



Energy Systems: Vulnerability – Adaptation – Resilience (VAR)

2009

Regional Focus: sub-Saharan Africa

Tanzania



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This project is supported in part with funding from:



**Mission d'Appui à l'Action
internationale
des Organisations non
Gouvernementales**

and

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On behalf of
Federal Ministry
for Economic Cooperation
and Development

Executive Summary

In Tanzania biomass is the main energy source. Because of high electricity tariffs, it is used primarily for cooking purposes both in urban and rural areas regardless of household's level of electricity access. While hydro contributes for about 60% of the total electricity generation, the country imports 100% of its petroleum and related products. Tanzania's dependence on climate sensitive energy sources (hydro and biomass) and its need to import petroleum makes the country vulnerable to drought and the volatility of global petroleum prices. Because of these factors—and despite of low consumption rates—Tanzania's electricity supply does not meet current demand levels.

Tanzania's power demand is expected to increase between 11%-13% over the next several years primarily due to urbanisation, population growth and an improved standard of living, all which will push communities higher up the energy ladder. From 1990-1998 demand for electricity increased by 4.45% and rose by 8% from 2003-2006 despite a prolonged period of power shedding due to drought and insufficient rainfall for hydropower reservoirs. Studies show that the demand for electricity is expected to increase from 925 MW to at least 3800MW by 2025.

Climate changes will also affect Tanzania's energy supplies. Studies show that temperatures will increase in many parts of the country and that rainfall will decrease. Reduced water flow in Pangani River (where three dams are situated) will affect electricity production. The largest three hydro dams are fed by rivers originating in areas which receive unimodal rainfall, which is expected to decrease by as much as 20% by 2100. Insufficient rainfall, increases in temperature coupled with other stress such as population growth and expansion of agricultural activities will increase competition over water resource and will impact electricity generation. Vulnerabilities in electricity importation include factors that extend beyond national control such as regional political instability, national willingness and the price fluctuations.

Tanzania has abundant renewable sources of energy: wind; solar; geothermal; and natural gas. Harnessing these resources will enhance energy resilience. The country should therefore take concrete steps to ensure the availability of affordable and reliable sources of energy in order to fuel the development and attainment of Millennium Development Goals (MDGs).

To increase energy resilience, both policy and measures should be put in place and should include:

- developing untapped mini hydro
- incorporating projected climate conditions in energy demand forecasting
- increasing transmission voltage
- enhancing the scale-up of efficient improved cook stoves
- promoting renewable energy sources
- having in place emergency energy repair plans
- recognising the economic value of water and equitable sharing of benefits
- funding research and development.

Table of Contents

Executive Summary	2
Table of Contents	3
List of Acronyms	4
Reporter Biography	5
Country Overview	6
General Description	6
Social-Economic Conditions	7
Economy	7
Privatisation and Globalisation	7
Food Supply	8
Income Gap	8
Public Health	8
Corruption	8
Environment	8
Country Statistics	9
Key Vulnerabilities	10
General Vulnerability Indicators	11
Environment	11
Economic	12
Technical	13
Social	14
Civic/Governance	14
Energy Situation	15
Current Situation	15
Primary Fuel Sources	15
Energy Demand	16
Energy Supply Situation	18
Legislative and Regulatory Changes	19
Energy Mix	20
Energy Systems	21
Hydropower	21
Natural Gas	21
Solar and Wind	22
Coal	22
Petroleum	23
Energy System Vulnerability	25
Energy system resilience	27
Recommendations and Policy Measures	29
Recommendations	29
Policy and Measures	31
Bibliography	34

List of Acronyms

AIDS	Acquired Immune Deficiency Syndrome
ASDP	Agriculture Sector Development Program
CEEST	Centre for Energy, Environment and Technology
CIA	Central Intelligence Agency
EARO	Ethiopian Agricultural Research Organisation
EWURA	Energy and Water Utilities Regulatory Authority
GDP	Gross Domestic Product
HIV	Human Immunodeficiency Virus
IPPs	Independent Power Plants
IPTL	Independent Power Tanzania Limited
IUCN	International Union for Conservation of Nature
LPG	Liquefied Natural Gas
MCL	Mwananchi Communication Limited
MDG	Millennium Development Goal
MKUKUTA	Mpango wa Kukuza Uchumi na Kupunguza Umasikini Tanzania
MW	Megawatt
NAPA	National Adaptation Program of Actions
NSGRP	National Strategy for Growth and Reduction of Poverty
PCCB	Prevention and Combating Corruption Bureau
PSMP	Power System Master Plan
PSRD	Parastatal Sector Reform Commission
RC	Regional Commissioner
REA	Rural Energy Agency
SIDA	Swedish International Development Agency
TANESCO	Tanzania National Electric Supply Company
TIC	Tanzania Investment Centre
TPDC	Tanzania Petroleum Development Corporation
UNFCCC	United Nations Framework Convention on Climate Change
URT	United Republic of Tanzania
USD	United States Dollar
°C	Degree Celsius

Reporter Biography



Mr. Damian Casmiri is a Programme Officer with Environmental Protection and Management Services (EPMS) on climate change and clean development mechanism (CDM) issues. He is the coordinator of the CDM related activities implemented under the CD4CDM programme supported by Dutch Government through UNEP Risø-Denmark. Damian has participated in the preparation of more than seven renewable energy PINs under CD4CDM.

Damian has worked with SouthSouthNorth to identify potential CDM candidates for Tanzania. With the support of International Institute for Environment and Development (IIED-UK) he also helped prepare reports on the economics of climate change in Tanzania and vulnerability of Dar es Salaam city to climate change impacts. Damian has attended various international meetings including Bonn II and III (2009) climate change talks under UNFCCC as an assistant to Least Developing Countries (LDCs) negotiators on mitigation issues.

Damian holds a Masters Degree in Integrated Water Resources Management from the University of Dar es Salaam (2007) and a first Degree in Environmental Sciences and Management from Sokoine University of Agriculture (2004). He has taken courses at Imperial College – London and University of Kwazulu Natal, South Africa on various issues as they relate to climate change.

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Country Overview

General Description

Tanzania is the largest country in East Africa in terms of size and population (TIC, 2007). It is bordered by the Democratic Republic of Congo, Rwanda and Burundi on the West, Zambia, Malawi and Mozambique on the South, Uganda and Kenya on the North and the Indian Ocean to the East. The country lies between meridians 30°E and 40°E and parallels 1°S and 12°S.



Source: www.infoplease.com/atlas/country/tanzania.html

Tanzania has a total area of 945 000 km² (which includes Zanzibar of approximately 2000km²). About 62 000km² of the land area is covered by water, including three fresh trans-boundary lakes of Victoria, Tanganyika & Nyasa/Malawi. Woodlands accounts for 33 500km² and arable, land suitable for agriculture is concentrated in the central part of the country, covering 44 million hectares.

According to Ministry of Agriculture and Food Security (URT 2006a), only 10.1 million hectares of arable land is under cultivation. The main crops grown for export purposes include coffee, cotton, cashew nut, sisal, tea and tobacco. Crops for local consumption (and grown throughout the country) include maize—a staple food for the majority of the population—sugar cane, rice, beans, bananas and a variety of fruit.

Agriculture¹ is the main economic activity employing 80% of the population and contributes about 44.7% to the GDP (URT, 2006b) and makes up approximately 66% of merchandise exports. However areas suitable for irrigated agriculture is under utilised. Currently, only 150 000 hectares are under irrigation and operated by both government institutions and small scale farmers.

Tanzania has the third highest population of livestock in Africa after Sudan and Ethiopia. Over 90% of the livestock population are indigenous which have low

¹ This includes crops, livestock, forestry & hunting and fishing.

genetic potential (URT 2006c). A total area of 60 million hectares are rangelands and are used for grazing 18.5 million cattle, 13.1 million goats, 3.6 million sheep, 1.2 million pigs and 30 million poultry. About 70% of the total livestock are raised in semi arid areas.

According to 2002 census (URT, 2002), Tanzania's population was 34 443 603 of which 16 829 861 were male and 17 613 742 were women. The rural population was measured at 26 500 042 with 7 943 561 people living in urban areas. In 2002 the population growth rate was 2.6% (URT, 2008) it increased to 2.9% by 2008, increasing Tanzania's population to approximately 40 000 000 (Lusekelo, 2008).

Tanzania has embarked on the expansion of primary and secondary education together with non formal education which has improved literacy levels. For instance in 2006, 70.5% passed the primary school leavers' certificate examinations exceeding the NSGRP target of 60%². In 2004 the literacy rate was 80% and 67.3% for male and female respectively.

The rate of urbanisation is estimated at 4.2% per annum for 2005-2010. In 2002 the urban population was 23% of the total population (URT, 2002) increasing to 25% by 2009 (CIA world fact book).

Social-Economic Conditions

Economy

The economy growth fluctuates year to year depending on several factors, the key being rainfall and drought levels. Due to its dependence on rain fed agriculture as well as hydropower—the main source of energy for many industries—the economy is adversely affected in drought years. From 1993-2002 the GDP increased steadily until 2003 when it dropped from 6.2% (2002) to 5.7%. In 2006 it dropped again from 6.7% (2005) to 6.2 % due to drought conditions.

Privatisation and Globalisation

In order to facilitate privatisation, the government formed Presidential Parastatal Sector Reform Commission (PSRC) which was given the mandate to privatise nearly all of its estimated 400 state-owned enterprises, including the energy companies. The Tanzanian Petroleum Development Corporation (TPDC) which used to import oil ceased to enjoy its monopoly in 1997. TANESCO was also to be privatised but there was a change in policy and it remains a state-run enterprise.

Like many countries, globalisation has brought new challenges to the country socially, economically and culturally. As a result of globalisation, privatisation and a free market economy have grown in Tanzania over the past ten years with both positive (increase in foreign investment; privatisation of parastatal companies) and negative (worker lay-offs) effects.

² Research and analysis working group of the MKUKUTA monitoring system, 2007

Food Supply

Ensuring sufficient food availability at the household and national level has remained a challenge primarily because of the limited role of mechanised technology and a dependency on rain-fed agriculture. Climate-related problems such as droughts/floods are likely to continue putting the majority of the population living in the affected areas at the risk of starvation. When there is sufficient rainfall food production can meet the country's demand. This illustrates that investment in irrigated agriculture would allow the country to collectively produce enough food to support itself and allow excess production to be exported.

Income Gap

The income gap between urban and rural dwellers and between men and women remains wide. While the majority of rural households (about 75% of the total population) depend on traditional rain-fed agriculture those in urban areas have a wider choice of income generating activities which are independent of weather conditions.

Public Health

Accessing better health services is difficult in rural areas where health centres are scarce and often located very far from households. Despite services which are offered free of charge, e.g. maternal and child care (under 5 years), treatment for T.B, HIV/AIDS and related complications, health care costs are still prohibitive for much of the population. Malaria and HIV/AIDS has continued to claim lives of Tanzanians although various initiatives are in place to address the problem.

Corruption

Like other countries, corruption is a challenge in Tanzania. The number of corruption cases reported to the Prevention and Combating of Corruption Bureau (PCCB) increased from 1224 (2000) to 3123 (2005) (Research and Analysis Working Group, 2007).

Environment

Tanzania is facing a serious challenge in balancing the goals of maximising social well-being through efficient and sustainable use of resources while at the same time minimising environmental damage. A national analysis (URT, 1997) identified about six major environmental problems which need immediate attention and include: deforestation, environmental pollution, land degradation, loss of wildlife habitats and biodiversity, deterioration of aquatic systems and lack of accessible, potable water for both urban and rural residents.

Climate change has been identified in Tanzania's National Adaptation Program of Actions (NAPA) as a new emerging challenge that will affect the country severely due to the country's dependence on the use of natural resources, rain fed agriculture, hydro power and biomass for household (URT, 2007a)

Scenarios reveal that mean daily temperature will rise by 3.5°C throughout the country, predominately during the cool months of June, July and August (URT, 2003a). Trend analysis results for the period 1961-2005 shows a significant increase in the mean annual temperature of 0.1°C to 1.8°C throughout the country (Matari et al, 2007).

Country Statistics

Basic Statistics	Year	Unit Value
Physical area		
Area of the country	2008	945 000Km2
Cultivated areas (arable land and area under permanent crops)		
--as % of the total area of the country.		6%
Arable land		44mil ha
--area under permanent cultivation for domestic use.		N/Aha
--area under permanent cultivation for export.		N/A ha
Population		
Total population	2002	34 443 603 Inhabitants
--% of which is rural.		77%: mainland 60%: Zanzibar.
--% of which is under 5 years old.	2002	18.25%
Population density	2003	39 Inhabitants /km ² *
<i>*This is the average figure, in urban areas the number is higher</i>		
Economically active population (15-64 years)	2002	17 910 674 Inhabitants
--as % of the population	2002	52%
--female (%)	2002	52.91%
--male (%)	2002	50.74%
Population economically active in agriculture	2001	13 363 833 Inhabitants
--as % of total economically active population.		79%
--female (%)		52.9%
--male (%)		47.1%
Economic and Development		
Gross Domestic product (GDP)		12 010 Mil USD/year
Value added in agriculture (% of GDP).	2003	43.4 %
GDP per capital	2005	744USD/year
Balance of trade (USD)	2005	-946.3 million
--% change from 1990 to current year.		-1.147%
Human Development Index (and ranking)	2005	0.467 (159)
Human Poverty Index (and ranking)	2004	32.5 (67)
Environmental Sustainability Index	2002	48.1
GHG Emissions (without land use change)	2005	0.1tCO ² eq/capital
Access to portable water (less than 500 meters)	2006	Rural: 39% Urban: 82%*
<i>*This number excludes Dar es Salaam which is 71%</i>		
Infant mortality	2004	68 per 1 000.
Literacy		
--as % of population	2004	73.6%
--female (%)	2004	67.3%
--male (%)	2004	80%

Key Vulnerabilities

Rainfall patterns

Variation in rainfall will differ from region to region. Areas with bimodal rainfall will experience an increase of rainfall between 5%-45% while those with unimodal rainfall will experience a decrease of rainfall by 5%-15%. Of concern are those semi-arid areas that currently have unimodal rainfall such as Singida, Dodoma and some parts of the Shinyanga and Mara regions. Here livestock keeping is practised by pastoralists and reductions in rainfall will put more pressure on water availability for irrigation, livestock, domestic use, energy production, etc (Matari, 2007). Competition for water resources may lead to clashes between users.

Biomass dependency

Biomass accounts for about 90% of the total primary energy use. Biomass is used both in rural and urban areas because it is more accessible and cheaper than other energy sources. The rate of deforestation is alarming; it is estimated at a rate of 412 000 hectares per annum and will jeopardize the availability of future biomass sources.

Energy imports

Tanzania imports 100% of the petroleum and the related product used in the transport, industries and electricity generation. Price fluctuations on the world market have a large negative impact on the economy. Increasing cost in the transport and industry sectors has a “knock-on” effect on nearly all other sectors. Equally important, instability of the economy will negatively impact the importation of energy sources.

Lack of diversification of power sources

Biomass is the main energy source. It is used primarily for cooking purposes both in urban and rural areas regardless of household's level of electricity access due to high electricity tariffs. Dependence on hydro power for more than 60% of total electricity generation increases the country's vulnerability to climate change impacts, e.g. decreasing rainfall affects hydro production; increasing temperatures can affect certain biomass production.

Corruption

Corruption allegations in the energy sector have surfaced recently. The scandal concerned the procurement of an emergency generator to supply electricity to mitigate the 2006-2007 energy crisis (which was precipitated by a drought). If such corruption continues, potential energy investors may refrain from investing in the country, leaving Tanzania to struggle with an inadequate electricity supply.

General Vulnerability Indicators

Environment

Indicator 1: Change in rainfall patterns

Year	Rate	
1990	502mm	
2007	863.7mm	
1990 – 2007		% change = 72%

The value used is of Dodoma Region which was taken as a sample. In 2007 the highest amount of rainfall was recorded since 1990. The rainfall has been fluctuating from year to year.

Rainfall variation will be experienced across the country. In areas with bimodal rainfall patterns, rainfall will increase by 5%-45% while areas with unimodal pattern the rainfall will decrease by 5%-15%. In unimodal areas rainfall will increase during long rain seasons and becomes much less during short rains. Models suggest that by 2100 mean rainfall will increase in the North-eastern areas and decrease towards the West. Studies show that doubling concentration of carbon dioxide in the atmosphere will lead to increased rainfall in North-eastern highlands and a decrease in the Southern coast and in the Southern, Central and Western areas.

Indicator 2: Variation in temperature

Year	Rate	Change
1990	22.709°C	
2008	23.084°C	
1990 – 2008		% change=1.65%

The sample value is from Dodoma Region. Temperature variation will differ from one part of the country to another depending on the locality. The trends show the highest temperature increase will be expected in Zanzibar with the lowest increase will be in Tanga. Data from 1961-2005 shows that temperatures in Tanga and Zanzibar have increased by 0.5°C and 1.8°C respectively.

Economic

Indicator 1: Proportion of households acquiring access to electricity in the last two decades

Year	Rate	Change
1990	23%	
2004	11.1%	
1990-2004		11.1%-23%=-11.9%

This is the percentage of households with electricity supply (Mosha, 2006). The decrease in the percent of household with access to electricity may be reflective of the rapid increase of households, which is not proportional to the provision of electricity services.

Indicator 2: Level of increased energy autonomy

(a) Electricity generated using imported oil

Year	Rate	Change
1990	NA	
2001	39.35%	
2009	27.00%	
2001-2009		39.35%-27.00%=12.35%

The generation of electricity using imported fuel (s) has decreased due to the discovery of natural gas in the country. It is expected that the rate will keep on going down over the near future.

(b) Electricity imported from the neighbouring countries

Year	Rate	Change
1990	NA	
2001	1.08%	
2009	1.38%	
2001-2009		1.38%-1.08%=0.3

The amount of electricity imported has not changed significantly as parts of Kagera and Rukwa regions are still depend on the electricity imported from Uganda and Zambia respectively. The proportion of imported electricity is expected to increase as interconnection with Zambia and Kenya or Ethiopia via Kenya are developed.

Since 1990 structural change have enhanced the autonomy in energy sector. Allowing the private sector to import petroleum and related product as well as generate,

transmit and distribute electricity undermined TANESCO's monopoly. With liberalisation of the Tanzanian electricity market, investors may wish to generate electricity using locally available sources thereby reducing dependence on imported fuels.

Technical

Indicator 1: Change in the amount of energy supplied by renewables

(a) Proxy Indicator: proportion of natural gas used in total power production

Year	Rate	Change
1990	NA	
2000	72.76%	
2009	84.66%	
2000-2009		84.66%-72.76%=11.9%

Natural gas is used here as a proxy to show the increased use of cleaner energy which illustrates some progress.

(b) Proportion of natural gas as a source of energy

Year	Rate	Change
1990	0%	
2009	26%	
1990-2009		26%-0%=26%

This has been calculated as the contribution of natural gas in electricity generation. The contribution of natural gas in the energy sector as a whole may be higher than this because of fuel switching in some industries. Moreover natural gas is now being used for cooking purposes in some areas of Dar es Salaam.

Indicator 2: Level of diversity of renewable energy sources and technologies

Year	Rate	Change
1990	NA	
2001	60.65%	
2009	85.73%	
2001-2009		85.73%-60.65%=25.08%

The percentage of renewable energy sources is calculated as the percentage of electricity generated using other sources other than oil. Biomass is used widely in domestic for heating purposes especially cooking.

Recently renewable energy sources have been used as a source of energy compared to the past. Natural gas is being used in generation of electricity, in industries, domestic and soon it will be used in vehicles after the inauguration of a compressed natural gas plant in Dar es Salaam in July 2009. Solar technology is being promoted in the country and it is being used widely in rural areas for various activities such as re-charging mobile phones, etc.

Social

Indicator 1: Change in prevalence of diseases

Year	Rate	Change
1990	43.56%	
2002	21.75%	
1990-2002		21.75%-43.56%=-21.81%

Here malaria was taken as a prevalent disease. The percentages of the two years were taken as the number of reported malaria cases to the total population.

Indicator 2: Change in employment

Year	Rate	Change
1990	N/A	
2000	12.9%	
2006	11.7%	
2000-2006		11.7%-12.9%=-1.2%

This table is based on the percentage of working age population not currently employed

Civic/Governance

Indicator 1: Land reform improvement

Year	Rate	Change
1990	Na	
2000	Urban: 16%	
	Rura19.2%	
2007	Urban: 14.5%	
	Rural:21.6%	
2000-2007	Urban	14.5%-16%=-1.5%
	Rural	21.6%-19.2%=2.4%

This is the percentage of households who own their land through official and owner-held certificates

Indicator 2: Change in public participation in planning process

This is still limited. However with the establishment of Energy and Water Utilities Regulatory Authority (EWURA) various stakeholders are normally consulted before adjusting energy tariffs.

Energy Situation

Current Situation

Coal, petroleum and hydropower are Tanzania's main sources of commercial energy. Solid biomass energy such as forest/agro residues and wood fuels—used throughout the country—accounts for 90% of total energy consumption while modern commercial energy contributes less³. Of the 21 mainland regions, Dar es Salaam region has the greatest access to electricity, however less than 50% of all households in the region are connected. Only 18 districts out of 118 districts identified in Tanzania's 2002 population and house census have more than 20% of households with electricity access

While rural dwellers depend on biomass as their source of energy, populations in urban areas depend on both electricity and biomass. Biomass—especially wood charcoal—continues to be the main source of energy for cooking purposes in urban area (about 80%) despite the high level of electricity access. The reason is that majority cannot affordable to pay for electricity bill due to low incomes and high tariffs. The annual, national consumption of charcoal is approximately 950 000 tonnes (URT, 2004). Despite low electricity consumption, supply is still unable to meet demand. This shortfall is attributed to the country's dependence on hydropower which in turn is affected by climate variation and climate change.

The power demand is expected to increase between 11%-13% over the next several years, due primarily to urbanisation, population growth and an improved standard of living.

Primary Fuel Sources

The primary sources of energy are as follows:

Table 2: Primary Fuel Sources

Source	Composition (%)
Petroleum	7
Electricity	1.4
Renewable (solar, wind, etc)	1.3
Biomass	90
Others (e.g. coal)	0.3
Total	100

Source: Sawe, 2008

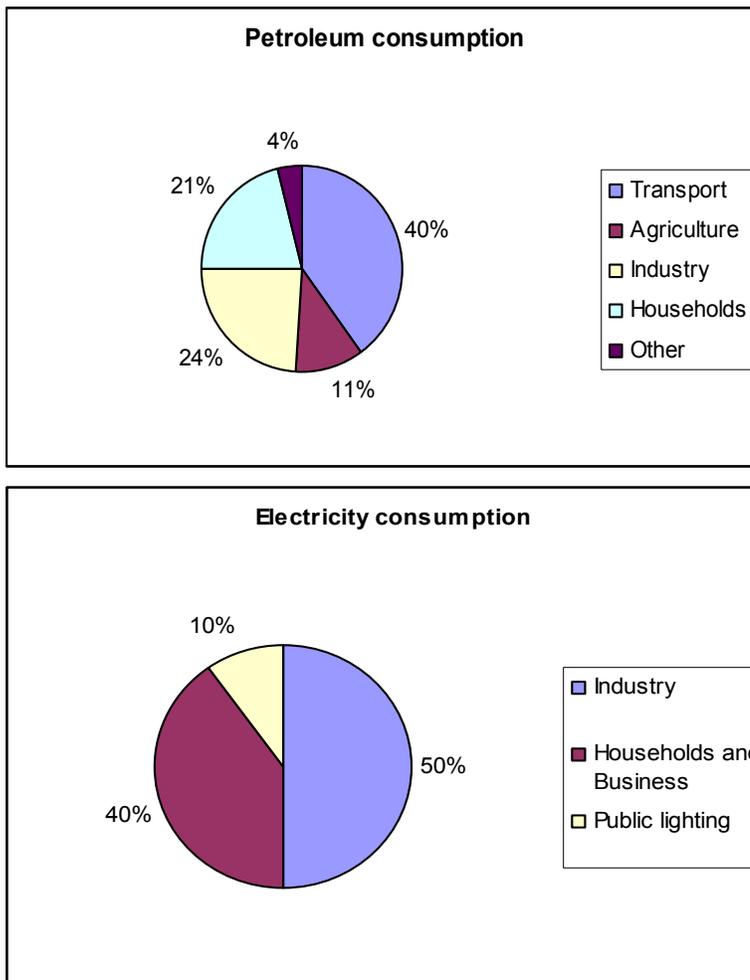
³ Electricity = 1.4%; petroleum= 7%; others = 1.6%

Energy Demand

The current level of energy demand and supply in Tanzania signifies low level of development in industry sector. Transport, commerce, industry and urban households depend to a considerable extent on energy sources such as electricity and petroleum products which are either imported or generated in the country. The traditional segment of the economy, mainly rural households and small scale industries depend on biomass as the main source of energy. Urban dwellers also depend on biomass (charcoal and firewood) as a source of energy for cooking purposes despite the fact that a large number of households have access to electricity.

The demand for electricity is growing at a fast rate. From 1990-1998 demand for electricity rose by 4.45%. Demand rose by 8% from 2003-2006 despite a prolonged period of power shedding due to drought and insufficient rainfall for hydropower reservoirs. According to Msaki (2006), the demand for electricity is expected to increase from the value of 925MW to at least 3800MW by 2025.

Figure 1: Petroleum and Electricity Consumption



Source: Uisso, 2005

Household

For years, households have been a large consumer of energy specifically for heating purposes. Biomass (firewood and charcoal) has been used as the main source of energy for cooking purposes. The percentage of rural and urban households using alternative sources of energy is less than 10%. Due to improved standard of living, many people at the household level are trying to move upward in the energy ladder to use more safe, accessible and clean sources of energy such as electricity and Liquefied Petroleum Gas (LPG). Kerosene has been used and is still used in rural areas for lighting purposes and the demand is expected to increase more.

Transport

In Tanzania petroleum is the main energy source used in the transport sector and is imported from Middle East⁴. Owing to the growth of transport sector, only 70% of the total petroleum demand is met at present. Apart from this growth the high demand for petroleum is contributed by low fuel efficiency of most cars (due to age and poor maintenance, which affects vehicle fuel efficiency) as well as traffic congestion (which increases unnecessary fuel consumption)

Industry

Industrial growth has lead to an increased demand for electricity and other energy sources such as natural gas, heavy fuel oils and coal. The demand for oil and coal has started to decline while the demand for natural gas which is clean and cheap is increasing. Recently more than 20 industries in Dar es Salaam have switched from oil to natural gas. Information from TPDC shows that the demand for natural gas in industries is increasingly annually⁵. Tanzania's energy master plan projects that demand for electricity in the industry sector will grow at an average of 2.6 % annually between 2010 and 2030.

Agriculture

The demand for conventional energy in agriculture sector is very low due to the low level of technology employed. Energy from human and animals remains the main energy input. Diesel and solar contribute a minor amount to total energy demand. The demand for diesel is expected to grow in the near future as the use of agricultural equipment increases in response to government agricultural sector reforms such as Agricultural Sector Development Program (ASDP).

Mining

The mining sector consumes a significant amount of grid distributed electricity as well as electricity produced from diesel generators. As this sector grows more energy will be needed to meet demand. Unfortunately most of the mining sites are in remote location where the natural gas supply is limited. With natural gas being economically unviable there will be increase pressure on fossil fuel- and hydro-generated electricity.

Commercial sector

According to the national energy policy (URT, 2003b), the commercial sector accounts for only 6% of the national commercial energy consumption and 1% of the

⁴ About 40% of all imported petroleum is used in this sector

⁵ <http://www.tpdc-tz.com/NATURAL%20GAS%20DEVELOPMENTS.pdf>

total energy. The sources of energy are from biomass (wood and charcoal), petroleum and commercial electricity.

Energy Supply Situation

Until 2008 the role of generation, transmission and distribution of electricity was vested under the government owned company, Tanzania National Electric Supply Company (TANESCO). Private companies (Independent Power Plants- IPPs) were allowed to generate electricity from various sources such as coal, natural gas and diesel and sell it in bulk to TANESCO for distribution. With liberalisation and amendment of energy law, private companies are allowed to generate and distribute electricity to end users. Tanzania imports 5MW-10MW of electricity from Uganda and Zambia to supply regions which are not connected to the national grid.

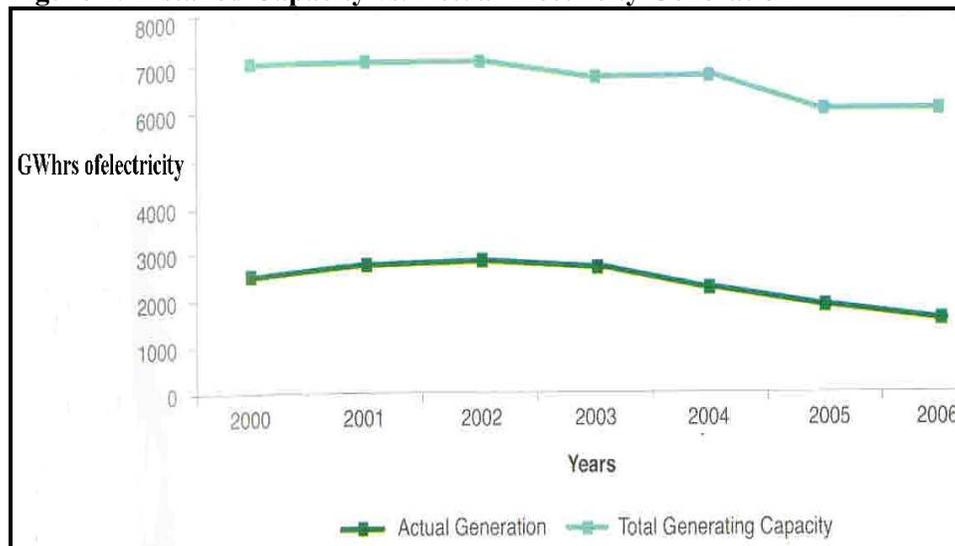
Electricity

TANESCO owns transmission lines of different voltage capacities across the country: 2624.36km of 220kV, 1441.5km of 132 kV, and 486km of 66kV making a total of 4551.86 km as of 2006. The transmission system faces problems including vandalism of towers and voltage loss due to deterioration of the transmission system. Distribution infrastructure faces even greater challenges including the theft of transformer oils and conductors, meter tempering, and illegal connections.

About 60% of total electricity generated comes from hydropower plants (Kidatu-204 MW, Kihansi-180 MW, Mtera-80MW, New Pangani Falls-68MW, Hale-21MW and Nyumba ya Mungu-8MW). In 2001 the hydropower contributed about 97.5%. Levels dropped precipitously to 50% in 2005 and then to 30% in 2006 due to severe drought conditions. The result was a high level of load shedding across the country.

Some parts of the country are supplied with electricity from isolated grids as well as from Uganda and Zambia. As illustrated in the figure below actual electricity generated is far below the installed capacity of the plants.

Figure 2: Installed Capacity vs. Actual Electricity Generation



Source: Research and Analysis Working Group, URT, 2007

Natural gas

Natural gas reserves are found in the Southern part of Tanzania and are expected to become a reliable and economical source of energy to replace coal and petroleum, particularly in the electricity and industry sectors. The gas is extracted from Songosongo and Mnazi Bay. It is then transported by pipeline (about 232 km) from Songosongo to Dar es Salaam by the Songas company under agreement with Tanzania Petroleum Development Corporation (TPDC). After being processed the gas is transported through a 25km, 12 inch pipeline to Somanga Funga and from there through a 207km, 16 inch pipeline to Ubungu, Dar es Salaam. From Dar es Salaam the gas is distributed to various users including industries and gas- power plants. There is no serious sabotage or vandalism which has been reported apart from demands to electricity access from those communities through which the pipeline passes.

Petroleum

Imported petroleum and related products are widely used in the transport and industrial sectors. It is also used to generating electricity in isolated grid-diesel power stations that have an installed capacity of 33.8 MW⁶ and are located in Mtwara, Lindi, Songea, Masasi, Tunduru and Kilwa Masoko, Kigoma, Mpanda, Ikwiriri, Mafia, Ngara, Biharamulo, Njombe and Liwale. Petroleum and related by-products are imported and distributed by private companies regulated by EWURA which controls the price and standard.

Coal

Coal is found in Kiwira and Mchuchuma and has been used in limited quantities for electricity generation as well as in some industries such as cement factories. Low coal consumption is due to part to huge investment costs and the quality of the coal itself.

Legislative and Regulatory Changes

Since 2001, various changes have been observed in the energy sector ranging from new laws to the establishment of authorities to ensure that energy remains affordable and accessible for the majority of the population. Significant achievements, among others, were the establishment of Energy and Water Utilities Regulatory authority (EWURA) which is the “energy watch dog” and the creation of the 2008 Electricity Act which broke up TANESCO’s monopoly. Key legislative changes are noted below.

Energy and water utilities regulatory authority Act of 2001

The act established a regulatory authority in relation to energy and water utilities known as “Energy and Water Utilities Regulatory Authority (EWURA)”. The authority is responsible for technical and economic regulations of the electricity, natural gas, petroleum and water sectors in Tanzania. Its function includes tariff review, licensing, monitoring performance and standards with regard to quality, health, safety and environment.

⁶ in 2006 the average was 17.5 MW due aging equipment

The National Energy Policy of 2003

This replaced the policy of 1992 which dealt with market mechanisms and means to achieve efficient energy sector, balancing national and commercial interests. Policy objectives include ensuring the availability of reliable and affordable energy supplies and their use in a rational and sustainable manner in order to support national development goals.

Rural Energy Act of 2005

This Act established a rural energy board, fund and agency responsible for promoting improved access to modern energy services in Tanzania's mainland rural areas. Through a fund the agency board provides grants and subsidies to developers of rural energy projects.

Rural Energy Agency

Established in 2007, the Rural Energy Agency (REA) promotes and facilitates improved access to sustainable modern energy services in rural areas of Tanzania mainland.

Electricity Act of 2008

The act provides for facilitation and regulation of generation, transmission, transformation, distribution, supply and use of electric energy as well as providing cross-border trade in electricity, and regulation of rural electrification.

Petroleum Supply Act of 2008

The act provides for regulation of importation, transportation, storage, distribution, sale and use of petroleum and petroleum products.

Energy Mix

Tanzania's energy mix is composed of hydropower, gas turbine and oil. The following table shows installed grid generation capacity of 939MW⁷ with hydro providing 61%, oil 27% and natural gas 12%.

Table 3: Electricity Generated by Sources

Energy Source	Plant	Installed capacity (MW)
Hydropower	Kidatu	204
	Kihansi	180
	Mtera	80
	New Pangani Falls	68
	Hale	21
	Nyumba ya Mungu	8
Natural gas	Songas	182
	Aggreko	40
	Dowans holdings	22
Oil	IPTL	100
	Dowans holdings	34
Total		939

Source: TANESCO, 2009

⁷ Figures as at 31st December 2006

Energy Systems

Tanzania's energy system is made up of biomass, coal, natural gas, hydropower, oil, wind and solar. The percentage contributed by coal, natural gas and oil has changed annually because of reforms and the investment in the energy sector. Due to availability of natural gas in the country, oil generators have been switched to natural gas. There has also been an increase in coal generated electricity in the Southern part of Tanzania. Currently the actual percentage contributed by the each source is not easy to establish. For instance in 2005 the ratio of hydro to thermal was 60:40 but in 2007 the ratio changed to 51:49 (EWURA, 2009).

Table 4: Estimated Contribution of Energy Sources to Electricity Production (in MW)

Source	Potential capacity (MW)
Oil	450
Coal	>600
Gas	>500
Hydro	4700
Renewable (biomass, solar, wind)	>200

Source: http://www.zjfdi.com/UploadFiles/aaf001200751084519_2.pdf

The power system is composed of both interconnected and isolated grids. The national grid is made up of hydro and thermal plants that use either diesel or natural gas fuel. Thermal power plants—connected to the grid—have been treated as peak power plants to supplement hydro that has been providing the normal base load.

Hydropower

Hydropower currently contributes more than 60% of the electricity currently generated. Given that supply is not meeting demand, deliberate efforts need to be taken to diversify other sources. Large areas are supplied with power from hydro stations include Nyumba ya Mungu, Hale, Kidatu, Mtera, New Pangani falls and Kihansi. Large reservoirs are located at Nyumba ya Mungu, Mtera and Kidatu with storage capacity of 4200million cubic metres while Hale, Pangani Falls and Kihansi have three head ponds with a total capacity of 2.26million cubic metres. The refilling of these reservoirs depends on the availability of sufficient rainfall from various basins including Rufiji and Pangani basins. The contribution of hydropower to the energy mix varies according to climatic conditions, specifically drought (Msaki, 2006). Competition with irrigation and livestock for upstream water sources as well as environment degradation in the catchments areas are addition challenges to hydropower sector.

Natural Gas

Tanzania has abundant natural gas reserves in coastal basin that estimated at 45 billion cubic metres (TIC, 2007). Significant gas discoveries have also been made on the coastal shores of Kimbiji, Mnazi Bay and Songosongo Islands. The gas from Songosongo is transported by pipeline to Dar es Salaam where it is distributed to

electricity generation plants and industries. Industries with access to natural gas have fuel switching from Heavy Fuel Oil (HFO), diesel and coal.

Gas supplied to the Songas gas power plant in Dar es Salaam—the largest gas fired plant in East Africa—generates about 190 MW of electricity. This is fed into the national electricity grid and distributed to end users by TANESCO. TANESCO has recently started operations using gas to generate about 100MW

In Mtwara the same gas is extracted by Artumus company and is used to generate electricity (Mtwara Energy Project, 18MW) that supplies the Southern parts of Tanzania which has an isolated grid (Mtwara and Lindi Regions). Gas generation has replaced diesel generators.

Solar and Wind

Solar and wind have not been utilised fully as energy sources event though Tanzania being one of the solar belt⁸ countries. Despite the huge solar potential, solar energy has predominately been used only for drying process. In the recent years solar PV technology has been promoted as an energy solution especially in rural areas where there is no access to the national or isolated grids.

Equally, wind energy has not been utilised; its main application over the last forty years has been to pump water. Despite the significant (anticipated) potential wind energy limited research has been carried out and data is not easily available. Recently, Power Pool East Africa and Wind East Africa companies have carried out a feasibility study in the Kesikida in Shinyanga region and found that the electricity generating potential via wind is 500MW (MCL,2009).

Table 5: Sample of Estimated Wind Speeds

Region	Speed (m/s)
Tanga	6.3
Mtwara	5.7
Dar es Salaam	5.4
Mbeya	5.4
Mwanza	4.9
Lindi	4.6
Ruvuma	4.5
Mara	4.3

Source: http://regionalenergy-net.com/index.php?option=com_content&task=view&id=36&Itemid=34

Coal

Coal is another source of primary fuel available in Tanzania. It is estimated that the country has some 1200 million metric tons of coal. The Kiwira coal mine supplies between 4-6 MW of electricity to the grid annually. Current plans are to produce more power so as to curb power shortages especially during drought seasons when hydro plants are affected. About 1.5 million tones/year are expected to be mined at the Mchuchuma coalfield where a 400MW thermal power plant will be built in an effort

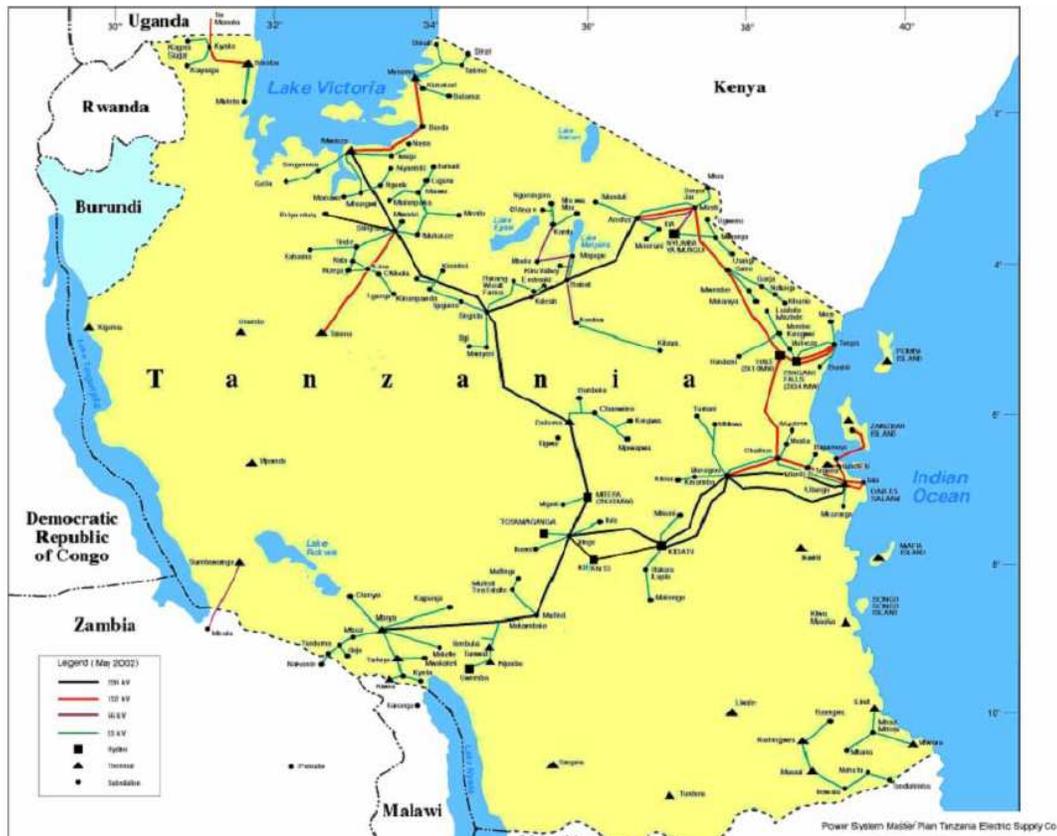
⁸ This refers to countries with 2800-3500 hours of sunshine per year and a global radiation of 4-7kWh/m²/day.

to increase the reliability and security of grid power. Apart from grid electricity generation, coal is used in some industries such as in cement manufacture.

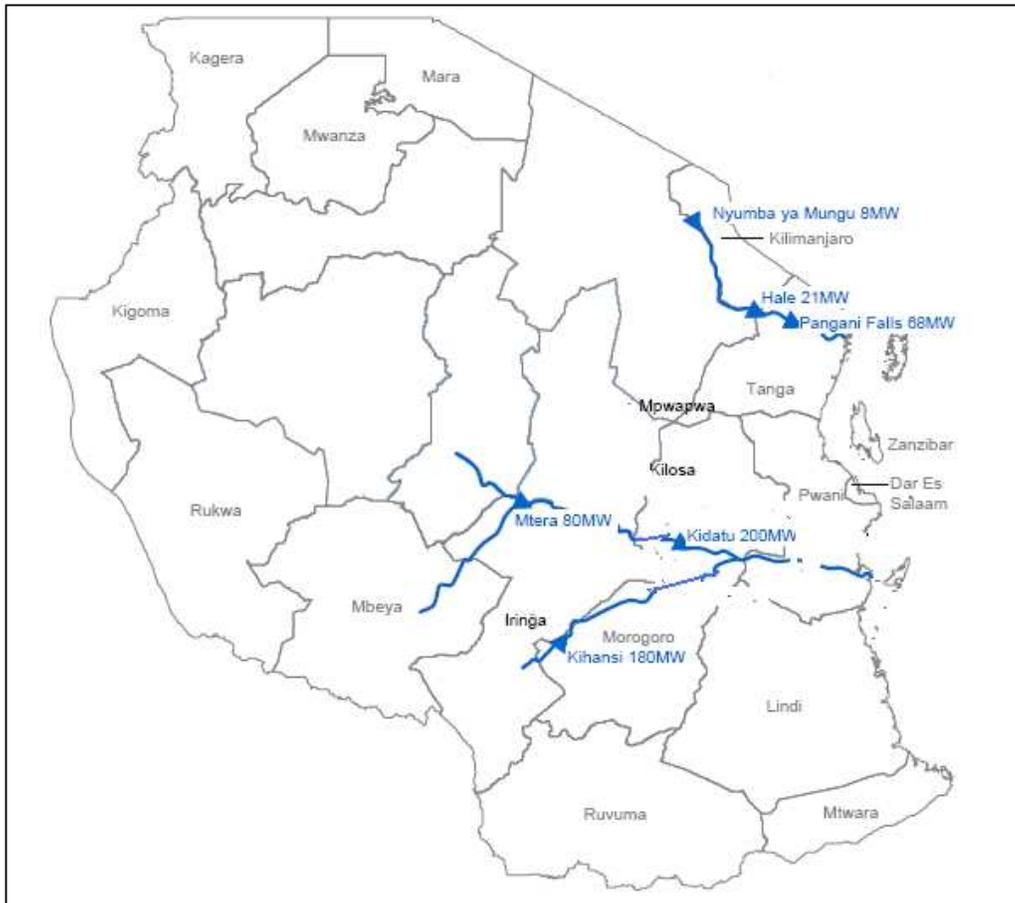
Petroleum

The consumption of petroleum and the related products in Tanzania is about 1.54 million cubic metres annually. Petroleum is imported from Arabian Gulf, Durban and the Mediterranean region. Most of the petroleum depots are in Dar es Salaam near the Dar es Salaam harbour. From Dar es Salaam petroleum is transported to up-country regions via trunk roads and some areas by railways. Thus for the country to have access to petroleum products, infrastructures i.e. roads and railways should be passable throughout a year regardless of climatic conditions. Flooding in rural areas poses a threat to the transportation infrastructure.

Figure 3: Major Energy Installations in Tanzania



Source: URT, 2008b

Figure 4: Major Hydropower Installations

Source: McKinsey&Company, 2009, Economics of Adaptation, Case study of Tanzania (adapted by author)

Energy System Vulnerability

Vulnerability Indicator	Calculation
Coal	
1. Number of coal mines plants located at less than 1m above sea level and within the area that could be flooded by a flood within a current recurrence period of 100 years. <i>All coal mine plants are located at least 1m above sea level.</i>	0
Oil and gas	
1. Share of offshore oil and gas installations likely to be hit by a storm of more than 70m/s gusts within the next 20 years (%) <i>Although there are currently no installations there are approximately 15 companies conducting oil and gas exploration mostly along the coastal area. All oil deposits are close to the coastline.</i>	0
2. Share/number of refineries likely to be hit by a storm of more than 70m/s gusts within the next 20 years (%) <i>The refinery is not currently operating – it is located close to the coast.</i>	1
All fossil fuels	
1. Number of thermal (coal, oil and gas) power plants located at less than 1 m above sea level and within the area that would be flooded by a flood with a current recurrence period of 100 years. <i>All plants are located at least 1m above sea level.</i>	0
Hydro	
1. Expected precipitation change over the next 20-50 years (%) and/or probability of floods in each watershed. <i>Floods are expected in Rufiji basin where Mtera and Kidatu dams are situated</i>	5%-45% increase 5%-15% decrease.
2. Number of multiple-use dams in the country today.	6
--volume of water (m3) of each dam	Kihansi = 1.6M Mtera = 3200M Nyumba ya mungu = 875M Hale= 1.8M Kidatu = 125M
2b. % of water used for --agriculture --power --domestic	NA

Vulnerability Indicator	Calculation
Transmission and distribution	
1. Length of in country, above ground transmission and distribution lines (km).	5411
--high (transmission,220kV) in km	2986
--middle and low voltage lines (distribution, 132kV&66kV) in km	2525
2. Number and length of power cuts (due to drought) <i>This is data for 2006/2007</i>	12 per day
2b. Average hours of interruption per year	NA
3. Percentage of energy supply requiring regional transport over 50 km. <i>This is only for the natural gas transported from Songosongo</i>	25.082%
3b. % that is transportation of fossil fuel. <i>This is for the diesel-electricity generating plants</i>	3.474%
3c. % that is transportation of biomass.	NA
Biomass	
1. Proportion of biomass used for energy purposes (%) in total biomass production --agricultural biomass harvest --electricity. --heat <i>Some sugar factories are using biomass to generate electricity but there is no data on the amount used.,Bbiomass as whole contributes about 90% of total primary energy supply (URT, 2004)</i>	NA
2. Expected precipitation change over the next 20-50 years <i>Bimodal rainfall type will increase while unimodal will decrease</i>	5%-45% increase 5%-15% decrease.
Wind	
1. Number of wind tubes less than 1m above sea level. <i>Currently wind power is used for pumping water, situated more than 1 m above sea level</i>	0
2. Projected change of average wind speed in the next 20 years based on regional climate models.	NA

Vulnerability Indicator	Calculation
Solar	
1. Capacity of solar installations already in place (m ²)	
--PV (MW) --thermal (m ²)	1.7 0
2. Quality of the insulation and of the building on which systems are installed and type of ownership. <i>Solar PV is installed mostly in dispensaries, hospitals, offices and communication technology. Owners are both private and government.</i>	NA
3. Expected temperature increase in the next 20 years (°C relevant for PV capacity) <i>This is according to SCENGEN model predictions by 2030</i>	0.8

Energy System Resilience

Adaptation Indicator	Calculation
Implementation	
1. Domestic capital formation (million USD per year)	3768.408
--Proxy: Domestic Savings (million USD per year)	1533.6
2. Domestic investment in renewable energy (million USD per year)	N/A
3. Number of technical engineers graduating annually as a percentage of the total population. <i>The country produces about 500 engineers per year.</i>	0.0014
4. Availability of hazard maps for floods/droughts <i>This has been done by various institutions but most of them are area specific.</i>	0
5. Existence and enforcement of power plants siting and construction guidelines taking climate change into consideration. <i>Not yet in place. The plants will be affected especially during floods season due to the fact that the design will base on the historical flood records.</i>	0
6. Existence of emergency plans to react to meteorological extreme events and availability of local emergency repair teams. <i>The country has disaster and risk management unit (located in the Prime Minister's office at Dar es Salaam) to deal with emergence. The speed to respond to extreme events depends on the nature and location of the event. Non government organisations such as Red Cross play a role also.</i>	Yes

Adaptation Indicator	Calculation
<p>7. Domestic availability of insurance schemes.</p> <p><i>Insurance schemes are available in the country however access to this service by farmers and small businesses is very limited.</i></p>	Yes
<p>8. Existence of citizens' users groups in the energy governance structure (enforcement of participatory decision-making)</p> <p><i>Citizen's user groups exist but their role is limited.</i></p>	Yes
Coal, oil and gas	
<p>1. Existence and use of siting map for mines and power plants taking into account projected storms, floods and drought areas.</p> <p><i>Records of disasters is based on historical data, but there is no specific base year</i></p>	NA
<p>2. Implementation of national regulations for thermal power plant siting at sites with sufficient cooling water availability over the next 50 years.</p>	NA
Hydro	
<p>1. Existence of a national plan for optimised operation of hydro plants under projected flow regimes for systems.</p> <p><i>The power system master plan has identified all potential hydro sites as well as suggesting an implementation time line. The plan was released in 2008.</i></p>	Yes
<p>2. Number of dams equipped with desilting gates and/or number of up-stream land use management and water catchment plans for each hydro installation.</p> <p><i>Most of dams have spill over gates to prevent destruction during heavy rains. The government has taken stringent measures to protect catchments, including the removal of pastoralists who have invaded the catchment area as well as banning agricultural activities.</i></p> <p><i>The economic value for water used to generated electricity has been calculated in the PSMP.</i></p>	NA
Biomass	
<p>1. Research, development and dissemination budget for heat and drought resistant crops, bio fuels, agricultural waste for energy and vulnerability of forest (million USD/year).</p> <p><i>Budget figure not available but the government (through the ministry of energy and minerals together with other stakeholders) has conducted a baseline survey to review the current state of biomass energy activities as well as setting regulations on how bio fuel activities will be carried out.</i></p>	NA

Adaptation Indicator	Calculation
2. In country utilisation of biomass fuels not traditionally used by private enterprises and cooperatives (% of total fuels).	NA
3. % of households used improved woodstoves out of total number of households using woodstoves.	NA
Wind	
1. Existence and enforcement of national regulations requiring storm proofing of wind power plans to withstand highest anticipated wind speed. <i>Wind mills has been used in rural areas to pump water and there is no "system resilience enhancing" regulations.</i>	NA
2. Existence of siting maps that detail projected changes in: wind speed; flood plains; and areas impacted by sea level rise.	NA
Solar	
1. Existence of siting map that detail projected changes in cloud cover.	NA
2. Existence and enforcement of national regulation requiring storm proof concentrating solar power plants (CSP) to withstand the highest anticipated wind speed. <i>No existing enforcement and regulations are in place and may be due to the fact that the technology is not fully utilised in the country.</i>	NA

Recommendations and Policy Measures

Recommendations

To make the energy sector more resilient the government needs to implement ambitious strategies ranging from short-, to medium- term and long-term. Some recommendations are to:

- **Develop untapped mini hydro**

The country has a lot of untapped hydro potential which can generate electricity and be connected to national/isolated grids. With committed resources more than 700MW of electricity could be generated from the following sources: Ruhudji, Mpanga, Rumakali, Masigara, Kakono and Rusumo falls. The electricity from these mini hydro systems would supply electricity to areas currently not connected to the grid. Excess power can be connected to the grid if economically attractive.

- **Incorporate anticipated climatic conditions in energy demand forecasting**

The Power System Master Plan (PSMP) has forecasted electricity demand through to 2031, at which time 75% of Tanzanian households are anticipated to have access to electricity. To meet this demand, potential electricity sources were identified. A significant percentage will come from hydropower. These projections should also allow for climate uncertainties and account for changing water flows. The likely increase of competing water uses up-stream must also be taken into consideration.

- **Invest in coal, wind and solar energy options**

Unlike hydro, these sources are less directly affected by changing climatic conditions. Utilising the coal resources available to generate electricity will ensure the availability of electricity irrespective of climate conditions. The plant should be erected close to mining site so as to avoid costs associated with the transportation of coal as well as dependence on road infrastructure.

Wind and solar can augment energy access for those areas not connected to grid/mini grid. While wind energy is regionally specific, solar energy can be utilised nearly all over the country given Tanzania's location in the solar belt.

- **Import electricity from neighbouring countries**

This is of paramount importance for those areas where it is not economically viable to be connected to grid and especially so if neighbouring countries have excess electricity. Importing electricity from neighbouring countries can be a short-term solution to fill the gap in the energy supply and serve as a short term solution while seeking a lasting, sustainable solution.

- **Protect catchments areas**

Catchment areas are crucial in ensuring steady water flow for hydroelectric installation, particularly once the rainy season has passed. There needs to be serious and well coordinated joint effort involving other relevant sectors in the protection of these sources. Involving community stakeholders will help in setting priorities in water allocation.

- **Construct petroleum and gas pipelines to reach up-country regions**

Currently petroleum and related products are transported from Dar es Salaam to other areas of the countries via roads and railways. The availability of these goods in the up-country region depends heavily on adequate road conditions. Many roads are not passable during rain seasons, especially in rural areas. Cost associated with long distance transportation contributes to increase prices which in turn affects the productivity of other sectors.

Currently the natural gas from Songosongo is being transported via pipeline to Dar es Salaam. Extending the pipeline to other regions would allow gas to be used in industries and allow for fuel switching from fossil fuel. The gas could also used to generate electricity in the closer proximity to the end users instead of transmitting across long distance and incurring voltage loss.

- **Ensure energy efficiency**

The high demand for energy is in part due to inefficiencies in its end use. If end users adopted energy efficient technologies a significant amount of energy would be

conserved. Conservation will be particularly important when climate conditions negatively affect hydro power generation levels.

- **Increase transmission voltage**

Ideally the country should build a backbone transmission system using a higher voltage (such as 400kV) to minimise the amount of electricity lost in the transmission system.

- **Enhance the scale up of efficient improved cook stoves**

Since biomass energy represent a major share of the total energy consumption, rapid scaling up of efficient cook stoves is necessary. This is particularly important in rural communities where the traditional, inefficient “three stone fire” cooking places are still widely used.

Policy and Measures

In order to minimise energy vulnerability and enhance resilient, there are number of issues which need to be addressed at the policy level.

- **Promote renewable energy sources**

Apart being environmental friendly, renewable energy sources are inexhaustible if managed properly. The only form of renewable energy currently utilised widely is hydropower despite its initial huge investment costs. The country has a significant solar and wind potential, which if a conducive environment is created, can supplement the energy from hydro and other unreliable sources. A policy should be created that provides incentives to investors to invest in renewables. Such a policy could waive tax on equipment imports, assurance of soft loan both to investors and users. Although the government eliminated the import duty for all solar powered equipment and reduced the duty rate on all energy saving bulbs in the national budget for fiscal year 2007/2008, the impact has not been significant. However it is important to keep such incentives in place in order to ensure market penetration. The policy should also encourage the coordination of small projects to understand the barriers and opportunities to renewable energy deployment and put in place appropriate measures such as subsidising improved cook stoves to reduce pressure on biomass resources.

- **Scale-up small innovations**

Some pilot projects especially in the area of wind and solar have been developed in various parts of the country and the result have been promising. Wind mills have traditionally be used in many regions of Tanzania for water pumping. As of 2006, 76% of all wind mills were owned by local communities; the government owned only 8%. If resources were committed and supported by political will, micro wind turbines could be installed. Findings from Solar Project (implemented in Iringa, Tanga, Morogoro and Coast regions under the support of SIDA) should be well documented and replicated to other areas of the country.

- **Encourage participation of private sector**

There is a need to invite more private organisations to participate in the provision of energy especially electricity from generation, transmission and distribution to the end

users. Competition is needed to push diversification of energy sources, increase network coverage and lower prices.

- **Put in place functioning, energy emergency plans**

Since hydro power accounts for more than 60% of total electricity generation and is vulnerable to climate change, emergency plans to complement a decrease in electricity output (due to drought or other calamities) must be implemented. A proactive approach would reduce the need to load shed an event that adversely affects industry, services and households alike.

The policy should also encourage the establishment of national petroleum reserves to be used in case of price soaring in the world market or when the commodity has become scarce in the world market. This is of paramount importance given that 100% of petroleum and the related products are imported and play an important role in the economy.

- **Set clear, transparent and enforceable procurement procedures to combat corruption**

Corruption if unchecked increases the vulnerability of the energy sector. As large sums of money are involved and the procurement process lengthy there, enforcement of procurement regulations should be adhered to and heavy punishment should be imposed to those who don't adhere to the process.

- **Recognise the economic value of water and equitable sharing of benefits**

For a long time water has been treated as a free commodity. The economic value of the amount of water used to generate X MW of electricity should be calculated and known. It should be remembered that water used to generate electricity resides in catchment areas where local communities are either involved in the management of the sources or forgo some economic activities, e.g. water for irrigation, timber harvesting etc., to ensure water flows for the reservoirs. A mechanism should be in place to ensure that up-stream communities have an incentive to protect the water shed area. A part from natural drought, experience has shown that anthropogenic activities in the catchment reduce the flow of water significantly in turn impairing electricity production.

- **Advocate energy efficiency in biomass use**

Since biomass accounts for about 90% of the country's total energy requirement, there is a need to advocate and emphasise the importance of using the resource efficiently. Biomass use is a strong driver of deforestation, which is occurring in at alarming rate. If the situation remains unchecked, its impacts will be huge, particularly with regards to water catchment areas. Communities in need of biomass will increasingly encroach on catchment areas causing soil erosion leading to increased siltation which adversely affect hydro installations. The policy should be designed so as to offer positive incentives such as subsidies for the purchase of improved technologies such as improved cook stoves. The use of modern biomass such as cogeneration in sugar and other industries to produce electricity should also be encouraged.

- **Stimulate research and development**

Tanzania has plenty of energy sources which are either not or under-utilised. This is compounded by a lack of scientific research and data collection on alternative energy

options such as solar wind, mini hydro, geothermal, waves etc. The government should provide sufficient funds to academic institutions and other competent organisation to conduct in depth “theory-to-practice” research on how different energy resources can be used wisely. For example, geothermal energy is currently not harnessed despite the presence of 15 hot springs with temperatures greater than 40°C (Hochstein et al, 2000).

- **Regular training of well-motivated technicians plans**

Measures to ensure regular trainings of technicians to cope with ever-changing technology is necessary to ensure that energy systems are adapted to changing climatic conditions as well as vandalism. Moreover illegal connections, theft of transmission/distribution wires and transformer oils are common. Under-motivated and under-trained technicians are unable to address these issues properly.

- **Map wind and geothermal resources**

Availability of quality data on various energy renewable sources is a key step in securing sufficient and reliable sources of energy. This information should be collected, compiled and easily accessible by communities and investors alike.

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