Malawi Biomass Energy Strategy

March 2009

GOVERNMENT OF MALAWI

euei
EUROPEAN UNION ENERGY INITIATIVE
for poverty eradication and sustainable development

Partnership Dialogue Facility (EUEI PDF)

Acknowledgements

The consultants responsible for drafting the national Biomass Energy Strategy are grateful to the Government of Malawi for its contributions to the Strategy development process. Particular thanks are due to the former Director of Energy Affairs (Dr. Charles Kafumba) and the Director of Forestry (Dr. Dennis Kayambazinthu).

The team would also like to acknowledge Peter McCarter (formerly Senior Advisor to the Improved Forest Management for Sustainable Livelihoods Programme) for his help with contacts and information in the forestry sector, Mercy Kanyuka (Deputy Commissioner for Statistics) for assistance with demographic and economic data, and Christoph Messinger and Christa Roth (formerly with the GTZ/SADC Programme for Basic Energy Conservation) for their considerable support and provision of information in the early stages of the process.

Space does not allow all contributors to be named here, but a list of all those consulted during the Strategy development process is provided in Annex B.

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March 2009

Abbreviations and Acronyms

Government of Malawi

DoE	Department of Energy Affairs
FD	Forestry Department
GoM	Government of Malawi

Development partners

ADB	African Development Bank
DfID	United Kingdom Department for International Development
EUEI-PDF	European Union Energy Initiative, Partnership Dialogue Facility
GTZ	*Deutsche Gesellschaft für Technische Zusammenarbeit GmbH* (German Agency for Technical Cooperation)
MARGE	*Marchéage et Gestion de l'Environnement*
ProBEC	GTZ Programme for Basic Energy Conservation in Southern Africa
UNDP	United Nations Development Programme
WB	World Bank

Other

BEST	Biomass Energy Strategy
CA	catchment area
ESCOM	Electricity Supply Corporation of Malawi Ltd.
GDP	gross domestic product
HDI	Human Development Index (UNDP statistic)
KCJ	Kenya ceramic jiko (type of charcoal stove)
LPG	liquefied petroleum gas
LRMC	long-run marginal cost
MGDS	Malawi Growth and Development Strategy
MK	Malawi Kwacha
MPRS	Malawi Poverty Reduction Strategy
SAPP	Southern African Power Pool

Units of measurement

Weight:	kg	kilogramme
	t	metric tonne (1,000 kg)
Volume	l	litre
Area	ha	hectare
Energy:	MJ	mega-joule (10^6 joules)
	MJU	mega-joules of usable energy
	GJ	giga-joule (10^9 joules)
	TJ	terra-joule (10^{12} joules)
	kWh	kilowatt hour
	GWh	gigawatt hour
	w.e.	wood energy equivalent
Power:	kW	kilowatt
	MW	megawatt
Time:	mth	month
	yr	year
%	percent	

Assumed Energy Values

Material	Energy value	Units
Molasses	10.0	MJ/kg
Agro-residues (air-dry)	12.5	MJ/kg
Animal dung (air-dry)	13.5	MJ/kg
Firewood (air-dry)	15.5	MJ/kg
Ethanol	23.0	MJ/l
	29.1	MJ/kg
Coal	29.0	MJ/kg
Charcoal	29.0	MJ/kg
Paraffin/kerosene	36.3	MJ/l
	43.2	MJ/kg
LPG	45.0	MJ/kg
Electricity	3.6	MJ/kWh

Conversion Factors

1.5 m^3 = 1 t. air-dry wood
6.67 m^3 of wood (air-dry) [4.45 t] required to make 1 t charcoal
Moisture content of air-dry wood, residues an dung = 15% (wet basis)
Moisture content of charcoal = 5% (wet basis)

Exchange Rate (mid-2008)

A rate of 148 Malawi Kwacha (MK) to the US dollar ($) is assumed throughout.

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1. Introduction

1.1 Background to the Biomass Energy Strategy

Malawi is a country heavily dependent upon biomass fuels, defined as firewood, charcoal, crop residues and animal dung. The National Energy Policy (2003) estimated that biomass accounted for 93% of total energy consumption in 2000 and new research conducted under this study suggests that the contribution of biomass was still 88.5% in 2008.

In spite of their significance, biomass fuels have historically been associated with environmental degradation, poverty and under-development. This applies especially to charcoal, Malawi's dominant commercial fuel in terms of volume and value, which is widely perceived as a destructive and inefficient energy source. Those involved in its production and supply are marginalised and often criminalised.

For a long time the national policy has been to transform the country's economy from high dependency on biomass energy towards greater reliance on other energy sources, particularly electricity, but the Government of Malawi (GoM) has recently recognised that a more pragmatic approach to the biomass energy sector is required at the same time. In 2007, the GoM therefore requested assistance from the European Union Energy Initiative Partnership Dialogue Facility (EUEI-PDF)[1] for the design of a national Biomass Energy Strategy (BEST).

The BEST objective was to develop a rational and implementable approach to the management of Malawi's biomass energy sector through a combination of measures designed to improve the sustainability of biomass energy supply, raise end-user efficiencies and promote appropriate alternatives. The resulting Strategy addresses thermal applications of energy, primarily cooking. It covers domestic, institutional and industrial applications for biomass, and includes both commercial and non-commercial users of fuel.

1.2 Approach to Strategy Development

The BEST development process was managed on behalf of EUEI-PDF by the German Agency for Technical Cooperation (GTZ) and implemented by a team from the French consulting firm *Marchéage et Gestion de l'Environnement* (MARGE). Guidance in Malawi was provided by the Department of Energy Affairs (DoE) and the Department of Forestry in the Ministry of Energy and Mines.

The MARGE team comprised five international consultants and additional experts recruited in Malawi to conduct empirical surveys in order to update existing energy supply and demand data. The team also liaised closely with a designated counterpart from DoE.

The Strategy was developed in accordance with Terms of Reference drafted jointly by EUEI-PDF and the DoE (see Annex A) and the EUEI-PDF BEST Guide[2].

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[1] EUEI PDF is an instrument developed by Austria, France, Germany, the Netherlands, Sweden and the UK to support the development of policies and strategies for the promotion of access to energy at national and regional level. See www.euei-pdf.org

[2] See www.euei-pdf.org/admin/gtz/upload/publications/-1%20BEST-Guide-07-08-08.pdf

During the Strategy development a wide range of resource persons and documentary sources were consulted, as listed in Annex B and Annex C respectively. A Task Force was formed by the DoE to provide feedback and guidance, and comprised representatives from a number of government departments, academia, NGOs and the private sector, as listed in Annex D. The Task Force met twice during the development of the Strategy and a sub-group was convened in November 2008 to provide feedback on the draft Strategy document.

1.3 Structure of the Biomass Energy Strategy

The Strategy document begins with contextual information on Malawi, its geography, socio-economics and strategies for achieving growth and development (**Chapter 2**).

Chapter 3 provides information on the policies and institutional arrangements that relate to the biomass energy sector, highlighting relevant energy and forestry legislation.

Chapter 4 summarises the current energy supply and demand situation, prior to a more detailed presentation in the chapters that follow.

Demand for biomass energy is then discussed in detail in **Chapter 5**, which looks at all cooking and non-cooking requirements, and domestic as well as non-domestic demand.

Chapter 6 balances this information with supply-side estimates, placing the consumption figures in context and highlighting those areas of the country facing the greatest sustainability challenges.

Chapter 7 focuses on commercial cooking fuels (i.e. those that are bought and sold) and makes projections of future demand based on particular supply and costing assumptions, using the GLOBUS computer model developed by MARGE.

Chapter 8 presents a package of suggested interventions to improve management of the biomass energy sector that cover the supply-side, demand-side and institutional arrangements.

Chapter 9 is a short summary of proposed interventions outside the biomass energy sector that will complement the recommendations of the Strategy.

Finally, **Chapter 10** presents an outline plan to move forward with development of the proposed institutional structures and implementation of the suggested package of interventions.

2. Context for Sector Development

2.1 Location

Malawi is a land-locked country 600 km from the Indian Ocean, bordered by Tanzania to the north, Zambia to the west and Mozambique to the east and south. Lake Malawi forms the eastern boundary for over half its length and water accounts for 20% of the country's total area of 118,000 sq. km. Refer to Figure 1.

Figure 1: Map of Malawi

2.2 Administration and Population

The country is divided into three administrative regions of similar size, whose areas and populations are summarised in Table 1.

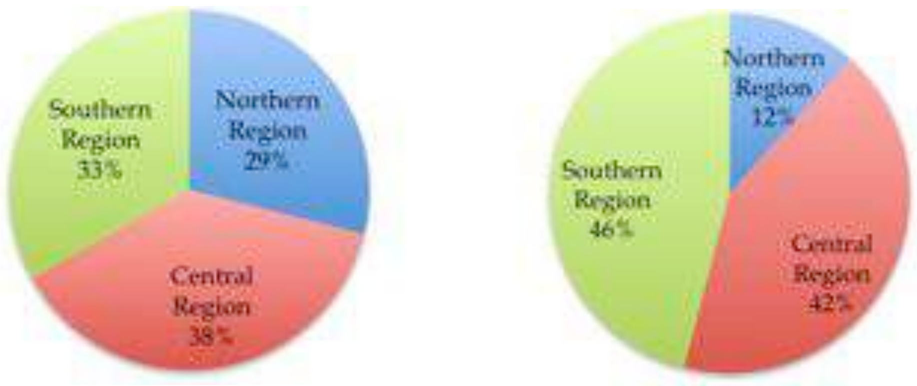
Table 1: Malawi land area and population by region, 2008

	Northern Region	Central Region	Southern Region	*Total*
Rural population ('000)	1,343	4,814	5,147	***11,304***
Urban population ('000)	251	959	1,116	***2,326***
Total population ('000)	***1,594***	***5,773***	***6,262***	***13,630***
Land area (sq.km.)	27,200	35,600	31,200	***94,000***
Population density (people/ha)	0.59	1.62	2.01	***1.45***

Source: Population projections from national census (Government of Malawi, 1998).
Areas from national biomass study (Government of Malawi, 1993).

As the table shows, Malawi's estimated population (mid-2008) was 13,630,000[3]. Malawi is only African's 37th largest country but is the fifth most densely populated country on the continental mainland, with an average of 1.45 people per ha. Although the annual rate of growth declined from 3.1% in 1975 to 2.6% in 2006, the population doubling time is still only 27 years and current rates of growth mean that there are 455,000 more people every year, and rising. This is placing significant pressure on Malawi's natural resources and leading to conversion of forests and woodlands to agriculture, alongside an intensification of agriculture in areas that are already farmed.

Figure 2: Comparison of Malawi's regions, by area and population



Area *Population*

[3] All population data are based on projections from the national census of 1998. A new census was conducted in mid-2008 but its findings were not published in time for inclusion in the BEST study. Summary figures that became available in November 2008 gave a national total only 4% lower than the projections used by the BEST team, sufficiently similar not to have major implications for the BEST findings or proposals. The BEST projections will in any case be achieved by late 2009.

As Figure 2 illustrates, the country's three regions are of approximately equal size, but Northern Region has a significantly lower population. Population density hence increases from north to south, with Southern Region having over three times as many people per unit of area as Northern Region. As this study will expound further, tree cover, environmental degradation and wood energy shortages all have a tendency to increase from north to south, largely as a result of the population density trend.

The population still remains largely rural, with only 17% of Malawians living in urban areas. But the urban population has been increasing rapidly and is projected to reach 22% by 2015. Rates of urbanisation increase slightly from north to south. Given that urban residents are the main consumers of commercially traded fuels, this progressive urbanisation of the population, in tandem with the rapid overall growth rate, has major implications for the growth of commercial woodfuel demand – as the projections in chapter 7 of this study will elaborate.

2.3 Land Use

Reflecting the fact that 90% of Malawians rely on smallholder agriculture fortheir livelihoods, 70% of the country's land area is under some form of agriculture, up from 62% in 1991 (see Table 2). Most farming takes place during the single annual rainy season between November and May (averaging about 1,000 mm). Maize is the staple food crop and tobacco is the principal cash crop. Other important smallholder crops are potatoes, cassava, sorghum, pulses and groundnuts.

Table 2: Malawi area by land-use type (1991 and 2008)

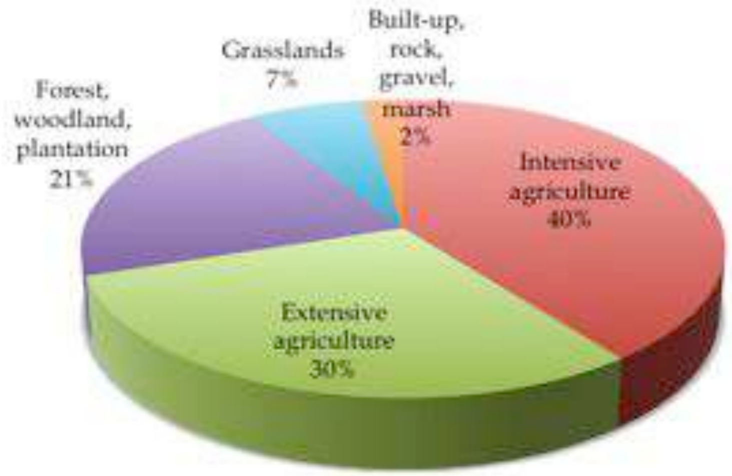
Land use category	**1991**		**2008**		***Change (1991 to 2008)***	
	area ('000 ha)	**%**	**area ('000 ha)**	**%**	***area ('000 ha)***	**%**
Intensive agriculture	3,091	33%	3,721	40%	*+630*	*+20%*
Extensive agriculture	2,669	29%	2,852	30%	*+183*	*+7%*
Forest, woodland & plantation	2,657	28%	1,988	21%	*- 669*	*-25%*
Grasslands	766	8%	614	7%	*-152*	*-20%*
Miscellaneous	216	2%	224	2%	*+8*	*+4%*
Total:	***9,399***		***9,399***			

Note: (i) Intensive agriculture covers both smallholder farms and large-scale farms and estates.
(ii) Extensive agriculture is defined as farming in wooded or grassy areas, with 20% to70% of the land cultivated.
(iii) Forest and woodland areas are defined as <20% open land.
(iv) "Miscellaneous" includes urban land (22,400 ha in 1991 and 30,100 ha in 2008) rocky land (16,100 ha in 2008) and marsh (177,200 ha).
(v) Lake area of 2,423,000 ha is not included.

Source: Dept. of Forestry/Satellitbild (1993) and BEST team projections. For details refer toAnnex K.

Based on the same data, the national land cover situation in 2008 is presented graphically in Figure 3.

Figure 3: Malawi land cover, 2008



Intensive agriculture is the country's largest land-use category and covers 40% of the land area, comprising mainly small farms with an average size of just over 1 ha[4] as well as commercial estates under coffee, sugar, tea and tobacco. A lack of fertilizers means that not all this land is farmed in any one year and some is left fallow to regain its fertility.

Extensive agriculture is the second largest land-use category at 30% and refers to agriculture scattered in wooded areas with 30-80% tree cover. This takes the form of patches of farmed areas in the forest or shifting cultivation, where an area of woodland is cleared and farmed for two to three years and then left to recover for another seven to 15 years.

Forests and woodlands are the third largest land-use category, occupying 21% of the land. More detailed analysis later in this report (Table 22, chapter 6) shows that Northern Region has about 32% of its land area classified as forest while Southern Region has 19%. Central Region has a slightly lower forest area than the south (15%) but nearly double the stocking density. Forest resources in Southern Region are under the greatest pressure and forests in Central Region will come under increasing pressure in the future.

Table 2 also shows that 669,000 ha of forest and woodland plus 152,000 ha of grassland have been lost since 1991, the majority converted to agriculture and a small amount (7,700 ha) to miscellaneous uses, mainly urban development. The rate of conversion of forests, woodlands and grassland to agriculture is closely tracking the rate of population growth, as section 6.3 will discuss in more detail.

The area under agriculture (intensive and extensive) has therefore increased substantially to now cover 70% of the country. However, this is only a 14% rise since 1991 and has not been as great as the estimated increase in cropping area (74%)[5]. This is because the area of grassland and forest land that can be converted to agriculture is decreasing, due to a diminishing

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[4] 40% of family plots are smaller than 0.5 ha.

[5] The cropped area rose from 1,999,600 ha in 1991 to 3,480,300 in 2008, according to Ministry of Agriculture cultivation and productivity statistics.

availability of suitable forest and grass lands for conversion. This has led to an increase in cropping intensity on the available arable areas through the division of farms into smaller parcels and a shortening of the shifting cultivation cycle.

Without sufficient input of fertilizers, these higher cropping intensities will lead to a decrease in agricultural productivity or an increase in the cultivation of less demanding crops such as cassava. This, in fact, is what has occurred, with the area under root crops increasing by a factor of six since 1991[6].

The government has been subsidising seed and fertilizers for the most needy farmers for the last three years, which should boost the productivity of grain crops. Unless agricultural productivity keeps pace with the increase in population, however, more forest land, much of it on steep slopes, along watercourses and in reserved areas, will inevitably be converted to agriculture. The country will also have to import increasing quantities of food to cover the supply - demand deficit.

2.4 Economy

Malawi has a relatively small economy with a 2007 Gross Domestic Product (GDP, official exchange rate) of $3.5 billion[7]. Agriculture is the mainstay of the economy, accounting for more than 80% of export earnings and supporting 90% of the population. Smallholders account for about three quarters of agricultural production and are mostly engaged in rain-fed maize production. The export trade is dominated by tobacco (53%), tea, cotton, coffee and sugar. The country's other natural resources include limestone, hydropower, coal, uranium and bauxite.

2006 per capita income (Atlas method) was just $230 ($690 PPP) and had increased by only 37% since 1990, when it stood at $180[8]. Hon. Bingu wa Mutharika became the country's President in 2004 and his administration has put in place policies that are widely credited with helping to turn the situation around.

Macroeconomic performance has started to improve significantly as a result of strict fiscal discipline. Buoyed by bumper harvests in 2006 and 2007, inflation was reduced to 7.5% by the end of 2007 and in 2006-2007 the economy grew by 6% p.a., double the average for the preceding ten years. The rate of GDP growth was expected to reach 8% in 2008. Malawi was approved for relief under the Heavily Indebted Poor Countries programme in 2006, greatly reducing its debt-to-exports ratio.

2.5 Development

In spite of the upturn in the economy during the last four years, Malawi remains one of the world's least developed countries. It ranks 164th (out of 177) in UNDP's Human Development Index (HDI) with a 2005 score of 0.44[9]. Although its HDI score has been improving over the last 30 years, it has consistently lagged behind the sub-Saharan average, as Figure 4 illustrates.

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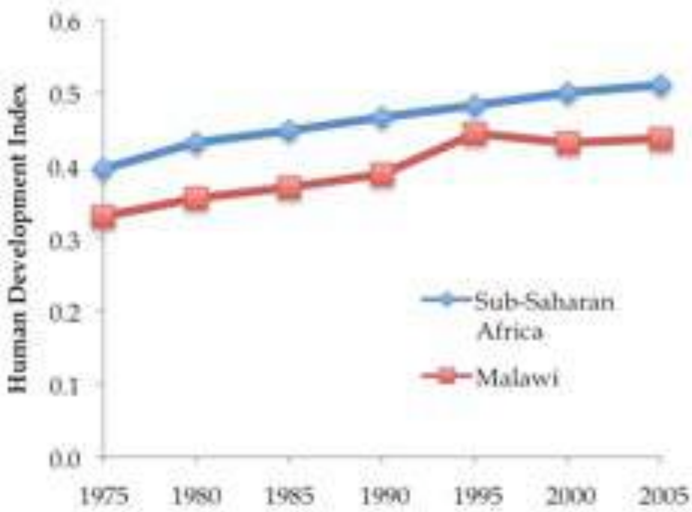
[6] 59,500 ha were under cassava, sweet potato and Irish potato in 1991 and this rose to 365,700 ha by 2007. This was in spite of infestation of cassava by mealy bug, which required farmers to plant new and more tolerant varieties.

[7] www.cia.gov/library/publications/the-world-factbook/geos/mi.html

[8] www.ddp-ext.worldbank.org

[9] http://hdrstats.undp.org

Figure 4: HDI trend, Malawi and sub-Saharan Africa



Source: http://hdrstats.undp.org

Major differences between rural and urban living conditions are reflected in Malawi's income disparity, with a Gini coefficient of 0.38 that is high even by African standards. 76% of the population earns less than $2 per day and a poverty headcount of 54% was recorded in the Malawi Integrated Household Survey of 2004/05, a figure which had hardly changed since the previous survey of 1997/98.

Social indicators are also very weak: the maternal mortality ratio is 984 per 100,000 live births and is one of the highest in the world; the rate of HIV/AIDS prevalence among adults is the eighth highest in Africa[10], which partly explains why life expectancy is only 48 years and has not increased significantly in the last 25 years; two thirds of the population has not completed primary education and adult literacy for females is only 54%; one third of the population still uses unsafe water.

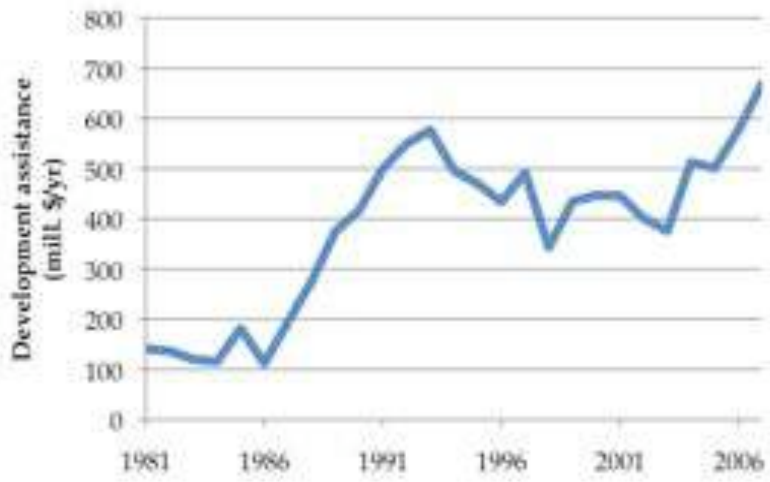
In summary, Malawi is a small and under-developed country, struggling to reduce poverty and improve social conditions in the face of rapidly increasing population, high levels of ill health and low rates of literacy. It has made encouraging macro-economic gains in the last four years and the challenge is now to ensure that these gains translate into improved health, education and welfare for its citizens.

2.6 Development Assistance and Donor Coordination

Donors contribute about 40% of Malawi's annual budget, 90% of this support coming from the UK's Department for International Development (DfID), the EU, World Bank, African Development Bank (ADB), Norway and USAID. The level of donor support has been rising consistently since 2000 (see Figure 5) and reached $668 million in 2007, a historical record.

[10] www.cia.gov/library/publications/the-world-factbook

Figure 5: Official development assistance to Malawi



Source: http://econ.worldbank.org

The donors are adopting increasingly harmonised approaches to their provision of development assistance, with pooled funding for sector-wide approaches (SWAps) now established in health and HIV/AIDS. Efforts are underway to develop SWAps in the education, agriculture and water sectors. General budget support is also provided in a harmonised way through the Common Approach to Budget Support group which comprises DfID, EU, Norway and the ADB, with the World Bank, IMF, UNDP and Germany as observers. The government is taking a stronger lead in coordinating donor support and has developed a Development Assistance Strategy, essentially a coordination plan aimed at improving the effectiveness of aid inflows.

2.7 Poverty Reduction Strategy

Poverty alleviation in Malawi has been a major policy focus for over a decade. Two documents have provided a strategic framework for poverty reduction, the Malawi Poverty Reduction Strategy (MPRS, 2002) and the Malawi Growth and Development Strategy (MGDS, 2005).

The MGDS incorporates lessons learned from the MPRS to provide a renewed framework for stimulation of economic growth between 2006 and 2011. The MGDS is founded on the premise that strong and sustainable economic growth is key to reducing poverty. It focuses on:

a) agriculture and food security;
b) irrigation and water development;
c) transport infrastructure development;
d) energy generation and supply;
e) integrated rural development; and
f) the prevention and management of nutrition disorders and HIV/AIDS.

These strategic objectives are to be achieved under the five broad themes of Social Protection, Social Development, Infrastructure Development and Improving Governance.

Infrastructure issues will be addressed through such projects as the Mozambique-Malawi Transmission Interconnection Project that is expected to connect Malawi to the Southern African Power Pool in the next few years and bring much-needed diversification to the country's electricity supply.

2.8 Linkages between Energy Supply and Poverty Reduction

Recognising that the MPRS had made inadequate progress in reducing poverty, the MGDS is more pro-active in setting targets for economic development by sector. In the energy sector, the MGDS focuses primarily on the development of electricity infrastructure. Indeed, the word "energy" is used interchangeably with "electricity". For example, the "Energy Generation and Supply" goals are to :

- reduce the number and duration of blackouts, increase access to reliable, affordable electricity in rural areas and other targeted areas (such as social facilitates); and

- improve coordination and balance between the needs for energy and the needs of other high growth sectors (such as tourism).

Under the Infrastructure Development theme, the MGDS seeks to increase access to electricity and reduce reliance on biomass fuels, as per the indicators set out in Table 3.

Table 3: Energy-related indicators from the Malawi Growth and Development Strategy

Energy infrastructure indicators	Baseline (2005)	Target (2011)
No. of new trading centres connected to electricity	45	148
Access to electricity	7.1%	10%
Proportion of population using solid fuels	94.2%	84.5%

Increasing electricity supply and improving electricity infrastructure are clearly critical to the development of productive sectors of the economy and to the improvement of household energy supply. Nevertheless, the MGDS does not provide clear guidance on how the energy needs of the over 90% of the urban, peri-urban and rural population that does *not* have access to electricity will be addressed.

Conservation of the natural resource base, a sub-theme of the Sustainable Economic Growth section, recognises improved forestry management as a part of the MGDS. However, the Strategy does not connect the role of sustainable forest management in energy supply and in the creation of viable jobs, or the opportunities for private sector development related to biomass supply. Moreover, reliance on biomass energy is seen as a *constraint to growth* rather than an opportunity for rural people to secure sustainable livelihoods based on meeting their own needs and those of commercial energy markets.

In short, the MGDS looks forward to a vastly increased electricity access scenario without recognising that the bulk of the population will be dependent on biomass energy for the foreseeable future. Addressing the needs of the biomass-dependent population with realistic and modern approaches is critical to the development of pro-poor economic strategies.

3. Institutional and Regulatory Context of the Biomass Energy Sector

3.1 Introduction

This section provides information on the current institutional and policy framework of the biomass sector. As in many sub-Saharan African countries, energy policy in Malawi is primarily directed towards the development of the electricity and petroleum sectors, with a fundamental objective of reducing dependence on biomass fuels.

Within the biomass energy sub-sector, prevailing policy and legal provisions consider biomass to be subject to forestry policy before it is harvested and energy policy thereafter. The Forest Department (FD) is therefore expected to handle the "supply side" and the DoE the "demand side". This may seem logical on paper, but the absence of a holistic approach to the biomass energy supply chain is problematic and means that although consumption of biomass energy underpins the national economy, its sourcing, production, transport and trade fall under separate regulatory environments and sometimes contradictory legal frameworks.

The case of charcoal illustrates this contradiction. Charcoal is a major fuel upon which a majority of the urban population depends. It is virtually unthinkable that charcoal might not be available any more: nowadays it has become the most significant urban energy source. Charcoal provides a relatively low-cost energy option and its trade supports a significant flow of income to rural areas. However, under Article 81 of the Forestry Act (1997), charcoal from indigenous trees is deemed illegal unless it can be shown to have been produced from a sustainably managed forest for which an approved management plan exists, and for which a production licence has been applied for and received. Given that no forest management plans have yet been enacted, either for Forest Reserves or forests on customary (village) land, no charcoal producer in the country can be legally recognised. Charcoal is regularly confiscated by government authorities and those involved in its production and transport are routinely harassed. So while charcoal satisfies nearly 40% of urban household energy demand and is the focus of several demand-side initiatives by the DoE and its development partners, its production is technically forbidden. A piecemeal approach to any industry that includes contradictory elements of both active engagement and criminalisation, clearly discourages modernisation or investments in more sustainable production.

3.2 The Energy Sector

3.2.1 National Energy Policy (2003)

A National Energy Policy was completed in 2003 by the Department of Energy Affairs, following a participatory process involving a large number of stakeholders. The policy was designed to achieve the following long-term goals:

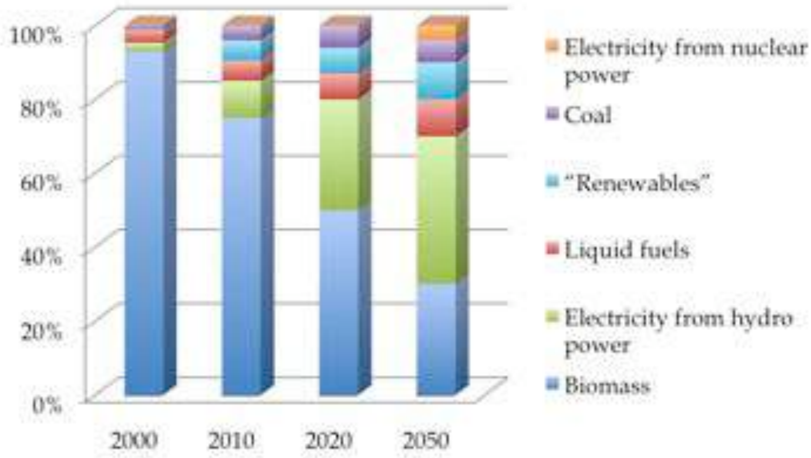
(i) make the energy sector robust and efficient, to support GoM's agenda of poverty reduction, sustainable economic development and enhanced labour productivity;

(ii) catalyse the establishment of a more liberalised, private sector-driven energy supply industry; and

(iii) transform the country's energy economy from one that is overly dependent on biomass to one with a high modern energy component.

The policy is focused on moving energy use away from "traditional biomass" to "modern"[11] sources of energy (electricity, liquid fuels and "renewables") that can "stimulate economic activity and reduce poverty." As shown in Figure 6, it sets a target of reducing biomass reliance from 93% in 2000 to 50% in 2020. The policy is thus primarily devoted to substituting away from biomass energy. Improving the supply and efficiency of biomass– the largest source of energy in the country - receives only a small portion of attention.

Figure 6: Energy mix projections, 2010-2050



Progress to date in substituting for biomass is falling well short of these policy targets. At current rates of change, biomass will still account for 82% of total national energy consumption in 2020, rather than the 50% that was targeted.

The National Energy Policy sees the private sector is seen as the main driver of sector development and government institutions are to manage the process with:

a) investments (e.g. in rural electrification, liquid fuels storage and infrastructure);
b) incentives and subsidies;
c) institutional support (training, promotion, etc); and
d) regulation of the sector.

The document notes that biomass energy supply is not a policy mandate of DoE and that the supply side is covered under the Land Policy Act (2002), the Forestry Policy (1996) and the Forestry Act (1997) (see below). Thus the task of managing the supply of woodfuel, the primary energy source in the country, is not seen as falling within the remit of the Department of Energy Affairs.

The chapter on biomass is one of the shortest chapters in the document. The guidelines for the biomass sector focus on:

a) **efficient utilisation** of woodfuels (through improved charcoal production and better stoves); and
b) **substitution** with ethanol gel fuel, biomass briquettes and biogas.

[11] While the National Energy Policy describes biomass as "traditional" and potential alternatives as "modern", these terms are avoided in the BEST study as they inadvertently create the impression that the energy source determines the society's level of development, rather than the other way around.

The policy envisages an ambitious transition from woodfuels to electricity, liquid fuels, coal and renewables. As described elsewhere in this document, the costs associated with implementing this policy would be extremely high (even if such transition were technically feasible), principally because the prevailing price charged for electricity by the state-owned power utility is well below the long-run marginal cost (LRMC)[12] of production so a large and sustained subsidy would be required.

There is little discussion in the document of the *modernisation* or *sustainability* of the woodfuel sector. This is critical, as in the absence of affordable alternative energy sources, most of the rural and urban poor are going to be reliant on biomass for the foreseeable future.

In addition, there is no mention of the fact that biomass is a local and in principle renewable resource, and therefore contributes to satisfying the energy security of the country. Biomass does not need to be imported and paid for in foreign currency, instead it is produced by the rural population and this can support substantial rural economic development.

To reduce the demand for biomass, the Energy Policy presents three categories of government intervention:

a) **Infrastructure Investments**. The policy suggests that investments in, among other things, rural electrification and liquid fuels storage and infrastructure would help reduce demand for biomass.

   Experience from elsewhere in sub-Saharan Africa suggests that rural electrification programmes do not in fact result in large uptake of electricity for cooking; and neither should they, given the cost of installing electricity generating capacity and the greater overall value in applying electrical power to the industrial and service sectors of the economy rather than as a biomass substitute for cooking. Rural electrification experience demonstrates that customers typically utilise electricity for lighting, entertainment, limited motive power (grinding, agro-processing) and small businesses.

   The Energy Policy recognises the potential value of investments in liquid fuels infrastructure. The most viable liquid fuel options are paraffin (kerosene) and LPG. Paraffin infrastructure is largely in place so the only logical intervention for this fuel would be liberalisation to allow the market to operate more efficiently (see below). Infrastructure investments would be more helpful in the case of LPG, for which current high prices arise in part from a lack of storage and distribution facilities. The policy therefore focuses appropriately on investment in LPG storage facilities, canisters and cooking appliances. Investments elsewhere in LPG storage (e.g. Senegal and Kenya) have resulted in lower consumer prices and have greatly increased the uptake of this fuel for cooking.

b) **Incentives and subsidies**. The Energy Policy suggests that incentives and subsidies should be provided to encourage substitution away from woodfuels to various alternatives. However, those incentives and subsidies are not elaborated. There is an opportunity in the BEST process to reconsider incentives to direct the market in clearer directions.

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[12] LRMC is defined as the cost of providing an additional kWh of energy output over and above energy currently being produced.

Electricity priced below its LRMC is a clear subsidy that has encouraged uptake of this energy source for cooking among the urban middle-class. However, it is unclear how much longer the electricity sector can subsidise the price of electricity, especially when there is need for new investments to increase the already-constrained supply capacity. The government's objective of increasing electricity availability for manufacturing clearly competes with the policy of making electricity more widely available for cooking. It will be difficult to satisfy both requirements simultaneously.

The price of paraffin is set by the government and is generally considered unattractive to the private sector. The result is a lack of interest in the importation of paraffin and this leads to regular shortages in the markets. Ironically, a price *increase* from the mid-2008 level of MK 132.6/l (US 90 cents/l)[13] would probably see greater uptake of paraffin for cooking as it would incentivise importation and improve availability. Few paraffin cooking stoves are available in Malawi markets (as compared to electric stoves, which are widely sold), indicating a lack of interest amongst the population in using paraffin as a cooking fuel. This may be as much about the fuel's availability as its price.

Because the price of LPG is high and supply is limited, LPG stoves and canisters are also largely unavailable in the market. Active implementation of policies that a) promote infrastructure development and b) subsidise the price of canisters and stoves (not the gas itself) have the potential to greatly reduce the cost of using LPG.

Finally, the development of incentives for uptake of more efficient charcoal cooking stoves could have an impact on charcoal use, as well as consumer perceptions about charcoal. However, further efficiency improvements will not be easy to achieve, given that the penetration rate of improved cooking stoves in urban areas is already high.

c) **Institutional support**. Training and promotion are key parts of any programme to substitute away from biomass. Such programmes cannot occur in a vacuum and must be part of a planned programme to introduce incentives and develop infrastructure for a given technology. For example, a training programme to teach installers to build biogas digesters is likely to fail if the economic incentives do not exist to convince consumers to take up the technology. The piecemeal approach may explain a number of failures in past alternative energy programmes in Malawi, which appear to have assumed that promotion and training can overcome inherent limitations of a fuel's price, performance and availability. Such limitations have undermined (e.g.) the promotion of ethanol-based fuels and biomass briquettes, as neither are attractive options for consumers based on prevailing price, performance and availability. Institutional support must be directed at those fuels which have realistic prospects of uptake by consumers, and by grounded in sound data on economic viability, functionality, availability and cultural acceptability. Biomass fuels – particularly woodfuels - largely meet those requirements.

3.2.2 Energy Laws (2004)

Four Energy Acts, together considered the Energy Laws (2004), were created to help in the formation of a regulated and liberalised energy sector in Malawi. These Acts set out the legal framework that governs the establishment of the Malawi Energy Regulatory Authority (MERA), the formation of a Rural Electrification Fund and the development of liberalised electricity and liquid fuels sectors. None of the Acts directly addresses the use of biomass as

[13] A rate of 148 Malawi Kwacha (MK) to the US dollar ($) is assumed throughout.

a cooking fuel, but they do provide a direction for the development of policy and incentives for the overall sector.

Act 20, the Energy Regulation Act, is chiefly concerned with the development of MERA, which has recently been operationalised. MERA has the legal authority to regulate *all forms of energy*. Biomass is included and specifically mentioned. However, the Act does not elaborate how the Authority should regulate biomass energy in practice.

Act 21, the Rural Electrification Act, lays the groundwork for the formation of a Rural Electrification Management Committee and a Rural Electrification Fund. Act 22, the Electricity Act, deals with electricity licences, tariffs, transmission and sales contracts, generation, distribution, land rights and related issues. Act 23, the Liquid Fuels and Gas (Production and Supply) Act is concerned with liquid fuels and gas production, licensing, fair competition, safety, strategic reserves, pricing and taxation. These three Acts do not deal with biomass fuels.

3.3 The Forestry Sector

The National Forest Policy (1996) sets out the policy framework for the forestry sector and the Forestry Act (1997) develops a legal framework for enforcing the policy.

3.3.1 National Forest Policy (1996)

In its Preamble, the Forest Policy recognises that the former Forestry Act (Cap 63.01, 1942) is out-dated; it "does not provide a mechanism for managing trees and forests on customary land; nor does it make it clear the rights of individuals and communities to own, manage and utilise, on a sustainable basis, indigenous trees growing on such land." The preamble also recognises the lack of scope "for the participation of the private sector" in forest conservation and management.

The policy provides a framework for sustainable production and conservation of wood resources and recognises the importance of woodfuels in the national energy supply and the need to bring about improvements in their sustainable production and supply.

In Section 2, the document lays out the general objective of "satisfying people's diverse and changing needs, particularly those of rural people who are the most disadvantaged." It specifically mentions the woodfuel needs of farmers in its General Objectives and Strategies, and recognises the importance of forest products in "improving the quality of life in rural communities and providing a stable local economy…".

In section 2.3, the Policy directs that communities should promote sustainable harvesting of forest resources through Village Natural Resource Committees (VNRCs). This section encourages such groups to engage in "woodfuel sales from planted trees." The policy provides for the introduction of "marketing and pricing policy reforms", which could (e.g.) give incentives to industrial woodfuel users for tree planting.

The Policy also recommends monitoring of "urban and rural demands for woodfuel and other forest products" to help ensure that forests can be managed sustainably. The Policy recognises the economic importance of woodfuels (including charcoal) as forest products.

In Section 2.3.11, the Policy calls for a reduction in "dependence on woodfuel as a source of energy" through switching to alternative sources of fuel and adopting woodfuel-saving devices. Implementation of this part of the strategy is envisaged through DoE.

The Forest Policy also calls for:

(i) active participation of the private sector in forest management and (woodfuel) planting; this includes the provision of an enabling environment for access to government-controlled plantations by small scale enterprises.

(ii) recognition of forestry as a driver of rural livelihoods; and

(iii) use of international funding arrangements for achieving incremental costs of forest conservation (including carbon trading funding).

In summary, the Forest Policy clearly recognises the value and importance of woodfuels, especially for the livelihoods of producers in rural areas, and explicitly promotes the idea of sustainable woodfuel production as a commercial enterprise. This is a positive and encouraging framework that forms a useful basis for developing a viable woodfuels industry.

Implementation in a practical sense has been constrained by entrenched views amongst politicians and law enforcement authorities that woodfuels should *not* in fact be encouraged, a view also propagated by the National Energy Policy, which has made it difficult to enact the woodfuel-friendly provisions of the Forest Policy.

3.3.2 Forestry Act (1997)

The Forestry Act, assented in May 1997, enacts many of the policy recommendations discussed above. It creates a Forest Administration, a Forest Management Board, Forest Reserves/Protected Areas, Customary Land Forests, afforestation and forest protection procedures, utilisation practices and a Forest Development and Management Fund.

Inasmuch as the Act provides the legal basis by which the policy is implemented, there is no need to discuss its substance in detail. However, it is noteworthy that the Act, unlike the policy document, makes clear and specific reference to the legal status of charcoal (in Section 81):

> *(1) No person shall make or sell charcoal from indigenous timber or tree except pursuant to a license issued under this section.*
>
> *(2) Upon application in the prescribed form, a licensing officer may, where the officer finds that the making of charcoal shall utilise plantation timber or indigenous timber or trees consistently with the applicable forest management plan or forest management agreement or forest plantation agreement, issue a licence to make charcoal in such quantity and from such timber or trees as may be specified in the licence.*

As explained above, the provision for legal charcoal production therefore exists. In spite of this provision, the BEST team was only made aware of one licence ever being issued for charcoal production since the adoption of the revised Act[14] and this licence was revoked before any charcoal could be brought to market. Therefore all charcoal produced in the country remains illegal.

3.4 Summary

Both the Forestry and Energy policies and laws impinge directly on the biomass energy sector, the former handling the supply side and the latter the demand side. Although the Departments of Forestry and Energy Affairs fall under the same ministry, this distinction has not been conducive to holistic and integrated management of the sector from source to end-user. This dichotomy is unique to the biomass sector and such as division is not present in the liquid fuels or electricity industries, where importation, distribution and supply are handled under single entities and sets of legislation.

While forestry legislation encourages the commercial production of woodfuels and specifically provides for the production of charcoal under specified conditions, those conditions have not yet been met to the satisfaction of those responsible for licensing. All charcoal made from indigenous trees therefore remains technically illegal.

The Energy Policy promotes a move away from biomass energy in favour of electricity and various suggested alternatives, but at current trends the country will still be 82% reliant on biomass energy in 2020.

Measures are required to operationalise the provisions of the Forestry Act, in order to provide consumers with a legal charcoal alternative. At the same time, a revision of the Energy Policy is justified to make it more pragmatic and realistic, acknowledging that the country is going to remain highly biomass-dependent for the foreseeable future. A more pro-active stance will be required towards managing and developing the biomass energy sector as a vibrant and productive part of the economy, rather than the current policy that only tolerates biomass fuels as an undesirable and retrogressive interim solution, pending the introduction of alternatives. It is the aim of this Strategy to present the means for developing the biomass energy sector in a more pro-active and positive way.

[14] The licence was issued in 2005 to a retired forester in Salima who was sustainably managing an *Acacia polyacantha* woodland and using a half-orange kiln to make charcoal efficiently, but was deemed to be degrading the environment.

4. Overview of Energy Demand and Supply

This chapter gives a summary of the energy demand and supply picture at national level. The two chapters that follow then explore demand and supply in detail.

4.1 Demand

4.1.1 Overview

BEST data analysis reveals that annual per capita energy consumption in Malawi is about 11.4 Giga-Joules (GJ) in 2008. This compares to an average of 80 GJ/c for upper-middle income economies and over 200 GJ/c in high income economies. What is more, much of the energy is consumed in relatively inefficient ways. Malawi can therefore be categorised as a low and inefficient energy consumer.

Some 93% of the country's energy supply comes from indigenous resources, practically all of which (97.4%) are conditionally renewable. Therefore over 90% of current energy demand is potentially sustainable. This is one of the cornerstones for long-term economic development and is something that the Biomass Energy Strategy can build upon.

Table 4 gives a summary of energy consumption for Malawi by sector and energy source in 2008. The same information is portrayed graphically in Figure 7 and Figure 8 which follow.

Table 4: Total national energy demand in Malawi, by sector and fuel

Sector	Energy demand by fuel type (TJ/yr)					
	Biomass	**Petroleum**	**Electricity**	**Coal**	***Total***	
Household	127,394	672	1,798	0	**129,864**	83.4%
Industry	9,664	3,130	2,010	3,481	**18,285**	11.7%
Transport	270	5,640	35	15	**5,960**	3.8%
Service	452	558	477	174	**1,661**	1.1%
Total	**137,780**	**10,000**	**4,320**	**3,670**	**155,770**	
	88.5%	6.4%	2.8%	2.4%		

Note: (i) Biomass = firewood, charcoal, crop residues and ethanol.
(ii) Petroleum = petrol, diesel, paraffin (kerosene), jet-A1, avgas, fuel oil and LPG.
(iii) Household demand for petroleum products comprises urban (432 TJ) and rural (240 TJ).
(iv) Hydro power accounts for 98% of electrical generation.
(v) The following inputs were used to produce final energy demand:

Energy input	*Energy output*
21,000 TJ wood	8,836 TJ charcoal
520 TJ bagasse	86 TJ electricity
420 TJ molasses	270 TJ motor ethanol
(12,702 TJ hydro power	4,234 TJ electricity)
21,940 TJ total input	**9,192 TJ total output**

(vi) The total energy inputs (21,940 TJ) plus final demand (155,770 TJ), minus the energy outputs after conversion (9,192 TJ), are an estimated 168,518 TJ.

Source: Table 6, Table 7 and Table 9 (below); National Statistical Office Trade Balance, projected to 2008; ESCOM Annual Report, 2007; BEST team projections.

Figure 7: Malawi total energy demand by sector

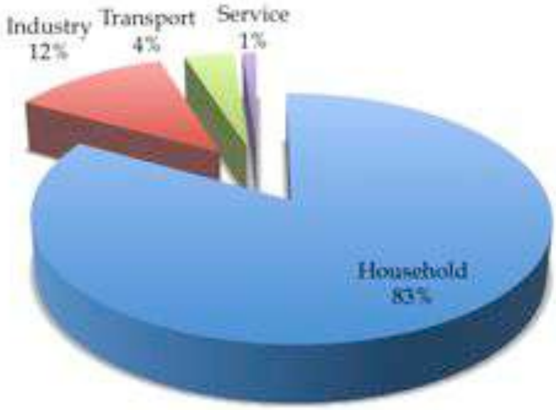
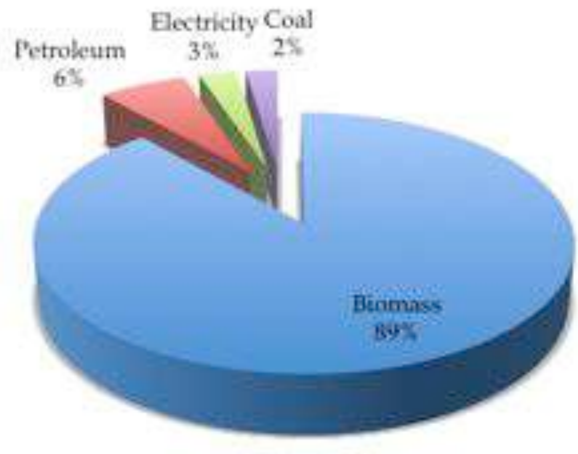


Figure 8: Malawi total energy demand by fuel



As the table and charts show, the household sector is the dominant energy user and accounts for 83.2% of total energy consumption. This is followed by the industrial sector (11.9%), with the transport and service sectors accounting for 3.8% and 1.1% respectively.

Biomass is Malawi's main source of energy, mainly in the form of wood. It accounts for an estimated 88.5% of total demand, ranging from 98% in the household sector through 54% in the industrial sector and 27% in the service sector to 5% in the transport sector.

In terms of wood equivalent (w.e.), the total demand for biomass energy in 2008 is 8.92 million t. w.e. (air dry) or about 13.38 million m^3 solid (or 24.3 mill. m^3 stacked)[15]. Wood and other forms of biomass are used for additional (non-energy) purposes such as construction, joinery and furniture. The additional demand for these applications is about 1.5 million m^3 for wood products alone.

While much of the demand for household energy in rural areas is met by self-collection, most urban biomass is purchased and practically all biomass for non-household uses is purchased or

[15]Accounting for the conversion loss in charcoal production, the biomass input is equivalent to 9.71 million t. or 14.56 million m^3 (air dry), or 26.5 mill. m^3 stacked.

plantation-grown for own use. This makes biomass the most important commercial fuel in the country, in terms of economic value, employment and energy security.

4.1.2 Non-Biomass Energy Demand

All Malawi's petroleum products are imported. As would be expected, the transport sector is the largest consumer of oil products. Locally-produced ethanol (from molasses) is blended with petrol seasonally, up to a maximum of 10%. Ethanol prices are based on importparity rather than production costs, with the price pegged at about 5% below the landed cost of petrol to ensure that blending remains an attractive option for the petroleum companies. This pricing policy is currently under review by MERA.

LPG and paraffin are important cooking fuels in many developing countries. However, they are rarely used in Malawi for cooking, principally because of high price (in the case of LPG) and inconsistent availability (in the case of paraffin). Paraffin and candles are used for lighting almost exclusively in the 97% of households without electricity.

Demand for electricity is limited by low levels of access, even in urban areas. There are about 3.12 million households in Malawi, of which 2.64 million are in rural areas and 0.48 million are urban. The number of households connected to electricity, both legally and illegally, is only about 145,000. This is only 5% of all households and 30% of urban households. Industry accounts for nearly 50% of demand for electricity, but only 10% of industrial demand for energy is met by electricity. This is because much of the energy required by industry is heat for agricultural crop drying or processing, for which biomass is a more cost-effective option.

Malawi consumes about 125,000 t. of lump coal per annum and 7,800 t. of duff (dust and fines). Coal is only used, to any significant extent, in the industrial sub-sector. A new plant is expected to come on-line in May 2009 to convert duff that is currently unmarketable into coal briquettes for tobacco curing and other industrial uses. This may increase total consumption of coal products, possibly at the expense of biomass if tobacco growers find the briquettes suitable and competitively priced.

4.2 Supply

4.2.1 Biomass Energy Supply

Nearly all of Malawi's current demand for energy is met from indigenous, renewable resources.[16] There has been considerable debate as to whether the supply of biomass is sustainable and this will be discussed in detail in the following sections.

In summary, for the country as a whole, the estimated annual growth of stem, branch and twig wood in all locations, whether in woodlands, forests or plantations, on farms, along roadsides or in towns, is estimated to be 29.8 million m^3 of solid wood. This is from a minimum growing stock of over 400 million m^3. The estimated annual sustainable supply of wood is therefore more than double current demand (14.9 million m^3).

Taking into account the additional annual production of crop residues and dung (12.1 and 0.5 million m^3 solid w.e. respectively), the estimated annual sustainable supply of all biomass (42.4 million m^3 of solid w.e.) is some 2.7 times current demand (15.8 million m^3).

[16] Biomass is considered a *conditionally renewable* source of energy, though current practice in Malawi is to refer only to wind, hydro and solar PV as "renewables".

This portrayal of a significant overall surplus of biomass should be interpreted with care. To be of use, especially as fuel, sources of biomass have to be close to the centres of demand. There may be large surpluses in the north of the country, but these are neither economically nor physically accessible to the bulk of the population living in the centre and the south. Some trees are also in national parks or other conservation zones and should not be cut. As a result, while there is an excess of biomass nationally, rates of harvesting are well in excess of sustainable supply in the country's main urban catchments around Lilongwe and (particularly) Blantyre and Zomba.

When analysing the supply and demand balance situation for biomass fuels, the availability within a physically or economically accessible radius has to be considered. The potential supply has to be judged on whether it is sustainable and whether there are more attractive alternative uses for the biomass resource or the land on which it is growing, both economic and environmental.

Not only is most of the surplus biomass inaccessible to the main zones of consumption, but the wood resource base is also diminishing, principally because woodlands and trees in agricultural areas are being cleared to open up new land for farming. Between 1991 and 2008, an estimated 669,000 ha of woodlands were converted to agriculture while over 70 million m^3 of wood were cleared for agricultural expansion. In 2008 alone, the area cleared will be an estimated 45,000 ha. The diminishing standing stock is resulting in a gradual reduction in the amount of biomass that can be sustainably harvested each year.

What is more, because of farm land scarcity, the average length of the shifting cultivation cycle has been reduced from about 15 to ten years. The soil fertility of cleared areas is therefore in decline, meaning that yields are lower and land must be left to recuperate after two years of cultivation instead of three. While land recovering under shifting cultivation systems yielded about 4.7 million m^3 of wood in 2008 from cleared trees, it experienced a permanent reduction in the above-and below-ground woody resource base of about 6.6 million m^3. In addition, non-timber forest products are being lost, thus reducing the overall value of the cleared areas.

Crop residues are only available seasonally and mainly used on-farm. They are also a fuel of low acceptability, especially in the household sector. Nevertheless, it is reported that more and more households are using crop residues out of necessity. In a 2002 study of labour allocation in three villages in southern Malawi, it was found that residues from cassava and maize were the *principal* household fuels in one village because of wood scarcity (Fisher et al, 2002).

Dung is burnt as fuel in some countries but is rarely used in Malawi; it can be considered a fuel of last resort and has a potentially greater value as a fertilizer. If dung is fed to a biogas digester then the loss of nutrients does not take place as the slurry is itself an excellent fertilizer; there are also hygiene benefits.

As will be discussed later, it is the catchment areas around the main towns of Lilongwe and Blantyre where the supply/demand situation is most critical. In these areas the tree capital is being over-exploited and the burning of crop residues for fuel is expanding. This applies to large swaths of Central Region and the majority of Southern Region, which are now providing fuel to the three largest towns of Blantyre, Zomba and Lilongwe.

The continuing increase in population, which is expected to double in the next 25 years or so, will place intolerable strains on the land and woody resource base in certain areas unless steps are taken to increase agricultural and silvicultural (tree) productivity. This can still be achieved, given proper inputs and incentives.

4.2.2 Non-Biomass Energy Supply

After biomass, hydro-power is the next largest indigenous renewable energy resource. It is used almost exclusively to generate electricity. At present 282 MW of hydro-electricity capacity are installed and a further 64 MW is expected to be available from 2011, with the commissioning of replacement turbines at the Kapichira hydro plant. Given a forecasted increase in demand for electricity of 6% p.a., this new generating capacity will merely result in a better quality of supply and as early as in 2012 there will be a deficit again. Malawi expects to rely on an inter-connector with the Southern Africa Power Pool (SAPP) to satisfy its demand thereafter. In order to maintain generating capacity, it is important to preserve the watersheds of the rivers flowing into and out of Lake Malawi, to avoid siltation of the hydro-station turbine intakes. It is of concern that one of the most over-harvested areas for woodfuels is the Shire Valley in Southern Region, within the Blantrye/Zomba urban catchment area, which is also where most of the hydro-power stations are located and where soil erosion and riverine siltation have far-reaching impacts beyond the biomass energy sub-sector.

Sugar cane waste (bagasse) is used in both of the country's sugar factories (at Dwangwa in the north and Chikwawa in the south) to produce heat and steam, about 10% of which is used to generate electricity for the factories and workers' houses (about 5 MW capacity). It has been estimated that the two factories could produce a surplus equivalent to about 10 MW during the crushing season of up to 200 days per year. This, however, would be dependent on a viable price being offered from the Electricity Supply Corporation of Malawi (ESCOM), which at present has a domestic tariff of US 2.65 cents, below the factories' cost of production.

Another potential supply of electricity could come from surplus wood grown in the Viphya plantations as a boiler fuel. A power station of 100 MW capacity could be built using thinnings and wood residues. For the stability of the national power transmission grid, an additional power plant in the north of the country would be very useful. Again, the viability of such a scheme depends on the price at which electricity could be sold into to the national grid, currently an unattractive prospect for independent power producers.

Coal is the last potential indigenous resource that could be used to generate electricity. There are four coal fields in Malawi, three in the north and one in the south, but only the Livingstonia and Ngachira Fields in the north are currently being mined, for industrial use. Table 5 summarises production and consumption of coal in 2008.

Table 5: Production and consumption of coal in Malawi

Mine	**Annual production (t.)**		
	Lump coal	**Duff**	***Total***
Mchenga (Livingstonia)	50,400	21,600	***72,000***
Livingstonia 2	5,000	2,200	***7,200***
Livingstonia 3	25,200	10,800	***36,000***
Livingstonia 4	3,800	1,600	***5,400***
Ngachira	6,300	2,700	***9,000***
Total Malawi production	***90,700***	***38,900***	***129,600***
Estimated consumption	90,700	7,800	***98,500***
Imports from Mozambique	34,643		***34,643***
Estimated total consumption	***125,343***	***7,800***	***133,143***

Source: Lincoln Bailey, owner, Mchenga mine

The estimated reserves of coal are about 80 million t. and proven reserves are approximately 20 million t. The coal is of variable quality, with energy values ranging from 17 to 29 MJ/kg. As the table shows, demand for lump coal is currently in excess of domestic supply and the shortfall is met through importation from Mozambique.

All petroleum products are imported via Tanzania, Mozambique or South Africa. The transport cost to the major market in Blantyre is at least $90 per t. for liquid products and $150 per t. for LPG. This high transport cost is the principal reason why it is profitable to produce in-country to blend with petrol. There are two ethanol plants, each linked to one of the two sugar factories but run by separate companies. With the current high price of petroleum, both factories have been able consistently to raise their ethanol prices, keeping them pegged about 5% below the landed price of petroleum. Ethanol has also been converted to gel and liquid fuels for domestic and industrial use, but these have not been judged economically viable or suitable for Malawian foods or cooking practices, according to independent assessments commissioned by GTZ and UNDP (see Owen & Saka, 2006; and Ethio Resource Group, 2007).

Finally, solar energy is available in large quantities but is not easily used for cooking purposes: photovoltaic energy is expensive at approximately $6 per installed Watt, while a cooking stove easily requires 1 kW. Solar thermal energy could be useful for agricultural processing (crop drying) but less so for household cooking as solar cookers are not user-friendly devices and do not suit the foods and cooking habits of Malawians.

5. Biomass Energy Demand

5.1 Introduction

Following the preceding summary of the national energy supply - demand situation, this chapter now looks in detail at the demand-side of biomass energy.

There have been remarkably few surveys of biomass energy consumption in Malawi, considering that biomass fuels account for over 88% of national energy demand. In order to keep this report as straightforward as possible, a description of the main surveys conducted prior to the BEST 2008 work has been relegated to Annex F.

The two past surveys deemed sufficiently reliable to be used as a basis for extrapolation to 2008 were those conducted by Arpaillange (1997) and Milner & Openshaw (1997), who considered (respectively) household and non-household energy consumption in urban areas as part of a previous biomass energy strategy development process funded by the World Bank. These studies were well-resourced, comprehensive and professionally conducted, and provide easily the most accurate assessment of biomass energy demand in recent decades. Extrapolation to 2008 based on these studies was therefore deemed a reliable approach, scaling up the mid-1990s data on the basis of population growth projections.

For household and non-household consumers in rural areas it was necessary to commission original studies of demand as part of the 2008 BEST development process. The energy consumption habits of 851 rural households in 22 districts were surveyed, representing the country's eight largest livelihood zones, as outlined in Annex G. This household survey included a questionnaire and an assessment of fuel consumption based on direct weighing. A survey was also commissioned of energy consumption in small-scale enterprises such as restaurants and resorts, brick burning operations, lime kilns and ceramic production. This report has been published separately (see Makungwa, 2008) and also included an assessment of energy consumption in institutions providing catering services such as schools, colleges, prisons, police stations, military barracks and hospitals.

5.2 Estimated Total Biomass Energy Demand

Based on the past surveys and the new studies commissioned under BEST, the total consumption of biomass energy for household and non-household uses in 2008 is estimated at just under 9 million t. in wood energy equivalent terms, as presented in Table 6.

Table 6: Estimated consumption of biomass energy by fuel and sector, wood equivalent

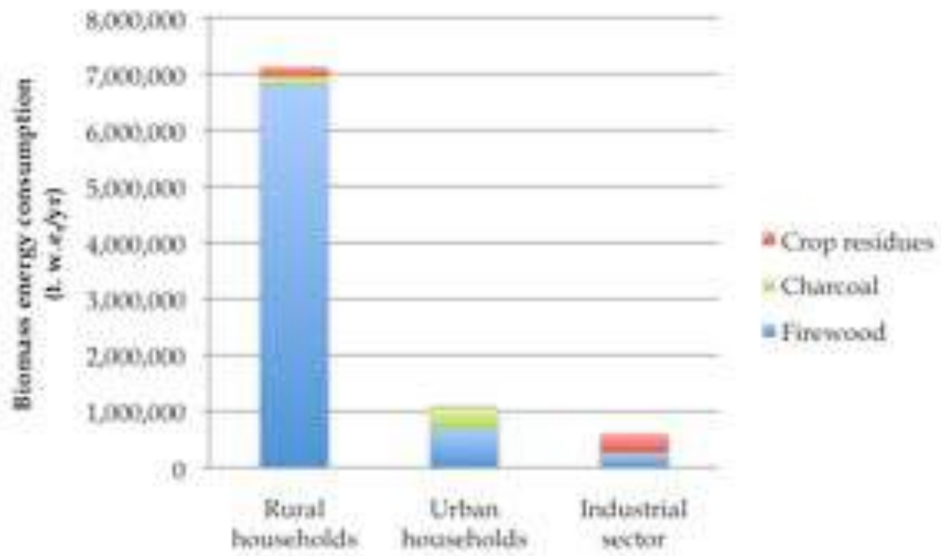
Sector	Consumption of biomass energy (t. wood equivalent, air-dry/yr)					
	Firewood	Crop residues	Charcoal	Wood residues	*Total*	
Rural households	6,794,790	192,350	152,430		***7,139,570***	79.9%
Urban households	681,290	710	409,035		***1,091,035***	12.2%
Industrial sector	255,500	379,180	2,000	8,500	***645,180***	7.2%
Transport sector		27,100			***27,100***	0.3%
Service sector	22,600		6,600		***29,200***	0.3%
Total	**7,754,180** *86.8%*	**599,340** *6.7%*	**570,065** *6.4%*	**8,500** *0.1%*	***8,932,085*** *(9,711,380 w.e. input)*	

Note: (i) Rural household energy demand includes 57,000 t. w.e. for cottage industries.
(ii) Urban household energy demand includes 6,000 t. w.e. for cottage industries.
(iii) Wood residues are sawdust, bark etc.
(iv) Crop residues include maize stalks and cobs, tobacco and cassava stalks, bagasse and molasses.

Source: Table 9 to Table 13 below. Figures are based on data from 1996 and BEST surveys in 2008, forecasts of population made in 1998, plus data from other sources. Allowing for data inaccuracies, actual consumption of biomass energy could range from 8.1 to 9.8 mill. t. in wood equivalent terms (8.8-10.7 mill. t. w.e. input).

Figure 9 presents the same information graphically.

Figure 9: Estimated consumption of biomass energy by sector



Note: Service and transport sectors are omitted from the chart (negligible relative consumption).

Rural household energy consumption accounts for 80% of total consumption, with urban households at 12% and the industrial and service sectors combined at 8%. If cottage industries are included in the industrial and service sector categories, the total for these sectors is increased slightly to 8.5%.

Firewood is clearly the country's dominant fuel, with crop residues and charcoal accounting for just under 13% between them. However, charcoal is an important (and growing) commercial fuel, especially in urban areas, and residues (mainly in the form of bagasse and molasses) are a significant industrial fuel.

Table 7 gives the estimated national biomass consumption in terms of energy and actual units.

Table 7: Estimated consumption of biomass energy by fuel and sector, actual units

Sector	Charcoal		Firewood & sawdust		Residues (incl. molasses)		*Total*
	t.	**TJ**	**t. wood**	**TJ**	**t. residues**	**TJ**	***TJ***
Rural households	81,470	2,363	6,794,790	105,319	238,510	2,981	***110,663***
Urban households	218,620	6,340	681,290	10,560	880	11	***16,911***
Industrial sector	1,070	31	264,000	4,092	470,185	5,877	***10,000***
Transport sector					33,605	420	***420***
Service sector	3,530	102	22,600	350			***452***
Total	***304,690***	***8,836***	***7,762,680***	***120,321***	***743,180***	***9,289***	***138,446***

Note: (i) Molasses has an energy value of about 10 GJ/t. Therefore, the actual amount of molasses input is about 42,000 t.
(ii) Cottage industries consume 57 TJ of charcoal, 851 TJ of firewood and 22 TJ of residues for a total of 930 TJ. This brings the service sector and the formal and informal industries sector to an estimated 8.2% of the biomass energy total. This may be on the low side.

5.3 Household Energy Demand

5.3.1 Introduction

The previous section summarised overall demand for biomass energy across all sectors. This section now addresses demand from the household sector only. Household energy accounts for over 80% of Malawi's final energy demand and the prime position of this sector will be maintained for several decades. Because of its importance, and because biomass fuels are so dominant (accounting for nearly 90% of total demand and 90% of household demand), surveys were undertaken to determine the quantities and type of fuels used by purpose and the supply sources for these fuels.

Such surveys are necessary because biomass fuels are produced principally by the informal sector and this production is not monitored or recorded in any consistent or systematic way. In addition, the supply of woodfuel comes mainly from customary lands and again is not recorded; neither is the supply of agricultural residues or dung. Even for more formally regulated fuels such as paraffin, LPG and coal, the breakdown of use by sector is known only roughly. Household supply of electricity is metered, but illegal connections are not recorded and neither are multiple households served from the same meter. For all fuels, end-use is not recorded, nor are people's preferences for different fuels known.

Thus if supply and demand for energy is to be monitored over time and meaningful demand forecasts are to be made, a more structured system must be put in place to conduct consistent surveys at more frequent and regular intervals.

5.3.2 Overall Household Energy Demand

Table 8 gives an estimate of total household energy consumption for urban and rural areas for 2008 by main fuel type.

Table 8: Estimated household energy consumption

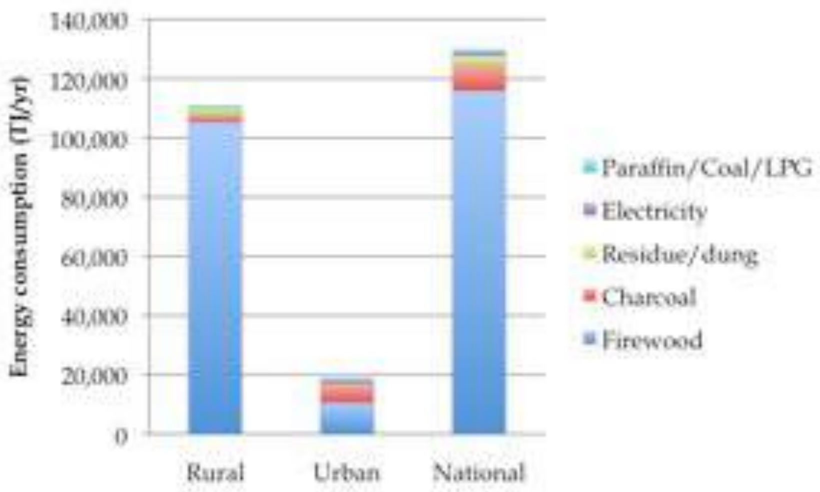
	Energy consumption (TJ /yr)			
	Rural	**Urban**	***National***	
Firewood	105,320	10,560	*115,880*	*89.1%*
Charcoal	2,360	6,340	*8,700*	*6.7%*
Residue/dung	2,980	11	*2,991*	*2.3%*
Electricity	70	1,728	*1,798*	*1.4%*
Paraffin	240	430	*670*	*0.5%*
Coal	0	5	*5*	*0.0%*
LPG	0	2	*2*	*0.0%*
Total	**110,970**	**19,076**	***130,046***	***100%***

Note: (i) The table shows median figures. For biomass the range is 10% either side of the median.
(ii) Non-household energy use has been excluded.

Source: Arpaillange, 1997. DoE; BEST 2008 rural survey; BEST team projections.

Figure 10 presents the same information graphically.

Figure 10: Estimated household energy consumption



The data show the paramount position of wood energy. This indicates it will take a massive shift in current practice to substitute other fuels for wood, hence the importance of sustaining the wood resource base.

5.3.3 Urban Household Energy Demand

Estimates of total energy consumption by urban households are presented inTable 9 and Figure 11.

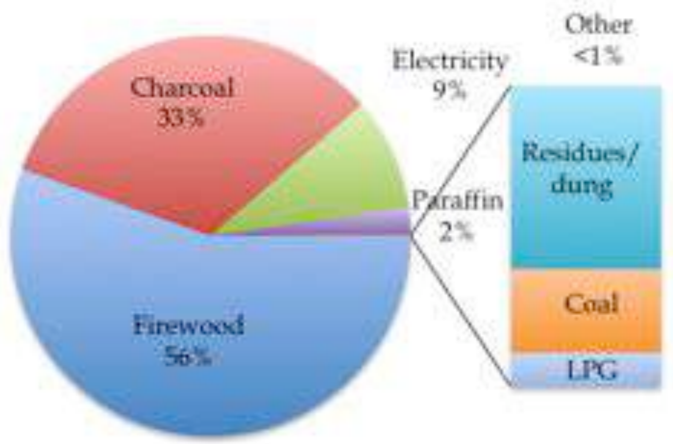
Table 9: Urban household energy consumption by fuel type

Fuel	Total urban energy consumption (TJ)			
	Median estimate		Range of estimate	
Firewood	10,560	55.4%	9,500 - 11,620	55-56%
Charcoal	6,340	33.2%	5,710 - 6,970	33-34%
Electricity	1,728	9.1%	1,728	8-10%
Paraffin	430	2.2%	430	2%
Residues/dung	11	0.1%	10 - 12	0%
Coal	5	0.0%	5	0%
LPG	2	0.0%	2	0%
Total:	**19,076**		**17,385 - 20,767**	

Note: (i) 2008 estimates, based on a total urban population of 2,326,200.
(ii) For biomass fuels, the range is 10% either side of the median.
(iii) Estimates cover all domestic uses of energy, not only cooking.

Source: Based on Arpaillange (1997), with corrections and updates. e.g. original consumption estimates were for only eight towns so were adjusted to include all district capitals and other urban centres, as listed in Annex E; original estimates were also based on a 360 day year and were adjusted to 365 days.

Figure 11: Urban household energy consumption by fuel type



The table shows that the median estimate for total energy consumption by urbanhouseholds in 2008 is 19,076 TJ p.a. The median estimate for biomass energy consumption alone is 16,911 TJ, equating to 1,091,030 t. w.e., of which 0.1% is residues, 37.5% charcoal and 62.4% wood.

The majority of urban households (66%) cook with more than one fuel, but firewood remains dominant and is still the first choice in three-quarters of urban households. This is perhaps surprising and is mainly a reflection of low disposable income. Taking into consideration accessibility, convenience and appliance cost, wood is the cheapest available option[17], especially as the poorest urban residents can still collect at least some firewood at no financial cost.

Low income also means that many urban consumers (43%) have to buy fuel on a daily basis and cannot afford to buy in bulk or to purchase stoves. Even charcoal is normally purchased daily rather than in bulk by the bag, which would be considerably cheaper. Unless incomes increase substantially, people will be unable to move to cleaner and more convenient fuels such as charcoal, paraffin or LPG. Movement up the "energy ladder" is inextricably linked to poverty reduction efforts and the country's wider economic prosperity.

Charcoal has become increasingly important and now accounts for 33% of total urbanenergy consumption, up from 24% in 1994, while firewood's share has gone down from 66% to 56% over the same period. In Blantyre the trend has been most pronounced and charcoal is now as important as firewood in energy terms. The contribution of electricity has doubled nationally, from 4% to 8% since 1994. Other fuels are stand-by options or used for particular tasks or dishes. Diversity of fuel use is income-related: the higher the income, the greater both the variety of sources and the overall consumption of energy.

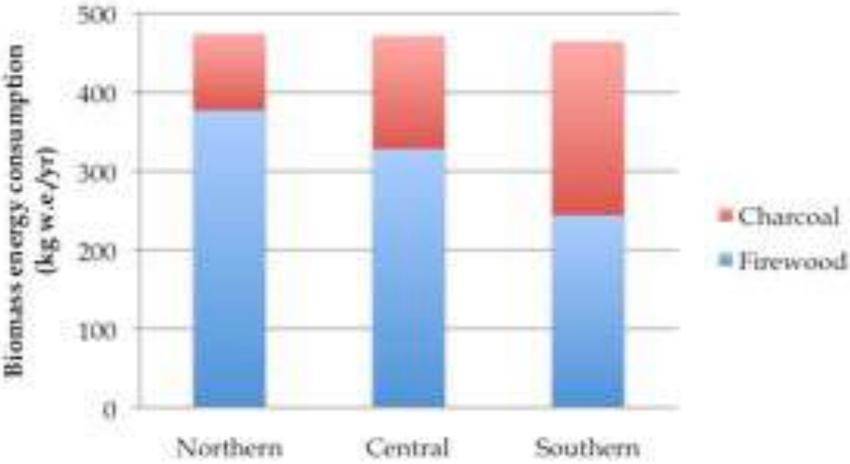
Table 10 and Figure 12 look in more detail at biomass consumption by urban households and presents average per capita consumption for each region.

Table 10: Urban per capita household consumption of biomass energy by region

Region	Wood	Charcoal		Residues		*Total*	
	kg/yr	kg/yr	kg (w.e.)	kg/yr	kg (w.e.)	*kg (w.e.)/yr*	*cu.m.*
Northern	377.16	51.99	97.27	0.37	0.31	***474.74***	*0.91*
Central	328.12	76.95	143.98	0.38	0.31	***472.41***	*1.01*
Southern	243.73	118.14	221.03	0.38	0.30	***465.06***	*1.15*
Weighted average:	***292.92***	***94.02***	***175.91***	***0.38***	***0.31***	***469.14***	***1.07***

[17] The comparative energy modelling in Chapter 7 will show that electricity is in fact the cheapest source of energy for urban cooking, assuming that wood is paid for, but this does not taken into account the cost of getting connected and buying the appliance, that fact that only 30% of urban households are connected; even many of the connected household cannot afford a monthly payment for electrical cooking, only a daily one.

Figure 12: Urban per capita household consumption of biomass energy by region



As the table and chart show, per capita consumption of energy in urban areas decreases slightly (2%) from north to south, even though there is a rise in the amount of charcoal (a higher energy fuel) being used. There is a clear trend from north to south towards greater commercialisation of woodfuels in urban areas, alongside more efficient use, in response to growing local shortages.

Firewood is mainly used for cooking (76%) and for heating water (22%), with only 2% used for space heating. Firewood is also used in 20% of households for commercial activities such as making hot food, sweets and cakes. About 80% of firewood users collect some of their requirements, including lopping branches off trees and collecting dead wood. In all, an estimated 20% of urban firewood is collected at no financial cost.

As stated above, charcoal is the second most common urban household fuel. It is mainly used for cooking, but secondary uses include the heating of irons, space heating and warming water; it is infrequently used for economic activities within the household. Charcoal is a more convenient fuel than firewood and is mainly used by middle- and upper-income families.

Consumption patterns differ between towns. Charcoal is most firmly established in the "old towns" of Blantyre and Limbe but is less common in smaller towns. Lilongwe falls between the two, being a large town but relatively young. Over time there is a switch to charcoal in all urban areas as firewood becomes scarcer and hence more expensive. The number of charcoal users will continue to rise as the population becomes more urbanised and woodbecomes scarcer, as the GLOBUS projections in chapter 7 outline.

Paraffin is used by 80% of urban households for lighting, including by some of those connected to electricity, but only 6% of urban households use paraffin for cooking, half of which use it occasionally and the balance all of the time. Some paraffin is used as a starter fuel to light charcoal fires.

LPG is used infrequently as a back-up cooking fuel as the market size is currently very small and prices remain uncompetitive compared with biomass fuels and electricity. This may change as the main importer (Afrox) launches a cheaper 6 kg bottle and an accompanying promotional campaign.

Officially, 25% of households in the four main towns[18] are connected to grid electricity. With illegal and shared connections the true figure could be closer to 30%, and about 25% for all urban areas. Illumination is the principal end use of electricity (in terms of numbers of users).

Most middle- and upper-income people with mains electricity cook with it. This is unsurprising because it is the cheapest fuel at present, except when firewood is freely collected. It has an added advantage of being cleaner and more convenient to use. Barriers to the even wider uptake of electricity for cooking include unreliability of supply, high cost of stoves and the unsuitability of available appliances for cooking a number of common foods, such as those that require grilling or roasting.

The current electricity tariff is estimated to be about 30% of the LRMC[19] so connected households are effectively being subsidised by the state-owned power utility. Upper-income households who consume the most power are receiving a subsidy of around $830 per year, medium-income users receive $320/yr and low income users receive about $80/yr[20]. Hence the well-off are benefiting most from the under-priced electricity. The present tariff system is justified by the government because it is helping the poor; however, this is contradicted by the evidence that richer consumers are in fact benefiting the most.

5.3.4 Rural Household Energy Demand

A rural household energy consumption survey covering 22 districts was undertaken as part of the BEST process. One district in Northern Region was sampled, plus nine in Central Region and 12 in Southern Region (see Annex G).

Based on this survey, Table 11 gives the estimated rural per-capita annual consumption of firewood, residues and charcoal for the three regions.

Table 11: Rural per-capita household consumption of biomass energy by region

Region	Wood	Charcoal		Residues		*Total*	
	kg/yr	kg/yr	kg (w.e.)	kg/yr	kg (w.e.)	*kg (w.e.)/yr*	*cu.m.*
Northern	678.56	5.22	9.77	22.44	18.10	*706.43*	*1.06*
Central	646.28	5.93	11.09	23.13	18.65	*676.02*	*1.01*
Southern	538.62	8.92	16.69	18.85	15.20	*570.51*	*0.86*
Weighted average:	***601.10***	***7.21***	***13.49***	***21.10***	***17.02***	***631.61***	***0.95***

Note:
(i) It is assumed that charcoal is used year-round.
(ii) It is assumed that residues are used in combination with firewood for 30 days/yr in Northern Region and 45 days/yr in Central and Southern Regions, coinciding with crop harvest periods.
(iii) To estimate consumption by region, equal weight was given to each sample by district for Central and Southern Regions. Only one district was sampled in Northern Region so estimates were made based on those sample districts from Central Region closest to Northern Region, and taking into consideration that the north has the highest availability of wood energy.

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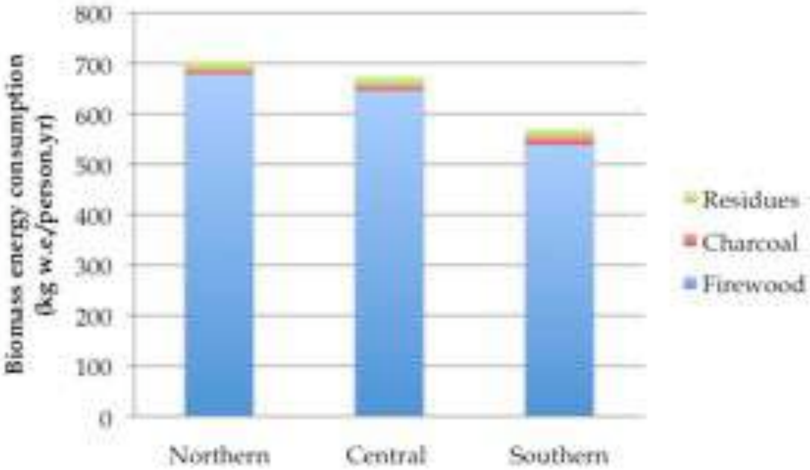
[18] Blantyre, Lilongwe, Zomba and Mzuzu, in order of decreasing size.
[19] US 2.65 cents vs. an estimated LRMC in the region of US 9 cents.
[20] Based on Openshaw (1997) adjusted for 2008 domestic tariffs (7% lower than in 1997) and higher LRMC (US 9 cents rather than 7 cents in 1997).

(iv) Estimated annual consumption of wood for space and water heating is 28.62 kg per capita. Estimated annual consumption of biomass energy for cottage industries is 5.04 kg per capita in w.e. terms. The average is weighted according to the population in each region.

Source: Rural household biomass energy survey conducted as part of BEST process, led by K. Sichinga.

Figure 13: Rural per capita household consumption of biomass energy by region



As in the urban areas, it is apparent that there is a decrease in per capita consumption of biomass energy in rural areas (in w.e. terms) from north to south, while the consumption of charcoal in rural areas increases. An increase in the relative scarcity of biomass from north to south results in this declining per capita consumption (due to efficiency measures), alongside an increase in the commercialisation of biomass.

Crop residues are increasingly used for fuel as wood becomes scarce. An estimated 0.02 million m[3] of residues (in w.e. terms) are estimated to be used in rural households in 2008. Because it was harvest time (April/May) when the rural survey was undertaken, the use of residues was found to be particularly high. Information from respondents suggests that residues are used for about 45 days per year in Central and Southern Regions and 30 days per year in Northern Region, usually in combination with firewood. However, residues, leaves and twigs are used year-round as kindling to light the fire.

Some residues, such as cotton stalks, have to be burnt to reduce the incidence of crop disease while others, such as tobacco, cassava and pigeon pea stalks, have wood-like stems and do not require as much tending as maize stalks. However, for most residues there are other competing uses such as animal feed, thatching and mulch. The trade-off between these uses is dependent on alternatives being available; if wood is scarce, then the most desirable end-use may be eliminated. One major rural industry, sugar production, uses huge volumes of crop residue (bagasse) as a boiler fuel to produce heat, steam and electricity.

Cooking is the most important end use of biomass energy in rural areas, but about 8% of total demand comes from cottage industries such as brewing and distilling, firing pottery, sweet and confectionery making, fish smoking, cloth dyeing, cassava drying, nut roasting and vegetable oil manufacture.

The survey found that charcoal is used in about 5% of rural households for cooking, to supplement firewood and residues; charcoal is also used for heating traditional irons. At higher elevations and during the cool season, additional firewood is used for heating and warming water. It is estimated that the cool season lasts for about 90 days per year and that an extra 20% of biomass energy is used during this time. Thus overall, 5% more fuel is used for space and water heating.

Using the per-capita consumption figures from Table 11, an estimate can be made of total rural household energy consumption for 2008. This is shown in Table 12 and Figure 14.

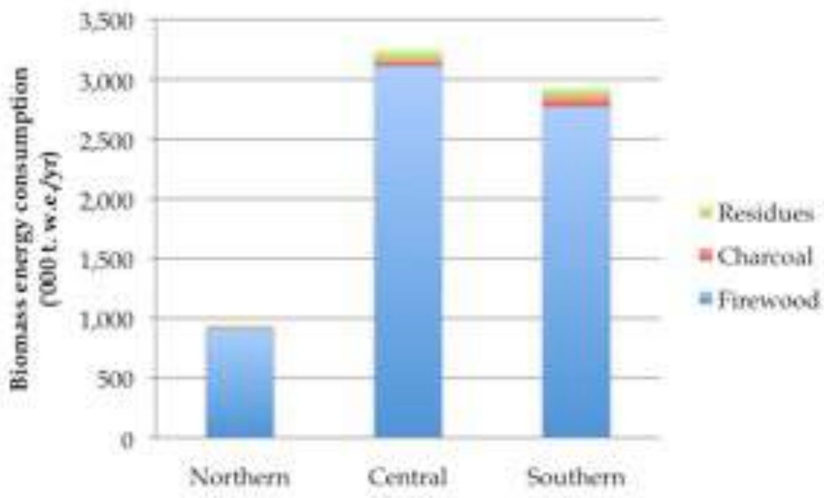
Table 12: Estimated rural household consumption of biomass energy by region

Region	Population	Wood	Charcoal		Residues		*Total*
		'000 t.	'000 t.	'000 t. w.e.	'000 t.	'000 t. w.e.	*'000 t. w.e.*
Northern	1,343,200	911.44	7.01	13.12	30.14	24.31	***948.87***
Central	4,813,900	3,111.13	28.55	53.41	111.35	89.80	***3,254.34***
Southern	5,146,900	2,772.22	45.91	85.90	97.02	78.24	***2,936.36***
Total	***11,304,000***	***6,794.79***	***81.47***	***152.43***	***238.51***	***192.35***	***7,139.57***

Note: (i) The wood input for charcoal production is an estimated 360,000 t. The wood equivalent is in terms of energy: end-use efficiency is not considered.
(ii) The estimated additional use of wood for water and space heating during the cold season is 323.52 million kg.
(iii) The estimated use of biomass energy for cottage industries is 57 million kg. (w.e.). See Table 13 below.

Source: Rural household biomass energy survey conducted as part of BEST process, led by K. Sichinga.

Figure 14: Estimated rural household consumption of biomass energy by region



In terms of wood energy equivalent, an estimated 7.140 million t. was used by rural households in 2008, of which 2.1% was charcoal, 2.7% residues and 95.2% wood. Residue consumption may have been underestimated, but the total estimate should be within 10% of actual consumption. Additional sample surveys are required and should ideally be undertaken at least twice per year, in the cool season and after harvest.

5.4 Non-household Biomass Energy Demand

As well as meeting domestic energy needs, biomass energy is also an important fuel for the industrial and service sectors, both formal and informal, and household cottage industries. Consumption surveys were undertaken by the BEST team and industries were contacted to ascertain their use of biomass energy. Secondary sources and previous surveys were also consulted where there were gaps in the figures.

Based on these assessments, Table 13 and Figure 15 give the estimated consumption of non-household biomass energy for 2008. The study commissioned by the BEST team on which most of these figures are based is available as a separate report (Makungwa, 2008).

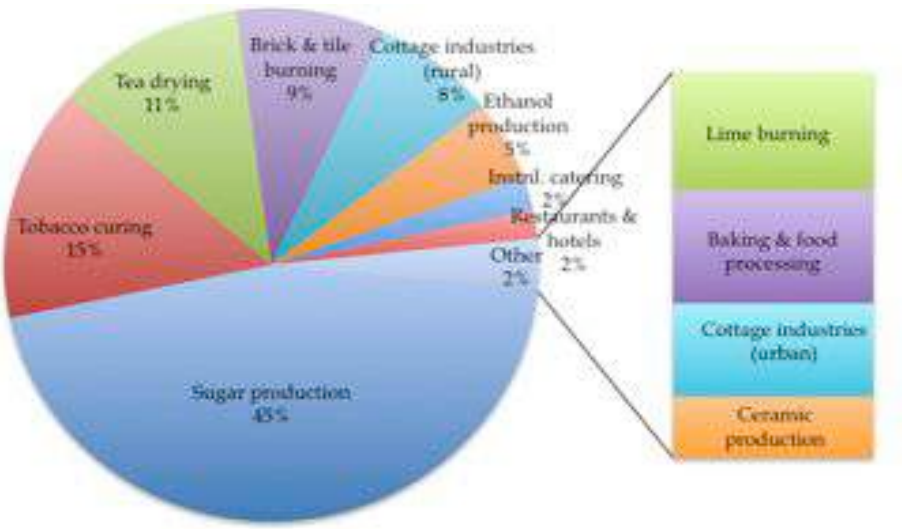
Table 13: Estimated non-household biomass energy consumption by sector

Sector	Biomass energy consumption (t. w.e., air-dry/yr)				
	Charcoal	**Firewood**	**Wood residues**	**Crop residues**	***Total***
Institutional catering		15,700			*15,700*
Restaurants & hotels	6,600	6,900			*13,500*
Brick & tile burning		54,000	7,000	7,000	*68,000*
Lime burning		7,600			*7,600*
Ceramic production		900	1,500	1,500	*3,900*
Baking & food processing		6,000		1,300	*7,300*
Sub-total	*6,600*	*91,100*	*8,500*	*9,800*	*116,000*
Tobacco curing	2,000	100,000		9,000	*111,000*
Tea drying		87,000			*87,000*
Sugar production				340,000	*340,000*
Ethanol production				38,000	*38,000*
Sub-total	*2,000*	*187,000*		*387,000*	*576,000*
Cottage industries (urban)	2,500	3,500			*6,000*
Cottage industries (rural)	1,200	54,400		1,400	*57,000*
Sub-total	*3,700*	*57,900*		*1,400*	*63,000*
Grand total	***12,300***	***336,000***	***8,500***	***398,200***	***755,000***

Note: (i) Sugar production based on 340,000 t. (w.e.) of bagasse.
(ii) Ethanol production of 15.46 mill. litres from ca. 59,000 t. of molasses (38,000 t. w.e.).
(ii) Cottage industries include brewing, sweet-making, cooking food and beverage for sale, soap-making and ceramic production.

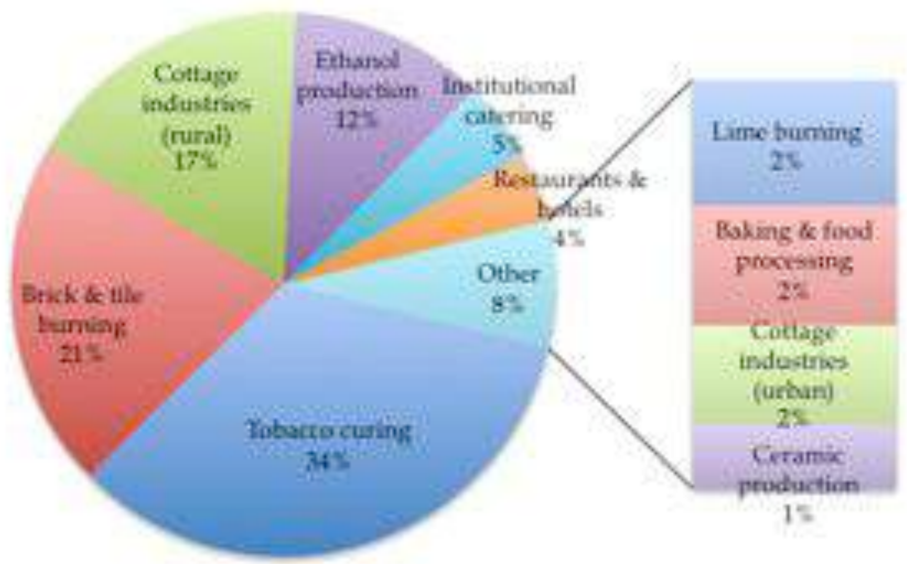
Source: Makungwa, 2008; Openshaw et al, 1996; RWEDP, 1989; Presscane Ltd. and Ethco Ltd. for sugar, bagasse and ethanol production; Alliance One for tobacco information; Eastern Produce Malawi Ltd. for tea information.

Figure 15: Non-household biomass energy consumption, by sector



The inclusion of the sugar and tea industries in the chart may slightly confuse the picture, as both industries are essentially self-sufficient in the energy they require for producing sugar and drying tea. While they are clearly major energy consumers, they are largely using energy that they produce from their own land (firewood in the tea estates and bagasse in the sugar estates). The same information is portrayed in Figure 16, minus these two industries.

Figure 16: Non-household biomass energy consumption, by sector (excl. tea and sugar)



The chart illustrates the importance of tobacco curing and brick burning as major biomass energy consumers in the non-household sector. Successful efforts have been made by GTZ's Programme for Basic Energy Conservation in Southern Africa (ProBEC) and the tobacco industry to develop more efficient smallholder tobacco curing barns. As evidence of success, in 2008 some 500 new "rocket"-type barns were expected to be built by Alliance

One out-growers using commercial credit. The new barns not only save fuel, but also produce a better grade of tobacco for which the farmers can secure a higher price.

5.5 Demand for Poles and Sawnwood

While wood energy is used daily and accounts for the largest proportion of wood use in Malawi, poles and sawnwood are used extensively in building, construction, joinery and furniture. They are also used for fencing in urban and rural areas and, in particular, by the tobacco industry to build sheds and racks for the curing of tobacco.

While no nationwide consumption survey of these products has taken place, baseline information is available for the tobacco industry (World Bank, 1992) and surveys have been carried out in neighbouring countries. The results from these surveys indicate that about 5% of total wood consumption is used as poles and 5% goes for sawlogs. However, because about 50% of the wood is wasted when converted to sawnwood, and this waste is usually used as fuel, the consumption of sawnwood is taken as 2.5% of total consumption to avoid double counting.

Consumption of other wood products from trees grown within the country are negligible and can thus be neglected.

5.6 Demand for Energy and Non-Energy Wood Products

Using the information from the various surveys and reports, estimates can be made of household biomass energy consumption plus the additional consumption of wood for poles and sawnwood. The latter is included so that a comparison can be made between sustainable wood supply and total demand for all uses. Refer to Table 14.

Table 14: Estimated consumption of wood products and crop residues for energy

	Consumption of wood products and crop residues ('000 m³ roundwood equivalent/yr)		
	Rural	**Urban**	***Total***
Firewood & sawdust etc.	*10,578*	*1,066*	*11,644*
Charcoal wood	*523*	*1,476*	*1,999*
Woodfuel wood	*11,101*	*2,542*	*13,643*
Poles	907	65	*972*
Sawnwood	180	100	*280*
Total roundwood	*12,188*	*2,707*	*14,895*
Crop residues for fuel	884	1	*885*
Total (wood equivalent)	***13,072***	***2,708***	***15.780***
Range in estimate	(11,880 – 14,380)	(2,460 – 2,980)	*(14,345 – 17,360)*
Total biomass energy	***12,018***	***2,543***	***14,528***
Range in estimate	(10,895 – 13,185)	(2,310 – 2,795)	*(13,210 – 15,980)*

Note:
(i) 1.5 m³ = 1 t. wood (15.5 GJ); 6.67 m³ = 1 t. charcoal.
(ii) The range estimate is 10% either side of the median.
(iii) Rural pole consumption includes 356,000 m³ for tobacco drying.
(iv) The sawlog total is double the sawnwood total, but it is assumed that off-cuts etc. are used for fuel, which already are counted as firewood.
(v) Annex H gives a breakdown by rural and urban for each region and each catchment area.

Firewood dominates both total wood consumption and total biomass energy consumption, accounting for an estimated 74% and 80% respectively. It must be cautioned that some of the figures in Table 14 were generated from rapid sample studies and estimates from other country surveys. While the order of magnitude is correct, it should be stressed that regular demand and supply surveys should be undertaken to monitor the changes in consumption patterns and the different supply sources.

Land-use patterns are constantly changing in response to population increase, migration, national and international demand for food and fibre, and technical/managerial innovations. This affects the type and quantity of biomass growing on the various land formations, which in turn affects the sustainable supply of the various flora and fauna. The dynamics of such changes must be monitored frequently if appropriate actions are to be taken.

5.7 Commercial Energy Demand

5.7.1 Volume of Traded Woodfuel

This section investigates commercial traded woodfuels. Biomass is not only Malawi's principal fuel source in terms of energy value, but is also its most important traded energy in terms of both value and employment. Most firewood is still collected, but practically all charcoal is traded and, in the sugar industry, bagasse has commercial value when used for generating heat, steam and electricity. Firewood is important to cure Virginia grade tobacco and the tea industry grows sufficient firewood to meet all of its tea drying requirements.

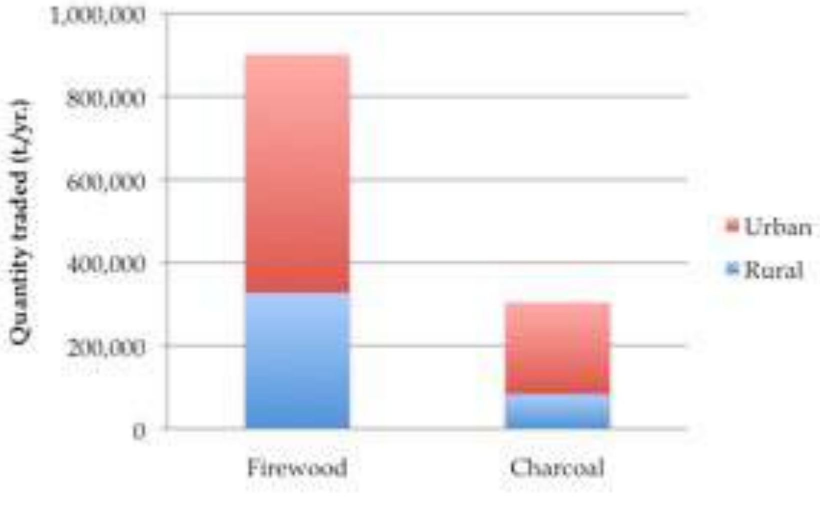
Table 15 gives an estimate of traded firewood and charcoal for 2008. This should be compared with Table 7, which gives total firewood and charcoal consumption.

Table 15: Estimated traded firewood and charcoal by sector

	Traded firewood (air-dry t./yr.)			**Traded charcoal (t./yr.)**		
	Household	**Non-household**	***Total***	**Household**	**Non-household**	***Total***
Rural	70,000	257,400	*327,400*	81,470	1,930	*83,400*
Urban	545,000	29,200	*574,200*	218,620	2,670	*221,290*
Total	***615,000***	***286,600***	***901,600***	***300,090***	***4,600***	***304,690***

Source: Extrapolation from Milner & Openshaw, 1997, based on population growth in rural and urban areas, with allowances for increased scarcity in main urban catchments.

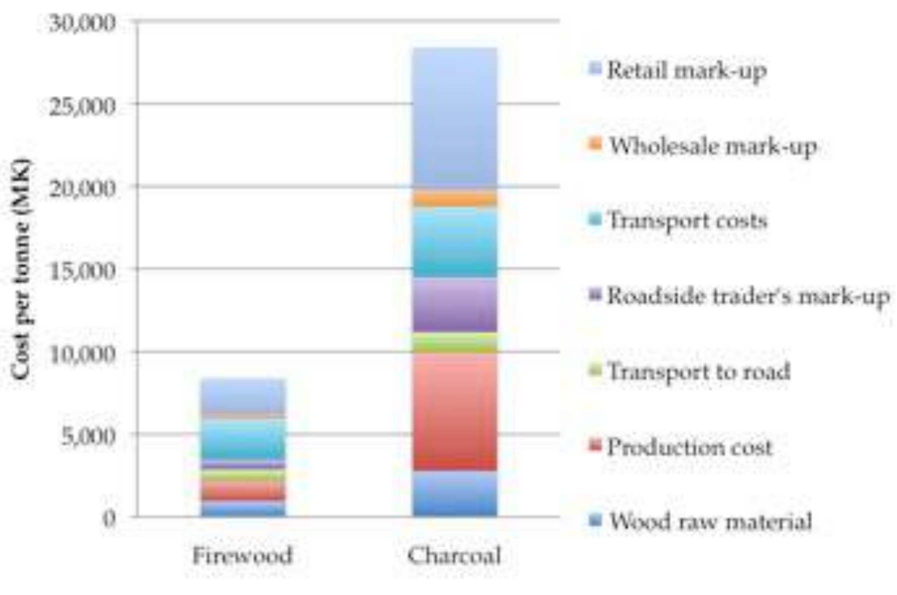
Figure 17: Estimated quantity of traded firewood and charcoal by urban-rural



5.7.2 Value of Traded Woodfuel

The price of firewood and charcoal was collected along the roadside and at markets in Lilongwe and Blantyre. This information was used in collaboration with the price build-up throughout the supply chain for the principal towns in 1996 to arrive at urban price build-ups for firewood and charcoal in 2008. This information is summarised in Figure 18 and the details are provided in Annex I.

Figure 18: Average price build-up for urban traded firewood and charcoal



The chart shows the average retail price of firewood and charcoal across all urban areas, while Table 16 breaks this information down by region and by town.

Table 16: Estimated average price for firewood and charcoal by town and region

Average price (MK/tonne)						
Region:	**Northern**	**Central**	**Southern**		**Various**	***Average***
Town:	**Mzuzu**	**Lilongwe**	**Blantyre**	**Zomba**	**Other towns**	
Firewood rural	6,070	7,400	6,510			***6,850***
Firewood urban	7,550	9,030	8,290	7,250	6,660	***8,390***
Charcoal rural	23,680	29,600	22,645			***25,795***
Charcoal urban	26,640	33,300	25,160	27,825	25,160	***28,120***

Note: The full price build-up, from source to retailer, is provided by fuel and by town in Annex I.

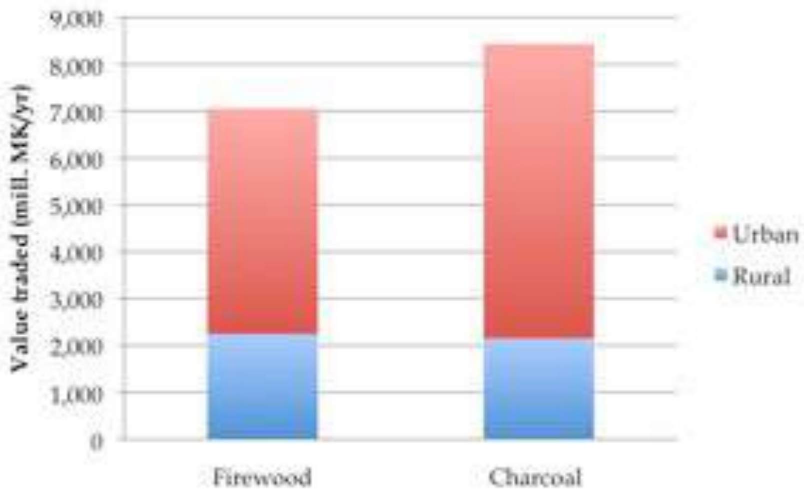
Source: Data collection in 2008; Appendix 3a and 3b in Milner & Openshaw 1997, adapted and updated.

Using the average prices for firewood and charcoal and applying them to the estimated traded firewood and charcoal consumption by region and urban area, an estimated value of traded woodfuel can be made for 2008. This is shown in Table 17 and Figure 19.

Table 17: Estimated value of traded woodfuel

	Value of traded fuel (mill. MK)		
	Firewood	**Charcoal**	***Total***
Rural	2,244	2,151	***4,395***
Urban	4,818	6,289	***11,107***
Total	***7,062***	***8,440***	***15,502***

Figure 19: Estimated value of traded woodfuel



As shown, the estimated value of all traded woodfuel in 2008 is over MK 15.5 billion, nearly $105 million. This provides the bulk of energy to urban households and rural industry. Without it, Malawi would have to spend much more to import substitutes such as paraffin and LPG or to provide electricity in place of woodfuel at a considerable cost, where feasible.

While Figure 17 shows that the size of the firewood market is larger a national level than the charcoal market, Figure 19 shows that the charcoal market is worth more in monetary terms.

5.8 Woodfuel Demand in Urban Catchment Areas

5.8.1 Introduction

The catchment areas[21] (CAs) supplying the four major towns within the country require special attention when considering energy demand, namely Mzuzu in the north, Lilongwe in the centre and Blantyre/Limbe and Zomba in the south. This is because these areas have relatively large population densities and are exerting the most pressure on the surrounding natural resources.

The CAs serving these four towns supply all kinds of products to the urban areas besides firewood and charcoal, such as poles and sawnwood; they also supply the non-household sector. In addition, the CAs supply the goods and services to rural people living within those areas. An assessment of the total demand for all these wood and other biomass products must therefore be made in order to determine if the supply of raw material is sustainable for each urban CA.

This assessment was based on a previous report *Urban Biomass Fuels: Production, Transportation & Trading Study* (Openshaw, 1997). In addition, a 1991/92 Forest Resource Mapping & Biomass Assessment for Malawi (GoM, 1993) was used to determine the quantity and type of indigenous trees growing in the various catchment areas, incorporating projections of land cover change for 2008. This information, together with more up-to-date data and surveys undertaken for the present study, were used to estimate the production, transport and trade of biomass.

5.8.2 Woodfuel Production for Urban Areas

Firewood is the dominant fuel supplied to urban areas. In energy terms, it accounts for 58% of biomass fuel used in towns, but only 42% in wood raw material terms. This is because only one-third of the wood energy is captured in the charcoal production process, the other two-thirds being lost in the conversion, whereas there are virtually no losses in the firewood production process.

Over 90% of the firewood originates in rural areas, mostly as roundwood, but some from sawmills as off-cuts, bark and occasionally as shavings or sawdust. The remaining wood comes from urban forests, roadsides, open areas as well as garden and farm trees.

Firewood production is an informal rural industry with an average of less than two people employed in each production enterprise, 90% being members of the same family. A few producers grow their own wood and some use part of their firewood production for cottage industries. Firewood production is a year-round occupation and is a principal income source for those involved; many producers or family members are subsistence farmers as well.

The urban areas provide the largest market for traded firewood, but it is also sold to some rural households, rural industries (such as fish smoking, lime burning and tobacco curing) and rural institutions (such as schools, hospitals and army camps). However, all the major tea estates are now self-sufficient in firewood for tea processing.

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[21] A catchment area is defined as the geographical supply zone from which woodfuels are sourced to satisfy the demand in the main urban centre.

In 2008, about 80% of urban firewood was traded – an estimated 574,200 air-dry tonnes, the remainder being self-collected. The smaller the town, the more self-collection takes place. All urban charcoal is traded – an estimated 221,290 t in 2008.

Table 18 gives an estimate of employment generation from traded firewood and charcoal in urban areas, from source to point of retail.

Table 18: Employment generated from urban trading of firewood and charcoal

	Firewood			**Charcoal**			***Total woodfuel***		
	Total value	**of which labour**	**Employ-ment**	**Total value**	**of which labour**	**Employ-ment**	***Total value***	***of which labour***	***Employ-ment***
	MK million		**person-yrs**	**MK million**		**person-yrs**	***MK million***		***person-yrs***
Growing	560	252	2,838	617	278	3,131	**1,177**	**530**	***5,969***
Production	688	607	6,836	1,585	1,341	15,100	**2,273**	**1,948**	***21,936***
Transport to road	400	320	3,604	276	221	2,489	**676**	**541**	***6,093***
Sub-total: prodn. + transpt. to road	*1,088*	*927*	*10,440*	*1,861*	*1,562*	*17,589*	**2,949**	**2,489**	**28,029**
Transport from road									
Manual	566	453	5,101	311	249	2,804	**877**	**702**	***7,905***
Motor	850	170	1,914	633	127	1,430	**1,483**	**297**	***3,344***
Sub-total	*1,416*	*623*	*7,015*	*944*	*376*	*4,234*	***2,360***	***999***	***11,249***
Roadside trading	352	343	3,863	736	718	8,085	**1,088**	**1,061**	***11,948***
Town trading									
wholesale	150	134	1,509	226	205	2,309	**376**	**339**	***3,818***
retail	1,252	1,128	12,702	1,905	1,720	19,369	**3,157**	**2,848**	***32,071***
Sub-total	*1,402*	*1,262*	*14,211*	*2,131*	*1,925*	*21,678*	***3,533***	***3,187***	***35,889***
Total	***4,818***	***3,407***	***38,367***	***6,289***	***4,859***	***54,717***	***11,107***	***8,266***	***93,084***
Quantity	***574,200 t.***			***221,290 t.***			***795,490 t.***		

Note: It is assumed that a person year is 300 days of 8 hours/day. The daily wage is MK 296 ($2) and the yearly rate is MK 88,800 ($600). The percentage of labour costs depends on the operation and the degree of non-manual inputs: this was quantified in the field.

Source: Milner and Openshaw, 1997; Openshaw, 1997; collected data in 2008; BEST team estimates.

An estimated 10,440 producers supply 574,200 t of wood to the urban fuelwood market. But because many firewood producers are transporters and traders as well, or engage in subsistence farming, the actual number of producers serving urban areas is over 15,000. Approximately 40% of these producers are women. In addition, about 2,500 person-years will be spent collecting and transporting wood for self-consumption in 2008, the majority by women and children.

Charcoal is the only other important urban biomass fuel. It has about twice the energy value of wood per unit of weight, is easier to control in a stove, can be extinguished and re-used, and imparts a desired flavour to some foods. In addition, it does not attract insects in storage or deteriorate as easily as firewood. It is a fuel of large towns and of middle-income households. As the radius of a CA increases, the cross-over point between the cost of supplying firewood and charcoal is reached and charcoal then starts to compete with firewood as an everyday fuel.

Thus in Blantyre, the largest town, approximately half the households use charcoal and half use firewood, excluding those cooking with electricity. Lilongwe is the other large town and, between 1996 and 2008, the proportion of its households consuming charcoal increased from about 20% to over 40%. In the other towns between 10% and 20% of households now use charcoal.

As with firewood, charcoal production is an informal rural industry with an average workforce of just over two, 90% of whom are related to each other. It is mainly a full-time, year-round occupation and is more labour intensive than firewood production. Like firewood production, it can be horizontally and vertically integrated. However, a recent industry survey (Kambewa et al, 2007) indicated that about one-third of charcoal is made by large-scale producers and that most small producers are organised by industry middlemen.

Charcoal is mainly produced using earth mounds, but the 2007 survey found that 16% of the producers use pit kilns and 1% use brick kilns. Pit kilns have to be used several times to be worth the effort of digging a pit and brick kilns are semi-permanent structures, thus there has to be a sustainable wood supply near by. The latter two technologies have a higher efficiency than the earth mound, but there are cost-effective ways of improving earth kilns and average conversion efficiencies of about 23% (by weight) are typically reached by traditional charcoalers in the region. This is much higher than the 10-12% recovery rate often quoted, but reliable studies based on empirical measurement confirm that conversion rates of 20% wet weight and 25% dry weight are commonly achieved under realistic operating conditions, questioning the validity of the more pessimistic figures.

Kimaryo and Ngereza (1989), for example, monitored nine kilns across three regions of Tanzania and recorded an average recovery rate of 19% (wet weight) and 25% (dry weight). Bailis (2005) measured the output of ten earth kilns in Kenya and recorded an average conversion efficiency of 20% on the basis of wet wood or 25% on the basis of dry wood. In Malawi, Makungwa (1997) recorded average conversion efficiencies of over 20% by weight. These are satisfactory recovery rates and much higher than commonly quoted. They could probably be increased further, however, if charcoal producers were not evading the law and cutting corners, but were instead operating in an open and legitimate environment where they would have an incentive, for example, to dry the wood for longer before conversion or to modify traditional kilns with a simple metal cover and/or chimney.

Urban areas are the largest market for charcoal. Non-household uses include restaurants, roadside meat roasting stands and blacksmiths. A little charcoal is used by rural households, some of which is self-collected or saved from fires. The only rural non-household uses of charcoal are for a little tobacco curing and by blacksmiths. The cement industry once tried (Viphya) charcoal on an experimental scale. Although this was technically feasible, the charcoal was not cost-competitive with other fuels.

Practically all charcoal is traded. In 2008, it is estimated that there were the equivalent of about 17,590 full-time producers supplying 221,290 t. of charcoal to urban areas. Because some producers were also involved in transport and trading, the actual number was in the region of 25,000 people, 35% of whom were female. The income received by these charcoal producers in 2008 was estimated to be MK 1,861 million ($12.57 mill.), of which MK 1,562 million was for labour. Thus firewood and charcoal producers serving urban areas, most of whom are rural-based, received about MK 2,950 million ($18.9 mill.) - a very substantial amount - and provided employment for over 28,000 rural people.

The wood raw material to produce firewood and charcoal comes from a number of land-use types, with variable ownerships and from a variety of species. The 1996 production survey found that less than 50% of the wood raw material came from natural woodlands and nearly

40% came from open lands, principally farmland, but also from roadside trees, grasslands and urban trees. 15% of the wood came from plantations and woodlots.

It is important to note that the vast majority of the wood (around 80%) comes from non-government-owned trees, mainly from customary and farm land. This is relevant when formulating policy initiatives, especially with regard to the management of the trees and the raw material price (stumpage price). It is widely assumed that the producers obtain much of their wood without paying for it. In fact most producers do pay a fee, either in monetary terms or by clearing land for agricultural expansion for "free" or at a reduced price.

Even so, the above percentage of wood coming from customary land is surprisingly high. It suggests that there is still much dead wood on the forest floor from natural attrition and from over-mature trees that have died. In addition, current thinking about forest management may not adequately address most of the charcoal produced in the country, which does not come from reserved forests but from trees on other lands.

5.8.3 Woodfuel Transportation to Urban Areas

As with its production, the transportation of woodfuel is mainly an informal business. Most of those involved are self-employed and cart the fuel by manual means. It is a business with few entry barriers; at its most basic level no capital is required if the fuel is head-loaded.

Road, track and path transport are the principal means of carting woodfuel to urban traders and consumers. A small amount of woodfuel is transported by boat to the islands within Lake Malawi. Some is also transported by train: every Thursday a train dedicated to charcoal travels from Balaka to Blantyre and is quickly offloaded and sold.

During a seven day road survey, it was found that 51% of the transporters use manual means of transport and 49% use motorised means. However, most manual transporters are in the business full-time and make several journeys a week, whereas only 43% of motorised transporters are exclusively engaged in woodfuel transport. These figures could account for the fact that about 80% of the workforce manually transport woodfuel and only 20% are employed in motorised vehicular transport.

There are differences in transport methods between towns and between fuels. The bicycle is the principal means of manual transport in the CAs of Lilongwe and Blantyre for both firewood and charcoal. In the Zomba CA, head-loading (of firewood) accounts for 70% of manual transport, whereas in the Mzuzu CA, head-loading and hand carts are nearly as common as the bicycle. These are indications of the closer proximity of firewood and charcoal sources to Mzuzu and Zomba, compared with Lilongwe and Blantyre.

An estimated 11,249 "full-time" people are engaged in transporting 795,490 tonnes of woodfuel from the catchment areas to serve the requirements of the main urban areas in 2008 (Table 18). The payment to this workforce is an estimated MK 999 million ($6.75 million) and the total cost of out-of-town transport is MK 2,360 million ($15.95 million).

Of the estimated 11,249 full-time people engaged in transporting woodfuel to all urban centres of Malawi in 2008, 7,015 transported firewood and 4,234 transported charcoal. The latter figures are a proportional breakdown as some transporters carry both fuels.

An estimated 136,290 t. of firewood were self-collected in 2008 for urban household consumption. On average it took about six days per tonne to collect and carry this wood back to the house. Thus, 2,730 person-years were spent collecting this wood. If labour is shadow-priced at MK 148 ($1) per day, then the value of the time collecting and transporting this firewood was MK 121.2 million, plus another MK 20 million for tools, materials and depreciation of bicycles and other equipment.

An average household of 5.6 people consumes about 2.8 t. of firewood per year. It requires nearly 17 days per year, equivalent to 2.6 hours per week or 22 minutes per day, to collect all the firewood requirements of such a household.

5.8.4 Woodfuel Trading for Urban Areas

The woodfuel trading survey found that trading occurs in two different locations, the first at or near the production site and the second in town. Most of the woodfuel procured in rural areas is transported into towns for re-sale. Some wood is bought directly for consumption by households, the service sector or industry. The amount of this direct purchase is not known, but has been estimated at 10% of rural production.

Not all firewood and charcoal is first sold in proximity to the production site. Some producers are also transporters and take the fuel directly from the source into town for sale to traders or to industries. Other producers are both transporters and traders, going round town hawking the woodfuel directly to customers or selling it from their homes. Therefore, it must be remembered that when the trading aspect of the woodfuel chain is separated out and employment statistics are generated, one person may be involved in all three aspects of the business – production, transport and trade. Bearing this in mind, an estimated 13% of woodfuel is sold at the production site or left the site to be sold in towns, while 87% is transported to the nearest surfaced road from where it is sold. Most of this is purchased by traders or their intermediaries for resale, but some is bought directly by users.

Lilongwe dominates the firewood market with nearly 60% of demand and Blantyre is the largest charcoal consumer, having 70% of the market. This influences the kind of trader found in the two towns. Charcoal is sold principally from markets, whereas firewood is sold by mobile traders and from houses. Thus 69% of market traders are in Blantyre and 67% of mobile and home-based traders are in Lilongwe.

In common with the production and transportation of woodfuel, trading is primarily an informal business and only about 20% of all traders operate from depots, markets or shops. Approximately three-quarters of traders are in the retail business, 20% do both retail and wholesale with the remainder being wholesalers only. Most are dedicated to selling woodfuel, but some sell other wood products such as poles. The average size of the business is 1.4 people; it is mainly family-owned and run.

The trading survey found that about 20% of businesses are out of town. These roadside (and production site) businesses employ 25% of all traders. Of the 80% town-trading businesses, one-third each trades from markets and private houses, with the other third hawk the fuel from door to door.

Using the information in the survey, it is estimated that there were about 7,500 roadside traders in 2008 across all urban areas, with a workforce of 11,950 full time people. In town, traders numbered over 28,000 and they employed about 35,890 people full-time (Table 18). The estimated total traders in 35,500 businesses was 47,840 full-time people.

Many businesses are open twelve hours or more per day, seven days a week. Roadside traders work in shifts or tend other activities nearby, leaving a minder in charge of a number of stalls. In town, house traders leave wood outside and wait to be called by customers from inside. Itinerant traders hawk the fuel round until it is sold and then go back to the production site to prepare more. It is therefore difficult to be precise about the actual number of people trading woodfuel.

However, it is estimated that for 2008 the roadside traders serving urban areas received an income of MK 1,088 million ($7.35 million), of which MK 1,061 million was for labour and MK 27 million for overheads. Firewood sales produced just over MK 350 million (32%) and charcoal sales nearly MK 740 million (68%). The income received by in-town traders was estimated to be MK 3,533 million ($23.87 million) of which labour received approximately MK 3,190 million. Firewood sales generated an estimated MK 1,402 million (40%) and charcoal sales MK 2,131 million (60%) (Table 18). The total estimated value of urban woodfuel sales was about MK 11,100 million ($75.05 million) and the trade employed over 93,000 full-time people.

5.9 Employment Generated from Rural Trading of Woodfuel

Most traded woodfuel goes to the urban areas, principally households, but the service sector and some small industries purchase wood and other biomass energy as well. Again, some rural households buy firewood (rather than collecting it) and important rural industries rely on "commercial" firewood for process heat. These industries include brick and lime burning, fish smoking and tobacco curing; the tea industry mainly grows its own firewood. Table 19 gives an estimate of the woodfuel trade in rural areas.

Table 19: Employment generated from rural trading of firewood and charcoal

	Fuelwood			Charcoal			Woodfuel		
	Total value	of which labour	Employ-ment	Total value	of which labour	Employ-ment	Total value	of which labour	Employ-ment
	MK million		person-years	MK million		person-years	MK million		person-years
Growing	260	117	1,318	210	94	1,059	470	211	2,377
Production	320	282	3,176	540	476	5,360	860	758	8,536
Transport to road	186	150	1,689	94	76	856	280	226	2,545
Sub-total: prod + transport to road	*506*	*432*	*4,865*	*634*	*552*	*6,216*	*1,140*	*984*	*11,081*
Transport from road to village/industry									
manual	264	210	2,365	110	88	991	374	298	3,356
motor	396	80	900	215	43	484	611	123	1,384
Sub total	*660*	*290*	*3,265*	*325*	*131*	*1,475*	*985*	*421*	*4,740*
Roadside trading	378	351	3,953	450	418	4,707	828	769	8,660
Village/industry trading									
wholesale	50	45	507	62	56	631	112	101	1,138
retail	390	350	3,941	470	422	4,753	860	772	8,694
Sub-total	*440*	*395*	*4,448*	*532*	*478*	*5,384*	*972*	*873*	*9,832*
Total	***2,244***	***1,585***	***17,849***	***2,151***	***1,673***	***18,841***	***4,395***	***3,258***	***36,690***
Quantity	327,400 t.			83,400 t.			410,800 t.		

Note: (i) It is assumed that a person year is 300 days of 8 hours/day. The daily wage is MK 296 ($2) and the yearly rate is MK 88,800 ($600). The percentage of labour costs depends on the operation and the degree of non-manual inputs: this was quantified in the field.

(ii) 1.5 m^3 = 1 t. air dry wood; 6.67 m^3 roundwood equivalent [r.e.]= 1 t. charcoal.

(iii) In addition, commercial crop residues were used by industry. An estimated 7,000 m^3. in wood equivalent [w.e.] terms was used by urban industry and 383,000 m^3 w.e. by the sugar industry. Also, 48,000 m^3 w.e. of molasses was used to make motor fuel. Tobacco farmers used tobacco stalks as fuel and together with other rural industries used an estimated 160,000 m^3 of residues. The employment created by the use of this biomass was small (150 -200 person-years) as most of these residues were produced at the factory or near the tobacco barn, and used in close proximity to the site by the owners of the residues.

Source: Milner and Openshaw, 1997; Openshaw, 1997; collected data in 2008; BEST team estimates.

An estimated 69% of woodfuel, in wood raw material terms, is used in urban areas, of which 90% is for household use. In contrast, about three-quarters of commercial woodfuel in rural areas is used by industry and the service sector.

An estimated 36,690 full-time jobs are created in rural areas producing and trading woodfuel of which 49% is for fuelwood trading (Table 19). The value of this woodfuel is MK 3,258 million ($22 million).

Table 20 is a summary of Table 18 and Table 19, and gives the total employment figures for the urban and rural woodfuel trade.

Table 20: Summary of estimated urban and rural employment from traded woodfuel

	Fuelwood			**Charcoal**			**Woodfuel**		
	Total value	**of which labour**	**Employ-ment**	**Total value**	**of which labour**	**Employ-ment**	**Total value**	**of which labour**	**Employ-ment**
	MK million		**person years**	**MK million**		**person years**	**MK million**		**person years**
Urban	4,818	3,407	38,367	6,289	4,859	54,717	11,107	8,266	93,084
Rural	2,244	1,585	17,849	2,151	1,673	18,841	4,395	3,258	36,690
Total country	***7,062***	***4,992***	***56,216***	***8,440***	***6,532***	***73,558***	***15,502***	***11,524***	***129,774***
Quantity urban	574,200 t. 861,300 m^3 r.e.			221,290 t. 1,476,000 m^3 r.e.			795,490 t. 2,337,300 m^3 r.e.		
Quantity rural	327,400 t. 491,100 m^3 r.e.			83,400 t. 556,300 m^3 r.e.			410,800 t. 1,047,400 m^3 r.e.		
Quantity total	901,600 t. 1,352.4 m^3 r.e.			304,690 t. 2,032,300 m^3 r.e.			1,206,290 t. 3,384,700 m^3 r.e.		

Note: r.e. = roundwood equivalent

The table shows that, for the country as a whole, the estimated full-time employment in traded woodfuel from the growing to the selling is nearly 130,000, of which charcoal accounts for 57%. Of course, many producers are not "full-time", therefore the number of people involved in commercial woodfuel production etc. could be in the region of 180,000 to 200,000. The estimated value of this trade is MK15,500 million, nearly $105 million.

There are regional differences in the amount of wood which is traded. This is directly related to population density, but also reflects rural industrial use and the amount of land devoted to tea and tobacco. Southern Region has the highest population density and the greatest consumption of woodfuel. Within this region, the Blantyre CA is the largest consumer. Therefore, it is not surprising that this region has the smallest area of "closed" forest, but probably the largest stocking of on-farm trees. This is a response to the diminishing natural forest resource.

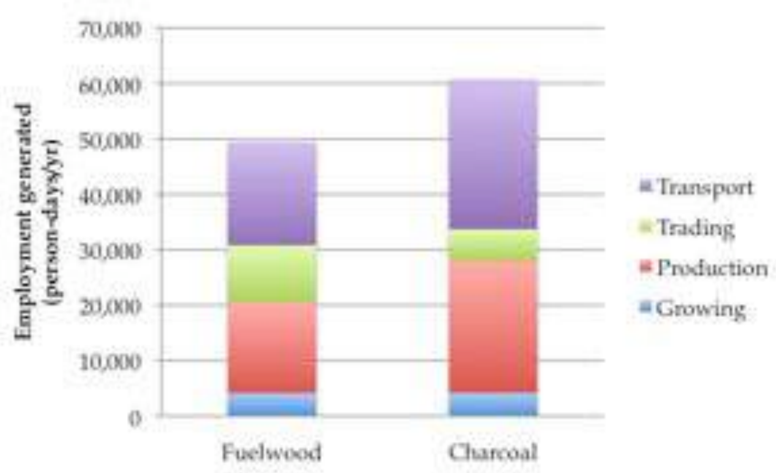
Some of the wood raw material is from planted and managed trees in plantations, farms or managed woodlands. Thus time and effort has been spent to plant and manage these trees. The precise time in person-years is unknown, but an estimate has been made using figures from other countries (Davis and Grant, 1955). In 2008, it is estimated that about 8,350 person years were spent on planting and/or managing trees for commercial woodfuel production, of which 5,970 person years were to grow wood for urban areas. A breakdown of employment by sub-sector is given in Table 18 and Table 19.

Commercial woodfuel accounts for 25% of all woodfuel consumption in wood raw material terms (firewood 12%, charcoal wood 100%). In 2008, the figures in the tables show that it gave full-time employment to an estimated 121,430 people in production, transportation and trade, about 80% of whom live in rural areas[22] and a further 8,350 people were engaged in the growing and tending of trees to supply this wood raw material. Thus nearly 130,000 people, mainly self-employed rural people, were fully occupied in the business of woodfuel energy, from the growing of the trees to the delivery of the product.

There is some uncertainty about the daily rate the various workers receive. Therefore, the estimated range in employment, from growing to trading, is 120,000 to 140,000 full-time people.

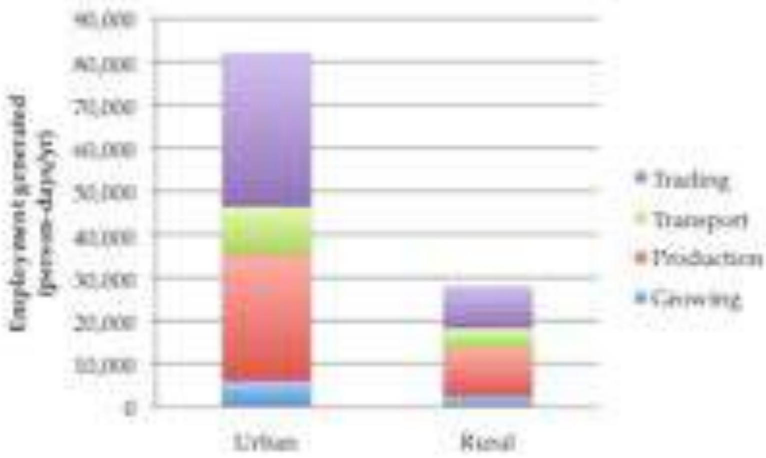
Figure 20 and Figure 21 illustrate the employment breakdown by type of fuel and by rural/urban.

Figure 20: Employment generated in the woodfuel trade, by fuel type



[22] Given that all production, most human transport and roadside trading takes place in rural areas, this gives a total of over 93,000 person-years.

Figure 21: Employment generated in the woodfuel trade, by urban and rural



In 2008, in comparison, the amount of *collected firewood* in urban areas was 0.2 million m^3 (2%), out of an estimated total of 10.1 million m^3 in rural areas, for a total of 10.3 million m^3. The time spent collecting and transporting this firewood, assuming that on average it takes 6 days (48 hours) per tonne of firewood (1.5 m^3) was:

1. Urban: 2,730 person-yrs
2. Rural: 134,600 person-yrs

   Total: 137,330 person-yrs

In addition, the equivalent of about 1,000 m^3 of crop residues were collected for household energy use in urban areas and 884,000 m^3 (wood equivalent) in rural areas.

The employment multiplier effect from the growing of wood, compared to the jobs it creates in production, transport and trading of woodfuel, is about ten. This is far higher than for substitute fuels such as paraffin, LPG and electricity. These other fuels create very little rural employment and are capital-intensive to produce and distribute, unlike wood energy. This gives an indication of the value of this indigenous resource for sustaining livelihoods and the importance of keeping it renewable.

The commercial woodfuel business is a relatively large generator of employment. This is a fact often neglected by economists when promoting job opportunities and when estimating the value of goods and services produced by the nation. And, not surprisingly, the people who collect their own energy are ignored completely in national accounts of GDP.

5.10 Total Value of the Commercial Woodfuels Industry

Table 21 summarises the estimated value of traded woodfuel, by fuel type, supplied to urban and rural areas in 2008. Over 90% of charcoal, by value, is purchased in urban areas and 65% of firewood, giving a woodfuel average of 72%. 75% of the total value is attributed to labour inputs (including the profit margin), ranging from 81% for charcoal to 73% for firewood. Thus this is clearly a labour-intensive industry.

Table 21: The value of commercial woodfuel

	Woodfuel value (MK million)		
	To rural areas	To urban areas	*Total (of which labour)*
Traded firewood value			
Wood raw material	260	560	*820 (369)*
P. + Tr. + T.	1,984	4,258	*6,242 (4,483)*
Total value	***2,244***	***4,818***	***8,782 (4,852)***
Traded charcoal value			
Wood raw material	210	617	*827 (372)*
P. + Tr. + T.	1,941	5,672	*7,613 (6,160)*
Total value	***2,151***	***6,289***	***8,440 (6,496)***
Total traded woodfuel value			
Wood raw material	470	1,177	*1,647 (741)*
P. + Tr. + T.	3,925	9,930	*13,855 (10,643)*
Total	***4,395***	***11,107***	***15,502 (11,384)***

Note: P. = production; Tr. = transportation; T = trade.

Source: Openshaw (1997) and BEST team estimates.

The total value of traded woodfuel in the market place for 2008 is estimated to be MK 15,502 million ($105 million). The estimated GDP for Malawi in 2008 was some $3.5 billion, thus traded woodfuel represented 3% of this total. Again, there is some uncertainty about the selling price of fuelwood and charcoal in the various markets. Thus the range in value of commercial woodfuel is MK 14,300 million ($97 million) to MK 16,700 million ($113 million).

A value can be put on the 10.3 million m^3 of collected firewood. If labour is shadow-priced at MK 148 ($1) per day and the wood raw material at MK 240 per m^3, then the cost of collecting firewood in 2008 was MK 6,098 million with a wood value of MK 2,472 million, for a total value of MK 8,570 million ($57.9 mill.). This is about 1.6% of GDP, accounting for the additional woodfuel value to GDP. Thus the combined value of traded and collected woodfuel ($163 million) is an estimated 4.4% of GDP[23].

If it were valued in terms of the substitution price for paraffin, assuming cooking as the principal end-use and taking into consideration stove efficiencies, the traded woodfuel would have a value of about $370 million per annum, 2.2 times the above sum, indicating how worthwhile this resource is to the nation.

The woodfuel business is the largest employer of people in the forest industries and energy sectors. Those involved are supplying an essential product to society for which there is no immediate practical and affordable substitute; paraffin would be the next best alternative but this would be at a large cost. Yet the government has done little to help the people in the woodfuels business. On the contrary, producers and transporters are harassed when

[23] After adding $163 million to the GDP figure because it is probably not included in it.

they carry out their normal business. This usually takes the form of cash payments to the people doing the harassing. Ultimately this increases the price of woodfuel.

The low status accorded to firewood and charcoal producers, transporters and traders and the fact that most are self-employed, makes harassment easier. It does not stop production, but makes it more expensive. Measures are required to bring charcoal production back into normalcy and reduce harassment.

Most previous studies have neglected the principal cause of deforestation, namely clearing land for agriculture. An examination of agricultural productivity, especially maize productivity shows that there have been only modest gains over the last 25 years. Yet during this period the population has almost doubled. Therefore, it seems obvious that forest land has been cleared for farming. Multiplying average yields by average consumption and hence farm land requirements confirms this.

How far this can continue without affecting the forest resource base, if it has not already done so in specific areas, will now be examined.

6. Biomass Energy Supply

6.1 Introduction

In order to determine the degree to which current levels of biomass energy consumption are sustainable, which will provide the information required to design appropriate sector interventions, it is necessary to establish the available annual supply.

The amount of biomass energy available is essentially a function of the woody growing stock and the annual yield. This chapter therefore develops estimates of the woody growing stock nationally, by region and for the four main urban catchment areas, and from this determines annual yield based on the relative coverage and known productivity of the different land cover classes. These yields are compared with estimated demand from the previous chapter, by region and for the main urban CAs, to establish the relationship between demand and sustainable supply both nationally and around the principal demand centres.

6.2 Land Cover

Table 22 summarises Malawi's land cover types by region and gives their estimated areas, with an indication of the changes in cover that have taken place since the last comprehensive assessment was undertaken in 1991.

Table 22: Land-use types and changes by region (1991-2008)

Land cover type	Area ('000 ha)				Change (1991- 2008)	
	North	Central	South	*National*	'000 ha	%
Forest, woodland, plantation	868	523	597	*1,989*	-669	-25%
Extensive agriculture in forests	1,337	771	486	*2,593*	+160	+7%
Extensive agriculture in grasslands	-	-	259	*259*	+23.3	+10%
Intensive agriculture	142	2,002	1,577	*3,721*	+630	+20%
Grasslands	365	227	23	*614*	-152	-20%
Built up areas, rocks/gravel, marsh	8	36	179	*223*	+7.7	+4%
Total	***2,720***	***3,560***	***3,120***	**9,399**		

Note. (i) The five land-use types are an aggregation of 23 categories described in full in Annex J.

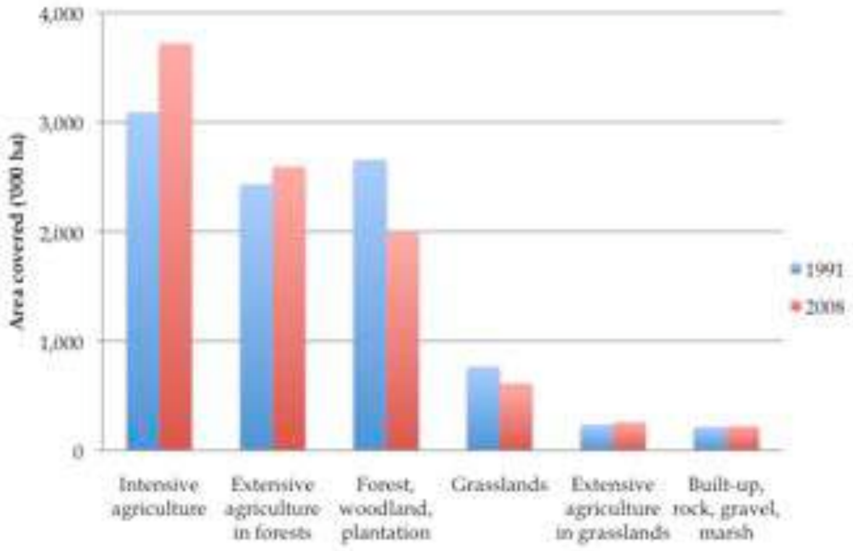
(ii) The land class "extensive agriculture in forests" is in some cases like shifting cultivation and in others comprises small plots amongst the trees. In "closed forest" terms about 90% of this area (2,334,000 ha) would be classified as woodlands and the remaining 260,000 ha as crop land. Thus the total estimated forest area in 2008 is 2,248,500 ha (24%) and the intensive agricultural land is 4,240,000 ha (45%), including extensive grassland areas that are farmed.

(iii) Detailed analysis of land cover by type and by region is in Annex K.

Source: Govt. of Malawi, 1993; Openshaw, 1997 (Appendix 1); BEST team projections.

Figure 22 illustrates the same information on land-use change at national level.

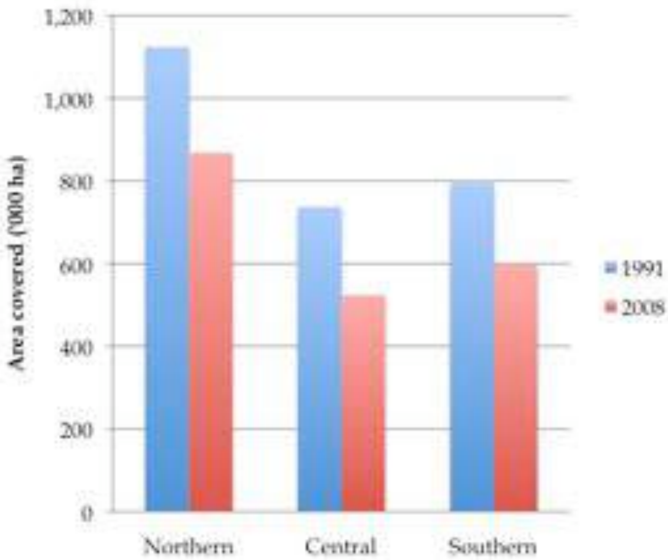
Figure 22: Changes in land use, 1991-2008



The figures reveal a significant loss of forest cover (25%) and grasslands (20%) since 1991 and their replacement by agriculture, plus some urban development. An estimated 669,000ha of woodland and 152,000 ha of grassland were converted to agriculture between 1991 and 2008.

Figure 23 illustrates the decline in forested land by region during this period.

Figure 23: Changes in forest cover by region, 1991-2008



Note: "Forest cover" includes forests, woodlands and plantations, as per definitions in Annex J.

Because Northern Region had the largest area of forest in 1991 it had the most forest land converted to agriculture (256,000 ha), followed by Central Region (214,000 ha)and Southern Region (199,000 ha). Up to 107 million m^3 of wood were felled to make way for agricultural expansion during this period, over 97 million m^3 of it coming from forest areas. However, there was an increase in the plantation area (33,800 ha), farmers planted some scattered trees and some trees were left on the land during clearing, which partly compensated for the natural forest loss and resulted in an estimated net loss of 78 million m^3 of wood.

6.3 Causes of Land Use Change

It is often said that Malawi is being rapidly deforested. Based on the preceding analysis this is certainly true. However, the term is commonly misused and it should be noted that deforestation strictly speaking only occurs when there is a change of land use. If charcoal producers go into a woodland area and clear a patch to produce charcoal, for example, this is not deforestation if the area is left to recover. It is more correctly called harvesting, although the area may not recover to its original state of biodiversity. The forest has then been degraded, although the annual yield may not necessarily be affected. Similarly during the practice of shifting cultivation an area of forest may be cleared and farmed for two to three years and then left to recover, meaning that it has not been deforested but degraded.

It is therefore incorrect to state, for example, that charcoal production causes about one-third of Malawi's total deforestation (Kambewa et al, 2007; p. 21). Only if farmers move into a cleared area and start permanent farming can this be considered deforestation. The cause is agricultural expansion, even if the harvested trees were converted into charcoal . Certainly deforestation is taking place at a rapid pace in Malawi, mainly when wooded land is converted to permanent agriculture or into urban settlement, but it is important to apply the term correctly if the causes and solutions are to be properly addressed.

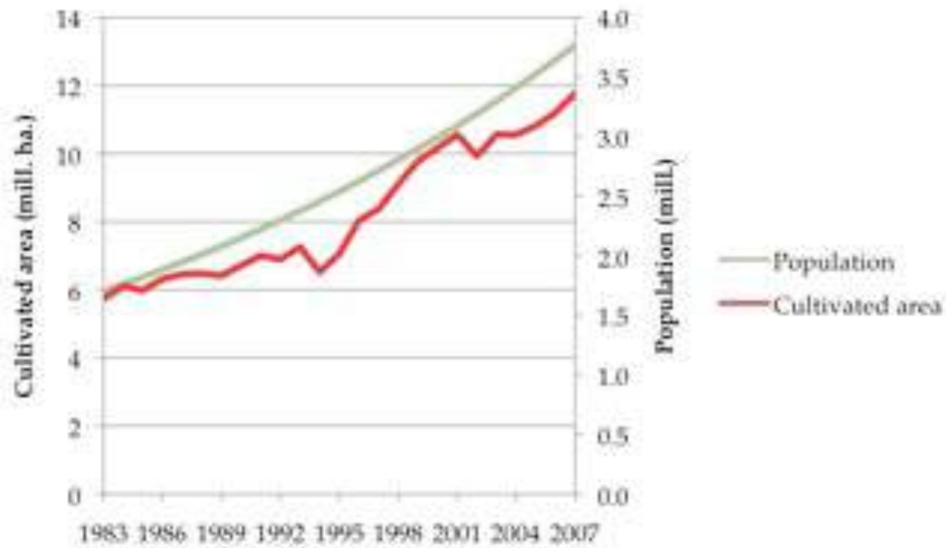
This is important in light of the tendency for past studies on energy and the environment to pinpoint woodfuel harvesting as the main cause of the deforestation that is taking place. The natural solution that arises from this incorrect line of reasoning is to ban charcoal production as it is said to be a destructive fuel. Such bans are not only based on false conclusions from the available data, but are also counter-productive. Banning the fuel makes charcoalers outlaws, which increases the price of charcoal and encourages producers to mine- rather than manage - the resource.

In addition, a true ban cannot be upheld for a long time under real life conditions. Households have no choice but to use charcoal as the alternatives are too expensive or unavailable. Countries that imposed a ban have shown that it is either ineffective, as in The Gambia where there has been a ban on the production, transport and use of charcoal for more than 20 years but where charcoal is still the most common urban fuel, or it leads to social uproar and an eventual revocation of the ban, as in Tanzania or Chad.

This report concludes that woodfuel production has led only to minor deforestation, although it has resulted in the reduction of the growing stock in some woodland areas. The root cause of the loss of forests and grasslands is *conversion to farmland driven by population growth.* In the absence of any significant improvements in agricultural productivity, it is inevitable that the growing population will need to cultivate more land in order to grow more food for sustenance. This can be confirmed through a simple comparison of population growth figures with statistics on cultivation and crop productivity.

The estimated population of Malawi was 5,962,964 in 1983 and rose to 13,187,600 by 2007. This represents an average annual growth rate of 3.3%. Meanwhile, according to Ministry of Agriculture statistics, the land under crops in 1983 was 1,639,482 ha and reached 3,364,100 ha in 2007. This is equivalent to an average annual increase of 3.0%. These two trends are summarised in Figure 24.

Figure 24: Population growth and expansion of area under cultivation, 1983 to 2007

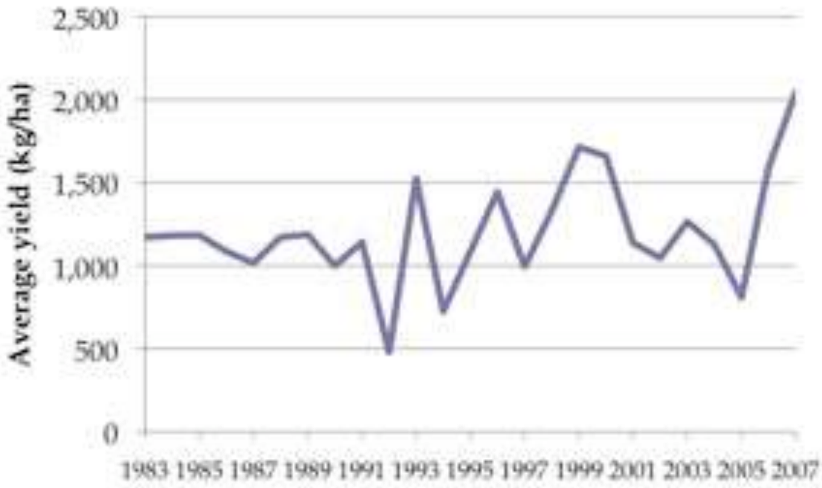


Source: GoM, 1998 (national census projections); Ministry of Agriculture cropping and area statistics, supplied by E. Chapasuka, FEWSNET.

It is apparent that the area under crops has expanded almost exactly in step with the growth in population. For each additional person, approximately 0.24 ha of new land has been brought under cultivation.

A key reason for this is that the productivity of maize, the country's staple food crop which accounts for 50% of all land cultivated by smallholder farmers, rose by only 10% between 1983 and 2005 (see Figure 25). Only in 2006 and 2007 was there a more impressive improvement in yields as a result of good rainfall and a donor-assisted subsidy programme for seed and fertilizer.

Figure 25: Average maize yields, 1983 to 2007



Source: Ministry of Agriculture annual statistics on cultivated areas and crop yields.

As well as the limited improvement in maize productivity, the need for more farm land has been driven by significant new planting of certain cash crops, especially tobacco and groundnuts. These crops saw an increase in cultivated area of 830% and 160% respectively from 1983 to 2007, and between them now account for 12% of the total cropped area.

The net impact of these two factors - a slow improvement in maize yields and the expansion of land under certain cash crops - has been that as the population has grown by 129% since 1983, the area under smallholder cultivation has grown by 112%. Given this very similar trend, in 2008 over 45,000 ha of forest and grassland were estimated to be cleared for agriculture.

Without rapid improvements in the productivity of staple crops and/or a significant reduction in the rate of population growth, the conversion of woodlands, forests and grasslands to agriculture will inevitably continue at a rate of up to 3% per annum. There will also be further intensification of cultivation on existing farmland through sub-division of plots, clearing of remaining trees on farmed land and a shortening of fallow periods. In the absence of new inputs (such as more organic and non-organic fertilizers or higher-yielding crop varieties), this will result in ever-decreasing yields and a continued requirement to clear more land and intensify the use of areas already farmed. If the trend is to be slowed and eventually reversed, there must be a concerted effort *to increase agricultural productivity among smallholders* to the levels achieved on larger and better-resourced farms.

6.4 Biomass Production by Land Cover Type

The previous discussion is intended to highlight the main driving forces behind Malawi's changing land use patterns, to ensure that the package of intervention measures developed by the government places due emphasis upon raising agricultural productivity and addressing population growth, and does not seek to tackle the biomass energy sector in isolation. It is, however, time to return to the estimation of sustainable biomass supply that forms the main focus of this chapter.

Having presented the land cover situation in each region, it is necessary to estimate standing stocks and annual yields for each of the land cover types in order to determine total yields. This can indicate the level of wood harvesting likely to be sustainable in each part of the country. The limitation here is the availability of accurate and up to date empirical data. The BEST team based their estimates on extrapolation from a remote sensing study conducted in 1990/91 and a forest inventory of 1995/96, the last reliable studies conducted at national level.

The first of these studies was an inventory of indigenous trees based on satellite imagery and ground sampling (Govt. of Malawi, 1993). The inventory classified landcover into 25 categories and sample plots were measured in 13 of these categories where indigenous trees might be present. However, no planted or regenerated exotic trees were measured in the sample plots, neither were exotic trees in plantations or woodlots, trees in clumps or lines, and trees in grasslands, areas of estate agriculture (except tobacco/maize areas) or urban areas. Thus while the inventory gave reliable information on the standing stock of indigenous trees in forests, woodlands and areas of extensive and intensive agriculture, a significant proportion of the country's trees were not captured. It also made no estimates of annual growth, which are obviously required for making yield estimations.

A second study on biomass growing stock was commissioned in 1995/96 as part of a national Biomass Supply Survey (see Masamba & Ngalande, 1997). This study investigated plantation areas and estimated annual increments, enabling assessments of growing stock and annual yields to be made for most areas not covered by the 1992/93 inventory. Yields of indigenous tree formations covered by the inventory were also estimated.

Based on these two pieces of research, maximum and minimum standing stocks, rotations and yields of woody biomass under the different land-use categories were estimated. These estimates are summarised in Table 23.

Table 23: Standing stock and yield under different land cover types, by region

Land classification	Average standing stock (m^3/ha)						Average annual yield (m^3/ha)					
	Northern		Central		Southern		Northern		Central		Southern	
	max	*min*	*max*	*min*	*max*	*min*	*max*	*min*	*max*	*min*	*max*	*min*
Evergreen forest	224	190	336	285	336	285	3.4	2.9	3.4	2.9	3.4	2.9
Woodland, hilly	122	105	123	105	81	70	3.7	3.1	3.7	3.1	3.0	2.6
Woodland, plains	105	90	109	90	61	50	4.4	3.7	4.4	3.7	3.0	2.6
Agric, within woodlands	77	65	35	30	63	55	5.8	4.9	4.7	4.0	4.7	4.0
Eucalyptus grandis	100		100		100		25		25		25	
E. spp. others	40		40		40		10		10		10	
Tea area plantations					105						30	
Pine spp.	238		238		238		17		17		17	
Other plantation spp.	70		70		70		10		10		10	
Leucaena					6						2	
Trees outside the forest	80		80		80		20		20		20	
Grassland	5		5		5		0.5		0.5		0.5	
Intensive agric. (planted)	4		4		4		1		1		1	
Intensive agric. (indig.)	16		16		4		1		1		0.4	
Coffee/tea	3		3		3		1		1		1	
Rice	1						0.1					
Tobacco/maize	5		5		5		1		1		1	
Urban	10		10		10		1		1		1	
Marsh/rock	0		0		0		0		0		0	

For details see Annex M.

Armed with the estimates of standing stock and annual yield for each land cover type, and knowing already the areas of each land cover type by region (Table 22), it is possible to determine standing stocks and annual yields of wood for each land cover type, for each region and for each of the four main urban catchment areas.

6.5 Note on Assumed Yields

Before proceeding it is worth noting that the annual yield figures under the different land cover classifications developed by the BEST team are markedly different from the figures given in a widely-quoted 1992 World Bank report on environmental policy in Malawi (World Bank, 1992), which estimated that the national demand for wood products in 1990 was 8.5 million m^3 against an annual yield of 5.7 million m^3.

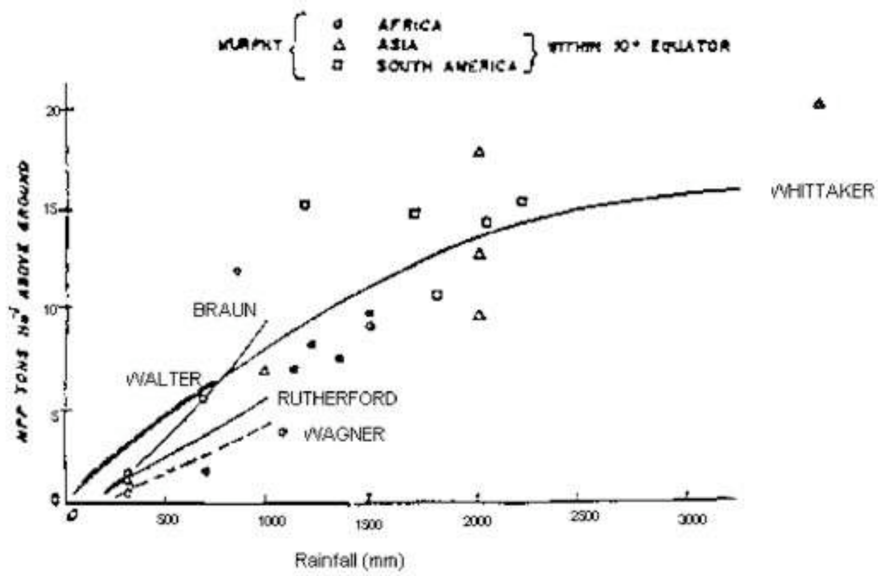
This rather pessimistic report ignored trees outside forests and thus overlooked areas supplying around one-third of woodfuels to the four main towns. It also appears to have recorded only the merchantable stem volume of commercial species[24].

The World Bank report gave a yield figure of 3.6 mill. cu.m. per year for forest and woodland areas, which works out as an annual yield of 0.9 m^3 per ha. This is less than 1% of the growing stock. Translated into rotation ages, this would give a nominal rotation of about 200 years for these areas, which is much too long[25]. Thus the yield figure is clearly far too low and this casts further doubt on the 1992 figures.

The higher yield estimates of the BEST team are backed up by research elsewhere into the relationship between rainfall and yields of above-ground net primary production (NPP), as presented in Figure 26.

Figure 26: Above-ground net primary production of biomass

units: dry tonnes/ha/year



Source: Western et al, 1981.

[24] In woodlands and natural forests, less than half the trees are considered "commercial" and over half the tree volume is non-merchantable stem wood and branches. In plantations, all trees are considered merchantable and about 25% of the wood is non-merchantable branches and tops.
[25] Rotation ages for woodlands are between 30 and 40 years and for evergreen forests about 100 years.

Malawi has an average rainfall of about 1,000 mm per year. For Africa, the range of NPP for 1,000 mm of rainfall (as per the chart) is from 4 to 12 t./ha/yr., with a mean of about 8 t.

This represents total production of plant material, including annual plants, grasses, the leaves of trees and woody tissue. In a woodland formation about 40% of annual production is wood, whereas in plantations it can be about 70%. Thus the anticipated annual yield of wood from woodlands with 1,000 mm of rainfall should be about 3.2 t. or 4.8 m^3 of wood, on average, ranging from 2.4 m^3 to 7.2 m^3. For plantations the average figure is 9.0 m^3, ranging from 4.5 m^3 to 13.5 m^3 (Western et al, 1981).

The average annual yields calculated for the Biomass Energy Strategy (as summarised in Table 23) work out as about 4.1 m^3 per ha for natural forests and woodlands, and 13.5 m^3 per ha for plantations. The latter figure may seem high, but is based on measured growth in Malawi plantations. The tea estates in the south-east are in fact obtaining an annual yield of about 30 m^3 per ha in their own eucalyptus plantations.

As a final check on the BEST yield figures, in 1994/5 a national biomass study was undertaken in Uganda (Govt. of Uganda, 1996). The growing stock of trees and bush was estimated to be around 1,350 mill. m^3 and the annual yield was 105 mill. m^3, of which 72 mill. m^3 was practically available. It was hence found that the yield was 7.8% of standing stock. This is a little higher than the 7.4% estimated in the BEST Malawi study, presumably due to higher productivity under Ugandan growing conditions. It is also nearly five and a half times the figure used in the 1992 World Bank Malawi study, further confirming that the figures in that report were a gross underestimate.

6.6 Woody Growing Stock

Based on the land cover situation presented in Table 22 and the standing stocks per hectare given in Table 23, estimates of minimum and maximum woody growing stock are given for each region in Table 24.

Table 24: Woody growing stock by region

Land cover type	**Woody growing stock (mill. m^3 above-ground)**							
	Northern		**Central**		**Southern**		***National***	
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	***Min.***	***Max.***
Forest, woodland, plantation	103.4	117.2	56.2	65.3	43.7	50.4	*203.3*	*232.9*
Extensive agriculture in forests	86.9	102.9	23.1	27.0	26.7	30.6	*136.7*	*160.5*
Extensive agriculture in grasslands	0	0	0	0	1.3	1.3	*1.3*	*1.3*
Intensive agriculture	4.7	4.7	39.1	39.1	17.8	17.9	*61.6*	*61.7*
Grasslands	1.8	1.8	1.2	1.2	0.1	0.1	*3.1*	*3.1*
Built up areas, rocks/gravel, marsh	0	0	0.1	0.1	0.2	0.2	*0.3*	*0.3*
Total:	***196.8***	***226.7***	***119.7***	***132.6***	***89.8***	***100.5***	***406.4***	***459.8***

Source: As per Table 22 and Annex N.

As shown in the table, the estimated 2008 standing stock of wood on all land formations was between 406 and 460 million m^3 (267 to 307 million t. air dry). Northern Region had the largest amount of standing wood (48%) and Southern Region had the least (22%).

Figure 27 and Figure 28 illustrate the same information graphically.

Figure 27: Woody growing stock by region (max. and min. estimates)

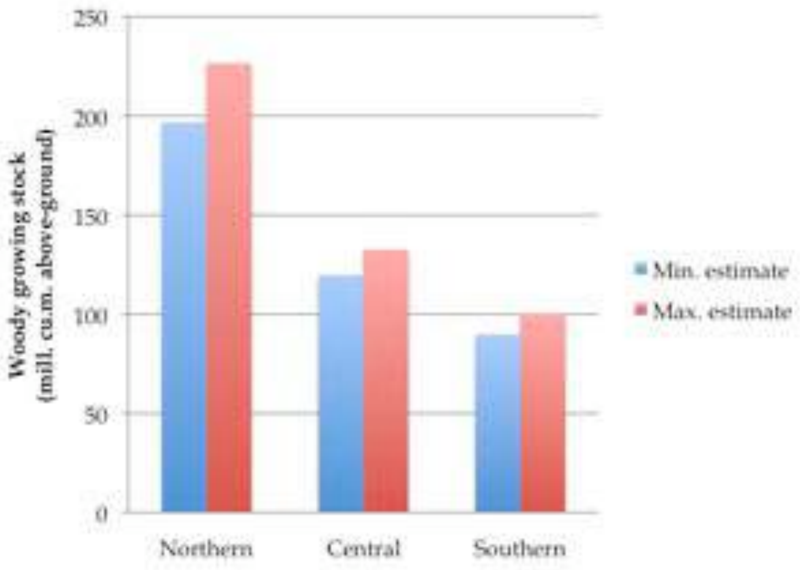
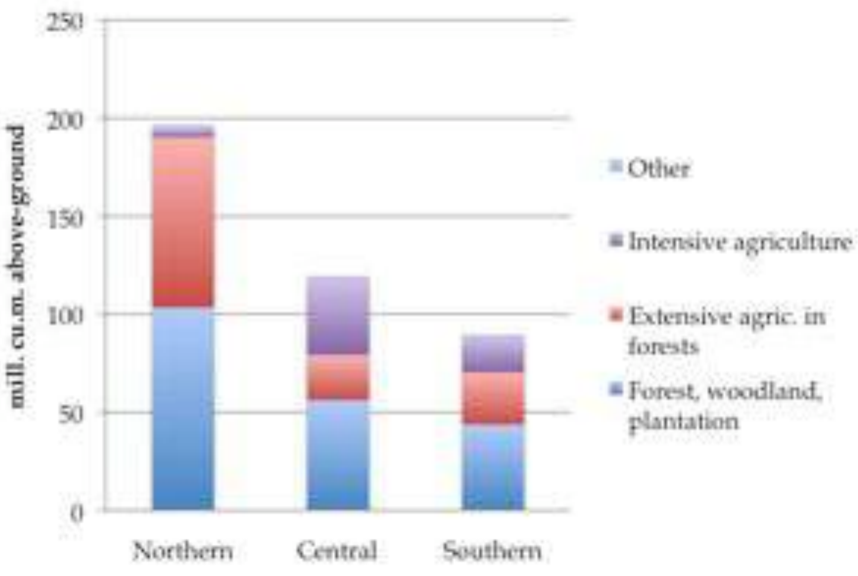


Figure 28: Composition of woody growing stock, by region (min. estimate)



Note: "Other" includes grasslands, extensive agriculture in grasslands, built-up areas, rocks/gravel and marsh

An important observation from these figures is that about half of the country's woody growing stock is found *outside* forests and woodlands, on intensively or extensively cultivated land. Areas under intensive agriculture are particularly important sources of wood in Central and Southern Regions. Overlooking this fact has contributed to underestimations of wood availability in earlier studies, which have tended to focus too heavily upon woodlands and forests when calculating available biomass and have not looked enough at non-forest areas that also contribute to the supply.

6.7 Biomass Production by Region

Having estimated standing stocks of wood for each land cover type, it is possible to estimate wood yields by region and for the country as a whole (see Table 25 and Figure 29).

Yields have also been calculated for the four main urban catchment areas, but to avoid over-complicating the report the CA data have been put into Annex O (standing stocks) and Annex Q (yields).

Table 25: Annual wood yield by region

units: '000 cu.m. per annum

Land cover type	Min. estimate				Max. estimate			
	N	C	S	*National*	N	C	S	*National*
Forest, woodland, plantation	3,909	2,347	2,730	***8,986***	4,379	2,652	2,952	***9,983***
Extensive agriculture in forests	6,549	3,085	1,942	***11,576***	7,752	3,625	2,282	***13,659***
Extensive agriculture in grassland	0	0	129	***129***	0	0	129	***129***
Intensive agriculture	822	4,328	3,570	***8,720***	822	4,328	3,570	***8,720***
Grasslands	182	114	11	***307***	182	114	11	***307***
Built up areas, rocks/gravel, marsh	3	12	15	***30***	3	12	15	***30***
Total	***11,465***	***9,886***	***8,397***	***29,748***	***13,138***	***10,731***	***8,959***	***32,828***

Note: For details see Annex P.

Figure 29: Annual wood yield by region, max. and min. estimates

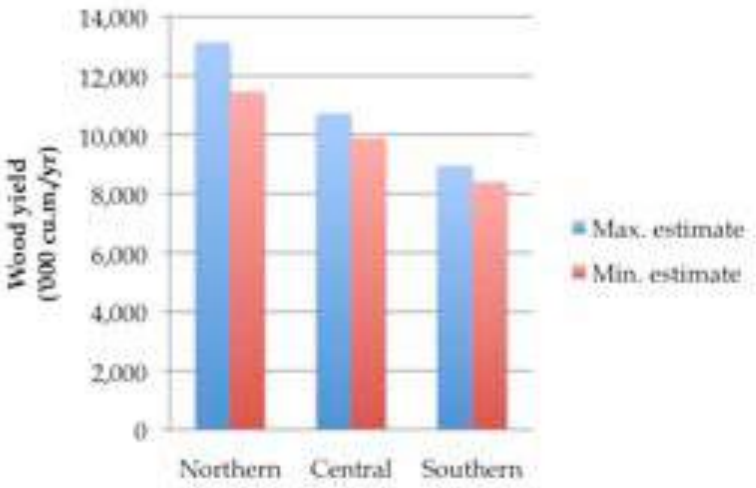
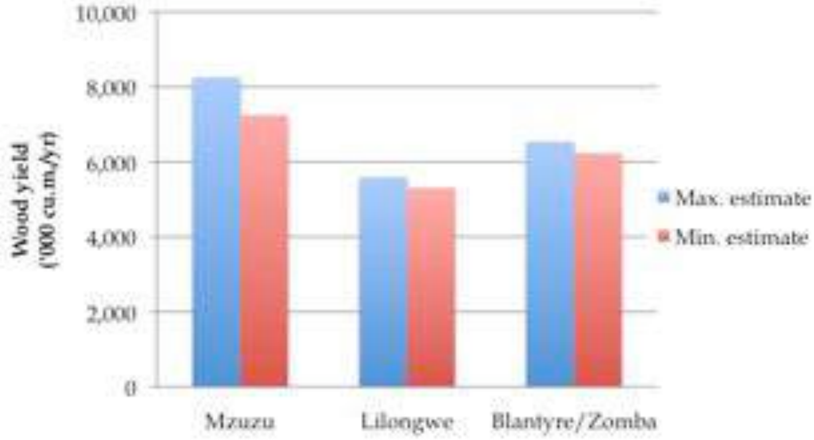


Figure 30 illustrates annual wood yields for the urban CAs. As stated, the complete yield data for the urban catchments can be found in Annex Q.

Figure 30: Annual wood yield by urban catchment, max. and min. estimates



In addition to wood production, Table 26 and Figure 31 consider also the annual production of crop residues and dung, the two additional sources of biomass available as energy sources.

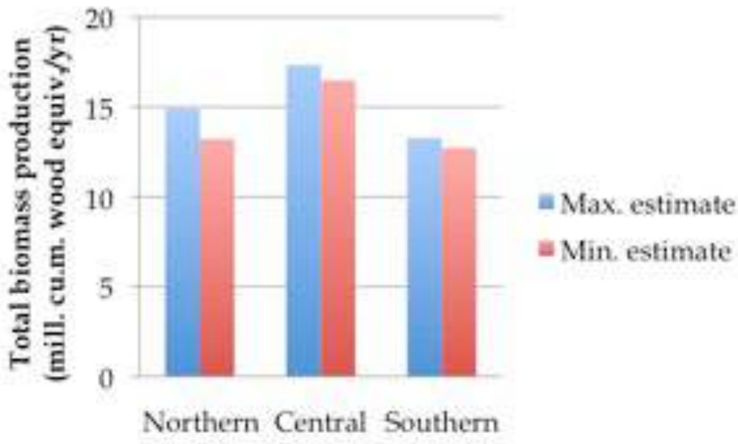
Table 26: Total annual production of wood, crop residues and dung

units: million cu.m. wood-equivalent

Biomass source	Min. estimate				Max. estimate			
	N	C	S	*National*	N	C	S	*National*
Wood	11.46	9.89	8.40	***29.75***	13.14	10.73	8.96	***32.83***
Crop residues	1.70	6.37	4.07	***12.14***	1.70	6.37	4.07	***12.14***
Dung	0.06	0.23	0.25	***0.54***	0.06	0.23	0.25	***0.54***
Total:	***13.22***	***16.49***	***12.72***	***42.43***	***14.9***	***17.33***	***13.28***	***45.51***

Source: As per Table 22 and Annex P.

Figure 31: Total annual biomass production, max. and min. estimates



When wood alone is considered, the data show that production is highest in Northern Region and declines consistently moving southwards (see Figure 29). When the availability of agricultural residues and dung are also taken into account, Central Region now has the highest production overall, at between 16.5 to 17.3 mill. cu.m. in wood-equivalent terms p.a., reflecting its combination of woodland, forest and plantation, *plus* agriculture (particularly tobacco).

These figures provide a minimum estimate of annual wood, crop residues and dung production for 2008. In wood equivalent terms, residues amount to 12.14 million m^3 and dung totals 0.54 million m^3. If all these "residues" could be collected and used for energy they would be sufficient to satisfy an impressive 85% of total biomass energy demand for 2008.

It is impossible to make full use of the biomass that is produced annually and this has been taken into consideration in the next stage of the calculations by assuming that only 70% of the yield is "available wood"– refer to Table 27 below, which summarises the *available* supply of biomass. The 70% figure is based on the above-mentioned national biomass study in Uganda, in which a complete inventory of all land-use types was undertaken (Govt. of Uganda, 1996). This is a conservative figure and it is probable that actual use goes above 70% of yield, given that all types and sizes of wood, from boles to twigs, tend to be used as fuel.

Table 27: Available supply of biomass, by region (min. estimate)

	Annual biomass supply (mill. m^3 roundwood equivalent)			
	North	**Central**	**South**	***National***
Total biomass production				
Land clearing – wood	0.57	1.98	2.15	***4.70***
Annual growth – wood	11.46	9.89	8.40	***29.75***
Annual crop residues	1.70	6.37	4.07	***12.14***
Annual dung	0.06	0.23	0.25	***0.54***
Total:	***13.79***	***18.47***	***14.87***	***47.13***
Annual biomass practically available				
Wood from clearing (70%)	0.40	1.39	1.50	***3.29***
Wood from annual growth (70%)	8.02	6.92	5.88	***20.82***
Crop residues (50%)	0.85	3.18	2.04	***6.07***
Dung (10%)	0.01	0.02	0.02	***0.05***
Total:	***9.28***	***11.51***	***9.44***	***30.23***

Note: (i) The Uganda Biomass Study (1996) determined that about 70% of above-ground woody biomass is available for use, taking into account trees reserved for protection purposes or for amenity (National Parks and Game Reserves) and others grown for their non-wood products.

(ii) The figure of 50% for the availability of crop residues and 10% for dung are best estimates. Crop residues are used for animal feed, construction (especially roofing), bedding, fertilizers and soil improvers, while dung is used as fertilizer.

In addition to an estimated annual growth of 29.75 million m^3 from the woody growing stock, another 4.7 million m^3 of wood were felled in 2008 when 45,000 ha of forest and 1,600 ha of grassland were cleared for agriculture. This is shown in the first row of the table.

Thus a minimum of about 47 million m^3 of wood equivalent per annum is potentially available to meet demand for energy and wood products, of which over 42 million m^3 is from renewable sources (the balance of 4.7 mill. m^3 coming from land clearing).

Of this total, the amount of biomass practically available is 30.23 million m^3 wood equivalent, of which 26.94 million m^3 is from renewable sources.

6.8 Sustainable Wood Yields vs. Current Demand

The estimated supply of wood and other biomass must be compared with the demand for biomass energy and other wood products in order to determine levels of sustainability for different regions of the country. Comparisons can be undertaken based on a number of scenarios based on "minimum", "average" or "maximum" estimates for supply and demand.

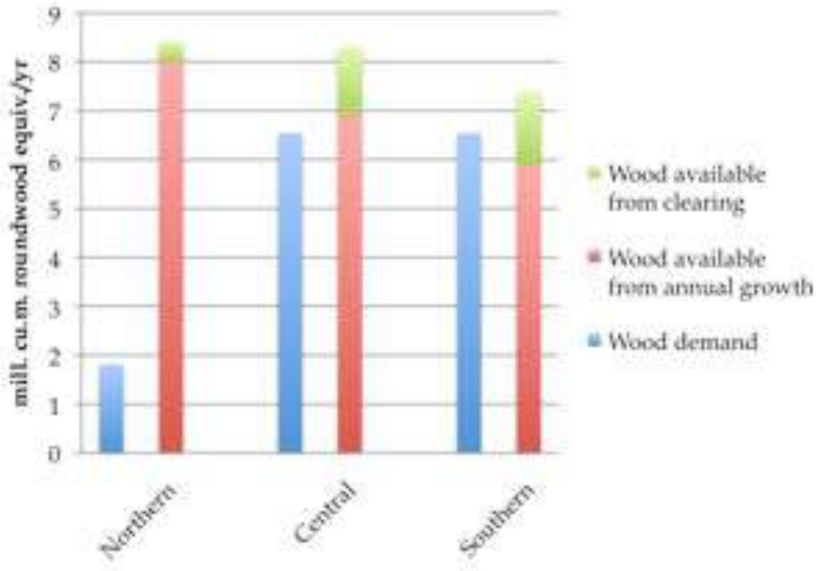
6.8.1 Most Probable Supply and Demand Assumptions

The most probable scenario, and the one that assumes worst-case biomass supply, is based on "minimum" yield and "average" demand. This scenario is summarised in Table 28 and Figure 32, which compare the minimum estimated sustainable supply of wood and other biomass with the average demand for biomass energy and other wood products for 2008, by region.

Table 28: Supply and demand for biomass by region (minimum yield, average demand)

	Supply or Demand (mill. m^3 roundwood equivalent)			
	North	**Central**	**South**	***National***
Annual growth of biomass practically available				
Wood from clearing (70%)	0.40	1.39	1.50	*3.29*
Wood from annual growth (70%)	8.02	6.92	5.88	*20.82*
Total wood	***8.42***	***8.31***	***7.38***	***24.11***
Crop residues (50%)	0.85	3.18	2.04	*6.07*
Dung (10%)	0.01	0.02	0.02	*0.05*
Total residues	***0.86***	***3.2***	***2.06***	***6.12***
Demand				
Demand for wood	1.81	6.55	6.54	*14.90*
Demand for residues	0.04	0.43	0.42	*0.89*
Combined wood &residue demand	***1.85***	***6.98***	***6.96***	***15.79***
Demand as a percentage of practically available biomass from:				
Wood annual growth only	23%	95%	111%	*72%*
Wood growth + clearing	21%	79%	89%	*62%*
Crop residues	5%	14%	21%	*15%*
Sustainable wood and residues	21%	69%	88%	*59%*

Figure 32: Demand for wood vs. available supply, by region



This chart is crucial for analysing the degree to which current woodfuel consumption is taking place within sustainable limits.

Northern Region

Northern Region shows no supply-demand balance problems as it has a relatively small population and about 80% of its land area under some form of tree cover. Therefore, it is not surprising that the figures confirm a large surplus of wood. Demand for wood in Northern Region is just 23% of annual growth. Some land is being cleared for agriculture, which gives an even larger surplus, much of which is lost through death of trees and branches and the burning of felled trees *in situ*. The problem in this region, which is remote from the large demand centres, is finding economic markets for the surplus wood.

Central Region

Central Region shows a tight balance between demand and supply of woodfuels; it has a relatively large population density. It is also the region with the largest production of tobacco, a crop that requires poles and firewood in the curing process. This explains why it has the largest area under intensive agriculture, about 60% of its land, and this also accounts for the extensive farming in forest areas. This region also has one of the two large sugar estates (at Dwangwa), the other being in the south (at Chikwawa).

For the region as a whole, demand for woodfuel and other wood products is about 95% of sustainable supply. When wood from land clearing is added in, the demand falls to 79% of supply. Thus in principle there is a positive balance and the supply is larger than the demand. However, as will be discussed later, around Lilongwe wood is being over-harvested in some areas. There is anecdotal evidence of shortages in tobacco growing areas and reports of vehicles foraging into Mozambique and Zambia in search of firewood and poles.

However, residue consumption may be higher than depicted in Table 28 and as a result wood consumption would be lower. Only 14% (0.43 million m^3 wood equivalent) of the estimated available residue supply was used. If the available sustainable supply of wood and residues are combined, then the demand for biomass energy and wood products in

Central Region would fall to 69% of supply. Therefore it could be that consumption of wood is overstated and that of residues understated.

The tobacco industry may have to point a finger at itself for not taking sufficient measures to ensure a sustainable supply of firewood and poles. It has in the past tried to enforce a requirement for all out-growers to maintain 10% of their land under trees, but by all accounts this directive is now ignored. It has been more attractive for farmers to buy wood or to obtain it from customary land or when opening up new land for tobacco growing, rather than grow or manage trees within their fields, although this may start to change given the expenses they are now incurring to source firewood from commercial traders.

Trees could assist tobacco growers in rejuvenating the land as well as supplying fuel. Most agro-forestry trees fix atmospheric nitrogen in the soil and can be grown on short rotations of one to three years. Thus, in the resting phase of tobacco management, trees could be grown to increase soil fertility and at the same time provide firewood and pole wood. Shelterbelts could also improve the micro-climate on tobacco estates and satisfy the pole requirement.

Southern Region

The Southern Region shows the most worrisome situation for the balance of supply and demand of woodfuels; it has the smallest area of tree cover and a large population density hence there appears to be a deficit between supply and demand, demand being an estimated 111% of sustainable supply. This is adjusted to 89% when wood from cleared land is included. Again, only an estimated 21% of residues are used. If the sustainable supply of wood *plus* residues are combined and compared to demand, then 88% of the supply is used. As in the case of Lilongwe, localised shortages and overcutting are occurring as the biomass supply is not evenly distributed across the CA.

The principal tea estates are in this region and, unlike in the tobacco growing areas, they are self-sufficient in plantation-grown firewood. The largest sugar estate is also in this region and it uses bagasse as a boiler fuel for heat, steam and electrical generation.

6.8.2 Alternative Supply and Demand Assumptions

Table 28 portrayed the supply - demand situation under the assumption of minimum yield and average demand for woodfuel. Alternative estimates of supply and demand were made assuming "maximum yield and maximum demand" and "minimum supply and minimum demand". These alternative scenarios are presented in full in Annex R.

The results under the first alternative (maximum yield and demand) are similar for those given in Table 28, with a slight increase in the excess of demand over sustainable supply for Southern Region from 111% to 115%. Only in the second alternative, when the minimum supply figures are compared to minimum demand, is there a slight improvement in the supply:demand ratio for Southern Region, where the estimated demand compared to sustainable supply falls from 111% to 101%. If crop residue supply is combined with wood, then the demand/supply percentage falls to 92% under the first alternative scenario and 80% under the second.

In Central Region the sustainable supply compared to demand ranges from 86% to 96%, with the median sustainable at 95%. If crop residues are included, then the demand/supply percentages fall to 71% and 63%.

In summary, the supply-demand situation is not dramatically different under the alternative scenarios. The tight supply situation in both Central and Southern Region clearly indicates that steps need to be taken to increase supply and reduce demand in these areas. Developing the right incentives for people to manage existing resources better and to plant more trees, especially on farms, is one of the initiatives that needs to be pursued. Recognising and working with charcoal producers is also an important part of the solution, and will be far cheaper in terms of environmental protection, local employment and saving on imports than efforts to switch to paraffin, LPG or electricity.

6.8.3 Supply and Demand in the Main Urban Catchments

Most wood products, to be competitive, have to be near the demand centres. Thus surplus wood in the north of the country is outside the economic or collection radius of woodfuel consumers in the south. Some manufactured products made from sawnwood and panel products can be transported over long distances. Much depends on the raw material cost and availability, compared to manufacturing and delivery costs.

As a general rule, collected firewood and poles have to be no more than two hours away from the house; purchased firewood and charcoal transported by bicycle have to be within a radius of about 25 and 50 km respectively; for motorised transport the economic radius for firewood may be up to 100 km and for charcoal and poles up to 300 km. At these extremes, the value of the wood raw material approaches zero.

A proposal has recently been made by a Lilongwe-based NGO to transport firewood from the Viphya plantations to Lilongwe, a distance of 300km. But the transport cost alone will beat least $45 per tonne of wood and such a venture will be very marginal. In addition, the type of firewood or charcoal available in plantations that were originally established to produce timber may not please the consumer: Viphya consists mainly of pine trees and firewood and charcoal from pine is more brittle and has poorer combustion qualities than that from indigenous or trees or other exotics (e.g. wattle or some eucalypts).

When examining the supply of wood and other biomass, it is important to pinpoint the main demand centres and then examine the biomass within economic (foot and vehicular) transport radii. Most rural people are scattered throughout the countryside, their density of habitation governed by the carrying capacity of the land, hence they are dependent on what is available in the immediate vicinity. As the most desirable forms of wood diminish, the collection radius increases and less desirable forms start being used for fuel- such as green wood, twigs and crop residues.

In towns, as population increases, the supply of wood products is commercialised and the catchment area expands. Similarly in rural areas, where localised demand for wood products is heavy, such as for tobacco curing, firewood becomes a commercial product and pressure is put on the surrounding wood resources. The tea estates have solved this problem by growing their own wood supply.

Therefore, when undertaking supply surveys, the availability within the economic radii of the principal demand centres must be estimated. The areas where they may be supply constraints then can be pinpointed and local or national remedies can be formulated and acted upon.

In the BEST study it was decided to focus upon the four largest urban centres in the county, which represent concentrated points of demand for wood products, especially firewood and charcoal. A sourcing radius of 75 km for Mzuzu and 100 km for Lilongwe and

Blantyre/Zomba was considered. For Mzuzu, this encompasses Mzimba and Nkhata Bay Districts, while for Lilongwe the catchment areas are Mchinji, Ntchisi, Dowa, Lilongwe, Salima and Dedza Districts. For Blantyre/Limbe and Zomba, all the southern Districts except Nsanje and Ntcheu are part of the urban CA. Refer to Figure 33.

Figure 33: Map showing the urban catchment areas

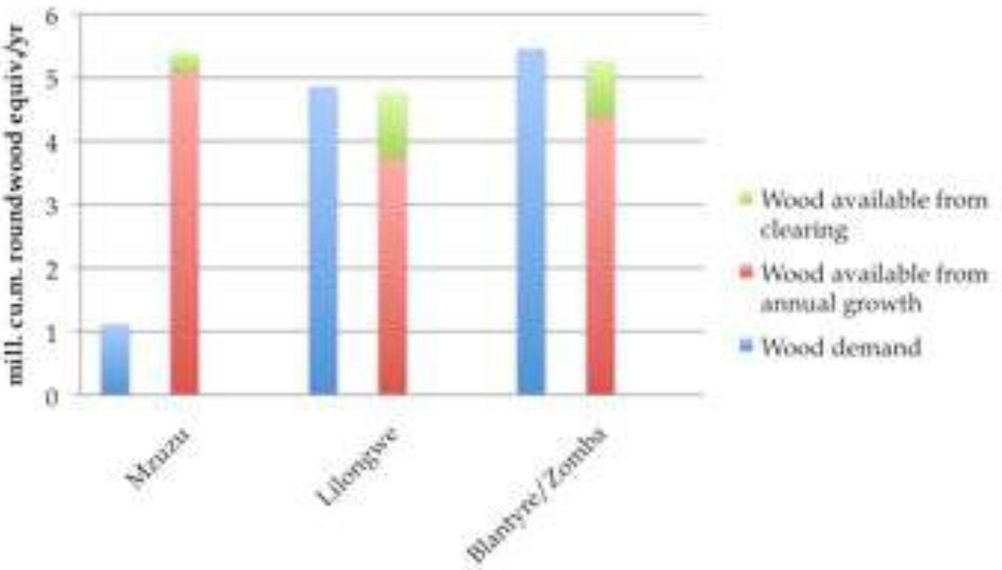
Table 29 is a summary of the supply/demand situation for these three catchments, covering the four main urban centres. The "minimum yield, maximum demand" scenario is presented.

Table 29: Supply and demand for biomass by urban catchment (min. yield, max. demand)

	Supply or demand (mill. m^3 roundwood equivalent)			
	Mzuzu (N)	**Lilongwe (C)**	**Blantyre/ Limbe & Zomba (S)**	**All catchment areas**
Woody growing stock	*113.20*	*56.92*	*57.24*	*227.36*
Land clearing – wood	0.47	1.54	1.33	3.34
Annual growth – wood	7.25	5.30	6.23	18.79
Annual crop residues	1.18	4.46	2.85	8.49
Annual dung	0.06	0.15	0.17	0.38
Annual growth of biomass practically available				
Wood from clearing (70%)	0.33	1.08	0.93	2.34
Wood from annual growth (70%)	5.08	3.71	4.36	13.15
Total wood	***5.41***	***4.79***	***5.29***	***15.49***
Crop residues (50%)	0.59	2.23	1.43	4.25
Dung (10%)	0.01	0.02	0.02	0.04
Combined sustainable wood & residues	***5.67***	***5.94***	***5.78***	***17.39***
Demand - wood	1.12	4.86	5.46	11.44
Demand - residues	0.03	0.32	0.35	0.69
Combined wood &residues demand	***1.15***	***5.17***	***5.81***	***12.14***
Demand as a percentage of practically available biomass from:				
Wood annual growth only	22%	131%	125%	87%
Wood growth + clearing	21%	101%	103%	74%
Crop residues	5%	14%	24%	16%
Sustainable wood and residues	20%	87%	100%	70%
Min. yield + felling & yield compared to demand	n/a yield>demand	116 – 134% (131%)	111 – 129% (125%)	mean in brackets
Max. yield + felling & yield compared to demand	n/a yield>demand	89 – 116% (101%)	95 – 112% (103%)	mean in brackets

Refer also to Figure 34 for an illustration of this demand vs. supply situation by urban catchment area.

Figure 34: Demand for wood vs. available supply by urban catchment area



Mzuzu

Although the Mzuzu CA has more people than the rest of Northern Region, the figures suggest that it still has a large surplus of wood. It is only in the immediate vicinity of the town where the pressure on wood resources is noticeable. Pressure is being put on the nearby Choma Forest Reserve, for example, and measures are required to ensure the sustainability of this supply. The main concern in this area is to find profitable markets for the surplus plantation (and other) wood.

Lilongwe

In the Lilongwe CA, overall sustainable supply has moved from a position of slight excess at the time of the last national biomass study (1996) to one where demand is greater than sustainable supply by 31%, based on the "minimum" yield figures. The catchment area has expanded and more charcoal is being substituted for firewood. The Lilongwe peri-urban plantations are being surreptitiously felled for poles and fuel.

Even when wood from land clearing is added to the available supply, there is still a slight deficit (1%). Only when the supply of residues is also taken into account is there a slight surplus of supply over demand (13%). Again, this is a generalisation across the CA, as in practice some areas are over-harvested and others are not harvested at all. At some locations the imbalance will be much more significant than the average for the CA.

Rural people within the Lilongwe catchment area are being forced to use more and more residues to substitute for firewood. Clearly this is not sustainable and, as stated above, measures are required to increase agricultural and silvicultural productivity, as well as improving end-user efficiency within Lilongwe and its catchment area.

Blantyre/Zomba

The overall picture for the Blantyre/Zomba CA, if the supply/demand figures are a good approximation of the actual situation, is similar to the Lilongwe catchment. Demand is greater than sustainable supply by 25% based on "minimum" yield figures. Even when wood from land clearing is included, there is still a small deficit (3%). Only if the "maximum supply/maximum demand" figures are used and the felling of wood for land clearing in included is there a slight surplus (2%).

The Blantyre peri-urban firewood plantations used to supply some wood to Blantyre and Limbe, but have now been largely invaded and are used for housing, grazing and farming. There is anecdotal evidence that wood is being brought in from Zambia and Mozambique, further indicating that there is an overall wood energy shortage.

Thus much more effort is required to increase the supply of wood and increase intermediate and end-use efficiency in the Blantyre catchment area. As in the case of Lilongwe, forest and farming yields in this area will have to increase to meet future demands without jeopardising the resource base. If this is not done, then the future for the country in terms of food security, energy supply and the state of the environment may be bleak, especially around the two largest cities.

6.9 Conclusions

This chapter has estimated the available supply of biomass and compared it with the estimates of demand from chapter 5. The results have been presented nationally, by region and for the four main urban catchments.

Based on a minimum yield and average demand scenario, **Northern Region** has an overall surplus of biomass at present, with demand representing just 23% of annual wood growth or 21% of wood growth plus available crop residues. The clearing of land for agriculture gives an even larger surplus. Even in the catchment area of **Mzuzu** there is a significant surplus of wood, although there are particular forest reserves close to the town being targeted for woodfuels and current protection measures are not effective.

Although Northern Region has a surplus of wood, the main problem preventing better management from taking place is the lack of economic markets for wood products. It is not economic at present to transport this surplus southwards to meet demand in other areas due to the high cost of road haulage. This would only change if woodfuel prices rose significantly in Lilongwe and transport costs came down, a scenario that looks improbable considering the rate of inflation and the rising cost of operating the required trucks.

In **Central Region**, under the minimum yield and average demand scenario, demand for wood products is currently about 95% of sustainable supply. In other words, the region as a whole is only just producing enough wood to meet its current needs and is likely to fall into a situation of unsustainable harvesting very soon as population rises and further clearing of the standing stock takes place. When wood from land clearing is taken into account, demand falls to 79% of supply. However, this assumes reliance on wood from land being cleared for farming and this is a resource that is not being renewed.

Wood is being over-harvested around **Lilongwe** as demand is greater than sustainable supply in the urban catchment by 31%. The catchment area is expanding and more charcoal is being substituted for firewood. The Lilongwe peri-urban plantations are being felled for poles and fuel, and replanting is inadequate. Even when wood from (non-renewable) land clearing is added to the available supply there is still a slight deficit (1%). Only when the supply of residues is also taken into account is there a surplus of supply over demand (13%). Due to the shortage of wood around Lilongwe, residue consumption may be higher than estimated. Even if this is the case, the situation around Lilongwe is clearly not sustainable and will only worsen if no intervention takes place.

Southern Region has the smallest area of tree cover and demand for wood exceeds sustainable supply by 11%. Only if wood from cleared land is included does supply exceed demand at regional level (demand being 89% of supply). In other words, this region is not producing sufficient wood to meet its needs and must rely on the unsustainable clearing of land for farming to generate sufficient wood.

The overall picture for the **Blantyre/Zomba** catchment area is worse than for Lilongwe. Demand is greater than sustainable supply from the CA by 25%, based on minimum yield figures. Even when wood from land clearing is included, there is still a deficit (3%). The result is over-cutting of wood within the catchment area, targeting in particular forest reserves where wood is most abundant and accessible through corrupt practices, and a progressive expansion of the wood harvesting radius further from the main centres of demand. In this region there are additional implications of over-harvesting for watershed degradation, riverine siltation and therefore the output of the hydro-power stations on the Shire river, upon which the country is heavily dependent for its electricity.

Intervention measures to better manage woodfuel supplies are clearly most required in (a) the urban catchment areas of Blantyre and Lilongwe, (b) the Shire watershed, and (c) those forest reserves within the urban CAs that are under the heaviest pressure from woodfuel harvesting. A second level of priority is (d) Southern Region as a whole, together with (e) those areas of Central Region where tobacco growing is prevalent.

These areas should therefore form the focus of the intervention package proposed in Chapter 8.

7. The Market for Cooking Fuels and Future Trends

7.1 Introduction

Whereas the two previous chapters have looked at total demand and supply of biomass, for all purposes, domestic and non-domestic, traded and subsistence, this chapter focuses specifically upon commercially traded cooking fuels. That is, those fuels which the end-user does not collect for him or herself at no financial cost, but which are paid for.

Commercial cooking fuels are a sub-set of the country's total energy consumption but arguably the most important as they relate to cooking – by far the biggest consumer of thermal energy – and to fuels that are traded, which are the drivers for the main energy supply chains.

From the point of view of the BEST development process, it is also the commercial fuels sector where the need for intervention is greatest and where there is the greatest possibility of developing viable response strategies: in terms of need, the commercial fuels sector is virtually synonymous with the urban energy sector and (as shown in the previous chapter) it is around the largest urban centres of Lilongwe and Blantyre that demand for wood energy is most in excess of sustainable supply and where action needs to be focussed; in terms of response, it is the commercial fuels sector which offers the greatest (and arguably the only) opportunity to achieve significant impacts on both the supply and demand sides, by using interventions that are incentivised by the desire to save or to make more money; the subsistence sector, on the other hand, presents few such opportunities as the fuel is self-collected. This explains why the modelling process focussed on commercially traded fuels.

7.2 GLOBUS Overview

7.2.1 Approach

The analysis of commercial cooking fuels was carried out using the "GLOBUS" energy modelling package. GLOBUS is a PC-based tool based on a series of inter-linked Excel spreadsheets. Assumptions are entered relating to demographics, household and non-household energy consumption, energy mixes and pricing, and the model provides simple graphical representations that enable fuels to be compared in terms of cost-effectiveness, relative demand and overall consumption under the current situation and variable future scenarios. The assumptions can be adjusted and this permits the consequences of different actions to be compared.

GLOBUS is based on best estimates, an unavoidable approach in a sector where data are scarce, unreliable and sometimes contradictory. But its hypotheses are transparent and can be easily understood, with the advantage that in the event that more accurate estimates become available, they can always be incorporated into the model. The main assumptions are provided with each analysis and the GLOBUS model is available on request from MARGE for readers interested in experimenting with different sets of assumptions.

7.2.2 Application

GLOBUS was used by the BEST team to:

- analyse the relative terms of competition between wood, charcoal and other fuels used by households and non-domestic customers for cooking and other uses; and

- project the fuel supply and demand situation 15 years forward to 2023.

The model can also be used to develop and quantify an investment programme related to a particular strategy scenario and to assess such a programme financially, economically and environmentally. In the Malawi case it was agreed at an earlier stage in the BEST process *not* to attempt this GLOBUS cost-benefit comparison for different potential intervention packages. It was realised that the negative connotations pertaining to biomass fuels were significant and that GoM sought to promote alternative sources of energy as a matter of policy. The Strategy development process – including the GLOBUS modelling component - therefore focussed on *making the case for biomass*, rather than assuming that such a case had already been made and going on to cost and compare different potential intervention packages.

This was an (approved) departure from the BEST terms of reference as originally conceived. It was justified by the realisation that GoM associates woodfuels, and commercial woodfuels in particular, with poverty, under-development, environmental degradation and ill health. The well-publicised national charcoal survey of 2007 served only to reinforce these perceptions, by continuing to link the charcoal trade with large-scale deforestation. National policy (as articulated in the National Energy Policy, 2003) is essentially to tolerate the woodfuels sector until such time as alternatives can be found, and in the meantime to pursue such alternatives vigorously – the preferred option being electricity.

It was therefore agreed that GLOBUS would serve the BEST process most usefully as a tool for presenting the implications of current energy sector trends and projecting those implications forward to predict future demand for different fuel sources. Alternative strategies (especially vis-à-vis energy pricing) could then be compared.

7.3 Comparison of Commercial Cooking Fuels

7.3.1 Terms of Competition between Fuels

The relative competitiveness of various cooking fuels was analysed using GLOBUS according to their financial prices (retail prices to customers), their energy contents and the efficiency of the cooking devices with which they are typically used. The analysis was based on the hypothesis that a household needs a certain amount of "useful energy" (the energy that goes into the pot), whatever the fuel used.

The results of this comparison are presented in Table 30 under current pricing conditions. The table includes woodfuels (using traditional and improved stoves) as well as electricity, LPG and paraffin. Charcoal in the ubiquitous improved ceramic-lined metal stove (known as the Kenya Ceramic Jiko, KCJ) was used as the baseline fuel/stove combination against which the other energy sources were compared. That is, how much of each of the other fuels would have to be used to deliver the equivalent amount of useful energy as 1 kg of charcoal burned in a typical metal/ceramic stove?

Table 30: Comparison of fuels in terms of usable energy and quantity required for cooking

Fuel	Energy content	Stove	Thermal efficiency	Usable energy	% relative to charcoal	Equivalency to 1 kg of charcoal	Quantity required for cooking
	MJ/kg			**MJU/kg**		**kg**	**kg/HH/yr**
Firewood	15.5	Improved	19.5%	3.0	249%	2.5	1,695
		3-stones	15.0%	2.3	324%	3.2	2,204
Charcoal	*29.0*	*Improved*	*26.0%*	*7.5*	*100%*	*1.0*	*679*
		Traditional	20.0%	5.8	130%	1.3	883
Paraffin	43.2	Wick stove	42.1%	18.2	41%	0.4	282
LPG	45.0		50.0%	22.5	34%	0.3	228
	MJ/kWh			**MJU/kWh**		**kWh**	**kWh/HH/yr**
Electricity	3.60		68%	2.4	308%	3.1	2,093

Note: (i) Improved firewood stove refers to portable household clay stove.
(ii) Improved firewood stove refers to ceramic-lined stove with metal cladding (KCJ).
(iii) MJU = usable mega-joules of energy; HH = household.
(iv) Last column assumes average urban household size of 4.44.

The figures show that for every 1 kg of charcoal used for cooking, a household would require 3.2 kg of wood, 0.5 litres of paraffin, 0.3 kg of LPG or 3.1 kWh of electricity to deliver the same amount of energy to the cooking pot, enabling the same quantity of food to be cooked.

Based on these comparative figures, the last column gives the amount of each fuel that would be required annually for cooking by an average urban household cooking exclusively with that fuel. This is again based on the charcoal baseline, which assumes consumption of 679 kg of charcoal/HH/yr using a KCJ, equivalent to 5,123 MJ of usable energy per HH (or 3.2 MJ/person/day).

It is apparent that an average household would need 2.2 tonnes of firewood to achieve the same result as 679 kg of charcoal, 282 kg (335 litres) of paraffin, 228 kg of LPG or 2.1 MWh of electricity; 2.1 MWh of electricity per year is equivalent to 5.7 kWh/day. This compares with the total average electricity consumption of ESCOM's domestic clients of 9 kWh/day, suggesting that over 60% of all energy supplied to households is being used for cooking. In fact approximately 50% of *total* electricity consumption in the country is being used for domestic cooking. This is a massive proportion and questions must be raised about the cost-effectiveness of allocating so much of the country's limited electricity supply to preparing food in homes.

Knowing the costs of each fuel, a comparison of the annualised costs of cooking with the different fuels becomes possible. Table 31 summarises the relative cost of cooking using each energy source, at current prices. Charcoal is again taken as the baseline. Refer also to Figure 35 for an illustration of relative cooking cost.

Table 31: Relative prices of fuel for cooking

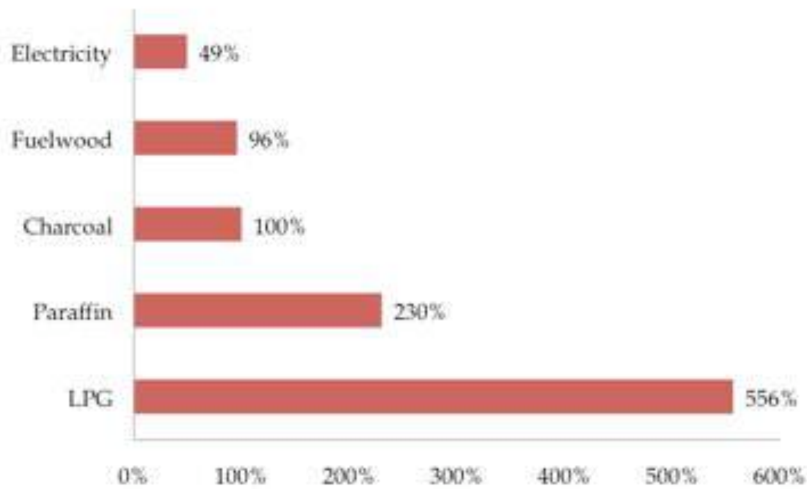
Fuel	Stove type	Quantity required for cooking (per HH/yr)	Fuel price (MK)	Household expenditure (MK/HH/yr)	Cost relative to charcoal (%)
Firewood	Improved	1,695 kg	8.4/kg	14,239	74%
	3-stones	2,204 kg		18,510	96%
Charcoal	*Improved*	*679 kg*	*28.4/kg*	19,311	*100%*
	Traditional	883 kg		25,104	130%
Paraffin	Wick stove	282 kg	158/kg	44,469	230%
LPG		228 kg	472/kg	107,452	556%
Electricity		2,093 kWh	4.56/kWh	9,545	49%

Note: (i) Quantity of each fuel required for cooking is taken from Table 30.

(ii) Paraffin is based on a retail price of MK 132.6/litre and a specific gravity of 0.84.

(iii) Electricity is based on ESCOM's domestic tariff of MK 3.9147 + 16.5% VAT per unit, for consumers using 30 to 750 kWh/month.

Figure 35: Relative cost of cooking with selected fuels, current prices



Note: Based on data from Table 31, assuming firewood is used on an open fire, charcoal in a KCJ and paraffin in a standard wick stove.

It is apparent that cooking with electricity currently costs less than half as much as cooking with charcoal. The cost of cooking with firewood is slightly below that of charcoal. Cooking with paraffin costs over twice as much as cooking with charcoal and cooking with LPG is 5.6 times more. The LPG price remains very high in Malawi due (mainly) to the small size of the market.

For those who collect wood for their own consumption (most rural households and a small percentage of urban households), this comparison does not apply. Those rural customers who buy their fuel also have access to lower prices for firewood and charcoal than those assumed in this analysis, meaning that these fuels would constitute the least-cost options for rural residents. The comparison is valid only for urban residents using purchased fuels.

7.3.2 Long-term Price Trends

It is widely believed that the prices of cooking fuels have been rising significantly over the last two decades. However, the reality is that although prices in present day Malawi Kwacha have indeed risen, in real terms prices of woodfuels and electricity have shown a consistent *decline* and only in the case of paraffin has there been an increase in price. Refer to Figure 36 for long-term prices of paraffin and Figure 37 for woodfuels and electricity.

Figure 36: Paraffin price trend in 1996 terms, 1996-2008

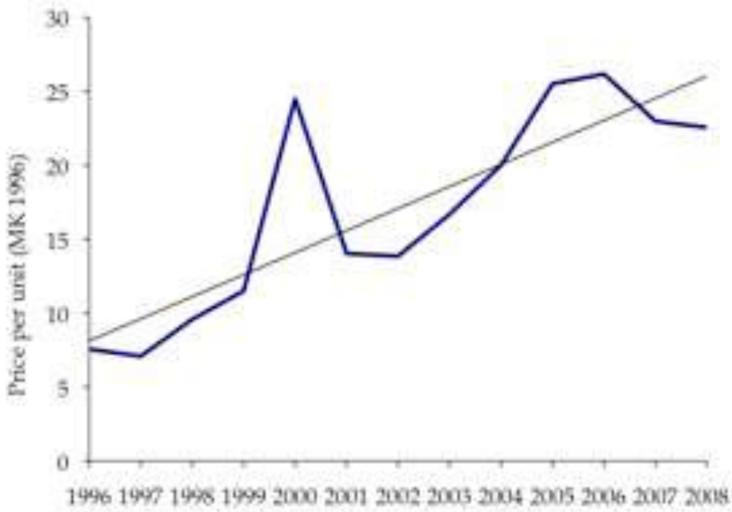
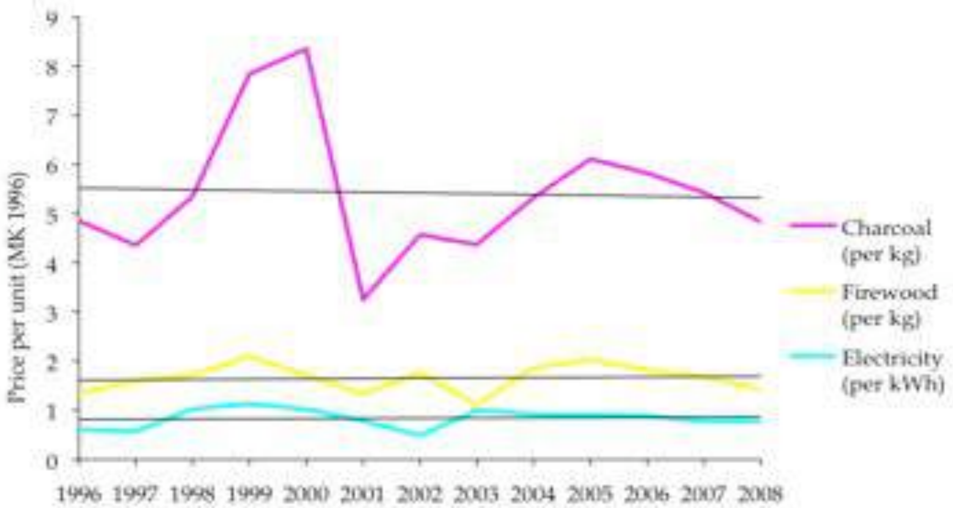


Figure 37: Woodfuel and electricity price trends in 1996 terms, 1996-2008



Note: Price trends in 1996 MK equivalent.
Source: Time series price data from National Statistical Office, Zomba.
Inflation figures and exchange rates from http://econ.worldbank.org

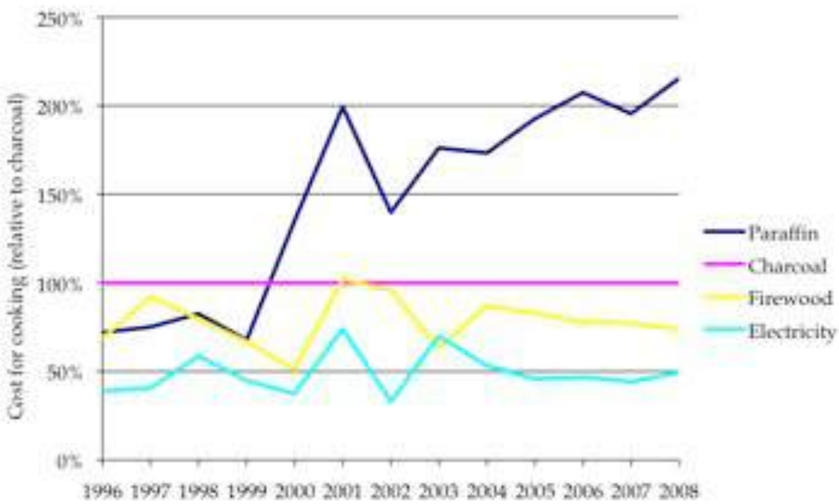
As the charts show, in real terms only the price of paraffin has been rising over the last 12 years, while the price of the other three fuels has been level or in decline. In nominal terms, corrected for inflation, it can be shown that prices of charcoal, firewood and electricity have considerably decreased.

Explaining the stagnation of wood and charcoal prices requires a thorough analysis of the market. It may be due to a number of factors such as:

- declining agricultural revenues and a growing need on the part of rural people to derive alternative revenue from tree harvesting;
- population growth and greater competition for rural employment opportunities between cropping periods, resulting in surplus rural labour with few competing livelihood opportunities; hence cheaper labour for woodfuel-based enterprise;
- better roads and more efficient (and larger) trucks, reducing transport costs to urban markets; and
- the effective "capping" of charcoal prices by cheap electricity, preventing charcoal traders from increasing their prices to more profitable levels for fear of losing market share.

Given the flat price trend, the comparative cost of cooking with the three cheapest fuels has not changed significantly over the last 20 years, as Figure 38 shows.

Figure 38: Comparison of the cost of cooking with different fuels, 1996-2008



Source: Time series fuel price data from National Statistical Office, Zomba. Relative requirements for different cooking fuels taken from Table 30.

Paraffin was competitive for cooking with the other fuels in the mid-1990s but is now considerably more expensive. This partly explains why less than 1% of urban residents now use it for cooking, although availability constraints are also important. Electricity has been the cheapest cooking energy option in urban areas for some time, remaining consistently below firewood and charcoal for those who have connections and electric stoves.

7.3.3 Conclusion

Electricity is by far the cheapest option for urban cooking in Malawi at present, followed by firewood and then charcoal. Paraffin and LPG are significantly more expensive. This situation has not changed much over the last 12 years, except that paraffin has moved from a competitive position to one of significant relative expense.

At first this conclusion seems to offer clear endorsement of the government's fuel-switching policy, as it apparently implies a win-win situation in which a clean and convenient source of cooking energy (electricity) is at the same time the cheapest option currently available. However, the price of electricity upon which the above analysis is based is not the same as the cost of electricity which would need to be considered in an economic analysis of the different development scenarios. There would also be very significant financial implications for the country if there were to be a significant move away from woodfuels towards electricity. The next section investigates how realistic such a large-scale switch might be.

7.4 Future Market Trends

7.4.1 Introduction

In order to predict the future market for different energy sources, the BEST team looked back at the historical trend for lighting and cooking fuels in rural and urban areas and used this as the basis for forward extrapolation. This can be called the "business as usual" scenario, in which the markets are assumed to evolve in line with recent historical trends.

Table 32 summarises the findings of the most reliable household energy surveys that have been conducted over the last 30 years, which were used to establish these long-term trends.

Table 32: Main energy sources used for cooking and lighting, 1974-2007

	1974	1978		2004		2006		2007	
	Urban	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Main lighting source									
Firewood		1.0%	1.9%	1.2%	4.2%			0.3%	1.6%
Electricity	16.0%	27.5%	1.1%	32.7%	1.9%			51.7%	2.2%
Paraffin	83.0%	68.3%	94.3%	56.0%	88.3%			38.1%	92.0%
LPG		0.1%	0.1%	0.0%	0.0%			0.0%	0.0%
Candles	1.0%	2.6%	0.1%	9.2%	0.6%			9.5%	0.7%
Grass		0.5%	2.4%	0.7%	4.5%			0.2%	3.5%
Main cooking fuel									
Firewood	72.0%	69.2%	98.6%	37.9%	97.0%	19.0%	97.2%	35.1%	93.4%
Charcoal	19.4%	15.6%	0.4%	48.2%	1.2%	42.4%	1.2%	43.7%	4.2%
Electricity	8.0%	13.4%	0.4%	11.5%	0.4%	38.2%	0.4%	20.0%	0.5%
Paraffin	0.7%	1.8%	0.2%	1.2%	0.0%	0.3%		0.6%	1.0%
LPG		0.1%	0.0%			0.1%		0.2%	0.0%
Residues		0.0%	0.4%	0.5%	1.2%	0.0%	1.2%	0.4%	0.9%

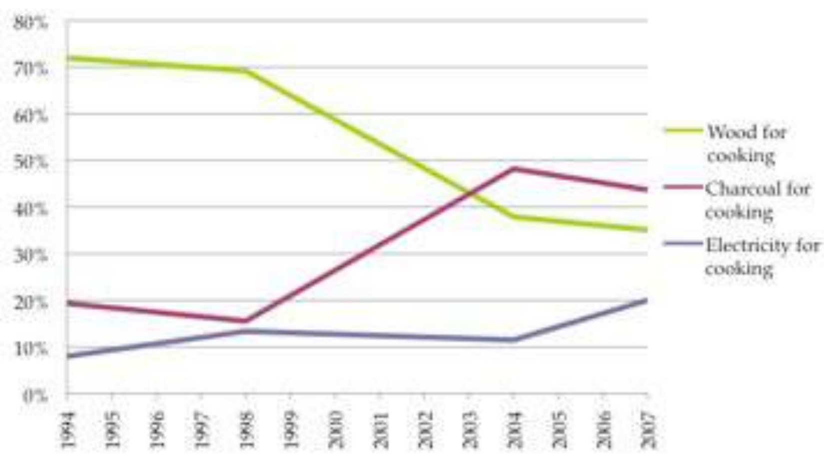
Sources: Arpaillange, 1997; Milner & Openshaw, 1997; GoM, 1998 (national census); GoM, 2005 (Integrated Household Survey); Kambewa et al, 2007 (USAID-funded charcoal survey); 2007 welfare monitoring survey by NSO, Zomba.

The data show that the urban cooking fuel market has been fully dominated by firewood, charcoal and electricity for the last three decades. Rural markets have been dominated by firewood, although charcoal is making significant inroads and has risen from almost nothing to capture 4.2% of the rural market.

Of the other fuels, paraffin peaked in 1998 with 1.8% of the urban market and then reduced its share to 0.6%, while LPG still represents only 0.2% of urban domestic customers.

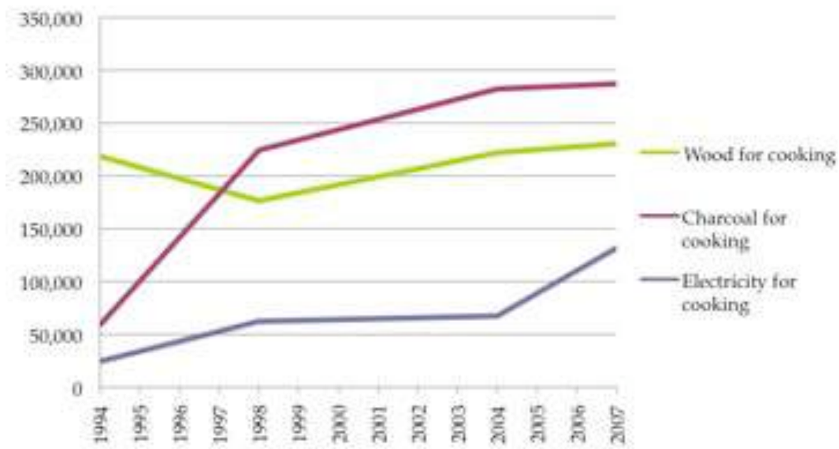
Excluding the data from Kambewa et al (2007) as not truly representative[26], the long-term market trends (in terms of both the percentage of households using a particular fuel and absolute customer numbers) are presented in the following two charts (Figure 39 and Figure 40).

Figure 39: Percentage of urban households according to main cooking fuel



[26] The 2007 sample seems to have been biased towards electricity users, perhaps because they were more readily accessible to the survey enumerators. This is indicated, for example, by a conclusion that 51.7% of urban households use electricity for lighting, which is not possible as the average urban connection rate is only about 30%.

Figure 40: Number of urban households according to main cooking fuel



In terms of urban market share:

- The percentage of urban households using firewood as their main cooking fuel has declined steadily, from 70% to 35% since the mid-1990s, its share being taken over mainly by charcoal;

- Charcoal, which had a significant presence only in Blantyre in the mid-1990s, has nearly doubled its urban market share from 20% to 40% of households; charcoal is seen as a clean and convenient cooking option, in spite of its higher price, particularly because it can be bought in small quantities on a daily basis; and

- Electricity's share has grown steadily from less than 10% to 20% of the urban cooking market; cooking with electricity is currently the cheapest option, though not available to all potential customers due to the cost of acquiring the cooking stove, the over-stretching of generation and distribution capacity[27] and the fact that non-permanent structures may not be connected by the utility.

In terms of urban customer numbers:

- There was an initial reduction in the number of households using firewood, but a subsequent increase due mainly to underlying population growth;

- The number of charcoal users is rising at a steady and consistent rate, and they now exceed the users of all other commercial fuels; and

- The number of households cooking with electricity has increased rapidly in the last five years, largely because of an attractive tariff that has shown no increase in real terms (as shown in Figure 37).

[27] ESCOM had 5,000 paid-up domestic applicants on its waiting list in May 2008, but lacked the resources to connect them.

Comparisons between households which use electricity for lighting and those which use it for cooking suggest that:

- around half of the households using electric lighting also cook with electricity as their main fuel (50% in 1994, 49% in 1998 and 39% in 2007);

- but in actual numbers, the households using electric lighting represent two to three times the number of official ESCOM connections (219% in 2004; 298% in 2007), presumably due to illegal and shared connections;

- as a result, the proportion of households cooking with electricity is similar to the number of official connections (72% in 2004; 109% in 2007).

7.4.2 Future Market Development

Based on population growth projections and the market trends summarised in the previous section, it is possible to predict the future development of the market for woodfuels and electricity. The assumed population growth trends and rates of urbanisation upon which these projections are based have been summarised in Annex S, the main fuel in use in Annex T and the total commercial demand by fuel in Annex U. These and other variables used in the modelling process are elaborated in full in the GLOBUS model, which has been made available to GoM for further experimentation.

The market development predictions under this "business as usual" scenario are presented, by fuel, in Figure 41 to Figure 44.

Figure 41: Likely development of the firewood market

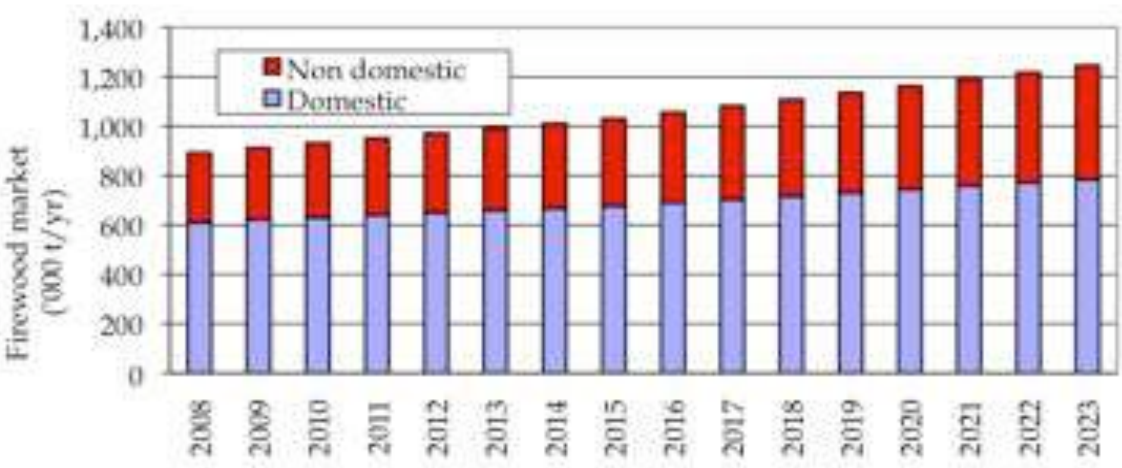


Figure 42: Likely development of the charcoal market

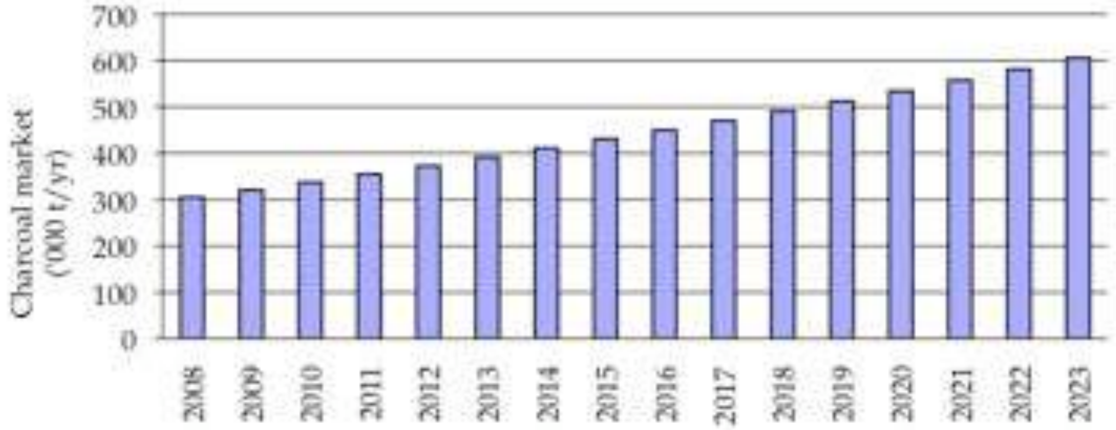
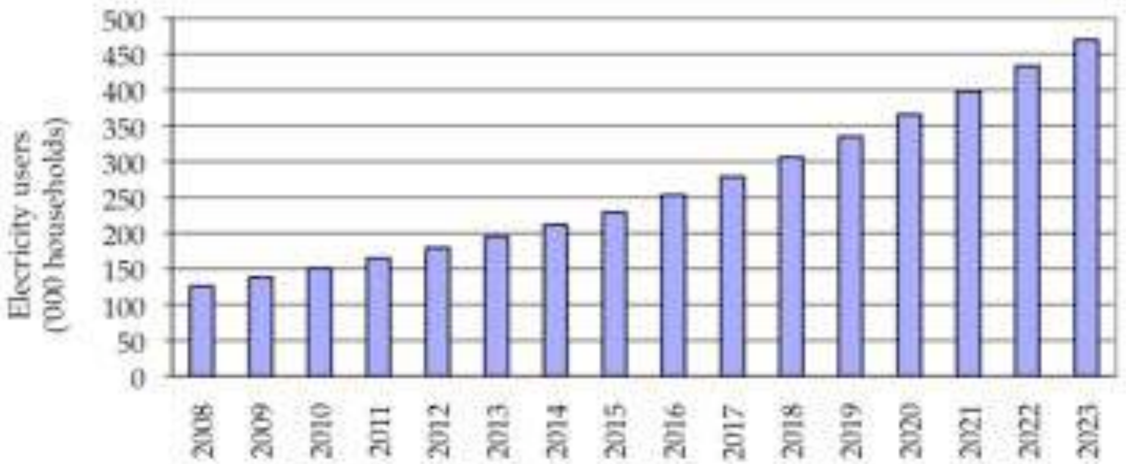


Figure 43: Likely development of the electricity market for cooking (energy)

Figure 44: Likely development of the electricity market for cooking (households)



Demand for all the main cooking fuels will clearly increase significantly in the next 15 years. Commercial firewood demand is predicted to rise by 39% from 890,000 to 1.25 million t./yr while demand for charcoal will almost double from 305,000 to 606,000 t./yr.

The development of the electricity market will be even more rapid and consumption for cooking purposes is likely to rise almost four-fold, from 241 to 910 GWh/yr; assuming, of course, that the current rate of new connections is sustained, that consumers continue to use electricity for cooking in the same way as they do at present and that the capacity exists to meet this demand.

The implications of this "business as usual" scenario are as follows:

- To sustain its current rate of network expansion, ESCOM will need to connect an average of 25,000 new households per year, rising from 15,000 in 2008 to 55,000 in 2023;
- Meeting this target will increase the proportion of households with electricity from 4.6% in 2008 to 10.6% in 2023;
- Total domestic connections will rise from 145,000 to 530,000 and urban electrification rates will have reached 55% in Lilongwe, 70% in Blantyre and 30% in smaller towns;
- There will be 470,000 households cooking with electricity nationally, up from 126,000 in 2008;
- 42% of households in Lilongwe, 56% in Blantyre and 23% in other towns will be cooking with electricity as their principal or back-up fuel;
- 910 GWh/yr will be required for domestic cooking, and increase of 669 GWh/yr on 2008 demand;
- This will require an additional 392 MW of generating capacity for cooking purposes alone, and perhaps an additional 784 MW of capacity overall, from the 2008 baseline of 285 MW;
- An additional 64 MW which is expected to come on-line in 2011 will bring the country's total generating capacity up to 349 MW, but demand by then will already have reached 370 MW (half of which will go for cooking); in other words a shortfall is already envisaged in the immediate future, not many years hence; and
- At an assumed installed cost of $1.5 million per MW, Malawi will need to spend $0.6 billion on providing the required 392 MW of new generating capacity for household cooking in the next 15 years, assuming such capacity is available either domestically or via the envisaged SAPP inter-connector.

7.4.3 Conclusions

There are two critical conclusions from this scenario:

a) The unsustainably low ESCOM tariff is creating the misleading impression that electricity is the most economical option for domestic cooking. While it may be the financially least-cost option at present, the tariff is unsustainable.

b) The low tariff is resulting in high rates of cooking with electricity among those households with connections and some 50% of all the country's power output is currently going to domestic cooking. Malawi lacks the generating capacity and finance to sustain this scenario of high electricity consumption for cooking and supply is already projected to fall short of demand by 2011; supporting large-scale domestic cooking with electricity is also a questionable allocation of resources that could otherwise be invested in industrial and economic development.

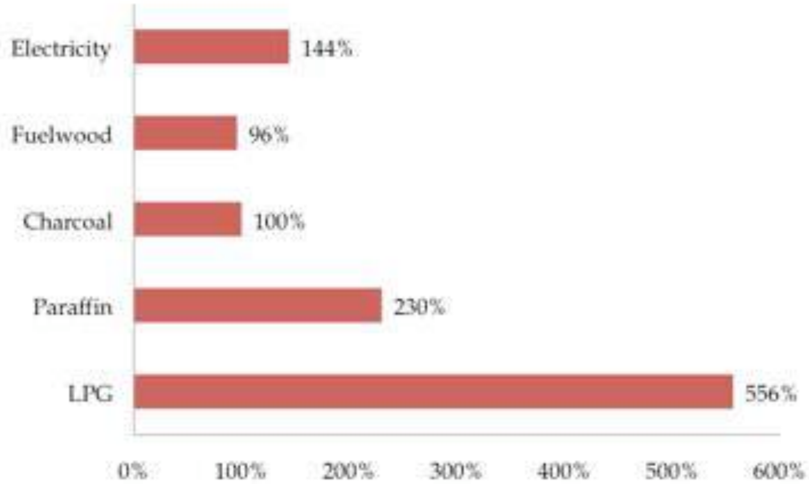
For the electricity subsidy to be allowed to continue, the following two questions will need to be answered: (i) who will continue to pay for the subsidy, as this cannot be ESCOM's responsibility; and (ii) how can it be justified that the richest households benefit most from that subsidy?

7.4.4 An Alternative Scenario

The present difficulties facing the power sector (system overload, lack of adequate generating generation capacity, inability to connect many new clients) are largely related to the under-capitalisation of the utility due to low tariffs. It is inevitable that those tariffs will have to rise and this will make electricity a less financially attractive option for cooking. Depending on the size of the tariff rise and the degree to which consumers switch fuels as a result, there are likely to be significant impacts on commercial energy markets.

An alternative scenario was modelled using GLOBUS in which electricity was priced at its conservatively estimated LRMC of US 9 cents[28]. Reworking the calculations of Table 31 based on this alternative tariff, the annual cost of cooking for an average urban family using electricity now rises from MK 9,545 to MK 27,877. Figure 45 shows the effect that this has on the relative cost of cooking with the different fuels.

Figure 45: Relative cost of cooking with selected fuels, with electricity at LRMC



Note: This comparison is based on financial (market) costs for each fuel, except for electricity where the LRMC is considered. Strictly speaking the economic cost of *each* fuel should be compared. This would require considerable additional research. As an indication, the price of firewood for urban markets currently averages MK 2.1/kg at source whereas a tea estate growing its own firewood works on an internal production cost of around MK 3.9/kg. Taking the latter as the economic cost at source, and assuming that there was some means by which to enforce such a cost on wood sourced from customary and government land, the retail price of firewood after transport and mark-ups in the supply chain would be around 20% higher than

[28] Note that this is still very low compared to cost-reflective tariffs applied in other African countries; e.g. $0.24 in Rwanda, $0.28 in Kenya and $0.29 in Uganda.

the current financial price. This gives a rough indication of how the figures might change if economic costing was applied.

Under this alternative pricing scenario, electricity becomes 44% more expensive than charcoal for cooking.

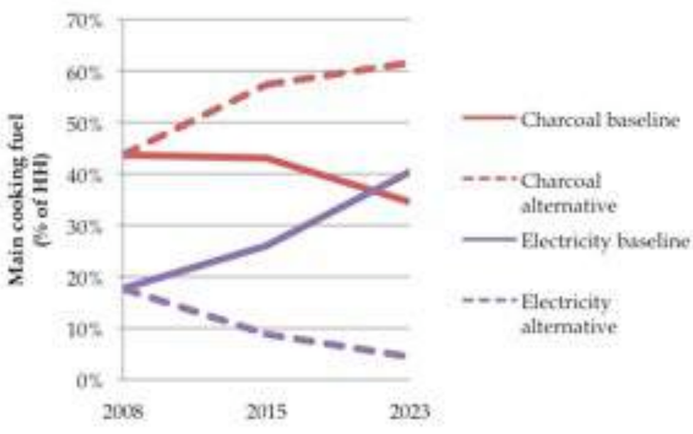
It is impossible to predict the effect that such a change in relative pricing would have on demand for electricity vs. other energy sources. On the one hand, electricity would remain an inherently attractive and convenient energy source, and would probably still be preferred by wealthier urban households, even if it cost much more[29]. On the other hand, many consumers would not be able or willing to pay the higher price when considered in tandem with the high frequency of power cuts, the cost of the cooking appliance and the inability of electric hot plates to cook several common foods. Many would switch to charcoal and some would opt for paraffin or LPG, having become used to a clean and convenient way of cooking[30].

In the GLOBUS model, an alternative scenario was modelled which assumes that the percentage of those households with electricity connections who cook with electricity would *halve* from 2008 levels by 2015, and would halve again by 2023. Levels of LPG, paraffin and commercial firewood use were assumed to remain unchanged, for the sake of simplicity, although there would probably be a modest increase in all three. The details of this alternative scenario are presented in Annex T.

Under the alternative scenario, the rate of new electricity connections is assumed to be the same as the first scenario. ESCOM's domestic connections will therefore still rise from 145,000 to 530,000 by 2023. The difference is that the percentage of those with connections who are now assumed to *cook* with electricity as their principal or back-up energy source would drop from about 18% of urban households in 2008, to 9% in 2015 and 4.5% in 2023.

The outcome of this alternative scenario is illustrated in Figure 46, which shows the percentage of households using electricity and charcoal as their main cooking fuel.

Figure 46: Comparison of the original and alternative energy mix scenarios



[29] In Senegal, when the subsidy on LPG was removed after more than ten years and LPG suddenly became more expensive than charcoal, consumers continued to use LPG because they were accustomed to it and because it was more convenient.
[30] In Zambia, an increase in electricity tariffs and the introduction of a pre-payment system resulted in a large-scale switch from electricity to charcoal for cooking in the country's urban areas.

Figure 47 to Figure 49 illustrate the effect this would have on the total markets for charcoal and electricity for cooking.

Figure 47: Alternative development of the charcoal market

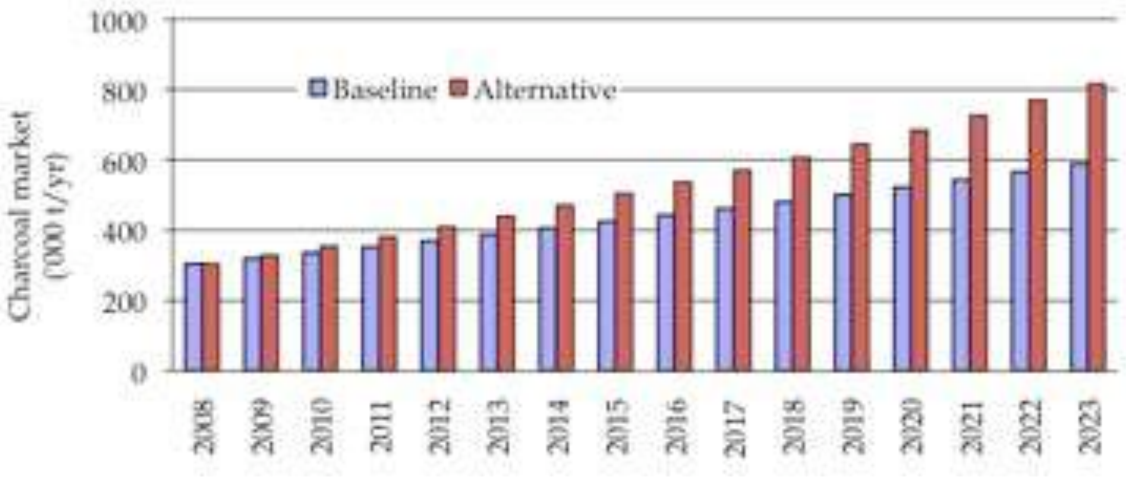


Figure 48: Alternative development of the electricity market for cooking (energy)

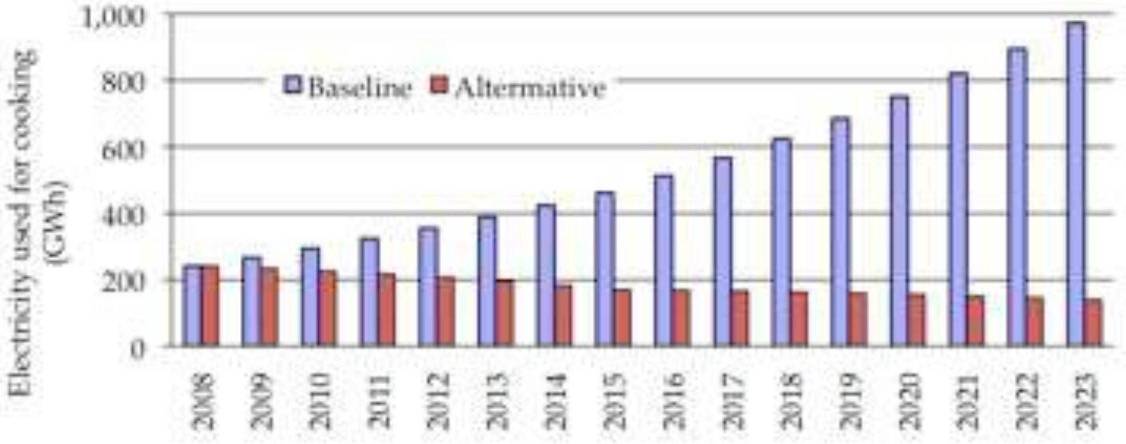
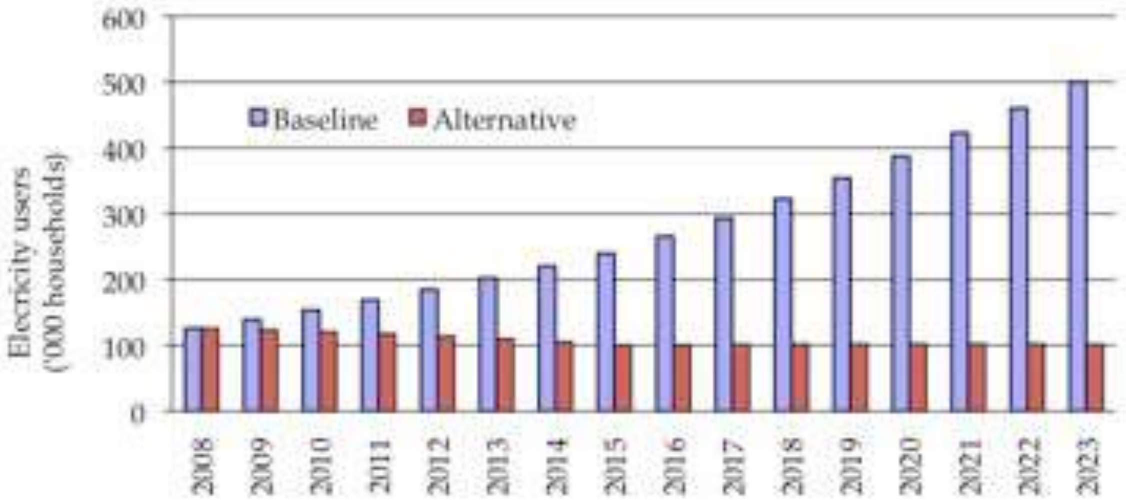


Figure 49: Alternative development of the electricity market for cooking (households)



Demand for charcoal would now rise more dramatically, from 305,000 to 816,000 t/yr (instead of 606,000 t./yr) by 2023. Commercial firewood demand would still rise by 39% as per the first scenario, from 890,000 to 1.25 million t./yr (not illustrated).

The development of the electricity market for cooking would now take a different course:

- Only 5% of households in Lilongwe, 6% in Blantyre and 3% in other towns would be cooking with electricity as their principal or back-up fuel by 2023;
- There would be a progressive reduction in the total amount of electricity required for cooking, from 241 GWh/yr to 140 GWh/yr;
- The number of households cooking with electricity would also go down, though only by 19% (from 126,000 to 102,000), given that the total number of households would still continue to rise due to population growth and urbanisation;
- Assuming that the country would still need approximately 400 MW of new generating capacity for *non-cooking* purposes by 2023, the reduced demand for cooking purposes could be offset against this requirement and would now mean that only about 320 MW of new capacity would need to be found in the next 15 years; and
- The country would avoid spending an estimated $0.6 billion on electricity generating capacity for domestic cooking.

This alternative scenario is considered a more realistic approximation of what will actually transpire than the baseline, given that it will simply not be possible for Malawi to sustain past rates of growth in electricity use if 50% of supply continues to go to domestic cooking. Not least, Malawi's key international financiers are unlikely to find this an appropriate application of their investments.

7.5 Conclusion

The main (and possibly surprising) conclusion from the GLOBUS analysis is that Malawi's energy markets face a heavily *charcoal-dominated future*. There will be massive increases in charcoal demand under *both* the baseline and alternative scenarios. Whether this is a doubling in the next 15 years (as under the first scenario) or a tripling (as under the second) is perhaps not relevant. The point is that there is going to be a huge increase in demand for charcoal *whether or not* ESCOM's ambitious electricity expansion scenarios are realised.

Woodfuel demand is already in excess of sustainable supply for large parts of Central and Southern Regions, and measures are therefore urgently required to prepare for, and to respond to, this substantial and imminent growth in the charcoal market. Holding out hope that electricity will relieve the pressure on woodfuels is unrealistic, based not only on the fact that the electricity growth scenario is founded on economically unsustainable pricing and impossibly high requirements for new power, but also on the fact that charcoal consumption is going to at least double even under the most optimistic electrification scenario.

There will be various adjustments in the market that will have minor effects on this overall trend: charcoal prices will inevitably rise faster than they have in the past, for example, as the wood resource becomes more scarce in the urban catchment areas through the combined effects of agricultural land clearing and over-harvesting; adoption of LPG and paraffin will increase as they are more aggressively promoted and their relative prices become more favourable, particularly as a result of scale-economies related to a growing market size; and there may be uptake of other alternative fuels in niche markets, such as modified ethanol as an industrial boiler fuel (from BluWave Ltd. in Blantyre).

But the bottom line will be a massive increase in woodfuel consumption, and particularly in commercial woodfuel consumption and the charcoal market, to which national development policies and the Biomass Energy Strategy must directly respond.

8. Components of the National Biomass Energy Strategy

8.1 Introduction

8.1.1 Justification

This Biomass Energy Strategy study has examined the supply of and demand for biomass energy, particularly wood, in Malawi's three regions and its main urban catchment areas. It has been confirmed that biomass is the most important fuel in the country in terms of the quantity used and accounts for about 88.5% of final energy demand and 92% of household demand. Woodfuels are the cheapest source of available energy (assuming no subsidies) and are expected remain so for the foreseeable future. As a result, the dominance of biomass will continue for many decades.

Woodfuels are also the most significant traded fuels, with an estimated 2008 market value of MK 15.5 billion ($105 million), of which 75% is labour inputs. The growing and trading of woodfuels accounts for an estimated 1.6% of GDP, rising to 4.4% if the shadow price of collected firewood and crop residues is included. The woodfuel business employs the equivalent of 130,000 full-time people in growing, production, transportation and trade, over 80% of whom live in rural areas.

In spite of the sector's huge economic and social importance, the non-issuance of production and transport licences effectively makes commercial production and trade in woodfuels illegal, preventing sustainable and effective management of the resource base and the industry as a whole. Signs of resource over-exploitation are clear in the more densely populated areas, particularly in the districts of Central and Southern Regions that supply fuel to Blantyre, Zomba and Lilongwe.

A strategy to guide the management of the biomass energy sector is long overdue and there is an urgent need to develop a more rational and coordinated approach. If wood is to become the sustainable source of energy that it could be, the GoM will need to adopt a more pro-active and supportive stance to establish a framework of incentives and disincentives for the private sector to behave more sustainably and to diversify and scale up its investments in the sector.

This chapter outlines ways in which the government and other sector players can intervene, through policy, regulatory and practical measures, to ensure that biomass becomes an energy resource that can fulfil its true potential by being more sustainably produced, harvested and utilised. A wide-ranging set of ideas are presented, which need to be discussed and fine-tuned in a process involving the key stakeholders from government (on the regulatory side), the private sector and NGOs (for implementation) and Malawi's development partners (for potential financial support). There must also be a systematic stakeholder review to establish who is already doing what in the proposed areas of action, in order to determine which activities can be implemented by existing actors versus those areas where new capacity is needed.

The proposed next stages to take forward the implementation of the Strategy are outlined in the final chapter (chapter 10).

8.1.2 Objectives

The overall objective of the Biomass Energy Strategy is to ensure a sustainable supply of affordable woodfuels. Its three specific objectives are to:

(i) Increase the supple of sustainable woodfuels (**section 8.2**);

(ii) Increase the efficiency of energy use (**section 8.3**); and

(iii) Create the institutional capacity to manage the biomass energy sector effectively and implement the Strategy (**section 8.4**).

The chapter begins with a description of the guiding principles that the Strategy should follow, followed by an outline of the Strategy's proposed elements.

8.1.3 Guiding Principles

The following guiding principles form the basis of the Strategy:

a) **Carrots as well as sticks:** Incentives for sound behaviour are considered more workable and effective than regulation based on enforced control. In other words, measures that *reward* sustainable practice are in general preferred over those that *penalise* poor practice. Incentives, subsidies and market-driven mechanisms for encouraging sound and sustainable supply chains are likely to be more effective and implementable than the imposition of financial or other penalties, although well-designed taxation systems can be a useful complementary tool if the right institutional mechanisms are in place to ensure enforcement, enabling revenue to be returned to communities at source and providing incentives for more sustainable behaviour.

b) **Decentralisation of responsibilities and benefits:** Most natural resources are controlled, officially or unofficially, by the communities who live close to them, yet most of the benefits currently accrue to outsiders who have no responsibility for maintaining the resource base. Improving the sustainability of biomass production requires community-based management systems that bring tangible benefits to those communities in return for sustainable management of the resources in their surroundings. A shift from open-access towards sustainable forest management by local people with security of tenure should be actively pursued.

c) **Private sector leadership:** The responsibility for managing natural wood resources is officially in public hands, although it has effectively been in private hands for a long time. This is causing friction between government and private actors which is not conducive to sound management of the resource base. The charcoal trade is a good example, since it is unclear whether charcoal production and sale is legal or illegal, meaning that producers, transporters and retailers are harassed - and respond accordingly. Given that the woodfuels sector is made up of numerous commercial supply chains and consumption centres that operate fully in the private sector, the private sector should be assigned the leading role in measures to improve the sustainability of supply and efficiency of end-use. The government has a role to play in providing the necessary legal and regulatory environment, with NGOs providing information and technical assistance.

d) **Realistic expectations**: The government has been expecting that electricity will be the panacea for Malawi's energy problems. However, the real cost of electricity supply is much higher than the current tariff so cooking with electricity will in future be more expensive than cooking with woodfuels. The required electricity generation capacity for significant expansion of supply is also lacking. It is therefore unrealistic to assume that a large switch-over will take place. Wood, meanwhile, is an indigenous resource, conditionally renewable, that can be produced with local skills and is not subject to OPEC or SADC policies that are beyond Malawi's control.

e) **More economically sustainable energy pricing:** Wood prices would be higher than they are now if they included full replacement and management costs. Electricity prices are also too low and, with every unit sold, ESCOM loses money. This does not favour proper management of the electricity infrastructure. Mechanisms are required to ensure that energy prices more closely reflect their true economic cost. In the woodfuels sector this would open the door for private sector investment in a business which is currently unattractive due to the under-pricing of competing products.

8.2 Increasing the Supply of Sustainable Woodfuels

8.2.1 Introduction

The first of the three Strategy components relates to the supply side. The underlying idea behind an increase in the sustainable supply of woodfuels is *professionalisation of the entire supply chain*, from local communities managing their natural resources and private farmers growing trees, via charcoalers who cut trees and make charcoal, to transporters who bring woodfuels to the market. This is a process that has started by itself but needs to be nurtured and accelerated through better regulation.

Professionalisation of the supply chain will result in greater incentives for growing wood, for making charcoal and for transporting woodfuels. This will be achieved through efficiency improvements from source to customer, with more professional actors working under a more rational system of economic incentives. Examples of such professionalisation of the charcoal supply chain can, amongst other countries, be found in Senegal and Chad, albeit the latter operating for a limited time only due to significant political interference. Senegal modernised its charcoal supply chain through the Sustainable and Participatory Energy Management Project, from community-managed forests through modern supply channels and more efficient end-user equipment. In Chad, the Household Energy Project showed that modernisation of the supply chain could provide incentives at all levels: at community level, transportation level and end-user level. The Ministry of Finance was also satisfied because of considerably increased tax revenues. The activity ultimately failed because of its own success: the organisational structure put in place was too strong to be influenced by political processes, making it worrisome for the country's leaders who set out to destroy it. For around four years, however, professionalisation of the supply chain demonstrated its merits.

Woodfuels – and especially charcoal - can be seen simply as commodities, produced on private land, customary land or community- or state-managed plantations or forests. The managers of this resource can maximise the returns on their investments to produce the commodity for profit, just as farmers do when growing tobacco.

Managing existing stands or planting new trees can provide environmental and other benefits, such as reducing wind and water erosion, lowering evapo-transpiration rates, recycling nutrients, controlling the flow of water into streams, sustaining biodiversity and increasing carbon sequestration. Some of these are of national benefit and others of global value. The various tree planting and management initiatives should therefore have both national and international backing. The Clinton-Hunter Foundation is already operationalising the globalisation concept, planting trees for carbon sequestration using financial incentives from UK sources.

The following four sub-components have been identified to increase the sustainable supply of woodfuels, through a more professional functioning of the supply chain:

a) Designing a Woodfuels Supply Master Plan;

b) Designing and implementing District Woodfuel Management Plans ;

c) Modernising and strengthening charcoal flow monitoring and control ; and

d) Promoting the production of affordable alternative fuels

The first three components are inter-related, in that the first provides general and strategic direction for the overall approach, the second guides implementation down to village level and the third is required for checks and balances. The fourth component can be implemented separately.

8.2.2 Woodfuels Supply Master Plans

Woodfuels Supply Master Plans (WSMPs) are proposed for priority areas where demand is already in excess of sustainable supply, or will be in the near future. This applies primarily to the *urban catchment areas of Blantyre/Zomba and Lilongwe*. For Lilongwe the catchment area covers Mchinji, Ntchisi, Dowa, Lilongwe, Salima and Dedza Districts. For Blantyre/Limbe and Zomba, all the southern Districts except Nsanje and Ntcheu are considered part of the urban CA.

The WSMP design will require setting of agreed priority guidelines for the organisation, regulation (location, quotas, specifications) and monitoring of commercial firewood and charcoal production, and the programming over the next ten years of the forest and plantation areas that should be exploited, protected or rejuvenated, as well as the related required investments (forestry activities, infrastructure, etc.).

The WSMP development process should include:

- an update of the tree cover inventory;
- identification and classification of commercial harvesting zones as “green”, “orange” and “red”, to indicate the sustainability of supply;
- assessment of accessible woodfuel resources by zone;
- projections of demand from cities and rural areas for woodfuels, timber and other wood products;
- analysis of charcoal flows, including imports from Mozambique and Zambia;
- development of conditions and technical specifications for sustainable charcoal production (simplified rules for forest / customary land /plantation/woodlot

management and exploitation such as simplified cutting permits, plus identification of required investments);
- definition of clear rules for sharing of responsibilities and coordination between FD staff and communities with regard to forest / customary land and plantation co-management and exploitation; and
- synthesis of all information into the design of the WSMP; implementation will be by catchment area at district and village level.

The expected results will be:

- a reliable, accurate and updated forest resource inventory and demand assessment for wood products in current and potential urban supply areas;

- simple methodologies and tools for each step of WSMP design, including tools for developing plans for co-management or Village Forest Area management;

- training of national and local staff and community members to apply these methodologies and tools; and

- increased engagement of FD personnel with villages managing wood resources, woodlot owners and charcoalers, in the organisation of charcoal production and supply channels.

8.2.3 District Woodfuel Management Plans

District Forestry Woodfuel Management Plans (DFMPs) are proposed for the red, orange and green zones. The aim of these plans will be to increase progressively the market share of commercial woodfuels that are sustainably produced and to generate significant long-term tax revenue for local and national forestry management funds.

The following actions are required to develop and enact the DFMPs:

a) ***Rehabilitation and better management of existing forestry resources***
Many of Malawi's existing forestry resources, whether state forests, plantations or common lands, are poorly managed, if managed at all. Improving the management of existing tree formations should be an important goal of the central government and district authorities. If farmers had been involved in their establishment then they should be entitled to benefit from their efforts with minimal hindrance. These areas should be vested in the local communities and simple co-management plans drawn up so that the communities benefit from their involvement. Once people realise the benefits flowing from management of their tree formations they will be more inclined to protect and improve existing resources and plant new trees. If agreements can be reached with the interested parties concerning co-management of these areas and sharing the assets, then the district authorities and FD should compile simple management plans in collaboration with the concerned villages. Binding agreements should be drawn up specifying responsibilities and sharing of costs and benefits to the contracting parties. Such agreements already exist in some areas but need strengthening and reinforcement. This fits directly into the ongoing work of the FD and the measures already proposed under the Improved Forest Management for Sustainable Livelihoods Programme. The main difference is a prioritisation of those specific forests (government and customary) that lie within the main urban catchment areas, rather than forest resources countrywide.

b) *DFMP design and implementation*

The DFMPs should be based on the updated forestry inventory data, with the objective of providing legal and sustainable sources of woodfuels from government Forest Reserves (which requires co-management plans) and customary lands (which require Village Forest Area Plans).

In "orange" zones the focus will be on the maximising the output of existing resources, whereas in "red" zones the focus will be on increasing the standing stock of trees through new planting and conservation of any existing stock. "Green" zones are not a short-term priority as demand from these areas is relatively small compared to sustainable supply.

Incentive packages should be developed for the promotion of tree planting on private land in the main urban catchment areas. A key mechanism in this regard is carbon financing, working where possible with existing groups (such as the Clinton-Hunter Development Initiative).

Implementation of the DFMPs, whether in co-managed government forests or on customary land, should be carried out by a group of professionals, either constituted from the surrounding villages or sub-contracted from private, specialised firms. These groups should have the in-house capability to produce charcoal efficiently. Charcoal production in the region is already relatively efficient at around 23% conversion from wood to charcoal by weight[31]. This is a satisfactory recovery rate and much higher than commonly quoted. It could probably be increased further, however, if charcoal producers were not evading the law and cutting corners, but were instead operating in an open and legitimate environment where they would have an incentive, for example, to dry the wood for longer before conversion or to modify traditional kilns with a simple metal cover or chimney. Professional charcoalers, working fully legally, will be assisted to acquire such improved techniques and equipment. Organised producer groups working with approved management plans will be recognised, and efforts made to link them with assistance they may require (e.g. tools, training, credit).

Required support for the development of the DFMPs includes:

(i) development of methodological tools (management and exploitation rules, terms of reference and simplified models of contracts for management plans at village level, supporting measures for sector officials and charcoalers);

(ii) setting up a support scheme (facilities for professional groups, information / awareness and training tools, recruitment and training of rural animators, information workshops for local authorities and officials, support to the development of expertise in DFMP engineering); and

(iii) field intervention in the districts (funding and monitoring the DFMP design and implementation by specialised contractors/service providers, rural animation, training workshops and support for the development of professional groups).

[31] Refer to empirical studies of conversion rates quoted in section 5.8.2.

c) *Increasing the productivity of forest resources*

Three different approaches are proposed to increase the output of woody biomass: agroforestry, farm tree planting initiatives and tree planting in woodlots:

(i) ***Agroforestry.*** Arable, pastoral and homestead planting is mentioned first because this is the key to improving farm productivity, providing woody biomass where it is most needed and producing tree products for home use and sale. Farm tree management should be the responsibility of farmers themselves and they should be able to manage the trees in the way they think appropriate, but management advice could be provided through training and at school level for the next generation of farmers. Farmers should not have to seek permission to cut down trees on their property, as is the case now. If farmers are capable of cultivating cereals then they should be equally capable of farming trees. If they feel restricted in harvesting what belongs to them, they will certainly not plant more trees.

Improving the woody biomass resource base on or near farms and assisting with agricultural productivity will also increase the supply of residues and dung. It is a win-win situation with several economic and environmental benefits.

Any major expansion of on-farm tree planting should take account of existing systems. Tree planting options include mini-woodlots around or near the homestead on variable rotation from two to ten years or more; single- or double-row hedging around fields and homesteads on a four-year rotation, and pollarding mature trees (10 to 15 years or more) along boundaries and in fields for fodder, poles and fuel. Promotion of tree planting requires providing seedlings to meet the tree planting objectives. However, many trees can be seeded directly. Also, some trees, shrubs and bushes can be propagated from cuttings and cloning, and some can come from digging up wildlings and replanting them on the farm or homestead. In addition, seed multiplication is vital to ensure that certified and superior seeds of the right species are available to farmers. More seeds may be required, particularly of agro-forestry species and fruit trees, if more intensive efforts are to be made to encourage a greater number of trees on farm.

This initiative should include multi-purpose crops as well as multi-purpose trees. There is, for example, a national programme of intercropping maize with pigeon peas, with the latter generating additional food without reducing the maize yield; improving soil fertility and generating fuel from stems.

(ii) ***Farm tree planting initiatives.*** Demonstrations should be established countrywide. These demonstrations should include nitrogen-fixing tree and shrub species on short rotations (one to three years); shelterbelts of trees or shrubs at right angles to the prevailing wind; trees and grasses planted along streams and riverbanks to slow down bank erosion (perhaps in combination with physical interventions such as terraces, gabions and levees); planting of trees, bushes and grass along contours or terraces; planting of fruit trees and fruit bushes in domestic compounds; planting of fodder species in grasslands/rangelands or enclosing grasslands, preferably with live hedges to exclude animals and rotating animals in pastures; planting of trees along field boundaries and along paths; expansion of school nurseries and trees around schools and in schoolyards.

Through meetings with farmers, such initiatives could be discussed and the *modus operandi* agreed upon. Farmers may also propose other initiatives. Farmers will have to agree if and where such demonstrations can be sited. It is preferable to have them on farmers' fields.

(iii) ***Tree planting in woodlots***, in school compounds, along roads and watercourses are other ways to improve the supply of woody biomass and tree products for rural and urban people and to give environmental protection. In spite of Malawi's high population densities, there is enormous potential for commercially-run woodlots to meet urban demand for woodfuel. At present, the economic incentives for establishing such woodlots on a private basis are insufficient, as cheap or free wood is available from government reserves or customary land being cleared for farming. Security of land tenure, investment incentives, tax breaks and avoidance of harassment en route to urban markets are all means by which the incentives could be tilted in favour of sustainable tree farming. Some of the large estate companies involved in tea, sugar and tobacco may be especially interested in commercial forestry to supply fuel markets if the incentives regime was more attractive. This can be done in areas where tree farming is the most economically appropriate land-use or where it is needed to prevent erosion or to provide shade. This is particularly important in a country where most electricity generation continues to depend on the availability of water resources. It is also suggested that assistance is provided to schools and other educational institutions to establish woodlots on their own land to increase self-sufficiency in fuel. This is both an educational initiative and an economically rational idea.

d) *Professionalising the charcoal value chain*

This requires action at all levels along the value chain, starting with:

(i) *Creation of professional charcoaling groups* in the form of associations, cooperatives or private firms. The aim is for these producer groups to operate more formally, with a clearly defined internal structure, and be more commercially-oriented, eventually gaining access to more up to date information about sources of wood available for carbonisation and obtaining access to credit. Conversion techniques applied by professional charcoalers would in principle be more efficient than those applied by non-professionals, and charcoalers perceiving themselves to be operating illegally will have less incentive to achieve the best conversion rates and will be more interested in minimising carbonisation time.

(ii) *Improve charcoal transport.* At the moment, bicycle transporters account for a large portion of charcoal transport, each with two or three bags, over distances of up to 40 km. The reason is that it is perceived illegal to transport charcoal by lorry, although for "own use" two or three bags can be transported without harassment. Police posts demand payment from vehicle transporters and some times confiscate entire lorry-loads; transporters do not want to take this risk and it is common practice to pay at roadside checks for a smooth passage.

The transport of charcoal should be allowed in just the same way as any other commodity may be transported by lorry without problem. A simple permit system should be set up to guide transporters to zones with sustainable production of charcoal. The system would then operate in a more efficient way according to prevailing market dynamics, rather than being biased towards small-scale transport methods in order to minimise harassment.

In this respect, a possibility might be to set up depots of charcoal produced by professional charcoalers. This will need to be analysed in more detail since a previous attempt at peri-urban depots in Lusaka failed, mainly because the charcoal quality deteriorated as a result of too much repacking in different bags. However, the benefit for charcoal transporters is clear as they do not need to look for charcoal throughout the region but can simply pay a visit to a charcoal depot, load their truck and leave. Much time can be saved and this should considerably reduce the transport costs. It could even become the default choice for transporters only to pick up charcoal at depots. The transport permit system could be adjusted to incorporate and facilitate the existence of the depots: transporters buy a permit on the spot, it is valid for the number of bags purchased and for transport to a indicated destination on that particular day; transport permits for pick up from other spots would not be available or more expensive. It should be made widely known that transporters with a valid permit would not be charged at a police check point.

The charcoal in the depots would be derived from sustainable sources and would therefore have a management or replacement cost built in, whereas illegal and unregulated charcoal would not factor in this cost and would therefore be cheaper. The incentive for suppliers to comply would come through the reduction in harassment and unofficial payments experienced by the transporter in possession of the correct documentation.

To assist charcoalers to obtain better prices, charcoal depots could be instrumental; some informal depots appear to exist already along the main roads. Charcoalers should be permitted to get organised and bring their charcoal to such centralised depots instead of waiting along the roadsides or in the interior for transporters to pass by and buy their charcoal. The depots would be staffed by people from the charcoaler associations (or an alternative institutional solution). Since large volumes of charcoal would be handled at the depots, it is likely that charcoal dust would accumulate. This can be transformed into charcoal dust briquettes and sold alongside the regular charcoal (as happens in Nairobi, Kenya, in a commercially sustainable way[32]). Eventually, information could become available about current availability of charcoal from particular farmers or locations; this could be the start of an information system linking wood owners and charcoalers. Statistics would be collected about the flow of charcoal, including its origin, its destination and who transports it.

(iii) *Uniform charcoal transport tax*. This is a potentially controversial idea and opponents may say that this is a stick rather than a carrot. However, if the system is properly designed it only represents carrots. The principle is that sustainably produced charcoal is taxed at a lower rate and all other (i.e. non-sustainably produced) charcoal is taxed at a higher rate[33]. Such a tax would simplify the current system considerably: it would replace all individual and

[32] See www.chardust.com

[33] A distribution of proceeds could be as follows: the proposed tax level is about 10% of the retail price if sustainably produced or 20% if not sustainably produced. For a sustainably produced bag, 80% is distributed between the source village, the charcoaling group and the district, and 20% goes to the FD. For unsustainably produced charcoal, 80% goes to the FD and 20% to the village and district.

semi-legal tax systems and provide funds to all involved, including the charcoal depots, district and village administrations.

The principle is simple: transporters pay a tax on the transport of charcoal; every bag needs to be accompanied by proof of tax payment; if charcoal is picked up from a depot run by professional charcoalers, the tax payment is simple and low; no other payments would then be required along the road to the market so anyone else demanding money en route to the market would be demanding an illegal payment, and this fact would be widely publicised. Any transporter travelling with charcoal but without proof of payment could be stopped and made to pay a higher level of tax on the spot, for which he would obtain proof of payment so that he could no be asked to pay another time. At the moment, the average level of "taxes" is about 12% of the retail price for Blantyre and 20% for Lilongwe; however, the proceeds benefit only a few individuals whole; the actual tax level could be lower if a uniform transport tax was introduced.

A uniform charcoal transport system provides benefits to villages and charcoalers: they are allowed to retain the largest share of the proceeds - as long as the charcoal comes from a sustainably-managed forest and is made by professional groups. Transporters benefit, as they pay a low tax as long as they pick up sustainably-produced charcoal. The FD benefits, because a higher tax is paid for all charcoal not procured from a charcoaling depot, and proceeds flow into the National Forestry Fund (NFF). As more villages apply co-management schemes, more charcoal is sustainably produced and more tax is applied at the lower tax level.

8.2.4 Charcoal Flow Monitoring and Control

The establishment of a modern, efficient and transparent system for monitoring and controlling charcoal flows is proposed to help enforce the WSMP, provide reliable and up to date information on charcoal production and supply, and ensure efficient collection of charcoal taxes to increase revenue for the NFF and/or District Forestry Fund. The expected results are also regulatory reforms where required, a better understanding of charcoal supply chains and price build-ups, and greater motivation of government personnel responsible for forest management at district and sub-district levels.

Modernisation and strengthening of monitoring and control requires:

- improvement of the transport permit system for forest products (new procedure for issuing permits coupled with tax collection, computerised registration and control of transport permits);

- setting up of the control system (construction of checkpoints at city "gates", recruitment and training of control officers); and

- establishment of computerised monitoring of charcoal flows and trade, and related tax revenues, to provide the information required to verify compliance with DFMPs, and redirect the operators if necessary.

Fraud can be combated if the process is transparent: how much charcoal leaves the production zones and how much charcoal is encountered in town. The uniform taxation system may weed out illegal taxes as long as transporters know the rules and report abuse.

In other countries, transporters have seen this as an opportunity to avoid paying illegal taxes and most of them have complied with the requirements, after fully understanding the system.

8.2.5 Alternative Fuels

Bottlenecks to the uptake of viable energy alternatives will be investigated and tackled, as long as those alternatives are cost-effective and desired by consumers. For example, there may be niche market opportunities for carbonised briquettes made from charcoal dust or agri-waste such as coffee husk or sawdust. A "technology watch" will be maintained for new fuels or appliances that come onto the market.

8.3 Increasing the Efficiency of Energy Use

8.3.1 Introduction

The second major element of the Biomass Energy Strategy will be increasing the efficiency with which energy is used.

The justification for energy efficiency is obviously clearer when energy prices are high, but it always makes sense from an economic point of view to use low-cost, high-efficiency equipment. The promotion of more efficiency appliances and a demand-side management programme is proposed for three different types of end-users:

1. urban consumers;
2. rural consumers; and
3. commercial and institutional users of woodfuels.

8.3.2 Urban Consumers

For urban consumers there are three proposed actions:

a) ***High-efficiency appliances and energy efficiency labelling***

Improved charcoal stoves are an obvious energy-saving solution for urban households, but rates of adoption of the relatively efficient KCJ are already high in Malawi's towns and the incremental results of disseminating more of the same stoves will be small. These stoves are not always well constructed, however; there is little if any insulation layer; the air space in the grate is insufficient; many lack doors. There may be an opportunity to give advice and training to the producers of these stoves, who operate in the informal sector.

There may also be opportunities for introducing entirely new stoves if they have the potential to result in significant efficiency improvements. An all-metal charcoal stove from Lusaka that has recently been tested by GTZ ProBEC looks like a promising option as it is cheap to produce and achieves 15-20% energy savings over the KCJ through a design that pre-heats incoming air.

It is also not known to what extent existing stoves are actually fuel-efficient and reduce fuel consumption in real working conditions over more traditionally used models. The work of Aprovecho and ProBEC on stove design, testing and standards-setting needs to be consolidated and applied more fully, incorporating objective, empirical performance monitoring methods.

A system is also proposed that would certify the safety and efficiency of end-use devices including wood stoves, charcoal stoves and paraffin stoves. This will require a testing programme, setting of standards (perhaps with the Malawi Bureau of Standards, MBS), verification of those standards, a publicity campaign and capacity-building for producers and importers of approved energy-efficient devices. This would require intensive capacity-building within MBS, if it is chosen as the most suitable standards-setting agency; it may also be possible to set up an independent appliance labelling system, if building capacity within MBS would be excessively time consuming or costly.

The focus of such a programme would not be a particular model of stove – as is the case now - but on all equipment able to carry out the desired task and meeting defined energy efficiency standards. Manufacturers need to be convinced to produce more energy-efficient models for which, as result of associated promotional activities, market growth can be expected. What is proposed is not another improved stoves programme, but a mechanism to promote the use of higher efficiency equipment similar to that used in the USA and Europe for consumer appliances and cars.

Initial setting of standards for cooking stoves could be expanded to cover electric appliances such as lamps, refrigerators, air conditioners and electric rings and ovens. The efficient equipment could be recognised by a visible energy efficiency label. By setting fuel efficiency standards and promoting the use of labelled equipment that meets or exceeds such standards, consumers could be made aware and possibly convinced to switch to better equipment.

The awareness campaign is needed to inform end-users about the standards, the label and the benefits from switching to using more efficient equipment. The focus should be on the label, which shows that a particular piece of equipment indeed meets transparent minimum standards and can thus be expected to be energy efficient and save the user money.

It will be necessary to assist manufacturers of stoves to understand the need for such a standard and the requirements to produce or import equipment that conforms to these new norms. Although no large changes are needed, the mechanism put in place will also allow the promotion of much more efficient equipment not yet available in Malawi. This would be the next generation of improved stoves, such as a gasifier stove or a stove with an in-built fan (e.g. those promoted by Phillips or Bosch-Siemens). Once consumers grasp the idea behind the labelling concept, it is possible that they will understand that much higher efficiencies will be worth the extra investment.

Finally, the standards will need to be enforced or manufacturers will not collaborate. They should be involved from the planning stage so they can provide their inputs in the programme. Enforcement should be announced and introduced gradually so that manufacturers have time to prepare themselves.

b) Fuel substitution

Energy sources such as paraffin and LPG are the next best alternative to biomass for urban domestic applications, albeit for the rich for the time being. It is normal for these fuels to be more expensive than woodfuels, but at the moment their prices are out of proportion.

This component of the Strategy will look at barriers to lower pricing and increased uptake of these alternative fuels, and will identify potential partnerships with commercial entities to promote greater market penetration. Supporting mechanisms could be credit or subsidy for cooking appliances and awareness and popularisation campaigns. There are believed to be major opportunities for LPG if the market size was increased, as scale-economies are large and costs can come down quickly. Investments in storage infrastructure, canisters and (possibly) stove subsidy will be particularly important in reducing down LPG prices, while for paraffin a liberalised market may be the best way to promote more reliable supply and greater consumer uptake.

c) ***Scalable pilot programme to promote sustainably-produced woodfuels***
It is vital that there are working examples of sustainably produce and licensed woodfuels available in the market. At present there is effectively not a single bag of "legal" charcoal in the country. This must change. It is unlikely that the mass market of low-income domestic consumers will be the first to purchase licensed charcoal that is demonstrably sustainably-sourced. The first buyers of "legal" charcoal are likely to be hotels, tourist camps and supermarkets who wish to be seen as environmentally responsible. Scaleable pilots for sustainably-produced woodfuel are therefore proposed. Partnerships will be developed with flagship clients to develop certifiable supply chains from source to market, to provide proof of concept for a larger-scale roll-out of sustainable charcoal production, transport and sale, and to assist communities and private farmers to start marketing the legally-produced outputs of tree farms and co-management schemes.

The price of certified charcoal may initially be higher than other charcoal, but the proven workability of the concept will demonstrate to potential tree farmers that this represents an attractive and viable investment opportunity, and critics of charcoal can be shown examples of its sustainable production and use in a credible and transparent industry. Prices will come down as volumes go up and as the range of buyers expands beyond those buying only for the product's environmental credentials.

8.3.3 Rural Consumers

Efforts may be made to scale up the promotion of rural woodstoves, but only after independent verification of the results of existing dissemination programmes.

Rural wood use is large, but the impact of its consumption on the natural resource base is minimal as rural households first use dead wood, leaves, small branches and agri-residues before they start cutting trees to meet their energy needs. It is also improbable that rural people will invest in a cooking stove when they have hitherto used an open fire, given that they usually source their fuel at no financial cost and therefore lack the economic incentive to invest in a fuel-saving device.

Nevertheless, for health reasons it may be worth considering a programme to disseminate better rural stoves, subject to the findings of the proposed independent verification of past experiences in this sector.

8.3.4 Commercial and Institutional Consumers

Institutions and industries use less wood energy overall than all rural households, but due to the concentrated nature of their consumption it may often be damaging to the environment. The firewood demand for a school, hospital or prison is usually met through a commercial service. This commercial supply is typically based on the cutting of whole trees for the sole purpose of providing firewood. Where indigenous trees are being sourced, these commercial supply operations have obvious potential to impact negatively upon the environment.

There are opportunities to look both at new efficiency measures and at ways to scale up the adoption of existing fuel-saving technologies (e.g. through credit or subsidy). Large-scale rural wood-consuming institutions and industries can be made aware of the benefits of investing in energy-saving equipment or in a sustainable supply of wood energy.

In the institutional catering sector, fuel efficiency is low and there are opportunities for improvement based on technologies already available in Malawi (eg. the ProBEC-promoted institutional rocket stoves, in both brick and metal versions, and the "Bellerive"-type metal stoves available from a manufacturer in Blantyre). In addition, biogas installations for agri-businesses, schools and other institutions should be considered. The benefits of these combustion devices go beyond fuel-saving to include better-tasting and more nutritious food, and safer and healthier kitchen environments.

The main bottleneck to wider adoption of these technologies is credit, as the payback period is lengthy and potential institutional or commercial customers generally lack lump-sums of finance for acquisition of capital assets. Repayment schemes could be worked out within their means.

The tea and sugar industries are based on estate farming and are already making maximum use of their own biomass for agri-processing at centralised factories. The tea industry is self-sufficient in firewood for tea drying and the sugar industry makes optimal use of molasses and bagasse. The industry that requires a more concerted efficiency programme is the smallholder tobacco industry, where massive quantities of indigenous firewood are harvested every year for curing, much of it on a commercial basis. This sector has received attention from ProBEC since 2005, working closely with industry players. Promising developments have been made in improved tobacco barns which would benefit from significant scaling-up.

It is proposed to launch a programme for efficiency improvement for institutional and selected commercial woodfuel users. Access to technological improvements as well as to financial support should be part of the programme. This will cover potential stoves, boilers, dryers and furnaces for:

- institutional catering (schools, hospitals, religious institutions, prisons, etc.)
- commercial catering (restaurants and small food outlets)
- tobacco curing
- brick and tile making
- lime burning
- fish smoking

The development of workable regulations and conditions for the use of sustainably-sourced woodfuels, targeting mainly commercial and industrial users, will also be an important part of the intervention for these users. Although some of the tobacco firms claim that they only use farm-grown trees, others make no such claims and there is no independent verification. It is proposed that at least all export-oriented commercial firms should only use woodfuels that are demonstrably sustainably-sourced for their energy needs, and possibly some of the non-export oriented heavy firewood users such as brick and tile industries.

The sugar industry uses waste cane (bagasse) as the main fuel to produce steam and generate electricity. Its end-use efficiency is relatively low and the factories also obtain some electricity from ESCOM, whereas it could be more than self-sufficient and perhaps even supply surplus electricity to the grid during the 200 day production season. The main reason why this does not occur is the present monopoly on electricity generation for the national grid and the low price that would be offered by ESCOM. Thus the sugar companies have little interest in improving their energy efficiency to generate a surplus. Given that the price of electricity will have to be increased to cover LRMC and the government will open up electricity supply to private industry, there may be opportunities for companies such as those producing sugar to profitably supply surplus electricity to the grid. It is recommended that the appropriate laws be enacted to allow this to happen and that the price of electricity be adjusted to reflect LRMC.

There are also potential uses for surplus wood in areas far from the main markets, particularly in Northern Region from plantation-grown wood. It is recommended that economic studies be undertaken into the profitability of supplying charcoal from the north to industry and the mechanics of doing so. However, the most profitable use of the plantation wood at the Viphya is for sawmilling and board production and this produces considerable waste that can be valorised as low-cost woodfuel. Also, many of the plantations need thinning to allow the remaining trees to grow to sawlog size in a timely way. Potential uses have to be found for these thinnings and factory wastes. The possibility of using the surplus wood to generate electricity has been studied, but although it was technically possible to have a 25 MW power station, it would only be economically feasible if electrical prices were increased to the LRMC level. A subsidy may be needed to purchase some of the capital equipment, but this could be justified on environmental and economic growth grounds. It is recommended that this study be updated, looking at the potential sustainable supply of wood from thinnings and factory residues for power generation up to 100 MW.

8.3.5 Complementary Actions

Two complementary actions are proposed as part of the effort to reduce demand for biomass energy:

(a) ***Research***
A research component will further develop energy-efficient alternatives that are cost-effective and marketable to future users. In particular, a more efficient, commercially viable successor to the ubiquitous Kenya Ceramic Jiko (for charcoal) could be investigated (e.g. based on the all-metal Lusaka stove or the rocket stove). The government and its partners (especially ProBEC) has already promoted the use of improved biomass cooking stoves, brick charcoal kilns and more efficient tobacco curing/drying technologies. This work should continue and be expanded(e.g. to include simple modifications to earth kilns such as metal covers or chimneys). Many of these industries are in the informal sector and do not have money to undertake research and market promotion for themselves. Government could assist through technical institutes, NGOs and private technical input in looking at ways to promote improved technologies, undertake product testing and field trials, assist manufactures with advice and loans, monitor production quality and undertake research in improving energy efficiency.

(b) ***Other measures***

For households and institutions alike, complementary actions could be promoted to further reduce the consumption of woodfuels, based on different kitchen practices or equipment. A combination of awareness of these different practices, coupled sometimes with small investments, may lead to considerable fuel savings. An awareness campaign and possibly assisting a firm to start promoting such alternatives will be required. Among the possible ideas to be promoted are:

- the use of pressure cookers, which can speed up the cooking process and reduce fuel consumption for slow-cooking foods such as beans;
- the use of a hay box for cooking beans or boiling rice, which has been trialled by ProBEC and found to have niche application (e.g. for home-based care groups): after bringing the food to a boil, the pan with food is placed in a hay box, a well insulated box that can be closed off, after which the temperature will remain high for a long time so that the food cooks without using additional energy;
- soaking beans overnight before cooking, which may reduce energy needs by over 30%; and
- the use of a lid (perhaps improvised) on the pan or pot when boiling water, which can similarly save about 30%.

8.4 Developing Institutional Capacity for BEST Implementation

Given the importance of biomass in the national energy balance, there is a need to integrate the biomass energy sector more fully within national energy planning and to allocate serious resources for its management. Woodfuel is a commodity that is locally produced, not imported, does not depend on OPEC supply and pricing decisions, generates significant employment, is not expensive and is conditionally renewable. The population readily accepts its use but the government generally regards it as a traditional, "non-commercial" fuel which is inconvenient to use and is an energy source that should be phased out.

It is in the interest of the government (and in particular the FD and DoE) to promote the use of wood and other biomass energy by enhancing its end-use efficiency and convenience, and by ensuring the accessibility and sustainability of supply. These goals are well within the capacity of the population. The growers of trees and the producers, transporters and traders of woodfuel, the makers of biomass stoves and other wood-burning devices could and should achieve much more if they were getting support and assistance from the government in their endeavours.

The government is now spending most of its energy budget on electrical generation and petroleum imports. While electricity and petroleum are important for economic development, rural industries, which are the main earners of foreign exchange, rely on biomass fuels, as do the bulk of households. The government is not putting the effort into sustaining the biomass resource base that the consumption statistics warrant. Rather, it is dissipating its efforts on renewable energy initiatives that are capital intensive - such as biogas and photovoltaics – but which cannot solve the majority of the thermal energy needs of the country. It has also been distracted by alternatives that are, at best, viable only for small niche market segments and will never represent serious alternatives to biomass at a large scale, such as ethanol (in liquid and gel forms) and biomass briquettes, both of which have had a consistently poor track record in the numerous developing countries where they have been tried. Thus there should be a more equitable and common sense balance in energy investments and the government should be at the forefront in ensuring that biomass energy remains sustainable. It is therefore recommended that biomass energy be given a more prominent position by government technocrats and policy-makers, commensurate with its importance within the country.

The isolated efforts of DoE and the FD to intervene in the biomass energy sector have not led to the results warranted by the importance of biomass energy to the energy security of the country. Rather than consider how the DoE and FD can collaborate, it is proposed to develop a new and more independent institutional structure to deal with biomass energy. This would be in the form of a ***Biomass Energy Agency*** to deal with all aspects of supply of and demand for woodfuels. This should be an *autonomous* agency, collaboratively governed by key stakeholders led by the private sector, including also NGOs and the government. This agency would be responsible for modernisation of the biomass sector and coordination of the various activities proposed under the national Biomass Energy Strategy.

The preferred operational model is for the government to define policy, develop regulations and collect revenue, and for the Biomass Energy Agency to responsible for overseeing implementation, while most operational measures will be undertaken by private firms and NGOs.

Given the close linkage between biomass use and electrification rates, the agency could also be responsibly for electricity, but its exact scope requires further discussion[34].

Finally, it is apparent from the findings of the BEST study that the current objectives of the National Energy Policy are unrealistic and its provisions are proving difficult to operationalise. The rationale for a dramatic reduction in the contribution of biomass to the national energy balance has been brought into question and the feasibility of a wholesale switch from biomass to other forms of energy, as the Policy mandates, has been shown to be unrealistic. There is therefore a need to review and revise the National Energy Policy to reflect a more pragmatic and pro-active approach towards biomass that recognises its economic value to the nation and elaborates more direct forms of government and private sector engagement in management of the biomass energy sector.

[34] In which case a different name would be more appropriate, such as the Woodfuels and Electrification Agency.

9. Complementary Interventions Outside the Energy Sector

9.1 Introduction

The biomass energy sector cannot be considered in isolation from the rest of the economy of Malawi. There are two particularly important areas outside the sector where complementary interventions are required if rates of environmental damage are to be slowed andif a level playing field is to be established for the country's competing energy options. The first relates to agricultural productivity and the second to electricity pricing.

9.2 Agricultural Productivity

An estimated 45,000 ha of natural woodlands were permanently cleared in 2008, not for firewood or other wood products, but for arable agriculture. Thiswas in response to an increased demand for food from an additional population of 455,000. By the year 2020, there may be 6.5 million more people living in Malawi, already one of Africa's most densely populated and food-insecure countries. If more is not done to increase agricultural productivity then an estimated 740,000 ha of forest and woodland, around 37% of today's forested area, will need to be cleared to provide farm land to meet the food requirements of these extra people over the next 15 years. This loss of forests will further jeopardise the sustainability of woodfuel supply in the central and southern regions of the country.

Thus if deforestation is to be slowed down and eventually reversed, agricultural productivity has to increase dramatically. Even if all woodfuel consumption ceased, deforestation would still occur in the absence of more effective measures to improve farm yields. This must be a major thrust of government policy, not only to ensure a sustainable supply of wood products, but also to protect the environment and its indigenous flora and fauna. It is beyond the scope of this study to explore in detail the types of measures that might be appropriate. There are numerous agencies already working with the Government of Malawi on measures to increase agricultural productivity and numerous approaches have been tried in recent decades. It can only be recommended that these efforts are sustained and intensified.

9.3 Electricity Pricing

Electricity is currently the country's cheapest commercial cooking fuel, simply because it is sold at around 30% of its estimated economic cost of production and supply. A key justificationfor the subsidy is to benefit the poor. However, the greatest benefits of cheap power in fact go to middle- and upper income-households: rich urban households who consume the most power receive an annual subsidy of about $830 while poor households who have a connection receive $80. Hence the well-off are benefiting most from the low tariff.

A case can be made to have a lifeline tariff up to about 30 kWh per month to meet the lighting requirements of poor households. But there can be no justification for subsidisingpeople who can afford to pay the full cost for electricity. This is especially so because ESCOM does not receive sufficient income to service its loans, never mind pursuing a vigorous policy of subsidised connections in urban and rural areas.

It is recommended that the tariff structure be adjusted so that people using more than 30 kWh of electricity per month pay its full cost, estimated to be at least US 9 cents per kWh via the expected SAPP interconnector. This will not only provide a level playing fidd as far as the prices of competing fuels are concerned, but also enable ESCOM to be placed on a sounder financial footing.

10. Implementation Plan

10.1 Introduction

The measures proposed in chapter 8 are extensive and will require government and private sector endorsement, the creation of new sector institutions and significant short- to medium-term financial support, much of which will need to come from donors. The proposals also represent a significant change in thinking towards biomass fuels which will require that they are fully recognised and supported in a much more pro-active and market-oriented way than at present.

It may take some time for the GoM (and indeed its NGO and private sector partners) to digest and accept this new way of thinking, given that anti-woodfuel views are entrenched in policy-making circles. There is a widely held view that woodfuels engender poverty and under-development, rather than (more plausibly) the other way round. It is rare outside the ranks of trained foresters to hear the view expressed that trees can (and should) be managed as crops; as a renewable resource that has the potential to generate significant wealth, employment and prosperity. Woodfuels are commonly blamed for "deforestation", which may be a politically easier line of argument than expressing the riskier view that high rates of population growth and low farmer productivity are the principal cause of the country's worrying loss of tree cover.

10.2 Acceptance of BEST Findings

The development of an implementation plan for the Biomass Energy Strategy is therefore dependent on a crucial first step: it must overcome the long-held belief that exists at all levels within government (and several of its international development partners) that woodfuels are inherently regressive and destructive, and that alternative sources of energy are required and can be found.

The first step for implementation is therefore acceptance: acceptance of the research findings outlined in this Strategy document and acceptance of the implications that these findings have for the energy sector. There needs to be explicit and high-level acceptance of the study's basic conclusions if efforts to develop an implementation plan are to be worthwhile.

Acceptance of the findings at the level of the Departments of Energy Affairs and Forestry would certainly be a welcome endorsement of the study, but will not be sufficient to ensure that its findings are taken seriously across a wider and more influential group of policy-makers and technocrats. It is suggested that acceptance should be requested in the form of a written communication the Minister for Energy and Mines to EUEI-PDF, giving a formal opinion on the BEST findings and expressing the government's own conclusions from the report. Hopefully those conclusions will be positive.

Acceptance of the Strategy has direct implications for the National Energy Policy, as it questions the viability of a major switch to "modern" energy sources within the Policy's planning timeframe. There is therefore a need for a review of the Policy to ensure a more supportive framework for implementation of the Strategy. This is one of the measures proposed in chapter 8.

It is also important to note that the Biomass Energy Strategy cannot be implemented in isolation. It is inextricably linked to other sectors and, in particular, to the productivity of the agricultural sector and to developments in the pricing of the key alternative fuels– electricity, paraffin and LPG - something touched upon in chapter 9.

10.3 Agreement on Broad Strategy Components

Assuming that the government accepts and adopts the main BEST findings, perhaps with its own modifications, then the logical second step will be to discuss in detail the proposed components of the Biomass Energy Strategy (Chapter 8). This could be done at a national stakeholder workshop or other suitable forum. The aim of this second step will be to gain the broad acceptance of the findings and proposals by interested stakeholders in government, NGOs and the private sector, and endorsed by those development partners (such as the EU and the World Bank) interested in supporting energy sector programmes.

There will then need to be a review of the Energy and Forestry Policies, to ensure vertical correspondence between these important documents and the BEST findings and proposals.

10.4 Development of an Implementation and Funding Plan

If the stakeholders agree with the BEST findings and can also agree upon the broad elements of the Strategy, then a more detailed implementation plan can be developed and funds sought for its enactment. It is suggested that an independent project management unit (PMU) is established to develop and supervise this more detailed implementation plan. It is recommended that this unit is run as an autonomous and impartial extra-governmental institution with a defined lifetime of five to ten years, under the management of an independent organisation such as an international consultancy firm.

The PMU could be housed within the proposed Biomass Energy Agency and would be mandated to elaborate the details of Strategy implementation with stakeholders, identify appropriate implementing partners, develop work plans and targets, coordinate implementation of the BEST activities and disburse funds as required. It would need to conduct a systematic stakeholder review to establish who is already doing what in the anticipated areas of action, in order to establish where new capacity and skills will be required and where existing institutions can take responsibility for implementation.

Funds will of course be required at each stage of this proposed plan, necessitating discussions between GoM and development partners in the energy and natural resources sectors on what scale of financing may be available for which types of activities.

ANNEXES

Annex A: Abridged BEST Terms of Reference

1. Objectives: The objective is to assist the Malawi Dept. of Energy Affairs (DoE) in developing a national biomass energy strategy (BEST) to ensure a more sustainable supply of biomass energy and to promote access to modern cooking fuels and efficient biomass combustion technologies for households and small enterprises. To achieve this, the consultant will carry out the following tasks in cooperation with the DoE and other relevant stakeholders.

2.1 Project coordination: The consultant will be responsible to the DoE for management and coordination, including organising meetings of the project team, formulating the work programme and communicating with the DoE, GTZ and other stakeholders.

2.2 Inception period: In cooperation with the DoE, form a multi-sector project team to:
- Identify sources of data on biomass energy and relevant policy and legal documents;
- Identify and meet relevant national stakeholders and donor representatives;
- Hold a kick-off meeting to agree on a work programme;
- Agree on the members of a steering committee (SC) to be chaired by the DoE;
- Formulate terms of reference for the committee; and
- Convene the SC and agree on the scope, vision and BEST objectives, clarify the mandate of the project team and responsibilities of the actors, and discuss and approve the proposed work programme.

2.3 Analysis of the initial situation: Analyse the initial situation by:
- Reviewing existing literature and statistics on biomass energy and alternative fuels;
- Collecting addition data if necessary;
- Consulting relevant stakeholders to understand their views on more sustainable supply and demand of biomass energy and alternative fuels;
- Identifying external factors that influence the availability and use of biomass energy and alternative fuels;
- Considering factors such as land-use patterns; use of agricultural residues; commercial supply chains of woodfuels and alternatives; main woodfuel supply areas and consumption centres; the enabling environment; consumption patterns; consumer preferences; environmental and health impacts of the use of traditional biomass; and
- Developing a baseline scenario for the likely development of forest stocks, and the share of households and small enterprises using different fuels and combustion technologies.

2.4 Formulating a strategy

Translate the BEST objectives into concrete targets and identify suitable interventions;
- Hold a workshop with stakeholder representatives where:
  - the baseline scenario and possible intervention scenarios are presented;
  - proposed targets and constraints to their achievement are discussed;
  - participants identify strategic actions and agree on an intervention framework, and develop an action plan that will assign responsibilities for implementation and will include information on funding sources.
- Based on the results of the workshop, formulate a draft strategy, including an M&E system with indicators for measuring progress; and
- Discuss the draft strategy with the SC and revise accordingly.

2.5 Initiate strategy implementation: Draw up a funding strategy with potential funding sources.

Annex B: People consulted

(in Lilongwe unless otherwise stated)

Government of Malawi

Ministry of Energy & Mines

Charles Msosa, Principal Secretary

Department of Energy Affairs

Charles Kafumba, Director (to June 2008)
Harry Chitenje, Deputy Director (Acting Director from June 2008)
Grace Amri, former Principal Energy Officer, Alternative Energy Sources
Lewis Mhango, Chief Energy Officer, Planning
Joseph Kalowekamo, Senior Energy Officer, Renewable Energy Technologies

Department of Forestry

Dennis Kayambazinthu, Director
Peter McCarter, Technical Assistance Team Leader, Improved Forest Mgmt. for Sustainable Livelihoods Programme (to June 2008)
Mrs Mvula, District Forest Officer, Lilongwe
Mr Manda, Chief Forester, Dzalanayama Forest Reserve (and Deputy)

Forest Research Institute of Malawi, Zomba

Mike Chirwa, Mensuration Section

Ministry of Agriculture

Department of Land Resources Conservation,

John Mussa, Director
Matthews Manda, Imprest Administrator, Farm Income Diversification Programme

Department of Planning

Dickson Kazembe, Economist

Department of Animal Health and Livestock Development

Wilfred Lipita, Director

Ministry of Finance

Revenue Division

Timothy Makamba, Deputy Director
Patience Masi, Revenue Officer

Ministry of Health

Humphrey Masuku, Chief Environmental Health Officer

Malawi Geographical Information Council (MAGIC)

Jeff Mzembe, GIS specialist

National Statistical Office, Zomba

Mercy Kanyuka, Deputy Commissioner for Statistics
Beston Chiwaya, Pricing Section
Mcleod Mwale, Demographics Section

University of Malawi

John Saka, Chancellor College (Chairman of Malawi Energy Regulatory Authority)
John Kadzandira, Deputy Director, Centre for Social Research, Zomba

Malawi Energy Regulatory Authority (MERA)
Mr. Kamenga, Officer in charge of petroleum fuels
Mrs. Potin, Officer in charge of electricity

Electricity Supply Corporation of Malawi (ESCOM)
Trensio Chisale, Director of Distribution & Consumer Services

Tea Industry
Steven Mullen, Chairman, Tea Association of Malawi, Blantyre
Clement Thindwa, Chief Executive Officer, Tea Association of Malawi, Blantyre
Mr Nindi, Deputy CEO, Tea Association of Malawi, Blantyre
Daron Naidoo, Technical Officer, Eastern Produce Malawi Ltd., Thyolo

GTZ
Uta Borges, Country Director
Christoph Messinger, ProBEC Regional Coordinator (outgoing), Mulanje
Christa Roth, ProBEC Regional Coordinator (outgoing), Mulanje
Sonia Lioret, ProBEC Regional Coordinator (incoming), Johannesburg
Chimwemwe ("CAPS") Msukwa, ProBEC National Coordinator
Topham Sukasuka, Assistant National Coordinator ProBEC/Dept. of Energy Affairs

Others
David Woolnough, Infratructure & Growth Advisor, UK Dept. for International Develpt.
Lincoln Bailey, Mchenga coal mine
Tim Mahoney, Bioenergy Resources Ltd.
Trent Bunderson, Total Land Care
Conor Fox, carbon trader
Evance Chapasuka, Famine Early Warning System Network (FEWS NET)
Tony Finch, sustainable charcoal experiment, Salima
Jeremiah Phiri, Afrox Malawi

Clinton Hunter Development Initiative
Molly Bartlett, Director of Integrated Rural Programmes.

United Nations Development Programme (UNDP)
Jan van den Broek, Broker, Growing Sustainable Business programme
Etta M'mangisa, Programme Officer, Environment

Tobacco industry
Ron Ngwira, Senior Agronomist, Alliance One Tobacco, Lilongwe
Peter Scott, Alliance One/Philip Morris, tobacco barn research
Nico Nijenhuis, Alliance One/Philip Morris, tobacco barn research

Ethanol fuel promoters
Gaffar Jakhura, Chairman, BluWave Ltd., Blantyre
Eddie McFadden, Technical Director, BluWave Ltd., Blantyre
Allister Pearce, Managing Director, Bestobell Ltd., Blantyre

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Annex D: BEST Task Force members

Institution	Representative	Meeting 1 6th Mar '08	Meeting 2 9th May '08
Dept. of Energy Affairs	Harry Chitenje, Deputy Director	X	X
	Grace Amri, Snr. Energy Officer	X	
	Joseph Kalowekamo, Snr. Energy Officer	X	X
	Lenard Gobede, Energy Officer	X	X
Dept. of Forestry	Custom Nyirenda, Forestry Officer	X	X
Department of Environmental Affairs	Juwo Sibale, Environmental Officer		X
Department of Land Resources & Consrvtn.	Mathews Manda, Farm Income Diversification Prog.	X	
	Kufasi Shela, Principal Land Resources Officer		X
Department of Crop Production	James Kwanthe, Principal Crop Prodn. Officer		X
Ministry of Agriculture	Erick Haraman	X	
Ministry of Finance	Patience Masi, Economist	X	X
Ministry of Health	Noah Silungwe	X	
Ministry of Trade & Private Sector	Clement Phangaphanga, Assistant Director	X	X
ESCOM	Evans Msiska	X	
GTZ ProBEC	Topham Sukasuka, Asst. National Coordinator	X	X
MIRTDC	John Taulo, Deputy Director	X	X
Mzuzu University	A.M. Juma, Senior Lecturer	X	X
Tobacco Association of Malawi	Christopher Beya	X	
	Tony Jamali, Communication Officer		X
Total Land Care	John Chisui	X	
	Lloyd Chamanza Banda		X
UNDP Energy & Environment Programme	Etta M'mangisa, Programme Officer	X	
	Akeel Hajat	X	X
	Alex Damaliphetsa, Programme Manager		X
	Total attendance:	**18**	**16**

Annex E: Towns and Traditional Areas classified as "urban"

Northern Region		Central Region		Southern Region	
Town	**Popn. ('000)**	**Town**	**Popn. ('000)**	**Town**	**Popn. ('000)**
Mzuzu	158	Lilongwe	783	Blantyre/Zomba	933
Chipata boma	10.5	Kasungu town	38.8	Mangochi town	34.9
Karonga town	36.9	Nkhotakota boma	26.1	Machinga boma	1.5
Nkhata Bay boma	11.6	Mtchisi boma	8.2	Chiradzulu boma	3.5
Rumphi boma	17.6	Dowa boma	5.8	Mwanza town	11.0
Mzimba boma	16.5	Salima town	29.1	Thyolo boma	7.1
		Mchinji boma	16.1	Mulanje boma	16.8
		Dedza town	21.2	Phalombe boma	3.6
		Ntcheu boma	12.1	Chikwawa boma	10.0
		Chipoka urban	5.7	Nsanje boma	21.4
		Mponela urban	12.6	Balaka boma	19.0
				Ngabu urban	9.3
				Monkey Bay urban	14.1
				Liwande town	19.0
				Luchenza town	11.8
Total large towns:	*158*	*Total large towns:*	*783*	*Total large towns:*	*933*
Total small towns:	*93*	*Total small towns:*	*176*	*Total small towns:*	*183*
Total:	**251**		**959**		**1,116**

Annex F: Discussion of previous energy surveys

Household Energy Surveys

An urban household energy survey was undertaken in 1991/92 by D.H. Ng'ong'ola of the University of Malawi (Ng'ong'ola, 1993). He sampled households in the four towns of Blantyre, Lilongwe, Mzuzu and Zomba. The sample sizes in Mzuzu and Zomba were insufficient to obtain an unbiased estimate and the results from Mzuzu were rather questionable.

The combined per capita firewood and charcoal consumption reported for Mzuzu was one-quarter that of the other towns, yet a similar percentage of the population were said to be cooking with both fuels and the expenditure on these fuels was similar. Estimated consumption of firewood and charcoal in firewood-equivalent terms for the sampled households, including Mzuzu, was 1,040 kg per capita per year. This compares to 650 kg/c/yr in the BEST 2008 survey and 480 kg/c/yr in a 1983 survey undertaken by the Energy Studies Unit, then located in the Ministry of Forestry and Natural Resources.

The percentage of people with electricity in the Ng'ong'ola sample was 37%, ranging from 27% in Blantyre to 62% in Mzuzu. These figures are well in excess of ESCOM's connection figures and suggest that the sample was biased towards houses along main roads and middle- and upper-income households.

For these reasons, the consumption figures given in the Ng'ong'ola report are not taken as a reliable estimate of urban household energy consumption.

Similarly, little reliance can be placed on a survey undertaken for the GoM and the African Development Bank by the Coordination Office for Donor-Aided Projects in 1991/2 (CODAP 1992). This survey was nationwide, covering both rural and urban areas. Sampling and analysis were deficient. This resulted in a 1990 estimate for final household energy consumption nearly three times greater than other estimates. Charcoal consumption was about 16 times the average of other surveys, thus consumption of wood for charcoal production accounted for over 50% of all wood energy input, whereas it should have been about 10%.

A more recent study was undertaken on urban household energy demand entitled *Charcoal: The Reality* (Kambewa et al, 2007), with funding from USAID. While this study concentrated on urban household demand for charcoal, it considered the wider energy consumption habits of 3,945 sampled households in the four main urban areas. It also looked at the production, transport and trade of charcoal.

The Kambewa report is full of inconsistencies, however, especially concerning electricity. For example, it states that 30% of households have electricity but that 38% of households cook with electricity, which is clearly not possible. Table 2 in the report summarises spending per month by households on electricity. When analysed, the table suggests that the yearly consumption of electricity works out to be 1,002 GWh, whereas ESCOM's figure is only 345 GWh. Even allowing for illegal consumption, urban household demand only averages about 380 GWh, just 38% of the report's findings. As with Ng'ong'ola, it seems that the sampling process was biased towards houses with electricity.

Turning to charcoal, the conversion factor for a standard bag of charcoal is stated in the report to be 38 kg, whereas it should have been 28 kg (pers. comm., Killy Sichinga, the report's statistician). This resulted in gross under-estimation of the number of standard bags consumed, although the estimated total consumption for 2006 of 217,177 t. for the four main urban centres is probably only 10-15% too high. But other tables and graphs contradict this figure and suggest that consumption ranges from 172,000 to 315,000 t. in the four urban centres.

While the charcoal consumption figures seem too high, the consumption estimates for firewood are too low. The sample households may have been biased towards households that did not use firewood as the principal fuel and/or did not provide reliable data. No account is taken of collected firewood, which is about 20% of total urban wood consumption. When analysing the expenditure on firewood in Table 2 of the report, annual consumption works out to be about 205,000 t. (and 256,000 t. when collected wood is included). However, in Table 4 it is stated that more money is spent on firewood per household than is spent on charcoal, except in shanty areas. This latter may be because the proportion of collected wood in shanty areas is relatively high. If the information in Table 4 is correct, then the quantity of purchased wood will be about 570,000 t. This is a more accurate figure.

For the reasons outlined, the demand estimates given in the 2007 charcoal report should be interpreted with great caution. The section of the report dealing with the production, transport and trade are considered in section 6 on Supply.

Non-Household Biomass Energy Surveys

The Energy Studies Unit, which is more than ten years old and part of the DoE, has undertaken surveys and studies on energy consumption in the tobacco, tea, brick, lime and fish smoking industries. These investigations provided information about energy consumption and existing technologies. They resulted in measures to improve conversion efficiencies in these industries. These improvements are ongoing.

A new study of firewood and pole use in the tobacco industry is ongoing by the Agricultural Research Institute based in Lilongwe. Preliminary results indicate that improved technologies have been widely accepted and that unit energy consumption has been decreased. From this information and the results from the previous studies (WB, 1992), estimates were made of non-household energy consumption in rural areas.

The 1995/96 Biomass Production and Marketing Study (DoE, 1997) undertook a small urban non-household energy survey to estimate the quantity of biomass energy used in the formal and informal industrial sector and the service sector, (restaurants, canteens, wayside cafes, schools, hospitals etc.). Traders were also questioned about the percentages of woodfuel going to the different sectors. From this information, backed up by surveys in other countries, it was determined that about 10% of urban energy is used in the non-household sector.

An investigation was undertaken for this study on industrial and service sector use of wood (Makungwa, 2008). The information was incorporated into Table 13. However, not all industries were covered and only wood and charcoal consumption was estimated.

Annex G: Areas sampled for rural household energy survey

Livelihood Zones

1 Central Karonga
2 Chipita Millet & Maize
3 Kasungu Lilongwe Plain
4 Lake Chilwa - Phalombe Plain
5 Lower Shire
6 Middle Shire Valley
7 Misuku Hills
8 Mzimba Self Sufficient
9 Nkhata Bay Cassava
10 Northern Karonga
11 Northern Lakeshore
12 Phirilongwe Hills
13 Rift Valley Escarpment
14 Shire Highlands
15 Southern Lakeshore
16 Thyolo Mulunje Tea Estates
17 Western Rumphia & Mumba
18 Not Zoned

Livelihood Zone	District	HH sampled
3: Kasungu/ Lilongwe plain	Dedza	33
	Dowa	32
	Kasungu	20
	Lilongwe	22
	Mchinji	19
	Ntchisi	8
4: Lake Chilwa/ Phalombe plain	Machinga	21
5: Lower Shire	Chikwawa	105
6: Middle Shire Valley	Balaka	20
	Neno	20
9: Nkhata Bay cassava	Nkhata Bay	81
11: Northern Lakeshore	Nkhotakota	53
12: Phirilongwe Hills	Mangochi	102
13: Rift Valley escarpment	Mwanza	20
	Ntcheu	27
14: Shire Highlands	Blantyre	47
	Chiradzulu	73
	Phalombe	40
	Zomba	40
15: Southern Lakeshore	Salima	28
16: Thyolo/Mulanje tea estates	Mulanje	20
	Thyolo	20
		851

Annex H: Demand for wood and residues by region and urban catchment

Table 1: Demand in Northern and Central Region and their catchment areas

units: '000 m^3 roundwood equivalent

	Northern Region			Northern urban catchments	Central Region			Central urban catchments
	HH	Non-HH	Total	HH & non-HH	HH	Non-HH	Total	HH & non-HH
Rural firewood	1,381	17	*1,384*		4,667	136	*4,803*	
Rural Ch wood	13	1	*15*		190	5	*195*	
Sub-total	***1,381***	***18***	***1,399***	***838***	***4,857***	***141***	***4,998***	***3,547***
Urban firewood	142	14	*156*		472	20	*492*	
Urban Ch wood	87	2	*89*		492	6	*498*	
Sub-total	***229***	***8***	***237***	***175***	***964***	***26***	***990***	***892***
Total firewood	1,509	23	*1,532*		5,139	156	*5,295*	
Total Ch wood	101	3	*104*		682	11	*693*	
Sub-total	**1,610**	**26**	***1,636***	***1013***	***5,821***	***167***	**5,988**	***4,439***
Poles	36	111	147	91	114	323	437	324
Sawnwood	28	3	31	19	110	11	121	90
Total roundwood	***1,674***	***140***	***1,814***	***1123***	***6,045***	***501***	***6,546***	***4,855***
Residues rural[1]	*40*	*0*	*40*	*29*	*132*	*296*	*428*	*317*
Population (mill):								
Rural	1.343				4.814			
Urban	0.251				0.959			
Total	**1.594**				**5.773**			
Catchment area popn. (mill.):								
Rural	0.804				3.416			
Urban	0.186				0.864			
Total	**0.990**				**4.280**			

[1]- Urban residues are negligible

HH = household
Ch = charcoal

Table 2: Demand in Southern Region and its catchment areas, and nationally

units: '000 m^3 roundwood equivalent

	Southern Region			Southern urban catchments	National			National urban catchments
	HH	**Non-HH**	**Total**	**HH & non-HH**	**HH**	**Non-HH**	**Total**	**HH & non-HH**
Rural firewood	4,158	233	*4,391*		10,192	386	*10,578*	
Rural Ch wood	306	7	*313*		510	13	*523*	
Sub-total	***4,464***	***240***	***4,704***	***3,821***	***10,702***	***399***	***11,101***	***8,206***
Urban firewood	408	18	*426*		1,022	44	*1,066*	
Urban Ch wood	879	10	*889*		1,458	18	*1,476*	
Sub-total	***1,287***	***28***	***1,315***	***1,214***	***2,480***	***62***	***2,542***	***2,281***
Total firewood	4,566	251	*4,817*		11,214	430	*11,644*	
Total Ch wood	*1,185*	*17*	*1,202*		1,968	31	*1,999*	
Sub-total	***5,751***	***268***	***6,019***	***5,035***	***13,182***	***461***	***13,643***	***10,487***
Poles	109	279	388	323	259	713	972	738
Sawnwood	116	12	128	106	254	26	280	215
Total roundwood	***5,976***	***559***	***6,535***	***5,464***	***13,695***	***1,200***	***14,895***	***11,440***
Residues rural[1]	*118*	*299*	*417*	*347*	*290*	*595*	*885*	*693*
Population (mill):								
Rural	5.147				11.304			
Urban	1.116				2.326			
Total	***6.263***				***13.630***			
Catchment area popn. (mill.)								
Rural	4.181				8.401			
Urban	1.029				2.079			
Total	***5.210***				***10.480***			

[1]- Urban residues are negligible

HH = household
Ch = charcoal

Annex I: Average cost build-up for urban traded fuels

Table 1: Firewood

units: MK per t. of firewood

Cost item	Mz	Ll	Bt	Za	Other	Wt. Av.
Wood raw material	975	975	975	975	975	**975**
Production cost of firewood	1,200	1,200	1,200	1,200	1,200	**1,200**
Cost at the production site	*2,175*	*2,175*	*2,175*	*2,175*	*2,175*	***2,175***
Transport to road	350	700	700	350	350	**695**
Cost at the road	*2,525*	*2,875*	*2,875*	*2,525*	*2,525*	***2,870***
Roadside trader's mark-up	610	610	610	610	610	**610**
Roadside price	*3,135*	*3,485*	*3,485*	*3,135*	*3,135*	***3,480***
Transport costs	1,275	2,350	2,860	1,560	1,275	**2,470**
Wholesale purchase price	*4,410*	*5,835*	*6,345*	*4,695*	*4,410*	***5,950***
Wholesale mark-up	300	325	185	265	250	**265**
Wholesale selling price	*4,710*	*6,160*	*6,530*	*4,960*	*4,660*	***6,215***
Retail mark-up	2,840	2,560	1,760	2,290	2,000	**2,180**
Retail price	***7,550***	***8,730***	***8,290***	***7,250***	***6,660***	*8,395*

Note: (i) Mz = Mzuzu, Ll = Lilongwe, Bt = Blantyre, Za = Zomba, Other = other towns.
(ii) Weighting factors (%): Mz, 4.7; Ll 53.1; Bt 35.0; Za 3.7; Other towns 3.5.
(iii) Average selling price per town from the demand survey was an average of recorded prices. Retail selling price by town was weighted according to proportion of principal outlets, namely markets, houses and mobile traders.

Source: BPTTS, analysis of survey forms, updated to 2008 prices.

Table 2: Charcoal

units: MK per t. of charcoal

Cost Item	Mz	Ll	Bt	Za	Other	Wt. Av.
Wood raw material	2,790	2,790	2,790	2,790	2,790	2,790
Production cost of charcoal	*7,170*	*7,170*	*7,170*	*7,170*	*7,170*	*7,170*
Cost at the production site	*9,960*	*9,960*	*9,960*	*9,960*	*9,960*	*9,960*
Transport to road	660	1,340	1,340	660	660	1,230
Cost at the road	*10,620*	*11,300*	*11,300*	*10,620*	*10,620*	*11,190*
Roadside trader's mark-up	3,330	3,330	3,330	3,330	3,330	3,330
Roadside price	*13,950*	*14,630*	*14,630*	*13,950*	*13,950*	*13,520*
Transport costs	2,230	4,140	4,370	2,700	2,300	4,270
Wholesale purchase price	*16,180*	*18,770*	*19,000*	*16,650*	*16,250*	*18,790*
Wholesale mark-up	1,470	1,630	750	1,530	1,450	1,010
Wholesale selling price	*17,650*	*20,400*	*19,750*	*18180*	*17,700*	*19,800*
Retail mark-up	8,990	12,900	6,940	9,640	9,600	8,615
Retail price	***26,640***	***33,300***	***26,690***	***27,820***	***27,300***	***28,415***

Note: (i) Mz = Mzuzu, Ll = Lilongwe, Bt = Blantyre, Za = Zomba, Other = other towns.
(ii) Weighting factors (%): Mz, 3.6; Ll 27.0; Bt 64.9; Za 2.5; Other towns 2.0.
(iii) Average selling price per town from the demand survey was an average of recorded prices. Retail selling price by town was weighted according to proportion of principal outlets, namely markets, houses and mobile traders.

Source: BPTTS, analysis of survey forms, updated to 2008 prices.

Annex J: Description of land cover categories

Forest	Evergreen forest having green leaves throughout the year, with the land containing less than 20% open land. Mature trees usually taller than 20 m.	
Woodland	Non-evergreen forest with the land containing less than 20% open land. Brachystegia is the main species. Trees typically branchy with flat canopy, usually less than 20 m. tall when mature. Two sub-classes recognised:	• Brachystegia in hilly areas. • Brachystegia in flat areas.
Plantation	Monocultures of exotic trees, with land containing less than 20% open land. Six sub-classes recognised:	• Eucalyptus (all areas). • Pine (all areas). • Gmelina (Lilongwe only). • Rubber (Nkhata Bay only). • Tung (Mzuzu only). • Leucaena (Machinga & Chikwawa districts only).
Extensive agriculture	Area of land in forest or grassland areas with between 20% and 70% of the land under cultivation. Two sub-classes recognised:	• agriculture in forest area (dominant type). • agriculture in mainly grassy area.
Open vegetation	Open natural vegetation with more than 20% open land and less than 20% of the total area under cultivation. Generally characterised by open grassland with scattered trees. Three sub-classes recognised:	• grass (found at high altitudes). • dambos (grassy areas along natural drainage patterns in flat & undulating areas). • savanna (natural grassland found in south-western shore areas of Lake Malawi).
Intensive agriculture	Areas with more than 70% of the area under cultivation. Five sub-classes recognised:	• arable agriculture (dominant). • coffee/tea/nut trees (Thyolo & Mulanje). • sugar (Nkhotakota & Chikwawa). • tobacco/maize (mainly central & south). • rice (Karonga).
Marsh	Marshy or swampy areas found in all districts.	
Non-vegetated	Land with no vegetation such as bare rocks, river beds or beaches.	
Built-up	Urban areas and large infrastructural areas such as airports.	
Water surface	Lakes or wide rivers.	

Annex K: Land cover by region, 1991 and 2008

'000 ha

Land use	1991				2008				Difference (2008-1991)
	N	C	S	Total	N	C	S	Total	
For. green	57.2	6.8	18.6	**82.6**	53.0	6.7	17.0	**76.7**	- 5.9
W hill	795.7	431.3	459.1	**1,686.1**	617.0	307.0	368.5	**1,292.5**	- 393.6
W flat	184.3	272.8	275.9	**733.0**	105.7	166.8	162.0	**434.5**	-298.5
Plantation	86.1	26.5	28.4[1]	**141.2**	91.5	42.9	36.0	**170.4**	29.0
Tea/coffee ptn.	1.0	0.0	13.4	**14.4**	1.0	0.0	13.4	**14.4**	0.0
Sub-total	*1,124.3*	*737.4*	*795.8*	***2,657.5***	*868.2*	*523.4*	*596.9*	***1,988.5***	*- 669.0*
Ex forest	*1,122.6*	*792.0*	*518.7*	***2,433.3***	*1,336.6*	*771.2*	*485.5*	***2,593.3***	*160.0*
Ex grass	*0.0*	*0.0*	*235.3*	***235.3***	*0.0*	*0.0*	*258.6*	***258.6***	*23.3*
Intensive agric.	66.9	1,458.5	1,257.6	**2,783.0**	119.0	1,796.0	1,498.0	**3,413.0**	630.0
(Trees outside forest)[2]	[1.6]	[3.4]	[4.0]	**[9.0]**	[28.3]	[27.0]	[69.9]	**[125.2]**	[116.2]
Leucaena	0.0	0.0	6.6	**6.6**	0.0	0.0	6.6	**6.6**	0.0
Maize/tobacco	13.5	195.6	35.3	**244.4**	13.5	195.6	35.3	**244.4**	0.0
Rice	6.6	0.0	0.0	**6.6**	6.6	0.0	0.0	**6.6**	0.0
Sugar	0.0	10.3	10.3	**20.6**	0.0	10.3	10.3	**20.6**	0.0
Tea/Coffee	2.7	0.0	27.1	**29.8**	2.7	0.0	27.1	**29.8**	0.0
Sub-total	*89.7*	*1,664.4*	*1,336.9*	***3,091.0***	*141.8*	*2,001.9*	*1,577.3*	***3,721.0***	*630.0*
Savannah	0.0	33.7	5.5	**39.2**	0.0	33.7	5.5	**39.2**	0.0
Open grass	281.7	10.5	20.3	**312.5**	278.5	5.5	8.2	**292.2**	- 20.3
O dambo	94.2	287.3	33.2	**414.7**	86.0	188.1	8.9	**283.0**	- 131.7
Sub-total	*375.9*	*331.5*	*59.0*	***766.4***	*364.5*	*227.3*	*22.6*	***614.4***	*- 152.0*
Built-up	1.7	10.4	10.3	**22.4**	3.1	11.9	15.1	**30.1**	7.7
Rock	1.8	3.4	10.9	**16.1**	1.8	3.4	10.9	**16.1**	0.0
Marsh	3.5	20.5	153.2	**177.2**	3.5	20.5	153.2	**177.2**	0.0
Sub-total	*7.0*	*34.3*	*174.4*	***215.7***	*8.4*	*35.8*	*179.2*	***223.4***	*7.7*
Total[3]	**2,719.5**	**3,559.6**	**3,120.1**	**9,399.2**	**2,719.5**	**3,559.6**	**3,120.1**	**9,399.2**	**0.0**

Note: 1 - Included 4,800 ha logged area in 1991.
2 - Trees scattered on land outside forests; the volume from these trees is added to the total.
3 - Total excludes large lakes, 2,423,000 ha.

Land cover types as follows (see Annex J for descriptions):

- Evergreen forests; Woodland in hilly areas; Woodlands in flat areas; Forest plantations; Tea plantations & Coffee with shade trees; Agricultural land in extensive forests; Agricultural land in extensive grasslands; Intensive agriculture; Trees scattered on land outside the forest, mainly agricultural land, long roadsides and rivers, round houses etc. These areas are already included in the other areas. Agro-forestry area with leucaena; Maize/tobacco areas; Rice schemes; Sugar estates, excluding outgrowers; Tea estates & coffee estates; Savannah; Open grasslands; Grasslands that flood in wet season (dambo); Built-up areas, mainly urban; Rocky areas/river beds; Marshlands.

Annex L: 2008 land cover, nationally and by urban catchment

'000 ha

Land use	Whole regions				Urban catchment areas			
	N	C	S	Total	Mz	Li	Bt/Za	Total
For. green	53.0	6.7	17.0	**76.7**	14.4	0.5	15.4	**30.3**
W hill	617.0	307.0	368.5	**1,292.5**	247.6	115.6	144.8	**508.0**
W flat	105.7	166.8	162.0	**434.5**	61.3	23.4	112.5	**197.2**
Plantation	91.5	42.9	36.0	**170.4**	89.7	27.3	34.9	**151.9**
Tea/coffee ptn.	1.0	0.0	13.4	**14.4**	1.0	0.0	13.4	**14.4**
Sub-total	*868.2*	*523.4*	*596.9*	***1,988.5***	*414.0*	*166.8*	*321.0*	***901.8***
Ex forest	*1,336.6*	*771.2*	*485.5*	***2,593.3***	*895.1*	*299.2*	*286.5*	***1,480.8***
Ex grass	*0.0*	*0.0*	*258.6*	***258.6***	*0.0*	*0.0*	*193.6*	***193.6***
Intensive agric.	119.0	1,796.0	1,498.0	**3,413.0**	21.4	1,316.6	1,258.0	**2,596.0**
(Trees outside forest)	[28.3]	[27.0]	[69.9]	**[125.2]**	[10.0]	[20.0]	[66.0]	**[96.0]**
Leucaena	0.0	0.0	6.6	**6.6**	0.0	0.0	5.7	**5.7**
Maize/tobacco	13.5	195.6	35.3	**244.4**	12.3	66.3	29.5	**108.1**
Rice	6.6	0.0	0.0	**6.6**	0.0	0.0	0.0	**0.0**
Sugar	0.0	10.3	10.3	**20.6**	0.0	0.0	10.3	**10.3**
Tea/Coffee	2.7	0.0	27.1	**29.8**	2.7	0.0	26.9	**29.6**
Sub-total	*141.8*	*2,001.9*	*1,577.3*	***3,721.0***	*36.4*	*1,382.9*	*1,330.4*	***2,749.7***
Savannah	0.0	33.7	5.5	**39.2**	0.0	20.0	4.5	**24.5**
Open grass	278.5	5.5	8.2	**292.2**	107.0	2.0	5.2	**114.2**
O dambo	86.0	188.1	8.9	**283.0**	35.0	113.6	4.5	**153.1**
Sub-total	*364.5*	*227.3*	*22.6*	***614.4***	*142.0*	*135.6*	*14.2*	***291.8***
Built-up	3.1	11.9	15.1	**30.1**	1.6	11.4	15.0	**28.0**
Rock	1.8	3.4	10.9	**16.1**	1.8	2.7	9.9	**14.4**
Marsh	3.5	20.5	153.2	**177.2**	0.3	7.2	110.9	**118.4**
Sub-total	*8.4*	*35.8*	*179.2*	***223.4***	*3.7*	*21.3*	*135.8*	***160.8***
Total	**2,719.5**	**3,559.6**	**3,120.1**	**9,399.2**	**1,491.2**	**2,005.8**	**2,281.5**	**5,778.5**

Notes: As per Annex K.

Urban Catchments include the following districts:

Town:	Mzuzu	Lilongwe	Blantyre/Limbe & Zomba
Districts in catchment:	• Nkhata Bay • Mzimba	• Ntchisi • Mchinji • Dowa • Lilongwe • Salima • Dedza	• Mangochi • Balaka • Manchingu • Blantyre • Chiradzulu • Phalombe • Mulange • Chikwawa • Thyolo

Annex M: Assumed standing stock, rotation and yield, by region

Table 1: Northern Region

Land classification	Average standing stock (m³/ha)		Standing stock maturity (m³/ha)	Assumed rotation (years)	Annual yield (m³/ha)		Notes
	max	min			max	min	
Evergreen	224	190	336	100	3.4	2.9	Indigenous
Hilly, Woodland	122	105	148	40	3.7	3.1	Indigenous
Plains, Woodland	105	90	130	30	4.4	3.7	Indigenous
Agric, within woodlands	77	65	116	20	5.8	4.9	Extensive agric. indigenous
Eucalyptus grandis E. spp. others	100 40		175 70	7 7	25 10		Exotic
Pine spp.	238		350	25	17		Exotic
Other ptn. spp.	70		140	14	10		Rubber/Tung
Trees outside the forest	80		140	7	20		Forest equivalent ha
Grassland	5		10	20	0.5		Indigenous
Intensive Agriculture	4 16		8 32	8 32	1.0 1.0		Planted Indigenous
Coffee/Tea	3		6	6	1.0		Estate agriculture
Rice	1		1	10	0.1		
Tobacco/Maize	5		10	10	1.0		Estate and smallholdings
Urban	10		20	20	1.0		Mixture of indig. & exotic
Marsh/rock	0		0	0	0		

Source: BPMS, Table 8.2 modified.

Table 2: Central Region

Land classification	Average standing stock (m³/ha)		Standing stock maturity (m³/ha)	Assumed rotation (years)	Annual yield (m³/ha)		Notes
	max	min			max	min	
Evergreen	336	285	336	100	3.4	2.9	Indigenous
Hilly, Woodland	123	105	148	40	3.7	3.1	Indigenous
Plains, Woodland	109	90	131	30	4.4	3.7	Indigenous
Agric, within woodlands	35 30		70	15	4.7	4.0	Extensive agric. indigenous
Eucalyptus grandis E. spp. others	100 40		175 70	7 7	25 10		Exotic
Pine spp.	238		350	25	17		Exotic
Other ptn. spp.	70		140	14	10		Gmelina
Trees outside the forest	80		140	7	20		Forest equivalent ha
Grassland	5		10	20	0.5		Indigenous
Intensive agriculture	4 16		8 32	8 32	1.0 1.0		Planted Indigenous
Coffee/Tea	3		6	6	1.0		Estate agriculture
Tobacco/Maize	5		10	10	1.0		Estate and smallholdings
Urban	10		20	20	1.0		Mixture of indig. & exotic
Marsh/rock	0		0	0	0		

Source: BPMS, Table 8.2 modified.

Table 3: Southern Region

Land classification	Average standing stock (m³/ha)		Standing stock maturity (m³/ha)	Assumed rotation (years)	Annual yield (m³/ha)		Notes
	max	min			max	min	
Evergreen	336	285	336	100	3.4	2.9	Indigenous
Hilly, Woodland	81	70	120	40	3.0	2.6	Indigenous
Plains, Woodland	61	50	90	30	3.0	2.6	Indigenous
Agric, within woodlands	63	55	94	20	4.7	4.0	Extensive agric. indigenous
Eucalyptus grandis E. spp. others	100 40		175 70	7 7	25 10		Exotic
Tea area plantations	105		210	7	30		
Pine spp.	238		350	25	17		Exotic
Other ptn. spp. Leucaena	70 6		140 6	14 3	10 2		Leucaena
Trees outside the forest	80		140	7	20		Forest equivalent ha
Grassland	5		10	20	0.5		Indigenous
Intensive Agriculture	4 4		8 12	8 30	1.0 0.4		Planted Indigenous
Coffee/Tea	3		6	6	1.0		Estate agriculture
Tobacco/Maize	5		10	10	1.0		Estate and smallholdings
Urban	10		20	20	1.0		Mixture of indig. & exotic
Marsh/rock	0		0	0	0		

Source: BPMS, Table 8.2 modified.

Annex N: Standing stock by region

million m³

Land use	Minimum estimate				Maximum estimate			
	N	C	S	Total	N	C	S	Total
For. green	10.07	1.91	4.84	**16.82**	11.87	2.25	5.71	**19.83**
W hill	64.78	32.24	25.80	**122.82**	75.27	37.76	29.85	**142.88**
W flat	9.51	15.01	8.10	**32.62**	11.10	18.18	9.88	**39.16**
Plantation	18.90	7.08	2.60	**29.58**	18.90	7.08	3.60	**29.58**
Tea/coffee ptn.	0.11	0.0	1.40	**1.51**	0.10	0.0	1.41	**1.51**
Sub-total	*103.37*	*56.24*	*43.74*	***203.35***	*117.24*	*65.27*	*50.45*	***232.96***
Ex forest	*86.88*	*23.14*	*26.70*	***136.72***	*102.92*	*26.99*	*30.59*	***160.50***
Ex grass	*0.0*	*0.0*	*1.29*	***1.29***	*0.0*	*0.0*	*1.29*	***1.29***
Intensive agric.	2.38	35.92	11.98	**50.28**	2.38	35.92	11.98	**50.28**
(Trees outside forest)[1]	2.26	2.16	5.59	**10.01**	2.26	2.16	5.59	**10.01**
Leucaena	0.0	0.0	0.04	**0.04**	0.0	0.0	0.04	**0.04**
Maize/tobacco	0.07	0.98	0.17	**1.22**	0.07	0.98	0.17	**1.22**
Rice	0.01	0.0	0.0	**0.01**	0.01	0.0	0.0	**0.01**
Sugar	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
Tea/Coffee	0.01	0.0	0.08	**0.09**	0.01	0.0	0.08	**0.09**
Sub-total	*4.73*	*39.06*	*17.86*	***61.65***	*4.73*	*39.06*	*17.86*	***61.65***
Savannah	0.0	0.17	0.03	**0.20**	0.0	0.17	0.03	**0.20**
Open grass	1.39	0.03	0.04	**1.46**	1.39	0.03	0.04	**1.46**
O dambo	0.43	0.94	0.04	**1.41**	0.43	0.94	0.04	**1.41**
Sub-total	*1.82*	*1.14*	*0.11*	***3.07***	*1.82*	*1.14*	*0.11*	***3.07***
Built-up	0.03	0.12	0.15	**0.30**	0.03	0.12	0.15	**0.30**
Rock	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
Marsh	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
Sub-total	*0.03*	*0.12*	*0.15*	***0.30***	*0.03*	*0.12*	*0.15*	***0.30***
Total	**196.83**	**119.70**	**89.79**	**406.38**	**226.74**	**132.58**	**100.45**	**459.77**

Notes: As per Annex K.

Annex O: Standing stock by urban catchment

million m^3

Land use	Minimum estimate				Maximum estimate			
	Mz	Li	Bt/Za	Total	Mz	Li	Bt/Za	Total
For. green	2.74	0.14	4.39	**7.27**	3.23	0.17	5.17	**8.57**
W hill	26.00	12.14	10.14	**48.28**	30.21	14.22	11.73	**56.15**
W flat	5.52	2.11	5.62	**13.25**	6.44	2.55	6.86	**15.85**
Plantation	18.52	4.50	3.49	**26.51**	18.52	4.50	3.49	**26.51**
Tea/coffee ptn.	0.10	0.0	1.05	**1.15**	0.10	0.0	1.41	**1.51**
Sub-total	*52.88*	*18.89*	*24.69*	***96.46***	*58.49*	*21.44*	*28.66*	***108.59***
Ex forest	*58.18*	*8.98*	*15.76*	***82.92***	*68.92*	*10.47*	*18.05*	***97.44***
Ex grass	*0.0*	*0.0*	*0.97*	***0.97***	*0.0*	*0.0*	*0.97*	***0.97***
Intensive agric.	0.54	26.33	10.06	**36.93**	0.43	26.33	10.06	**36.82**
(Trees outside forest)[1]	0.80	1.60	5.28	**7.68**	0.80	1.60	5.28	**7.68**
Leucaena	0.0	0.0	0.03	**0.03**	0.0	0.0	0.03	**0.03**
Maize/tobacco	0.06	0.33	0.15	**0.54**	0.06	0.33	0.15	**0.54**
Rice	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
Sugar	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
Tea/Coffee	0.01	0.0	0.08	**0.09**	0.01	0.0	0.08	**0.09**
Sub-total	*1.41*	*28.26*	*15.60*	***45.27***	*0.50*	*26.66*	*10.33*	***37.49***
Savannah	0.0	0.10	0.02	**0.12**	0.0	0.10	0.02	**0.12**
Open grass	0.54	0.01	0.03	**0.58**	0.54	0.01	0.03	**0.57**
O dambo	0.17	0.57	0.02	**0.76**	0.18	0.57	0.02	**0.77**
Sub-total	*0.71*	*0.68*	*0.07*	***1.46***	*0.71*	*0.68*	*0.07*	***1.46***
Built-up	0.02	0.11	0.15	**0.28**	0.02	0.11	0.15	**0.28**
Rock	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
Marsh	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
Sub-total	*0.02*	*0.11*	*0.15*	***0.28***	*0.02*	*0.11*	*0.15*	***0.28***
Total	**113.20**	**56.92**	**57.24**	**227.36**	**128.64**	**59.36**	**58.23**	**246.23**

Notes: As per Annex K.

Annex P: Annual yield by region

'000 m³

Land use	Minimum estimate				Maximum estimate			
	N	C	S	Total	N	C	S	Total
For. green	154	19	49	**222**	180	23	58	**261**
W hill	1,913	952	958	**3,823**	2,283	1,136	1,106	**4,525**
W flat	391	617	421	**1,429**	465	734	486	**1,685**
Plantation	1,421	759	900	**3,080**	1,421	759	900	**3,080**
Tea/coffee ptn.	30	0	402	**432**	30	0	402	**432**
Sub-total	*3,909*	*2,347*	*2,730*	***8,986***	*4,379*	*2,652*	*2,952*	***9,983***
Ex forest	*6,549*	*3,085*	*1,942*	***11,576***	*7,752*	*3,625*	*2,282*	***13,659***
Ex grass	*0*	*0*	*129*	***129***	*0*	*0*	*129*	***129***
Intensive agric.	238	3,592	2,097	**5,927**	238	3,592	2,097	**5,927**
(Trees outside forest)[1]	566	540	1,398	**2,504**	566	540	1,398	**2,504**
Leucaena	0	0	13	**13**	0	0	13	**13**
Maize/tobacco	14	196	35	**245**	14	196	35	**245**
Rice	1	0	0	**1**	1	0	0	**1**
Sugar	0	0	0	**0**	0	0	0	**0**
Tea/Coffee	3	0	27	**30**	3	0	27	**30**
Sub-total	*822*	*4,328*	*3,570*	***8,720***	*822*	*4,328*	*3,570*	***8,720***
Savannah	0	17	3	**20**	0	17	3	**20**
Open grass	139	3	4	**146**	139	3	4	**146**
O dambo	43	94	4	**141**	43	94	4	**141**
Sub-total	*182*	*114*	*11*	***307***	*182*	*114*	*11*	***307***
Built-up	3	12	15	**30**	3	12	15	**30**
Rock	0	0	0	**0**	0	0	0	**0**
Marsh	0	0	0	**0**	0	0	0	**0**
Sub-total	*3*	*12*	*15*	***30***	*3*	*12*	*15*	***30***
Total	**11,465**	**9,886**	**8,397**	**29,748**	**13,138**	**10,731**	**8,959**	**32,828**

Notes: As per Annex K.

Annex Q: Annual yield by urban catchment

'000 m³

Land use	Minimum estimate				Maximum estimate			
	Mz	Li	Bt/Za	Total	Mz	Li	Bt/Za	Total
For. green	42	1	45	**88**	49	2	52	**103**
W hill	768	358	376	**1,502**	916	428	434	**1,778**
W flat	227	87	293	**607**	270	103	338	**711**
Plantation	1,393	483	698	**2,574**	1,393	483	698	**2,574**
Tea/coffee ptn.	30	0	402	**432**	30	0	402	**432**
Sub-total	*2,460*	*929*	*1,814*	***5,203***	*2,658*	*1,016*	*1,924*	***5,598***
Ex forest	*4,386*	*1,197*	*1,146*	***6,729***	*5,192*	*1,406*	*1,347*	***7,945***
Ex grass	*0*	*0*	*97*	***97***	*0*	*0*	*97*	***97***
Intensive agric.	119	2,633	1,761	**4,513**	119	2,633	1,761	**4,513**
(Trees outside forest)[1]	200	400	1,320	**1,920**	200	400	1,320	**1,920**
Leucaena	0	0	11	**11**	0	0	11	**11**
Maize/tobacco	12	66	30	**108**	12	66	30	**108**
Rice	0	0	0	**0**	0	0	0	**0**
Sugar	0	0	0	**0**	0	0	0	**0**
Tea/Coffee	3	0	27	**30**	3	0	27	**30**
Sub-total	*334*	*3,099*	*3,149*	***6,582***	*334*	*3,099*	*3,149*	***6,582***
Savannah	0	10	2	**12**	0	10	2	**12**
Open grass	54	1	3	**58**	54	1	3	**58**
O dambo	17	57	2	**76**	17	57	2	**76**
Sub-total	*71*	*68*	*7*	***146***	*71*	*68*	*7*	***146***
Built-up	2	11	15	**28**	2	11	15	**28**
Rock	0	0	0	**0**	0	0	0	**0**
Marsh	0	0	0	**0**	0	0	0	**0**
Sub-total	*2*	*11*	*15*	***28***	*2*	*11*	*15*	***28***
Total	**7,253**	**5,304**	**6,228**	**18,785**	**8,257**	**5,600**	**6,539**	**20,396**

Notes: As per Annex K.

Annex R: Supply and demand for biomass by region

Table 1: Minimum yield and average demand

	Supply or Demand (million m^3 roundwood equivalent)			
	North	**Central**	**South**	**National**
Population	*1.60*	*5.77*	*6.26*	*13.63*
Woody growing stock	196.80	119.7	89.90	406.40
Land clearing – wood	0.57	1.98	2.15	4.70
Annual growth – wood	11.46	9.89	8.40	29.75
Annual crop residues	1.70	6.37	4.07	12.14
Annual dung	0.06	0.23	0.25	0.54
Annual growth of biomass practically available:				
Wood from clearing (70%)	0.40	1.39	1.50	3.29
Wood from annual growth (70%)	8.02	6.92	5.88	20.82
Total wood	**8.42**	**8.31**	**7.38**	**24.11**
Crop residues (50%)	0.85	3.18	2.04	6.07
Dung (10%)	0.01	0.02	0.02	0.05
Combined sustainable wood/residues	**8.87**	**10.10**	**7.92**	**26.89**
Demand - wood	1.81	6.55	6.54	14.90
Demand - residues	0.04	0.43	0.42	0.89
Combined wood/residue demand	**1.85**	**6.98**	**6.96**	**15.79**
Demand as a percentage of practically available biomass from:				
Wood annual growth only	23%	95%	111%	72%
Wood growth + clearing	21%	79%	89%	62%
Crop residues	5%	14%	21%	15%
Sustainable wood and residues	21%	69%	88%	59%

Note: (i) The Uganda Biomass Study (GoM 1996), determined that about 70% of above-ground woody biomass is available for use.

(ii) The demand for wood includes energy, poles and sawnwood. Only energy is included in residues.

(iii) The figure of 50% for the availability of crop residues and 10% for dung are best estimates.

Table 2: Maximum yield and demand

	Supply or Demand (million m^3 roundwood equivalent)			
	North	**Central**	**South**	**National**
Population	*1.60*	*5.77*	*6.26*	*13.63*
Woody growing stock	226.7	132.6	106.5	450.8
Land clearing – wood	0.57	1.98	2.15	4.70
Annual growth – wood	13.14	10.73	8.96	32.83
Annual crop residues	1.70	6.37	4.07	12.14
Annual dung	0.06	0.23	0.25	0.54
Annual growth of biomass practically available:				
Wood from clearing (70%)	0.40	1.39	1.50	3.29
Wood from annual growth (70%)	9.20	7.51	6.27	22.98
Total wood	**9.60**	**8.90**	**7.77**	**26.27**
Crop residues (50%)	0.85	3.18	2.04	6.07
Dung (10%)	0.01	0.02	0.02	0.05
Combined sustainable wood/residues	**10.05**	**10.69**	**8.31**	**29.05**
Demand – wood	1.99	7.21	7.19	16.39
Demand - residues	0.04	0.43	0.42	0.89
Combined wood/residue demand	**2.03**	**7.64**	**7.61**	**17.28**
Demand as a percentage of practically available biomass from:				
Wood annual growth only	22%	96%	115%	71%
Wood growth + clearing	21%	81%	93%	62%
Crop residues	5%	14%	21%	15%
Sustainable wood and residues	20%	71%	92%	59%

Note: (i) The Uganda Biomass Study (GoM 1996), determined that about 70% of above-ground woody biomass is available for use.

(ii) The demand for wood includes energy, poles and sawnwood. Only energy is included in residues.

(iii) The figure of 50% for the availability of crop residues and 10% for dung are best estimates.

Table 3: Minimum yield and demand

	Supply or Demand (million m³ roundwood equivalent)			
	North	**Central**	**South**	**National**
Population	*1.60*	*5.77*	*6.26*	*13.63*
Woody growing stock	196.80	119.7	89.90	406.40
Land clearing – wood	0.57	1.98	2.15	4.70
Annual growth – wood	11.46	9.89	8.40	29.75
Annual crop residues	1.70	6.37	4.07	12.14
Annual dung	0.06	0.23	0.25	0.54
Annual growth of biomass practically available:				
Wood from clearing (70%)	0.40	1.39	1.50	3.29
Wood from annual growth (70%)	8.02	6.92	5.88	20.82
Total wood	**8.42**	**8.31**	**7.38**	**24.11**
Crop residues (50%)	0.85	3.18	2.04	6.07
Dung (10%)	0.01	0.02	0.02	0.05
Combined sustainable wood/residues	**8.87**	**10.10**	**7.92**	**26.89**
Demand – wood	1.65	5.95	5.95	13.55
Demand residues	0.04	0.43	0.42	0.89
Combined wood/residue demand	**1.69**	**6.38**	**6.37**	**14.44**
Demand as a percentage of practically available biomass from:				
Wood annual growth only	21%	86%	101%	65%
Wood growth + clearing	20%	72%	81%	71%
Crop residues	5%	14%	21%	29%
Sustainable wood and residues	19%	63%	80%	54%

Note: (i) The Uganda Biomass Study (GoM 1996), determined that about 70% of above-ground woody biomass is available for use.

(ii) The demand for wood includes energy, poles and sawnwood. Only energy is included in residues.

(iii) The figure of 50% for the availability of crop residues and 10% for dung are best estimates.

Annex S: GLOBUS Assumptions: Population growth projections

The following table summarises the growth projections used in the GLOBUS energy market modelling, extrapolated from the 1998 census.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Lilongwe	783,388	823,108	863,538	904,641	946,410	988,876	1,032,349	1,077,116	1,123,212	1,170,711	1,219,738
Blantyre	813,457	848,571	884,124	920,082	956,426	993,150	1,030,488	1,068,681	1,107,751	1,147,731	1,188,658
Mzuzu	158,204	166,539	175,061	183,765	192,645	201,696	210,927	220,346	229,955	239,756	249,753
Zomba	119,150	125,325	131,628	138,052	144,589	151,223	157,979	164,898	171,983	179,237	186,654
Other urban	451,875	465,489	479,574	477,487	507,132	522,314	537,974	554,238	570,983	588,326	606,249
Total urban	***2,326,074***	***2,429,032***	***2,533,925***	***2,624,027***	***2,747,202***	***2,857,259***	***2,969,717***	***3,085,279***	***3,203,884***	***3,325,761***	***3,451,052***
Rural	***11,304,090***	***11,656,313***	***12,019,086***	***12,409,697***	***12,780,753***	***13,178,125***	***13,589,321***	***14,016,570***	***14,459,736***	***14,918,690***	***15,393,653***
N. Region	1,594,437	1,639,052	1,684,786	1,731,837	1,780,357	1,830,151	1,881,291	1,933,981	1,988,222	2,043,969	2,101,072
C. Region	5,773,267	5,984,950	6,203,319	6,428,335	6,659,898	6,897,915	7,143,959	7,399,523	7,664,494	7,938,882	8,222,847
S. Region	6,262,460	6,461,343	6,664,906	6,873,552	7,087,700	7,307,318	7,533,788	7,768,345	8,010,904	8,261,600	8,520,786
Total	***13,630,164***	***14,085,345***	***14,553,011***	***15,033,724***	***15,527,955***	***16,035,384***	***16,559,038***	***17,101,849***	***17,663,620***	***18,244,451***	***18,844,705***

	2019	2020	2021	2022	2023
Lilongwe	1,270,789	1,324,314	1,380,392	1,439,092	1,500,468
Blantyre	1,230,834	1,274,564	1,319,893	1,366,862	1,415,505
Mzuzu	259,968	270,423	281,131	292,103	303,348
Zomba	194,257	202,076	210,118	218,393	226,911
Other urban	624,763	644,071	663,975	684,494	705,647
Total urban	***3,580,611***	***3,715,448***	***3,855,509***	***4,000,944***	***4,151,879***
Rural	***15,887,864***	***16,404,382***	***16,943,866***	***17,506,779***	***18,093,552***
N. Region	2,159,597	2,219,747	2,281,579	2,345,150	2,410,515
C. Region	8,518,704	8,828,760	9,153,327	9,492,748	9,847,363
S. Region	8,790,174	9,071,323	9,364,469	9,669,825	9,987,553
Total	***19,468,475***	***20,119,830***	***20,799,375***	***21,507,723***	***22,245,431***

Annex T: GLOBUS Assumptions: Main domestic fuel

Main fuel in use	Location	2008	Business as Usual Scenario		Alternative Scenario	
			2015	2023	2015	2023
Firewood and residues	Lilongwe	40.8%	33.2%	27.1%	33.2%	27.1%
	Blantyre	21.8%	17.5%	14.1%	17.5%	14.1%
	Other urban	50.7%	38.7%	29.6%	38.7%	29.6%
	Rural	95.5%	92.7%	89.9%	92.7%	89.9%
Commercial firewood	Lilongwe	38.8%	31.6%	25.7%	31.6%	25.7%
	Blantyre	18.5%	14.9%	12.0%	14.9%	12.0%
	Other urban	35.5%	27.1%	20.7%	27.1%	20.7%
	Rural	1.0%	0.9%	0.9%	0.9%	0.9%
Non-commercial firewood and residues	Lilongwe	2.0%	1.7%	1.4%	1.7%	1.4%
	Blantyre	3.3%	2.6%	2.1%	2.6%	2.1%
	Other urban	15.2%	11.6%	8.9%	11.6%	8.9%
	Rural	94.5%	91.7%	89.0%	91.7%	89.0%
Charcoal	Lilongwe	40.0%	38.6%	29.4%	56.6%	67.0%
	Blantyre	53.0%	45.9%	29.7%	69.6%	79.2%
	Other urban	38.0%	44.6%	44.5%	54.4%	65.2%
	Rural	4.0%	6.6%	8.9%	7.1%	9.9%
Paraffin	Lilongwe	0.4%	0.6%	1.0%	0.6%	1.0%
	Blantyre	0.6%	0.5%	0.4%	0.5%	0.4%
	Other urban	1.1%	1.7%	2.7%	1.7%	2.7%
	Rural	0.0%	0.0%	0.0%	0.0%	0.0%
LPG	Lilongwe	0.3%	0.3%	0.3%	0.3%	0.3%
	Blantyre	0.2%	0.2%	0.2%	0.2%	0.2%
	Other urban	0.1%	0.1%	0.1%	0.1%	0.1%
	Rural	0.0%	0.0%	0.0%	0.0%	0.0%
Electricity	Lilongwe	18.5%	27.2%	42.2%	9.3%	4.6%
	Blantyre	24.4%	35.9%	55.7%	12.2%	6.1%
	Other urban	10.2%	14.9%	23.2%	5.1%	2.5%
	Rural	0.5%	0.7%	1.1%	0.3%	0.1%

Annex U: GLOBUS Assumptions: Commercial fuel demand under different scenarios

Commercial demand under Business as Usual Scenario ('000 t/yr)

	2008	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*
Firewood (domestic)	611	621	631	641	650	660	668	677	690	704	718	731	745	758	772	785
Firewood (non-domestic)	282	292	301	311	321	332	343	354	366	379	391	405	418	432	447	462
Firewood (all)	***893***	***913***	***932***	***952***	***972***	***992***	***1011***	***1031***	***1057***	***1083***	***1109***	***1136***	***1163***	***1190***	***1218***	***1246***
Charcoal (domestic)	291	305	320	336	352	369	387	405	422	440	458	477	497	518	539	561
Charcoal (non-domestic)	15	15	16	17	18	18	19	20	21	22	23	24	25	26	27	28
Charcoal (all)	***305***	***320***	***336***	***353***	***370***	***387***	***406***	***425***	***443***	***462***	***481***	***501***	***522***	***544***	***566***	***589***
LPG (domestic)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LPG (non-domestic)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LPG (all)	***0***	***0***	***0***	***0***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***
Paraffin	1	1	1	1	2	2	2	2	2	2	3	3	3	3	4	4
Electricity (GWh/yr)	241	267	294	324	355	389	424	462	513	567	625	686	751	821	894	973
Power (MW)	163	180	198	218	239	261	284	309	343	379	417	457	500	545	594	645

Commercial demand under Alternative Scenario ('000 t/yr)

	2008	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*	*2022*	*2023*
Firewood (domestic)	611	621	631	641	650	660	668	677	690	704	718	731	745	758	772	785
Firewood (non-domestic)	282	292	301	311	321	332	343	354	366	379	391	405	418	432	447	462
Firewood (all)	***893***	***913***	***932***	***952***	***972***	***992***	***1011***	***1031***	***1057***	***1083***	***1109***	***1136***	***1163***	***1190***	***1218***	***1246***
Charcoal (domestic)	291	314	338	364	391	419	449	481	512	544	578	614	652	692	734	777
Charcoal (non-domestic)	15	16	17	18	20	21	22	24	26	27	29	31	33	35	37	39
Charcoal (all)	***305***	***329***	***355***	***382***	***410***	***440***	***471***	***505***	***537***	***571***	***607***	***645***	***685***	***727***	***770***	***816***
LPG (domestic)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LPG (non-domestic)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LPG (all)	***0***	***0***	***0***	***0***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***	***1***
Paraffin	1	1	1	1	2	2	2	2	2	2	3	3	3	3	4	4
Electricity (GWh/yr)	241	234	226	217	207	196	184	170	168	166	163	159	155	151	145	140
Power (MW)	163	160	156	152	147	142	136	130	131	131	132	132	132	132	132	132