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Energy and Sustainable Development in Tanzania

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Summary of Report

Tanzania has a very low level of industrialization hence low levels of income, modernization, and emission levels. Less than 10% of the population has to access electricity compared to the African average of 30%. The heavy reliance on wood-based biomass and the use of inefficient wood-to-energy conversion technologies are listed among the leading culprits of the deforestation as well as poor, indoor air quality. Currently the country imports 100% of the fuel oil for electricity and power generation although efforts are being made to explore the oil and coal potential and to meet its fuel oil requirements.

Preface

The author prepared this report through consultation with various resources, reports from affiliated non-governmental organizations and government personnel. Gathering of energy data from the government ministry was a key component. Although it was not easy to obtain and compile all relevant information during the timeframe of the report preparation, colleagues at the Ministry of Energy and Minerals provided valuable background information on the Energy sector situation in Tanzania. Review and useful comments from Pierre Mukheibir, HELIO Regional Co-ordinator, were much appreciated.

The background data, referred reports and all relevant information used to prepare SEW report for Tanzania for year 2005 can be obtained by request to the author via email address: lyimo@hotmail.com

Author

This report has been compiled by Bartholomew Makiya Lyimo, who is the Senior Research and Development Officer for Tanzania Greenhouse Gas Action Trust (TAGGAT) based in Dar es Salaam. This is the second Sustainable Energy Watch report prepared by the author, the first being in 2002. Mr. Lyimo is a Chemical Engineer who holds a Master of Engineering with specialization on Sustainable Energy Technology. Mr. Lyimo has worked for over six years on Research and Development of Clean Energy projects in Tanzania which are geared to address climate change through Clean Development Mechanism of the Kyoto Protocol.

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Executive Summary

This report is a compilation of the HELIO Sustainable Energy Watch Indicators 2006 for Tanzania. The eight indicators described in this report are a comparison of the year 2005 estimates collected from various sources and to the base year 1990.

The report indicates that Tanzania is close to sustainability on three indicators 1, 6 and 8 inherently due to utilization of renewable energy with biomass as the main resource and low investment on conventional large scale energy resources. The performance indicators values which are close to the sustainability goal for year 2006, e.g. indicator 1- CO2 emissions (-0.4), indicator 6- burden on energy investment (0.028), and indicator 8- renewable energy deployment (0.023), are due to low energy consumption and highly dependence on renewable energy, predominantly biomass. The negative value on indicator 1 (CO2 emissions) is because the country is not energy intensive and approximately 70% of commercial energy generation is from hydropower. In addition the level industrialization and economic development has contributed to the low energy generation from commercial energy sources such as coal.

Since biomass use accounts for over 90% of the total primary energy supply, the choice of the most significant local pollutant for indicator 2 was linked to inefficient use of biomass in households. The search of background information on the extent of particulate matter released on typical Tanzanian household was not productive. The values for indicator 2 for Tanzania were therefore calculated from similar information from neighbouring Kenya because of similarities in culture and primary energy consumption pattern. For the primitive open air, three stones cooking stoves that use firewood, the level of particulate matter varies between 200 and 5000 $\mu g/m^3$ depending on specific parameters and situations. An indicator value equivalent to 10% of the maximum reported value which is typical for charcoal usage was chosen for analysis which is 500 $\mu g/m^3$ of particulate matter resulting in a vector value of 0.89.

The government power master plan and policy focus on energy is on large scale hydropower and thermal units. This plan is anticipated to increase the electrification level from 10% to 15% by year 2015 or stabilize the electrification at 10% until year 2010. The value for the indicator on household access to electricity (indicator 3) for year 2005 is 0.1 with the calculated vector value of 0.9. Since the country's economic development is low and there is an excessive use of wood biomass, there has been modest investment on clean energy. The result is a high value of the vector (0.986) for indicator 4.

The country's thermal energy generation is based on fuel oil and natural gas. Tanzania imports 100% of the fuel oil for electricity and power generation

although efforts are being made to explore the country's oil potential to meet its fuel oil requirements internally. This dependency on imports makes the country vulnerable to changes in oil market. The increase in fuel oil prices for example has occasionally forced the IPTL to raise its selling price of electricity to TANESCO. As TANSECO cannot increase the tariffs to customers accordingly it has been necessary for the government to subsidize TANESCO's operations. The calculated vector for indicator 5 is 0.44 which is based on the energy generated from non-renewable imports as a share of the total. The burden of energy investment on public is moderate since investment is predominately through the private sector.

The total primary energy supply is more than 90% biomass therefore the commercial energy compared to the GDP is high. The calculated vector for indicator 7 is 0.68. This indicates that more than half of the GDP is directed to the energy spending. Renewable energy deployment is small since there is no significant investment in renewable compared to the total investment in the sector. The vector value for indicator 8 is 0.023 for year 2005.

In summary, the vectors in this report show that Tanzania has a very low level of industrialization (low agricultural mechanization, few, underutilized or no primary industries) hence low levels of income, modernization, etc. The reliance on wood-based biomass and the use of inefficient wood-to-energy conversion technologies are listed among the leading culprits of the deforestation.

General Discussion of Tanzania

The United Republic of Tanzania covers a land area of 945,749 km^2 and is located in eastern Africa along the Indian Ocean coast between Mozambique and Kenya and includes the island of Zanzibar. More than 37.1 million people live in Tanzania where 70% of the national population live in rural areas. The population is overwhelmingly native African (99%) speaking both Kiswahili and English as official languages. The population growth rate was estimated at 2.1% in 2001. The country's terrain includes coastal plains, a central plateau, and highlands in the north and south. It is home to Mt. Kilimanjaro (the highest point in Africa), Lake Victoria (the second largest lake in the world), and the Great Rift Valley. The climate varies from tropical along the coast to temperate in the highlands.

Tanzania is listed as one of the poorest countries of the world, with an estimated GNP per capita in US$ 270 in 2001. In addition, Tanzania has been either at or near the top of the list of African nations in per capita receipt of international aid. The country's GDP in 2004 was U$10.3 billion and growing at a rate of 6.7%. In 2005 the inflation rate was 5%. The country exports and imports are estimated at US$827 million and US$1.55 billion respectively[1].

Various energy resources are present in Tanzania including biomass, hydro, coal, natural gas, geothermal, solar, wind, uranium and ocean. The country imports white petroleum products, although pre-2000 it was importing crude oil which was then refined at the Tanzania and Italy Petroleum Refinery (TIPER). Except for hydropower and natural gas, other energy sources are commercially untapped as major energy sources. The installed electricity generation is a mix of hydropower, natural gas and fuel oil making the collective capacity in 2005 to around 950MW (Mwihava and Mbise, 2005) [2]. This capacity serves the nation at the electrification level conservatively estimated at 10% for 2002 to 2005. The percentage of urban and rural electrification was 39% and 2% respectively. About 50% of the urban consumption is in the economic capital Dar es Salaam. The electricity generation per annum in 2005 was approximately 3,000 GWh. The electricity consumption per capita in 2002 was 84 kWh (Mwihava and Mbise, 2003).

The main source of primary energy both in urban and rural areas is woody biomass. It is estimated that its consumption per capita is $1m^3$ or about 183 kgoe (Kaale, 2005). This generates a serious threat to the biomass resources which is predominantly natural forests, depleting at an annual rate estimate to be from 90,000 to 300,000 ha (2004 estimates).

[1] Various sources give slightly different economic values due to time and information availability. This information has been gathered from the country's website www.tanzania.go.tz

[2] The electricity information can be found from the national electricity company's TANESCO website : www.tanesco.com

Tanzania is considered the most politically stable country in the East African and Great Lakes region. Since independence from Great Britain is 1961, it has suffered from chronic debt that has impacted heavily on its social services budgets. Since 1985, the country has adopted policies geared to improving the economy. However, the economic transition and associated transitional impact is felt most heavily by the most vulnerable in the community, resulting into severe social concerns: increased unemployment, higher food costs, lower wages, urban migration and reduced governmental services. Table 1 shows the country's development status as well as other selected indicators.

Table 1: Selected indicators[3]

Indicator	Value in 2003 (rank)
Human Development Index (and ranking)	0.418 (164)
Human Poverty Index (and ranking)	35.8% (65)
Environmental Sustainability Index	50.3 (63)[4]
GHG Emissions (per capita)	0.1 (2002)
GDP and GDP per capita	$10.3 bn and $700 (2004)
Gini Coefficient (ranking)	38.2 (160)[5]

While there have been negligible outflows of populations in Tanzania due to its general political stability, it has become a home of more than 0.5 million[6] refugees from the region. With one physician per 20,500 people, life expectancy is 51 years for men and 53 for women, Malaria and HIV/AIDS pose serious health concerns. HIV/AIDS alone affects 9.4% of the adult population which places an increased demand on an overtaxed health infrastructure. The situation further exacerbates the problems of economic recovery due to a reduced labour force According to UNAIDS[7], a total of 800,000 AIDS cases have been estimated since the beginning of the epidemic in Tanzania mainland in 1983, representing 2% of the total population. However, the real number is expected to be higher since only one in five cases are reported[8].

The country's primary environmental concerns include soil degradation, deforestation, desertification, droughts and destruction of coral reefs. Recurrent floods and droughts have placed pressure on the most vulnerable and increased demand on stretched government services. In addition, drought has caused problems in electricity generation since about 70% of generation is hydro-based. Of particular concern are education problems, caused by the limited governmental infrastructure; only 68% of adults are

[3] These indicators have been compiled from the information available from http://hdr.undp.org/statistics/data/country_fact_sheets/cty_fs_TZA.html
[4] http://www.yale.edu/esi/ESI2005_Main_Report.pdf
[5] http://www.undp.org/hdr2003/indicator/indic_126_1_1.html
[6] This figure is according the World Vision International
[7] http://www.unaids.org/en/Regions_Countries/Countries/tanzania.asp
[8] http://data.unaids.org/Publications/IRC-pub06/JC1048-CountryLevel_en.pdf

literate. Compulsory primary education for children with 7 to 14 years is mandated.

The level of underdevelopment and poverty is exacerbated by an energy sector where, despite an emphasis on establishing efficient energy production, procurement, transportation, distribution, and end-user systems in an environmentally sound manner and with due regard to gender issues[9], the lack of financial resources and poor implementation mean that the local environment and women continue to bear the heaviest burden.

Tanzania's primarily agrarian economy is constrained by geography and environmental factors such as low and erratic rainfall, soil erosion and deforestation. Only 8 % of Tanzania's land is under cultivation, although about 80% of its population is employed in agriculture. The principal cash crops coffee, cotton, sisal and tobacco have been affected by instability in world market demand and rising costs of imported fuel, fertilizer and equipment.

The local infrastructure has been deteriorating over the years due to poor economic situation and inability of the government to finance social and public services. The communication and transport sectors have been neglected and left as non-priorities; a third of the country is isolated and does not have access even to inferior transport services. Its 134,000 motor vehicles travel 52,800 miles of highway. Only 127,000 landline telephones exist. There are 115,000 internet users and an estimated 3 televisions per 1000 people.

[9] http://www.tgnp.org/downloads/AGDI_REPORT.pdf

Overview of National Sustainable Development (SD) Strategy

Since 1990, Tanzania has been developing a sustainable development strategy which includes environment as a cross-cutting issue. A National Environmental Action Plan was established in 1994, leading to the adoption of the 1997 National Environmental Policy. The drafting of the National Strategy for Sustainable Development was initiated in 2000 through the Poverty Reduction Strategy Paper (PRSP). The implementation of the action plan and the principles laid down in the policy is ongoing. The National Strategy for Growth and Reduction of Poverty, known as MKUKUTA[10] was approved by Cabinet in 2005 for implementation over five years. MKUKUTA is the successor to the Poverty Reduction Strategy Paper (Mwanyika, D, 2005) which sets a policy framework for sustainable development in Tanzania alongside the targets laid down in the Millennium Development Goals (MDGs).

Despite an existing sustainable development policy framework, Tanzania has not been successful in reversing the loss of its environmental resources, due to ever increasing dependency on natural resources and increase of poverty levels for the 51% of population living below the poverty line.

Currently, Tanzania reserves 23% of its territory as protected areas to conserve its biodiversity. However, these natural resources have come under increasing pressure, and effective implementation of the sustainable development strategy is compromised. This is due to insufficient institutional framework for coordination; limited governmental capacity for environmental management; insufficient involvement of local authorities and communities in environmental management and conservation; and the poverty.

With regards to the poverty level, implementation of MKUKUTA in the light of Vision 2025[11] illustrates Tanzania's downward spiral: while poverty contributes to environmental degradation, so environmental degradation contributes to the intensification and perpetuation of poverty. The government's effort to promote public awareness about the importance of environmental management and conservation has been through Community Based Organizations and NGOs. The organizations are considered as partners during implementation of strategies related to environmental conservation, management and sanitation in both urban and rural areas. These community-based efforts have been complemented with public education programmes on the environment, which are broadcast on radio and television and reported in the print media. Together, these efforts are helping to raise

[10] This acronym is based on the Swahili: Mkakati wa Kukuza Uchumi na Kupunguza Umaskini Tanzania

[11] This vision was prepared in year 1999 and aims to guide Tanzania's development effort into the 21st Century and achieve a certain level of development by the year 2025. The document for the Tanzania Development Vision 2025 is available on the National website: http://www.tanzania.go.tz/vission_2025f.html

the public's interest in, and commitment to, environmental conservation and management in Tanzania with the long-term goal of increasing the prospects for achieving environmental sustainability goals.

Other Energy-Related Developments

For many years electricity generation in Tanzania was from hydro (both macro and micro), diesel oil, imports (from Zambia and Uganda), coal, biomass, and to a minor extent, solar photovoltaic. Since 2004 electricity has been generated from natural gas as well. Contribution of electricity to the total primary energy consumption is about 1.5% which is expected to increase modestly when rural electrification program is in effect by 2010 (MEM, 2005). In 2005 the peak demand in Tanzania on both the interconnected and isolated systems operated by the Tanzania Electricity Supply Company (TANESCO) was approximately 550 MW. Although the 2005 overall installed system capacity is almost double the peak demand, too much dependence on hydro threatens security of supply particularly due to drought and the limited availability of thermal systems.

In addition to dependency on hydropower for electricity generation, there are significant technical and non-technical losses including increasing vandalism on power system infrastructure. According to a study report by SAD-ELEC, during the financial year 1999/2000[12] the total TANESCO power loss was 23.8% of the sent-out amount. The unreliability of the services offered by TANESCO to 450,000 customers in the country (about 90% are grid connected) has forced the government to revisit its master plan and look for other possible investment in other resources.

The milestone of the policy development started in 1994 when TANESCO's monopoly on electricity generation, transmission and distribution was removed. Independent power producers (IPPs) were allowed to generate electricity and sell to TANESCO. However, the company still maintains a lion share of the electricity sector in Tanzania despite customer dissatisfaction with operational performance (persistent low access to electricity, low installed capacity and unreliability) and the government's inability to finance further investment in the sector. TANESCO operational problems are related to long lags in electricity billing, customer non-payment for services and delays in tariffs reviews by the government, power shortages and blackouts.

The pressure to change to a more liberalized electricity sector is due to the ideological shift away from the public sector world-wide and pressure from multilateral finance organizations such as the World Bank who now favour doing business with commercialized public business or the private sector (Mwihava and Mbise, 2005). During this transition of the unbundling of TANESCO's operations, the government maintains the policy making and regulation of the electricity industry under the umbrella of the Energy and Water Utilities Regulatory Authority (EWURA). The establishment of EWURA was passed by the Parliament in April 2001. The act divided the energy sector into various groups, leaving rural energy issues (including rural electrification) to be handled by the Government.

[12] SAD-ELEC (PTY) LTD, 2001, Electricity prices in Southern and East Africa,

According to Mwihava and Mbise 2005, through EWURA, the government will implement an extensive restructuring and privatization of the electricity sub-sector in order to attract investment and increase efficiency. In the new electricity industry structure, TANESCO, which is presently a vertically integrated utility, will be divided into separate segments responsible for power generation, transmission and distribution. Generation and distribution activities will be further divided into a number of companies to allow private participation and competition. Transmission and distribution will be maintained by TANESCO as a single entity for the short to medium term. The single transmission company and the distribution companies will remain natural monopolies and hence will need to be appropriately regulated.

The actual sale or concession of the unbundled companies was expected to commence in early 2004, with the target divestiture to be completed by 2005 (Mwihava, and Mbise, 2003). Information on the current status is not available however the actual divestiture of TANESCO will be in place once the physical implementation of recommendations for unbundling of TANESCO and trading arrangements are complete. The new legislation, including the necessary amendments, have been enacted and EWURA is on fully operational. The NET Group Solutions which assumed responsibility for managing TANESCO in 2002, was tasked to engage a consultant to work on electricity trading arrangements and regulatory environment [13].

The government is responsible for issuing licenses to IPPs and controling prices in electricity and petroleum sub sectors. The law governing electricity is contained in the Electricity Ordinance of 1931 and in the 1957 amendment. A new Electricity Act (to replace the Electricity Ordinance) has been drafted and is awaiting approval (MEM, 2005). To address the problems facing the power sub-sector, a number of reforms including commercialization, introduction of IPPs, Contract Management, and privatization of non-core assets are being pursued.

Based on the report by Mwihava and Mbise 2003, the IPPs generating and selling power to TANESCO and their corresponding generation capacity in bracket are as follows:

- Kiwira Coal Mine (6MW);
- TANWAT (2.5MW);
- Independent Power Tanzania Limited – IPTL (100MW); and
- Songas Ltd (180/200MW).

IPTL is a diesel fuelled thermal power station in Dar es Salaam. 70% pf the shares are held by Malaysian investors with an associated investment cost of approximately US$160 million. Songo Songo gas development and power generation was initiated in 1994 as a joint venture between Tanzania and

[13] http://www.tanesco.com/mancontractor.html

two Canadian companies. With the project's implementation through Songas Ltd. the company is the sole supplier of gas for power generation

Other power enterprises include Kagera, Mtibwa and Kilombero sugar estates, as well as smaller power systems of Mbinga and Urambo run by consumer cooperatives. There is a plan to expand the power generation capacity at Kiwira Coal Mine from 6 MW to 30 MW under a joint venture with Chinese investors, CHITEC. The Government, through the National Development Corporation (NDC), is promoting the use of coal at Mchuchuma for power generation. Feasibility studies for the coal-based Mchuchuma power (400 MW) project and the hydro based Rumakali and Ruhudji projects have been carried out and included in the Power System Master Plan[14].

The Ministry of Energy and Minerals (MEM) is currently promoting energy efficiency and conservation through household access, industrial and commerce sectors in order to save energy, money and protect the environment (Mwihava and Mbise, 2005). Tanzania spends up to 25% of its foreign currency earnings on petroleum imports as rising living standards lead to a greater demands for energy services, such as private transportation and home appliances. Moreover, rural electrification is crucial for Tanzania, where a small supply of electricity can significantly improve living conditions. The Government is therefore in the process of establishing a Rural Energy Agency (REA) and Rural Energy Fund (REF) to ensure accessibility to rural energy services in order to ensure socio-economic improvement of the majority of Tanzanians.

[14] TANESCO, 2002, Power System Master Plan report, Updated annually.

Environmental Sustainability

Indicator 1: Per capita energy sector carbon dioxide emissions

The impact of the energy sector on CO2 emissions is a result of several factors: the fuel mix used to produce energy; the efficiency of conversion of primary energy into useful energy (including distribution); the technology uses; and the total level of energy used. With its low level of development and less intensive industrialization the CO2 emissions from Tanzania are expected to be low. According to the country study reports by the Centre for Energy Environment Science and Technology (CEEST, 1994, CEEST,1999), the energy sector CO2 emissions for 1999 accounted for a mere 10% of the 2.23 million metric tonnes of CO2, the percent change compared to 1990 was estimated to be decreasing by 2%[15]. More than 80 % of rural energy requirements for agriculture and transport activities are human generated (Sawe, 2005) and are mainly to meet basic needs and hardly for productive purposes. Energy sector CO2 emission are small compared other countries in Africa e.g. South Africa, neighbouring Kenya etc.

The energy-related CO2 emissions in Tanzania for 2005 are difficult to establish although figures do exist for generation: 200MW from gas, 100MW IPTL from diesel fired plant and about 100 MW from TANESCO diesel units both on and off grid. Although coal and natural gas are being used for electricity generation, most of the energy sector's CO2 emissions are from fuel oil. The economic base of the country is primarily a low level of mechanized agriculture which contributes more than 50% of the economy's GDP.

To calculate this indicator data from International Energy Agency for 2003 are used. Total CO2 emissions for Tanzania are estimated at 2.8 million tones[16]. With a population of 37 million, the per capita emissions are calculated to be 75.7 kg CO2/capita. The metric data can then be calculated by converting the CO2/capita emissions to C/capita units by diving by 3.67 (i.e. 44/12). For the base year (1990) the per capita CO2 emission was taken from the 1990 greenhouse gas inventory report which was 6.36% of the total country greenhouse gas emissions (68,885 Gg): 22.59 kgC/capita.

For this indicator the value of 1 on the vector is the world's average of carbon emissions from fossil fuel production whereas the value of 0 on the vector is the sustainability goal.

The vectors for Tanzania for year 2005 are thus calculated by (20.64 - 339) / 791=-0.402.

[15] Similar values can also be obtained from http://earthtrends.wri.org/pdf_library/country_profiles/cli_cou_834.pdfm
[16] http://earthtrends.wri.org/pdf_library/data_tables/cli2_2005.pdf

Metric (actual data) for 1990: 22.59kgC/capita and for 2005: 20.64 kgC/capita

Vector value for 1990: -0.4 and for 2005: -0.402

Discussion
The negative value shows that Tanzania has very low emissions (more than 15 times less) compared to the world average, implying that Tanzania has a less industrialized economy. The 2005 value is on a low side probably due to increased gas and oil consumption because of power shortages as a result of drought. The mining sector for example was also projected to use 100MW from its own thermal plants. This did not actually occur until 2005. Compared to 1990, the slight decrease from the 2003 is because of connection of the 180 MW Kihansi hydropower project to the national grid in 2000.

Values are likely to be uncertain for 2005 due to data consistency and lack of availability from the MEM because there is no transparent feedback on individual fossil fuel consumption. To increase electricity generation capacity, the current government has been discussing about revising the power sector master plan to favour coal power, which will lead to increased CO2 emissions. This increase is expected to occur with the implementation and commission of Mchuhuma- Liganga coal power plant. The plant is expected to generate a total of 400MW with 200MW of electricity generated in the first phase (2018) and the remaining 200MW generated in the second phase (2023). With the unreliability of hydro-based energy this plan is likely to be brought forward. The new government has set this as a priority, and is estimated to cost US$ 200 million and US$ 175 million for the first and second phases respectively.

Indicator 2: Most significant energy-related local pollutant(s)

In many areas of the country energy utilisation is characterized by high and low per capita consumption of traditional and commercial energy sources respectively. Since more than 80% of the total energy is consumed in rural areas (where majority of the population live) and who have low purchasing power biomass (predominantly wood) fuel is used for cooking and kerosene for lighting. Indoor pollution is very high and posses a significant threat to human health. Indoor air pollution, for example, is the fourth leading cause of premature death in developing countries. Exposure to indoor air pollution i.e. particulate matter, along with carbon monoxide, nitrogen dioxide, benzene and other gases leads to serious illness, including acute respiratory infection, chronic obstructive pulmonary disease and pulmonary tuberculosis(Desai et al, 2004). The biomass combustion technologies used in rural areas are very primitive and lead to negative consequences for the environment and the human health. In 2005 the total energy consumption in Tanzania was estimated at about 30 GJ per capita (Kaale, 2005), a significant share coming from rural areas.

Consumption of firewood for domestic purposes in Tanzania is influenced by many factors: availability, climatic conditions, cooking habits and end use efficiencies (Kaale, 2005). It is estimated that firewood consumption for general domestic uses in areas with abundant firewood supply ranges from 1.5m^3 to 2.5 ^{m3} while wood deficit areas have consumption levels as low as 0.5 m^3 per capita per annum. It is not possible to establish the actual pollution levels in Tanzania from the burning of biomass and efficiency of the burning stoves as this information is not documented. Thus, for this indicator biomass burning based on the above factors is used to calculate and estimate the corresponding pollutants.

Despite large scale use of biomass for cooking using traditional three stones fire place, there is very little documented information in Tanzania on the local effects of indoor air pollution since no specific study has been undertaken on the issue (Sawe, 2005). Household energy in Tanzania and sub-Saharan Africa is largely derived from woodfuels burned in simple stoves with poor combustion characteristics. These devices emit products of incomplete combustion that both damage human health and contribution to greenhouse gas emissions. From empirical studies done in Kenya (which share many of the same characteristics as Tanzania), a significant relationship between the incidence of respiratory illness and exposure to particulate matter and the level of particulate matter in indoor kitchens using firewood and charcoal was observed to vary between to 200 and 5000 µg/m^3 (Ezati M and Kammen, D.M, 2002). In the same study the authors recommended the use of charcoal as a "clean" alternative as compared to firewood (three stones stoves use firewood - Monela et all, 1999).

To calculate this indicator the value for charcoal particulate emissions of 500 µg/m^3 (Bailis et all, 2003) was chosen as in most villages women cook outside on three stones stoves. Since the values for particulate matter emissions for charcoal for 1990 were not reported in the above literature the same value for the base year was assumed to be 500 µg/m^3. The report showed that after intervention a reduction of 36% of local pollutants was achieved. Because of the uncertainty in the used data an overall of 10% decrease in local pollutants is assumed such that for 2005 the level is 450 µg/m^3

For this indicator the value of 1 on the vector is set for 1990 year level which is 500 µg/m^3. The value for 0 on the vector was set at 10% of the base year 1990, which is 50 µg/m^3 and corresponds to the WHO maximum levels of total particulate suspension.

Metric (actual data) for 1990: 500 µg/$m^3$and for 2005: 450 µg/m^3
Vector value for 1990: 1 and for 2005: 0.89

Discussion

Women, children and elderly are the most vulnerable members of the community. There is a need to intensify efforts to facilitate greater adoption of well ventilated kitchens with improved woodstoves with appropriate ventilation, e.g. chimney. Where relevant, efforts which facilitate adoption of alternative cleaner fuels i.e., biogas, solar cookers and lighting, LPG and electricity should be scaled up at all levels (Sawe, 2005).

Biomass and kerosene will continue to be the major energy sources in Tanzania for the unforeseen future. Even if rural areas are electrified electricity tariffs will continue to escalate; prices for petroleum products (kerosene inclusive) will continue to be unstable and installed renewable energy capacity will not significantly increase due to high investment costs. This situation will perpetuate utilization of unclean energy technologies. This is attributed to inadequacy of resources and low purchasing power of poor people in the urban and rural areas.

In addition, the higher prices for petroleum products (especially kerosene) and increased electricity tariffs will shift some urban and rural energy demand back to traditional fuels. With this situation in place, indoor air pollution will still be a problem, although the magnitude of its adverse health effects will not be clearly known due to unavailability of research and documented information. Indoor pollution will continue to contribute to acute infections like tuberculosis, respiratory infections, lung cancer some of which may be exacerbated by HIV/AIDS. There is also a risk of death due to particulates, poisonous gases such as carbon monoxide and carcinogenic poly-aromatic hydrocarbons. The effect will continue to enlarge in complement with unorganised house construction and in areas with non-ventilated houses. In view of prevalence of effects of indoor air pollution, there is need of further research in order to determine extent of acute respiratory infections and to collect reliable data that will help to determine possible measures specific to particular areas and biomass fuels consumption patterns.

Social Sustainability

Indicator 3: Households with access to electricity either through the transmission grid or by stand-alone systems

Although the government considers electricity as an important source of modern energy, less than 10% of the total population has access to electricity supply with rural access being lower than urban access. 2005 estimates from Mwihava, 2005, shows that less than 2% of the population has access to electricity, despite this issue being a subject of both international and national concern. The electrification pace is slow since TANESCO is under tough economic pressure and rural electrification is a large financial burden (rural areas constitute about 80% of the total population).

Annual per capita consumption of electricity in Tanzania is about 80-100 kWh. A socio-economic study (Mwanyika, 2005) among rural households and especially rural enterprises shows that customers are willing to pay for access to electricity, if only reasonably reliable and services are available. These findings are supported by UNDP which estimates that households in Tanzania spend an average of $15-32 per month, essentially for wood, charcoal, kerosene and dry batteries[17]. The estimates by UNDP indicates that poor households once electrified, would initially consume about 30-200W during 5 hours per day, corresponding to 55–360 kWh per year. Numerous electrification programs have been undertaken, but as the population and number of customers are growing faster than the connection rate, the number of household electrified expressed as a percentage of the population is still decreasing. The slow connection rate is due to the high costs associated with extending the national grid over vast areas that are scarcely populated as well as the high costs of local, small scale electricity generation

According to information gathered from TANESCO the 70% of the electricity supply is from hydro with the remaining 30% coming from diesel oil and imports from neighbouring Uganda and Zambia. The supply consists of both interconnected and isolated grid systems. The national electricity installed capacity is 950 MW out of which the effective capacity is about 806 MW. Out of this effective capacity 555 MW is from hydro and 251 MW is thermal units making the total annual electricity generation is 3,000 GWh. The suppressed demand is 500 MW and the annual growth in demand is anticipated to be approximately 8% up to 2015 (according to power demand forecast in the master plan).

For this vector the value of 0 indicates 100% access while the value of 1 indicates 0% access. The 2005 vector value for Tanzania can be approximated by the lumped figure of 10%, making the vector value of 0.9.

[17] This information is summarised from the extracts from UNDP website www.undp.org

The electricity access for the base year 1990 was estimated at 4% (CEEST,1994).

Metric (actual data) for 1990: 4% and for 2005: 10%
Vector value for 1990: 0.96 and for 2005: 0.9

Discussion
Most rural electrification programs have focused on connecting rural areas to national or local grids. However, for the moment, grid-supplied electricity in Tanzania is not the lowest cost alternative under all conditions (Mwihava and Mbise, 2005). The problems of rural energy in Tanzania are complex due to the existing infrastructure (Sawe 2005). For example, more than 98% of rural energy used for heat comes from the inefficient burning of wood and crop residues. More than 90 % of lighting is through kerosene wicked lamps. In addition, poor housing and unplanned residential set-ups make it even more difficult to access households.

According to MEM (2004) TANESCO's plan to undertake a massive rural electrification project is expected to either increase the access of electricity in rural areas or stabilize the current level of consumption (10%) until 2010. However, it is unlikely that the current problems of TANESCO's financial and technical constraints with regards to electricity generation, distribution and marketing will bear fruit in the near future. The good news is the interest by some IPPs especially private companies like Sao Hill Industries Ltd in Mufindi district which intends to establish a 10MW CHP, fuelled by woodwaste, for its own use, feeding the surplus to grid.

Another challenge regarding sustainability and the requirements of small, stand alone conventional energy sources in rural areas, is that the actual demand and supply for rural electricity is unknown (Sawe et al, 2003).

Until 1) the rural energy infrastructure and the need for a clear rural energy strategy are addressed; 2) data collection on rural energy is improved; 3) there is better knowledge about rural energy issues; and 4) there is the capacity to assess existing local capacity to implement rural energy projects and programmes the expansion of the current grid and introducing mini-grids networks is unlikely.

For example in many villages where there is access to grid, it was found that only few households (1-5 %) of the households were connected despite the fact that the village had been electrified 15 year previously as almost all the rural households have never used electricity for cooking (Sawe, 2005).

New initiatives by the Ministry of Energy and Minerals (MEM) are being implemented (MEM, 2005). The proposed programmes by UNDP/GEF and SIDA to support solar PV market development and the planned World Bank initiatives on rural transformation through energy are working to improve the energy situation (Sawe et al, 2003).

Indicator 4: Investment in clean energy (a proxy for employment)

Investment in clean energy resources is difficult to estimate since most of the renewable energy are privately owned schemes. As such, actual data are not easy to obtain (Gwang'ombe, 2004). Investment in solar power for example is limited to individual solar systems mainly to power hospitals, mobile telephone antennas and a few households. This is largely due to higher investment costs and lack of proper policy incentives to promote solar systems.

TATEDO[18] estimated the current installed PV capacity in Tanzania to be 550kWp with an annual growth rate of about 20%. Solar systems for a typical rural household costs between U$ 250 to U$ 1,250 depending on what individuals can afford. This price includes all costs of components and installation. Maintenance is very minimum, normally less than 2% of investment per year. Private companies initiatives such as SONET, Merry Water, Dynamic Electronic Systems Ltd., Northern Energy Saving Co. Ltd. And Likungu Investment are yet to be documented.

Investments in small scale hydroelectric systems are limited to religious missions and hospitals. The government is encouraging companies and individuals to invest in small scale renewable energy systems especially in rural areas via the Clean Development Mechanism (CDM) activities. Since CDM activities are tailored by a financial mechanism from the sale of carbon credits it is an opportunity to implement and increase the existing 4.7MW of the country's mini/micro hydro potential (the potential is estimated to be 14MW). It is estimated that 100 GWh/yr could be produced from micro/mini systems. Currently only around 32 GWh/yr is produced from these smaller systems.

Based on information available from MEM, much of the wind resource in Tanzania is located along the coastline and the highland plateau regions of the Rift valley, on the plains and around the Great Lakes where wind speed range from 0.9 to 4.8 m/s. At some locations, on the spot measurements are around 12m/s. Currently, wind energy is used to pump water for irrigation and to meet domestic and livestock water needs. A very limited number of attempts have been made to install wind turbines for electricity generation. Preliminary wind resource assessment at four selected sites is underway with the assistance from the Danish Government, the objective which is to assess the feasibility of a long-term wind regime.

Investment in biomass technologies especially cogeneration (Ngeleja, 2000), comes from utilizing baggase in sugar mills (32.3MW), wood logs (2.5MW) and wood waste (1.02MW). The biomass use can be estimated from co-

[18] The information can be obtained from www.tatedo.org

generation potential in the existing biomass fuelled power plants where more than 315 GWh per year can be generated. This is 10.5% of the national electricity generation. The current energy generation potential from excess bagasse in sugar mills is about 99 GWh per year and is equal to 3.5% of the national electricity generation. An additional 1000 biogas systems have been installed countrywide since 2001, each costing about U$ 100[19].

The Songas project started in 2001 with a total project cost estimated at US$ 375 million. Total investment in 2004 can be found by calculating an annual average of Songas project and assign a share for 2004, which equals U$ 75 million. A conservative estimate of clean investment from biogas systems and 1000 solar PV systems (Mwihava and Mbise, 2005) is calculated to be U$ 1 million.

For this indicator the value of 1 on the vector is the 2005 share of clean energy investment out of the total energy sector investment, while the value of 0 would be 95% clean energy investment relative to the total. This vector value can be calculated from (0.95-0.013)/0.95. The value for the base year 1990 was taken from the HELIO Report by Lyimo and Mwakifwamba, 2002 as 0.

Metric (actual data) for 1990: 0 and for 2004: 0.013
Vector value for 1990: 1.063 and for 2004: 0.986

Discussion
Since TANESCO's grid is not expected to expand significantly in the near future employment opportunities lie with renewable energy systems. In addition, TANESCO is unlikely to embark on small and clean energy over coal and large scale hydropower generation systems. The majority of the rural population is not expected to be connected to the national grid over the next 15-20 years because of low energy consumption need (1-100kWh/month). Numerous sparsely populated areas make grid extension technically and financially unattractive to TANESCO. In electrified urban setting high-energy consumers subsidize low energy consumer tariffs. For example energy consumer of less than 50 kWh (50 units) pay Tsh 25 per unit/month whereas consumers above 50 units pay Tsh 115/ excess unit/month.

Rural households, whose energy needs fall within the subsidy range, are therefore denied subsidy opportunity because they are not connected. The government decision to establish EWURA will form a good basis for speeding up investments in clean energy systems as will the establishment of a Rural Energy Agency (REA) which is being formed through a specific statutory instrument (Act) passed by Parliament and assented to in June 2005. The Rural Energy Fund (REF) is implemented as on on-going energy strategy and has been designed to incorporate projects, programmes and initiatives, which

[19] GEF/UNDP, Biogas technologies in Agricultural regions in Tanzania, http://sgp.undp.org/download/SGP_Tanzania2.pdf

together will form the foundation for the National Energy Strategy (Ulisso and Mwihava 2005)

Wind energy is still a difficult option due to the technical and financial expertise required. However, wind farms for water pumping for irrigation will increase employment in agriculture. Private companies dealing with solar PV systems will increase employment since technicians are needed especially for storage and connection. The sale of PV panels and retail shops will increase as a result of availability of electricity. Private schools in rural areas will increase as a result. One of the issues regarding deployment of solar PV raised by TATEDO is higher taxes and import duties imposed on PV systems and accessories. For all solar modules imported into Tanzania a 20 % VAT and a 5% tax have to be paid. For other components such as batteries and charge controllers, a higher tariff applies: a 30% tax and a 20 % VAT. The government is discussing the issue of reducing the VAT and taxes on solar equipment. In July 2005 all taxes on solar energy appliances and small scale wind turbines, were removed. [20]

CDM projects if approved will make a significant impact on the rural energy supply since the investment costs will be covered by the sale of carbon credits. Currently Green Resources Ltd is designing an energy portfolio which will include establishment of CHP, mini hydropower and biofuels from Jatropha seeds.

[20] Energy and Environment in Tanzania, http://www.unep.org/GC/GCSS-IX/DOCUMENTS/Tanzania-1G-EnergyGen.doc

Economic Sustainability

Indicator 5: Energy resilience: energy trade benefits

Tanzania does not export energy and relies on oil imports for its thermal electric units. Except for biomass use in small scale households, Tanzania's commercial energy is generated from hydro and thermal power plants. The hydropower resource is comprised of large scale and small scale systems. The electricity generated at thermal power plants is currently estimated at 400 MW from the 200MW Songas project and 100MW IPTL and 100MW from TANESCO units. Out of the 400MW total, interconnected grid plants comprise 80%, the rest is generated at isolated mini-grids. With exception of 200 MW, now running on natural gas, the rest uses imported diesel, although TANECO plans to convert its Dar e Salaam based 80 MW diesel fuelled power plants to run on natural gas. Some regions, districts and townships are dependent on isolated diesel – run generators with a combined installed capacity of 31 MW. However, the effective contribution of the diesel based generators is estimated at 50% of the installed capacity due to aged machinery and lack of spare parts (Mwihava, 2005).

According to fuel oil imports report from the Tanzania Revenue Authority (TRA, 2005) the country's import for 2005 was estimated at U$ 626.5 million. Out of the oil imports the fuel oil share was about 40%. For the non-diesel power plants, coal contribution is about 6MW (Kiwira Coal Mine) while biomass (bagasse) fired plants at sugar processing plants is approximately 32.3MW, with wood logs and sawmill waste contributing 2.5MW and 1.025MW respectively. The electricity imports from Republic of Uganda are about 8MW and the Republic of Zambia supplies about 5MW generated from hydropower.

To calculate the indicator energy generated from non-renewable energy resources was chosen. For this indicator the value of 1 on the vector is 100% non-renewable energy imports share of the total national imports, while the value of 0 on the vector is 0%.

The 2005 vector value is therefore obtained from the total energy generated from fuel oil fired TANESCO units and the IPTL (200MW) and the Songas plant (200MW) which is X=200/450=0.44. The values for year 1990 were obtained from Lyimo and Mwakifwamba, 2002.

Metric (actual data) for 1990: 0.96 and for 2005: 0.44
Vector value for 1990: 0.96 and for 2005: 0.44

Discussion
Tanzania has been importing fuel oil to generating electricity to meet peak demand. However, with inclusion of the 100MW IPTL plant as a base power supply and the unreliability of hydropower systems the country may be

forced to extend its imports to fill the gap. The fact that the government has appealed to private sector to invest in energy generation supports this conclusion. In the early 1990s, the government, considering the lack of adequate investment and insignificant private participation in energy development, changed its role from that of implementation to one of supervisions. The government's policy is to promote Spatial Development Initiative (SDI) or Development Corridors (DC) approach to catalyse and accelerate development in the inherently large but mostly under/unexploited economic potential of the various parts of Tanzania, in collaboration with the private sector.

In the electricity sub-sector, private power producers have been allowed to generate electricity and sell it in bulk to the distribution companies or major consumers through the Transmission Company. The new policy now allows independent power producers (IPP) to generate electricity using any source including new and renewable sources energy (biomass, solar and wind) particularly for the rural population of Tanzania. Ideally investments should focus on various energy sources to bring productive, income generating opportunities, access to communications and other services.

Indicator 6: Burden of public energy investments

Consistent with Tanzania's policy to encourage private sector participation in energy sector development and promoting energy supply efficiency and reliability, the petroleum products trade was liberalized in 2000. As a result of hydrocarbons exploration activities natural gas has been discovered on Songo Songo Island (about 220 km South of Dar-es-Salaam) and the Mnazi Bay near Tanzania and Mozambique border. The Songas project started in 2001, with the total project cost estimated at US$ 375 million. Funding was provided by Ocelot Energy (US$ 50 million), TransCanada Pipelines (US$ 50 million), the World Bank (US$ 200 million), the European Investment Bank (US$ 37 million), the Commonwealth and a local project finance company[21].

Coal reserves are estimated at 1200 million tonnes of which 25% may be considered proven. Plans are under way to utilise coal at Mchuchuma-Katewaka for the generation of up to 400 MW of electricity. Feasibility studies for the coal-based Mchuchuma power project and the hydro based Rumakali and Ruhudji projects have been carried out, and have been included in the power master plan. Under the master plan, the supply of electricity to gold mines in the area south of the Lake Victoria, where future mining activity is expected to be concentrated, has been evaluated. The power demand of mines in that area is expected to grow to over 100 MW within the next few years. When the demand for power in the mining areas increases significantly, TANESCO's transmission system will require additional investments to reinforce it and increase its capacity and reliability. While the

[21] http://www.mbendi.co.za/indy/powr/af/ta/p0005.htm

mines will initially install their own generators, they will consider using power delivered from the grid system or other external sources if tariffs and power supply reliability and tariffs are at acceptable levels.

In 2005 the Songas had an investment of US$ 75 million. Averaged out over 5 years and using the GDP purchasing power parity of U$26.62 billion (2005 est.) this gives a value of 0.28%.

For this indicator, the value of 1 on the vector is non-renewable energy investment as 10% of GDP. The value of 0 on the vector is 0 public investments in non-renewable energy. The 2005vector value is therefore 0.028 (i.e. 0.0028/0.1). No data for the public investment for the base year 1990 was obtained during the survey.

Metric (actual data) for 1990: 0 and for 2005: 0.28%
Vector value for 1990: 0 and for 2005: 0.028

Discussion
Petroleum exploration has occurred in Tanzania but so far no oil has been discovered. As a result the nation imports all of its liquid fuels. Nonetheless the downstream oil industry is an important sector of the country's economy absorbing on average 55% of the country's foreign exchange earnings. Government policies are directed at petroleum product substitution by exploiting indigenous resources. In the upstream oil industry, oil and gas exploration and production is also being encouraged.

The hydrocarbon industry is regulated by the Ministry for Energy and Minerals. Upstream activities governed by the Petroleum (Exploration and Production) Act 1980 and downstream activities are controlled by the National Investment (Promotion and Protection) Act 1990.[22]. According to TPDC, companies currently conducting oil exploration in Tanzania include PanOcean Energy, Aminex plc and EnerGulf. The TPDC is the government corporation that implements petroleum exploration and development policies. It is the agency through which the Government participates in production sharing agreements and joint ventures in all facets of the petroleum industry from exploration to distribution

[22] Information on these entities can be obtained online on the Tanzania Petroleum Development Corporation (TPDC) website http://www.tpdc-tz.com/

Technological Sustainability

Indicator 7: Energy intensity (energy consumption/GDP)

Tanzania has an estimated annual per capita energy consumption of 29,300 MJ (0.7 TOE) about 90% which comes from biomass and is used mainly for cooking. 8% comes from petroleum and gas with 1.5% from electricity. The contribution of coal and other renewable (non- hydro and non woody) sources of energy is less than 0.5%. The distribution of energy consumption indicates that Tanzania has very low level of industrialization (low agricultural mechanization, few, underutilized or no primary industries)

In calculating this indicator data was obtained from the IEA database for Tanzania. The energy intensity values are for 1990 and 2003 and are based on US$ exchange rates for 2000. The IEA figures are 8.5MJ and 7.6 MJ/US$ for 1990 and 2003 respectively.

For this indicator the value of 1 is the 1990 global average energy intensity and the value of 0 on the vector is 10% of the 1990 value. Therefore the vector value for Tanzania is 8.5MJ and 7.6 MJ/US$ respectively

Metric (actual data) for 1990: 8.5 MJ/U$GDP and for 2003: 7.6MJ/U$ GDP
Vector value for 1990: 0.77 and for 2003: 0.68

Discussion
The low energy intensity used as commercial energy resources is low due to TANESCO's inefficient operations and weak performance, particularly in customer services (billing, collections and system losses). Despite charging an average tariff that should be adequate (about US $0.093 per kWh excluding 20t VAT), TANESCO has been unable to cover its operation and maintenance costs, debt service requirements and to make a reasonable contribution to its investment program. As a consequence, maintenance has been deferred, system reliability has suffered, and there has been little investment in distribution facilities required to expand access. There have been revenue shortfalls due to delays in tariff increases and poor collection performance. Why the government has improved its regularised payments for electricity consumption, TANESCO has not been able to meet the growing demand for electricity or to increase service coverage.

Although there have been policy changes in the generation side, the on-going dispute over alleged unreasonably high power tariffs between the IPTL and TANESCO can be partially explained by a lack of an appropriate regulatory framework. IPTL's initial power purchase agreement with the Tanzanian government in 1996, that would have allowed it to charge TANESCO 21.5 US cents per kWh (over twice the then prevailing TANESCO tariff of 9 US cents) led to an international outcry and charges of lack of transparency in how the agreement was reached. Under pressure from the World Bank and bilateral

donors, the project was suspended in mid 1998 and the matter was referred to the International Centre for the Settlement of Investments. A settlement was reached recently, with IPTL accepting a substantially lower tariff level.

Indicator 8: Renewable energy deployment

The deployment of renewable energy technologies in Tanzania is at various stages of advancement, although it is not well quantified and its documentation is outdated. The policy focuses on renewable deployment on biomass, solar, micro/mini hydro and wind since as it was felt that technologies for these energy sources could be disseminated in the short term (Mwihava and Mbise, 2005). Geothermal, the existing potential of >100 MW exploitation is considered a long term option since the costs of its development are comparably high (Karekezi et al,2005).[23]

The use of energy sources such as solar, biogas and LPG especially in the household sector is very low. It is estimated that about 1.2 MWp of photovoltaic (PV) power has been installed countrywide for various power applications of which 30-40% of the total installed capacity is from solar home systems (SHSs). The estimated average sales between 2000 and 2005 were about 500-600 PV systems per annum. The system components are imported through various private sector initiatives. The common PV applications in Tanzania are for telecommunications, lighting, vaccine refrigeration, water pumping, powering electronic accessories e.g. radios, computers, TVs, etc. schools and health centres/ rural dispensaries and missionaries.

Based on a report by Gwang'ombe, 2004, much of the wind resource in Tanzania is located along coastlines, the highland plateau regions of the Rift valley, on the plains and around the Great Lakes. Currently, wind energy is used to pump water for irrigation and to meet domestic and livestock water needs. Wind speed range from 0.9 to 4.8 m/s. At some locations, on the spot measurements are as high as 12m/s. A very limited number of attempts have been made to install wind turbines for electricity generation. Known wind turbine installations amount to 8.5 kWe (Karekezi et al 2005). A wind resource assessment (where wind speeds and solar insolation are being measured) at four selected sites is underway with the assistance from the Danish Government. It is expected that after these pilot sites, if resources allows, the measuring instruments would be used to assess other areas as a process of coming up with a wind energy resource map for the country.

The country's small/micro hydro potential is estimated at 314MW of which under 2% is developed through privately run schemes. It is estimated that

[23] The geothermal potential is based on approximations since a thorough assessment has not been done and yet to be confirmed (Uiso and Mwihava, 2005).

100 GWh/yr could be produced from micro/mini hydro systems, of which only 32GWh/year is currently produced.

According to EIA Energy statistics, 2003, the share of renewable energy to TPES (about 200,000 GWh) in 2003 was 93% and was predominantly based on biomass. The share of small scale hydropower is far below 0.01% of the total energy supply. Electricity which is based on large scale hydropower accounts for only 1.3%.

Value of 1 on the vector is the world's average renewable energy supply; the value of 0 is close to the sustainability goal of 0.95. This means the value of Tanzania for year 2003, is 0.023. The values for year 1990 were obtained from Lyimo and Mwakifwamba, 2002.

Metric (actual data) for 1990:94% and for 2005: 93%
Vector value for 1990: 0.012 and for 2005: 0.023

Discussion
That Tanzania's value for this indicator is seen to be close to sustainability is due to heavily dependence on biomass for energy supply, especially in rural areas as compared to other energy resources. The renewability of biomass in Tanzania is questionable due to resource availability. Woody biomass consumption per capita is equivalent to about 2.12MWh (Uiso and Mwihava, 2005). The annual sustainable yield is 24.5 million m^3 which does not satisfy the national average of mean annual increment (MAI) of around 67 million m^3 of solid wood and the average demand which in 2003 was estimated to be about 50 million m^3.

However, this is only a theoretical balance between wood fuel demand and supply potential. The experience has shown that many regions are experiencing acute scarcity of wood fuel due to uneven distribution of forest resources (Kaale, 2005). Deforestation and scarcity of biomass fuels in general affects women and children as they have to walk long distances to fetch firewood.

Reduction of deforestation has been addressed in the energy policy through use of efficient woody biomass to energy conversion technologies and techniques. The policy also allows independent power producers (IPP) to generate electricity from any source including biomass. By utilising the available 15 million tons per annum of crop residues and 1.1 million tons per annum of forest residues Mwihava and Mbise (2003) estimate a co-generation potential as 157 GWh. Although biomass co-generation technology is not new in Tanzania, its contribution to the country's energy supply is barely 15GWh. The technology is used to generate power to meet the demand of companies like Sao Hill Industries Ltd, TANWAT, Sugar processing plants: Tanganyika Planting Company (TPC), Kilombero Sugar Company, Mtibwa Sugar Estates and the Kagera Sugar Company.

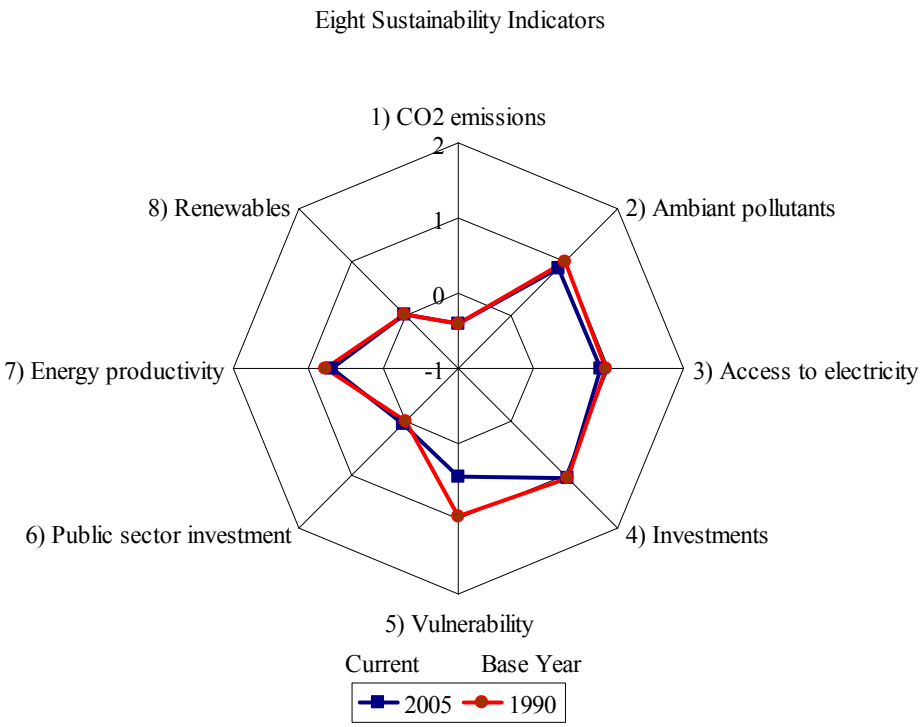
Considering that solar PV is an excellent renewable energy technology for application in remote areas where the national grid may not reach for another ten years, the rate of deployment is not as fast as the required supply. The household sector constitutes the largest share of the total energy consumption in Tanzania. In addition, the main energy end uses in the household sector: cooking, brewing, smoking, ironing and lighting may not make solar power as a feasible short term solution as compared to biomass. In rural areas, firewood is mostly used for cooking, while in urban areas charcoal is mostly used. Electricity, even in areas where it is readily available, is rarely used for cooking while kerosene is used for lighting by the low-income population.

Tanzania's energy policy needs to be clear on the sustainability of many objectives. For example the policy mentions ad campaigns for the renewables as a sustainable solution in Tanzania without setting a clear goal or milestones for the deployment of renewables. Furthermore a lot of emphasis is on large scale hydro plants. In addition, the rural electrification programs focuses on extension of the national grid to villages. However, from TANESCO's definitions, rural electrification ends at the district level.

In calculating this indicator data gathering from 1990's reports can be misleading which have been quoted in the new reports which have limited updates.

Presentation of Tanzania Star

The figure below is a graphic representation of Tanzania's SEW indicators for 1990 and 2005.



Analysis of Indicators

Tanzania's energy sector is characterized by a low per capita consumption of commercial energy (Petroleum and Electricity), and a relatively large dependence on non-commercial energy i.e. biomass (in form of firewood, charcoal and bio-waste) as well as human and animal waste. The energy balance of Tanzania shows that biomass use accounts for over 90% of energy consumption. Petroleum and electricity account for about 8% and 1.2% respectively with coal and other renewable energies contributing 0.8%. This heavy dependence on wood fuel as the main energy source contributes to deforestation, while the importation of oil has forced the nation to spend between 25% and 35% of its foreign earnings.

Tanzania's energy situation has been presented both numerically and visually in the body of this report.

Based on 1990 CEEST studies on CO2 emissions it is clear from these values that Tanzania is on track to achieving sustainability. However this figure can be misleading if it is not compared to the level of country development. Form the policy point of view it could be considered as an opportunity for Tanzania to continue investing in coal, oil and gas energy projects as emission levels are still low. The low value also presents an opportunity to attract CDM projects investment. Currently the new government is trying to reverse the master and prioritize coal, gas and oil for power generation. The result will be higher emissions over the next few years at least. Indicator 1 values could be calculated more reliably using data from MEM if reliable data are obtained and updated accordingly.

On indicator 2, indoor pollution from inefficient biomass burning on household cooking results in large amounts of particulate matter. Although the vector and value for the most significant pollutant are derived from a most likely scenario in Kenya, the actual data of indoor pollution which could enable calculating the particulate matter for Tanzania households was not found during the survey. Based on the data obtained is will be difficult to reduce the consumption of biomass and kerosene as they are the major providers of primary energy for households. Measures and efforts to facilitate greater adoption of well-ventilated kitchens with improved woodstoves with appropriate chimney should be adopted to safeguard health. For rural areas alternative cleaner fuels such as biogas, solar cookers and lighting, LPG and to a less extent electricity scaling up at all levels although the electricity tariffs and infrastructure can be a problem.

Less than 10% of the population has to access electricity in Tanzania which is low compared to the average of Africa (about 30%). This is primarily due to low investment in the electricity sub-sector. Connecting rural areas to national or local grid through the rural electrification program can increase or stabilize access at 10% until 2010. However, there is a need to quantify the

actual demand of electricity in rural areas before this program is fully in place. This will also help to create a much needed framework for the clean energy investment (indicator 4) which currently is not be the most cost-effective option. In addition, since TANESCO's grid is not expected to expand significantly in the near future the employment opportunities lie in renewable energy systems. Even if the TANESCO's current financial situation was resolved and its vertically integrated structure dismantled it is unlikely that the recipient companies will embark on small and clean energy systems over coal and large scale hydropower generation systems. The government decision to establish EWURA to form a basis for speeding up investments in clean energy systems is a good step. The anticipated Rural Energy Agency (REA) and Rural Energy Fund (REF) will also facilitate the implementation of on-going planned activities, including the formulation of a National Energy Strategy.

Tanzania does not export any of its energy resources and imports 100% of the fuel oil needed for its power generation requirements. The downstream oil industry is absorbing an average of 40-55% of the country's foreign exchange earnings per annum. This makes Tanzania highly vulnerable as is illustrated in the indicator on energy resilience and trade (Indicator 5). Inclusion of the 100MW IPTL plant to supply the base power due to unreliability of Tanzania's hydropower systems necessitates continued fuel oil importation at the expense of its foreign earnings. The government's appeal to the private sector to invest in energy generation and the revised power master plan (to invest in coal and oil exploration) will change the import trend and the country will likely become an energy exporter. Encouraging more private sector participation will ease the public burden on energy investments which to date has been dependent on TANESCO's business performance. Coal and petroleum exploration combined with proven gas reserves will encourage private investment in the sector.

Investment on commercial energy power systems has been limited by various factors including revenue shortfalls due to delays in tariff increases and poor collection performance. While there has been improved regularity by the Government in paying its dues to TANESCO, the company has been unable to meet the growing demand for electricity or to increase service coverage especially investment in distribution facilities required to expand access. From TANESCO's point of view, the grid needs to be expanded to meet expected load increase.

Renewable energy deployment indicator value for Tanzania is seen to be close to sustainability due to heavily dependence on biomass for energy supply, especially in rural areas as compared to other energy resources. There are renewability questions regarding biomass due to the fact that the country is undergoing net deforestation compared to the afforestation initiatives. This has raised the alarm especially in regions currently experiencing acute scarcity of wood fuel due to uneven distribution of forest

resources. Deforestation and scarcity of biomass fuels in general affects women and children since they have to walk long distances to fetch firewood.

Conclusions and Recommendations

The Tanzania Sustainable Energy (SEW) indicators presented in this report have been compiled from information gathered from various sources and reports. The report describes eight indicators for 2005 estimates and compares them from the base year 1990. The report indicates that Tanzania is inherently close to sustainability on three indicators namely indicator 1, indicator 6 and indicator 8 due to utilization of renewable energy with biomass as the dominant energy resource and low investment on conventional large scale energy resources. The calculated vectors show that Tanzania has very low level of industrialization i.e. low agricultural mechanization, few, underutilized or no primary industries resulting in both low income and modernization levels. There are data gaps which highlight the need for better data collection. The use of coal, oil and gas for example was not included in the year 2005 estimates.

The electricity sub-sector is highly underdeveloped although the demand for electricity is high. The government's plan to increase access to electricity through the TANESCO is not likely to bear fruit in the near future because of financial problems. The government's power master plan and policy focus on energy is on large scale hydropower and thermal units. Since the country's economic development is low there has been modest investment on clean energy. The country's thermal energy generation is from fuel oil and natural gas. Tanzania imports 100% of the fuel oil for electricity and power generation although efforts are being made to explore the oil and coal potential and to meet its fuel oil requirements. The energy resilience vector was calculated based on the total spending due to oil imports. The burden of energy investment on public is moderate since investment to date has been private, yielding a low value for the vector. The total primary energy supply is more 90% biomass therefore the commercial energy compared to the GDP is high.

Due to high dependency on biomass for energy demand the commercial energy supply very small. This is partly due to inaccessibility of modern energy resources as a result of the aging monopoly by TANESCO. The vector on energy intensity is very high due to low utilization of commercial energy resources. Renewable energy deployment is small since no significant investment in renewables, compared to the total investment in the sector, has been made. Renewable energy deployment policy focuses on solar, biomass, wind and biomass energy resources. However the biomass resource especially the natural forest is being depleted. The reliance on woody-based biomass and the use of inefficient wood-to-energy conversion technologies are listed among the leading culprits of the deforestation. The data on the actual deployment of renewable energy resources has been difficult to access since most are run by the private individuals and their public information is inadequate for a realistic analysis.

The private sector intervention can be the option if unbundling of the TANESCO is successful. This will also stimulate the private sector to increase its investment in clean energy resources. Review of the energy policy, taking into account the MKUKUTA, is important in reversing the currently focus on clean energy which is considered by the MEM as the medium or long term energy option.

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