institutional, technical, awareness, standards, quality of renewable energy technologies (RETs) and information and data on renewable energy resources, the policy advances strategies and programmes to tackle the challenges, including:

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

The oil and gas subsector is guided in particular by the 2008 National Oil and Gas Policy for Uganda, which aims to "use the country's oil and gas resources to contribute to the early achievement of poverty eradication and bring lasting value to society."

Along with Kenya, Uganda has a progressive feed-in tariff policy to incentivize renewable energy development. In the Phase 2 programme managed by Electricity Regulatory Agency (ERA), technology-sensitive tariffs are offered for power generated from renewable energy technologies application (see Table 62), offering tariffs ranging from $0.073/kWh for hydro to $0.36/kWh for Solar PV.

For the oil and gas subsector, the Energy Policy of 2003 deals with broader issues in the upstream and downstream areas of the oil and gas sector. It takes into consideration petroleum product import, going through the mandatory biocode since 2000 to tackle illegal imports and product adulteration. It also takes into account that following the 1994 deregulation of petroleum product prices, prices have risen sharply to reflect market conditions, but deregulation also brought investments. Since 1997, the sector has been opened to oil marketing companies. The policy also takes into consideration the public strategic reserve of petroleum products at Jinja Storage Tanks for strategic purposes, and to offer storage facility for new oil companies as an incentive to help them in the competition.

The oil and gas subsector is guided in particular by the 2008 National Oil and Gas Policy for Uganda, which aims to "use the country's oil and gas resources to contribute to the early achievement of poverty eradication and bring lasting value to society." The Policy puts forth the objectives of efficiency in licensing, efficient management of oil and gas resources, the use of revenues to bring lasting value to society, and to ensure

Table 62: 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.

that oil and gas activities are undertaken in a manner that conserves the environment 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) were 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 participation of the following:

> 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, among other things); Petroleum Authority of Uganda (monitoring and regulating petroleum operations, managing petroleum data, among other things); Uganda National Oil Company (managing business side of State participation, administering contracts, optimizing value to shareholders, among other things); 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, among other things); 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 roads in Uganda, among other things); 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 Labour (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 the 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 a 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 has constituted key sectoral institutions, in conjuction with the cross-institutional bodies mentioned above. The Minsitry of Energy and Mineral Development is the overarching institution mandated to "establish, promote the development, strategically manage and safeguard the rational and sustainable exploitation and utilization of energy and mineral resources for social and economic development." These broader responsibilities of the Ministry are 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) were unbundled.

Energy access in Uganda is quite low, at 12 per cent for national electricity access and according to REA at 6 per cent for the rural electrification rate from just 1 per cent in 2002.

The Uganda Electricity Generation Company Limited (UEGCL), which owns the Kira and Nalubaale Hydropower Stations in Jinja, operates from these sites, under a private sector 20-year management deal with ESKOM, the South African power generation company, since 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. UETCL is therefore the single buyer of power to the grid system, and sells 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-year lease with UMEME Limited, commencing in 2005. To address rural electrification targets, the Rural Electrification Agency (REA) was instituted, as an agency for the Rural Electrification Board. The activities of REA are supported by the Rural Electrification Fund. There is active private sector participation in Uganda, particularly at the generation level through IPPs.

9.4.3 The state of energy access and key lessons

9.4.3.1 The state of energy access

Energy access in Uganda is quite low, at 12 per cent for national electricity access (although estimates vary up to 12 per cent), and according to REA at 6 per cent for the rural electrification rate from just 1 per cent in 2002. The national access rate is much lower than the Eastern African subregional average access rate of 27 per cent. Given the stated goal of energy sector development of Uganda which is to tackle poverty and accelerate socioeconomic development, such low level energy access pose critical constraints to the achievement of these broader social objectives. To draw key lessons from the state of energy access and strategies so as to tackle them, it is important to review broadly, the energy sector of Uganda, particularly the 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 to 9 per cent per annum. Therefore, rapid expansion of generation capacity seems a relevant energy planning strategy to prevent power shortage crisis. Existing generation capacity comes from hydro and thermal generation (see Table 63), totalling 590 MW, receiving hydroelectric power from Nalubaale, Kiira, Bugoye,

Table 63: 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.

Mpanga and Ishasha large and small plants. Since the 2006 power shortage and the need for emergency generation, following a drop in water levels at Lake Victoria and the 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) acknowledges that "current power generation mix is dominated by thermal power, which is expensive, hence accounting for the high power tariffs. A programme to develop cheaper and more reliable power is being undertaken using the newly created Energy Fund." Uganda removed part of the subsidy it provided to the power sector in 2012, partly due to the expensive thermal generation that has come into the system, causing tariffs to rise, and passing part of the cost to consumers.

The hydropower capacity expansion is largely based on the development of the Nile River. Some of the proposed projects in the Hydropower Development Master Plan include Kiba, Ayago, Oriang, Karuma, Michison, Isimba and Kalagala, with a combined capacity of 3,010 MW.

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, had an impact on the economy, and GDP contracted by 5 per cent in the 2005/2006 period, and by 6.5 per cent in the last 10 years (Baanabe, 2012).

To address these challenges, short-, medium- and long-term measures are being taken. The short-term measures include expansion of thermal capacity to generate emergency power[50], savings from reducing energy losses, energy efficiency and demand side management; the medium-term strategy involved development of Bujagali and Karuma hydro plants (combined power of 850 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).

To enhance generation capacity, Uganda aims to rely on its energy resources. The hydropower capacity expansion is largely based on 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 Figure 106).

50 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.

Figure 106: 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).

Moreover, there is a power generation potential based on agricultural waste, for an estimated equivalent power output of 407 MW from bagasse, rice husks and straw, sunflower and cotton seed hulls, tobacco dust, maize cobs, coffee husks and groundnut shells (see Table 64). The capacity of peat in Uganda is estimated at 6,000 million m3, about 250 Mtoe (equivalent to million tonnes of oil), which at 10 per cent of feasible exploitation can generate 800 MW for 50 years (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 65) sourced from green energy resources.

The power generation projects from 2012 to 2020, if fully developed, are expected to produce 2,217 MW to 2,237 MW, nearly threefold the current capacity.

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 to be developed in the coming years. The power generation projects from 2012 to 2020, if fully developed, are expected to produce 2,217MW to 2,237 MW, nearly threefold the current capacity (see Table 66). The 250 MW capacity of Bujagali was already commissioned in phases in 2012, bringing the much needed short-term capacity expansion to

Table 64: 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.

meet the rapid expansion of demand, and to relieve the endemic energy crisis in the electricity subsector of Uganda over the last few years.

The strategy to develop new generation capacity is further explored through the hydroelectric small and large capacity development, prioritized in the Hydropower Development Master Plan, and other renewable energy sources, prioritized in 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, it is believed, will lead to expanded rural energy access, as well as to the introduction of energy efficient household appliances (see Table 67). 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) has identified core challenges to effective operation of UETCL, including:

> Restricted water release regime, reducing hydropower generation, and reliance on thermal for compensation of power loss; Uganda Shilling depreciation affecting power purchase prices in hard currency; fuel price increases and power purchase price impacts; lack of adequate reserve capacity compromising system stability; tariffs being out of sync with power purchase prices; rampant vandalization of infrastructure; acquisition of site for transmission construction;

Table 65: 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.

Figure 107: Aerial view of Bujagali hydropower plant

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

finance; procurement delays; delayed remittance of subsidy to honour 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. At the distribution end, Umeme receives about 30 per cent of electricity tariff from 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 per cent in 2011; commercial losses (theft); land acquisition; high power tariff; depreciating currency; gap between finance and investment needs; and generation mix gearing towards more expensive thermal sources as a result of hydrology constraints. Along with the transmission infrastructure constraints, these challenges necessitate a system-wide approach to addressing the challenges of accelerating 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.

9.4.3.2 Energy access – lessons from Uganda

A review of the Uganda electricity subsector reveals important lessons for Eastern Africa subregional member States, particularly those considering the development of various

Table 66: 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.

domestic energy resources to expand energy capacity and access, and those considering opening up 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 the goal of reducing the constraints energy places on socioeconomic transformation. Uganda has put in place a comprehensive national energy policy, inclusive of the power and oil and gas subsectors, electricity act that privatized the power sector by unbundling generation, transmission and distribution. It has also formulated an oil and gas policy, renewable energy policy and feed-in tariff structure (to boost contribution of renewable energy), a biofuels programme, a rural electrification authority and fund, thus becoming one of the first countries to implement Sustainable Energy for All (SEFA) initiative of the United Nations Secretary-General, to obtain universal access to sustainable energy by 2030. Despite the structural challenges in the energy sector in Uganda, the policy reforms and implementations have introduced a marked change in the energy sector, particularly with the participation of the private sector, albeit with its own challenges relative to Government expectations. For countries within the Eastern Africa subregion 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 a comprehensive national energy policy, targeted incentive

For countries looking for a comprehensive national energy policy, targeted incentive policies for renewable energy, a programme and fund for rural electrification, and how to take SEFA initiative on-board and for what the outcome of a privatized energy sector would look like, Uganda offers comparable key lessons.

Table 67: 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 (m3/a)	0	720,000	2,160,000
Energy Efficiency			
Solar water heaters (m2 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.

policies for renewable energy, a programme and fund for rural electrification, and how to take SEFA initiative on-board and for what the outcome of a privatized energy sector would look like, Uganda offers comparable key lessons in the subregional energy sector environment. With an engaged public sector that prioritizes energy sector development, progressive energy policies/reform development and implementation are possible, and given the timeliness of positioning the energy sector in the subregion, such efforts will also be useful.

Lack of adequate energy planning and generation capacity development, particularly in States that are hydropower dependent are vulnerable to drought, which is risky, will lead to emergency power generation, and result in the unintended consequence of raising power costs, thus undercutting economic competitiveness.

- **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 greatly exposed to drought and hydrological vulnerabilities. Energy planning was inadequate. The result has been a dramatic increase in thermal emergency power generation, as in Kenya, Rwanda and Tanzania, pushing the generation portfolio into high-cost and importation of fuels. This has led to a system-wide rise in per unit cost of energy. The lesson is clear – lack of adequate energy planning and generation capacity development, particularly in States that are hydropower dependent are vulnerable to drought, which is risky, and will lead to emergency power generation, and result in the unintended consequence of raising power costs, thus 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 programme sustainability**: the Uganda experience of emergency generation and shift in generation portfolio to high-cost thermal generation, leading to rising costs, has further implications. The cost has risen so significantly that sustaining power subsidies has become costly, and beyond estimated budget provisions. For example, from May 2005 to October 2011, a total of UShs1,135.20 trillion had been paid in subsidies (Ministry of Energy and Mineral Development, 2012). Consequently, Uganda scaled down its subsidy in 2012, exposing consumers to a price hike. Energy price increases discourage efforts to expand access, and reduce economic competitiveness. Commercial and industrial consumers have already complained of sharp tariff increases. These challenges are avoidable through energy planning and generation expansion efforts. Uganda has since embarked on ambitious plans of power generation comprising the short-term plan of expanding thermal generation, a medium-term strategy of thermal, hydro and renewable energy generation and a long-term strategy of hydro, use of local oil and obtaining power from regional interconnection. Countries in the subregion with inadequate energy planning can draw lessons from the Uganda experience.

- **Energy sector reform, private sector participation and tariffs**: power sector reform in Uganda has involved the participation of the private sector, in the area of generation. For the private sector, there is a great incentive to invest less capital and generate high returns, which often lead to a lot of interest in rental thermal generation, and relatively less uptake in large-scale hydropower projects which are often costly, require large capital and involve great risks. While reform and private sector participation in the energy sector are crucial to bringing 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 it is also interested in seeing cost-reflective tariffs, thereby creating a wedge between "socially appropriate" and "commercially appropriate" tariffs. High generation cost, from the 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 adjustments are often sticky matters. 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 by 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, through subsidies, and part of the cost to consumers in the form of higher tariffs.

Policy dialogue is needed to get the best of reform from system efficiency improvement and infusion of investment capital to the energy sector by 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, through subsidies, and part of the cost to consumers in the form of higher tariffs.

9.4.4 The state of energy security and key lessons

9.4.4.1 The state of energy security

Uganda depends on imported petroleum products, through the Kenya route (90 per cent) and the southern corridor through Tanzania (10 per cent), to satisfy demand which is growing at 7 per cent, and requires a fuel import expenditure of $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 in supply 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 by short-run supply disruptions, along with Rwanda and Burundi.

Aside from the global and regional challenges of petroleum price hikes, political instability in exporting countries, and the 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 at the Ministry of Energy and Mineral Development, based on the 2003 Petroleum Supply Act (PSA), establishing a technical committee to advise the Minister on petroleum supply matters. The PSA is strengthened by the 2009 Petroleum Supply Regulation (PSR), offering institutional and regulatory framework for the management of petroleum supplies.

To deal with the risks associated with disruption, Uganda has adopted route diversification, restocking strategic reserves, improving import pipelines, tackling adulteration and initiating fuel monitoring and an information system.

To deal with the risks associated with disruption, Uganda has adopted route diversification, restocking strategic reserves, improving import pipelines, tackling adulteration and initiating fuel monitoring and an information system. Regarding 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 this has its challenges, such as axle regulation on Tanzanian roads and the relative cost of using 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 addressed through the drawdown of strategic stock, largely due to the depletion of the stock. The existing strategic reserve capacity of Jinga Storage Tanks is 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.

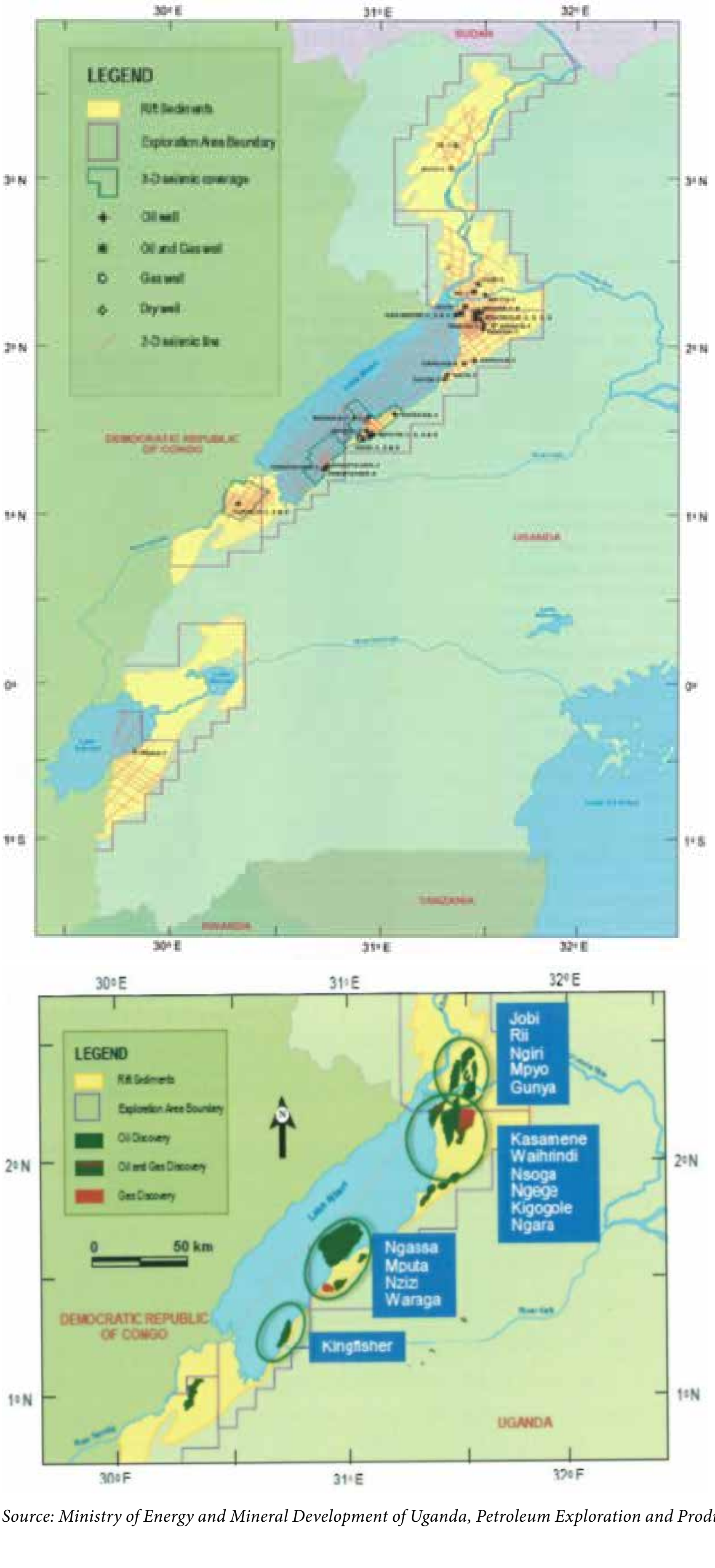
In 2011, the Fuel Marking and Quality Monitoring Programme was initiated to deal with adulteration and fuel smuggling challenges, and quality is monitored against the established fuel standards. From 2000, a biocode marking of imported petroleum was mandated.

Product adulteration, as in much of the subregion, is also a concern in Uganda. In 2011, the Fuel Marking and Quality Monitoring Programme was initiated to deal with adulteration and fuel smuggling challenges, and quality is monitored against the established fuel standards. From 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 necessary. 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 per cent) 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

Figure 108: 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

Table 68: 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."

infrastructure needed for energy security, and will contribute to enhance both Uganda and Kenya energy security capacity.

The future options for 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.

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 per cent recovery rate, with prospective discoveries of up to 4.2 bbls. The proven reserves are nearly equivalent to the proven oil reserves found in South Sudan.

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 subregion. From 2002 to 2011, a total of 39 oil wells were drilled (see Figure 108, 1st panel), and 36 wells showed signs of containing hydrocarbons, and 16 discoveries of oil and gas (see Figure108, 2nd panel) were announced (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 per cent recovery rate, with prospective discoveries of up to 4.2 bbls (see Table 68). The proven reserves are nearly equivalent to the proven oil reserves found in South Sudan.

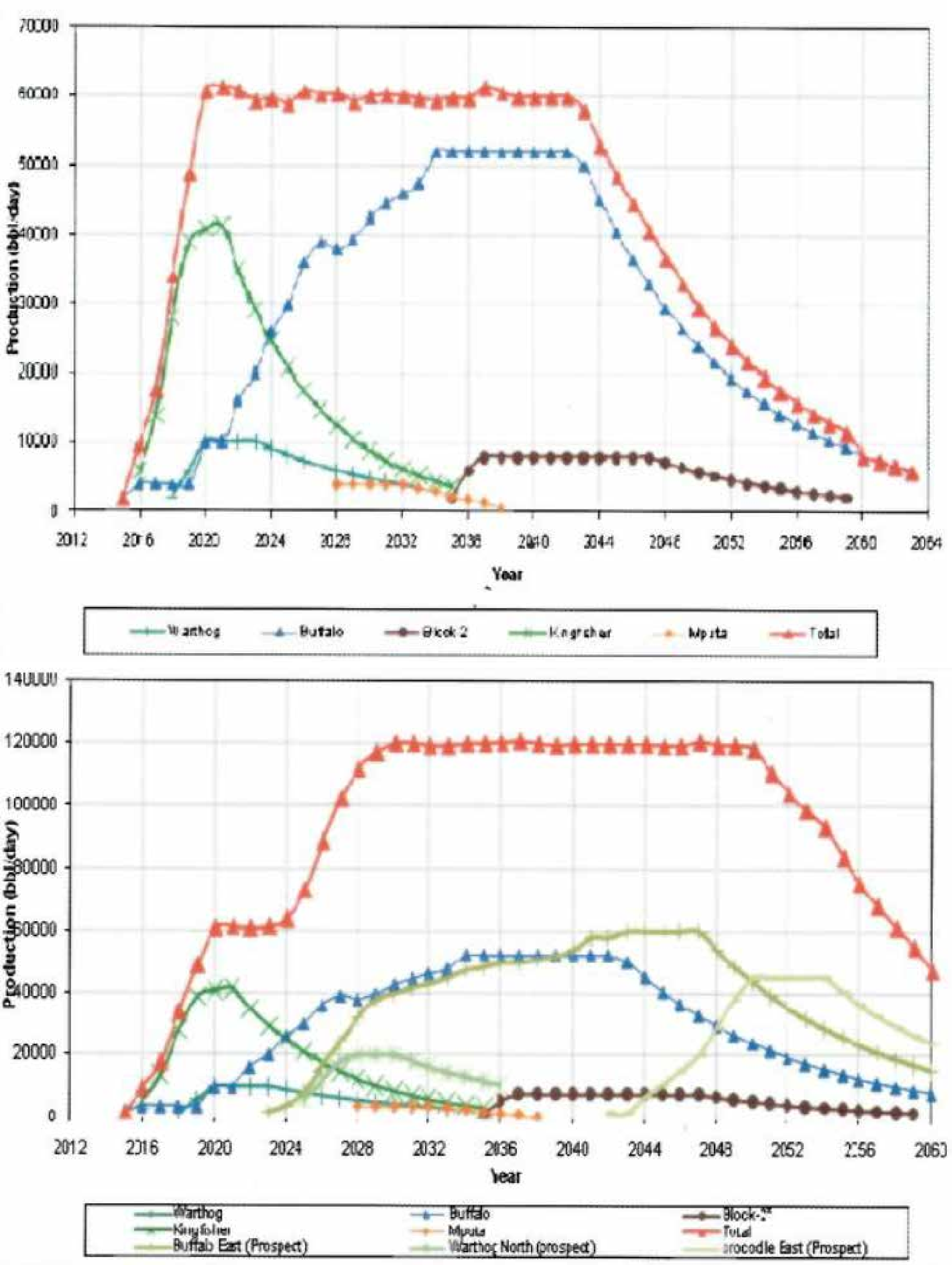
In addition, there is an estimated gas reserve of 12 BCF (billion standard cubic feet). These deposit assessments have so far been conducted based on 40 per cent exploration of the total area. These oil and gas finds are significant, and have great potential to help enhance subregional energy security. 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, enhancing the petrochemical industry and conversion of fuel to thermal power generation. To assess the feasibility of these choices, the Government commissioned a study in 2010 to determine the feasibility of a large-scale refinery in Uganda. The study, completed in 2011, found that "an oil refinery in the country to supply the Ugandan and regional markets rather than constructing a pipeline to export crude oil in the medium-term" was a preferred and feasible option (Ministry of Energy and Mineral Development, 2012).

The commercialization strategy has considered the options of exporting crude oil as a commodity, local refining, enhancing the petrochemical industry and conversion of fuel to thermal power generation.

Furthermore, the discovered oil is waxy, meaning it will not flow through a pipeline below temperatures of 40°C. This will require that the pipeline is 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

Figure 109: Production profile for 60,000 bpd (panel 1) and 120,000 bpd (panel 2) refinery



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

bbls/day capacity, eventually increasing 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 most of the prospects is achievable (see production/refining profile by crude oil input capacity in Figure 109).[51] 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. The

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

Uganda 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 the Tanzania gas sector.

Nuclear energy: another option to enhance energy security in Uganda is the application of nuclear energy in times of peace. The institutional and legal framework for atomic energy took shape in 2008, with the Atomic Energy Act and the establishment of the Atomic Energy Council, with a mandate of regulating and monitoring nuclear technology utilization and safety. The regulatory framework was formulated 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:

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 for shielding the economy from the impacts of unmitigated disruptions.

> Nuclear power can significantly contribute to national development. In view of the increasing energy needs and urgent environmental concerns related to 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.

Biofuels: Uganda produces nearly 200,000 tons of sugar cane, generating 80,000 tons of molasses waste, with the potential to produce million litres of alcohol per year, based on a conversion factor of a ton of molasses to 320 litres 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 Programme is encouraging, but a lot remains to be done to replace imported petroleum based on a diversified and locally resourced biofuels development.

9.4.4.2 Energy security – lessons from Uganda

A review of the overall energy security profile of Uganda offers valuable lessons for member States in the Eastern Africa subregion, including the following.

- **Strategic petroleum reserve and short-term supply disruptions**: the importance of strategic reserves as a management scheme to mitigate the impact of short-term petroleum supply disruptions is obvious. The experience of Uganda in the Kenyan post-election violence with the termination of oil supplies has made that quite clear. The strategic reserve of Jinja had to be transferred to private sector management, for refurbishment and restocking. Insufficient strategic reserve continues to pose the 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 for shielding the economy from the impacts of unmitigated disruptions.

- **Fuel supply infrastructure and route diversification**: for landlocked 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 in 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 of 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 which depend largely on one route, such as the reliance of Ethiopia on Djibouti and the reliance of South Sudan on Kenya.

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

To member States considering the development of an information system on petroleum, and other energy sector data, Uganda offers a best practice initiative to consider.

- **Information system**: in managing energy security, information is key to bring valuable analysis and data to decision makers to make informed decisions. Uganda instituted the National Petroleum Information System in 2011 to monitor global and local prices, stock levels and quality. The absence of realtime information will hamper measures to effectively respond to potential supply disruptions, and efforts to avert them. To member States considering the 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 and valuable commodity everywhere. The approach of Uganda to give priority to local industrial development on petrochemicals, invigorating the development of refinery capacity to enhance energy security locally, putting in place strategies to tap and test well oil output and gas for thermal electricity and the cement factory as well as 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 subregion could consider the Ugandan model and feasible strategy and be implemented in existing markets in the subregion.

The approach of Uganda to give priority to local industrial development on petrochemicals, invigorating the development of refinery capacity as well as a long-term plan to boost refining capacity to serve the regional market is indeed a best practice of domestic energy resource development with regional energy security benefits.

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 subregion, particularly in relation to uranium discoveries and planned mining in Tanzania and Madagascar. Just like Kenya, Uganda has formulated a nuclear energy policy and a regulatory framework, as well as an institutional partnership with IAEA, laying the groundwork on energy and other civilian use of nuclear technology. Nuclear energy is not yet in the short to medium range planning in the majority of the subregional States, but future efforts of broadened energy sector development may consider the potential application of nuclear energy, which would start with formulating the requisite policy, regulatory and institutional frameworks. Uganda offers an example of considering the policy, regulatory and institutional issues, on nuclear energy, just like Kenya.

Conclusion

From the 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 from cleaner and sustainable energy sources. Despite the strong linkages between energy sector development and socioeconomic transformation, Eastern Africa is one of the few subregions with poor energy access. As the subregion continues to enjoy robust economic growth, sustaining the momentum will require tackling energy problems such as: 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 among 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 subregion, with severe impacts on the macroeconomy of member States, 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 transboundary hydropower systems is ripe, energy trade is barely leveraged in the subregion, 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 subregion, and growing interest in biofuel development also offer pathways to dealing with energy insecurity through regional frameworks. These, and other opportunities, constitute the possibility of an energy transformation and revolution in the subregion.

Recognizing that energy access and security are indispensable to economic transformation, member States of the Eastern Africa subregion 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 regarding subregional and country targets and strive to achieve the 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 for the development of strategic energy resources such as oil and gas; engage in the exchange of information and experiences pertaining to enhancing energy access and security and ultimately address the energy constraint to resilient economic transformation through workable strategies implemented in the Eastern Africa subregion and beyond.

This report offers a subregional picture on energy access and security, reviews case studies from selected member States to highlight lessons on energy access and security, looks at the environmental, transboundary 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 programmes and strategies that will collectively enhance the state of energy access and security. The United Nations Economic Commission for Africa (UNECA), including its Subregional Office for Eastern Africa (SRO-EA), will continue to engage policymakers and energy sector stakeholders, particularly regarding 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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