ENERGY POLICY RESEARCH BASELINE STUDY FOR MULANJE AND PHALOMBE DISTRICTS

Prepared by

J.L. Taulo, R.W. Mkandawire and K.J. Gondwe

Malawi Industrial Research and Technology Development Centre, Malawi

Submitted to

Mulanje Mountain Conservation Trust

With

Financial Support from Practical Action

JULY 2008

ACKNOWLEDGEMENTS

The study was made possible through funding provided by Mulanje Mountain Conservation Trust (MMCT) in the process of implementing the E-Mindset Project. MMCT contracted the Malawi Industrial research and Technology Development Centre (MIRTDC) to implement this work. Management of MIRTDC is commended for putting together the team that carried out this assignment. MMCT is also commended for their input in the implementation of the consultancy and writing of the report.

In undertaking the assignment, various organizations, Government Departments and individuals based in Mulanje, Phalombe, Thyolo, Blantyre, Zomba and Lilongwe rendered their support to the consulting team. The various groups provided primary and secondary data that has been used in coming up with the recommendations contained in this report. In addition to data, the organizations and individuals recommended other organizations that were deemed to have additional data relevant to the project. We acknowledge contributions made by these organizations and individuals, without which this work would not have been possible. The List of institutions and individuals consulted during the assignment have been attached as Appendix 2

The consulting team is also indebted to the 800 households that took time to respond to our data collection questionnaire. Their contribution made this work possible.

EXECUTIVE SUMMARY

Malawi has a low access to clean energy resources; at least 93% of the 14 million Malawians still use primary sources of energy. Combustible biomass energy resources that 2.5 million households depend on are susceptible to health problems and use inefficient conversion technologies. A number of factors have been highlighted as constraints to the energy sector in Malawi; some of them are weak energy policies, high cost of upgrading energy sources, high distributions costs and losses and insufficient knowledge and awareness of the new and renewable energy technologies.

The objectives of the present study are to provide baseline information for benchmarking the energy situation in Mulanje and Phalombe Districts; conducting a situation analysis in terms of planning and budgeting process in meeting economic growth, equitability and environmental sustainability. The study summarises socioeconomic profiles of the two districts and reviews the energy resources and their potential in the two districts. An analysis of the current energy consumption, energy costs, and indoor air pollution in the household sector as well as household energy programmes in the district is presented. This is followed by a brief overview of major Government policies related to energy, budgeting and planning. An evaluation of Government support for national energy projects in the two districts is made. The study also outlines a case study on promotion of fireless cooker and discusses factors that affected the adoption of the technology.

To effectively establish the energy baseline information for the districts, potential for biomass, petroleum, wind, solar and hydro energy resources for the two districts were studied. Biomass energy resources were further split into fuelwood, charcoal, animal dung, and agricultural wastes. The study established that average wind speeds (measured at two metres) of 1.1 and 1.2m/s for Mulanje and Phalombe are too low for power generation. Hence it was recommended that wind energy is not an option for Mulanje and Phalombe. It was, however, established that the districts receive an average daily solar radiation of 4.25-6.86 kWh/m^2 and an annual sunshine duration of 2,596 hours. It was, therefore, recommended that solar energy is a viable option for use either as solar photovoltaic (PV) or solar-thermal.

It has already been recognised that biomass energy resources form the bulk of the energy resource for Mulanje and Phalombe. Biomass fuel comprises agricultural wastes, wood and

wood wastes, animal dung and municipal solid wastes. Mulanje and Phalombe have 55,607 and 11,805.5 hectares of forestry cover. From the forest resources, Mulanje harvests an average of 95 thousand tons of wood fuel and 3.8 thousand tons of charcoal annually. Agricultural wastes, especially pigeon peas stalks, supplement firewood as a main energy source for cooking and heating.

Due to stabling system prevalent in Mulanje and Phalombe, collection of animal dung is limited. Where it is feasible, there is potential for production of 2,131,500m^3 (46,040 GJ) of biogas per year. This is enough to meet energy needs of 4,300 households. It is recommended that biogas promotion be targeted only at areas that have high potential; households that have more than six heads of cattle. Another potential source of biogas substrate is the municipal wastes. With a population of 19,000 and 3,000, Mulanje and Phalombe have a municipal waste potential of 6,336 tons per year. If converted to biogas, the waste has potential of generating 427,680m^3 (9,238 GJ), which is enough energy for approximately 1,000 households. However, the municipal waste handling system in Mulanje and Phalombe is household based, hence cannot be feasibly used for energy generation except in schools and hospitals.

Michesi and Mulanje Mountains provide a terrain that gives potential to micro hydro power. Lujeri Tea Estates is currently exploiting this potential through its three plants, two on Ruo River and one on Lujeri river generating a total of 840 kW. The mean runoff of Mulanje rivers is estimated at 51.63 m^3/s. The maximum potential for Mulanje and Phalombe is 104 GWh per annum. However, limitations like reservoir storage sites and spillage reduce the realisable hydro potential to 15.6 GWh per annum. In addition to the potential for locally generated hydro power, Mulanje and Phalombe are connected to the national grid. Currently, Mulanje is served by a 7 MW powerline. Most of the power is used in the tea industry.

There are no petroleum reserves in Mulanje and Phalombe. Most of the petroleum products are supplied through three service stations run by Total Malawi in the districts. Mulanje has two filling stations, one supplying petrol and diesel while the other exclusively supplies paraffin. Phalombe has one filling station.

TABLE OF CONTENTS

ACRONYMS AND ABBREVIATIONS

ADC	Area Development Committee
DEAP	District Environmental Action Plan
DEC	District Executive Committee
ESCOM	Electricity Supply Corporation of Malawi
FAO	Food and Agriculture Organisation
FRIM	Forestry Research Institute of Malawi
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
IFSP	Integrated Food Security Project
HIS	Integrated Household Survey
MEGS	Malawi Economic Growth Strategy
MEM	Ministry of Energy and Mining
MEP	Malawi Energy Policy
MGDS	Malawi Growth and Development Strategy
MIWD	Ministry of Irrigation and Water Development
MMCT	Mulanje Mountain Conservation Trust
PAESP	Promotion of Alternative Energy Sources Project
ProBEC	Programme for Biomass Energy Conservation
SEP	Socio Economic Profile
UNFCCC	United Nations Framework Convention on Climate Change
VAP	Village Action Plan
VDC	Village Development Committee
USAID	United States Agency for International Development

Units of Measure

GWh	Gigawatt- hour
GJ	Gigajoules = 10^9 Joules
kW	kilowatt
kWh	kilowatt-hour
MW	Megawatt
MWh	Megawatt- hour
PJ	Petajoules = 10^{15} Joules
TWh	Terawatt- hour
TJ	Terajoules = 10^{12} Joules
TOE	Ton of oil equivalent = (42GJ or 10^7 kilocalories)

1.0 INTRODUCTION

1.1 Background and Rationale for Action

Access to clean, affordable and sufficient energy for all is an important prerequisite for a nation's development. Energy occupies the centre stage in almost all daily production activities – cooking, access to clean water, agriculture, education, transportation, employment generation and environmental sustainability. Malawi, with a current population of about 14 million[1] people, uses a variety of both commercial and non-commercial energy sources. However, 93% of the population do not have access to modern energy services (IHS, 2005).

Lack of access to sufficient and sustainable supplies of clean energy is one of the underlying contributing factors to many social welfare problems, such as poverty. Almost 2.5 million households still rely entirely on combustible biomass like animal dung, crop residues, wood, and charcoal as their fuel (IHS, 2005). Impoverished communities dedicate a high percentage of their income acquiring biomass fuel (either directly or in the form of this very high opportunity cost they pay in terms of collection and preparation, estimated at 25% of the total household labour) (Hainess and Kammen 2000; Brouwer et al, 1996; Culler et al.,1990; Chidamoyo, 1997). Furthermore, using solid fuels, such as biomass, has numerous direct and indirect impacts on population health, accounting for more than 8.1% of asthma and other respiratory diseases reported in 2005 (IHS, 2005).

There are a number of key constraints in the Malawian energy sector. These include energy-related policies which require further strengthening, uncomfortably high levels of energy imports in terms of petroleum products which threaten energy security and strain foreign exchange levels. This has been more critical with world market price of crude oil reaching a record of nearly 150 United States Dollars (USD) per barrel. In addition, extending grid electricity to rural areas is considered uneconomic due to the cost of infrastructure, dispersed nature of the population, low consumption and poor load factors (MEM, 1997). Furthermore, a severe constraint to the development of power sector by the national utility has been the high transmission and distribution losses (estimated at 18%), difficulties in billing and collection, and

[1] An estimate based on 1998 census data, and a growth rate of 2% per year

continuing capacity shortages (MEP, 2003). These reasons contribute to making grid extension to rural areas impractical. The problems are compounded by insufficient knowledge and awareness of traditional and renewable energy sources and uses that could be balanced to optimize the provision of clean, efficient and accessible energy. In addition, Malawi has a relatively weak energy conservation culture. These sectoral constraints are coupled with systematic challenges such as relatively limited economic development and productive capacity, limited human capacity in the public and private sectors, poor public participation frameworks and inadequate data availability for decision-making. Consequently, the need for a comprehensive approach to district energy planning is clear and a study that presents and documents viable, innovative and integrated policy options for these issues is an urgent priority.

Practical Action Southern Africa in partnership with Mulanje Mountain Conservation Trust is implementing an energy programme titled "*Energising the Millennium Development Goals – Setting the Enabling Environment (E-MINDSET) in Southern Africa''* with funding from the European Commission. The project was launched in January 2007. The project seeks to develop, test and adapt planning toolkits for linking energy planning and MDGs at the local planning unit in Southern Africa. Its specific objectives are to: (a) develop toolkits and strengthen partners' capacity in knowledge transfer and linking planning and development; (b) improve communities' capacity to link energy planning and development; (c) influence energy policy and regulatory framework to reflect and prioritise energy requirements for attaining MDGs targets; and (d) disseminate tools for linking energy and the MDGs.

The project aims at working with district planning systems to address the energy planning gap at a sufficiently low level to respond to the needs of the poor. The district level is the first integrating unit in development planning and therefore offers an opportunity to link energy and other sectors more directly. This will be achieved by developing planning toolkits to link energy and development plans for achieving national MDGs targets. A toolkit is a teaching, planning or decision making aide in a training package. These toolkits will be tested and applied against prioritised MDGs particularly to encourage integration of energy budgets into other sector budgets; for example, health and education.

The project will also develop greater awareness on current negative policy loopholes especially on disproportionate allocation of state subsidies to grid extension and petroleum products against alternative technology options for rural communities.

Towards developing the programme for achieving the above objectives, the Malawi Industrial Research and Technology Development Centre was commissioned to carry out a detailed study on energy issues in Phalombe and Mulanje Districts, to establish a concrete baseline for incorporating energy into development plans at District Assembly level.

1.2 Study Objectives

The objectives of this study are to provide baseline information for energy module writers and information for benchmarking the energy situation in each target district and clear indications of situation in terms of the planning and budget processes in meeting economic growth, equitability and environmental sustainability.

1.3 Methodology

A two pronged methodology was employed for the study: one of collecting data and information from available secondary sources like official reports and surveys, and annual reports; interviews with relevant departments at national level and the two districts (Mulanje and Phalombe) covered in this study, and with NGO's working in the districts. The other component of the study was a field-based study of four selected villages - Kukada, Ndala, Nande, and Nkhulambe, identified by Mulanje Mountain Conservation Trust.

Household data was collected from a sample drawn from the four villages. Two hundred households were interviewed from each village, thus making a total of 800 households. A questionnaire, attached as Annex 1, was developed to facilitate the data collection. The questionnaire was pilot tested to eight respondents before being administered to the sampled households.

Random sampling technique was used in selecting the 800 households used in the survey. Eight enumerators, two per village, were engaged from the selected villages to administer the questionnaire, thus each enumerator was assigned 100 households. Recruiting enumerators from the selected villages helped in making possible quick local arrangements for stay, transport and access. The data from the interviews was collated and analysed using Microsoft Excel and Statistical Package for Social Scientists (SPSS).

1.4 Limitations

Secondary data was not consistently found in each district especially for Phalombe. The quality and extent of information became scant as one went down the administrative tiers. Some institutions like ESCOM refused to provide electricity demand and supply for both districts. There are also data gaps; for instance hydrological and meteorological data is not available.

1.5 Structure

This report is organized in seven sections. Section 1 presents the introduction and methodology applied in this study, followed by summarised profiles of the two districts provided in section 2. A review of the energy resources and their potential in the district is described in section 3, followed by results of the household energy survey, presented in section 4. Section 5 and 6 provide an overview of policies, budgeting and planning and an assessment of institutions at district level. Section 8 is the concluding section that brings the salient features of the study together and makes suggestions for further specific investigations/research to be included as part of project implementation. Annexes and references are presented at the end of this report.

2.0 BACKGROUND

2.1 Physiography and Demographics

Mulanje District

The district is located in the Southern Region of Malawi, approximately 65 kilometres east of Blantyre (Map 1). It is named after the highest Mountain in the South-Central Africa. The highest peak on the Mountain, Sapitwa, is 3002 metres above sea level (Bouvier, 2006). The total area of the district is 2056 km^2 (205,300 hectares), 25 % of which is taken up by the mountain (580 km^2 or 50,200 hectares). Mulanje District has a tropical climate with two main seasons, of wet and dry seasons. The wet season starts in November and ends in April; the dry season covers the remaining months. The Mountain has a big influence on local weather conditions, causing high rainfall on the windward (South East side of the Mulanje Mountain) while limiting it on the leeward side. The influence also results in occasional rain and fog in the months of June to August.

The temperature ranges between hot and cool in summer and winter. Average maximum temperature is 24^oC in summer and 12^oC in winter while the minimum temperatures are 15^oC and 9^oC in summer and winter respectively. The hottest summer days could reach as high as 35^oC, experienced between September and April. During the cold months of May to August, temperatures at higher altitudes can drop to as low as minus 3^oC. One most distinctive feature of Mulanje climate is the variation of rainfall over short distances, a characteristic attributed to the influence of Mulanje Mountain. Annual rainfall at the tea estates (650m altitude) averages 1626mm with 16% falling during the dry season. On the mountain (Lichenya, 1875m altitude) the average increases to 2849mm with 19% falling in winter. On the western side of the Mountain, the rainfall is considerably lower, with very small amounts falling during the dry winter months.

Mulanje has both natural forest reserves and plantations. There are four major forest reserves covering an area of 52,907 hectares (Tables 1a and b show the forest reserve details). There are five public plantations covering an area of 6777 hectares and a number of private

plantations totaling an area of 300.3 ha. Much of the private plantations are in the tea industry where together with the tea plantations cover an area of 14,847 hectares.

The main ethnic groups in Mulanje are Lomwe, Yao and Nyanja. The Lomwe are the most dominant tribe with presence in all the Traditional Authorities in the district. Notwithstanding that, other tribes have migrated to the district and have influence on the language spoken therein. As of 1998 the main languages spoken in the district were Chichewa 52.64%, Chinyanja 33.62% and Chilomwe 10.26% respectively (Mulanje SEP, 2007).

According to the National Statistical Office (1998), there are approximately 539,753 people in the district, with an annual growth rate of 3.2% and a sex ratio of 91%. Forty eight percent (48%) of the population is below the age of 15 and 75% is below the age of 30. With a family size of 4.0, Mulanje has relatively small families when compared to the national average of 4.5 and a rural average of 4.6 (IHS, 2005). However, Mulanje is one of the highly populated districts in Malawi, having an average population density of 307, which is almost twice the national average of 135 (NSO, 2006). Over 80% of the population live in rural areas and largely depend on natural resources such as land, trees, water and wildlife for their livelihoods and survival.

Phalombe District

Phalombe District is located in the Southern Region of Malawi, approximately 81 kilometres east of Blantyre. It is bordered by Mozambique to the eastern side, Zomba to the north and Mulanje to the west and south. The district covers 163,300 hectares, 124,500 of which are arable and are under cultivation and human settlement. The rest is covered by marshlands that include Lake Chilwa and Mpoto Lagoon and forest reserves, the biggest of which is the Michesi Forest Reserve on Michesi Mountain. Phalombe District, like Mulanje, has a tropical climate with two main seasons, of wet and dry seasons. The wet season starts in November and ends in April; the dry season covers the remaining months. Michesi Mountain juts out of the Phalombe plains; like Mulanje Mountain, it has a big influence on local weather conditions especially rainfall.

When compared to Mulanje, Phalombe has a warmer climate. Maximum temperatures are experienced from October to December. Temperatures would sometimes rise to 39^{o}C, while the minimum temperatures experienced from May to July would rarely fall below 18^{o}C. Rainfall in Phalombe is affected by Michesi Mountain. The rainfall that falls between November and March

ranges from 700 to 1200mm at the plains. Rainfall is much higher up in the mountain. Phalombe District was once part of Mulanje District, hence its people have many things in common. Like in Mulanje, the main ethnic groups are Lomwe, Yao and Nyanja. Similarly, the most dominant tribe is the Lomwe followed by Nyanja and Yao. Despite Lomwe being the majority tribe, Chinyanja is the most commonly used language. Chilomwe and Chiyao are the other dominant languages with Chichewa and English also being spoken.

Phalombe population growth rate together with that of Mulanje are among the lowest in the country. The intercensal growth rate for 1987 to 1998 was recorded at 0.5% for Phalombe and 0.2% for Mulanje; this can be compared to a growth rate of 3.7% for the Southern Region and a national rate of 2%. The low rates were attributed to migration of Mozambican refugees back to their country at the end of a civil war in that country. According to the 1998 Population and Housing Census, Phalombe has an 88% sex ratio. The average density for the district is 166 persons per square km.

2.2 Governance Systems

Malawi's population is 80 percent rural (MGDS, 2005). Recognizing this fact, Government put a lot of emphasis on local governance structures when developing national development and good governance policies. The objective is to devolve central government powers, functions and resources to district level through local assemblies. This approach is enshrined in the Decentralisation Policy of 1998 and is backed by the 1998 Local Government Act. As a result, both Phalombe and Mulanje follow the local government structures where the District Assembly, set up as a statutory body, possesses executive powers at district level. The local assembly is mandated to pass by-laws; raise funds to enable it carry out its functions, and maintain peace and security. The Assembly is also mandated to mobilize resources for the district development. It also makes plans for the social economic development of the district.

The District Assemblies have two structures: political structure and the Secretariat. The political structure is composed of councilors, Members of Parliament (MPs), Traditional Authorities and interest groups such as NGOs, youth groups and women groups. This structure is chaired by a councilor. However, in recent years, the present government has operated without councilors, largely because of technicalities involved to elect them as well as lack of financial resources. Their absence has in part affected the long term conceptualization of decentralization and district development activities. There seems to be duplication on the role of councilors and

Members of Parliament. The former represents wards and development activities are funded through district development fund, the latter represents a constituency which receives funding through parliament. As a result, Government has continued to fund constituents and chose village headmen to carry out some development activities. Consequently, such development activities have not been equitably distributed.

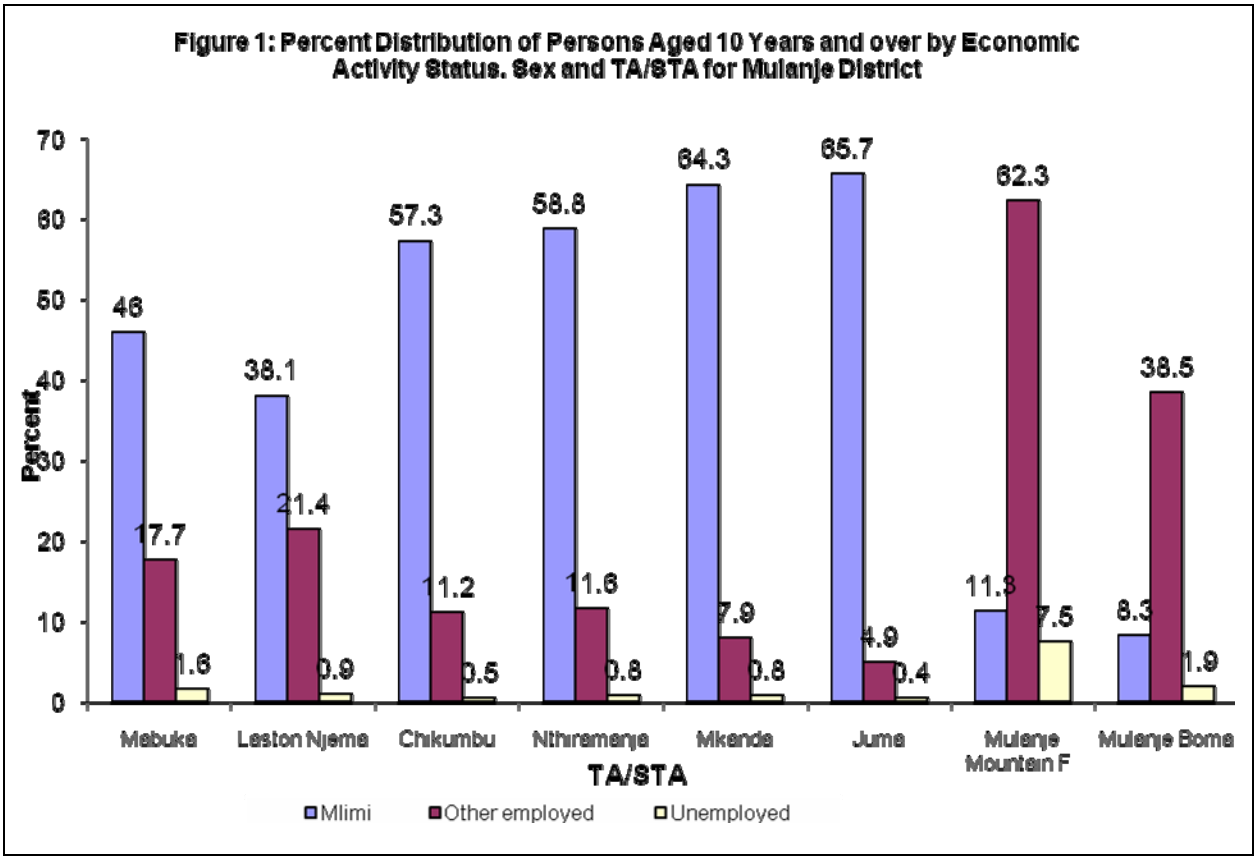
The Secretariat is composed of Government employees. The District Commissioner is the head of the Secretariat. Administratively, he is assisted by Directors of the Assembly's departments. Directly under the Assembly is the District Executive Committee (DEC). DEC is the technical advisory body to the District Assembly. It is composed of heads of Government line ministries, statutory corporations and NGOs operational in each district.

At Traditional Authority level there are Area Development Committees (ADC). The ADCs are composed of the Traditional Authority, ward councillors, heads of religious groups, youth groups, women groups and business representatives from the area. The ADCs are chaired by a councillor. They are responsible for mobilising community resources and determining the type of development appropriate for the area. Technical input to the ADCs' programmes is provided by the Area Executive Committees (AEC). The AECs are composed of government and non-governmental organizations extension workers operating in the area.

At the base of the districts' governance systems there are Village Development Committees (VDC). Ideally, each village is supposed to have its own VDC; however, some villages are small such that for practical purposes a number of villages are pooled together to form one VDC. There are 79 VDCs (546 villages in total) in Mulanje, each having an average of 7 villages. Similarly, Phalombe has 46 VDCs (445 villages in total) which corresponds to an averages of 10 villages per VDC. The VDC is composed of one elected person, four elected women and one from each sex of the youth from each member village. The VDCs, with assistance from the AECs carry out Village Action Planning (VAP). The VAP provides a platform for grassroots participation in needs identification and project formulation. In this way, the Village Action Plans form the basis on which the District Development Plan is developed. The District Development Plan has a three year cycle.

2.3 Economic Sector

Households in Mulanje and Phalombe are very fortunate in having a number of different income-earning opportunities. Most households obtain income from activities such as growing of crops, fishing, selling groceries and petty trading, and wages from employment, albeit employment (from tea estates) playing a more significant role in Mulanje (Figure 1).



About 69% of the households are engaged in subsistence farming. Major crops among smallholder farmers are maize, rice, sorghum, groundnuts, cassava and sweet potatoes. The tea industry employs between 10-18% of the adult (over 15 years) Mulanje population concentrated on the 10 percent of the arable land of the district. Thus about 40% of the district population can be said to be directly benefiting from the tea industry. Some 8,280 smallholder farmers were engaged in tea growing. This makes tea a backbone of Mulanje's economy; providing cash income and creating demand for goods.

Fishing is also a primary activity of the people in Phalombe. While Mulanje relies only on pond farming (487 ponds), capturing an average of five tons a year, Phalombe boasts of Lake Chilwa and Mpoto Lagoon as natural water bodies for fishing. According to the District Fisheries Office,

between January and June 2008, Phalombe registered 293.76 tons of fish landings from the two natural water bodies. Matemba(*Barbus paludinosus*), Mlamba (*Clarias gariepius*) and Makumba (*Oreochromis shirana chilwae*) are the fish species that are commercially harvested from the two water bodies. In addition to harvesting fish from natural water bodies, Phalombe also practices fish farming. In 2007/08 season there were 167 fish farmers who harvested close to two tons of fish. (Mulanje and Phalombe DFO, 2008)

Livestock farming, except for poultry, is not a major farming practice in the districts of Phalombe and Mulanje. Of the five major livestock of the country, Mulanje and Phalombe make the following contributions; cattle 1.9% and 1.2%; goats 4.6% and 2.8%; poultry 9.2 and 7.0%; pigs 2.1% and not available; and sheep 0.04% and 0.08% respectively. (Mulanje DVO, 2008)

The micro and small enterprise livelihood system is dominated by petty trading, established wholesalers, retailers and hospitality enterprises. The sector has been boosted by the availability of loans and grants from micro-financing institutions and government programmes. Of note are Highly Indebted Poor Country (HIPC) resources, Malawi Rural Development Fund (MARDEF) resources, Agricultural Production and Investment Project (APIP) and One Village One Product (OVOP) as Government programmes and Pride Malawi, FINCA, Malawi Rural Finance Company (MRFC) and Savings and Credit Cooperative (SACCO) as micro-financing organizations. These are complimented by commercial banks, National Bank, NBS Bank and MSB Bank. The reduced interest rates, within the commercial banks sector, have made borrowing for businesses feasible.

Employment in Mulanje district is dominated by agriculture, especially the tea industry. According to SEP (2007), trading, tea estates and agriculture absorb about 69% of the total labour force in Mulanje followed by casual employment that takes up 18%, Figure 2 shows casual labour working in a tea estate. Government employees comprise 6.6% of the labour force. Besides the tea industry, Mulanje also boasts of a fruit processing factory owned by Dairiboard, the Mulanje Canning Factory that also offers employment. On the other hand, Phalombe does not have as many employment opportunities as Mulanje. Most of its manpower migrates to the Central and Northern Regions of the country to farm in tobacco estates. Of those that remain in the district, 80% are employed in the agriculture sector while 9.5% are engaged in petty trading and provision of other services. Professional and technical services

take up 8.1% with the rest engaged in various other occupations (Phalombe SEP, 2006). Thus livelihood figures in Phalombe more accurately mirror the national livelihood systems.

Figure 2: Tea Harvesting, Mulanje

Mining, to a small extent, is another economic activity in both Phalombe and Mulanje. Though MetChem Canada Inc. (1993) reported that Mt Mulanje has 25.6 million tons of bauxite reserves (30% Al_2O_3 cut-off), no major mining activity takes place in the two districts. Small-scale quarry aggregate mining is the dominant mining activity followed by ceramic mining. The quarry mining is used in the construction industry whereas ceramic mining is for pottery products, notable of which is the production of chitetezo mbaula liners and cooking pots.

2.4 Health Sector

According to the Integrated Household Survey of 2004/5 provided by the National Statistical Office, 68.6% of the population in Mulanje and Phalombe lives on less than $1 a day (NSO,2005) and the health indicators remain among the poorest in the region (see Table 2.4a). For instance, for every 100,000 live births, 1,120 mothers die due to limited access to quality reproductive and health services, infant mortality and child mortality are estimated at 76 and

133, respectively per 1000 live births (MGDS, 2005). The poor health indicators are attributed to limited access to health services and malnutrition. Though Government is making efforts to bring about improved health, it faces a number of challenges like inadequate health personnel, HIV/AIDS, inadequate drugs, to cite just a few.

In Malawi, inadequate health personnel has been caused by high attrition due to deaths caused by HIV/AIDS, tuberculosis, malaria, acute respiratory infections, among others, and migration to other countries in search of better working conditions. Most districts of the country have population of more than 100,000 yet they usually have only one physician. Another challenge is the inadequate supply of essential drugs due to budgetary constraints, which is compounded by pilferage. In general, the health infrastructures or facilities (buildings, equipment, water and electricity) are inadequate in quantity and very poor in quality.

The HIV/AIDS prevalence rate among adults (15-49 years) is 14.4% (NAC,2004 estimates) and HIV/AIDS-related conditions are estimated to account for more than 40% of all inpatient admissions (GoM,2002). The national HIV/AIDS prevalence rate is estimated at 8.4% (MGDS, 2005), the prevalence rate for Phalombe is at 8.53%, which is within that of the country, while the prevalence rate for Mulanje at 20% is by far much higher. The good thing, however, is that the 20 percent is an improvement on a prevalence of 25% recorded in 2001 (MDHS, 2004). Life expectancy has recently fallen to 36.3 years, mainly as a result of the HIV/AIDS epidemic, Tuberclosis (TB), once on the decline has also been increasing, with 70% of the TB patients also testing HIV positive. Malaria, pneumonia, diarrhoea, food deficiency syndrome and trauma are the most common health problems among infants in the districts. The current causes of maternal deaths in both Phalombe and Mulanje are infection, loss of blood, obstructed labour, anaemia and malaria.

The health infrastructure consists of dispensaries and clinics; health centres and district and central hospitals. There are few health facilities in both districts. The Ministry of Health and Population, through the District Assembly operates one district hospital in Mulanje, 16 health centres and dispensaries. The Christian Health Association of Malawi (CHAM) operates one hospital and three health centres. The two hospitals have five medical doctors between them. Thus with an estimated population of 539,573, Mulanje is within the national average of one physician per 100,000 persons.

In addition to the 21 centres, there are a number of private clinics in the district; notable are clinics at tea estates, Banja La Mtsogolo Clinic and Machado Private Clinic. For more serious injuries or illnesses people are referred to the referral hospital, located in Blantyre. However, financial accessibility to services is also a big problem, especially at CHAM and private facilities, where user fees are charged. The poor spend about 7.4-10% of their annual income on healthcare.

Phalombe, with an estimated population of 231,448, has one CHAM hospital, 12 Health Centres, one dispensary and 66 outreach clinics. The hospital has one medical doctor. Health personnel in the districts are supported by student nurses that are at two nursing schools, one each at the two CHAM hospitals.

The hospitals provide full Essential Health Package (EHP) in order to combat health problems in the districts. The EHP includes provision of the following services: (1)control and management of vaccine preventable diseases; (2) malaria prevention and treatment;(3) reproductive health services (Family Planning, Safe Motherhood and PMTCT), (4) prevention and treatment of tuberculosis and its complications; (5) prevention and treatment of acute respiratory infections and their complications, (6) prevention and treatment of acute diarrhoea diseases, cholera inclusive, (7) prevention and treatment of sexually transmitted infections and HIV/AIDS (Including ART, testing and counseling); (8) prevention and treatment of malnutrition, nutrition deficiencies and their effects, (9) prevention and treatment of eye, ear and skin infections (10) prevention and treatment of common injuries and related complications

For EHP to be implemented, a facility requires the following: (1) Essential Laboratory Services, (2) Drug Management; (3) Information, Education and Communication; (4) Training (Human Development); (5) Planning, Budgeting and Management systems; and (5) Monitoring and Evaluation systems. Thus in Mulanje, only the District hospital and the Mulanje Mission Hospital are equipped to offer the EHP while in Phalombe, only the Holy Family Hospital offers the services.

2.5 Agriculture Sector

As Malawi has lower mineral resources, agriculture is the backbone of its economy and thus people depend on agriculture for their livelihood in terms of food and cash. It provides 37% of the Gross Domestic Product (GDP), contributes over 90% of the foreign exchange and employs

about 85% of the population (Malawi Statistical Year Book, 1985). The main food crop in Malawi is maize supplemented by cassava, sorghum, millet, pulses, rice, vegetables and fruits. Tobacco is the largest cash crop, followed by tea, sugar, and cotton. Mulanje alongside Thyolo and Nkhata Bay are the main tea growing districts of the country.

The country's agricultural sector is characterized by a dualistic structure – a high input – high productivity estate sector and a low input – low productivity smallholder sector. The estate sector comprises a small number of large-scale farmers, occupying about 60% of the fertile land and producing entirely for the market. The smallholder sector comprises a very large number of smallholder farmers growing mainly food crops for their own consumption. Some 55% of smallholders own an average size of less than 0.5 hectares; more than 75% cultivate less than one hectare of land. This is barely enough land on which to produce enough food to support a family of five to six people even with purchased inputs (MGDP, 2005).

In Mulanje and Phalombe, the majority of the population is smallholder farmers, having an average land holding is 0.6 hectares. Major crops grown in both districts include: maize, peas, sorghum, cassava, sweet potatoes and rice. Of the 137,546 hectares of arable land available for smallholder farming in Mulanje, maize is grown on 37% of it while pigeon peas cover 22% and sorghum takes up 7.4%. In Phalombe the situation is more typical of the situation in Malawi, with maize taking up 76.4%, sorghum 13.8% and cow peas 8.6% of the 63,887 hectares of arable land respectively.

Though the ratio of agricultural extension workers to farmers is low, 1:2123 for Phalombe and 1:4595 for Mulanje against a recommended ratio of 1:750 (Phalombe SEP, 2006), a number of programmes aimed at improving agricultural productivity are in place in both districts. Agricultural productivity improvement programmes include use of organic and inorganic fertilizers, use of improved varieties, soil and water conservation methods and irrigation. Livestock farming, except for poultry, is not a major farming practice in the districts of Phalombe and Mulanje. Of the five major livestock of the country, Mulanje and Phalombe make the following contributions; cattle 1.9% and 1.2%; goats 4.6% and 2.8%; poultry 9.2 and 7.0%; pigs 2.1% and not available; and sheep 0.04% and 0.08% respectively. (Mulanje DVO, 2008). In Phalombe, chickens are about 89% of the livestock population while in Mulanje they are 80%. Other livestock include rabbits, guinea fowls, turkey ducks and doves.

2.7 Education Sector

Improvement and relevance of education system in Malawi faces and continues to face a number of challenges. Some decisions which have been taken in the past, have negatively affected the quality and relevance of the education being provided. The declaration of Free Primary Education Policy in 1994, the conversion of Distance Education Centre's (DECs) into secondary schools and the use of untrained and under qualified teachers has affected the quality of education at both primary and secondary levels.

The relevance of the education has further been negatively affected by lack of timely review and reform of the school curriculum consistent with the new national needs and aspirations. The unwarranted addition of irrelevant subjects to the old curriculum and the removal of relevant subjects such as technical, vocational and entrepreneurship education subjects has not helped matters. Other factors compromising education quality and relevance include: backward cultural attitudes of education for girls, inadequate infrastructure (including for people with special needs), internal inefficiencies such as high absenteeism, repetition and dropout rates, and also lack of school inspection or ineffective supervision and monitoring. These have rendered the system to be inefficient. The completion pass rates and transitional rates from one class to the next and from one level to the next are very low.

In order to reverse the deteriorating education standards, the education sector has identified three priority goals. These are to equip students, especially at the basic education level with basic knowledge and skills that would enable them function as competent and productive citizens in a free society; to provide the academic basis for gainful employment in the informal, private and public sectors; and to produce high quality professionals with relevant knowledge and skills in relevant fields.

According to results of the Integrated Household Survey (2005), education indicators for Phalombe are worse than those of the Southern Region and the country, while those for Mulanje compare well with those of the country. 52.7% of the population aged 5 years or older are able to read and write at least one particular language. The literacy rate for males is estimated at 61.8% and for females 44.8%. Literacy rate at the Boma is higher than other areas, averaging 73.4%. Similarly, in Phalombe, 52% of the population (aged 5 years or older) is able to read and write. The literacy rate for males is 61.4% and for females 43.8%. A summary of the

percentage distribution of persons aged 5years or older and the highest level of education attained in both districts is shown in Figures 3 and 4.

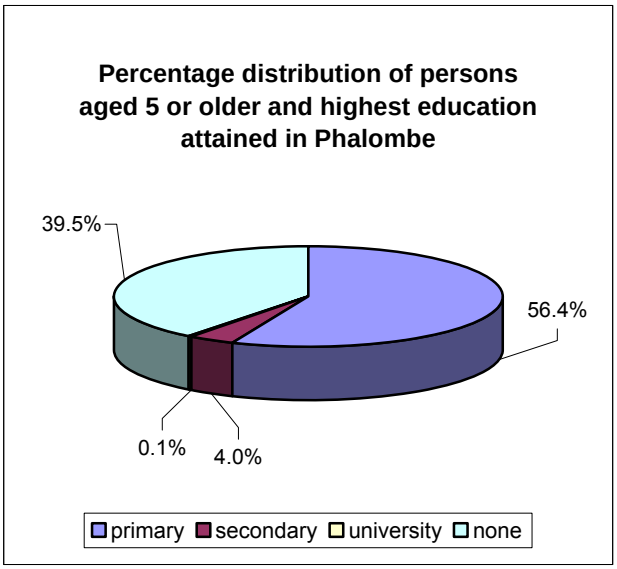


Figure 3. Percentage distribution of persons aged 5 or older and highest education attained in Phalombe

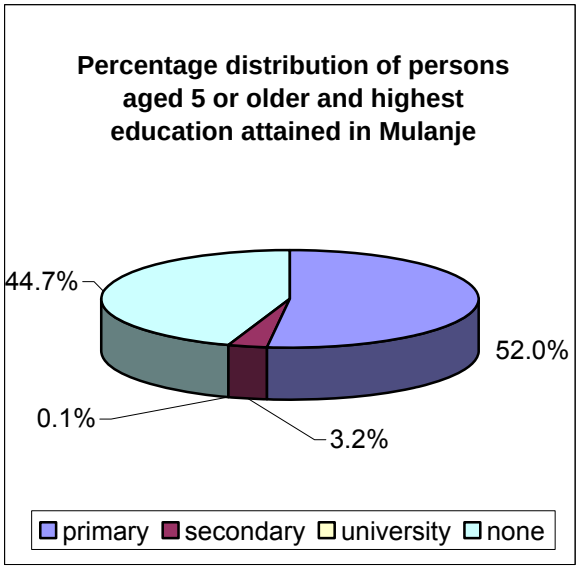


Figure 4. Percentage distribution of persons aged 5 or older and highest education attained in Mulanje

Education enrolment for Malawi is 80%, which for the Southern Region is 76.8%, for Mulanje and Phalombe is 81.8% and 68% respectively. Dropout rate is equally bad for Phalombe. The dropout rate is 5.1% for Malawi and 5.3% for the Southern Region; for Mulanje it is 4%, yet for Phalombe it is 7.3%. To improve the situation and guided by the national strategies and policy framework, both Phalombe and Mulanje Districts have their District Education Plans that are modeled on the National Policy and Investment Framework (PIF), National Education Sector Plan (NESP) and the Malawi Growth and Development Strategy (MGDS).

The education infrastructure consists of primary and secondary schools, classrooms and teacher houses. Mulanje District has 150 primary schools, 146 of which are run by the Ministry of Education, Science and Technology, and the rest are registered private primary schools, managed by the tea estates, the Muslim Association of Malawi and a private individual. There are 27 public and 10 private secondary schools. Total enrolment is 119,881 pupils (59,424 or 49.6% are girls) and 7018 students (42.7% being girls) for primary and secondary schools, respectively. The district has 1227 primary school teachers, 1157 classrooms (128 being temporary), and 550 teachers' houses. It has 282 secondary school teachers, 105 teachers' houses and 137 classrooms. The overall teacher-pupil ratio is 1:98 and 1:30 for primary and secondary schools, respectively. This does not compare with the recommended teacher –pupil

ratio of 1:60 in all primary schools (MoEST, 2001 cited in Mulanje SEP,2007). This indicates a great shortage of teachers. The number of classrooms is not adequate to accommodate all enrolled pupils.

Phalombe District has 83 primary schools, 2 conventional and 11 community day secondary schools. Total enrolment is 70,433 pupils (35,291 are girls) and 2523 students (1023 being girls) for primary and secondary schools, respectively. The district has 656 primary schools teachers, 783 classrooms (155 being temporary), and 404 teachers' houses. It has 105 secondary school teachers, 77 of them are unqualified. The overall teacher-pupil ratio is 1:112 and 1:30 for primary and secondary schools, respectively.

Phalombe explicitly states in its Vision that by 2020 it shall have adequate qualified teachers who will be properly and regularly supervised, have permanent structures, adequate instructional materials, and minimal dropout rate amongst girls and marginalized groups; improved attendance and sound community participation. With such aspirations, the districts expect to increase primary school enrolment from the current 79992 (Phalombe) and 119,881 (Mulanje), improve the teacher to pupil ratio from the current 1:134 (Phalombe) and 1:98 (Mulanje) to the recommended 1:60 in primary schools.

While the link between energy and education is quite clear, this is less apparent in the district development plans being implemented in Mulanje and Phalombe. The significant role played by modern forms of energy, electricity in particular, is not well recognised. There is a dearth of information that demonstrates that providing electricity for lighting would improve the quality of education, since children would have more time available for study after sunset. Sufficient light and fans for comfort would also improve the quality of that study time. Access to television would strengthen their knowledge base and this in turn increases the appetite for learning. In addition, parents would devote more time in assisting children's education compared to before electricity. Consequently, this would improve the overall literacy rate of the two districts.

2.8 Transport Sector

Malawi is a landlocked country. Its transport infrastructure is inadequate. The inadequacy of the transportation infrastructure results in high costs of production, where transportation represents 55% of costs, compared to 17% in other less developed countries. Poor roads access mainly results from the deteriorating condition of the country's overall road network, especially in the

rural areas. This problem is compounded by the enormous backlog for maintenance of the road infrastructure, unsafe and impassable road network, (37% is in poor condition), lack of competition due to restrictions on foreign operators for road transport, taxes on vehicles and equipment increases the cost of trucking and poor logistic chains. This has led to high domestic road transport costs. Poor quality of feeder roads also impacts the ability of rural areas to engage in economic activities.

Despite this being the case on the national level, Mulanje boasts of one of the best road networks in the country. The district is serviced by two major roads, the Limbe-Muloza via Thyolo Highway and the Robert Mugabe Highway. Soon the district shall be connected to Zomba through the Zomba-Jali-Mulanje Highway. The road network has meant easy transport for agricultural produce, spearheaded by tea. The transport network has also heralded the transportation of other products such as the revered Mulanje Cedar and charcoal to markets in Blantyre to the detriment of Mulanje's ecosystem. The road network story for Phalombe is different. Phalombe is waiting for the completion of the Zomba-Jali-Mulanje Highway in order for it to see a tarmac road. However, prospects look good with the road construction going on as per plan and the newly launched Chiradzulu-Chiringa road promises to open up the district even more.

2.9 Household energy demand and supply; policy and plans

As in most districts in Malawi, people in Mulanje and Phalombe rely heavily on traditional energy resources, as no significant deposits of fossil fuels are available. Households in these districts use the lowest commercial energy (around 30 kWh per capita per year). The total energy consumption in Mulanje for the year 2006 was estimated to be 3.12 million Giga-Joules or 75,552 ton of oil equivalents (toe). The share of modern fuels (electricity and paraffin) was 1,740 toe[2] (2.3%), while total biomass consumed was 72,694 toe (97.5%). Electricity only provided 0.26% of the total energy consumption. Given that data on energy use in the agriculture and transport sectors is unavailable; this figure should be taken as conservative estimates. More rigorous analysis of the energy demand and supply is beyond the scope of this study, but would be required to be undertaken.

The sufficient, reliable and sustainable production and supply of affordable energy throughout Malawi is the main objective of the Government's policy in the energy sector (MEM, 2003). The

[2] Tonne of oil equivalent

general policy is to provide the energy services based on a diversified supply of energy sources. More specifically, government intends to facilitate the economic growth through the provision of adequate, reliable and sustainable energy as well as improving the living standards of the population through the provision of affordable energy.

As part of achieving the above objectives, the Government in 2006 launched a four-year project "Promotion of Alternative Energy Sources Project" (PAESP). The project's objectives are to significantly increase the country's reliance on non-traditional fuels, for cooking and heating, thereby improving the state of the country's environment; to promote the utilization of the various market ready viable alternative energy sources (AES); and to substitute firewood and charcoal as preferred fuels for cooking and heating with the overall objective of reducing deforestation. Through PAESP Government intends to promote, among other alternative fuels, biomass briquettes and ethanol based fuels that include biogas, gel-fuel and super-blue 80-nol.

As outputs, PAESP envisages to annually deliver the following: market 500 million biomass briquettes in towns and cities; promote the use of efficient firewood stoves at institutional and household levels; promote the use of coal at household level; promote use of gas based fuels where 6000 new 6kgs LPG cylinders are rolled out, 200 biogas plants are constructed and rehabilitated throughout the country; 30 million litres of paraffin is marketed; 10 million litres of gel fuel, 10 million litres of ethanol and 12 million litres superblu-80nol are marketed as household fuels.

All the efforts in PAESP also extend to Mulanje and Phalombe. Through the Public-Private Partnership (PPP) initiatives, entrepreneurs in both Phalombe and Mulanje can be assisted to participate in this programme. Through this initiative, Government is supporting PROBEC and Ken Steel efforts in disseminating the 'chitetezo' and 'rocket' stoves in Mulanje/Phalombe and elsewhere in the country.

Additionally, the Department of Energy Affairs is now implementing phase five of the rural electrification project guided by the master plan developed with technical and financial support from the Japanese Government. This master plan has been developed to serve as a roadmap to prepare action plans for achieving the national target of 30% electrification by 2020. A total of 249 trading centres are expected to be connected to the national grid, by the year 2020. Fifty

two trading centres, including Namphungo (Mulanje), Nkhulambe and Phaloni (Phalombe), Kambenje and Chambe rural growth centres will be electrified in each phase.

2.10 Household health, sanitation and livelihoods; policy and plans

Household health as an important factor in addressing poverty is one key theme recognized in the Malawi Poverty Reduction Strategy Paper (2004). It is recognized that the health of an individual is directly related to economic and social well-being. The paper notes that livelihoods improvements cannot be secured without addressing health and sanitation. The loss of household labour due to poor health and the need to cover the cost of treatment are undoubtedly, two major causes of households slipping into poverty.

Additionally, energy use by rural people is associated with a variety of safety risks and detrimental effects on people's health. In Malawi awareness of the indoor air pollution problem seems to be almost completely lacking, even at strategic level. Unfortunately, there are no specific policies and plans that address these issues. However, government is implementing an 'essential care package' in both Mulanje and Phalombe Districts. The key areas for preventative health care are nutrition, water and sanitation, and prevention of common diseases such as malaria.

Energy related health issues for Phalombe and Mulanje are both indoor and outdoor. Due to lack of direction and favourable policies, the population is ignorantly subjected to pollution levels that are detrimental to their health. Energy related indoor air pollution is mainly a result of burning biomass fuels for cooking and heating. The threat from extended exposure to burning of biomass is posed by carbon monoxide (CO). It is renowned for causing dizziness, headaches and visual aberrations on light doses and instant death on higher concentrations. However, this threat is only critical when cooking is done in poorly ventilated kitchens. Another problem related to biomass fuels is that of exposure to smoke. Extended smoke inhalation leads to headaches, nausea, eye irritation and chest pains.

Outdoor energy related health issues for Mulanje and Phalombe include air pollution resulting from bushfires, automobile exhausts, tea factory exhausts and dust particulates from the road construction currently underway in the two districts and tea dust in areas surrounding tea factories. Bush fires on the Mulanje Mountain pollute the air through smoke emissions in addition to causing tree destruction that eventually affects carbon sequestration. Efforts by

Mulanje Mountain Conservation Trust, the Department of Forestry and other stakeholders have seen a decrease in the bushfires on the Mountain.

Automobile and tea factory exhausts add concentrations of carbon dioxide (CO_2), carbon monoxide (CO) and sulfur dioxide (SO_2). Carbon dioxide is a greenhouse gas that is, to a large extent, responsible for climate change. Sulfur dioxide is largely a result of burning of fossil fuels. It has a suffocating odour at concentrations greater than 3ppM (Henrichs & Kleinbach, 2002). Sulfur dioxide inhalation can result in damage of the upper respiratory tract, damage to lung tissue and aggravation of lung diseases. Dust particulates are a mainly pronounced in environments next to dusty road sides. The construction of the Zomba-Phalombe-Mulanje road has resulted into heavy road construction machinery loosening up the gravel road surfaces hence increasing the emission of dust each time a vehicle passes by. The construction of detour roads whose surfaces are loose have not helped matters. Tea dust is another source of particulate pollution. Particulates affect breathing, aggravate existing cardiovascular disease and sometimes damage the body's immune system.

The causes of outdoor pollution as listed above were observed in Mulanje albeit on low concentrations, save for the dust particulates. This assertion, however, is not a result of measurements taken; but rather a conclusion derived from observations. There is no office in the two districts that is monitoring air quality levels. It is, therefore, recommended that such a responsibility be placed in the office of the District Environmental Officer. At a higher level, policies should be put in place that where road construction of the scale of the Zomba-Phalombe-Mulanje road are taking place, the detour roads should either be frequently watered or surfaced by a temporal binder such as molasses. As for tea dust particulates, the factories should be encouraged to put in place good occupational health and safety practices and the responsible officers at District Labour Office encouraged to undertake regular inspection.

2.11 Local environmental concerns, policy and plans

Malawi is a party to United Nations Framework Convention to Climate Change (UNFCCC) and therefore has reporting obligations to the Convention on climate change levels of greenhouse gas emissions and sinks, vulnerability and adaptation options. UNFCCC's main goal is to stabilize greenhouse gases (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with climate.

The Local Government Act of 1998 empowers District Assemblies to be making district development plans. Among the plans to be developed is the District Environmental Action Plan (DEAP). The DEAPs are developed in a way that environmental issues are looked at holistically in order to effectively deal with all environmental problems. Both Mulanje and Phalombe have their DEAP albeit at six years the Plan for Mulanje needs to be revised.

There are seven main environmental issues in the Mulanje-Phalombe areas. The areas are, not in order of importance, land degradation where issues of soil erosion and loss of fertility are a concern; environmental education and public awareness; encroachment in protected areas that has led to deforestation and extinction and/or endangerment of some flora and fauna, notable of which is the Mulanje Cedar. Near townships encroachment has led to unplanned settlements. Water pollution is another environmental concern especially when considering bauxite mining on Mulanje Mountain and waste disposal in general. In addition, degradation of aquatic environment has led to lowering of fish production and biodiversity. Another environmental concern for the area, especially Phalombe is the infestation of water hyacinth. Incidences of forest fires and wanton cutting of trees on MMFR are also a major concern though now lowering due to concerted efforts of stakeholders and MMCT.

3.0 ENERGY RESOURCES AND POTENTIAL IN THE DISTRICT

Major energy resources consist of biomass, hydroelectricity and petroleum products. Biomass used as fuel wood and charcoal is the dominant household energy source in Mulanje and Phalombe Districts, accounting for over 98.3% and 82.1%, respectively, of the primary energy consumption (IHS, 2005). The districts have significant potential for hydroelectricity, but currently this remains mostly untapped. Other commercial forms of energy are not known to exist in any significant amounts.

3.1 Wind Energy

Wind is created primarily by global temperature fluctuations and thermal interactions between land, sea, and air. Wind energy systems convert the power of moving air into electricity or mechanical power. Aerodynamic forces act on the rotor to convert the linear motion of the wind stream into the rotational motion needed to turn an electrical generator or windmill. According to Betz, the maximum possible power theoretically obtainable is 59.3% of the total energy. In practice an overall efficiency of 40% is assumed. The maximum power output (P) is given by the relation:

$$P = 2.83 \times 10^{-4} D^2 V^3 \quad [kW]$$

where D is the blade diameter in metres; V is the wind velocity in metres per second.

The cubic dependence of wind power on wind speed implies that energy output, and consequently the economics of a wind turbine installation, is highly sensitive to wind speed. It is therefore essential to have detailed knowledge of the wind and its characteristics, if the performance of wind turbines is to be estimated accurately. The parameters of the wind energy that need to be known are mean wind speed, directional data and velocity variations periodically, daily/monthly/yearly, and height of the anemometer.

Mulanje and Phalombe do not have good wind regime, though the study found potential power available in places of mountains. Table 3.1 depicts the generally low wind profile observed at Mimosa (in Mulanje) as well as Fort Lister and Naminjiwa (in Phalombe). The average wind speed, measured at 2 m is 1.1 m/s and 1.2 m/s for Mulanje and Phalombe, respectively. This is far lower than 6-8 m/s optimized for lower wind speed European conditions. As a result, wind speeds for the two districts had been assessed to be low and inadequate for power generation.

This study attempted to find a range of turbine designs suitable for most sites in Mulanje and Phalombe, taking into account wind speed, wind shear, turbulence, and terrain effects. The data collected at the measured height (2 m) were extrapolated to 10, 30 and 50 metre heights above the ground using the power law to estimate wind speeds at these various heights. The estimated velocities were then used to quantify approximately how much power could be harnessed at higher rotor heights. All the sites were found to be unsuitable for both water pumping applications as well as electricity generation. Hence, the installation of small remote area wind turbines is unlikely to make a significant contribution to energy supply needs in the two districts. However, if wind is to be considered, site specific wind regime analysis needs to be conducted. There is a possibility that in the plains and valleys wind speeds could be of levels that can be harnessed.

3.2 Solar Energy

Solar energy presents substantial potentials to provide a significant portion of future energy needs for people of Mulanje and Phalombe Districts. The districts are generally endowed with solar energy receiving an average daily solar radiation of 4.25-6.86 kWh/m^2 (15.3–24.7 MJ/m^2), and a corresponding annual sunshine duration of 2596 hours. Maximum radiation is available in the months of September- December and minimum in March-July. The Malawi Meteorological Department have measured time series of global radiation, direct or beam radiation, diffuse radiation, sunshine hours and temperatures of different parts of the district. Monthly global solar insolation and daily average bright sunshine hours for Mimosa in Mulanje district and Naminjiwa in Phalombe district are presented in Tables 3.2 and 3.3. Solar energy has already made substantial (but unquantified) contribution to the energy supply in Mulanje and Phalombe. Applications include traditional activities such as sun drying of crops, fuel wood, fish and clothes. There are already approximately 147 Stand alone solar systems installed in the two districts (Milner et al., 2005). However, a proper database on solar energy, required for analysis and planning, has not been established.

3.2.1 Solar Photovoltaic (PV) Electricity Generation

Photovoltaic systems providing electricity for lighting, refrigeration and telecommunication networks are not common in some parts of the two districts. A recent study (Milner et al. 2005) found that about 77 and 58 systems were installed in Mulanje and Phalombe Districts, respectively. Solar installations are done by certified companies, located in the main cities of Blantyre, Lilongwe, Zomba and Mzuzu. This brings overhead costs for solar installations since

the companies have to travel long distances to install and maintain the systems. There is also limited capability in Mulanje and Phalombe for research and development for the absorption of sophisticated solar technologies, especially in the case of PV cells.

The potential of photovoltaic energy was estimated using the data of solar radiation intensity at two sites, Mimosa and Naminjiwa. The electricity production using a 1 kW solar battery was estimated as listed in Table 3.2.1a. Using the intensity of solar radiation I , electricity production per month was calculated using equation (1).

$$E = eD = \frac{PI}{Po} k_1 D$$

where e is the electricity production per day, D is the number of days per month, P is the solar battery capacity, Po is the standard solar radiation (1 kWh/m^2), and k_1 is the loss coefficient of the solar battery. The solar battery capacity[3] P applied was 1 kW. The loss coefficient was chosen as 0.69 (Shimizu,1999). As can be seen from Table 3.2.1b, the electricity production per year was 1382 and 1132.1 kWh at Mimosa and Naminjiwa, respectively. Taking these two values as representative for Mulanje and Phalombe respectively, the potential energy was estimated as shown in Table 3.2.1b. It was assumed that each family builds a 100 ampere-hour [4](1.2 kWh) solar battery on the house.

3.2.2 Solar thermal energy

Solar water heaters, solar cookers, solar dryers and even simple glass windows all allow solar energy to be trapped and used to heat water, air, food and even industrial processes. The solar water heater and cooker have not achieved wide adoption in perhaps the most important potential market, low and medium income households for domestic cooking and water heating. Milner et al. (2005) estimated that approximately 58 and 54 solar water heaters of unknown

[3] Battery Capacity is a measure of a battery's ability to store or deliver electrical energy. Commonly expressed in units of ampere-hours. Design features that affect battery capacity include: the quantity of active material, the number, design and physical dimensions of the plates, and the electrolyte specific gravity. Operational factors affecting battery capacity include: the discharge rate, depth of discharge, cut off voltage, temperature, age and cycle history of the battery. Sometimes a battery's energy storage capacity is expressed in kWh, which can be approximated by multiplying the rated capacity in ampere -hours by the nominal battery voltage and dividing the product by 1000. For example, a nominal 12Volt, 100 ampere-hour battery has an energy storage capacity of (12 x 100)/1000 = 1.2kWh

[4] Ampere-hour (Ah) is the common unit of measure for a battery's electrical storage capacity, obtained by integrating the discharge current in amperes over a specific time period. It is equal to the transfer of one-ampere over one hour, equal to 3600 coulombs of charge. For example, a battery which delivers 5 Amps for 20 hours is said to have delivered 100 ampere-hours.

collector sizes have been installed in Phalombe and Mulanje, respectively. The number of units of solar dryers and solar cookers in these two districts is also unknown.

The potential of solar thermal energy was estimated using the data of solar radiation intensity at two sites, Naminjiwa and Fort Lister. The collected thermal energy using a 1 m^2 solar panel was estimated as listed in Table 3.2.2a. Using the intensity of solar radiation I, the collected thermal energy per month Q was calculated using equation (2).

$$Q = 3.6qD = 3.6I k_2 D$$

where q is the collected thermal energy per day, D is the number of days per month and k_2 is the loss coefficient of the solar system. The loss coefficient was chosen as 0.4 (www.solarsystemkyokai.or.jp). As can be seen from Table 3.2.2b, the collected amounts of thermal energy of a 1 m^2 collector per year were 2156 and 4814 MJ/m^2 at Naminjiwa and Fort Lister, respectively.[5] Taking these two values as representative for Mulanje and Phalombe, the potential of solar thermal energy was estimated as shown in Table 3.2.2c. It was assumed that each family builds a 2 m^2 solar panel on the house, and each institution (boarding school and health centre) installs an 18 m^2-solar panel on the building.

3.3 Biomass

The principal biomass resources in Mulanje and Phalombe include wood fuel, agricultural residues, animal wastes, and charcoal. The two districts have an abundant supply of biomass resources, which could be a potentially significant source of energy. Some resources are already being exploited for energy, but considerable amounts are still treated as waste, and remain untapped. The other area that requires consideration is the competition the biomass poses between use as energy source and manure for agricultural produce.

3.3.1 Agricultural residues

Agriculture is an important part of the economy in Mulanje and Phalombe Districts. Approximate land use for agriculture is 67% and forests are 25% of total land area of the Mulanje District. For Phalombe, 51% of land is for agriculture and forests cover 6.8% of the total land in the district. Besides the crops themselves, large quantities of residues are generated every year. Maize, cassava, rice, pigeon peas and sorghum are just a few examples of crops that generate

[5] Note: 1300 MJ/m^2/year = 1 kWh/m^2/day

considerable amount of residues. These residues constitute a major part of the total annual production of biomass residues and are an important source of energy for household as well as industrial applications. The main household applications are cooking and water heating. The production of some major crops and their residues in 2007 is presented in table 3.3.1.

Average figures for energy from biomass production were estimated throughout the two districts over a five year period. Crop yield data for major crops were taken from the District Agriculture Offices. The data reflecting the ratio of residues to yield for each crop were consolidated from several sources. The energy content of biomass residue was estimated from the data of crop-to-residue ratio, moisture content, and the heating value of residue of the selected agricultural products. Table 3.3.1b shows the energy content of the biomass residue.

3.3.2 Wood and wood wastes

Firewood and charcoal are the primary energy source of about 98.3% of people in both urban and rural areas of Mulanje and Phalombe Districts (IHS, 2005). Total average annual wood fuel and charcoal consumption in Mulanje is 95,000 tons and 3,800 tons, respectively. Compared to wood fuel, the consumption of charcoal is lower. The low consumption can be attribution to the burning of charcoal being illegal and the need for acquiring of conversion equipment (cookstoves) before use. Thus most of the charcoal produced is mainly for income generation realized through sales to semi-urban areas as well as City of Blantyre. According to Department of Forestry, total revenue from forest product sales amounted to MK4.5m in 2005.

The theoretical potential of wood and wood waste energy was estimated using statistical data collected from the forestry offices in the study districts. There is 55,607 ha (out of which 2700 ha is for tea estates) and 11,805.5 ha of forest area in Mulanje and Phalombe Districts, respectively. The mean annual increment is $2m^3$/ha for miombo (Hecht, 2006), $15m^3$/ha (pine), and 30 m^3/ha (eucalyptus) [FORINDECO, 2000]. This means wood production for Mulanje is 834,075 m^3 (500,445 tons) per year or 5,004 TJ (under 60% moisture content and an energy content of 10GJ/ton). In Phalombe, the wood production is 177,082.5 m^3 (106,249.5 tons) per year or 1062 TJ. These figures represent upper level which cannot be completely utilized for several reasons including environmental ones.

The accessible wood energy potential is calculated based on harvesting wood resources from sustainable plantation areas. According to Mulanje District Forestry Office, the standing volumes

for pine, eucalyptus and Mulanje cedar is estimated at 330,000 m^3 (2245ha), 802,000 m^3 (2850ha), and 115,398 m^3 (845.3 ha), respectively (Makungwa, 2004; Osieno et al, 1994; FORINDECO, 2000). Plantation forests, mainly pine and eucalyptus, account for 13% of total forest area. Indigenous forests, representing 7,077 ha (Mulanje) and 300 ha (Phalombe) of production forests, have great potential for value added products such as veneer, plywood and quality furniture (Mulanje SEP, 2007). Phalombe has 1826 ha of forest plantations, of which 451.5 ha is pine trees and 422.82 ha is eucalyptus (Phalombe SEP, 2006). The calculated energy potential from wood and wood products is presented in Table 3.2.2. The gross annual biomass energy production potential for Mulanje and Phalombe is 2,399 TJ and 198.43 TJ, respectively.

However, it has to be mentioned that when considering potential contributions from biomass, it is critical to distinguish between resources that are used sustainably and those that are not. For example, in almost all rural areas of the country, biomass is the most important source of energy for cooking and water heating, with more than 99% of households using wood for cooking. However, while the supply/demand balance is reasonable in some areas, the wood is being used faster than it grows in other areas, with significant environmental and socio-economic consequences. Given that biomass data is based on projections from household and industrial surveys with small samples, details on the percentage of biomass energy that derives from sustainable resources are currently impossible to establish.

3.3.3 Animal dung

Animal dung is an important biomass energy, which could be used as raw material for biogas production. Cattle, pigs, goats, sheep and chickens are the main livestock in Mulanje and Phalombe. The District Veterinary Office in Mulanje estimates the total livestock populations of cattle, pigs, goats, sheep and chickens for both districts as 1.3 million heads (2006 estimates). The total dung produced annually was calculated by multiplication of the animal dung production per year and the number of heads of different animals taking the average of the lower and higher dung yield. Figures used in calculating the dung yield were those provided by Gate (1989).[6] The number of different livestock heads and their annual production of residues are presented in Table 3.3.3.

[6] Yields can only be achieved if animals are in stables all the time, for night only, half the figures should be adopted

The biogas production from livestock in the two districts has potential to meet energy requirements of 17,000 households in Mulanje and Phalombe. The challenge, however, is that most of the animals are on free range, thus most of the dung is lost. In addition, the animals are sparsely populated, such that only isolated places have a realistic potential for harvesting. Another challenge is that the designs of kholas in use are not suited for optimum dung harvesting. Hence only cattle owners can be said to have a realistic potential to harness biogas. Thus considering cattle owners and the fact that most of the cattle is in stables at night only, the feasible potential for biogas in the two districts drops to 2,131,500m^3 (46,040 GJ) per year. This is enough biogas to meet annual energy requirements of 4,300 households. It can, therefore be recommended that biogas be carefully targeted. Cattle owners with more than six heads of cattle would be ideal targets when promoting the biogas technology.

3.3.4 Municipal solid wastes

Total numbers of semi-urban centers in Phalombe and Mulanje are one and two, respectively. The major sources of municipal solid wastes are households, commercial areas, industries, and hospitals. At present around 3000 and 19000 of the Phalombe's and Mulanje's people live in urban areas (IHS, 2005). In the fiscal year of 2006-2007, it was reported that 22 manufacturing industries were running in Mulanje. Almost all are in urban areas. Among them, about 20 industries are producing energy-based organic solid wastes which are categorized in Table 3.3.4. There is one factory in Mulanje District producing canned products while the other one produces fizzy drinks. Besides, Mulanje district has two hospitals, The Mulanje District Hospital that has 300 beds and Mulanje Mission Hospital that has 182 beds. Both hospitals are around the Boma[7]. On the other hand, Phalombe has one private hospital (belonging to the Archdiocese Health Board) with 223 beds.

According to World Bank study; the rural population generates only 0.15 kg per capita per day of human waste, while their urban counterparts generate 0.4 -0.5 kg per capita per day. Using the population data and waste production averages to calculate the quantity of daily municipal wastes production results in a resource estimate of 6336 tons/year, on an as-received basis. Had all this waste been available for conversion to biogas, 427,680 m^3 (9,238 GJ) of gas would be produced per year. This gas would be adequate to meet energy needs of about 1000 households. However, municipal wastes at both Mulanje and Phalombe are not collected by the Assemblies; instead they are disposed of individually. The disposal system is, therefore not

[7] Local name for district head quarters

conducive to processing of the waste for energy purposes. The exception could be in hospitals and schools. Despite the potential in these establishments, cultural beliefs and general mindset may not favour the exploitation of human waste for energy purposes.

3.4 Micro hydropower

Hydropower or hydro energy depends ultimately on the natural evaporation of water by solar energy. The evaporated water precipitates at high elevations and is stored as potential energy in water reservoirs, before it runs off in streams and rivers towards lower elevations as kinetic energy. Energy resource is specific to each site location and the merit of developing the site will depend on the head and flow conditions, engineering issues, consentability, cost of generation, and the distance to load centres.

The topography of Mulanje and Phalombe areas has quite some potential for the use of hydropower. The slopes of Mulanje and Michesi Mountains provide high head while high rainfall rates at elevated altitudes provide significant water flow. The average annual rainfall of Mulanje as a whole is 1600 mm, reaching 2849mm at elevated altitudes, compared to a world average of 860 mm. Surface run off is the main water source in the district, notwithstanding the fact that on average only about 9% of the rainfall reaches the rivers. The mean annual run off of Mulanje Rivers is estimated at 51.63 m^3/s (NRWP, 1986). The rivers being cited are Likhubula, Thuchila, Likulezi, Phalombe, Sombani, Nandiwo, Muloza, Lichenya and Ruo. Because of the variability and evaporation losses only about 66% of the mean annual run off can be exploited economically with present methods. It has been estimated that the maximum theoretical potential for Mulanje and Phalombe is 104GWh per annum. Owing to the high run-off variability from year to year, limited reservoir storage sites, losses by spillage during floods, the uneconomical scale of some sites, among other reasons, a more conservative estimate of the realizable hydro potential would be nearer to 15% of the maximum theoretical potential; thus the realizable potential is estimated at 15.6 GWh per annum. Details parameters of potential sites are presented in Table 3.4.

Lujeri Tea Estates are already exploiting some of the hydro potential of the Mulanje Mountain. The Estates are generating 840kW through exploitation of Ruo and Lujeri rivers hydro potential. Much more can be achieved by exploring other rivers especially in areas far from the national grid.

3.5 National Grid

The estimated maximum theoretical hydro-potential for Malawi is about 1600 MW or 6000 GWh per annum, out of which only 56% (900 MW) is potentially available for development. Hydropower utilization is currently one third of the proven potential. The total installed hydroelectric capacity is 285 MW (DoEA, 2006). About 7MW of this installed capacity is supplied to Mulanje District. This power has been made available to 170 000 consumers throughout the country. Mulanje alone has 2337 customers the large of which are the tea factories, while Phalombe has 404. The national grid represents the overall hydroelectric industry of Malawi as it accounts for over 90% of the capacity and 99% of the energy supplied. Apart from the national grid, the private sector manages isolated supply systems. At present there are two small/ mini hydroelectric plants in operation in the country.

3.6 Petroleum

Preliminary exploration studies have been made in Malawi, but so far no proven reserves of petroleum suitable for commercial exploitation have been found. Thus nearly all (97%) petroleum products (diesel, petrol, paraffin, LPG, jet-A1 and avgas) consumed is imported in refined form for direct consumption. The remaining 3% is met by ethanol, produced locally and blended (20:80 ratio) with petrol (MEP, 2004). Annual demand for petroleum products is about 258.5 mega litres. In 2004, the country spent about USD75,940 million on importation of petroleum products that is about 10% of the country's foreign currency earning (NSO,2006). The total annual cost for paraffin imports is around MWK862.92 million (USD 5.95 million) for 22.026 mega litres. Reliable data on consumption of these fuels in the two districts were not made available to this study. In addition, the alternative fossil fuels, natural gas and coal, have not also been discovered as yet in the two districts.

4.0 HOUSEHOLD ENERGY SITUATION

4.1 Household energy sources

A number of domestic energy sources that are commonly used in other parts of Malawi were found to be present amongst the sampled households. The most prominent of these included firewood, paraffin, candles and charcoal.

4.1.1 Paraffin

Paraffin is the major alternative energy to biofuels in the rural areas of Mulanje and Phalombe. The survey revealed that 99.5% of the sampled households, from all income groups use it. 92.5% of the households commonly use paraffin for lighting purposes.

4.1.2 Candles

Candles were used in 10.8% of the sampled households. With illumination representing the sole function for candles. An analysis of end-uses was rendered unnecessary. However, given the unpredictable nature of incomes in these villages, households are forced to purchase single candles at a significantly higher cost, as opposed to packets, that could afford some benefit from economies of scale. Households used on average three candles a month, with the highest and lowest recorded usage being 12 and one respectively. It is clear from the average consumption that not all households use candles every night.

4.1.3 Firewood

All of the sampled households (800) use wood for fuel. Looking at the multiple end-uses of firewood, the survey established that 100% of the households use firewood for their cooking requirements. Seven hundred sixty households (95%) claimed to use firewood for heating water, while 15(less than 1%) households use firewood for baking and beer brewing. However, it is important to note that from the true dynamics of firewood consumption, the likelihood of multiple end-use scenarios is employed.

Firewood is freely available in rural settlements across much of Mulanje and Phalombe. Traditionally, it is the responsibility of women and children to collect firewood for the household. The sight of middle-aged men collecting wood is not a common one, and this explains why some households resorted to paying others to collect or transport wood on their behalf. The

average distance traveled and round – trip time taken to collect firewood varies from less than one kilometre to ten kilometres, the average being two to five kilometres. A study conducted in Malawi by Culler et al. (1990), found that the closest source of fuel wood was an average of 5.4 km away, with a range of 4 km to 24 km especially for communities living around the tea estates; Figure 4.1 shows a typical village firewood bundle for a house near tea estates. The study further showed that the average number of trips per week was 2.5. The three main firewood sources established by the survey are, market, natural forests and own woodlots.

Figure 4.1: Typical Village Firewood Bundle

4.1.4 Charcoal

Use of charcoal is uncommon in rural areas. Of the sample of 800 households, 27 (3.4%) use charcoal for fuel. It is mainly used by households in the semi-urban areas as a cleaner source of energy to firewood. Charcoal is produced by communities around indigenous forest reserves. According to the Forest Act, this charcoal is harvested from unsustainable resources, and therefore considered illegal. This reason coupled with the need for acquiring a cookstove in order to effectively use charcoal may explain the low utilization of charcoal in rural households.

4.1.5 Dry-cells and Car Batteries

Approximately 33% of households incorporate dry cells into the household energy budget. Over 90% of these households use dry cells to operate radios. Most households acquire dry-cells from groceries and trading centers in and around their villages. Fifty-eight of the sampled households (7.2%) use car batteries in fulfilling certain domestic energy requirements. The majority of these households (70%) use car batteries for operating Hi-fi's and radios while less than 1% use them for domestic lighting and charging cellular-phone batteries. Most of these households recharge their batteries in the main trading centres that are connected to the national grid.

4.2 Energy costs

Average monthly income includes income from employment, incoming remittances and farm produce sales and petty trading sales. The survey established that the mean rural household income is K2637.71 per month, but ranges from MK200.00 to MK10, 000.00. The enumerators, almost invariably, reported that the response on household income might not be realistic, as people were reluctant to tell the true income, especially their farm incomes. This observation is commonly reported in similar surveys throughout the world.

The average expense per rural household for energy is K327.37 per month. As a comparison, the average monthly income in rural Malawi is K4166.67 per household and the average expenditure on energy is K1022.51 per household. Thus the survey indicates an energy expenditure of 12.4% against a national average of 24.5%. It is tempting to assign the low energy expenditure to inaccuracies in monetary information provision; however the fact that most rural people collect much of their energy resource (wood) free also comes into play.

4.3 Water and fuel availability

Domestic water is often the highest development priority in the rural areas of Phalombe and Mulanje. In many areas the average consumption of water is of the order of 10-20 litres per person per day. This can be compared to the World Health Organisation's recommended daily minimum of 50 litres per person per day. Energy is often required to meet domestic water needs. The following water supply systems are found in the district: (1) protected sources; (2) groundwater extraction by means of hand pumps on boreholes; (3) local water supply systems (gravity fed schemes) ; and (4) centralized water supply schemes. According to statistics, there

are 1,036 boreholes, nine gravity fed schemes (1235 taps serving 52,680 people) in Mulanje District. In addition, Southern Region Water Board provides water to; 900 households, 70 institutions, 81 commercial premises, 27 community water points-with a total population of 9,400. Phalombe District has six gravity-fed schemes (1157 taps); 552 boreholes, and 49 shallow wells.

The energy requirement for water-pumping varies considerably. At present human energy contributes significantly to domestic water provision in rural areas, as the use of hand pumps is common in many areas and water generally has to be fetched at considerable distances (approximately, 2.5 km) along steep slopes. There is need in both districts, to equip boreholes or other sources with either wind mills, diesel pumps, electric pumps, even solar/hybrid systems.

4.4 Per capita energy consumption at household level

According to the survey findings, most rural households in Mulanje and Phalombe rely on traditional fuels. Table 4.4 shows the aggregated result of the household energy consumption survey by fuel types per capita. Consumption level of firewood for domestic purposes is influenced by an interaction of many factors such as: availability, climatic conditions, cooking habits and end use efficiencies (Taulo, 2007). Based on 2004 estimates, the number of people in Mulanje and Phalombe was 539,753 and 231,448, respectively (IHS, 2005). It is estimated that around 98.3% and 82.1% of the total population are using fuel wood as their main source of domestic energy. About 1 %(Mulanje) and 0.014% (Phalombe) of the households use charcoal for cooking and water heating. The mean fuel wood consumption for routine household energy purposes is determined to be 351 kg and 478 kg per capita for Mulanje and Phalombe, respectively. This does not compare with findings of other studies reported in literature. These studies showed that in rural areas, fuel wood consumption was at the rate of 1.1 m^3 or 0.66 tons per capita per year (Lele and Stone, 1989 cited in Chidamoyo, 1997; MEM, 1997, as cited in Masangano, 1997). Brouwer (1998) found that a rural Malawian family of 4 people, cooking three meals per day would use about 6.3 kg of firewood on average.

The average annual charcoal consumption per family was calculated to be 518.4 kg, at the rate of 1 bag of about 38 kg each per month. Available statistics indicate a national average charcoal consumption of 680 kg per annum per household (MEM, 1987 cited in Matinga, 2003). Family size is estimated at 4 members as such the per capita annual consumption is around 129.6 kg. At the average consumption rate of 129.6 kg per annum per capita, the total amount of charcoal

consumed in Mulanje and Phalombe is estimated at 202 .5 MT (5,328 bags) and 16.7 MT (440 bags). A possible reason for the low consumption is attributed to the low income by the majority of charcoal users and unavailability of affordable and alternative energy sources.

Paraffin consumption is estimated at 1,922 metric tons. The per capita consumption of rural areas varies from 3.5 litres/cap/annum or 1.03 litres per month per household in Mulanje to 4.9 litres/cap/annum in Phalombe. The variation of per capita consumption indicates that there is uneven distribution of paraffin. The expansion and distribution of kerosene to rural areas will certainly improve the standard of living. Therefore, a mechanism should be devised that would improve distribution of paraffin to rural areas.

Access to electricity for both districts is considerably low. Electricity supply is restricted to semi-urban centres with insignificant extension to rural areas. In Mulanje, 2,337 (1.5%) households are electrified while in Phalombe, only 404 (0.44%) households have access to electricity. None of the sampled villages had electricity. The estimated total electricity consumption in 2007 was 288,614 kWh (Mulanje) and 48,366 kWh (Phalombe).The per capita consumption for domestic purposes in Mulanje was calculated to be 30.87 kWh, equivalent to 0.3 kWh/month per household. The monthly electricity consumption per household is 9.9 kWh in Phalombe. These figures are much lower than the national averages. The national mean for electrification level of the population is 7.5%, which translates to 88.4 kWh /cap/year.

4.5 Indoor air pollution situation

Indoor air pollution has been identified by the World Health Organisation as one of the causes of death worldwide. It is a pressing health threat that, at its root, is really an energy problem. Indoor air pollution arises from the combustion of biomass for cooking, water heating and space heating. The biggest pollutant in biomass cooking is carbon monoxide (CO). The air quality standard set for CO levels is a maximum of 9 ppM or 10,000 $\mu g/m^3$ (Henrichs & Kleinbach, 2002). According to Smith et al. (2000), combustion of wood emits 50 times more household pollution than gas stoves. Indoor air pollution is more rampant where cooking takes place in an enclosed kitchen. ProBEC has been promoting improved kitchen management practices. However low technology take-up has left many household still cooking in the open air, Figure 4.2 shows a typical cooking place. Lack of equipment to test household CO levels hindered establishment of the indoor pollution levels for Mulanje and Phalombe. Household air pollution has been associated with a number of health effects which include: respiratory illnesses,

pneumonia, lung cancer, bronchitis and emphysema, weakened immune system, and reduced lung function (WHO, 2002).

The Integrated Household Survey (2005) reported that approximately 98.3% of households in Mulanje use biomass, in the form of wood, charcoal, crop residues and dung for cooking, water heating and space heating. The indoor air pollution situation is similar to that of other parts of the country. Available statistics indicate that pneumonia accounted for 23% of hospital admissions in the first half of 1999. In hospital case fatality rate was up to 26%. There is inadequate capacity to manage several cases of pneumonia in the district due to inadequate skills; poor environment; inadequate drugs; poor data collection, collation, analysis and utilization. Thus the substitution of cleaner fuels for solid fuels used for cooking and heating in Mulanje and Phalombe is essential to poverty and public health issues in rural and some urban areas.

Figure 4.2: Typical Cooking Place, Mulanje 2008

4.6 Analysis of household energy programs in the district

Few government and non-government organizations are already operating in rural development programmes that may involve energy. However, their interaction with the Department of Energy

or with one another is less satisfactory for effective, economic and secured rural energy service delivery. For instance, the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH has since 1996, implemented an improved cook stove programme through the Integrated Food Security Programme (IFSP). The programme has developed and promoted two types of stoves: the portable clay stoves “Chitetezo Mbaula” and the fixed mud stoves. These stoves are made out of locally found materials and used in private households in the rural areas of Mulanje.

The programme also focuses on the promotion of commercial supply and demand systems for efficient biomass-using technologies for two other groups: social institutions and small and medium enterprises. According to statistics, between October 2004 and December 2007, four commercial stove producers produced 4200 Rocket Stoves for institutional kitchens. Tea estates constructed 66 large scale Rocket stoves.

The programme not only focuses on the production, marketing and use of fuel-saving stoves, but also the application of health-protecting and energy-saving related techniques when using the improved stoves. Further to this, it also envisages other advantages for the local population, such as income and employment-generating effects, the acquisition of new skills and knowledge, improved working conditions and health status of the cooks, the preservation of forest cover, including the protection of water, flora and fauna and maintaining biodiversity.

However, the drive to conserve wood fuel is confronted with one obstacle, that of scale. The input made by the programme (information dissemination and production of stoves) is negligible. The result is that the impact of the programmes’ efforts is limited to very small segments of the population in the rural areas of the districts. Yet the fuel problem spans the whole districts, with the most dissipating effects in the rural areas. In turn, the problem of scale is caused by inadequate finance, inadequate material support, and to some extent, by poor organization and limited coordination between GTZ and other institutions.

5.0 POLICIES, BUDGETING AND PLANNING

5.1 Poverty Alleviation and other development policies and strategies at District level

The overriding objective of Malawi's developmental effort is poverty alleviation. The Malawi Growth and Development Strategy (MGDS) focuses on achieving remarkable and sustainable reduction in the poverty level in Malawi from 65% of the population in 2006 to 57% by 2011. However, it is worth mentioning that the prevailing policy documents affect accessibility of individuals and communities to natural resources. Both national and international policies affect the quality of people's livelihood. For the MGDS to be effective there is need for national policies to respond to and satisfy the basic human needs. Moreover, when embarking on District Development Planning a careful consideration of national policies and strategies has to be applied as a guidance and framework for future development steps in line with the nation's goals and ambitions. Some of the most important sectoral national policies influencing District Planning are listed in the subsequent subsections.

5.2 Current development policies

5.2.1 Malawi Vision 2020

In the late 1990s Malawi developed Vision 2020 which was launched in 2000. This set out a long-term development perspective. It emphasizes long term strategic thinking, shared vision and visionary leadership, participation by the population, strategic management and national learning[8]. The Vision 2020 states that "by the year 2020 Malawi as a God fearing nation, will be secure, democratically mature, environmentally sustainable, self-reliant with equal opportunities and active participation by all, having social services, vibrant cultural and religious values and a technologically driven middle-income economy". The fundamentals of the MGDS are based on the shared Vision 2020 and commitment of Malawians to improve their economic welfare.

5.2.2 Malawi Growth and Development Strategy (MGDS)

The Malawi Growth and Development Strategy has been formulated by the Malawi Government. It is not an alternative to the past development policies but rather encompasses and builds on the goals and objectives of the long-term country policy formulated in the *Malawi Vision 2020* as well as the medium-term development strategies of the *Malawi Poverty*

[8] Vision 2020 conceptual framework.

Reduction Strategy (MPRS) and the *Malawi Economic Growth Strategy (MEGS).* The MGDS is the overarching operational medium-term strategy for Malawi for a period of five years starting from 2006/07 to 2011/12.

The overall objective of the MGDS is to make life better for all Malawians by reducing poverty through sustained economic growth and infrastructural development. The new approach of this policy is to transform the country from being a predominantly importing and consuming economy to a predominantly manufacturing and exporting country. The policy's emphasis of stimulating economic growth has to be addressed especially to the rural areas in order to integrate the rural masses of subsistence and small scale farmers and businesses into the economic market system leading to growth dynamics in all sectors of the economy.

Additionally, the scarce commodity *land* in a densely populated country like Malawi makes it necessary to transform this policy into an imperative and immediately needed solution for development. The six priority areas of the current MGDS are: (1) Agriculture and Food Security; (2) Irrigation and Water Development; (3) Transport and Communications Infrastructure; (4) Energy generation and supply; (5) Integrated Rural Development; and (6) Management and Prevention of Nutrition Disorders, HIV and AIDS.

These six key priority areas are also expected to accelerate the attainment of the Millennium Development Goals (MDGs) in the areas of health, education, gender, environment and governance. As an impact to the priority area of integrated rural development, the creation of *Rural Growth Centres* is part of this concept and needs to be addressed at district development planning concepts. The objective is to re-distribute wealth to all citizens while also mitigating the negative consequences of rural-urban migration. Emphasis will be placed on infrastructure development such as roads and communications, energy supply, agro-processing and manufacturing. This is envisaged to promote private sector investment that will create employment and improve incomes of the rural people.

The five thematic areas of the MGDS are: (1) Sustainable Economic Growth; (2) Social protection; (3) Social Development; (4) Infrastructure Development; and (6) Improved Governance.

5.2.3 Decentralisation Policy and Local Government Act (1998)

In 1998 Malawi Government approved the National Decentralisation Policy and the Local Government Act. The Decentralisation Policy aims to devolve political and administrative powers and responsibilities to the District Assemblies. It seeks to improve the delivery of services to local people, to strengthen local democracy, to mobilize the masses for socio-economic development at the local level and to promote good governance. The participatory local community approach aims to achieve a more people and needs based planning and development articulation and implementation for the respective local environment.

The Local Government Act (1998) seeks to empower local communities through the lower structures to take part in decision making, resource mobilization, implementation and monitoring of development interventions. It is hinged upon democratic principles, accountability and transparency in carrying out development work.

5.2.4 Environmental Policy and Act

The Government in compliance to the agenda 21 also developed and instituted a National Environmental Policy (NEP) which emphasizes empowering local communities in management of their own natural resources.

The Environmental Policy, among other things, seeks to:

- Promote sustainable use and management of natural resources;
- Facilitate the restoration and maintenance of essential ecosystem and ecological process;
- Enhance public awareness of the importance of sound environmental management, and ;
- Promote co-operation between government, local communities, Non-Governmental Organizations, private sector and the religious community in the sustainable use and management of natural resources and environment.

5.2.5 Forestry Policy

Malawi Government adopted a new Forestry Policy in 1996 followed by an Act in 1997. Both legislations reflect requirements for involvement of boundary communities to take an active role in natural resources management. The Department of Forestry deals mainly with downstream activities of forestry. The downstream activities are geared towards care of a tree from nursery up to harvest time. The policy permits charcoal making only from sustainable sources. It has made a commitment to issue license for charcoal production. Unfortunately this has never been

implemented as no license has ever been issued, hence all the charcoal being produced in the country is illegal. As a result the government is losing millions of money which it would have used towards the attainment of the MGDS.

The other constraint is that the illegal charcoal making is resulting into deforestation which leads into soil erosion. Soil erosion on the other hand results into siltation of rivers, notable of which is the Shire River. Since River Shire is the major source of hydro power in the country, the result is low production levels of electricity. With low production levels of electricity there is low economic development thereby affecting the attainment of MGDS.

5.2.6 The National Land Policy

The National Land Policy was adopted in 2002 and focuses on land as a basic resource common to all people of Malawi. The policy provides opportunities for the people of Malawi to embark on a path of socially and environmentally sustainable development. In addition, the policy highlights a number of approaches for addressing problems facing land resources. The policy recognizes several sectoral policies and strategies in physical planning, fisheries, and environment.

5.2.7 Malawi Energy Policy

The Malawi Energy Policy (MEP) presents the country's policy goals and objectives for the energy sector in support of its initiatives in poverty reduction and rural transformation. The MEP recognizes that energy infrastructure is capital intensive hence investments require careful planning to balance the needs of the principal energy users and the needs of other social sectors. The MEP finds it essential to provide clear guidelines clarifying the roles of the state and of private players so that energy is efficiently and effectively supplied to all. It takes energy planning as a means of taking cognizance of market liberalization of the private sector and of synergies between energy demand and supply on the one hand, and economic development and the environment on the other. The state has further undertaken to take a defined involvement in energy market so that social, economic, environmental and security concerns are adequately addressed. The GoM through the MEP has undertaken to meet structural, operational and institutional challenges in order to unlock the potential of the country's natural resources.

Though the energy policy guidelines sound good, accessibility to modern energy is still a pipeline to many Malawians. Implementation at the grass roots level is still lagging behind.

5.2.8 Millennium Development Goals

The Millenium Development Goals (MDGs) put forward by the United Nations are development milestones to be achieved in Malawi, but localized to the Malawian context. The strategy recognizes that without economic growth there will be little chance of reducing poverty in the country. Therefore, economic growth is central to achieving the MDGs as it reduces poverty directly and expands availability of resources for improved service delivery. The MGDS recognizes the importance of the MDGs hence the strategies in the MGDS have been aligned to the MDGs outcomes. However, each of the milestones outlined hereunder, requires the usage of energy.

- *Halving extreme poverty*: The goal of the MGDS is to decrease poverty by 8% through a combination of (a) economic growth, economic empowerment and food security so that Malawians are less vulnerable to economic shocks, and (b) measure to protect those who temporarily fall into poverty through measures to increase assets for the poor. The strategy seeks to decrease the fluctuations in poverty by providing economic conditions to help keep those that move out of poverty out and ensure that those who are already out of poverty do not fall back into poverty due to economic shocks. Thus energy for income generation is vital.

- *Halving the number of people living with hunger*: The MGDS seeks to directly decrease the proportion of the population who suffer from hunger and to improve the nutritional status of the population. Cycles of hunger are a factor in people moving into poverty. Food security is one of the key priorities. This will entail the use of energy for agriculture, food processing and irrigation.

- *Achieving universal education*: The MGDS seeks to improve the quality of the educational system at all levels. The provision of energy for lighting, communications and internet is recognised.

- *Promoting gender equality*: The MGDS addresses gender by integrating targeted programs for women to enable women to be part of economic growth (such as targeted programs for business development and micro-finance). The strategy for gender directly targets mainstreaming gender into the programs of government and disaggregates information by gender. The strategy notes that female headed households are more likely to be poor. Energy will contribute to the reduction in the burden of firewood collection and cooking time and indoor air pollution, as well as offer opportunities for education.

- *Reducing child and maternal mortality*: The MGDS addresses child mortality through improved access to the essential health care services (including integrated management of childhood illness plus immunization (e.g., oral dehydration therapy, antibiotics for diarrhoeal disease and acute respiratory infection). In addition, the strategy seeks to increase access to clean water and sanitation, improve the nutritional status of children and ensure food security.

- *Environmental Sustainability:* The MGDS recognizes that managing its natural resources is an essential component of environmental sustainability. Thus, not only does the strategy directly consider environmental sustainability in forestry resources and fisheries and enforcement and education of environmental standards, but also it seeks to identify areas, such as eco-tourism, which have a positive spill over effect on economic sustainability.

- *Access to water:* The MGDS seeks to achieve the MDG of access to clean water and sanitation

5.3 The process of policy development

The approach employed in development of policies is highly consultative and interactive. The consultation process for preparing policies is done in a number of phases. Depending on the type of policy to be developed, the process would begin with internal Government discussions in order to develop a framework for consultations. A multi-disciplinary task force with membership from Government, non-governmental organisations, civil society, and affected groups is formed to lead in the drafting of specific policy process. This task force is supported by expert services of national as well as international consultants. A number of consultative meetings and workshops are held with all stakeholders to seek their input in the strategy. This is done to (a) build consensus among the key stakeholders and thus place ownership of the policy in the public domain so as to improve chances of implementation success; (b) establish synergies and thus avoid conflicts between the respective policy and other policies; and (c) identify policy drivers from the local, national and international environments.

5.4 Planning and Budgeting Process

At district level, output based budgeting is done in accordance with specific pillars of the Malawi Growth and Development Strategy. As per the Local Government Act 1998, each District Assembly is required to prepare a budget that focuses on planning and controlling the use of resources for achieving desired objectives during a defined period. Budgeting for development

projects follows a bottom-up and participatory approach that begins from the Village Development Committee (VDC) level. The community identifies projects and the VDC prepares project proposals including cost estimates. The proposals plus the cost estimates are then submitted to the Area Development Committee (ADC). The ADC assisted by the Area Executive Committee (AEC) will appraise, select and prioritize the proposals for submission to the Development Committee of the District Assembly. The Development Committee with the assistance of the District Advisory Team (DAT) screens the project proposals to see if they fit into the District Development Planning Framework. It refines the proposals and cost estimates by conducting desk and field appraisals. Projects prioritized according to the development objectives of the assembly are submitted to the Ordinary Meeting of the Assembly (OMA) for approval. All approved projects with related budgets are incorporated in the Development Plan of the assembly. The annual development budget will be extracted from the DDP for incorporation in the Annual Estimates of the assembly.

5.5 Role of women in decision making

The relationship between rural energy and gender is quite complicated. The burden of biomass fuel collection is borne by women who, by tradition, are required to meet household energy needs. Women are particularly impacted by the lack of modern and sustainable energy services and growing scarcity of wood fuels, because generally they are the ones who must expend large amounts of time and physical effort to supply fuel for their household and productive needs. This exercise subjects them to health hazards caused by indoor air pollution and difficulties in carrying heavy loads over increasingly long distances, at great risk to their health and safety. There is little time and opportunity for education or income generating activities.

Most government policies recognize the need for increasing women's representation at the decision making levels in the Government, non government and semi-government sectors. Though the gender policy recommends increasing women's participation in the poverty alleviation and income generation related projects, it does not specifically address the important role of women in energy related projects and activities. At the policy level the issues of women have not been addressed properly. Often times, in the name of gender mainstreaming, policy documents spell the term gender and /or women and forget about it completely during the program formulation and/or implementation.

6.0 INSTITUTIONAL ASSESSMENT AT DISTRICT LEVEL

6.1 Government support for national energy projects

In evaluating Government's support for national energy projects, Mulanje has been identified as a case study. Mulanje has a number of institutions operating in the district that support or can support energy programmes. The Government structure has the Ministry of Energy and Mines that houses the Department of Energy. The Department of Energy provides policy guidelines and implements some energy programs on behalf of Government. The energy policy of 2003 links energy to overall poverty reduction strategies. The policy entails Government's deliberate shift towards private sector energy delivery, emphasizing on strengthening decentralized energy service markets, thinking holistically, promoting competition where possible and where necessary and introducing regulation.

In line with the policy, the Government has engaged the private sector through the public-private partnership initiative in operationalising the Promotion of Alternative Energy Sources Programme. Other Government departments, through the guidance of District Assemblies, have taken up energy as a core area in implementing their projects. In Mulanje, the District Assembly approves developmental projects that have an energy component in its design. Projects dealing with construction of clinics and schools are approved if energy needs of staff and clients (patients and pupils) have been considered. In this way, powering of the structures forms part of the project design. The policy, however, is short in that it does not include domestic energy requirements for staff (health workers and teachers) in their considerations.

6.2 Functions/services, roles and responsibilities of institutions at district level

Since energy programmes will be implemented at district level, it is important that it takes the lead in owning the programmes. As a consequence, identification of programmes, implementation supervision and operating management should be left in the hands of the district. In order for the districts to effectively carryout their roles, capacity building at various levels will be required. Village Development Committee level will need community mobilization and leadership skills. Area Development level will need project identification and management skills. The District Executive Committee level will need project management and accounting skills. Basic energy, especially among the available alternatives needs to be known by all levels.

The private sector at district level, in line with public-private partnership initiatives, can take lead in production and servicing of energy based technologies. Production of energy saving stoves, installation and maintenance of solar home systems, wind mills and micro-hydro can, in the medium and long term, be localized to the districts.

6.3 Providers of the required functions/services and their energy capacity needs

Provision of the required functions and services should, in the short term, be open to both national and regional organizations. However, in the medium to long term, sustainability and affordability will be assured if the functions and services are delivered by locally based organizations. Government should endeavor to have district based Energy Officers. The District Energy Officer will provide guidance in ensuring that programmes at district level have adequately incorporated energy issues. Government should extend the regulation of installers now in practice among solar pv installers to other energy source installers such as wind, biogas and micro-hydro.

The private sector should be encouraged to invest in the energy market. The decentralization of the sector as espoused in the Energy Policy of 2003 should be implemented. The private sector should be encouraged, through regulation, to engage well qualified staff to handle various energy sectors as need may arise. Wherever possible, Government should extend training opportunities to the relevant private organizations in the energy sector.

6.4 Possible role of Practical Action and partners in provision of energy services

Practical Action and partners, in the short-term are expected to mobilize resources that would open up the district staff to the need for including energy in development issues. They should also spearhead an awareness campaign of the existing energy options through organization of open days and/or study tours for stakeholders. Practical Action and partners should also identify resources for the installation of pilot/demonstration plants of various alternative energy resources. The pilot/demonstration plants should serve communities either by powering schools, clinics or community centres. Practical Action can also move the Malawi Bureau of Standards to develop standards in the energy sectors where Malawi does not have operating standards.

6.5 Availability and possible role of other development agencies

Currently, Mulanje, Phalombe and other districts do not have locally based organizations that can provide a package of all the necessary services to run a comprehensive district based energy programme. However, with ProBEC, commercial banks, Kensteel, Oxfam, the District Assembly and MMCT, among other organizations, Mulanje can assemble a strong team from which it can provide most of the sought after services. Government needs to build capacity within the certification section of the Department of Energy so that it can register installers of various energy sources and inspect and certify their work as is the case with solar photovoltaic systems. The Universities of Malawi, Mzuzu and Lilongwe and Malawi Industrial Research and Technology Development Centre can be tasked to develop appropriate technologies for local use. The technologies once developed would form the backbone for local production efforts.

6.6 SWOT Analysis

This SWOT analysis gives a short but concise overview of the strengths, weaknesses, opportunities and threats challenging the energy sector in the two districts. Strengths and weaknesses are characterized as internal factors, whereas opportunities and threats refer to the external factors and developments facing the energy sector.

Strengths

(a) Diversity of energy sources: energy production is currently coming from varied sources. This makes the energy sector less vulnerable than for example, the transport sector, which is almost completely dependent on oil;

(b) An increasing demand for energy services in the two districts arising from population growth.

Weaknesses

(a) Limited indigenous energy resources;

(b) Limited awareness of existing potential energy resources;

(c) A weak legislation and regulatory framework and standards;

Opportunities

(a) Existence of a large population without access to modern energy forms, which presents a potential for untapped modern energy market;

(b) Increased production of domestic resources (primarily wood)

(c) Diversification of energy supply sources

(d) Existence of conducive environment to facilitate empowerment and increased opportunities for private sector participation (e.g. Decentralization Policy[1998] and Local Government Act [1998]; Investment Promotion Act[1991]; Electricity Act [1998]; and general liberalization policies being pursued by the Government of Malawi.

(e) The establishment of Malawi Energy Regulatory Authority

Threats

(a) Doing business as usual – if the current investment in energy resources and infrastructure are not made, the sector will not be able to meeting rising demands.

7.0 CASE STUDY ON PROMOTION OF FIRELESS COOKERS

7.1 Introduction

Information Centre for Food and Fuel program (IFSP) under the German Technical Cooperation (GTZ) is implementing a Program for Biomass Energy Conservation (ProBEC) in the Mulanje Mountain border zone. The program aims at encouraging efficient use and conservation of available fuelwood. The program, among other technologies, introduced a fireless cooker in 2003.

A fireless cooker is an insulated enclosure in which a pot of food that has been brought to boil is placed. The pot is allowed to simmer after the heat source has been removed. In this way, food is cooked even without being paid attention to. Best results are achieved if the pot has a tight fitting lid. The cooking nature of the fireless cooker only allows for cooking of food stuffs that do not need stirring during the cooking process. Thus fireless cookers can be used for the cooking of grains, legumes, cassava, sweet potatoes and simmering of meat. It can also be used as a food warmer or flask.

7.2 Objectives,

The overall objective of the fireless cooker project was to mitigate against the scarcity and the cost of firewood in Mulanje.

7.3 Output targets

The target of the project were women who travel long distances to fetch firewood and those that cannot access legume protein due the high prices of firewood required in their preparation.

7.4 Program

Information about the fireless cooker was widely disseminated through demonstrations and extension campaigns conducted by the Integrated Food Security Project and the Promotion of Biomass Energy Conservation (ProBEC) Programme in Mulanje district.

7.5 Assessment of energy needs and how they were met

An analysis of household energy in the district revealed scarcity of firewood such that women were walking long distances in search of firewood. Furthermore, the prices of firewood were

high. Many households could no longer afford the cost of firewood for preparation of legumes and hard foods due to increasing costs of fuelwood. Such households tended to avoid or reduce consumption of such foods. This affected the quality and quantity of foods consumed as household members were deprived access to readily available protein (legumes) leading to malnutrition of vulnerable groups.

7.6 Lessons learnt (Factors that affected technology adoption)

In 2006 ProBEC engaged Lucy Ndiwo to assess the extent to which the technology had been adopted and is being used in the target areas. The assessment revealed that the overall percentage of households that had adopted the fireless cooker was quite low at 1.1%. The percentage of adopters varied amongst villages with a range of 0.2% for some villages to 6.4 % for Juma Village.

An analysis of strategies used and their impact on adoption revealed the following:

- **Well Articulated Purpose for the Technology**

Juma Village showed a higher percentage of adopters followed by Makina Village. These villages use the technology as one of the mitigation measure for the care of the chronically ill people. These villages reported that the fireless cookers assisted them in keeping food warm for their patients. It was further revealed that the realization of its benefits made these households continue using the technology even if the patients passed away. Households that used pigeon peas and maize stalks as fuel, a sign of difficulties in accessing firewood, embraced the technology. Compared to those that had easy access to firewood, 74% of those that had difficulties in access firewood adopted the technology against 20.5% of those that easy access to firewood.

- **Work with a Community Based Organization**

Juma and Makina Villages worked with a local organization known as Restored Hope Foundation for Rural development (REFORD) that also played a bigger role in advocating the use of these fireless cookers through its home based care programmes.

- **Organized Local Committees**

In villages like Mpondesi, Nguwo, Likhomo, Liwonde, Namphungo and Tambala, the technology was also introduced as a mitigation measure for the care of the chronically ill. However, due to weaknesses of the committees in the villages, there was inadequate farmer-to-farmer

technology transfer. These villages were also renown for low turn up for extension meetings in general consequently missing out on important information.

This survey showed that messages through extension workers had a success rate of 82% against a lowly 15.4% achieved for messages from friends.

- **Recipient targeting**

Age

A study conducted by Kapanda et al. (2003) revealed that young households are more risk takers relative to older adults. Older people may not like an innovation because they are used to their old ways of doing things.

Education

Education had a positive influence on the adoption of the fireless cooker. Households with one or both parents with some formal education accepted the fireless cooker technology more readily.

Marital Status

Ndiwo's survey revealed that married women adopted the fireless cooker technology more readily than unmarried ones. Most of the married women used the food warmers to keep food warm for their husbands and school children since most husbands and school children are often away from home during meal preparation time. Use of the fireless cooker was thought to be a good low cost technology that would help these people eat warm food and save money for buying fuel wood.

Household size

Household size ranged from 4-12. A greater percentage (61.5%) of adopters had small household size (4-6). Households with 10-12 members had the lowest percentage of adopters (10%). The low adoption amongst the bigger household sizes could be attributed to the design of the fireless where a specific pot size can be used. It is possible that the cookers being promoted were of the sizes that were suitable for small households' requirements.

Number of meals

Fifty-one percent of households that prepared three meals per day adopted the technology as compared to 48.7% of those that prepared only one meal per day. Though the difference is insignificant, those that prepare more meals would have a higher need for saving energy.

8.0 CONCLUSIONS AND RECOMMENDATIONS

This study is oriented towards district energy policy formulation and implementation. It seeks to provide data for spearheading research, project identification, planning and implementation covering major aspects of energy resources in Phalombe and Mulanje. From the findings of this report, it is clear that there is overdependence on biomass fuels, especially fuel-wood. The rate, at which the wood is being consumed, however, is not sustainable; consequently posing an environmental threat to the ecosystem of the district. To avert the eventual catastrophe, alternatives to fuel-wood need to be identified and promoted. It is recommended that a household strategy be drawn up, with the aim of increasing the biomass supply by reforestation programmes, fuel substitution and conservation programmes.

The study further recommends that residue fuel of assorted categories be developed as a matter of priority, supported by serious tree planting throughout the two districts. The development of biomass-derived residue fuel requires a costing study to assess the magnitude of capital outlays involved.

Energy resources could play an important role in alleviating the energy needs of a large proportion of households in Mulanje and Phalombe. Findings of this report indicate resource abundance in solar and hydro energy and limited resource in wind and other biomass. Petroleum products such as paraffin are already in use but their availability and conversion systems are limited, hence paraffin is restricted to lighting use only. Other petroleum fuels, especially ethanol based fuels are not known. Electricity is the most sought after alternative technology. Since the communities are already paying for their energy requirements, it may not be difficult for them to pay for their energy bills. It is, therefore, recommended that efforts be made to create awareness of the available alternative energy resources.

The study recommends that preference be given to mini/micro hydro-electric power plants for which the potential is equally sizeable, on account of capital outlay considerations and the desire for decentralized development. The assemblies should encourage and support the application of solar energy devices for use in rural institutions such as schools and health centers. When promoting alternatives, programmes should include the promotion of complete packages, that is the energy resource plus accessories like lights/lamps and cookers. Taking

cognizance of the fact that a changeover in energy resource utilization is a long term effort, promotion of energy efficient conversion systems, some of which are already in place, should be given primary priority. For quick results, efforts should start in areas that have acute energy problems.

During data gathering, it was observed that organizations with interest in energy promotion are working in isolation. Information and resource sharing is very low. This has resulted in other departments whose work would feed into the energy information bank either to relax in their work or not to produce reports at all. A case in point is the Water Department whose information is not current while other departments take what would otherwise be public information as classified. Such an approach defeats the tenets of the Decentralization Policy where planning is to be done at district level. It is, therefore, recommended that each district should have a District Energy Desk Officer. All information on energy for the district should be available at this desk.

Traditionally in Malawi, energy matters have been linked to fuel-wood. It has, therefore been assumed that when energy issues are being tackled, the Forestry Officer has been considered as the central person. Whereas it remains true that the bulk of the energy resource for developing countries remains wood, primarily used for preparing food, such an approach has made other departments ignore energy issues in their plans. The plain truth, however, is that when an agriculture person is thinking about irrigation he/she should also think about the type of energy that would be used in lifting and distributing the water, similarly if an education expert is thinking about building a school he should think about the type and source of energy; the list long, including a medical specialist who would want to know the type of energy for his refrigerators where vaccines will be stored.

The household survey revealed lack of awareness on household energy programs being implemented in the district. As a result the study recommends the following:

- Identify measures to enhance awareness of modern energy and energy conservation in rural as well as urban areas;
- Prepare information brochures on key elements of efficient and cleaner use of biomass resources;
- Conduct information dissemination through local and district workshops and seminars.

The burden of considering and implementing those policy recommendations lies with the Government. However, donor agencies and NGOs have an important role to play. For example, donor agencies could consider funding the following:

- A study on institutional development of district based energy service companies (ESCOs)
- A detailed resource assessment of the two districts is regarded as necessary to assess the status and use of renewable energy resources in Mulanje and Phalombe; so that strategic plans can be drawn up.
- Assess and map existing and potential wind power, hydro, solar and biomass data in Mulanje and Phalombe;

The study recognizes that the formulation of district energy policy could be severely hampered by lack of the information required to develop a textured understanding of energy use as well as lack of relevant experience with regard to the implementation of energy –related strategies in rural areas. A framework for energy planning would need to comprise the following elements: an integrated approach, a systems-oriented and people-centred approach, flexibility and responsiveness; and accountability and participation.

Finally, in the present study, some data are based on a limited field survey carried out in four villages in Mulanje and Phalombe. It is desirable to conduct more comprehensive field surveys for more reliable and general results.

9.0 REFERENCES

Bouvier I (2006). Mount Mulanje Land Cover Time Series Analysis, STTA Draft Report, Community Partnerships for Sustainable Resource Management in Malawi

Brouwer, Hartog, Kamwendo and Heldems (1996). Wood quality and wood preferences in relation to food preparation and diet composition in Central Malawi. Ecology of food and nutrition, 35: 1-13.

Brouwer, I.D., (1998). When households run out of fuel; responses of rural women in Malawi to decreases fuelwood availability, Energia 2(2)

Chidamoyo, E.N.(1997). Wood fuel and deforestation in Africa- a misconceived association. Renewable Energy for Development, 10(2), 1-5. Retrieved July 2008- from http://www.sei.se/red/red9707c.html

Culler, Peterson, and Matenje (1990). The survey of women in agriculture. Ministry of Agriculture, Malawi. Lilongwe

FORINDECO (2000). Second Draft Report on Forest Productivity (Plantations and Mulanje Cedar). Prepared for MMCT by FORINDECO, Flatdal, Norway.

GATE.(1989). Biogas Plants in Animal Husbandry, Vieweg and John Verlagsgesellschaft GmbH, Braunschweig, Germany

Haines A, Kammen D. Sustainable energy and health. Global Change and Human Health 2000;1:85-87.

Hecht J(2006). Valuing the resources of Mulanje Mountain: current and projected use under alternative management scenario, USAID-Malawi Occassional Paper No. 14.

Henrichs R. A. & Kleinbach M. (2002) *Energy: Its Use and the Environment.* Edn 3. Thomson Learning Inc. USA.

http://www.solarsystemkyokai.or.jp

IHS. (2005). Integrated Household Survey 2004-2005. Household Socio-economic characteristics, National Statistical Office, Zomba, Malawi

Lawrence M.J., Osieno A and Chinguwo C.(1994). Mulanje Cedar Inventory. FRIM Report No. 94010, Forestry Research Institute of Malawi. Malawi: Zomba

Makungwa S.D. (2004). Inventory Results of Mulanje Cedar Resources on a Mulanje Mountain. Consultancy Report. University of Malawi, Bunda College of Agriculture.

Malawi Government (1986). National Water Resources Master Plan, Annex 2A, Department of Water, Lilongwe, Malawi

Malawi Government (1987). Malawi Energy Survey, Malawi; Ministry of Energy and Mining. Malawi: Lilongwe

Malawi Government (1996). National Environmental Policy. Ministry of Natural Resources and Environmental Affairs, Malawi: Lilongwe

Malawi Government (2005). Profile of Poverty in Malawi: Poverty Analysis of the Integrated Household Survey, 1998, Table 36

Malawi Government. 2002. Malawi Poverty Reduction Strategy Paper, Lilongwe: Ministry of Finance and Economic Planning

Malawi Government. 2003. Malawi Energy Policy, Lilongwe: Department of Energy Affairs.

Malawi Government. 2006. Promotion of Alternative Energy Sources Project, Project Document, Lilongwe: Department of Energy Affairs

Masangano, C.M.(1997). Practice of selected agro-forestry technology: Farmer perceptions of influential factors. Unpublished doctoral dissertation, Michigan State University, USA

Matinga, M. (2003). Malawi: Implications of Power Sector Reforms in Malawi for Investment and the Poor, AFREPREN

MEM (1997), National Sustainable and Renewable Energy Programme, Ministry of Energy and Mining, Malawi

MetChem Canada Inc. (1993) www.sdnp.org.mw/geosoc-mw

Milner, A. G. (2005). Baseline Inventory/Developmental Impact Survey of PV/Thermal Systems in Malawi, Final Draft Report, Center for Social Research, University of Malawi.

Ministry of Economic Planning and Development (2008) MGDS Annual Review 2006/07 Year

Mulanje District Assembly (2007) Mulanje District Socio-Economic Profile

NSO (1998). Malawi Demographic and Health Survey, National Statistical Office, Zomba, Malawi

Phalombe District assembly, (2006) Phalombe District Socio-Economic Profile

Shimizu Y(1999). Technology for renewable energy utilization.,Power-Sya, Tokyo (1999),p75-76

Taulo, J.L. (2007). A study of Small-scale Hydropower for Rural Electrification In Malawi, MSc thesis, University of Cape Town, South Africa

WHO (2002). The World Health Report 2002-Reducing Risks, Promoting Healthy Life, World Health Organisation

Appendix 1

Terms of Reference for District Energy Policy Research Studies

1.0 Background Information.

Practical Action Southern Africa in partnership with Mulanje Mountain Conservation Trust is implementing an energy programme titled ‘’*Energising the Millennium Development Goals – Setting the Enabling Environment (E-MINDSET) in Southern Africa’’ with funding from* European Commission. The project was launched in January 2007. The project is implemented in Mulanje and Phalombe District specifically in villages close to Mulanje Mountain. In Mulanje, the project shall focus in Ndala and Nande Village Development committees (VDCs). In Phalombe the focus is in Phweremwe and Nkhulambe VDCs.

The project seeks to develop, test and adapt planning toolkits for linking energy planning and MDGs at the local planning unit in Southern Africa. Its specific objectives are to:

a) Develop toolkits and strengthen partners’ capacity in knowledge transfer and linking planning and development
b) Improve communities’ capacity to link energy planning and development
c) Influence energy policy and regulatory framework to reflect and prioritise energy requirements for attaining MDG targets
d) Disseminate tools for linking energy and the MDGs.

Description of the work

The project will work with district planning systems to address the energy planning gap at a sufficiently low level to respond to the needs of the poor. The district level is the first integrating unit in development planning and therefore offers an opportunity to link energy and other sectors more directly. This will be achieved by developing planning toolkits to link energy and development plans for achieving national MDG targets. A toolkit is a teaching, planning or decision making aide in a training package. These toolkits will be tested and applied against prioritised MDGs particularly to encourage integration of energy budgets into other sector budgets, for example health and education. The project will also develop greater awareness on current negative policy loopholes especially on disproportionate allocation of state subsidies to grid extension and petroleum products against alternative technology options for rural communities.

Work Package 2 looks at – Toolkit development and strengthening partners' capacity in knowledge transfer and linking energy planning and development (Partners' Capacity Building): One of the key outputs of Work Package 2 is the understanding of the environmental factors (internal and external) obtaining at the district level, their effect or influence on pro-poor energy service delivery. This study is expected to feed into the preparation of the training modules which are part of Work Package 2 outcomes and to establish the baseline situation for evaluation purposes.

Work package number :	2				
Relative start month [1] :	3				
Participant:	CO	CB	SC x 3		

1 Month 0 being the start of the project.

Objectives of ToR's

To provide baseline information for energy module writers and information for benchmarking the energy situation in each target district and 'clear indications of situation in terms of the planning and budget processes in meeting economic growth, equitability, environmental sustainability, etc'.

Description of Work

TSD will coordinate this activity and will collaboratively work with country partners (SC's) to collect, analyse and document the findings from the districts. The results will be used to prepare the training toolkits and will also form part of the baseline information for the purposes of monitoring and evaluation.

Time Schedule

The missions shall be completed within a period of three weeks starting mid July 2007.. The draft report shall be submitted before 30 July 2007. Practical Action and partners in Malawi, Mozambique, Zambia and Zimbabwe will provide the draft report. The final study report will be consolidated and presented to University of Twente. Delivery of final report is expected by 31 August 2007.

Expected Output

The report on the feasibility study shall be well-structured and clearly written in English not exceeding 20 pages excluding annexes. The table of contents for the report is appended to these ToRs.

The key Topics

1. **More specifically, the study will address the following areas for each district:**
    - Provide district background, including distribution and analysis of poverty in rural areas, development status in the agricultural and livestock sectors, energy demand and supply in the household sector, energy policy and plans for meeting energy needs of the household sector, health and sanitation needs, policies and plans, and local environmental concerns such as deforestation and water quality as well as global environmental concerns such as greenhouse gas emissions

2. **General Demographic and Economic Aspects at District**
    - Population of the wards in the district
    - Livelihood options of families
    - Average household size
    - Direction of migration of people
    - Key economic activities, employment levels, wages,
    - Types of crops, agriculture production systems and yields
    - What is the price of crops produced in the area?
    - Where is the market for crops produced?
    - What are the constraints faced by farmers in getting to the market
    - Financial institutions and systems at district to village level. (e.g. loan and saving clubs)

3. **Education**
    - Literacy levels
    - Schools Enrolment (Primary & Secondary)
    - No and types of Schools and Tertiary Institutions
    - Teacher pupil ratio
    - Constraints for delivery of quality education services

4. Health

- Infant Mortality Rates (per 1000 live births)
- Life Expectancy at birth
- Type, Numbers, Carrying Capacity of Health Institutions in District: Hospitals, Clinics and Other medical centres
- Staffing level and qualifications
- Level of service delivery and key constraints
- Health programmes undertaken
- Key health issues like the most prevalent diseases related to children, mothers related to household energy issues
- Safe water and sanitation coverage: Constraints to better service delivery
- What are the health policies?
- Specify figures for under 5 mortality
- Percentage low birth weight (< 2,500 gm)
- Malnutrition (level of moderate and severe underweight (below minus two standard deviations from median weight for age of reference population), for under 5's
- Malnutrition (level of severe underweight (below minus three standard deviations from median weight for age of reference population), for under 5's
- HIV/AIDS - adult prevalence rate
- Describe the typical role of women and community participation in health
- What awareness is there of linkages between energy use and health issues among low-income households (describe separately awareness for women and men)
- Describe any programmes related to indoor air pollution reduction (low smoke fuels programmes, use of chimneys in low income housing, etc)

5. Energy Use in the District

Traditional and Modern Biomass

- Describe commercial wood supply to households
- Describe the informal wood supply
- Describe the use of agricultural residues in households
- Describe charcoal supply

- Describe fuel availability (agricultural residues in cubic metres solid or toe/yr, wood-processing wastes in cubic metres solid or toe/yr, and firewood in cubic metres solid or toe/yr)
- Direct combustion potential (MW)
- Co-generation potential (MW)
- Biogas potential in households (number of units) and farms
- Biogas installed capacity (number of units)
- Status of biogas for households (animals per family)
- Describe the relevance of modern biomass alternatives to the household energy sector (use, number of households, supply to low-income households, constraints)

Microhydro Potential

- Estimated technical potential (MW, year)
- Installed capacity (MW, year)
- Generation (GWh, year)
- Description of local small hydro programmes (where they are taking place, what their aims are, status)
- Future plans for mini and micro hydro

Solar

- Average solar insolation (peak sun hours per day)
- Mean insolation recordings
- Mean June insolation
- Estimated technical potential of solar PV (MW, year)
- Installed capacity of PV (MW, year)
- Generation of solar PV (GWh, year)
- Description of household level solar PV programmes
- Total number of households with solar PV systems
- Future plans for solar PV
- Relevance of solar PV to household energy sector (descriptive text, use in toe, availability (which regions), supply to low-income households (how is it supplied to/purchased by households), types of systems in use (solar lanterns, solar home systems, battery charging etc.))
- Number of solar cookers in use (number, year)

- Description of household level solar cooker programmes
- Future plans for solar cookers
- Relevance of solar cookers to household energy sector (use in toe and number of households, types, availability (which regions), supply to low-income households (how is it supplied to/purchased by households))
- Give typical solar system prices

Grid Electricity

- Installed capacity (GW, year)
- Generation type (coal, gas, hydro, nuclear) and proportions
- Generation (GWh, year)
- Electricity Imports
- Domestic electricity consumption (GWh)
- Percentage of households with grid electricity

Candles

- Describe supply, use and relevance of candles to the household energy sector
- Describe supply, use and relevance of briquettes to the household energy sector
- Describe supply, use and relevance of gel ethanol fuels to the household energy sector

6. Energy Resources in the District (from the nearest weather station)

- Monthly rainfall pattern from January 2000 to December 2005.
- Temperature profile from January 2000 to December 2005.
- Wind profile from January 2000 to December 2005
- Solar radiation from January 2000 to December 2005
- Potential energy resources and their potential application at household level

7. Energy Capacity Building Needs Assessment for the District

- Of the levels in the district (What training has been delivered on energy, by whom, when and how it has helped the in enhancing service delivery
- What gaps exist in ensuring enhanced energy service delivery in the district
- What training is desired to enhance service delivery?

8. Policies and Institutions at District level

- What policies & plans exist for the alleviation of poverty at District level?
- What institute is in charge of the MDG's at National level, District, Province
- What are the local MDG's strategies and priorities
- What plans exist at district level and what are the processes undertaken to make them, review and update them. Attach the plans if available.
- What are institutes available at district level and their roles and responsibilities
- How is policy formulated at district level and who is involved.
- What are the existing energy and related development policies at district level: eg Rural electrification, MDG strategies, Natural Resource Management, etc.
- how development policy is made with respect to energy policy
- How do decisions to provide infrastructure such as clinics incorporate their "energisation"?
- When clinics, schools are built, is energy a key issue?

9. District Budgeting

- What are the main budget components?
- Is energy a key consideration for budget allocation or it is budgeted separately
- What is the basis of budget allocation?
- What are the monitoring and review tools used?

10. Case Study selection

Get an examples of micro enterprise related programs aimed at contributing to poverty reduction: get case studies of health, education and poverty reduction programs in the last few (5 to 10 years)

- assess the energy component in them (whether it was considered, how it was considered, whether there were resources allocated for including energy services, what type and what were the support plans (e.g. maintenance etc).
- how was energy incorporated?
- What issues were considered?
- Whether it is energy to help productivity- such as powered sewing machines, better lighting, or water pumps for gardens or energy management training for smallscale industries such as brick makers.

Tentative table of contents for the report on the feasibility study

Title page

Acknowledgements

Executive Summary (with key findings and recommendations)

Table of Contents

Abbreviations

1. Introduction and objective, methodology and limitations
2. Background
    - District background
    - Governance System(s)
    - Economic Sector
    - Health Sector
    - Agriculture Sector
    - Education Sector
    - Transport Sector
    - Household energy demand and supply; policy and plans
    - Household health, sanitation and livelihoods; policy and plans
    - Local environmental concerns, policy and plans
    - Safety situation
3. Energy Resources and Potential in the District
    - Assess the energy resources available in the district to include:
    - Solar
    - Biomass
    - MicroHydro
    - National Grid Coverage
    - Wind
    - Conventional sources
4. Household Energy Situation
    - Household energy sources
    - Energy costs
    - Water and fuel availability
    - Per capita energy consumption at household level
    - Indoor air pollution situation
    - Analysis of household energy programs in the district

5. Policies, Budgeting and Planning

- Poverty Alleviation and other development policies and strategies at District level
  - Current development policies
- Strategic plans and their objectives
- How are they reviewed?
- The process of policy development
- Planning and Budgeting Process
- Role of women in decision making

7. Institutional Assessment at District Level

- Evaluate government support for a national energy projects, including an assessment of willingness to support program implementation, particularly among the ministries responsible for Energy, Agriculture, Health, and Finance, Planning and Economic Development.
- Functions/services, roles and responsibilities of institutions at district level
- Providers of the required functions/services and their energy capacity needs
- Possible role of Practical Action and partners in provision of energy services
- Availability and possible role of other development agencies related to: micro-finance, third-party quality assurance, dissemination of health and sanitation information, training for entrepreneurs, manufacture of systems and appliances, management of household level financial incentives, marketing and promotion, agricultural extension for livelihoods programs, partnerships with ongoing development programs sanitation and hygiene.
- SWOT Analysis
- Risk assessment

8. Outline for Case Studies

- Objectives, output targets and program
- Assessment of energy needs and how they were met
- Lessons learnt

9. Conclusions and recommendations

10. References

Annexes:
- ToR
- Itinerary of the mission
- Contact details of visited organisations and individuals
- Data

Appendix 2

Contact details of visited organisations and individuals

1	Moffat Kayembe Mulanje Mountain Conservation Trust Mulanje	15	Mr Chinkhunda Director of Public Works Phalombe
2	Mr Tembo Director of Public Works Mulanje District Assembly	16	Mr Bwanali Monitoring and Evaluation Coordinator World Vision, Phalombe
3	Mr Nyirongo Agriculture Extension Methodologies Officer, Mulanje RDP	17	Ms Maness Zinyemba Evangelical Lutheran Development Services, Phalombe
4	Trywell Khonje Monitoring and Evaluation Officer ProBEC Malawi	18	Mr Moyo Crops Officer Phalombe RDP
5	Mr MM Jamu District Community Development Officer Mulanje District Assembly	19	Mr Kamdonyo Director of Meteorological Services Blantyre
6	Mr Mendulo Officer in Charge ESCOM- Mulanje	20	Mr Jimmy Mkandawire National Statistical Office Zomba
7	Mr L Kadzitche Tea Research Foundation Mulanje	21	Mrs Zione Uka Data Manager Hydrology Section, Lilongwe
8	Mr Kanyuka Lujeri Tea Estates Mulanje	22	Mr Harry Chitenje Acting Director of Energy Affairs Lilongwe
9	Pastor Chimphepo District Commissioner Mulanje District Assembly	22	Mr K Lungu Senior Energy Officer Department of Energy Affairs, Lilongwe
10	Mr J.M. Mselera District Hydrological Officer Thyolo	23	Mr Sinkonde National Spatial Data Centre Department of Surveys, Lilongwe
11	Mr Lipunga District Fisheries Officer Mulanje		
12	Mrs Chimphepo District Environmental Officer Mulanje		
13	Mr I Mkandawire Director of Planning and Development Phalombe		
14	Mr Masonje District Forestry Office Mulanje		

Appendix 3

E-MINDSET Project

Household Energy Survey Questionnaire

SECTION A: HOUSEHOLD DETAILS

1. Name of Respondent:_____ Sex: Male[1] ___ Female[2]____

Occupation: Farmer[1]__ Businessman[2]__ Civil servant[3]___Other(specify)[4]___

Number of people in the household:_____ Household income (MK/month): less than 1,000[1], 1000-5000[2] 5000-10,000[3], 10,000 – 20000 [4], greater than 20,000 [5]

Household expenditure (MK/month): Food_____Water_____Clothing_____ School fees_____medicine, other (specify):_____

2. PRESENT ENERGY SOURCES AND USE

2.1 What is the main fuel used in your household for

[1] Lighting---------- [4] Water heating---------- [7] Other (specify)....
[2] Cooking---------- [5] Baking----------
[3] Ironing---------- [6] Beer brewing

2.2 Is firewood generally available in your area? Yes [1] No [2] Don't know [3]

2.3 Does the household use any firewood at any time of the year? Yes [1] No [2]

2.4 How often does your household use firewood?

Every day [1] 3 to 4 times per week [5] 2 times per week [8]

once per week [2] 3 times per month [6] 2 times per month [9]

once per month [3] less often/irregularly [7] during power failures [10]

when no electricity units [4] Other (specify) .....

2.5 Does the household collect firewood or buy or do both?

Collect firewood [1] Buy firewood [2] Collect and buy firewood [3]

If they say they buy firewood, GOTO question 3. *If they collect firewood, ask the following questions:*

2.6 How often does the household collect firewood?

Every day [1] Every second day [2] Once a week [3] Other (specify)…..

2.7 How much firewood does the household generally collect at one time?

One head load collected by one person [1] Two head loads collected by two people [2]

One truck load [3] One cart load [4] Other [19] (specify)……

2.8 How long does this firewood last?

Less than one week [1] 1 week [2] 2 weeks [3] 1 month [4]

Other (specify)…… ……

2.9 Who in the household usually collects firewood?
Women [1] Men [2] Female children [3] Male children [4] Other (specify)……

If they buy firewood, ask the following questions:

3.0 How often does your household buy firewood?

Every day [1] 3 to 4 times per week [2] 2 times per week [3]

once per week [4] 3 times per month [5] 2 times per month [6]

once per month [7] less often/irregularly [8] during power failures [9]

when no electricity units [10] Other (specify) .....

3.1 How much firewood does your household generally buy at one time? (headloads*)* ……

kg. (note 1 headload = 25kg)

3.2 How long does this firewood last?

Less than one week [1] 1 week [2] 2 weeks [3] 1 month [4] Other(specify)…

3.3 How much does the household pay for this firewood? *Amount in local money*…….

3.4 How much does your household spend on firewood per month? *Amount in local money……*

3.5 Does the household sell firewood? Yes [1] No [2]

If yes, 3.6 How much firewood does the household sell per month? *Weight in kilograms or pounds*…….

3.7 How much income does the household get per month from selling firewood? *Amount in local money*……

3.8 Who are your usual suppliers for firewood? *Indicate Yes [1] or No [2]*

A. Member/s of the community		B. Market		Other (specify)……	

3.9 How far from home are your usual suppliers?

Less than 1 km [1] 2 to 5 km [2] 6 to 10 km [3] More than 10 km [4]

3.10 Does your household pay for transport to get to your suppliers? Yes [1] No [2]

If yes , 3.11 How much does the household pay for the return journey including the transport of firewood? *Amount in local money*……

3.12 Does your household have any woodfire place (three stone fire) / Chitetezo stove? Yes [1] No [2]*If no,* GOTO Section 4 . *If yes*,

3.13 What type of fireplace / stove does your household have? *Indicate Yes [1] or No [2]*

A. Outside fireplace		B. Inside fireplace		C. Special wood stove		D. Other (specify)……	

4.0 OTHER ENERGY SOURCES

4.1 Do you use paraffin in your household? Yes [1] No [2] Don't know [3] [ ]

4.2 Amount of paraffin used (litres per month_____ Price per litre_____

How often does the household use these fuels?

A. Every day [1]		E. 3 to 4 times per week [2]		H. 2 times per week [3]	
B. 3 times per month [4]		F. 2 times per month [5]		I. During power failures [6]	
C. Once per month [7]		G. Less often/irregularly [8]		J. Once per week [9]	
D. When no money for electricity [10]		K. Other (specify)……			

4.3 Do you use charcoal in your household? Yes [1] No [2] Don't know [3]

4.4 Amount of charcoal used (bags per month)_____ Price per bag_____

4.5 How often does the household use these fuels? _____

4.6 Do you use candles in your household? Yes [1] No [2] Don't know [3]

4.7 Amount used (candles per month)_____ Cost (MK/candle)_____

4.8 Do you use dry cell batteries in your household? Yes [1] No [2] Don't know [3]

4.9 Number used per month)_____ Cost_____

4.10 Does your household use a car battery? Yes [1] No [2] Don't know [3]

4.11 How often do you charge it? _____ 4.12 Charging price_____

5.0 FUTURE ENERGY SOURCES

5.1 Given the following energy sources available, which one would you prefer? How would use it and how much are you willing to pay per month?

Electricity [1], Gel fuel [2] LPG Gas [3] Biogas [4] Solar [5] [6] Diesel [7]

Use : Lighting[1]. Cooking [2]_____

Amount in willing to pay:(MK/month) ____K_____

Appendix 4

Table 1.a: Locations and Size of Indigenous Gazetted Forest Reserves

Name of Forest reserve	Location	Size (Km^2)	Tree species
Mulanje Mountain Forest Reserve	TAs (Nkanda, Laston Njema and Mabuka)	502	Brachestegia spp, evergreen forests, Afro-montane, Widdlingtonia forests and grass land area.
Thuchila	TA Mabuka	20,77	Eucalyptus
Lichenya	TA Mabuka	0,54	Evergreen forests
Likhubula		5,76	
Total		529,07	

Source: Mulanje DFO

Table 1b: Location and Sizes of Plantation

Name of the Indigenous Forest reserve	Location	Size (Ha.)	Tree species
Thuchila,	Senior Chief Mabuka	2078.00	Eucalyptus species
Eastern Outer Slopes (EOS),	Chief Laston Njema	1298.00	Pine species
Likhubula,	Chief Nkanda	101.00	Pine species
Chambe	Chief Nkanda	450,00	Pine species
Nanchidwa	Chief Laston Njema	2850.00	Eucalyptus and Pine species
Private plantations (Tea estates) Grenorchy area and Esparanza	Chief Njema and Mabuka	157.2 and 143 ha. of forest respectively at the edge of the Mountain including graveyard	Eucalyptus Spp

Source: Mulanje DFO

Table 2.4 : Health Indicators

Indicator	Baseline	MPRS target	Current situation
Maternal mortality rate	1,120/100,000 deliveries	400/100,000	1120/100,000
Deliveries conducted by trained health personnel	56%	-	58%
Contraceptive prevalence rate	25%		33%
Infant Mortality Rate	104/1,000	90	76
Under five mortality rate	189	150	133
Fertility Rate	6.3	5.5	6.0
Children underweight (%)	30	20%	22%
Under 1 immunization rate	54%	-	55%
ITN Coverage	13%	-	42%

Table 3.1.1 **MIMOSA MEAN MONTHLY WINDSPEED (M/S)**

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	Mean
1990	0.8	0.7	0.9	1.0	0.8	0.8	0.9	1.0	1.2	1.4	1.2	1.0	1.0
1991	1.0	0.9	0.9	0.8	0.9	0.8	0.9	1.0	1.1	1.2	1.3	1.2	1.0
1992	1.0	1.0	1.1	1.1	1.0	0.8	1.1	1.1	1.3	1.5	1.4	1.1	1.1
1993	1.0	0.8	0.9	1.0	0.7	0.8	0.9	1.0	1.2	1.5	1.1	1.1	1.0
1994	0.9	0.8	0.8	0.8	1.0	1.0	1.2	1.1	1.4	1.6	1.5	1.2	1.1
1995	1.1	0.9	1.2	1.1	0.9	0.8	1.0	1.3	1.4	1.6	1.6	1.0	1.2
1996	1.0	0.5	0.1	0.6	0.7	0.7	0.8	1.0	1.2	1.4	1.5	1.1	0.9
1997	0.7	0.3	0.7	0.5	0.7	0.9	1.1	1.3	1.4	1.6	1.3	1.1	1.0
1998	0.3	0.7	0.6	0.6	0.6	0.9	1.2	1.3	1.6	1.8	1.6	1.1	1.0
1999	0.9	1.0	1.2	1.0	1.0	1.0	1.0	1.2	1.5	1.4	1.4	1.4	1.2
2000	1.2	1.0	1.1	1.1	0.8	1.2	1.0	1.2	1.4	1.6	1.1	1.0	1.1
2001	0.9	0.8	1.0	1.0	0.9	1.1	1.3	1.2	1.5	1.8	1.8	1.2	1.2
2002	1.3	1.0	1.2	1.1	0.9	1.1	1.0	1.3	1.4	1.7	1.5	1.2	1.2
2003	1.1	1.1	1.0	1.1	1.1	1.1	1.3	1.2	1.4	1.4	1.6	1.3	1.2
2004	1.3	1.1	1.2	1.1	1.3	1.3	1.2	1.4	1.4	1.3	1.3	1.0	1.2
2005	1.1	1.0	1.1	1.2	1.4	1.5	1.5	1.4	1.4	2.2	1.7	2.1	1.5
2006	1.7	1.9	1.7	1.6	1.4	1.7	1.8	1.2	1.5	1.5	1.4	1.0	1.5
2007	0.9	1.0	0.9	1.0	1.0	1.1	1.0	1.0	1.3	1.7	1.2	1.0	1.1
MEAN	**1.0**	**0.9**	**1.0**	**1.0**	**1.0**	**1.0**	**1.1**	**1.2**	**1.4**	**1.6**	**1.4**	**1.2**	**1.1**

Long Term Estimated Averages

STATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
FORTLISTER	1.2	1.2	1.1	1.0	1.1	1.2	1.2	1.2	1.3	1.2	1.2	1.2	**1.2**
NAMINJIWA	0.8	0.8	0.6	0.3	0.5	0.4	0.5	1.0	1.2	1.3	1.2	0.8	**1.2**

Table (3.1.2) MIMOSA MEAN MONTHLY SUNSHINE HOURS													
YEAR	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**MEAN**
1990	5.1	6.5	7.7	7.9	6.0	7.4	8.1	6.9	7.3	9.1	8.1	7.5	7.3
1991	6.6	6.3	5.3	7.1	7.7	7.3	6.8	8.1	9.0	8.5	7.9	6.6	7.3
1992	7.2	9.1	7.2	8.2	8.0	6.8	6.9	7.3	9.6	9.3	7.7	5.9	7.8
1993	5.1	5.4	6.7	8.2	9.2	6.3	5.9	7.1	8.6	8.2	7.5	7.8	7.2
1994	6.2	7.4	6.9	8.4	9.1	5.9	5.2	6.4	9.0	6.9	9.4	7.6	7.4
1995	4.6	7.4	8.3	8.1	6.7	7.7	7.7	7.6	9.0	10.0	8.0	5.1	7.5
1996	6.0	5.3	3.8	6.0	5.0	6.4	7.3	9.0	9.2	9.9	9.2	5.0	6.8
1997	4.4	3.0	6.5	5.7	7.6	7.9	5.2	8.9	6.6	7.1	8.0	5.1	6.3
1998	4.2	6.9	6.8	7.9	8.9	7.5	7.1	6.4	8.7	9.0	7.3	6.6	7.3
1999	3.9	3.4	5.9	5.1	8.2	7.5	5.1	6.6	8.0	7.2	7.8	8.3	6.4
2000	6.0	6.0	6.5	6.1	6.7	6.7	5.6	6.2	8.8	8.6	5.6	5.3	6.5
2001	5.4	4.2	5.6	8.2	7.0	7.0	6.0	8.8	9.0	9.2	9.3	5.6	7.1
2002	6.6	7.0	6.6	7.6	8.1	5.7	8.9	7.5	8.2	8.7	9.0	7.4	7.6
2003	5.4	6.1	5.2	8.7	7.6	5.5	5.7	7.5	8.7	10.2	9.4		6.7
2004			6.2	5.1									5.7
MEAN	**5.5**	**6.0**	**6.3**	**7.2**	**7.6**	**6.8**	**6.5**	**7.5**	**8.6**	**8.7**	**8.2**	**6.4**	**7.0**
Long Term Estimated Averages													
STATION	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**MEAN**
FORTLISTER	5.8	6.0	4.9	6.1	6.1	5.0	5.5	7.2	7.0	6.5	6.7	5.9	6.0
NAMINJIWA	5.9	5.9	6.1	6.6	7.3	6.9	6.5	7.9	8.6	8.5	7.4	5.9	7.0

Table 3.1.3: Solar Radiation Data

STATION	JAN	FEB.	MAR	APR	MAY	JUN	JUL	AUG.	SEPT	OCT.	NOV.	DEC.	TOTAL
BVUMBWE	20.5	19.1	18.7	17.1	17.4	15.6	16.4	20.0	23.1	24.7	23.1	20.0	235.7
MIMOSA	21.0	19.9	19.5	16.7	17.3	15.3	15.6	19.6	23.1	24.7	23.9	20.5	237.1
THYOLO	21.5	19.7	19.2	17.4	17.7	15.6	16.3	20.6	22.5	25.3	23.8	19.9	239.5

Source: Meteorological Department, 2008

Table 3.1.4: METEOROLOGICAL DEPARTMENT

MIMOSA MET : MONTHLY AND SEASONAL RAINFALL TOTALS (MM)

SEASON	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOTAL
1989/90	53.9	29.5	33.5	106.0	255.9	186.6	481.6	266.1	146.8	54.2	89.2	24.5	**1727.8**
1990/91	11.9	57.0	69.6	5.2	208.8	46.8	226.5	236.4	427.3	147.6	14.5	42.7	**1494.3**
1991/92	87.6	21.4	44.9	2.6	117.5	133.4	136.3	40.1	92.8	17.7	14.1	102.8	**811.2**
1992/93	23.2	52.9	0.0	0.0	69.3	123.8	691.8	266.2	160.7	159.1	10.3	78.2	**1635.5**
1993/94	36.6	0.0	0.0	58.7	238.7	120.7	404.2	90.2	322.7	32.8	1.4	38.4	**1344.4**
1994/95	28.2	80.5	29.8	88.7	41.1	195.5	386.6	381.2	57.8	82.7	107.5	32.9	**1512.5**
1995/96	32.4	6.6	0.0	1.5	103.2	303.8	140.2	300.5	422.3	126.8	58.4	83.2	**1578.9**
1996/97	85.6	19.8	1.8	19.8	106.7	282.3	226.7	251.8	153.3	301.0	66.1	0.0	**1514.9**
1997/98	96.6	3.2	100.2	95.0	201.5	326.9	469.4	289.0	245.7	28.1	2.3	13.4	**1871.3**
1998/99	58.7	65.0	3.8	66.5	66.1	429.0	521.3	259.4	423.4	240.9	24.5	7.3	**2165.9**
1999/00	54.5	18.8	22.9	19.2	92.9	155.9	220.1	248.7	236.1	171.6	163.5	16.5	**1420.7**
2000/01	99.2	23.2	0.4	41.9	275.7	394.0	365.3	463.8	327.2	80.5	37.3	2.8	**2111.3**
2001/02	37.2	22.0	51.9	9.0	102.6	316.7	447.6	366.6	222.6	180.4	11.2	36.7	**1804.5**
2002/03	11.2	31.5	25.1	53.5	107.0	242.1	465.3	229.9	267.4	26.8	38.8	99.5	**1598.1**
2003/04	51.2	30.8	27.4	16.9	112.0	92.3	113.9	167.3	154.3	163.1	26.9	35.7	**991.8**
2004/05	47.3	28.1	2.7	81.0	66.8	399.0	199.9	99.0	63.3	15.2	15.6	50.9	**1068.8**
2005/06					59.6	443.8	398.7	197.5	478.1	78.7	34.3	17.2	**1707.9**
2006/07	4.4	2.3	4.6	36.4	74.3	299.6	481.0	240.2	254.5	58.5	53.9	17.3	**1527.0**
2007/08	88.0	23.5	0.0	33.5	109.1		580.3	148.5	187.2	20.4			**1190.5**

Source: Meteorological Department, 2008

Table (3.2.1a): Estimating electricity production using solar battery of 1kW

Site	Phalombe			Mulanje		
	I	e	E	I	e	E
Month	Intensity of solar radiation [kWh/m^{2}d]*	Electricity production per day [kWh/d]	Electricity production per month [kWh/month	Intensity of solar radiation [kWh/m^{2}d] *	Electricity production per day [kWh/d]	Electricity production per month [kWh/month
Jan	4.6	3.17	98.3	5.83	4.02	124.7
Feb	4.9	3.38	94.6	5.53	3.82	106.8
Mar	4.9	3.38	104.8	5.42	3.74	115.9
Apr	4.8	3.31	99.3	4.64	3.20	96.0
May	3.6	2.48	76.88	4.81	3.32	102.9
Jun	2.8	1.93	57.9	4.25	2.93	88.0
Jul	3.5	2.42	75.0	4.33	2.99	92.6
Aug	4.1	2.83	87.7	5.44	3.75	116.4
Sep	4.9	3.38	101.4	6.42	4.43	132.9
Oct	5.9	4.07	126.2	6.86	4.73	146.7
Nov	5.6	3.86	115.8	6.64	4.58	137.4
Dec	4.4	3.04	94.2	5.69	3.93	121.7
Sum			1132.1			1382

* Inclination angle = 20°, azimuth = 0°

Table (3.2.1b): Potential of photovoltaic energy

District		Number of sites	Solar battery capacity (kW)	Annual electricity production per site (MWh/y)	Annual electricity production (GWh/y)
Phalombe	Households	91,268	1.2	1.36	124
Mulanje	households	156,230	1.2	1.66	259
Sum					383 (= 1379 TJ/y)

Table (3.2.2a): Estimating collected thermal energy using a solar panel of 1m^2

Site	Phalombe			Mulanje		
	I	q	Q	I	q	Q
Month	Intensity of solar radiation [kWh/m^{2}d]	Collected thermal energy per day [MJ/m^{2}d]	Collected thermal energy per month [MJ/m^{2}month	Intensity of solar radiation [kWh/m^{2}d]	Collected thermal energy per day [MJ/m^{2}d]	Collected thermal energy per month [MJ/m^{2}month
Jan	4.6	6.62	205.3	5.83	8.40	260.3
Feb	4.9	7.06	197.6	5.53	7.96	222.9
Mar	4.9	7.06	218.7	5.42	7.80	241.9
Apr	4.8	6.91	2o7.4	4.64	6.68	200.4
May	3.6	5.18	160.7	4.81	6.93	214.7
Jun	2.8	4.03	121.0	4.25	6.12	183.6
Jul	3.5	5.04	156.2	4.33	6.24	193.3
Aug	4.1	5.90	183.0	5.44	7.83	242.8
Sep	4.9	7.06	211.7	6.42	9.24	277.3
Oct	5.9	8.50	263.4	6.86	9.88	306.2
Nov	5.6	8.06	241.9	6.64	9.56	286.8
Dec	4.4	6.34	196.4	5.69	8.19	254.0
Sum			2155.9			4814.2

Inclination angle = 20°, azimuth = 0°

Table (3.2.2b): Potential of solar thermal energy

District		Number of sites	Collector area (m^2)	Collected thermal energy per site (GJ/y)	Collected thermal energy [TJ/y]
Phalombe	Households	91,268	2	4.3	394
	Institutions	16	18	38.8	0.62
Mulanje	households	156,230	2	9.6	1504
	Institutions	23	18	86.7	1.99
Sum					1900

Table (3.3.1a): Energy potential from agricultural residues in Mulanje

Crop	Total production (kton)	Residue	Residue coefficient	Residue production (kton)	Moisture content	Dry weight (kton)	Calorific value GJ/ton	Energy Content (TJ)
Maize	83.2	cobs	1.00	83.2	0.0753	76.93	16.28	1252
Paddy rice	5.9	shells	0.23	1.4	0.1237	1.2	19.33	23.2
Sorghum	10.9	stalk	1.00	10.9	0.08	10.0	16.28	162.8
Groundnuts	3.6	shells	0.5	1.8	0.082	1.65	15.66	25.8
Tobacco	6.7	stalk	1.00	6.7	0.2	5.36	15.00	80.4
Cassava	166.5	stalks	0.088	14.65	0.3	10.26	17.50	179.6
Tea	17.0	dust	0.07	5.95	0.05	5.65	13.5	76.3
Total								1800.1

Table (3.3.1b): Energy potential from agricultural residues in Phalombe

Crop	Total production (kton)	Residue	Residue coefficient	Residue production (kton)	Moisture content	Dry weight (kton)	Calorific value GJ/ton	Energy Content (TJ)
Maize	37.0	cobs	1.00	37.0	0.0753	34.2	16.28	556.8
Paddy rice	2.2	shells	0.23	0.51	0.1237	0.45	19.33	8.7
Sorghum	6.9	stalk	1.00	6.9	0.08	6.3	16.28	102.6
Groundnuts	3.5	shells	0.5	1.75	0.082	1.6	15.66	25.1
Tobacco	0.1	stalk	1.00	0.1	0.2	0.08	15.00	1.2
Cassava	18.25	stalks	0.088	1.61	0.3	1.13	17.50	19.8
Total								714.2

Table (3.3.2): Number of livestock and their residues production in 2006

Livestock Type	Heads	Dung yield (kg/animal/day)	Residues (tons/year)	Annual biogas potential ('000m^3)	Paraffin equivalent ('000litres)	Energy Content (TJ)
Cattle	23958	15	131,170	4,263.0	2557.8	85.26
Goat	122,483	0.9	40,236	1,609.4	965.4	32.18
Sheep	1424	0.9	468	18.7	11.2	0.37
Pigs	9817	1.1	3942	212.9	127.7	4.26
Chicken	1,169,590	0.07	29,883	2,336.9	1402.1	46.74
Total				8440.9	5,064.2	168.81

Table (3.3.3): Energy potential from municipal solid wastes in Mulanje

Waste	Production (tons/year)	Moisture content	Dry weight (tons)	Calorific value (GJ/ton)	Energy content (GJ)
Fruit	1642	0.5	821	21.0	7241
Biomedical	395	0.5	197.5	14.0	2765
Household	3212	0.5	1606	4.0	6424
Total	6336		2624.5		16430

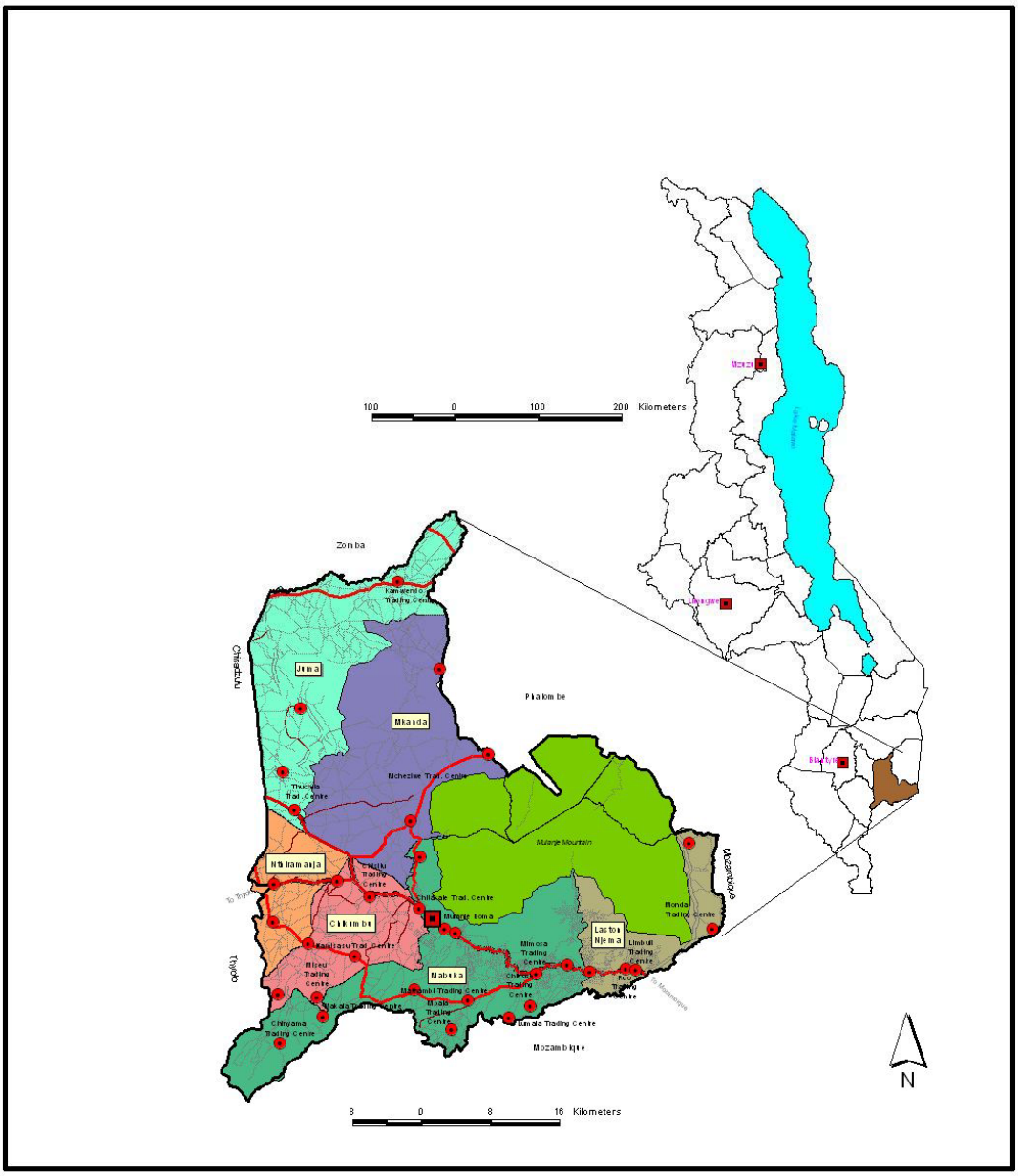
Table (3.3.4):Small-scale hydropower potential

Name of hydropower scheme	**Estimated Parameters**				**Firm power (MW)**	**Energy output (MWh/a)**
	Gross head (m)	Mean flow (m^3/s)	Load factor (%)	Catchment area (km^2)		
Lichenya	304	3.57	50	62.3	7.6	33,288
Likhubula	137	1.41	50	33.1	1.35	5,913
Thuchila	120	0.10	50	84.2	0.084	368
Phalombe	152	0.85	50	55.8	0.904	3960
Muloza	180	0.068	50	50	0.086	377
Ruo	215	1.484	50	193	2.23	9767
Lujeri	457	3.6	50	39.5	11.5	50,370
Total estimated small-scale hydroelectric potential					**23.75**	**104,043**

Table (4.1): Per capita Household Energy Consumption by Fuel Type

Mulanje				Phalombe		
Fuel type/unit	Total	Per capita	Energy content	Total	Per capita	Energy content
Electricity (kWh)	288,614	30.87 kWh	111.1 MJ	48,366 kWh	30 kWh	108 MJ
Paraffin (tons)	1922	3.5 lt	117.6 MJ	1123 tons	4.9 lt	163 MJ
Firewood (tons)	189,412	351 kg	5440.5 MJ	110,653 tons	478 kg	7410 MJ
Charcoal (tons)	202.5	129.6 kg	3732.5 MJ	16.7 tons	32.4 kg	933.1 MJ
Candles (pkt)	186,951	2.9 pkt	60.9 MJ	109,215	2.8 pkt	58.2
Total			**9,462.6MJ**			**8,672.3 MJ**

Map:__ Location of Mulanje District



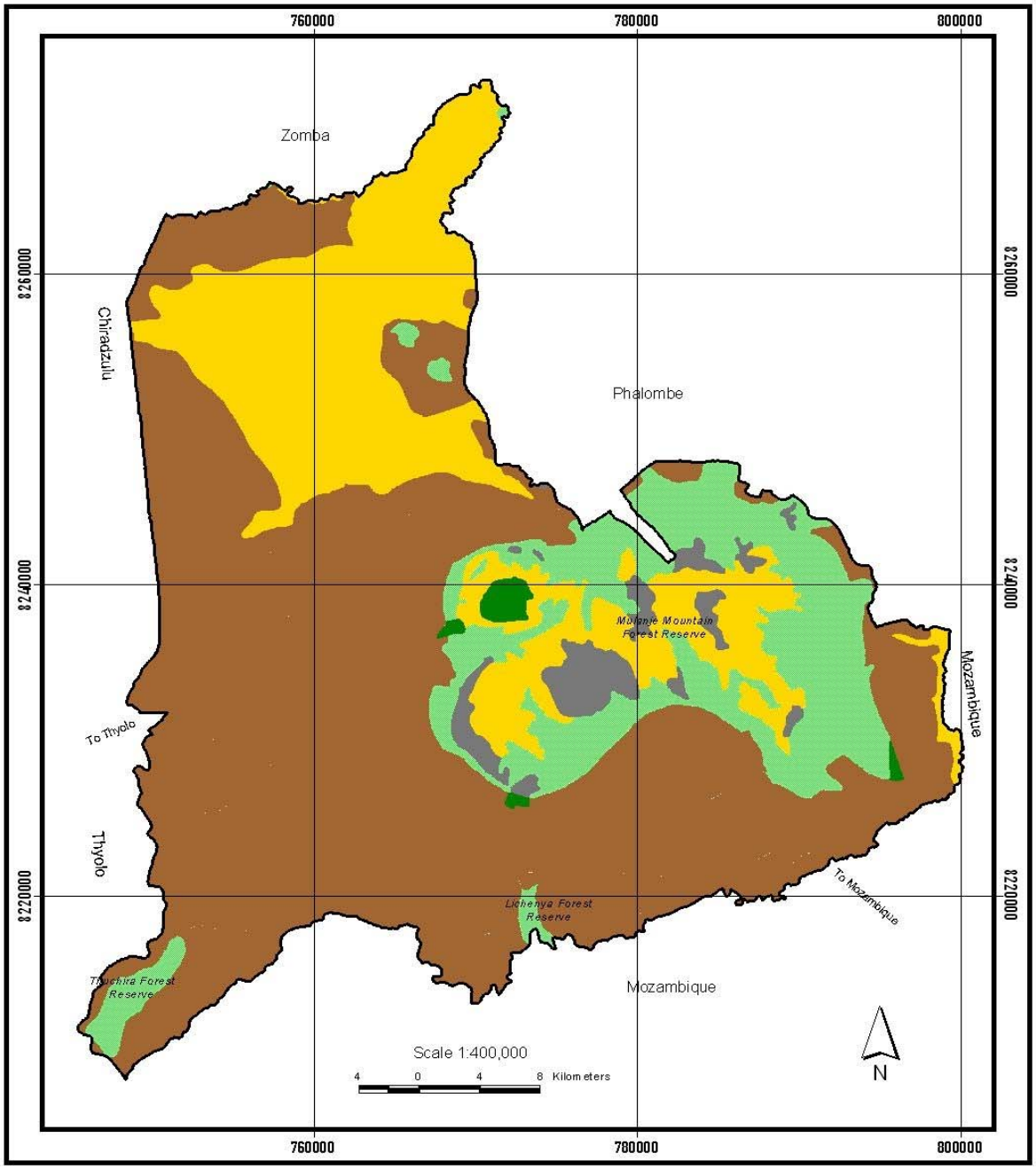
Legend

- Main Trading Centres
- Main Cities
- Main Road
- Secondary Road
- Tertiary Road
- District Road
- Other Roads
- District Boundary

Mulanje District Assembly

Date: 8 March 2007 / Source: Arc View 3.3, Arc GIS 8.1 / Scale: 1:600,000 (Mulanje)/ Projection: UTM Zone 36 / Prepared by: Costly Chanza - 08202336

Map:__Land Use Cover and Forest Reservs in Mulanje District



Date: 8 March 2007/ Source: Arc View 3.3, Arc GIS 8.1 / Scale: 1:400,000 / Projection: UTM Zone 36 / Prepared by: Costly Chanza - 08202336