Government of Malawi

REPORT

ON

MALAWI'S CLIMATE TECHNOLOGY TRANSFER AND NEEDS ASSESSMENT

UNDER UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)-EXPEDITED PHASE II.

ENVIRONMENTAL AFFAIRS DEPARTMENT
MINISTRY OF NATURAL RESOURCES AND ENVIRONMENTAL AFFAIRS.
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ACRONYMS AND ABBREVIATIONS

ADD	Agricultural Development Division
BNF	Biological Nitrogen Fixation
CFC	Chlorofluorocarbons
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
DAHI	Department of Animal Health and Industry
DARTS	Department of Agricultural Research and Technical Services
DFID	Department for International Development
EAD	Environmental Affairs Department
FAO	Food and Agricultural Organization
FEWS	Famine Early Warning System
GAP	Guide to Agricultural Production
GDP	Gross Domestic Product
Gg	Gigagrams
GHG	Greenhouse Gases
H_2O	Water
Ha	Hectare
HFC	Hydroflourocarbons
IPCC	International Panel on Climate Change
MNLDMP	Malawi National Livestock Development Master Plan
MOAI	Ministry of Agriculture and Irrigation
N_2	Nitrogen
N_2O	Nitrous oxide
NEAP	National Environmental Action Plan
NMVOC	Non-Methane Volatile Organic Compounds
NO_x	Oxides of Nitrogen
NSO	National Statistical Office
O_2	Oxygen
O_3	Ozone
OECD	Organization for Economic Cooperation and Development
PFC	Perflourinated Compounds
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
WWM	Waste Water Management
COP	Conference of Parties

UNFCCC	United Nations Framework Convention on Climate Change
GEF	Global Environmental Facility
REIAMA	Renewable Energy Industries Association of Malawi
MIRTDC	Malawi Industrial Research and Technology development centre
ITCZ	Inter Tropical Convergence Zone
PCC	Petroleum Control Commission

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FOREWORD

The Climate Change Technology Transfer and Needs Assessment Report has been compiled in line with the recommendation of the Conference of Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC) decision 4/CP.4. Non-Annex 1 parties to which Malawi is grouped are encouraged to submit their prioritised technology needs. Furthermore, Article 4.5 of the UNFCCC urges Least Developed Countries to identify technologies, practices and reforms in different sectors of the economy to reduce greenhouse gas emissions, climate variability and contribute to developmental goals.

It is recognised that climate change threatens all regions of the world with profound effects on all human activities such as in agriculture, hydrology and water resources, human habitat, forests, wildlife, finance, insurance, energy industry etc. The Initial National Communication of Malawi April 2003 has identified vulnerable sectors of the economy and identified options and measures to adapt to and or mitigate climate change impacts.

Human response to adapt to or mitigate climate change has identified and is developing technologies and practices for various economic sectors, which meet needs for sustainable goals although most of them are still in the developmental stages.

Malawi has reviewed in the present status report the current use of climate change technologies in most sectors and investigated further needs to promote further socio-economic development. There is low utilisation of renewable energy technologies at present although the potential is great with profound effects to improve the quality of life more especially in the provision of stand alone systems for electricity power supply and water pumping. This status report is part of an on-going effort by the country to fully utilise and integrate renewable energy technologies that may enhance poverty reduction.

It is recognised that constraints and barriers have been identified especially those involving financial support to access, acquire and utilise the technologies. The UNDP, Global Environment Facility (GEF) and the World Bank are encouraged to support Malawi in the efforts to utilise more climate change technologies to uplift the socio-economic standing of the country as well as meet the obligations under the climate change convention. The proposed way-forward for Malawi in this report needs to be supported by all donors because there is need for extensive and intensive use renewable technologies in the country especially at the rural levels.

I take this opportunity to thank the UNDP and GEF for supporting this study. The Climate Technology Initiative (CTI) for the technical and financial support including the facilitation of the national workshop. All national stakeholders, experts, and scientists are highly commended.

Mr T. R. O'dala
Secretary for Mines, Natural Resources and Environment.

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The Taskforce Team headed by Mr. T.S. Madovi, President of the Renewable Energy Industries of Malawi for the leadership in the consultative process.
Gratitude extends to all chapter authors for the time devoted to this report.
The UNDP for facilitating financial and international technical support for Climate Change Enabling Activities project on which the Technology Transfer and Needs Assessment has been carried out.

Lastly thanks go to all members of staff at Environmental Affairs who enabled the successful completion of this report.

Mr. R P Kabwaza
Director of Environmental Affairs

EXECUTIVE SUMMARY

The Climate Change Technology Transfer and Needs Assessment report is in line with the UNFCCC especially article 4.5 and the National climate change enabling activities. These aspects have also been captured in the initial national communication of Malawi submitted to the conference of parties through the UNFCCC secretariat.
Malawi now has an integrated Energy Policy in place in addition to other existing energy programmes such as NSREP, which will enhance the use and utilisation of renewable energy technologies for sustainable development taking into account adaptation and mitigation needs to climate change. This Technology transfer and needs assessment will enable Malawi to light up to a greater percentage than what is existing at the moment.

Needs Assessment
In this process the assessment included development and climate response needs and opportunities in the country based on some of the outlined activities in the Initial National Communication of Malawi. The need to focus on the priority area of Poverty Reduction was maintained in assessing the various sectors. The assessment is a first step and may not be very comprehensive.

Technology Prioritisation
Technology transfer was considered as a flow of experience, know-how, and equipment between and within nations. Standard criteria were used such as developmental benefits, market readiness, GHG emission reduction potential, environmental benefits, job creation etc. The analysis has potential for expansion in future. The technologies prioritised were, solar photovoltaic (PV) systems, biogas, wind, mini/micro hydros. The Solar PV systems were given the highest priority for lighting and water pumping.

Biogas
Biogas technologies were introduced in the country in the 1970s but their diffusion rate has been very slow and limited. The technology faces a number of barriers and constraints among which are poor animal husbandry practices, poor project planning, cultural beliefs, inadequate skills etc. Donor funding has been minimal and success minimal. However, the country has high potential for biogas technologies especially in rural areas where power for lighting and cooking is in high demand.

Energy Efficiency
The study has shown that Malawi stands to benefit from energy efficiency activities if undertaken with skill. Barriers to initiatives to application of energy efficiency applications have been elaborated such as: free biomass energy resource and lack of policy etc.; low disposable income per capita; and, inadequate or lack of energy data and information systems on energy efficiency. Donor support has been forthcoming but not large enough. There is much room and scope to implement energy efficient activities in the energy supply and energy end-use sectors in the country for the benefit of the country.

Wind Power Resource
Wind power potential is considerable in the country especially for water pumping. The spatial and temporal distribution of wind power is considerable more especially for power

generation. Wind infrastructures for systematic observations have declined with time especially at the 10-metre height and above vital for energy studies and other applications. Donor support has declined in wind assessments although new avenues need to be exploited.

Wind Technologies

The imported wind technologies for water pumping have been in the country from the early 1940s but their diffusion rate has recently even declined further. Imported wind technologies are still expensive including operation costs. However, local wind technology manufacturing has sprouted designed for the Malawi conditions for water pumping. The costs are still on the higher side and these technologies are for shallow wells only. Wind pumping has a potential using the local technologies especially for water pumping for crop and animal production throughout the country.

Mini/Micro Hydros

Since the 1950s, Malawi has had mini/micro hydropower infrastructures especially in the southern region. However, barriers have constrained the growth of mini/micro hydros in the country including high initial investment cost. Assessment of mini/micro hydros shows good potential mainly in the northern region. With improved donor funding and private investments, mini/micro hydros would greatly improve the lighting up of Malawi thereby improving the quality of life in the country.

Solar Photovoltaic (PV) Systems

Malawi has great solar potential output in most areas amounting on average to 3000 hours of sunshine per year. Solar PV systems have so far been used for off-grid solar home systems, public/street lighting, vaccine refrigeration and also irrigation water pumping. The diffusion rates are still very low. Enabling environments have improved and a barrier removal project is in place as such PV systems may now see an accelerated pace of diffusion. Donor funding has been considerable although more private investment could be a catalyst. There is need for extensive and intensive use of solar PV-systems.

Way Forward

Malawi aims at reducing the biomass pathway in the energy future. Renewable technologies especially solar PV systems, mini/micro hydros and wind are to be given prominence. Donor funding and support will be very crucial. Tables 9.1-9.4 summarise for each technology the required investment.

CHAPTER 1

NATIONAL CIRCUMSTANCES

1.0 Introduction

There is a growing awareness that the increase in the amount of greenhouse gases (GHGs) being released into the atmosphere will have adverse effects on the global weather systems. The warming is not expected to be globally uniform but could differ significantly between geographical regions and vary between seasons (Ottichilo *et al.*, 1991). This will likely affect the natural resources. The key natural resource sectors that might be susceptible to changes in climate include agricultural crops, livestock, forests, water resources, coastal resources, fisheries, and wildlife (USA government, 1994). African countries are more vulnerable than industrialized countries to the effects of climatic change for two reasons. First, the current economic and ecological crises have weakened the capacity of many countries to adjust to drastic economic and ecological changes. Second, most of the people depend on agriculture for their subsistence, and agriculture depends a great deal on climatic patterns (Mkanda, 1995).

Malawi is one of the countries that have ratified the United Nations Framework Convention on Climate Change (UNFCCC). Under this Convention, parties to the Convention must communicate to the Conference of the Parties (COP) their national inventories of anthropogenic emissions of all greenhouse gases by sources and sinks using comparative methodologies. Malawi undertook their greenhouse gas inventory based on the years 1990 and 1994. Additionally, Malawi has started to assess the vulnerability of important sectors (water, agriculture, and wildlife) to climate change impacts and recommend adaptation and mitigation measures.

The aim of this chapter is to give the context in which Malawi exists, especially in relation to climate change and Malawi's capacity to respond to climate change impacts. The subsequent sections give a summary of Malawi's geography and climate, natural resources, land use, history and climate, population, energy, mining industry and tourism, socio-economic and development profile, forestry and agriculture.

1.1 Geography and Climate

Malawi is located south of the equator between latitude 9^0 $22^/$ and 17^0 $7^/$ south and between longitudes 32^0 $40^/$ and 35^0 $55^/$ east (Fig 1.1). It is bordered to the north and northeast by the Republic of Tanzania, to the west by the Republic of Zambia and to the southwest and east by the Republic of Mozambique (Fig 1.2). The total area is 118,483 sq km of which 94,275 sq km is land and 24,208 sq km is water. Malawi is divided into three regions namely southern, central and northern regions. There are four major urban areas in the country; Lilongwe, which is located in the central region and is the capital city of the country, Blantyre in the Southern region is the commercial city of the country, Mzuzu in the Northern region is the regional headquarters and Zomba is the former capital city and seat of Parliament.

The Malawi climate is generally subtropical. The climate of Malawi is strongly influenced by its position within the sub-continent in relation to the pressure and wind systems of the Southern Hemisphere. Changes in the distribution of rainfall take place in response to the movement of the Inter-Tropical Convergence Zone (ITCZ) and associated belts of distribution. Climate change and variability are caused amongst others by disturbance of the ITCZ, shifts in the global circulation pattern, deforestation, rate of evapo-transpiration, green house gas emissions and disruption in the hydrological system (EAD, 1998). Malawi has three seasons: cool and dry, from May to August; hot and warm and wet, from December to April. During the cool and dry season, temperatures range from 15.5 to 18 degrees Celsius in the plateau regions and from 20 to 24.5 in the rift valley areas. During the hot and dry season, temperatures range from 22 to 25 and 27 to 30 degrees Celsius in the plateau and rift valley respectively. From mid November to April, it is hot and wet with almost 90% of annual rainfall occurring during this time. The wettest months in Malawi are December and January. The annual rainfall averages between 760mm and 1,015mm with some areas in the plateau recording more than 1,500mm each year (Southern African marketing Co. (Pty) Ltd and Southern African Development Community (SADC)a , 2001) .

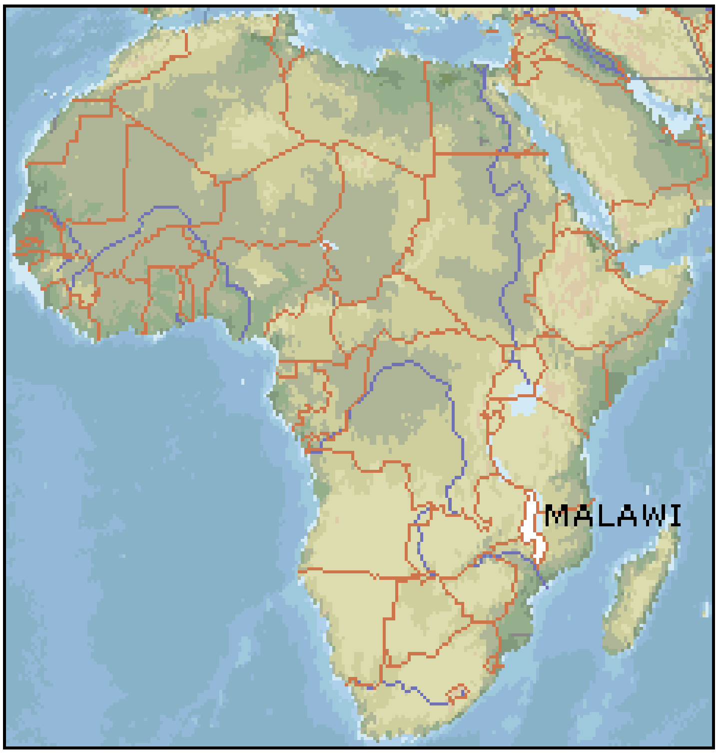

Fig 1.1: Location of Malawi in Africa

Fig 1.2 Map of Malawi and its Neighbouring countries
Source: DOS recommended

1.2 Natural Resources

Malawi has a lot of natural resources and some of them are forestry, wildlife, rivers and lakes, and land. This section gives a brief summary of Malawi's natural resources.

1.2.1 Vegetation and Forestry

The predominant vegetation of Malawi is the savannah woodland. The vegetation on highlands mainly consists of sparse forest, changing in wooded savannah in the most densely populated regions, and meadow at high altitude. There are savannahs with acacias in the gulf of the south, which is drier. Many natural reserves, especially in the north and in certain parts of the southern gulf, have allowed for the conservation of some sorts of vegetation that have been cleared elsewhere by farmers.

Malawi's vegetation consists of the following zones: Miombo wood in humid regions, Mopane wood in hot plains, forests with somehow evergreen trees, along the rivers and slopes, forests with evergreen trees at high altitude, alpine meadow between 1,800 and 2,000 metres, thick woods along rivers and swamps covered with reeds and grass.

Forests and woodlands provide 90% of Malawi's energy, (Energy Affairs Department (EAD), 2000) environmentally project catchment areas, provide timber and also preserve biodiversity of flora and fauna.

The forestry resources were estimated in 2000 to be 9.4 billion hectares (EAD, 2000) representing 28% of the total land area in Malawi.

Forest resources in Malawi are experiencing a lot of deforestation and in 2000 the deforestation rate was estimated to be 2.8%. The rate of deforestation is different for the three regions of Malawi namely, Central region with 2.4% deforestation rate, Southern region with 2.7% and Northern region with 3.4% deforestation rates. The high deforestation rates in Malawi are due to the adverse poverty, high population growth, development economic activities, and conversion of forested land to agricultural land as the demand for food increases. The major causes of deforestation that have been listed are (EAD, 2000) tea and tobacco curing, agricultural expansion, fuel wood demand, shifting cultivation and wild forest fire.

Some of the mitigation measures that have been propped are:

- Introduction of alternative and efficient sources of energy, renewable or energy saving device,
- Reduction of tariffs on electricity,
- Introduction of improved agricultural practices to reduce demand for more land,
- Provision of alternative value added non consumptive use of forest or alternative income generating activities,
- Increase in wood production from national plantations,
- Protection of existing forest reserves through co-management with communities, and

- Empowerment of district assemblies to manage their resources.

1.2.2 Water Resources

Malawi is rich in water resources in form of lakes, rivers and aquifers. Fig 1.3 shows the major water resources in Malawi. The trend of annual mean flows in most rivers in the country for the past four decades shows no change apart from random fluctuations mainly due to variation in annual rainfall (EAD, 2000).
The trends in water quality indicate that the resources are increasingly at risk (pollution) in all rivers due to increases in the intensity of land use as the result of population growth, contamination arising from poor sanitation and improper, disposal of waste and chemical contamination due to improper application of fertilizers and pesticides in agriculture, disposal of chemical wastes from industry and discharge of hazardous waste from hospitals and other institutions (EAD, 2000).

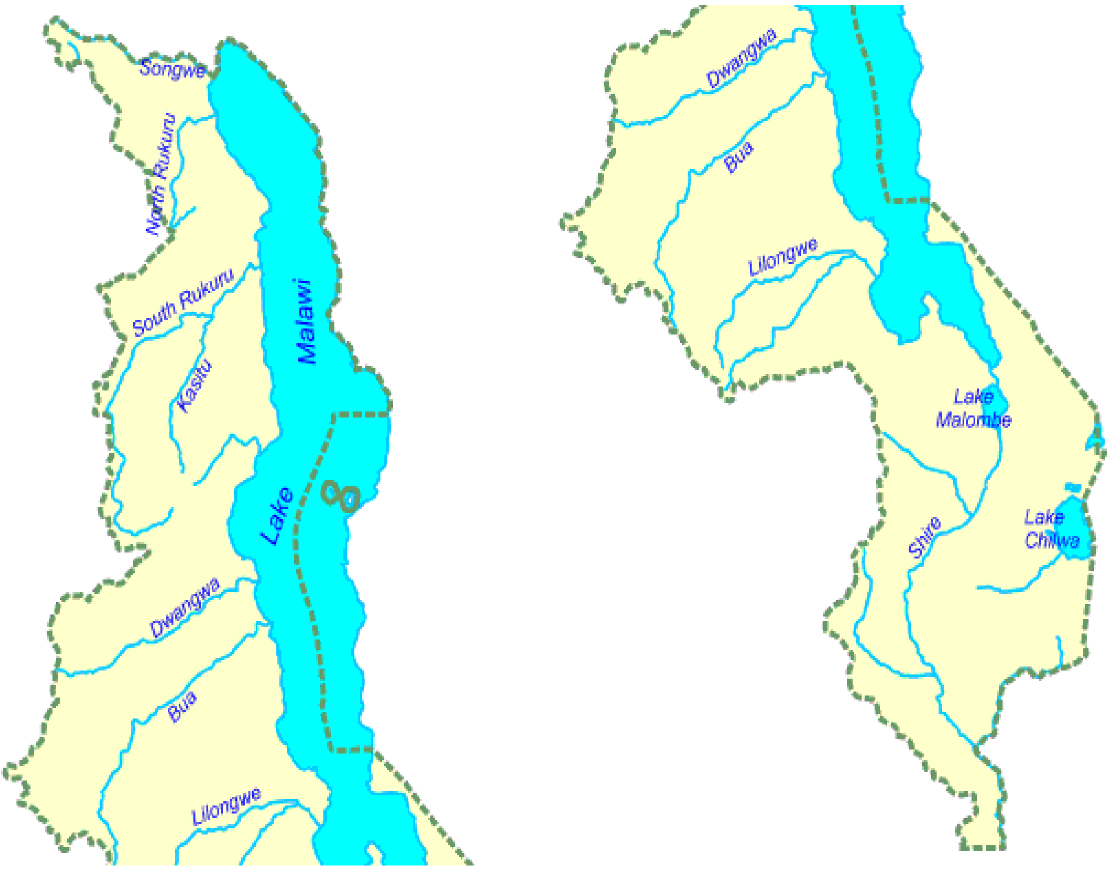

Fig 1.3: Malawi major rivers and Lakes
Source: French Embassy to Zimbabwe and Malawi

1.2.3 Land and Agriculture

Agriculture is the dominant sector of the economy, accounting for about 43% of the gross domestic product (GDP) in 1996, about 85% of the labour force and almost all of the country's exports. Malawi has favourable environmental, ecological and soil conditions which are conducive to the production of a wide variety of agricultural crops and a wide range of tree species (Ministry of Energy and Mining, 1997).

Malawi has a land area of approximately 9.4 million hectares of which 28%, 38% and 34% in the northern, central and southern region respectively (EAD, 2000). The relatively fertile land and lack of mineral resources makes the land and fisheries the basis of the country's economic infrastructure.

There are three categories of land tenure in Malawi and these are customary land, private land and public land. Customary land forms the bulk of land and is held, occupied or used under customary law. Public land is the land that is used by government and this includes any land that is not customary or held under freehold or leasehold title. The public land consists mainly of forests, wildlife reserves and other public places.

The land under private estate is estimated at 1.1 million hectares (The Estate Land Utilization Study, 1997) and the land under public tenure stand at 1.8 million hectares while the land under customary tenure is estimated at 6.2 million hectares. (BDPA, 1997)

There is a lot of pressure being exerted on the land due to increase in population, bad land use practices that is resulting in land degradation. Soil erosion is the most serious environmental problem in Malawi (EAD, 1998). Also cultivation has encroached into environmentally fragile areas like steep slopes, wetland, and stream banks often with no conservation measures.

There is a National Environmental Management Policy and National Environmental Act (1996), apart from other sectoral policies (e.g. forestry act), laws and legislative rules, that deal with several aspects of land. Because of lack of human and financial resources, land degradation and other land problems are still continuing despite these policies and regulations (EAD, 1998).

The land holding sizes have dwindled over time and will continue to do so as long as population increases. This has serious implications on the country's food security (EAD, 2000)

1.3 Culture and History

The main ethnic groups are the Chewa, Tumbuka, Lomwe, Yao, Sena, Tonga and Ngoni. English is the official and business language in Malawi. Chichewa is the national language and is widely spoken throughout the country. Malawi has a varied religious make-up comprising of traditional religions and Christianity with Hindu and Muslim minorities (Southern African marketing Co. (Pty) Ltd and Southern African Development Community (SADC)a , 2001).

The first Malawians to leave traces of their lives were knappers of sturdy stone axes and scrapers some 100,000 years ago. From the 3rd Century AD modern African peoples settled in villages on the shores of Lake Malawi. The Chewa founded the important Maravi empire at the southern end of the Lake in the 16th Century, trading with the Portuguese on the coast, while the Yao built an empire around the area of Blantyre and Zomba (Tindall, 1997 and SADC, (2001)a). In the 19th Century the Ngoni, relatives of the Zulus, swept up into Malawi and soon settled in the area. The Swahili set up on the shores of the Lake, establishing links as far north as Zanzibar.

The course of Malawian history changed when Scottish explorer David Livingstone, thwarted by the Cabora Bassa rapids on the Zambezi river, turned his small steamer north up a tributary, the Shire river, towards the great lake he had heard report of. Greatly impressed by Lake Malawi, he returned two years later to what he called *`the Lake of Stars'*. There was sporadic settlement by other British missionaries and settlers from the 1860s. Britain installed a consul in 1884 to look after the interests of her citizens. The present borders were drawn up as the British Protectorate of Nyasaland in 1891.The country gained independence in 1964 and became a Republic within the Commonwealth. In 1994, Malawi became a multiparty. The new constitution guarantees freedom of speech, religion and assembly. Malawi's civil administration is committed to the principles of good governance, transparency and accountability. The government encourages investment and is looking to the private sector to assume the leading role in the economic development of the country.

Malawi has a hybrid legal system. Criminal and civil law is based on English common law. Malawi's written constitution guarantees protection of investments, irrespective of ownership (Southern African marketing Co. (Pty) Ltd and Southern African Development Community (SADC)a, 2001).

1.4 Population

Malawi is the most densely populated country in southern Africa Development Community (SADC) with approximately 105 people per square kilometre. The total population is currently estimated at about 9.8 million with an estimated growth rate of about 1.9% per annum. The population is not evenly spread and about 88% are concentrated in the southern and central regions (National Statistical Office (NSO), 1998). Population growth is a critical problem in Malawi as most of the suitable land is already under cultivation. Malawi is one of the most densely populated countries in Africa with 171 persons per sq. km of arable land.

1.5 Socio -Economic Profile and Development

Malawi is a least developed country and has about 85% of the population living in rural areas highly dependent on agriculture for their livelihood. Agriculture accounts for about 30-40% gross domestic product (GDP) and about 90% of export revenues most of which comes from the smallholder sub-sector.

Tobacco is the main export earner accounting for 40% of export earnings. Because Malawi's economy is largely dependent on agriculture, it is highly reliant on climatic conditions conducive to agricultural production, as well as on favourable international process for its export commodities. Malawi is also dependent on substantial inflows of economic assistance from International Monetary Fund (IMF) and the World Bank.

The manufacturing sector accounts for about 13% of GDP in 1999. The manufacturing sector mainly consists of agricultural processing, textiles, clothing and footwear production. The Malawi industrial sector still remains in its infancy.

The World Bank and the IMF have influenced economic policies since the early 1980's. The emphasis on large-scale agricultural and industrial development in the 1980's, which caused widening income disparities, has since been reversed. The overarching goal of economic policy is now to alleviate poverty. Strategies to achieve this have included the liberalisation of domestic markets, the privatisation of parastatals that previously dominated the economy and improvements in conditions for smallholder farmers, including liberalisation of agricultural marketing arrangements. The World Bank estimates that for poverty to fall in the next two decades, economic growth rates in excess of 6% per year must be achieved. At present the economy is falling short of these requirements.

In December 2000 the IMF approved a three-year US$58m PRGF loan, disbursements dependent on the approval of a full poverty reduction strategy paper (PRSP). Aims of the PRGF programme include the promotion of macroeconomic stability, fostering private-sector development, improving public services and tackling HIV/AIDS. The objectives of the interim PRSP focus on raising the productivity and income of the rural poor (with an emphasis on smallholder agriculture); promoting private-sector growth to expand non-farm employment; and improving and increasing social service provision.

Though Malawi welcomes foreign investment, the economy offers relatively few attractions, and the country remains heavily dependent upon foreign aid. Generous support from foreign donors (mostly in the form of loans) is received to help finance its structural reform programmes. Although these loans are concessional, the debt stock has risen much more rapidly than exports or gross domestic product (GDP), jeopardising Malawi's creditworthiness.

In December 2000 the government was awarded significant debt relief of US$643m under the IMF and World Bank's HIPC initiative. Malawi belongs to a number of African organisations such as:

- The Common Market for Eastern and Southern Africa (Comesa), the successor to the regional Preferential Trading Area (PTA). (Malawi was a founder member).
- African Union
- Southern African Development Community (SADC): Some South African manufacturers have been drawn to Malawi to make use of the extremely cheap labour available, and a liberal tariff regime within SADC would bring undoubted benefits.

1.6 Energy

The current energy sources available in Malawi can be divided into non-renewable and renewable.

1.6.1 Non-Renewable Energy Sources

1.6.1.1 Petroleum Products

Malawi imports all its petroleum products. Petroleum products (petrol, diesel, paraffin, Jet Al and Avgas) used to be imported solely by the Petroleum Control Commission (PCC) which then sold the products to the oil companies. This has since changed and Petroleum Importers Limited (PIL), which is a consortium of oil companies, imports 80 % of the petroleum products and PCC imports 20% of petroleum products (The Economist Intelligence Unit (E.I.U.), 2000b). The petroleum products are brought into the country via five routes (incurring substantial transport costs): by road from Harare, by road and rail from Beira, by rail from Nacala, by road and rail from Dar es Salaam and by road from Mbeya (Ministry of Energy and Mining, 1997, E.I.U., 2000a). Because of good fuel depots built in Tanzania, the northern transport routes through Dar es Salaam and Mbeya are the major petroleum supply routes, carrying almost 44% of Malawi's fuel imports. Fuel imports via the ports of Nacala and Beira are set to rise over the coming years, but fuel storage facilities will have to be developed to handle the increase (E.I.U., 2000a). Petroleum products contribute 3.5 % of Malawi's energy supply (E.A.D, 2000). Most of these fuels are used by the transport sector, with households using a relatively small quantity of paraffin (Chiwaya, 1999).

1.6.1.2 Coal

Coal contributes 1.0% of Malawi's energy supply (E.A.D, 2000a), and the national demand for coal is estimated to be 74, 000 tonnes per year (E.I.U., 2000a). The Mchenga coal mine, Malawi's sole producer of coal, was privatised in 1995 (E.I.U., 2000a) and has been operating below capacity owing to financial constraints, providing only 34,000 tonnes per year. The remaining 40,000 tonnes is imported.

1.6.2 Renewable Energy Sources

1.6.2.1 Hydroelectricity

Electricity provides 2.3% of the Malawi's energy needs (E.A.D, 2000) and hydroelectricity contributes 95% of the total electricity used (SADC Energy Sector, 1998). The electricity is generated, transmitted and distributed by the Electricity Supply Cooperation of Malawi (ESCOM). ESCOM supplies power mainly through an interconnected hydroelectricity system. The electricity is mainly used in urban areas, where only 15% of the total population reside, in industries and households. Of the total urban population, less than 20% have access to electricity and the percentage falls to 1% in the rural areas (Chiwaya, 1999).

Although the Malawi government's macro-economic policies emphasize rural electrification as a means of improving the quality of life of the majority of the population and promoting their socio-economic development, it has become clear that fulfilment of this goal can not be achieved solely through the extension of the national grid due to economic reasons (Ministry of Energy and Mining, 1997).

1.6.2.2 Solar, Wind And Biogas

Despite the existence of government plans to harness and develop these renewable energy sources, solar, wind and biogas remain the least developed energy sources in the country. The harnessing of solar, wind and biogas are constrained by inadequate local knowledge and the high cost of the end use technologies commensurate with these sources of energy. These factors have led to very low investment, research and development of these energy sources compared with other energy sub sectors (e. g. mini hydro systems) (Ministry of Energy and Mining, 1997). For the case of biogas technology, over 50% of the biogas plants in Malawi are non-operational due to poor dissemination approach, lack of commitment by owners, breaking up of biogas plant groups, lack of technical support and back up services and poor institutional frame work (SADC Energy Sector, 1998, Ministry of Energy and Mining, 1997).

1.6.2.3 Wood Fuel

Wood fuel (charcoal and firewood) is the most important source of biomass energy in Africa, and its increasing scarcity is a subject of major concern in Africa and the rest of the developing world. It is the dominant source of energy in Malawi for both rural and urban households and provides about 93% of the household and industrial energy requirements (EAD, 2000). Of all wood consumed in Malawi, 70% is consumed by households, 25% by agriculture (for tobacco curing or related activities) and about 5% by tea estates and brick making works (Chiwaya, 1999, Ministry of Energy and Mining, 1997).

In 1996, the demand for wood fuel was estimated at 15.2 million cubic meters and was growing at two percent per annum (Ministry of Energy and Mining, 1997). This growth is greater than sustainable supply, particularly in the densely populated southern and central regions. The decline in wood supply is already one of the principal problems faced by

Malawian energy planners (Chiwaya, 1999). About 55% of the total wood supply is estimated to be from sustainable yield, while 45% is supplied from non-sustainable stock cutting (Ministry of Energy and Mining, 1997). According to Kgathi (1997), although population growth is the driving force behind the process of deforestation, market failure (failure to price a resource at the full social cost of production) and the introduction of distortions by government policy or the failure of government to intervene when its necessary and beneficial to do so are 'accelerating forces'. These failures are exacerbated by the lack of property rights in the open-access regimes of most developing countries, which encourages over-exploitation of wood fuel resources.

1.7 Mining Industry and Tourism

The Malawi government is actively pursuing investment in the country's tourism industry as it is seen as a sector with great potential for economic growth and diversification and for foreign exchange earnings. Malawi has a National Tourism Policy, which aims to gear tourism to be the leading economic sector. The government is supporting tourism by providing adequately maintained infrastructure and strengthening the capacity of the Ministry of Tourism, Parks and Wildlife to coordinate public and private sector activities industry. Despite the government's effort, there are several constraints that hinder the development of tourism in Malawi and some of the constraints are: lack of investment in international standards accommodation and tourism facilities; inadequate and poor infrastructure which limits access to most tourist attraction areas in the country; and, lack of specific incentives for private investment.

To boost wildlife-based tourism, the government has adopted a policy that allows private operators to manage tourism enterprises in all national parks (ref).

The principal tourist attraction in Malawi is the Lake Malawi which has diversities of fresh water fish in the world. Malawi has several national parks and game reserves namely Nyika national park, Kasungu national park, Liwonde national park, Lake Malawi marine park, Lengwe national park, Vwaza marsh game reserve, Nkhotakota game reserve, Majete game reserve and Mwabvu game reserve. (Fig 1.4)

Fig 1.4: National Parks and Game Reserves in Malawi

CHAPTER 2

THE NEEDS ASSESSMENT PROCESS

2.0 Background

Malawi signed the United Nations Framework Convention on Climate Change (UNFCCC) in Rio de Janeiro, Brazil in June 1992 during the United Nations Conference on Environment and Development (UNCED). The UNFCCC was then ratified by Malawi in April 1994.The Initial National Communication (INC) based on the recommended base year of 1994, was completed and submitted at the Ninth Conference of Parties (COP-9) of the UNFCCC held in Milan, Italy in December 2003.

Article 4.5 of the UNFCCC states that developed countries who are members of the UNFCCC "shall take all practicable steps to promote, facilitate, and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other parties, particularly developing country parties, to enable them implement the provision of the convention."

Prior to the UNFCCC era, technology transfer had occurred in all socio-economic sectors but the focus was not to address climate change through adaptation to and mitigation of climate change although indirectly some of them met the climate change needs.

Article 4.5 further enhances the process of technology transfer to meet the UNFCCC objective. Technology transfer will also enhance the diffusion and use of appropriate technologies for the purposes of adaptation to and mitigation of climate change.

2.1 Technology Needs Assessment Process

Malawi implemented a United Nations Climate Change Enabling Activities Project-Expedited Phase II from March 2003 to June 2003. Among the activities of Expedited Phase II was technology transfer and needs assessment component. As such local consultation processes started as part of Phase II activities.

The Climate Technology Initiative (CTI) was approached for technical assistance for the technology transfer and needs assessment, which was duly offered. CTI had earlier on undertaken a similar function for some of the Southern African Development Community (SADC) including Malawi. The climate change project unit, under the Environmental Affairs Department (Implementing Agency) spearheaded the initial national consultations.

2.2 Institutional Arrangements.

During stakeholder consultations, a Taskforce Technology Team with a chairperson was formed to lead the foundation of the technology transfer and needs assessment. Through consultations the Institutional Arrangements were agreed upon as follows:

- Climate Change Technology Steering Committee with a Chairperson.
- Environmental Affairs Department- Secretariat
- Lead Technical Institution- Department of Energy Affairs.
- Five technology sub-teams for: PV-Systems; Biomass; Biogas; Wind and, others
- A short scooping report was also developed.

The taskforce team identified a list of stakeholders that included government institutions, private sector, NGOs, academia, faith groups and international technical donors and institutions.

Using some of the materials from CTI technical publications that included a SADC and Ghana reports, a scoping report was compiled on technology transfer and needs assessment.

2.2 Initial Technology Transfer and Needs Assessment Consultative Workshop.

An initial national consultative workshop for a wide range of stakeholders was held in September 2002 at which the scooping paper on climate change technology transfer and needs assessment in Malawi was presented. In addition some invited stakeholders were requested to prepare and present papers at the workshop.

The Climate Technology Initiative (CTI) sent Ms. Shalini Ramanathan to assist in running the workshop and also provided technical materials for the workshop.

The consultative workshop produced a number of outputs vital for the technology transfer and needs assessment process in the country. The following are some of the outputs:

- Endorsement of the technology transfer and needs assessment process
- Stakeholders agreed on sectors to be considered
- Criteria for selection of the national technologies agreed upon
- The initial identification and prioritisation of technologies was undertaken
- Technology taskforce steering team endorsed
- Technology sub-teams were formed
- Outline of the climate change technology transfer and needs assessment developed
- Chapter authors and peer reviewers identified

2.5 Criteria Establishment for Selecting Technology Priorities.

Through a consultative process held at a scooping workshop, stakeholders agreed to use the three basic globally accepted criteria namely: Development benefits, Implementation potential and lastly Contribution to climate change response measures and goals. The three basic criteria were sub-divided for depth and completeness taking national circumstances into consideration as follows:

A-DEVELOPMENT BENEFITS

-Employment creation potential

-Capacity building
-Health and quality of life improvement
-Resource mobilisation (human and materials)

B-MARKET POTENTIAL

-Affordability
-Cost
-Finance
-Investment
-Barriers
-Durability and availability

C-CLIMATE CHANGE

-Reduction of GHG emissions
-Enhancement of sinks
-Effects on the environment

2.6 Priority Sectors and Sub-Sectors.

The stakeholders during consultative workshop identified and prioritised the sectors in the country as follows: Energy, Agriculture, Irrigation, Water Development, Meteorology, Industrial, Health and Education. This prioritisation will be reviewed with time to cater for new developments.

2.7 Technologies and Market Information

Malawi in 1997 developed a National Sustainable and Renewable Energy Programme (NSREP) that identified barriers that limit the use and accessibility of climate change technologies. The marketing potential of renewable technologies is still very low resulting in low diffusion rates of the technologies.

CHAPTER 3

ENERGY EFFICIENCY

3.0 Background

Energy is an important tool for socio-economic development. It is required for the production of all goods and services. At household level energy is used for lighting, cooking and others chores. Building construction, farming, industrial production, recreation and other services, all call for energy. Studies have shown that there is a relationship between a particular type of society and its energy consumption. However, for many countries since about 1975 an increase in gross domestic product (GDP) has not been accompanied by a prorata increase in energy consumption (Hill and O'Keefe, 1995). This has been made possible through efficient energy use in the existing processes. Less energy intensive industries are replacing older and less efficient industries.

The demand for energy is increasing every year and is expected to double within the next 20 years (Muneer, Asif and Kubie, 2003). Unfortunately one of the traditional primary sources of energy (fossil fuels), are being depleted at a faster rate than ever before. Further, energy systems contribute most to the environmental burden being faced by the world, and if the slide towards rapid environmental degradation is to be averted, there is the need to apply best practices in sustainable development to the energy sector (Hayes and Schofield, 2002). Therefore economic growth can be sustainable if it is fuelled by energy systems that are increasingly more efficient, less expensive and cleaner. Malawi needs to make an effort to invest in and develop energy systems that would increase economic productivity and competitiveness, creates job opportunities and reduce environmental degradation.

3.1.1 Energy Supply

Malawi with a human development index of 0.397 is one of the poorest countries in the world (UNDP, 2001). The population of Malawi is predominantly rural (Malawi Government, 2001 a). The household sector uses the lion's share of the total energy consumption as show in Fig 3.1.

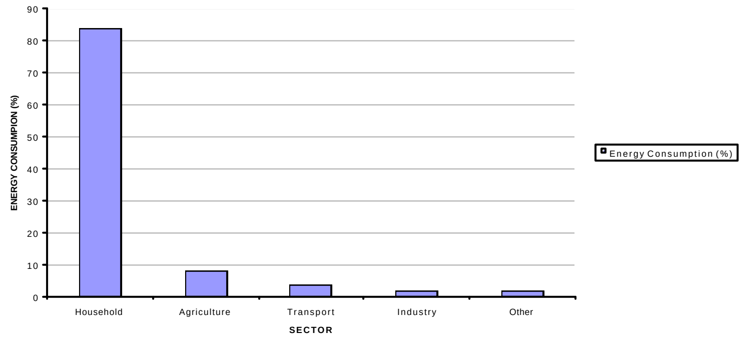

Fig 3.1: National energy Consump tion by Sector (Malawi government 2001)

The main sources of energy in Malawi are electricity, liquid fuel, biomass and other renewable sources such as Solar. About 4 % of the population has access to electricity (Malawi Government, 2001 b). The total installed capacity as in 2000 was 355.3 MW. Electricity Supply Commission of Malawi (ESCOM) contribution is 87 % while private generators contribute 13%. Fig 3.2 shows the distribution of electricity consumption by tariff sector [ESCOM, 1999].

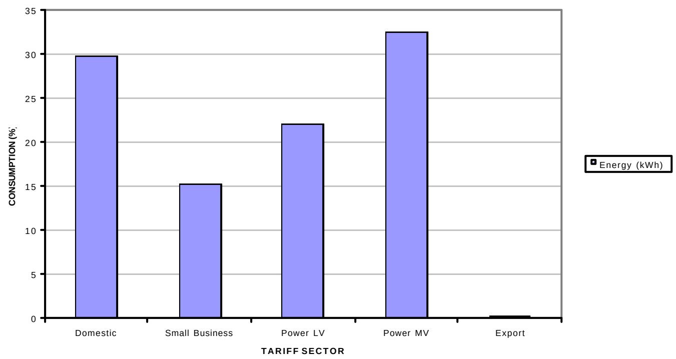

Fig 3.2: National Annual Energy Consumption Report

3.1.2 Energy Efficiency in Households and Schools

The household energy consumption accounts for 84 % of the total energy used in Malawi, the dominant energy source being biomass (99 %) (Malawi Government, 2001 b). Although economic structures in Malawi favour the urban population over the rural population, both the urban poor households and rural households predominantly use low efficiency end-use devices. The rural households are characterized by high incidence of poverty (61 %) accompanied by low availability and/or quality of modern infrastructure (Malawi Government, 2001 a). The majority of the households are dependent on agriculture for their livelihood. The predominant sources of energy are firewood and charcoal with 92% of the firewood collected free from the surrounding woodlands and gardens. The low efficiency 3-stone fire stove is the dominant firewood end-use systems for cooking. The high household preference for low efficiency firewood and charcoal end-use technologies threatens the sustainability of the environment due to deforestation and greenhouse gas emissions.

The principal energy end-use application for paraffin and electricity in the urban households is illumination. 80% of electric lighting sub-circuits use incandescent lamps, which have the lowest efficiency off all types of lamps available on the market. A large number of urban households use the traditional low efficiency one-wick paraffin lamps for lighting (Malawi Government, 2001 b). However the use of paraffin contributes to in door air pollution and adversely affects the health of both adults and children. Electricity accounts for 0.5% of energy while very little paraffin is used for lighting. Yet studies have shown that investment in energy such as rural electrification have a very significant impact on economic development and poverty reduction in the rural areas [Yang, 2003]. Other devices include candles and wood fire.

Almost all primary schools in the rural areas and the majority of the urban public primary schools have no access to grid electricity. This denies the pupils the opportunity to study at night, which has negative effect on the standard and quality of education in the country. Where electricity is used, especially secondary schools and colleges, it is used mostly for lighting. The dominant appliance used is the incandescent lamp.

3.1.3 Energy Efficiency in The Agricultural Sector

Although agriculture is the backbone of the Malawi Economy, with tobacco contributing the lion's share of the export earnings, the sector uses only 8.8 % of the total energy and 12 % of the commercial energy. This is so because agriculture in Malawi is characterized by inefficient technologies dominated by manual labour.

3.1.4 Energy Efficiency in The Health Sector

The need for reliable and affordable energy supplies is essential to the efficient delivery of health services in Malawi. Uninterruptible energy supply is required in the theatre and for refrigeration in the laboratories. Energy is required for cooling, cooking, heating, and lighting. Although urban hospitals have a monopoly on modern energy infrastructure the equipment in these hospitals is old and inefficient. This is aggravated by lack of maintenance because of shortage of qualified technicians and engineers. Low efficient end-use devices are used for lighting and cooking. The condition is worse in rural hospitals, clinics and health centres. Most rural clinics and health centres have no access to electricity, while electricity supply in some rural hospitals is limited and unreliable.

3.1.5 Energy Efficiency in Industrial & Commercial Sector

The first phase of Industrial Energy Management project in the SADC Region was launched in 1987, under the sponsorship of the Canadian International Development Agency (CIDA). The second-phase, the SADC Industrial Energy Management Project (SIEMP), was initiated in 1994 with an original mandate to provide energy management training in eleven SADC countries. In March 2000, the project turned to developing partnerships agreements with a variety of partners, to ensure the project's training programmes continue to be delivered in an optimally effective manner within the region (Stiles, 2000). SIEMP wound up its activities at the end of 2002. In Malawi the training partners are the Polytechnic Industrial Energy management Unit (PIEMU) and the Tea Research foundation of East and Central Africa.

Results of the Energy Management Training Needs Assessment Survey conducted by PIEMU in August 2000 revealed that although some energy conservation activities were being undertaken by some industries in Malawi, such activities were not properly organized and coordinated. The results showed that industries in Malawi had not implemented comprehensive and sustainable energy management programmes for their companies. The survey showed massive support for industrial energy management training. However the response to the first training workshop organized by PIEMU was very poor. Results of Energy Audits projects carried out by BSc. in Electrical Engineering final year students in some companies correlate with the needs assessment survey findings. Companies complained of high-energy bills and did not know why their energy bills were high. For example, in one company, which uses coal fired boilers it was found that the company did not know how much coal is used per production shift per day. Many energy saving opportunities were identified and energy saving measures were recommended.

3.1.6 Energy Efficiency in The Transport Sector

The transport sector is the main consumer of petroleum fuel. However the public transport is not efficient due to a number of factors including types and condition of vehicles, poor road networks countrywide and in cities and poor maintenance and lack of spare parts. This state of affairs contributes to higher energy consumption in the transport sector.

3.2 Barriers to Implementation of Energy Efficiency

(a) The availability of free biomass energy resource and lack of policy and management systems and pricing mechanisms for harvesting woodlands makes regulation and control of use of biomass impossible. Therefore, encouraged use of biomass thus hinders the rural households from being energy efficiency conscious.

(b) Poor economic climate threaten private sector investment in the economy and thus makes companies hesitant to adopt energy efficiency technologies and introduce conservation measures.

(c) The few affordable option to biomass currently available on the market means that biomass characterized by low efficient end-use devices will continue to dominate the energy balance in the country. Environmental degradation would be accelerated unless some thing is done to balance the effect.

(d) Low disposable income per capita discourages companies to invest in modern efficient technologies because the market for such technologies is small.

(e) The lack of knowledge by industry in Malawi on the benefits of Energy conservation and implementing energy management programmes in industry, threatens the implementation and sustainability of Industrial Energy Management programmes Developed by SIEMP and adopted by PIEMU in the country.

(f) Among the key barriers to investment in energy efficiency are uncertainties about projected energy saving and potential disputes over stipulated savings (Hayes and Schofield, 2002).

(g) The lack of awareness and knowledge of importance of energy and the need to conserve energy retard adaptation of energy efficient technologies by both urban and rural households, educational institutions, hospitals and other sectors.

(h) Lack of energy data and information systems on energy efficiency makes energy policy review and planning difficult.

(i) Lack of human capacity to effectively initiate, promote and implement energy issues particularly relating to energy efficiency and conservation programmes.

(j) A high level of illiteracy makes dissemination of information on energy efficiency and conservation difficult because the majority of the population would find it difficult to grasp the concept.

3.3 Promotion of Energy Efficiency In Malawi

Although increased energy consumption has often been used as an indicator for economic growth, this is not always the case. Improving the quality of life and enabling economic and industrial growth, calls for increased amounts of usable energy, but what is also required is an increase in end-use efficiency. A very effective way of interfacing energy systems with sustainable development is through the improvements in energy efficiency in all activities that involves the exploitation, supply and demand of energy (Hayes and Schofield, 2002). To achieve energy efficiency end-use, different energy users must implement energy management programs. Energy Management is the process of understanding energy costs through implementing the Energy Efficiency and Earnings (3E) Strategy. The four major steps involved in Energy Management are energy Data Analysis, Energy Audit, Implementation and Monitoring.

3.3.1 Energy Efficiency & Conservation Legislation

Knowledge about the mode of energy use and the attitudes and aspirations of the consumers is essential for mapping out strategies to reduce energy consumption. Of equal importance is an appropriate framework of institutions, standards and legislation favourable to improvements in energy efficiency. One of the goals of the Malawi Energy policy is to reduce the national annual energy growth. Therefore the energy act should include energy conservation initiatives as follows:

(a) Utility conservation programme for residential buildings
(b) Energy conservation financing programme
(c) Schools, hospitals and public building grant programme
(d) Appliance efficiency standards
(e) District energy conservation grants

(f) Energy conservation in Government buildings
(g) Industrial energy conservation
(h) Transport fuel conservation programme

3.3.2 Utilization of Energy Efficiency End-Use Devices

A central feature of an end-use energy policy is the pursuit of cost-effective opportunities for more efficient use in modern sector (UNDP, 2001). For example, in Malawi changes in cooking methods, which are at present very inefficient could have a big effect on reducing energy intensity. Fortunately, energy efficient technologies used in industrialized countries are relevant to developing countries including Malawi. The following interventions are needed to remove barriers in adapting and developing efficiency technologies in the urban and rural household, schools, agricultural and health sectors:

(a) Support energy efficiency technology transfer in industry.
(b) Support replacement of low efficiency appliances with high efficiency ones (e.g. relamping incandescent lamp with compact fluorescent lamps - CFL) in urban household and schools.
(c) Introduce Eco-labelling for energy efficiency (Banerjeee and Solomon, 2003).
(d) Support implementation of efficient low power lighting systems in rural households and schools.
(e) Introducing energy efficiency and conservation techniques in the renewable energy industry.
(f) Promoting energy efficient conversion technologies for water pumping for irrigation.
(g) Making finance available for energy efficiency investment.
(h) Develop management systems and pricing mechanisms for harvesting biomass woodlands
(i) Mobilise technical and financial support from organizations such as the Global Village Energy Partnership [

3.3.3 Energy Efficiency in Industrial & Commercial Sectors

Although building owners and managers may agree in principle, that energy conservation is necessary, they are often reluctant to commit the resources and funds to conduct technical surveys and implement retrofit projects (Ottoviano, 1983). The reluctance stems from their fear of interruption of the normal operation of the facility, as well as potential decline in the comfort of the building. However, contrary to this misconception of energy management, an Energy Management Programme is a systematic approach for controlling energy utilization in a facility in order to reduce energy waste to absolute minimum without adversely affecting the functional requirements of the facility. The following activities must be implemented in order to promote energy management programmes in Malawi:

(a) Energy awareness workshops should be organized and conducted for middle and top management.

(b) Promote and introduce to Energy Saving Insurance (ESI) programmes to transfer and spread both types and risk over a large pool over of energy efficiency projects.
(c) Implement promotional energy management pilot projects in 3 carefully selected companies/institution (e.g. one industrial company, one hospital, and one educational institution).
(d) Companies should implement mandatory energy management programmes
(e) Support energy efficient technology transfer in industry

3.3.4 Promote Energy Efficiency in The Transport Sector

The following interventions must be implemented to improve energy efficiency in the transport sector

(a) Improve transport networks.

(b) Improve maintenance systems.

(c) Promote mass transport.

(d) Promote use of efficient fuel consumption vehicles.

3.3.5 Research and Development

Applied research is an essential step in the development of more effective energy policies to understand and examine the forces driving production and energy end-use. It is necessary to introduce effective monitoring systems to produce credible information to allow for accurate assessment of likely future fuel mixes and economic benefits and costs associated with different forms of provision of investment in efficiency and of consumption. Information is urgently required in a number of areas such as:

(a) Household energy use.
(b) Fuel markets.
(c) Opportunities for energy efficiency.
(d) Fuel wood resource base, tree and woodland management systems.
(e) The speed, direction and causes of fuel transition, the real cost of different fuels in different localities.
(f) The potential role of renewable sources of energy for different forms of energy demand.
(g) Research and development in Energy Efficiency End-Use Technologies and Energy Management.
(h) Market Energy Efficiency End-Use Technologies.
(i) Continuing research into the environmental implication of the enhanced greenhouse effect

3.3.6 Human Capacity Building

For the majority of industrial and commercial buildings presently consuming more energy than necessary to operate efficiently, the possibility of implementing an energy management programme should be more properly viewed as a positive investment opportunity that will generate return on investment at higher rate of profit than any other investment, which the owner could make. However for this to be accomplished there is need to train personnel in industry and commerce in the field of energy management.

The promotion of efficient use of energy resources with minimum effect on the environment, climate and global warming through the promotion of Energy efficient end-use technologies and conservation is the key to sustainable development in Malawi. In order to achieve this goal Malawi must make a deliberate effort to develop human capability required to research, develop, implement and adopt energy efficient end-use technologies and energy efficiency techniques, and also to educate the masses on the importance of energy and energy efficiency in sustainable development. Thus suggested interventions related to human resource capacity building are:

(a) Organizing energy management training in industrial and commercial sector.
(b) Introducing energy conservation in secondary education.
(c) Introducing energy management training in tertiary education.
(d) Organizing training and/or awareness in energy efficiency and conservation for urban and rural households.
(e) Introducing renewable energy studies in engineering education.
(f) Conducting energy efficiency awareness workshops and introducing energy conservation techniques (designing for conservation) in REIAMA training programmes.
(g) Establishing partnerships with stakeholders in the SADC and other regions and to develop Standards and common certification at all levels in Energy Efficiency and Management.

3.4 Benefits of Energy Efficiency

3.4.1: Developmental Benefits

Understanding the role of energy efficiency end use is fundamental to understanding the relationship between energy and sustainable economic development. For many industrial facilities, the top three operating expenses would include energy, in addition to labour and material expenses. Of these three the one with the most potential savings is energy. As the price of energy increases the return on investment gets shorter and the money invested by industries in energy conservation and retrofitting will double in proportion the increase in energy [Ottoviano, 1983]. Thus, investment in energy efficiency will help the industrial and commercial sector in Malawi to increase economic production and competitiveness, and create job opportunities.

The economic benefit of investing in energy efficiency can out weigh the economic cost of building additional electricity generating station. In turn this means large savings to the utility, increased service to the customer. In addition the use of best practices in demand-side management would reduce the amount of resources required on the supply side of energy in the country. The interaction between local and foreign expertise would assist to improve energy efficiency in Malawi.

3.4.2: Environmental Benefits

One of the most intractable, and at the same time long term, policy issues in environmental maintenance and sustainability, is the direct and indirect effect of energy use and resource development on the environment. The problems of massive emission of carbon dioxide (CO2) from the burning of fossil fuels and their climatic impact have become major scientific and political issues [Jean-Baptiste and Ducroux, 2003]. Energy conservation is essential in the sustainability and protection of the environment because if less fuel is used in the provision of given services, then

(a) The use of fossil fuels will be slowed down and they will last longer.
(b) Reduction in fuel would result in reduction in waste generated form energy supply systems.
(c) With smaller power requirements the prospect of using renewable sources of energy is enhanced, which will make the development of sustainable economics more possible.
(d) Greenhouse gas emissions would be reduced so that adverse climate change would become less likely.

The opportunity to supply the present and future energy needs of the country while conserving and promoting environmental sustainability is very great. This is vital at a time when excessive CO_2 production largely from fossil fuels use threatens the stability of the Global Climate System. The development and implementation of inexpensive, reliable low powered lighting systems for rural households and schools in Malawi would greatly enhance utilization of PV solar electricity in the household and schools. Smaller PV systems would be required and thus reducing the initial cost to the consumer.

3.4.3: Educational Benefits

Education is one of the most important catalysts of sustainable development. Access to education is a basic right of all the youth because it is essential for their professional, mental and socio development. Introduction of cost effective energy efficient lighting systems in both urban and rural communities and schools would go a long way to improve educational standards and quality of education in the country because adequate light would be available during study time. Improvement in education would have a positive ripple effect in the other sectors of the economy

3.4.4: Health & Social Benefits

Improvements in the economy, education, agriculture and environmental management would bring both health and social benefits to the people of Malawi. Improvement in the national economy would lift the majority of Malawians from the poverty trap. More people would be engaged in income generating activities and employment opportunities would increase. People would be able to buy goods and services and lift up their social status. Improvement in agriculture would improve the food situation in the country. Adequate food would be available and people would be able to buy. This coupled with improvements in the health delivery systems would improve the health status of the people. Lastly, the heavy burden put on government to provide for social services would be reduced.

3.5: Stakeholders

3.5.1: National

Department of Environmental Affairs, Department of energy, Barrier Removal to Renewable energy in Malawi (BARREM), Ministry of Education, Ministry of Agriculture, University of Malawi (Polytechnic), Malawi Bureau of Standards (MBS), Renewable Energy industries Association of Malawi (REIAMA) and other NGOs, Chamber of Commerce and Industry, ESCOM Limited, National Electricity council of Malawi, City. Town and District Assemblies, National research Council of Malawi and Local financial institutions

3.5.2: International

Global Environmental Facility (GEF), Global Village Energy Partnership, European Union (EU), SADC, World Bank, United States Agency for International Development (USAID), Canadian International Development Agency (CIDA), GTZ, United Nations Development Programme (UNDP), UNEP and Commonwealth Service Council

CHAPTER 4

TECHNOLOGY PRIORITIES

4.1 Background

The developmental vision of the nation is spelt out in the Malawi Poverty Reduction Strategy Paper (PRSP) in 2002 and also in the Vision 2020 produced in the year 2000. Malawi aspires to be a middle-income country with a technologically driven economy by the year 2020.

4.2 Priority National Sectors

Malawi is a Least Developing Country (LDC) under the United Nations Classification system. Its economy is based mainly on agriculture with very small industrial and mining sectors. The nation has undertaken Greenhouse Gas (GHG) inventories based on the recommended base years of 1990 and 1994. The sectors inventoried are:

- (i) Energy
- (ii) Industrial Processes
- (iii) Agriculture
- (iv) Land Use Change and Forestry
- (v) Waste Management

The Land Use Change and Forestry sector has consistently shown to produce the largest amount of Carbon Dioxide (CO_2) amounting to 18,528.00Gg of CO2 while removals were only –1016.00 Gg of CO_2 in 1994. This was followed by the Energy sector with 660.9 Gg of CO_2. In 1990, the same trend occurred with 21,200Gg of CO_2 and –1321.8Gg for emission and removals respectively. From the Energy sector 619.1 Gg of CO_2 were emitted.

Malawi undertook mitigation studies in 1994 in the Energy sector, Agriculture sector, and Forestry sector although it is not obligated under the climate change convention. The studies enabled the country to develop strategies to reduce/abate emission of greenhouse gases especially in the Forestry and Energy sectors.

The large net GHG emissions are attributed to the high rate of deforestation in the country, small plantation hectarages, charcoal production, biomass use for traditional cooking and housing.

In the energy sector, coal and diesel were used to generate electricity in Malawi. These sources were highly polluting but the CO_2 emission has not been quantified. In 1964/65, the first hydropower station was inaugurated and replaced the coal/diesel-fired power generating systems. The trend is continuing with the installation of new hydro power station.

Malawi is in the tropical belt of the southern hemisphere as such is endowed with large amounts of solar radiation, a renewable energy source, for most parts of the year. In October up to 25-28MJ per square metre per day are attained at many sites.

However, the wind resource has not fully been assessed for energy purposes. The available information from the meteorological department is from sites at airports and agricultural research where the environments may not be ideal for energy uses. The present data assessed show the speeds to support wind-pumping operations for water other than for power generation. With new hybrid wind technologies even the present assessed resources could be harnessed for power generation. The wind resource has high spatial and temporal variations.

Dairy farming in the country has potential provided source for power generation for lighting using the waste in rural areas. Municipal wastes, especially human waste have not been utilized fully because of constraints including cultural. Power generation using animal waste through biogas technologies will replace use of paraffin in lanterns, a source of CO_2.

4.3 List of Technologies

Various technologies have been introduced and tried in the country although the country has a small industrial base. During stakeholders' meetings, lists of technologies were drawn as shown below which have been used in the country.

A: Technologies in Power Generation.

(i) Solar photovoltaic
(ii) Wind
(iii) Mini/micro Hydro
(iv) Biomass
(v) Solar fired thermal (combined cycle)

B: Solar Thermal

(i) Solar Water Heaters (SWH)
(ii) Solar drying (crops and fish, tobacco curing)

C: Biomass (Non-Power)
(i) Improved and efficient cook stoves
(ii) Improved charcoal production

(iii) Liquid bio fuel

D: Demand Side Management (DSM)

(i) Industrial efficiency

(ii) Retrofits

E: Waste Technologies

(i) Biomass Wastes
 -Sawdust stoves, briquettes, co-generation.

(ii) Animal and human waste- Biogas

(iii) Crop Residues

4.4 Criteria for Selecting Priority Technologies.

The section of priority technologies was done through consultative workshops and special taskforce teams. The general considerations for developmental benefits market potential and effects on the environment including contribution to GHG emission reduction.

4.4.1 Technology Prioritisation

Stakeholders used a point system to rank the technology using various sub-criteria as depicted in table 2.1 below. The system ranked one (1) as least in contribution and five (5) having the greatest contribution. The technology with the highest total was then given priority number one (1). Other weighting factors were considered such as location specificity, availability etc. The result of the exercise is detailed in Table 4.1.

Table 4.1: Ranking of Renewable Technologies

Criteria for RETs	Bringing down Cost of living	Job Creation	Health & Care	Poverty Reduction	Improved Quality of Education	Increased Income Generation	Produ-ction	Food Security	Quality of life	Potable Water	GHG Emission Impact
1. PV-System	4	2	5	3	5	3	4	4	4	5	4
2.Biomass (Gel fuel)	2	4	3	3	1	3	1	1	3	1	4
3.Biogas	4	2	3	3	5	3	3	5	4	1	4
4,Wind (Water Pumping)	3	2	3	3	1	3	4	4	4	5	4
5.Min/Micro Hydro	1	3	5	3	5	4	4	3	4	4	4
6.Industrial Energy Efficiency	1	2	2	2	1	1	4	1	1	1	3
7.Others (coal, Geo and solar Thermal)											

The prioritisation exercise and tallying of points resulted in the following technology prioritisation as in Table 4.2:

Table: 4.2 Technology Prioritisation.

RANK	*A- TECHNOLOGY*	TOTAL POINTS
1	Solar PV-System	43
2	Mini/Micro Hydro	40
3	Biogas	37
4	Wind (Water Pumping)	36
5	Biomass (Gel fuel)	26
6	Industrial Efficiency	19

This prioritisation is in line with an earlier CTI assisted process whereby the solar PV-System was ranked priority number one but the other rankings below differ considerably. The various stakeholders have confidence that the present prioritisation is in line with development needs of the country.

CHAPTER 5

SOLAR PHOTOVOLTAIC TECHNOLOGIES

5.0 Background

Solar photovoltaic technologies include the off-grid solar home system, PV for grid integration, public/street lighting, vaccine refrigeration, irrigation and water pumping.

Solar PV can enable Malawi to reduce its reliance on charcoal in rural areas, avert atmospheric and other forms of environmental degradation that would result from conventional power sources and still provide electricity for the majority of its population. With an average of 3000 hours of sunshine per year falling at the rate of up to 2200 kilowatt hours (kwh) per square meter, solar radiation in Malawi is 20 to 25 percent higher than in the east or west Africa and is surpassed only by that in desert regions.

In September 1999 the Government of Malawi launched the National Sustainable Renewable Energy Programme (NSREP) to promote renewable energy technologies among them Solar PV. The following month the Government of Malawi initiated the formation of the Renewable Energy Industries Association Of Malawi (REIAMA) whose core function besides lobbying for industry is to promote the use of renewable energy technologies in a sustainable manner. Solar PV enjoys the highest number of companies in this association. In October 2001 the Government launched the Energy Policy White paper to be considered for enactment into an act of parliament. The main aim of the energy policy is to offer an integrated approach to guiding developments in the energy sector and maximize its contribution to the country's economic growth. Malawi since independence in 1964 has never had such a policy. Renewable energy technologies for the first time have been included as a major driver towards rural electrification. and overall development of Malawi's rural areas. Cabinet as of year 2002 had passed this policy and it is expected that this will become an act soon.

Various other programmes supported by DANIDA and JICA have also gone a long way in promoting solar PV dating as far back as 1995.

As of year 2000 Malawi had installed 5000 solar PV systems averaging 45watt peak. More systems have since been installed as of the past two years and more are coming in largely attributed to a number of initiatives and projects currently taking place.

5.1 Off-Grid Solar Systems

This can be looked at based on four sectors of the Malawian society. These are Education, Health, Agriculture, Telecommunications and household use.

5.1.1 Education

Solar PV can be used to power lights, laboratory equipment, and appliances, as well as providing water to schools. This water can be put to various uses at the school including irrigation to promote self-sufficiency.

Statistics gathered so far has shown that pass rates improve from as low as 20% to as high as 80% when solar lighting is provided at a school. This enables students to read at night. Two Community Day Secondary Schools can be given as examples; these are Makanjira in Mangochi district and Chigodi in Mchinji. It is yet to be seen if the same can be realised at Chibadzi, and Kambulu in Dowa district as well as Matandani in Mwanza district. International Power Control Systems, which is one of the certified solar suppliers and the leading solar lighting company at the time of writing this paper, did all these installations.

It is also interesting to note that schools can benefit from the simple low cost household lighting systems as opposed to the usual more expensive institutional systems. A simple four or five light household lighting system costing MWK74,000.00 and MWK76,000.00 can be used effectively to power two classrooms with two lights in each classroom. A six light system costing MWK85,000.00 will power both the two classrooms and administration office where teachers supervising evening studies will be, this will also give teachers the opportunity to do marking and other tasks in the evening. Their performance will greatly improve.

Water is also a key requirement at any school for the obvious sanitation and hygiene reasons. A solar water pump will allow students to have more time for studies as opposed to spending time fetching water for their use. Beyond this they can irrigate their vegetables at school and reduce costs.

Rural Community Day Secondary Schools (CSS) are a growing alternative to formal secondary schools. In rural areas these are normally boarding schools to allow for a conducive studying environment. A study conducted by the Malawi center for Distance Education in 1991 showed that the majority of rural CSSs rely on candles and paraffin for lighting. This was found to be inadequate, expensive and inconvenient for the students. The use of generators was also found to be beyond their reach. The only solution found to be ideal was the use of Solar PV. Government plans to build 48 more secondary schools in each district of Malawi over the next three years, this should also include renewable energy.

5.1.2 Health

The Health sector has witnessed the most active use of solar PV. This is largely because of the very critical nature of this sector. Solar PV indeed plays a major role here; it helps on lighting, water supply and refrigeration as well as radio communication.

a) Lighting

This is very critical as most births or deliveries have been found to occur at night. The infant mortality rate has also been found to be high for births done at night. One of the main reasons for this has been seen to be lack of proper lighting. Nurses fail to attend to complications and postpone till the following morning. This has seen so many mothers loosing their lives due to excessive bleeding and infections. Lighting therefore makes a big difference in nurses' performance. Mothers also play a more effective nursing role at night when both the Maternity and Post Natal wards are properly lit.

b) Water Supply

It is sometimes argued that human beings or a health center can do without lighting but not without water. This just shows how critical water is at a health center. Provision of piped water is made easy by having a solar pump supplying water to a tank.

There are over 50 solar water pumps in operation in remote locations of Malawi. Most of them are installed at health centers and a few for domestic use pumping from shallow wells.

c) Radio Communications

When the health center has done everything possible and the patient still remains critical, the normal option is to call for support from the district hospital. This is normally difficult given that most health centers by design are near the point of need or people and normally far away from major roads or infrastructure. For health centers to communicate effectively they would therefore require the use of codeless radios. These radios however require power in order to run. The only option in a remote set up therefore would be to have these running on solar.

d) Refrigeration

The need for cooling vaccines and other medicines cannot be overemphasized. This can be termed to be what defines a health center or health facility. Solar fridges have been found to very convenient as they do not require any support in terms of fuel or gas, once installed they run smoothly until after about five years when batteries get replaced.

There are over 50 solar refrigerators in use in the country of which 25 are used in the health sector. Most of these are used in Government and mission hospitals.

5.1.3 Household Use

Solar use in homes is normally seen to be the main driver in improving standards of living. It allows people in rural areas to run small appliances like TVs and radios as well as lighting. This is seen as a good indicator of better standards of living and improved overall performance.

It is also important to note that the same systems for household use can be utilized in remote border posts, remote police posts, prisons etc. These are very critical areas of the Malawi society. Power to remote border posts will definitely improve revenue collection of these posts will be in a better position to work extra hours.

5.1.4 Solar PV for Irrigation

Climate shifts or changes and the effects of desertification and global warming normally top the charts in this ear. Droughts are now more frequent than before, this then calls for more innovative way of farming under drought conditions. Water pumps running on solar which can draw water from as low as 100 metres and supplying about 10,000 litres of water per day are now in a number of areas in Malawi. This to some extent shows the interest in this technology.

Solar water pumps are the easiest to run as they have very low maintenance or running costs.

5.1.5 Solar PV for Telecommunication

The Post and Telecommunications Department installed their first Solar PV system at Zoa estate in Thyolo District way back in the 70s. This was used to power a Plessey manufactured PRD single channel subscriber radio terminal equipment. This was a simple installation of a solar PV system. Since then, numerous other simple and, in recent times, complicated installations have been made. In addition radio communication systems have also been installed.

5.2 Barriers

A number of barriers towards the effective use and adoption of Solar PV in rural areas have been identified. These are:

5.2.1 Institutional Barriers

a) Lack of clear government policy on energy in general and renewable energy in particular.

Although the government had developed a National Energy Plan in 1988 and undertaken some activities that have dealt with the development of renewable energy, a comprehensive government policy and strategy to promote the use of these technologies has been lacking.

b) Lack of awareness of the importance of energy, more especially renewable energy, in the social economic development of the country

Government and other actors have not normally included energy in most of the priority programmes such as Poverty Alleviation Programme, Malawi Social Action Fund, and other donor funded development programmes. Overall, renewable energy has not been given sufficient attention in policy formulation as evidenced in the Statement of the Development Policy 1987-1996.

c) Energy planning is not integrated into the overall socio-economic development planning;

Energy economic activity requires energy but despite this fact, energy planning has not been sufficiently integrated into most of the planned socio-economic activities. This has led to most of the development projects, especially in remote areas, not achieving their goals. For instance, most of the schools, dispensaries, community centres constructed in the rural areas, would have been more effective if they were provided with a source of energy such as electricity from photovoltaic.

d) Lack of effective and comprehensive institutional framework;

Although there is the Ministry of Energy and Mining, there are no institutions or general framework in Malawi through which development of renewable energy can be promoted. This has led to different groups working on renewable energy development to operate individually or in isolation resulting in fragmented efforts that have not produced tangible results.

e) Lack of co-ordination of the activities among the government , research institutions, academic institutions , non governmental organizations (NGO) and the private sector;

As a result of lack of institutional framework, co-ordination of all the efforts undertaken by the government, research institutions, academic institutions, non governmental organizations and other stakeholders has been haphazard and nearly absent.

5.2.2 Economic Barriers

a. Affordability

Although it is projected that by the year 2030 wind, solar and biomass power may be cheaper than fossil fuels or nuclear energy, only few households can afford the initial costs associated with the installation of these systems. The banks and other financing or lending institutions are reluctant to provide credit for RE projects.

There are no focused financing arrangements that could provide credit facilities on non-commercial rates to promote the use of renewable sources of energy.

There are no revolving funds to promote the renewable sources of energy.

b. Lack of competition

There are very few players involved in the manufacture and supply of renewable energy technologies in the country; hence the prices are usually high.

c. Lack of direct incentives

There have been complaints that the import duties as well as surtaxes on energy technologies and appliances are usually too high although this problem is not only unique to Malawi. According to World Bank estimates, direct fossil fuel subsidies to $220 billion world-wide in 1991. Solar and other renewable energy subsidies were virtually zero. In Malawi, there are no subsidies even on fossil fuels.

d. Lack of suitable financing arrangements

Most of the renewable energy projects are micro in nature, appropriate for small-scale business and as such financial institutions have not shown muc h interest in funding such projects. Where a person can manage to secure a loan from these financial institutions, the interest rates are usually too high for the loan to be of benefit to the borrower.

5.2.3 Information Technological, Education and skills Barriers

a. Lack of capacity in the manufacturing, distribution, installation and maintenance of renewable energy systems

One of the reasons why renewable energy technologies are not widely used in Malawi is the lack of manufacturing capacity of renewable energy technologies components. What is available has been imported at high cost. For a successful development and utilization of renewable energy in Malawi an industrial or manufacturing backup is absolutely a prerequisite. Where manufacturing is attempted most of the raw materials, which are used in the manufacturing of renewable sources systems, are usually imported into the country. There has been very limited research in the use of local materials for the manufacturing of the Renewable Energy Technologies.

b. Lack of necessary information

There is a general lack of public awareness of the technologies for renewable energy at all levels of the society including policy makers, decision makers, and the community at large.

In addition, there is very little technical information or data concerning each energy source such as incidence of isolation, wind speed and extent of biomass; one could therefore consider it unavailable. For successful dissemination of information it would therefore, require proper packaging of such information to meet the needs of different target groups.

c. Knowledge of market including energy needs of target groups

Needs assessment surveys to determine individual and community needs of this renewable energy resources in the country has not been conducted which could have helped to determine the requirements in the development of different sources of renewable energy.

d. Lack of Trained man power at all levels

Energy planning, management and development does not appear in the training and educational curricula at any level in Malawi. Therefore, although officials attend workshops or short courses, it still takes years for one to develop a productive degree of competence. The lack of technical capacity is a barrier to the initiation and sustainability of renewable energy activities. Technical schools are not focusing sufficiently on energy.

As a result people are not trained in the development of the renewable energy equipment and its maintenance.

5.2.4 Social and cultural Barriers

a. Gender insensitivity

In Malawi, many of the projects including those in renewable energy have failed to take off and achieve their goal because the planning and the implementation process has not involved women, although in the case of renewable energy, women are responsible for the management of household as well as community energy needs. For example, women as collectors of fuel wood have not been involved in the planning and implementation of afforestation programmes. In addition women's involvement in environmental conservation is minimal. Yet women will harvest dead wood from trees while men will cut down the entire tree for charcoal and firewood without replacement.

At household level, men are usually reluctant to perform any fractions related to energy because traditionally it has been taken for granted that it is the sole responsibility of women to perform these duties. For instance, in management of the biogas digester at household level, the work entails collection of cow dung and water, mixing the cow dung and water, and removal of the sludge from the digester. These tasks would best be performed by both men and women but traditionally, men have left all these tasks to women.

b. Cultural aspects

Some Malawian Societies are inhibited from adopting new technologies, like biogas from a pit latrine, because of strong cultural requisites.

5.3 Suggested Actions to Remove Barriers

From the previous discussions it is abundantly evident that conventional energy from hydroelectric power and fossil fuels are capital intensive. The requirements for connection to the national grid are equally non-achievable by the majority of the communities in rural areas. It is also apparent that the fuel wood deficits are becoming more and more acute. The only option therefore is the diversification into sustainable and renewable energy sources such as solar, wind/biogas, biomass and micro hydro.

5.3.1 Existing programmes & policies

a) The National Sustainable Renewable Energy Programme (NSREP)

The main goal of NSREP is to enable the majority of the Malawi population and villages have access to efficient, sustainable, and affordable renewable energy sources for their socio-economic development. The overall purpose is therefore to increase the access to sustainable and efficient use of renewable energy in Malawi for a larger cross-section of rural, peri-urban population and to provide a viable and sustainable contribution to the country's energy mix.

Development Objective

The NSREP aims at enhancing the efficient and sustainable utilization and marketing of renewable energy resources in rural, peri-urban Malawi in order to:

- Raise the living standard of the poor
- Improve the socio-economic status and empowerment of women
- Develop and promote sustainable and renewable energy technologies; and
- Strengthen institutional and household capacity for the management of sustainable and renewable energy.

Environmental Objective

Promote the widespread utilization of energy-efficient technologies, and enhance the exploitation of sustainable and renewable energy technologies which:

- Minimize environmental degradation and climatic change;
- Reduce utilization of wood fuels as energy sources;
- Improve human health and
- Lead into greater afforestation

Programme Strategy

Technological options (hydropower, biogas, wind, solar and biomass) are presently available which would allow provision of useful and adequate quantities of energy to rural households by the Government, NGOs or private sector and other stakeholders. This would significantly to the socio-economic development of the rural areas and the associated communities. The full realization of such technologies is dependant on an enabling framework. In order to achieve the overall goal, five major strategies will be pursued.

Creation of An Enabling Environment

There is an urgent need to develop, finalise and adopt an enabling policy and legal framework. The strategy is to develop and implement an enabling policy that will promote the utilization and marketing of sustainable and renewable energy sources in Malawi. The policy should:-

- Encourage and support private sector involvement;
- Provide for community and consumer participation, rights and choice;
- Protect intellectual and property rights;
- Support the formulation and implementation of good and alternative sector policies such as incentives for investment, e.g. reduction of import duties and levels on components;
- Provide the means of financing of the NSREP, and commercial cottage industries;
- Support the human and infrastructural development necessary to develop the energy sector;
- Provide for the means for public awareness; and,
- Ensure the inclusion of this energy sector in all government development initiatives (e.g. schools, hospitals, housing, etc.).

Co-ordination and Networking

The programme will ensure that there is effective networking and co-ordination in order to:-

- Create awareness to both potential users and investors of recent (?)
- Publicise research and development efforts and results to the public;
- Ensure that the public has access to those technologies which are efficient and environmentally friendly for their utilization;
- Maximize the participation of the NGOs, rural communities, private sector and development agencies in the setting of national priorities and dissemination of information;
- Identify and utilize existing trained human capacity in various disciplines to effectively contribute to the development of this energy sector; and,
- Promote and establish strong linkages between the community, local industry, banking institutions, NGOs, co-operatives, training and research institutions development and government agencies within the country and without.

Priority Setting

There is an urgent need to set priorities in the sustainable and renewable energy sector. In order to achieve this strategy, it is important to:-

- Determine the full range of sustainable and renewable energy technologies, their design and costs;

- Maintenance opportunities, availability of spare parts and skills for repairs;
- Conduct a national survey to collect information on user needs, target group options, sources of energy, utilization, marketing, barriers and user priorities;
- Organise a planning workshop for priority setting; and,
- Conduct economic analysis of grid and off-grid options and determine which option is economically feasible for different areas.

Industrial Sector Development and Marketing

To emphasize increase output and efficiency of cultural production at smallholder level, the current agricultural policy of government of Malawi needs to include sustainable and renewable energy. This strategy would:-

- Ensure that both direct and embodied energy are included into the agricultural system;
- Enable smallholder agricultural production sector access wide range of viable and sustainable technologies;
- Enable the establishment of pilot and private sector cottage industries;
- Facilitate the production of quality and efficient energy technologies in enough quantities and at least cost;
- Expand the business sector;
- Allow the training of the private sector, technical human capacity and communities including NGOs to handle and process sustainable and renewable energy;
- Promote the establishment of for example, solar, wind mini and micro hydro power to enhance smallholder irrigation schemes;
- Sensitise the public, private sector, NGOs and other stakeholders in marketing and promotion of sustainable and renewable energy; and,
- Facilitate national and international study tours for farmer groups and other stakeholders.

Research and Development

An important policy objective will be to make Malawi self-reliant in new and renewable sources of energy technologies. In this regard, deliberate steps should be taken to:

- Develop local capacities in manufacturing spare parts and key components of technologies, installation and maintenance works, research and development, consultancies, dissemination and training of all stakeholders;
- Introduce technologies which reduce pollution and improve human health;

- Evaluate imported technologies for their performances under local conditions before being adopted and marketing; and,
- Fully exploit in the abundant natural resources: sunlight, water, and biomass.

Capacity Building and Public Awareness

The implementation of the NSREP will depend largely on sustainable human resource capacity in the energy sub-sector: There is a need to:

- Have adequate skills, and attain a good balance between and among other skills;
- Provide adequate and attractive incentive schemes to attract and retain qualified human capacity; Emphasise training including short refresher courses at all levels by various institutions;
- Introduce sustainable and renewable energy and environment into school curricula;
- Sensitize and utilize mass media to provide education and information on sustainable and renewable energy and environment issues to the public;
- Strengthening and expand existing learning, research and development institutions such as Natural Resources College (NRC) and Malawi Industrial Research and Technology Development Centre (MITDC) respectively and where necessary, create new ones;
- Create and support multidisciplinary teams in solving energy problems;
- Establish programme implementation units in lead institutions involved with energy issues;
- Develop extension kits for the public, NGOs, private sector and other stakeholders;
- Utilize effectively existing human resource capacity; and ,
- Develop local capacity to undertake monitoring, review and evaluate of this and related programmes.

Monitoring and Evaluation

To ensure that the NSREP is implemented successfully and according to the time frame, it is very critical to:

- Undertake annual and mid-term reviews; including meetings and workshops to involve a wider spectrum of stakeholders;
- Monitor the implementation of the programme;
- Develop local expertise in project monitoring, review and evaluation;

- The Danish funded fast track project on Renewable Energy has facilitated the Installation of Demonstration Systems in 14 Health centers throughout the country covering Lighting, Pumping and Refrigeration;
- The Danish project also provided seed money to be used as a guarantee fund on the Solar Home System Financing scheme which is run through the Commercial Banks;
- Unesco Funded the first Demonstration Solar Village in Makanjira in 1997;
- The GEF funded Barrier Removal to Renewable Energy project started in 2002 with a five year life span. This project's main thrust is on Solar PVs;
- The Japanese Government through its development Agency Jica funds Solar PVs for five health centers every year under the Administration of the Christian Health Association Of Malawi (CHAM). This covers lighting, refrigeration and radio communication. The programme started in 2002;
- DFID through the Safe Motherhood Project is funding Solar PV projects for health centers as well; and,
- The Malawi Social Action Fund has also accepted to incorporate solar PVs in the projects that they are funding, since most of them are in the rural areas where electricity is also needed.

5.3.2 Additional Actions

A number of interventions need to be taken, among them;

a) Mounting public education at targeted beneficiaries, there is also need to consider grant financing, producing of materials locally as well as to improve the training of manpower.

b) Solar refrigeration needs to be integrated into primary health care delivery by using it to sustain the cold chain requirements in non – grid rural and remote locations. There is need for maintaining vaccine temperature at plus 8^oC to minus 8^oC from point of production to distribution and usage.

5.3.3 Actions Expected From International Community

a) Opportunities abound for the promotion of PV technology in the southern African Sub region. Malawi can be used as the gateway for such a project. Since it is the least electrified country in this region and has the lowest rate of electrification.

b) Operations in the form of joint-venture initiatives could be set up to fabricate subsystem components such as regulators and assemble PV modules for market in Malawi and the rest of Southern Africa. This is even more attractive given that Malawi has been the most stable country economically and politically in the region.

c) Promote cooperative programmes between researchers in local universities, research institutions, public and private sector institutions to have access to facilities in advanced countries in order to help update and improve skills and consequently strengthen the local capacity.

d) Assist Malawi to develop code of installation and practice as well as regulations for the local PV industry.

5.4 Expected Results

5.4.1 Market Penetration And Sustainability

a) Lighting is among the major, about second or third developmental needs of rural communities in terms of priorities.

b) Automotive batteries are used in the rural communities to operate television sets and sound systems. The batteries are then sent to the nearest grid-connected town for re-charging.

c) There is a desire for reliable electricity by NGOs and rural based institutions to meet their business and soc ial obligations.

d) Rural communities could be motivated to accept the solar PV option if adequate information on the systems is made available to them.

e) Adoption of new energy technologies could be encouraged through credit incentives and other purchase arrangements that would allow the rural inhabitants to use the systems on rental or hire purchase basis.

f) Distributed solar photovoltaic system is the option for remote communities since it is less complicated to in stall and operate. PV comes in modules and with battery storage could provide electricity during the day and night.

5.4.2 Development and Economic Benefits

Even though, widespread use of Solar PV has been hampered by the high initial capital cost coupled with low economic status of rural dwellers, it is envisaged that, the social viability and the life cycle cost competitiveness of Solar PV for rural electrification will over-ride its high initial cost. Some of the benefits are detailed below;

Relief Of Women From Burdensome Chore Work

Renewable energy would relieve women and female children from the burden of travelling long distances in search of fuel wood and carrying heavy loads as a result of extensive deforestation that has taken place and which will definitely continue taking place, women will be travelling longer distances to fetch the fuel wood. Accidents do also happen from snakebites and fuel wood logs falling onto parts of their bodies causing serious injuries. This burden will be removed if sustainable renewable energy were developed for their use. The time spent on fetching firewood could be spent on other more productive activities such as farming, childcare, business ventures, improvement of the home and other community activities.

Use of firewood has many health effects on the women who prepare the food for the family. Some of the hazards are exposure to poisonous smoke e.g. carbon monoxide from the fuel wood fire and charcoal, and also accidents resulting from the burning wood logs being levered off the fire place onto the body. Availability of a continuous source of energy will enable the woman to prepare more nutritious foods and improve the household members nutritional status. In addition women have reduced exposure from poisonous and hazardous fumes.

Benefits from Lighting From Renewable Energy

Fuel wood cannot be used effectively for lighting. This means the family and community cannot utilize parts of the evenings for social events and studies. The lighting provided by renewable energy would make such activities possible. Most students in rural areas could benefit from such light for their studies. Teachers too could make better teaching preparations if they had lighting in the evening. In most parts of the country, communities use fuming open-lamps, which are a health risk.

Provision of renewable energy at household and community level would raise the standards of living of the members of the family and the community at large through better management of their lives and enabling more activities to be performed by the extension of the day through better lighting.

The Economics

Conventional sources of energy such as petroleum, coal, and electricity derived from fossil fuels or large hydroelectric schemes require vast sums of capital outlay, which in any way are not economically viable for extending supply to far away places from the conventional grid. This is the main reason for Rural Electrification Programme not taking off. Most of the renewable energy sources can be developed without requiring vast capital costs. Renewable energy can also be developed on a small scale for a household or community and make economic sense. Even the Rural Electrification Programme can effectively be launched using Renewable Energy.

5.4.3 GHG Reductions and Other Environmental Benefits

An issue of concern is the disposal of spent storage batteries, since nationwide mass promotion of solar home systems would involve a large disposal of spent batteries after a few years. Improperly disposing of the electrolyte, lead sediments and plates could leak into the air as PM_{10} into the ground with likely contamination of soil and groundwater.

Long term programme for battery recycling or safe disposal should run along side PV programmes.

5.5 Existing Capacity

5.5.1 Local Universities throughout The Country.

The universities in Malawi are involved in a number of capacity building initiatives on solar PV systems. The university is currently running a BSC in Environmental Sciences, BSc in Electrical and Electronics Engineering and Masters in Environmental Science. These programs are providing valuable human resource on Solar PV systems and other renewable energy sources. For the first time Malawi now boasts of a Renewable Energy Test and Training facility at Mzuzu University as well as having a fully fledged renewable energy curricular at the same university.

There are also a number of vocational training colleges that are also involved in renewable energy activities.

5.5.2 Renewable Energy Industries Association of Malawi (REIAMA)

This is a grouping of mainly private sector companies and individuals with an interest in the promotion of renewable energy technologies in Malawi. Membership covers researchers, the local solar industry and enthusiasts. Most of the reliable dealers in solar energy systems in the country belong to the organisation. Funding of its activities is mainly by the sector ministry, membership fees and donations. Some of the organizations with activities related to promoting Solar PV and can be used are the following;

5.5.3 Malawi Industrial research and Technology Development center.

5.5.4 Malawi Environment and Endowment Trust.

Currently the fund manager for the Solar Home system financing scheme.

5.5.5 Commercial Banks.

National Bank Of Malawi, StanBic Bank and Malawi Savings Bank are currently giving out solar loans on a commercial rate basis.

5.6 Capacity Needs

Capacity building for material resource development to facilitate technology transfer in setting up PV assemble plants and the local manufacture of PV components such as regulators, inverters etc. There is also need to increase the human resource capacity as well as providing adequate training materials. The promotion of the technology in general needs to be improved to cover various requirements.

5.7 List of Stakeholders

National

- Meteorological Services Department
- Ministry Of Natural Resources And Environmental Affairs
- Local Solar Dealers, The Country Has 18 Government Certified Solar Pv Companies.
- Reiama
- Ministry Of Local Government.
- Escom
- Ministry Of Health
- Health Related NGOs
- Ministry Of Agriculture
- Ministry Of Education
- Local Universities
- Mirtdc,
- Mbs

- International
- National Renewable Energy Laboratory (NREL) – US
- World Bank
- JICA
- GTZ

- CIDA
- European Union
- USAID
- France (CDF)
- British (ODA)
- DFID
- UNDP

CHAPTER 6

MINI AND MICRO HYDRO POWER TECHNOLOGIES

6.1 Introduction

Hydropower is a term given to power, which can be extracted, from falling water, or from fast flowing streams or rivers. Hydropower is also referred to as waterpower.

In order to profit from streaming water, structure and devices are put in place to convert the waterpower into useful power, like electrical and mechanical power. This is referred to as a hydropower scheme.

Hydropower schemes are usually classified into three levels of size: full-scale, mini and micro. But sometimes the full-scale is referred to as large–scale while mini and micro are combined into one group known as small-scale hydropower.

Full-scale hydro schemes produce more than 10 MW of power. Mini-hydro schemes produce in the range of 300 KW to 10 MW.

Micro-hydro schemes are smaller still and produce power less than 300 KW, typically enough to supply one rural community or industry. These schemes are used in remote areas where the grid does not extend. (Micro-Hydro Design Ma nual, 1993)

Mini and Micro-hydro power schemes is believed to have been introduced in Malawi from 1950 by white Missionaries. Some of the well-known schemes were installed at Matandani S D A mission, Livingstonia Mission, Malosa, Zomba (Escom). Later Lujeri Tea Factory installed a mini hydro, which supplies almost half of its electricity requirement and is currently working and ESCOM built Wovwe mini-hydro scheme in Karonga in 1996.

Apart from Lujeri, Wovwe and Livingstonia (Grinding Mill) schemes, the other hydro plant is not operational.

At Matandani the infrastructure and some of the equipment is still in working condition but the generator and transmission system is dilapidated. The two hydram, which were installed along side the turbine, are still working.

At Livingstonia there are two micro-hydro Projects, one driving a grinding mill and the other generating electricity.

In 2000, a major study was done on the Matandani Scheme by Japan Consulting Institute. The study was looking at the possibility of rehabilitating and expanding the scheme to supply electricity to Neno Trading Center, 8 Km away from Matandani. The study revealed that it is technically possible but it is more expensive than extending grid.

Now another major study is underway whose objective is to come up with a Master Plan for Rural Electrification in Malawi. Part of this study is looking at potential small hydro sites in Malawi. The potential sites are already identified (Table 6.1) but further studies are underway on some of these sites.

Table 6.1 Potential Sites for MicroHydro In Malawi

SITE	DISTRICT	RIVER	ESTIMATED Capacity (kW)	DISTANCE FROM the grid (km)
Chisenga	Chitipa	Chisenga	15	35
Mulembe	Chitipa	Kakasu	15	35
Nthalire	Chitipa	Choyoti	60	102
Katowo	Rumphi	Hewe	45	45
Nchena Chena	Rumphi	Nchena chena	30	23
Khondowe	Nkhatabay	Murwezi	5	*
Ruarwe	Nkhatabay	Lizunkhuni	50	*
Usisya	Nkhatabay	Sasasa	20	50
Kwisimba	Mangochi	Ngapani	5	38
Katema	Mangochi	Mtama Nkhokwe	25	23
Sandama	Thyolo	Nswadzi	75	6

6.2 Barriers to Mini/Micro Hydro Power Technology Dissemination in Malawi

6.2.1 High Investment Cost

A mini or micro-hydro power project is too expensive to be financed by most rural households in Malawi.

6.2.2 Lack of Technical and Management Skills

Though we have a few local engineers who are knowledgeable in mini/micro-hydro power technology a few have little experience in project implementation. This is because foreign consultants did a few projects, which exist now.

6.2.3 Lack Of Spare Parts

Almost 50% of the components for mini/micro-hydro are not available in Malawi, therefore, most of the components are imported and expensive.

6.3 Suggested Actions

The suggested actions that need to be taken are:

6.3.1 Pilot Project

Deliberate action must be taken by government to implement one or more mini/micro hydropower schemes at any of the identified sites so that there is greater awareness of the technology, test new technology and provide practical field experience to local engineers and end users.

6.3.2 Research On The Use Of Local Materials

In order to reduce the investment cost, research should be conducted to find local materials, which could replace some of the imported and expensive materials.

6.3.3 Capacity Building

a) During the project implementation some local engineers and technicians will have to undergo on-job training in order to build local experts.

b) Those companies which have the capacity, in terms of machinery, to make some parts of the system will have to be identified and asked to manufacture the relevant parts.

6.3.4 Encourage Investors

There is need to encourage investors to develop mini/micro-hydro power schemes in the areas where there are no plans to extend the national grid.

6.4 Expected Results

The expected outputs are as follows:

6.4.1 Greenhouse Gas Reduction

The master plan study on rural electrification in Malawi indicates that the communities living near the potential sites of micro-hydro sites depend mainly on fuel wood as a source of energy. Assuming that all the projects are implemented then a total power of approximately 345 kW will be produced. This will contribute in the reduction of GHG emissions because more households will have access to electricity and hence may shift to from using biomass for cooking to using electricity (a more clean energy source) for cooking.

6.4.2 Social Benefits

All the potential micro-hydro sites are near trading centers that have public facilities like clinics and schools. If these institutions are electrified, the health, education and other services will improve and people will live better lives.

6.4.3 Economic Benefits

Economic activities in the communities that will be electrified is bound to increase, so too employment.

6.5 Stakeholders

The following is the list of stakeholders

- Department of Environment Affairs
- Department of Energy Affairs
- University of Malawi (Polytechnic)
- Renewable Energy Industries Association of Malawi (REIAMA)

CHAPTER 7

BIOGAS TECHNOLOGY

7.0 Background

With over 90% of Malawians depending on biomass as their major source of energy for cooking and lighting, and only 4% of Malawians accessing electricity, there is need to look at alternative and preferably renewable energy sources such as solar, wind and biogas.

Biogas, as a source of renewable energy, can be used a number of ways. Its main application includes lighting, heating, electricity generation and refrigeration. This technology fits very well with agriculture-based economies of developing countries such as Malawi. The technology is simple to manage and its raw materials are readily available. In addition to being an energy source, the biogas systems also contributes towards nutrient recycling, waste treatment and odour control.

In Malawi, Biogas was introduced in the 1970's at Bunda. In 1990/91 with a GTZ funded project at Mwansambo in Nkhota-Kota District (Wasser, 1997). Magomero also disseminated a number of biogas digesters to various places under the Women In Development (WID) project. Currently, there are around 20 biogas digesters in Malawi, but the majority do not operate regularly.

The animal census of 1995, Malawi could produce about 317000 cubic metres of biogas per day, with an energy equivalent value of 280000 cubic metres of firewood (Wasser, 1997). The distribution of potential by animal type is shown below in Figure 7.1.

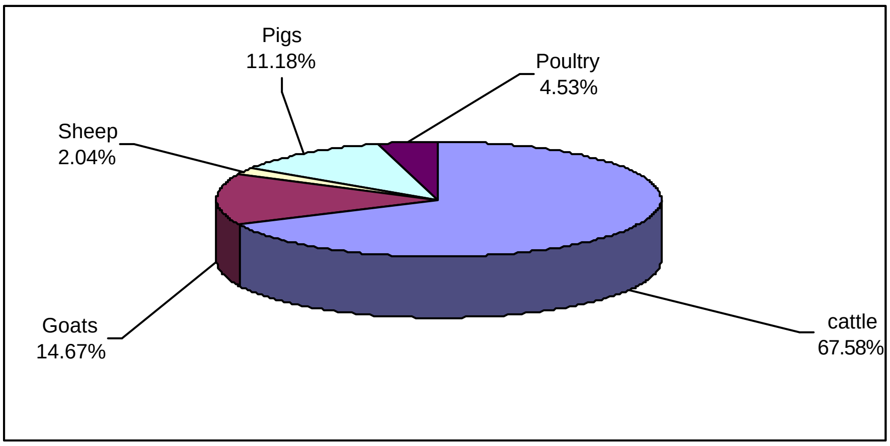

Figure 7.1: Biogas Production Potential by Animal Type (Wasser, 1997)

From the figures above it shows that two-thirds of biogas from animal dung would come from cow dung. The study also showed that industrial wastes from the city of Blantyre could potentially produce 1.1 million Nm^3 of biogas per year, enough to run a generator of 270 KW. It is therefore fair to say that Malawi has adequate quantities of raw materials from various sources to support a biogas programme.

7.1 Barriers to Biogas Technology Dissemination in Malawi

7.1.1 Poor Animal Husbandry Practices

Malawian farmers normally graze their ruminant farm animals on free range, bringing the animals back to their pen for the night. This means about half of the potential raw material, dung, is unavailable. In addition, the animal shelters consist of fences made of pole (reinforced with barbed wire at times) with no roof on top and no hardened floor. This further reduces the available dung as the animal hoofs mix it with soil or mud. Thus such practices do not lend themselves to be easily linked to biogas technology.

7.1.2 Poor Project Planning

Most of biogas plants fail to operate reliably due to poor planning at the various stages of the project cycle. There is a need to take cognisance of the social and economic differences of various target groups in terms of social acceptability of the technology and affordability. On the technical side, there is need for careful consideration on siting of animal shelter and the biogas plant, biomass supply, energy demand, sizing of the digester and gasholder among other issues.

7.1.3 Lack of Appropriate Technical Skill at All Levels

There is need for a certain level of basic knowledge at different levels to ensure successful implementation of a biogas project right from planners, designers, builders to operators.

7.1.4 Cultural Beliefs

Cultural belief may have an impact on the technology. A classic example is usage of human waste as raw material for biogas production which might be accepted in one society while another would totally reject it. Study by Rick Wasser (1997) reported of community's rejection to discuss use of human waste at Likoma Island, while Phwezi secondary School gladly accepted and adopted the concept (Gondwe, 1997).

7.1.5 Lack of Public Awareness

In general, very few Malawians understand and appreciate the technology. And of the few who know something about it have never seen one that is working satisfactory. People travel long distances to Magomero to see demonstration plants or learn something about it.

7.1.6 Investment Costs

The initial capital investment cost for the technology is not cheap. A digester of a medium size family costs 300 to 800 USD (K24, 000 to K64, 000). This cost is well below the reach of majority of Malawians most of whom (65.4%) live below the poverty line (Malawi Poverty reduction Strategy paper (MPRSP), 2002). Unless appropriate financing arrangements are put in place, the technology investment cost remains one of the major barriers for adoption. In addition to construction cost, an average household would need at least 5 heads of cattle to maintain a biogas plant. This is also another barrier.

7.2.7 Standards

For any technology to function properly, it is supposed to meet certain minimum specification standards to ensure that it operates optimally. Malawi has not yet established its standard for biogas construction. Failure of some of the plants to operate well might be attributed to poor workmanship and poor quality building materials used in the construction of the plants.

7.3 Suggested Actions

(I) Coordinated Approach

The biogas taskforce should be revamped under the leadership of NSREP at Department of Energy, and appropriate resources should be made available to ensure effective implementation of its terms of reference. Participation of NGOs and private sector should be encouraged.

(Ii) Capacity Building

Need to develop human capacity for planning and construction of biogas plants, as well as institutional infrastructure to lead technological aspects of biogas projects including getting of standards, inspection, certification etc. External assistance to transfer skill to Malawians will be necessary.

(Iii) Public Awareness

People should be made aware of the benefits of promoting and adoption of biogas technology. Demonstration plants should be built in all the three regions to popularise the technology.

(Iv) Financing Mechanism

Appropriate financing mechanism should be put in place to ensure that those who would like to adopt the technology could get the necessary credit facilities and other incentives.

(V) Targeted Dissemination

The programme should target dairy farmer associations who are already stall-feeding their animals. Thus the biogas digester becomes a logical addition to be integrated into the existing infrastructure.

7.4 Expected Results

4.4.1 Market Penetration and Sustainability
The targeted the dairy farmers and extending financial facilities to the programme will ensure that the project succeeds in a sustainable manner. These farmers could thus act as demonstration sites to popularise the technology.

7.4.2 Economic Benefits
Farmers will be able to reduce their energy bills since biogas would replace both paraffin and firewood or charcoal. Biogas sludge is also a very good bio-fertiliser, which has also a potential for sale as organic manure, or the farmer could use to replace chemical fertilisers.

7.4.3 Greenhouse Gas Reduction
Biogas has a potential to reduce firewood consumption and thus conserve forests. Thus biogas popularisation would reduce greenhouse emission resulting from firewood replaces as well as enhance the sinks from the forests that have been saved. In addition, release of methane from animal waste would be significantly reduced through its capture and use as a biogas fuel. This can have a significant GHG impact due to the high global warming potential of methane.

4.4.4 Other Environmental Benefits
Biogas also contributes toward better waste management and sanitation. Analysis of digested slurry has shown to contain be markedly lower level of pathogens compared to the raw waste material fed into the digesters.

7.5 Stakeholders

The study by Wasser (1997) showed that there were a number of institutions who were involved in biogas technology. However, most of these institutions were working in isolation producing little or no impact.

Current list of national stakeholders include:
- Department of Energy
- Environmental affairs Department
- MIRTDC

- Ministry of Gender, Youth and Community Services/ Magomero
- University of Malawi (Bunda and Chancellor College)
- NGO- Renewable Energy Industries Association of Malawi (REIAMA)
- Malawi Bureau of Standards
- Barrier Removal to Renewable Energy in Malawi (BARREM)
- City and Town Assemblies

International stakeholders may include GTZ/GATE, Biogas Technology Institute (BTI) and CAMARTEC.

CHAPTER 8

WIND RESOURCE AND WIND ENERGY TECHNOLOGIES IN MALAWI

8.0 Background

The power from the wind was especially recognized from antiquity and Bible times. Comprehensive treatises on this topic are given by many authors especially Hills (1994), McVeigh (1977) and McGregor et al (1982). A considerable interest in wind was lost when man learned of other energy sources such as steam, petroleum and later nuclear power. Due to the oil crunch, environmental degradation (owing to the use of non-renewable sources) and the public stereotypes of nuclear hazards, many countries – industrialized and under- developed- are turning to the renewable energy sources with wind receiving considerable research and development attention. In Malawi, however, a number of wind projects have been frustrated due to a lack of information on local wind characteristics and comprehensive and up- to- date wind maps, apart from scarcity and exorbitant prices of suitable materials.

Wind has proved to be a viable source of renewable energy in several countries for electricity generation and water pumping and other industrial applications. In Malawi windmills for pumping water on farms existed several years back (the 1940- 60s). Unfortunately these windmills fell out of favour with the advent of diesel-powered water pumping machines and hydro-electricity. It would thus appear that there exists wind energy potential in Malawi especially for water pumping. Malawi being in the rift valley, the trade wind zone, and in addition having almost a third of its total surface as water, is definitely guaranteed to have winds in the speed range of 2-6m/s at any time of the year.

8.1 Wind Data Analysis

It is important to note that the energy extracted from wind and its implications depends on the wind speeds. The Department of Meteorological Services maintains a limited amount of wind data in summarised format. Some of the wind statistics are contained in Climatological Tables for Malawi and Surface Wind Frequency Tables. A world estimate of the wind potential areas globally was done by Eldridge (1980) and we reproduce herein to highlight where Malawi feature on the world estimates in Fig.8. 1

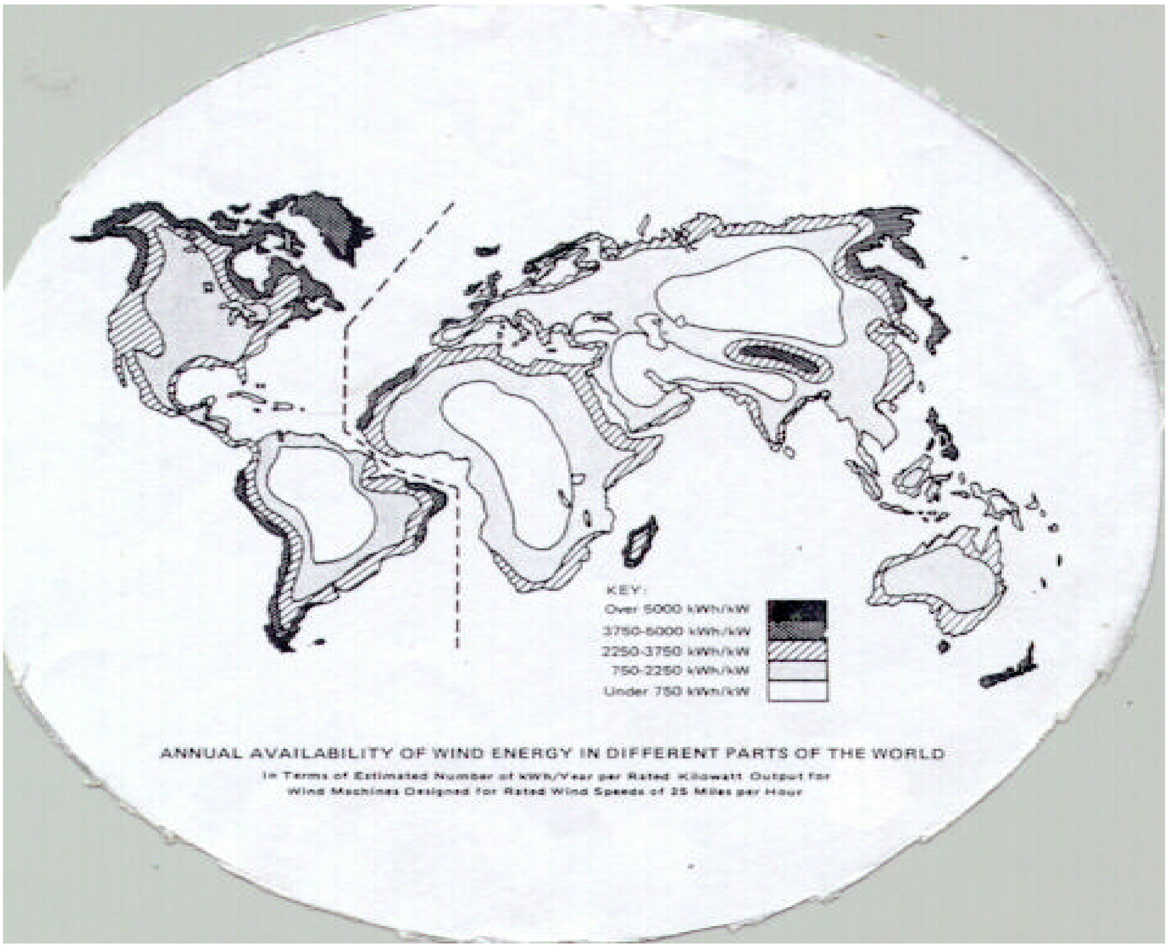

Fig.8.1: This is a world map of wind potential areas.

The calculation is based on the number of kWh per year per rated kW output for wind machines designed for rated wind speeds of 11 m/s. Note that Malawi falls between two regions with the Southern tip at a higher potential than the northern. This is in sharp contrast with real data on the ground as shown in following figures.

A number of Malawian researchers have, hitherto, carried out wind data analyses at different times. Kamdonyo (1988) gives a comprehensive analysis of the winds in Malawi up to that time. However, a wind map obtainable from the Department of Surveys shows the wind characteristics for Malawi before 1983 (Fig 8.2 and Fig 8.3).

Figure 8.2: Wind rose map for the Central and Northern regions of Malawi before 1983

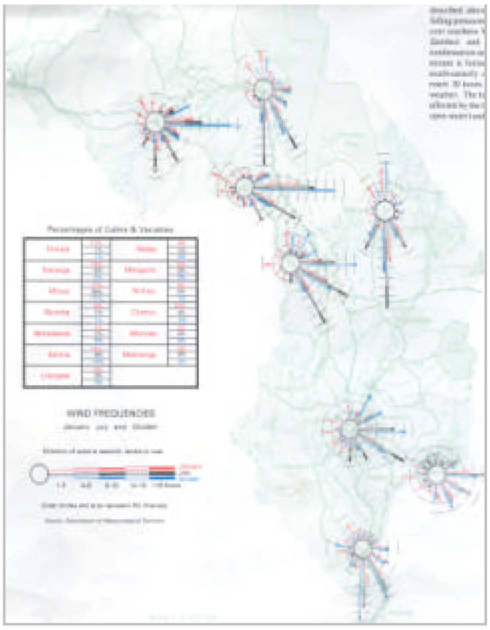

Fig 8.3: Wind rose map for Central and Southern regions of Malawi before 1983

Table 8.1 gives mean wind statistics at two-metre height as given by Kamdonyo (1988). From the table it can be deduced that the transitional period between winter and summer, which is represented by the month of October, has the highest winds, a wind regime which is suitable for harnessing. Wind speeds greater that 3.5 meters per second are dominant during this period.

Table 8.1: Mean wind (metres per second) at two-metre height

STATION	JAN	APR	JUL	OCT	MEAN
CHITIPA	3.1	5.6	7.7	9.6	6.3
KARONGA	2.8	3.7	4.5	4.7	3.8
MZIMBA	2.3	3.0	4.0	4.7	3.4
MZUZU	3.3	4.1	3.8	4.8	3.9
NKHATA BAY	2.4	2.5	3.3	3.7	3.0
CHITEDZE	2.9	3.0	4.1	5.4	3.9
DWANGWA	1.7	2.6	3.9	3.6	3.0
NKHOTA KOTA	3.4	4.5	6.0	6.2	5.0
SALIMA	3.2	4.6	5.1	4.8	4.3
CHICHIRI	3.5	4.3	5.6	7.1	5.5
DEDZA	3.9	4.0	4.1	6.2	4.5
NTCHEU	3.6	4.6	5.0	5.1	4.6
MAKOKA	3.2	3.2	4.0	5.4	3.9
CHILEKA	5.3	5.6	6.2	7.4	6.1
MANGOCHI	2.8	3.7	4.3	4.8	3.8
MIMOSA	2.0	1.8	1.9	2.8	2.1
BVUMBWE	3.3	4.1	4.5	5.5	4.2
THYOLO	3.0	2.2	2.2	4.2	2.9
NGABU	3.0	2.3	2.5	6.4	3.5
MAKHANGA	2.6	2.6	2.6	5.5	3.3

Table 8. 2 gives the mean wind speeds for four stations at ten-metre height again as presented in Kamdonyo (1988). The table shows that the same wind regime at two-metre height once extrapolated to ten-metre height, increases and becomes more promising for harnessing. The mean wind speeds increase by about 15% for Chileka and Mzuzu while for Mzimba it increases by about 85%.

Table 8.2: Mean wind (metres per second) at ten-metre height

STATION	JAN	APR	JUL	OCT	MEAN
CHILEKA	5.3	6.6	7.1	8.2	6.8
LILONGWE	3.5	4.4	5.5	6.6	4.9
MZIMBA	3.5	6.0	7.4	9.0	6.3
MZUZU	3.6	5.0	4.5	5.9	4.5

According to Kamdonyo (1988), Table 8.3 shows daylight wind frequencies for October. The wind frequencies show that for all the stations, there is a high frequency of wind in the category 4.5–6.5 metres per second during the day time which is suitable for water pumping.

Table 8. 3: Daylight Wind Frequencies for October

STATION	CALM	0.5-1.5 M/S	2-4 M/S	4.5-6.5 M/S	>6.5 M/S
CHITIPA	1	8	35	46	10
KARONGA	5	36	38	20	2
MZIMBA	1	4	17	44	35
MZUZU	6	11	30	43	9
LILONGWE	11	6	21	51	13
NKHOTAKOTA	6	13	55	18	10
DEDZA	0	9	62	26	0
BVUMBWE	1	21	67	15	0
MANGOCHI	5	28	58	10	0
MAKHANGA	3	49	45	6	0

Tembo et al (2001) presented their analysis and reported thus "The Malawi's Department of Meteorological Services has reported areas such as Chitipa, Rumphi, Mzimba, Balaka and Chileka have wind speeds of more than 4.7 m/s and therefore have potential for electricity generation using wind.." and their analysis is summarized in Table 8. 4:

Table 8. 4: Wind Speed and Frequency in Various Parts of Malawi

Period	Wind speed(m/s)	Region	Frequency (%)
January	2.0- 4.4	Central and Southern	40- 60%
	4.5 or over	**Middle highlands**	**20- 40**
April	2.0- 4.4	Northern highlands	40- 60
	4.5 or over	**Mzimba District and surroundings**	**40- 60**
July	2.0- 4.4	Whole country	40- 60
	4.5 or over	**Northern highlands**	**40- 60**
October	2.0- 4.4	Central and Northern	20- 40
	4.5 or over	**Mzimba District and surrounding**	**60- 80**

Munthali (2001) alludes to the winds in Malawi and how they affect climate and agronomy. He writes "… strong winds were report associated with thunderstorms and hailstorms. The negative impact was damage to physical structures as well as agricultural produce. Isolated cases where winds of more than 15 meters per second were reported resulted in loss of property. Furthermore, hailstorms reduced the quality of crops, particularly tobacco. Strong winds do also have negative impacts on the fishing industry over Lake Malawi and transport operations as well. Conversely it promotes sporting events over the lake that is sailing [or yachting] and is the source of wind energy, although this is of negligible importance…"

A more recent analysis was done by Mwakikunga (2002) where data obtained from the Department of Meteorological Services for ten sites and for the period 1999 to 2001 were analysed using the standard statistical method of the Weibull probability density function or basically the histogram of wind speeds. In this method data for a specific site are analysed for mean wind speed and standard deviation. The various combinations of the two parameters produce the scale factor k (which gives an idea of the magnitude of the wind speed at the site) and the shape factor c (which gives an idea of how regular, reliable and frequent the wind speed is for that site) Details of how to compute c and k can be obtained in Mwakikunga (2002), Balouktsis et al (2002) and a number of authors. The analysis by Mwakikunga (2002) is summarized in Table 8.5 and 8.6 wherein site rankings are based on k and c respectively.

Table 8. 5: Ten Malawian sites sorted by the scale factor or magnitude of wind speeds

		v(mean)									
Site No	Site Name	1.5m high	10mhigh	?	k1	k2	c1	(c2)1	(c2)2	Eas h=1.5	Eas h=10m
9	Dedza	3.7333	4.896794	0.9991	4.185213	4.207339	4.21173	1.104581	1.104238	278.69	628.8951
5	Nkhotakota	3.1666	4.15348	0.7674	4.661338	4.687841	3.572407	1.097397	1.097011	170.0679	383.7772
1	Chitipa	3.1555	4.138921	1.2628	2.703577	2.713499	3.559884	1.12784	1.12771	168.2857	379.7555
10	Chileka	2.8916	3.792776	0.5374	6.218603	6.260604	3.262165	1.077077	1.076591	129.4963	292.2229
2	Karonga	2.3222	3.045921	0.7526	3.399525	3.414881	2.619795	1.117218	1.116967	67.07204	151.3556
6	Salima	2.2861	2.99857	0.6174	4.144022	4.165778	2.579069	1.105224	1.104884	63.99239	144.406
7	MonkeyBay	1.8888	2.47745	0.3977	5.43026	5.464207	2.130854	1.086776	1.086334	36.09114	81.44369
8	Mangochi	1.6194	2.124091	0.536	3.322658	3.337386	1.82693	1.118469	1.11823	22.746	51.3289
4	Mzimba	1.3583	1.781618	0.4017	3.754879	3.773222	1.532369	1.111425	1.111128	13.42239	30.28912
3	Bolero	1.1613	1.523223	0.5926	2.076398	2.081993	1.310123	1.13168	1.13171	8.388339	18.92922

Table 8. 6: Ten Malawian sites sorted by standard deviation σ

		V (mean)									
Site No	Site Name	1.5mhigh	10mhigh	?	k1	k2	c1	(c2)1	(c2)2	Eas h=1.5	Eas h=10m
1	Chitipa	3.1555	4.138921	1.2628	2.703577	2.713499	3.559884	1.12784	1.12771	168.2857	379.7555
2	Karonga	2.3222	3.045921	0.7526	3.399525	3.414881	2.619795	1.117218	1.116967	67.07204	151.3556
3	Bolero	1.1613	1.523223	0.5926	2.076398	2.081993	1.310123	1.13168	1.13171	8.388339	18.92922
4	Mzimba	1.3583	1.781618	0.4017	3.754879	3.773222	1.532369	1.111425	1.111128	13.42239	30.28912
5	Nkhotakota	3.1666	4.15348	0.7674	4.661338	4.687841	3.572407	1.097397	1.097011	170.0679	383.7772
6	Salima	2.2861	2.99857	0.6174	4.144022	4.165778	2.579069	1.105224	1.104884	63.99239	144.406
7	MonkeyBay	1.8888	2.47745	0.3977	5.43026	5.464207	2.130854	1.086776	1.086334	36.09114	81.44369
8	Mangochi	1.6194	2.124091	0.536	3.322658	3.337386	1.82693	1.118469	1.11823	22.746	51.3289
9	Dedza	3.7333	4.896794	0.9991	4.185213	4.207339	4.21173	1.104581	1.104238	278.69	628.8951
10	Chileka	2.8916	3.792776	0.5374	6.218603	6.260604	3.262165	1.077077	1.076591	129.4963	292.2229

Conclusions made by Mwakikunga (2002) indicated Chitipa as a high potential site in terms of both wind speed magnitudes and reliability whereas Dedza comes second due to low performance on reliability. The two sites are recommended, on comparison with other analyses, for experimental aero generators or wind turbines for electricity generation. Most of the sites in Malawi are suited for water pumping but with high enough tower, aero generators could be recommended in sites like NkhotaKota and its related lakeshore areas and Chileka. The estimated size in terms of wattages of the wind turbine generators are indicated in last two columns at a tower height of 10 meters.

The above analysis agrees with the 1983 wind map.

8.2 Evaluation of Wind Energy Potential

An evaluation of wind energy potential in Malawi was done by analysing wind data at ten-metre height for Mzuzu, Mzimba, Lilongwe and Chileka and also by extrapolating two-metre wind to ten metres for Chitipa, Karonga, Nkhotakota, Salima, Dedza, Mimosa and Ngabu (Kamdonyo, 1988). The objective was to evaluate the potential of wind energy for electricity generation. The analyses revealed that:

- There is ample wind energy potential for electricity generation for small-scale applications in Malawi. For water pumping, the potential is far much greater.

- The potential is greatest during the dry season and lowest during the wet season.

- The potential is also greatest during daytime as opposed to night time.

8.3 Wind Energy Technologies in Malawi

Energy from wind in Malawi can be traced back to the unknown past including the discovery of Lake Malawi soon after which European explorers first used a sail boat to cross the lake from the north down to south and through the river Shire and Zambezi to the Indian Ocean. Through the lake, the explorers used wind to propel the boat and that continues to today on the lake in form of yachting and other forms of wind- related sports as already alluded to by Munthali (2001). Wind turbines came into site with missionaries and colonialists in the 1940s and 1960s as comprehensively discussed by Kamdonyo (1988).

In 1979, some German agriculturists installed a windmill for water pumping at Lifuwu Fish Landing point in Salima to help in water supply to the Europeans and the surrounding communities. The windmill was at about 6 meters from the ground and a few kilometres from the lakeshore. The windmill is reported to have been very inefficient with time due to unreliable winds and considerable obstruction from nearby trees and other structures. The turbine was taken apart for re- installation possibly offshore where winds are reportedly more reliable at the site.[1]

Wind turbines for electricity generation have also been tried. A remarkable case is that windmill which was set up by the Physics Department of Chancellor College, University of Malawi at the then Ntonda Distance Education Centre for lighting. This was a hybrid system with photovoltaic (PV) solar energy as indicated by Tembo et al (2001). Due to

[1] This information was collected through a telephone conversation between Mwakikunga B W, a wind energy researcher at the Polytechnic and Messrs. C G Mwalabu and B Duncan and A Muyepa in the irrigation department of Salima ADD, Malawi.

the fact that the blades were made from wood, the turbine lost one blade after operating for a few years. Efforts to restore the windmill at Ntonda have been suffocated by financial constraints and due to the pulling out of the Danish government who were one of the interested parties to the Ntonda project.

A wind mill for water pumping fabricated by Climax of South Africa is in operation along Blantyre- Chikwawa road. This turbine is a home based machine.

Attention needs to be given to Malawian manufacturers especially to Marine and Rural Engineering based in Mangochi district. This manufacturing company is managed and own by Mr C Mzamu, a mechanical engineer. The company had by the year 2002 produced about 8 wind pumps scattered through out a number of estates and government-owned farms. With droughts and pressure for irrigation, this is a very promising solution to the so many problems experienced by motorised pumps as Mwakikunga (2002) reports in a survey conducted in the 8 ADD's throughout Malawi. One of the Mzamu machine is given in Fig.6. 4

The Polytechnic, a constituent college of the University of Malawi situated in the industrial city of Blantyre, also has spearheaded research and development in wind technologies. Work has been commenced on both horizontal axis machines and vertical axis rotors. The S- shaped or popularly called the Savonius rotor (after its inventor) has been characterised. Innovations have been proposed and tested in the Physics laboratory at the Polytechnic, albeit the limitations of the absence of a wind tunnel. Mwakikunga (2002) has reported on the vane tilt angle of about 7 degrees to the vertical for optimum efficiency of the Savonius rotor. A model is given in Fig 6.5. A real Savonius rotor planned to be installed on top of one of the buildings of the Polytechnic for water pumping has been fabricated and assembled thanks to the support of the University of Malawi College - based Research and Publications Committee for the support. This machine made out of semi- cylinders of steel oil drum is shown in Fig 8.6. Another 12 bladed horizontal axis windmill is under development. The blades are made from plywood of several laminations and this is shown in Fig 8. 7

8.4 Barriers to Wind Energy Utilisation in Malawi and Suggested Barrier Removal Measures

The following points were listed as the main barriers to wind energy technology development in Malawi:

- High initial capital investment.
- Weak and unstable local currency tends to make important machines expensive.
- As there are so few working systems this is treated as "unproven technology."
- Poverty makes the potential users (i.e. rural population) unable to afford the system.
- Lack of standardization.
- There are no regulations and codes of installation practice.

- Lack of expertise in wind technology.
- Lack of countrywide wind data.

A number of measures to curb the above listed barriers have been proposed and outstanding measures are listed below:

- Establishment of Barrier Removal to Renewable Energy in Malawi (BARREM). to help barrier removal in renewable energy
- Establishment of the Renewable Energy Industries Association of Malawi (REIAMA) to coordinate activities pertaining to renewable energy.
- Government of Malawi has already waived import duties on some renewable energy capital equipment pieces and components.
- REIAMA has technology exchange and transfer programmes to hold to increase expertise in renewable energy activities.

The Specific barrier removal measurers are also listed:

- Carry out countrywide data collection for use in possible future electricity generation activities.
- Put in place standards, regulations and code of installation and practice.
- There is also need for efforts to create a local demand in the wind market before focusing efforts on the supply of local products.
- Facilitate local windmill manufactures acquire modern manufacturing techniques.
- Introduce appropriate financial schemes for villagers to enable them to buy locally manufactured windmills.

Actions Expected from the International Community

- Help in capacity building for local windmill manufactures and possible joint venture opportunities with other foreign firms. .
- Identify and facilitate reliable wind technologies especially in electricity generation.
- Identify sources of concessionary loan and grants.
- Help in a comprehensive Malawi wind map project.

8.5 Past Efforts to Promote Wind Technology In Malawi

A DANIDA funded renewable energy project in 1997 conducted a study on how wind energy technologies could be promoted in Malawi. The project entitled "Study of Assessment of Alternative Sources of Energy in Malawi" was discontinued but the main objective was to enable widespread access to wind energy technologies in Malawi specifically for water pumping in order to complement the national rural water supply programme. Some of the specific objectives were:

- To promote and enhance the capability of the private sector in manufacturing, distribution, installation and maintenance of wind energy technologies.
- To improve knowledge of wind energy in government and non-governmental agencies through training.
- To strengthen the Malawian government's capability to disseminate and mobilize resources for the implementation of wind energy projects.
- To involve a multiplicity of institutions ranging from government ministries/departments, research establishments, private companies and non-governmental organisations (NGO's) in the promotions of wind energy technologies.
- To strengthen the contact and cooperation among institutions involved in research and development of wind energy technologies with a view to establishing consistent product standards in Malawi.
- ,To raise awareness of wind energy to the general public; and
- To empower end-users technically - to be able to service the systems.

The strategy for achieving the objectives was to establish programmatic and/or commercial linkages between local industry/importers, banking institutions, NGO's, cooperatives, training institutions, and Government agencies through the financing, design, installation and maintenance of wind systems in selected pilot areas. The project was to introduce different sizes and types of wind systems to the rural/peri-urban target-groups on demonstration/pilot/paid-for basis, to show that wind energy is a possible attractive alternative to wood fuel.

The promotion was to be conducted in two components:-

- Individually adapted wind energy converter for lighting and water pumping.
- A wind demonstration farm with several windmills which can be connected to one grid for serving a community.

The following activities were envisioned for the project:

- Selection of pilot sites by utilizing existing wind-speed data available at the Meteorological Department and also from the previous study.
- Installation of wind measuring equipment in the selected sites, data and evaluation of the energy potential.
- Selection, procurement and installation of wind energy converters (windmills) in the pilot sites.
- Visits to similar projects in other countries such as Zimbabwe.

The final out comes of the project are not known since the project was not finished because the donors are stopped funding the project due to some disagreements with the then Malawi Government.

8.6 Summary and Conclusions

A number of wind data analyses have been presented. All of them agree to the fact that some areas like Chitipa are potential sites for wind turbine generators whereas a number of sites in Malawi are suited for windpumps for irrigation and water supply purposes. Wind technology in Malawi is still in infancy and barriers to its development have been highlighted alongside some of the suggested solu tions.

Fig.8.4 Six- steel bladed horizontal axis machine built and installed by Marine and Rural Engineering

Type II Windmill produced by Marine and Rural Engineering of Mangochi

Fig 6.5. An X- type of the Savonius rotor that has recently been tested for optimum angle of tilt ϕ for a maximum efficiency and rotor control at the Polytechnic. Full details can be found in Mwakikunga (2002).

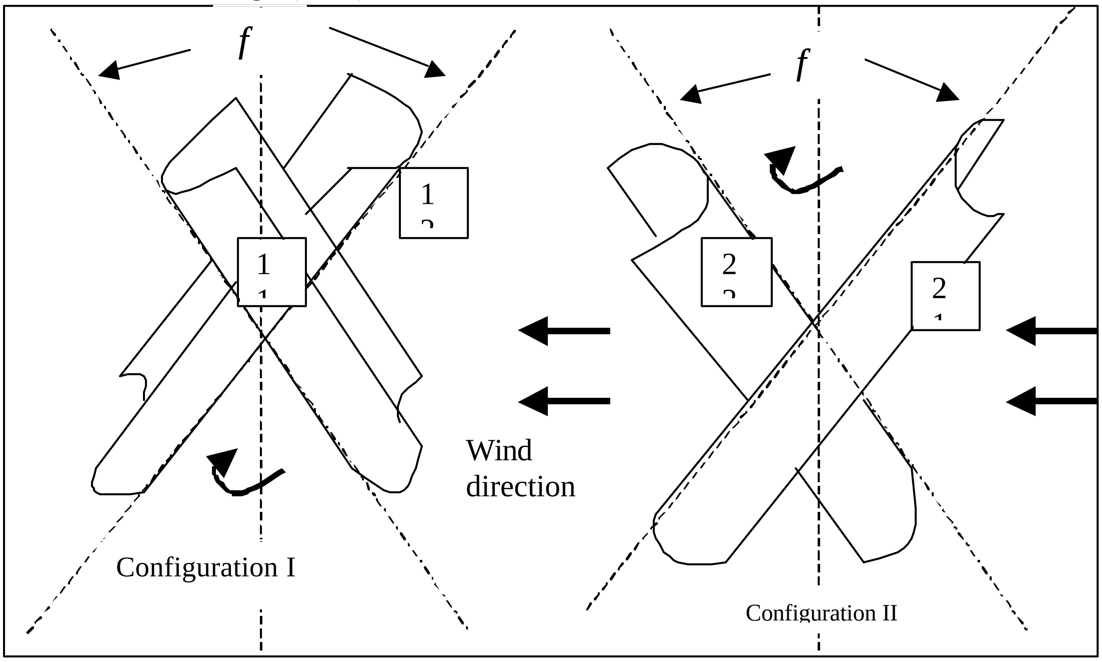

Fig 6.6. This a Savonius wind mill made out of semi- cylinders of steel oil drums. The design emphasizes the simplicity of the Savonius machine hence its possible adoption by the Malawian local communities.

Fig 6.7 This is plywood, 12- bladed horizontal windmill under development at the Polytechnic in Blantyre suited for water pumping.

CHAPTER 9

OTHER TECHNOLOGIES

9.0 Background

Apart from the technologies elaborated in the previous sections, Malawi has the opportunity to tap other technologies, which would be useful in minimizing climate change impacts at the local and international level. These technologies are presented in the following sections.

9.1 Solar Thermal

Malawi is endowed with high solar radiation (estimated at 21.1 $MJ/m^2/day$) adequate for both photovoltaic and photo-thermal applications. Photo-thermal applications are applied for water heating systems and are ideal in institutions such as hospitals and schools in both rural and urban areas, where using either geyser running on hydro electricity or firewood does water heating. With many hospitals and schools scattered throughout the country, there is high potential for photo-thermal applications in Malawi. Attempts have been made where over 500 solar thermal installations have been installed particularly in some private hospitals throughout the country. Unfortunately, it is estimated that over 50% of these installations are not functional due lack of maintenance. If Malawi is to succeed in this area, there is need to undertake market-priming activities for this technology. The market priming could be modelled on the one that is currently being undertaken by the Department of Energy that is focusing on solar photovoltaic (PV). The major aspects of such priming is local capacity building and cultivating a maintenance culture after the technology has been installed.

9.2 Geothermal Power Generation

A number of hot springs are located in several places in the country including one in Nkhota-Kota District and another at Chiweta in Rumphi District, which can be used for geothermal generation. Malawi does not have geothermal power generation plant. However with the availability of hot springs in the country, there is great potential to generate geothermal electricity. There is therefore need to work closely with institutions such as the geological survey department and undertake a study to explore the possibility of geothermal power generation.

9.3 Thermal Power Generation

Power generation in Malawi is predominantly hydro electric with major stations, generating 285 MW, located on the Shire river, a natural outlet of the Lake Malawi. The location of the power stations on one river makes them (power stations) vulnerable to any vagaries of nature affecting the Shire River and Lake Malawi. Environmental degradation, through deforestation, in the catchment areas of the Shire River and Lake Malawi and drought, expose hydropower generation stations to power security and reliability risks. As a pointer to such risks, Nkula Power Station was flooded with water reducing the stations generation capacity to 100 MW, and in the process negatively affecting businesses and industries as well as domestic consumers dependent on electricity. Such problems associated with hydro electricity can be circumvented, to a large extent, by adopting thermal power generation. In the context of Malawi, thermal power generation can be accomplished by using either coal or biomass (firewood).

9.4 Coal Fired Power Generation

Power generation using coal is not new to Malawi having been established in the 1950s and 1960s in Blantyre using coal from Wankie. There is now an opportunity to use coal from Malawi.
There are several coal fields in Malawi with untapped reserves, estimated to be in the order of 800 million tonnes have been identified. Quality of coal varies but included the following fields:

a. Ngana Coalfield
b. Livingstonia Coalfield
c. Lufira Coalfield
d. Mwabvi Coalfield
e. Lengwe Coalfield
f. Nthalire Coalfield

The coalfields identified in Malawi can sustainably be utilised to support a power plant that is capable of generating 120 MW.

9.5 Biomass Fired Power Generation

An opportunity also exists to use biomass resources to generate power for use within Malawi. A specific resource target for potential biomass power generation is Viphya Plantation at Chikangawa in Mzimba District, which is a home to more than 50000 hectares of established pine plantations. Established more than 50 years ago, most plantations have reached maturity and are available for productive use such as power generation.

Biomass power generation plans from Chikangawa call for a two-phase development of generation plants of 25 MW each, giving a total of 50 MW.

9.6 Benefits of Thermal Power Generation

Multiple benefits can be realised from proceeding with implementation of thermal power generation through the use of coal and biomass. Whilst bringing the much needed additional power to the country, utilisation of coal and biomass will have parallel effect of revitalising the economy through the provision of employment opportunities for a significant number of people, thereby contributing to the government's central development agenda of poverty reduction.

Hydropower generation has been associated with security and reliability risks as highlighted above. Such risks are not associated with thermal power generation.

Investment in the thermal power generation would also expand the government's revenue resource base through collection of taxes, levies and loyalties from sectors that have remained semi-dormant for a long time.

Thermal power generation has been associated with atmospheric pollution time immemorial through emitting gases such as carbon dioxide, carbon monoxide, particulate matter, nitrous oxides, sulphur dioxide, and mercury. However, with advances in technology, experts have developed state of the art thermal power generation technology with minimal harmful gases emissions though the most advanced "scrubber" technologies remain relatively expensive This makes thermal power generation more desirable than ever before.

CHAPTER 10

TECHNOLOGY TRANSFER AND NEEDS ASSESSMENT: A SYNTHESIS/CONSPECTUS

10.0 Background

Climate change is one of the critical environmental problems, which the world is facing today. Effects of climate change in various sectors affect many countries including Malawi. The consequences may be profound on agriculture and terrestrial systems, hydrology and water resources, human health, forests and wild life, coastal zones, finance, insurance, energy, commerce, industry and urban and rural settlements.

Presently, initiatives are underway to identify and develop technologies and practices for mitigating climate change and adapting to it. The development and use of the technologies is fully consistent with the general goals of sustainable development.

Article 4.5 of the UNFCCC calls for country parties to undertake technology transfer and needs assessment with the aim of adapting to and mitigating the effects of climate change. In undertaking the task, the Malawi Government reviewed its national circumstances and identified priority climate change issues that need intervention through technology transfer and needs assessment.

10.1 National Circumstances

The review undertaken on the national circumstances indicates that the country has a wide diversity of natural resources that includes water, forestry, 'favourable' climate, fertile soils, land, wildlife, vegetation and clean air. However, recent trend analyses have indicated that the natural resource on which more than 95% of the rural population depends is declining due to a number of factors. The factors include wanton cutting down of trees for charcoal and firewood; water pollution due to poor sanitation and land use practices and use of obsolete technologies and inefficient sources of energy.

Due to the adverse factors mentioned above, it has been reported that over 65% of the people in the country are vulnerable to effects of climate change because they have no alternative sources of energy and mechanisms to cope with effects of climate change.

10.2 Technology Needs Assessment [TNA]

The role of technology needs assessment has been defined and justified under the Climate Change Convention. From a climate change and developmental perspective, technology needs assessment entails the identification and evaluation of technologies, practices and reforms that can be implemented in different development sectors to reduce green house gas emissions and climate change vulnerability and also to contribute towards national development goals.

Many of the technologies and practices for adaptation to and mitigating adverse effects of climate change are well suited to the needs of the country's socio-economic development. Also, many of such technologies have become economically important sources of supplying and utilizing energy efficiently.

In Malawi, Government has established institutional structures and arrangements to engage various stakeholders and development partners in technology transfer and needs assessment. Priority technologies have been identified and appraised based on a special criteria that encompasses development benefits, market potential and adaptation to climate change. Presently, the priority sectors selected for climate change adaptation include energy, agriculture, irrigation, water, meteorology, industry, health and education.

10.3 Technologies Identified

Based on the development vision contained in the Malawi Poverty Reduction Strategy Paper [2002], Malawi Millennium Development Goals [MDGs], and Vision 2020, Malawi aspires to become a middle-income country with a technologically-driven economy by the year 2020.

However, according to the United Nations Classification system, Malawi is one of the Least Developed Countries [LDC] with its economy largely dependent on agriculture and a small industrial and mining sector. According the GHG inventories, studies on climate change vulnerability and adaptation, the country has significant potentials for development of climate change friendly technologies. The technologies with high potential for development are as follows:

Power generation technologies [e.g. solar, solar photovoltaics, wind power, mini/micro hydro systems, biomass].
Biomass technologies [non-power] e.g. solar power heaters.
Demand Side Management technologies and
Waste technologies.

10.4 Technologies Prioritized

The technologies were prioritised and ranked based on several factors including: GHG emission impact; job creation, poverty reduction; income generation, food security and reduction of the cost of living. After rating, the technologies selected were in the following order of importance: solar PV-system, mini/micro hydro systems. Biogas. Wind power, biomass and industrial efficiency.

10.5 Technologies Characterized

In a further assessment of the technologies, individual systems were characterised and evaluated in terms of feasibility, current status of implementation, constraints to development, likelihood of success and number of stakeholders involved or number of beneficiaries from technology implementation.

a) solar photovoltaics: According to the status and performance studies, this technology has high potential for development in many parts of the country since solar power is abundant in many parts of the country throughout the year. However, significant barriers identified from years of implementation include high investment capital; lack of awareness; lack of economic incentives; lack of trained manpower and lack of suitable financing mechanism.

   To contribute towards rapid development of the country within the context of poverty reduction and the Vision 2020, Government needs to pursue and promote development and adoption of this technology aggressively.

b) Mini/Micro Hydro Power Technologies: Malawi has a number of areas with high potential for electricity generation from Mini/micro hydros. This would greatly boost the lives of many rural masses that are currently far away from the grid electricity system.

c) Biogas Technologies:

According to the information reviewed, Malawi has adequate materials to support development of a biogas programme. However, the key barriers to development of the technology include poor animal husbandry practices, lack of technical skills, poor project planning, high investment costs and lack of public awareness.

For the country to harness this source of energy, there is a need to coordinate development of the technology, develop capacity, establish financial mechanism and embark on an awareness programme.

d) Malawi has target areas where the potential for development of wind technologies is significantly high. The technology is, however, not developed due to a number of factors that include lack of human and financial resources, high investment capital, low awareness, and lack of technical expertise.

Government should therefore deliberately develop this source of energy especially for water pumping in schools; farms, homes and other institutions.

d) Biomass Technology: Malawi has high potential for development of biomass technologies such as improved stoves and biofuels. The technologies are presently being developed by the private sector in collaboration with Government. Examples include development and promotion of efficient stoves, Gel Fuel and Blu Wave technologies. Barriers to rapid development of the technologies include inadequate financial resources, high end price for the products and lack of technical capacity.

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e) Energy Efficiency: Economic growth and development can be sustained if it is driven by efficient energy systems. In Malawi, the industrial sector is powered by relatively older and less energy efficient machinery. However, recently, there has been a deliberate campaign to replace the old less efficient systems with efficient ones under the ISO 14000 campaign. Key barriers include lack of awareness, accessibility to the technology and high investment costs. Government should therefore promote use of energy efficient systems especially under the ISO 14000 initiatives.

Chapter 11

WAY FORWARD

11.0 Way Forward For Climate Change Technologies in Malawi

11.1 Policy Anchorage

According to the new Energy Policy for Malawi, the emphasis is on increasing access to electricity by increasing access to electricity by 10% in 2010, 30% in 2020 and 40% by 2050. Apart from extending the national grid to rural areas, use of renewable energy sources is expected to significantly contribute to the above goal.

This is reflected in table 11.1 which shows the proportion of the energy risk projections for Malawi up to the year 2050. It will be observed from these projections that the contribution of renewable energy will more than quadruple by the year 2050 as 10% of the energy rise will come from renewable energy will come from renewable compared to the present 0.2%.

Table 11.1: Energy Mix Projections For Malawi (%)

Energy Source	YEARS			
	2000	2010	2020	2050
Biomas	93.0	75.0	50.0	30.0
Liquid Fuels	3.5	5.5	7.0	10.0
Electricity	2.3	10.0	30.0	40.0
Coal	1.0	4.0	6.0	6.0
Renewable	0.2	5.5	7.0	10.0
Nuclear	0.0	0.0	0.0	4.0
TOTAL	**100**	**100**	**100**	**100**

Source :Department of Energy Affairs (Energy Policy Document)

11.2 Priority Actions To Be Undertaken

In order to achieve the above projections the following priority actions will be undertaken in RETS.

11.2.1 Supply and Warehousing

The Energy Regulator which has been created in the new Energy Policy and regularly provided for in the Energy Regulation Bill, will register operators in supply and warehousing and will certify each approved supplier. Equipment will be subject to quality certification by the Energy Regulator. The certified supplier will be permitted to run a bonded warehouse for RET's equipment and spare parts which will be imported duty-free.

11.2.2 Retail Market (Installation And Maintenance)

Renewable Energy Technology retailers will obtain a retailers' licence from the Energy Regulator. Installers should be willing to issue warranty, enter into service agreements with end users, have accredited technicians abs own a maintenance workshop. These requirements will allow a certified retailer to get contracts on government sponsored RET's installation programmes.

11.2.3 Financing Mechanisms

Government through the Energy Department will establish a dedicated financing mechanism in support of market priming activities. The mechanism will have the following features:

i) A loan guarantee fund to be managed by a private fund manager
ii) Commercial credit facilitates provided by commercial banks for RET suppliers and end-users.
iii) Fiscal incentives in the term of exception from import duty and import surtaxes for all RETs systems.

11.3 Regulatory Functions

The functions of the regulatory shall include but not limited to:

i) licensing RETs suppliers, retailers and installers
ii) preparing and enforcing regulations and bylaws
iii) developing standards and code of conduct
iv) testing and certifying equipment
v) training and accrediting technicians in collaboration with other agencies
vi) approving RETs prices
vii) inspecting and commissioning installations

Table 11.2 presents detailed matrices for solar PV systems, biogas, wing and mini/micro hydro power, technologies, depicting barriers, foreign action, funding, steps to implementation, domestic action, lead agency and the role of private sector.

TABLE 11.2 (a): SUMMARY MATRIX FOR SOLAR PV SYSTEMS

Barriers	Foreign Action	Foreign funding	Step to Implement	Domestic Action	Domestic Funding	Steps to Implem
Lack of local capacity in manufacturing distribution installation and maintenance of solar PV	Information and technology transfer, invest in local assembling and or manufacturing of some PV components	US$ million	Step 1 information exchange Step 2 feasibility analysis on joint venture on local assembling and manufacturing of some components Step 3 investment on joint venture	• Regulate the PV market • Put up policies to attract investors • Remove duties & taxes on manufacturing of PV components	US$50 million in lost revenue from taxes and direct private sector investment	Step 1 put legislation to l the playing fielc Step 2 Inst policy incentive investment manufacturing assembling of components
High first costs of solar PV	• Information and technology transfer on cheaper PV systems • Assemble some parts locally	US$30 million	Step 1 information exchange on cheaper PV systems Step 2 Assemble some parts locally	Remove duty & taxes on PV imports and encourate local assembling of components	US$50 million in revenue loses from duties and taxes and direct investment	Step 1 Remove and taxes on al imports Step 2 incou local assemblin part by remc investment barr
Lack of dedicated financing mechanism	Information & technology transfer on working financing mechanisms for PV end users	US$20 million as seed fund	Step 1 information exchange on working loan funds Step 2 set up a fund with seed money	Identifying a fund manager for the financing mechanism and inject seed funds	US$20 million for energy fund over 5 years	Step 1 design fund manager the fund Step 2 ide Commercial B to run the loan f Step 3 inject money
Limited delivery modes	Information & technology transfer on working Energy Services Companies (ESCOs)	US$35 million	Step 1 information exchange on ESCO operation Step 2 establish local ESCOs Step 3 Fund the ESCOs	Identify areas where ESCO operation on PV lighting is viable Identify local companies	US$20 million to prefinance ESCO operations	Step 1 Train ES on the new deli mode Step 2 Pilot ES activity in sele area Step 3 Esta more ESCOs

TABLE 11.2 (b): SUMMARY MATRIX FOR WIND TECHNOLOGY

Barriers	Foreign Action	Foreign funding	Step to Implement	Domestic Action	Domestic Funding	Steps to Implem
Lack of local capacity in manufacturing installing and maintaining wind technology	Information & technology transfer invest in local assembling of wind technology for water pumping	US$ 30 million	Step 1 information Step 2 Feasibility analysis for joint venture with local companies/entrepreneurs Step 3 invest	• Remove market barriers for investment • Encourage joint venture arrangement with local entrepreneurs	US$ 20 million	Step 1 Identify entrepreneurs wind technolog Step 2 Enco and arrange for venture with fo investors Step 3 Invest
High first cost of wind technology	Information & Technology transfer on cheaper wind technologies	US$ 25 million	Step 1 Information exchange on cheaper wind technology Step 2 Acquire cheap technology and assemble locally	• Remove duty and taxes on wind technology imports and local manufacturing	US$ 20 million	Step 1 Remove & surtax on technologies water pumping Step 2 Encou local assemblir cheap technology
Small niche market for wind technology	Information & technology transfer on widening the wind technology for market water pumping	US$15 million	Step 1 Information exchange on market niche for wind technology Ste 2 Replace MASAF hand pumps with wind pumps where wind are high	• Identify areas where wind speeds are high to warrant installation of wind pumps. • Identify bore holes for replacement with wind pumps	US$ 40 million	Step 1 Identify areas where are high Step 2 Identify boreholes demonstration wind water pum Step 3 Involve communities

TABLE 11.2 (C): SUMMARY MATRIX FOR BIOGAS TECHNOLOGY

Barriers	Foreign Action	Foreign funding	Step to Implement	Domestic Action	Domestic Funding	Steps to Impleme
Lack of local capacity to manufacture and install Biogas system	Information & technology transfer, invest in local assembling and or manufacturing of some biogas components	US$ 10 million	Step 1 Information exchange Step 2 Feasibility analysis on joint venture on local assembling & manufacturing of some components Step 3 Investment on joint venture	• Regulate the biogas market • Put up policies to attract investors • Remove duties and taxes on manufacturing of biogas components	US$ 10 million	Step 1 Put up legislation to leve playing field Step 2 Institute p incentives investment manufacturing assembling of b components
Lack of information on afficacy biogas technology	Information & technology transfer on the afficacy of biogas technology	US$ 20 million	Step 1 Information exchange on biogas Step 2 Train local experts on biogas technology Step 3 Implement pilot biogas	• Identify areas suitable for biogas technology • Train local entrepreneurs on biogas technology	US$ 15 million	Step 1 Train t mansons Step 2 Establish demonstration t units Step 3 Expand b technology
Limited delivery mode on Biogas Technology	Information & technology transfer on working Energy Service Companies (ESCOs)	US$ 10 million	Step 1 Information exchange on ESCO operation Step 2 establish local ESCOs Step 3 Fund the ESCOs	• Identify areas where ESCO operation on biogas lighting is viable • Identify lo cal companies	US$ 10 million	Step 1 Train ESC the new delivery m Step 2 Pilot ES activity in selected Step 3 Establish ESCOs

TABLE 11.2 (d): SUMMARY MATRIX FOR MINI/MICROHYDRO POWER GENERATION

Barriers	Foreign Action	Foreign funding	Step to Implement	Domestic Action	Domestic Funding	Steps to Implement	I
Lack of local capacity to install and maintain mini/micro hydropower	Information & technology transfer invest in local assembling of mini/microhydro technology for water pumping	US$ 40 million	Step 1 Information exchange Step 2 Feasibility analysis for joint venture with local companies entrepreneurs Step 3 Invest	• Remove market barriers for investment • Encourage joint venture arrangement with local entrepreneurs	US$ 30 million	Step identify local entrepreneurs in mini/microhydro technology Step 2 Encourage and arrange for joint venture with foreign investors Step 3 Invest	I r t l
High first cost of Mini/Micro Hydro power	Information & technology transfer on cheaper mini/microhydro technologies	US$ 35 million	Step 1 Information exchange on cheaper mini/microhydro technology imports and local manufacturing	• Remove duty and taxes on mini/microhydro technology imports and local manufacturing	USD 30 million	Step 1 Remove duty & surtax on mini/microhydro technologies for water pumping Step 2 Encourage local assembling of cheap mini/microhydro technology	I r e r

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