Energy and Sustainable Environment in Tanzania

E.M. Masunzu

Introduction

Energy is an essential input in all aspects of economic activities. The promotion of social development, therefore, requires the availability of affordable, reliable and sufficient sources of energy.

In Tanzania about 92% of the energy supply is derived from biomass - mainly woodfuel - consumed in the households for domestic cooking. The remaining 8% is derived from petroleum products, electricity and other non-conventional sources like solar and wind energy.

The National Energy Policy launched in 1992 spells out the objective of energy development in the country as being to "provide an input into the development process of the country through the establishment of an efficient energy production, procurement, transportation, distribution, and end-use system in an environmentally sound manner and with due regard to gender issues."[1]

This paper highlights the impacts of different energy sources on the environment in Tanzania. It also suggests ways of mitigating or minimizing some of the negative impacts on the environment and points out some of the efforts which are already underway or in place to safeguard the environment.

Renewable Energy Sources

Most renewable energy systems have specific local but no global environmental impacts at the plant level; biomass and municipal waste burning are exceptions. Generally, some renewable technologies offer an alternative path for reducing pollution at the plant level.

Wind Power

The resource base for wind energy is immense. However, actual use is limited to preferred areas with special wind characteristics. To harvest wind energy to

the maximum possible extent, it is necessary to deploy local wind speed surveys, detailed wind maps and adequate technologies as prerequisites because windmill performance is very sensitive to wind speeds. Some potential environmental problems created by operating wind mills can be identified as: public safety, visual impacts (aesthetics) and hazards to birds.

Solar Thermal Systems

Solar thermal electric generating systems produce electric power by concentrating sunlight to heat a working fluid to high temperatures. Thermal solar systems operate most efficiently around the equatorial belt. They have no airborne emissions at the plant level. Accidents with external consequences are negligible. Two unique hazards to health may arise however, namely, reflected light and the accidental release of heat transfer fluids. This technology is, however, not at present being used in Tanzania.

Photovoltaic Power

Photovoltaic power generation is based on the conversion of direct and diffuse sunlight into electricity using photovoltaic cells. The efficiencies of today's modules range roughly from 5-15%, while concentrator modules have efficiencies in the neighbourhood of 20%.

Production of photovoltaic solar generators can involve hazardous gases, liquids and solid substances. Great care is normally required when disposing such toxic materials from photovoltaics manufacturing, as well as the disposal of solar cell modules and bateries at the end of their shelf life (which is about 25 years) in order to minimise negative environmental impacts.

During their operation, however, photovoltaic systems discharge no gaseous or liquid emissions or heat and are, therefore, considered ecologically benign.

Geothermal Power

Geothermal energy resources in Tanzania is still untapped although the potential is high. There is a possibility for electricity generation in future. Conventional geothermal technology is mature, and the electricity generating components are similar to those of conventional power stations.

Electricity generation using geothermal energy affects the environment in different ways. Airborne emissions include carbon dioxide as exhaust of the spent steam into the atmosphere, hydrogen sulphide, mercury, ammonia and radon. Pollution of rivers and lakes may occur if spent geothermal fluids are not re-injected into the reservoir. Hot waters and steam condensates generally carry a variety of toxic chemicals in suspension and in solution. Possible further environmental effects are land subsidence, induced seismicity, noise from newly drilled wells and some solid waste.

Biomass Energy

Biomass energy can be produced from almost any organic material, including terrestrial and aquatic plants, and agricultural residues. Certain industrial and municipal wastes can also be considered as biomass.

Municipal wastes can be used for electricity generation, both directly as fuel at incineration and pyrolysis plants and indirectly through anaerobic digestion as a result of methane production. The Ministry of Water, Energy and Minerals will soon implement a project aimed at utilizing organic wastes being generated in urban area. Biogas production from waste decreases uncontrolled release of methane and will generate energy (electricity) and organic fertilizer.

Biomass Resources and Minimization of Woodfuel Consumption

The country's energy sources comprise of biomass (woodfuel and agriculture residues), petroleum, electricity and to some extent coal. Biomass accounts for about 92% of the primary energy use. Other sources of energy whose current utilization degree is too low to appear on the overall energy balance include solar and wind energy. However, their potentials are high had they been explored. Bio-fuels are therefore the most dominant sources of energy and it is forecast that the contribution of these fuels to the energy balance will remain the same for the foreseeable future.

Unfortunately, woodfuels are utilized in a very inefficient way. The sector which consumes the largest share of woodfuels is the domestic sector. In rural areas and even in towns firewood is burnt on three-stone stoves on open fires. Charcoal is burnt in traditional all-metal stoves in urban households. The thermal efficiency of the traditional three stone and open fire places is said to be below 10%. For the traditional metal stoves, the efficiency ranges from 15% to 18%. Charcoal is produced in traditional kilns whose conversion efficiencies are below 20%.

Other agro-processing industries (including fish smoking) use enormous amounts of wood in an inefficient manner. The current demand for wood fuels is far in excess of supply, while conversion and utilization processes are inefficient. Annual bush fires are frequent. There is excess harvesting of wood on a unsustainable basis and is causing a series of environmental impacts including soil erosion, rapid run-off from watersheds and infiltration of water sources. Mascarenhas and Kilahama[2] have observed that in some regions such as Shinyanga, Mwanza, parts of Arusha and Singida where wood is very scarce, the use of cowdung or farm residues remains the only means for the people to sustain life. Animal manure could otherwise be used as fertilizer to improve farm productivity. It is estimated that the total demand for fuelwood in Tanzania is 44 million cubic metres per year.[0]

It is in view of the above considerations, that the National Energy Policy stresses on efficient energy production, procurement, distribution and end-use system in an environmentally sound manner.[0]In order to address some of these issues, the Ministry of Water, Energy and Minerals (MWEM) has embarked on a programme to improve woodfuel end-use efficiency at the household and institutional levels. In this endeavor it is being assisted by interested non-government organisations (NGOs). The objective here is to develop and disseminate improved charcoal kilns and cookstoves.

Charcoal Production

In order to reduce the current heavy pressure on Tanzania's natural forest resources, the MWEM has instituted a programme designed to introduce woodfuel saving technologies. These technologies include the improved earth mound *casamance* kiln and brick kilns. *Casamance* kilns are meant for small holder charcoal production in public lands and the brick kilns are for places where biomass density is higher. They can also be used to utilize such untapped resources as sawmill residues.

Casamance kiln technology was introduced to Tanzania from Senegal in 1988 through a pilot project in the Coast and Kilimanjaro regions. Field tests have revealed that these kilns have higher yield in terms of charcoal quantity compared to the traditional earth kilns. Efforts are underway to improve the existing traditional kilns to enable those who are not able to afford *casamance* kilns to use them efficiently.

The half orange brick kilns were introduced in the country around the same time through a pilot project at the Tanganyika Wattle Company (TANWAT) Njombe and at Sawmills in Tanga region.

Improved Cookstoves

The Ministry of Water, Energy and Minerals has been involved in the dissemination of improved charcoal stove (*jiko*) technology which was introduced in 1988. The project started in Dar es Salaam where todate more than 100 enterprises are involved in charcoal stove production. This stove has a heat transfer efficiency of about 30% which is nearly twice that of the traditional stove, rated at 15-18%. The overall performance of this type of stove in terms of charcoal saving largely explains its popularity among charcoal users.[0]

Utilization of Bio-Wastes

In Tanzania agricultural wastes such as rice husks and saw dusts are abundant. However, the major problem with these wastes is that in most cases they have a vast volume to weight ratio making storage and transportation difficult and uneconomical. Nevertheless, more efforts should be made to promote the use of the fuels. What is needed is a process that can refine these materials into a usable fuel. Briquetting may be a feasible means of raising the density to facilitate handling and transportation.

Agro-Forestry and Wood Fuel Plantations

These are land use practices whereby a farmer produces both agricultural crops and forest crops and from the same land and in so doings maintain a sound environment. People should be sensitized to employ such land use systems. For example, woodlots may be established for energy purposes on communal or individual basis using fast growing species wherever possible. *Coppicing* species are recommended.

Energy Conservation

By its very nature energy conservation is environmentally friendly. Energy conservation is one of the most cost effective ways to achieve environmental improvement. Energy planners and managers in the sector should, therefore, include energy conservation programmes in their plans.

Household Sector

Household (indoor) pollution which mainly affects women and children is common both in rural and urban areas. Considering that 92% of primary energy consumption is in the form of wood fuels and agricultural residues, it is evident that this type of air pollution is significant.

Because of fuel scarcity in many parts of the country, more and more families are forced to use straw, crop stalks, cow dung and agricultural residues as alternative cooking and heating fuels.

The burning of firewood, dried cattle dung and other agricultural wastes, some of them with contaminated pesticides, releases such toxic gases as carbon monoxide, sulphur dioxide and hydrocarbons in addition to soot and ash particles. The introduction of improved energy efficient stoves for households should improve kitchen hygiene and minimize pollution. In those areas where there is woodfuel scarcity, efforts are being made to disseminate coal stoves (with chimney) and coal briquettes.

Industrial Sector

Air is polluted mainly by industrial emissions and motor vehicles. The polluted air and rains which absorb some pollutants from the atmosphere have detrimental effects on flora, fauna and human beings. Water is also polluted by industrial wastes.

Energy efficiency is clearly the answer to sustainable industrial operations. Nothing could dramatically improve Tanzania's energy situation as energy efficiency. Industrial energy efficiency not only leads to economic growth, it also reduces the threats of acid rain, the occurrence of smog and global warming. Studies conducted in the country show that simple and inexpensive but efficient technologies and practices can deliver savings of up to 20% of energy consumed. Reduction of energy consumption can be achieved through a balanced combination of regulatory, economic, and technological measures such as:

- the manufacture of energy efficient appliances;
- the introduction of emission limits for all imported equipment;
- the imposition of penalties on energy inefficient technologies;
- the promotion of energy efficient and environmentally friendly forms of production; and
- the institution of various types of environmental taxes.

Industry can make a vital contribution to environmental protection and the

reduction of pollution only if the production processes and the energy waste flows are properly mapped. In such a monitoring system, attention should be paid to:

- The nature of the production process;
- The use of raw materials;
- The relation of the production process to the waste flows and energy flows;
- The recycling of waste flows and energy flows;
- The relation of the type of product to the energy flows; and
- The energy losses and consumption per process component.

Transport

Energy conservation in the transport sector is very important as far as environmental protection is concerned. Our transport sector (where 50% of all petroleum goes) is totally dependent on combustion of petroleum fuels where emissions constitute a major contribution to urban pollution and to the build-up of greenhouse gases. It is, therefore, necessary to set an overall energy target to reduce fuel consumption in the personal and commercial transport fleet and monitor its effectiveness. Specific targets and objectives could be set for reducing fuel consumption through:

- he purchase of fuel efficient vehicles;
- improving the fuel efficiency of existing fleets;
- employee awareness of the company's environmental policies and transport strategy;
- training of drivers to help achieve fuel efficiency and minimise vehicle noise.

Furthermore, consideration should be given to the use of diesel-powered cars since they are usually more efficient than their petrol-driven equivalents and can thus help keep carbon dioxide emissions down. On the other hand, diesel engines emit more nitrogen oxides and softy parties which affect local and regional air quality. Routes should be planned to take account of environmentally sensitive areas, maximising efficient use of the driver, vehicle and fuel. Dar es Salaam City alone, whose total length of available roads (rough and smooth)is 1182km of which 85% are in a pathetic state, currently accommodates about 50,000 vehicles.

Coal Utilization and Development

Tanzania has a proven coal reserve of 304 million tonnes and inferred reserves of about 1,200 million tonnes. The use of coal as a substitute fuel in industries such as the Southern Paper Mills and Mbeya Cement Factory, power generation, agriculture and households is being promoted.

Producing and transporting coal has a negative impact on the environment. Great importance has to be attached to the Environment Impact

Assessment (EIA) conducted before a mining project is started. An EIA is usually wide ranging, covering the initial environment - soil, flora and fauna in the potential impact of a new mine, including subsidence, the effect on ground water, methane emissions, waste disposal, noise and dust.

While land can be improved through a rehabilitation process, problems of noise and dust can be reduced by designing modifications to equipment and selected screening such as planting trees or cladding buildings.

In many cases, waste materials are returned to the mined-out areas as part of the rehabilitation process. It can also be used for road building, landfill, brick making or the manufacturing of cement. Pollution of the Songwe - Kiwira river by the coal mining company is due to dumping of particulates into the river. This pollution causes acidification and can be prevented by mixing waste water with a neutralising material such as limestone.

The government plans to utilize coal for power generation on a wider scale. A small scale plant designed to produce 6MW is operational at Kiwira. Burning coal to generate electricity produces both solid wastes and flue gases. In terms of impact on the environment, the main gaseous emissions of concern are particulates (fine air-borne ash), sulphur dioxide and nitrogen oxides which, can in turn lead to the formation of another pollutant ozone. In particular, the emissions of sulphur dioxide and nitrogen dioxide can lead to acid rain. Carbon dioxide emissions also may be contributing to a possible global warming or enhanced green house effect.

In order for the energy sector to contribute to the preservation of the environment the following measures will need to be taken:

(i) renewed efforts to substitute other sources such as electricity and coal for wood fuel for tobacco curing and tea drying;

(ii) tobacco curing and tea drying areas should be encouraged to initiate wood lots for wood production;

(ii) the design and production of more efficient tobacco curing barns should be encouraged and supported.

(iv) afforestation and reforestation campaigns should be continued;

(v) environmental considerations should feature in the planning and design of coal fired electric power stations including the use of modern pollution control equipment.

Petroleum and Gas

Environmental protection in hydrocarbon exploration and exploitation is a condition that is desired by any country which is a petroleum resource owner. The petroleum sector is divided into two main categories, namely; upstream and downstream. The upstream sector mainly deals with the search of hydrocarbons both on-shore and off-shore using geological and geophysical techniques and the drilling of exploratory wells. The downstream sector deals

with transportation of crude oil, refining, conveyance of its petroleum product marketing and end use

Upstream
Under this sector we will deal with environmental issues associated with seismic data acquisition and drilling.

Land Based Seismic Operations
This activity involves land line clearance on an area of interest depending on the planned seismic grid. Line clearance entails tree cutting and removal of vegetation cover, a process which may expose the area to soil erosion by wind, rainfall and animals. In some cases, crops and buildings may need to be destroyed to give way to seismic lines. In Tanzania, exploration of oil and gas dates back to the early 1950's. To date a total of 24,000 line km of onshore seismic surveys has been recorded. This is equivalent to clearance of about 72 square km of bare land (the width of seismic line is approximately 3 m). However, this situation, is, in some places, temporary because the grass and other vegetation usually start to regenerate soon after clearance. From experience, the soil erosion impact of line clearance is very negligible.

Off-Shore Seismic Operations
Education in environmental awareness has been, and continues to be, an important tool in convincing oil companies that their activities should be environmentally friendly and operated by environmentally aware personnel.

In order to preserve marine life such as planktons, fish etc, explosive seismic sources are not a viable option in the planning of any marine survey. Instead, acoustic seismic sources should be used. In addition information detailing areas and seasons of breeding and spawning on the marine habitat should be obtained prior to seismic operations. So far 21,000 line km of marine seismic surveys have been recorded in Tanzania with no apparent environmental impact to marine ecology.

On-Shore Drilling Operations
Following seismic data interpretation, sub-surface structures in the area of interest should be identified and mapped in preparation for drilling. The aim of drilling is to test whether or not the structures contain any hydrocarbons. The activity involves land clearance at the drilling site, digging an area for drilling and mud disposal. After completion of drilling activities land restoration to bring the area almost to its original state has to be made.

Marine Drilling Operations
Just like land-based drilling operations, the purpose of drilling in the offshore area is to test the contents of sub-surface structures. Prior to the siting of the marine drilling operations, the bathymetric data of the area of interest should be utilized to avoid fragile reef areas wherever possible. Crucial to the entire marine ecology are the measures taken to avoid blow-outs during exploration

drilling through using equipment capable of withstanding pressure from the underlying geology. Since corals and many invertebrates require silt free waters to thrive, precautions ought to be taken to ensure that the rig has adequate deck drainage and trapping facilities to retain all drilling fluids and cuttings to prevent discharge into the sea. These wastes should then be shipped to the shore for proper disposal.

In order to continue with the search for oil and gas and to protect the environment, the government has made a relevant provision in the model Production Sharing Agreement (PSA) (Article 22: Protection of the Environment). This article, among other things, calls for any contractor carrying out petroleum exploration operations in the country to observe the following:[0]

(i) Prevent pollution and protect the environment and the living resources; and
(ii) Ensure adequate compensation for injury to persons or damage to property caused by the effect of petroleum operations.

Downstream

The following are possible negative effects to the environment that might result from various activities in the downstream section of the petroleum sector:

Crude Oil Refining

(i) Leakage of crude oil and white products due to defective storage tanks.
(ii) Emission of sulphur and sour gases into the atmosphere caused by improper treatment of crude oil to remove sulphur and also caused by the inability of the refinery to produce minimum levels of sour gases.
(iii) Flaring of both valued and sour gases caused by limitation of storage facilities and the inability of the refinery to produce minimum levels of sour gases. The act of flaring these gases pollutes the atmosphere.
(iv) Use of Fuel Oil (Fo) as energy source in the furnace as a result of which the refinery emits carbon dioxide to the atmosphere.
(v) Emission of super heated stream to the atmosphere due to improper maintenance of broiler, pipes and valves.

Transportation of Petroleum Products

(i) Oil spills caused by defective marine transportation vessels.
(ii) Leakages caused by defective rail/road vessels.

Storage

(i) Leakages due to unmaintained storage tanks.
(ii) Leakages caused by defective loading and unloading facilities.

End User

The use of unserviced machinery and old vehicles cause incomplete combustionof the fuel and thus the emission of carbon dioxide into the atmosphere.

Remedial Actions
The following precautionaly measures can be applied:

Refining
(i) use of natural gas as energy sources for the furnace;
(ii) full de-sulphurization of crude oil;
(iii) timely refinery maintenance to prevent fuel and stream leakages.

Transportation
(i) regular check-up and service of products transporting equipment;
(ii) maintenance of loading and off-loading facilities.

Storage
(i) storage tanks should be serviced regularly and painted.
(ii) maintenance of distribution facilities should be observed.

End Use
(i) people should avoid the use of old vehicles and other machinery.
(ii) encourage regular servicing of vehicles and other machinery.

Electricity

Electricity accounts for less than 2% of the total energy consumption in Tanzania. The predominance of biomass in the energy balance is indicative of an underdeveloped economy.

In Tanzania about 80% of the total electricity generated is from hydropower. The rest is mainly from conventional thermal generated using gas oil or heavy fuel. Some electricity generation is from coal and there are plans to expand it.

The National Energy Policy puts emphasis on the continued development of the abundant hydropower potential while recognizing the need for developing other sources like natural gas, solar and wind energy which are available locally.

Tanzania has about 4.7 GW of potential hydroelectric capacity, 3.2 GW being firm. At present only about 10% of this potential is exploited.

Hydroelectric Power
The construction of hydroelectric dams causes extensive areas to be submerged by the resulting reservours. This has the following negative impacts on the environment:

(i) The decomposition of submerged biomass contribute to green house gases, mainly methane;
(ii) The local eco-systemic balance is disrupted;
(iii) There is a possibility of extinction of some flora and fauna species; and
(iv) Reservoirs result in the displacement of both human and animal populations.

Despite these potentially negative effects on the environment, Tanzania will continue to develop hydropower because of the following reasons:

(i) The nature of hydropower as a "tree fuel"
(ii) It is renewable
(iii) It is an indigeneous resource.
(iv) Hydroelectric power projects catalyse local development by making the localities accessible after the construction of access roads.
(v) Hydropower dams generally lead to improved local climatic conditions.

In order to make hydropower sustainable it is imperative that the delicate ecological balance of the catchment areas is maintained through:

(i) control of water utilization through water rights, and instituting water user fees to finance catchment area policing.
(ii) control of bush fires.
(iii) preventing agricultural activities very near water sources or water channels (e.g. within 30-50m).
(iv) prohibiting planting of exotic tree species (or water fillic trees) near water sources.

Thermal Electric Power Generation

Convention thermal plants use gas oil or heavy industrial fuel which burn to release carbon dioxide, sulphur dioxide and other pollutants into the atmosphere. Fuel transportation and storage systems for these plants are also a potential source of pollution. In addition, these plants cause heat and noise pollution.

Gas Turbines

Tanzania has acquired two gas turbines each of 18MW which run on gas oil. When Songo Songo gas becomes available in Dar es Salaam, the turbines will run on natural gas. The combustion of natural gas is relatively cleaner than petroleum based fuels. Restrictions on fuel compositions and the use of combined heat and power plants reduces the amount of pollution from petroleum fuel - based gas turbine plants. But since the generation of electricity using thermal - based sources will continue, the following steps should be taken to minimize damage to the environment:

(a) institution of pollution level monitoring during generation of power in power plants and industry;
(b) institution of penalties against polluters;
(c) institution of standards for air, water and soil quality as far as emissions are concerned.

Transmission and Distribution

The main environmental problem with electric transmission and distribution lines is the visual impact. They can also be hazardous to birds and interfere with their migratory routes.

General Comments and Recommendations

The exploitation of energy has some negative impacts on the environment. This is why the National Energy Policy of 1992 recognizes the need to make energy development environmentally sound. It is recommended that the following measures should be instituted:[0]

(i) deliberate awareness campaigns should be mounted to make the general public aware of the finite nature of resources.
(ii) efforts should be made to include the subject "energy and a sustainable environment" in school curriculum.
(iii) a regulatory body should be instituted in order to ensure compliance with environmental standard requirements like: pollution levels, and standard cleanness of air, water and soil by industry and individuals.
(iv) laws and regulations relating to the protection of hydropower sources should be instituted and/or strengthened.
(v) institutions dealing with the prevention of forest and bush fires should be strengthened.
(vi) maximum allowable levels of permissible green house gases emission beyond which penalties should be exacted, should be set.
(vii) authorization of any energy development project should not be given without an Environmental Impact Assessment.

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