Bioenergy, rural development and poverty alleviation in Southern Africa

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Contents

Executive summary

Wood is the oldest energy source and today about 75% of the sub-Saharan African population still cook with wood and charcoal on open fires in unventilated kitchens. Globally about two million deaths annually are attributed to inhaling fumes from such traditional cooking fires. Dependence on woodfuels has raised concern about the sustainability of wood supply as growing populations clear forests for food crops and grazing. Fuelwood harvesting also leads to forest degradation particularly around population centres.

Biofuels – liquid fuels of plant origin – are relatively new and they are expected to improve the security of supply, to save greenhouse gas (GHG) emissions, to create employment particularly in rural areas, and to open new export opportunities for developing countries. Woodfuels can be replaced by more efficient fuels such as kerosene, gas, ethanol-based gelfuel and electricity, but the majority of the poor in sub-Saharan Africa could not afford these fuels even if they were available. In the short-to-medium term they will have to rely on traditional woodfuels. To save wood and avoid dangerous emissions improved cookstoves have to be disseminated more widely.

The reasons for growing and using biofuels for developed countries are energy security and the reduction of GHG emissions. Developing countries prioritise job creation, rural development and export earnings rather than emissions reduction. Countries without fossil oil resources prioritise substituting oil imports which are a major drain on their foreign exchange reserves.

South Africa, Mozambique and Malawi have been selected for this study because they differ in land resources, bioenergy potential and population density and are taking different approaches to bioenergy and biofuels in particular.

South Africa has limited agricultural land and water resources. Only 14% is arable, using 60% of the national water supply. The country has a well developed commercial agricultural sector but smallholder and subsistence farming in historically disadvantaged areas was neglected. Since 1994 these inequalities are being addressed through policies of land redistribution and sustainable development. Only 20% of the population used woodfuel in 2007, down from 27% in 1996. Woodfuel use is declining steadily because alternative fuels such as kerosene, LPGas and electricity are made widely available and electricity for the poor is subsidised. At present South Africa is producing biofuels at a pilot scale and estimates indicate that

An assessment of the macroeconomic impact of renewable energy suggests that the largest electricity contribution of over 5000 GWh will come from sugar bagasse. It could contribute more to the income of poor households and create the highest number of jobs compared with landfill gas and biomass from paper mills as well as as hydroenergy and solar water heaters.

Government policies have generally supported bioenergy. The Biofuels Industrial Strategy (2007) supports the production of bioethanol and biodiesel for the transport sector and while stimulating rural development and reducing poverty. The strategy aims at a balanced development between emerging farmers and established commercial farming areas to ensure sustainable development for the biofuels industry. The strategy intends to achieve a two% biofuel contribution to the national liquid fuel supply within five years. Commercial farmers do not benefit from the subsidies in the first five years of the strategy. Thus far, however, the Strategy has not been effective in stimulating the production of biofuels.

The other relevant policy for bioenergy is the Renewable Energy Feed-in Tariff (REFIT) published in 2009. Solid biomass and biogas are the two bioenergy sources included in the subsidy for electricity generation. The private sector has taken interest in the REFIT and details of implementation are still being worked out.

Policies and programmes in agriculture support reduction in poverty and inequality and promote agricultural production in disadvantaged rural communities. The Land and Agrarian Reform project and the Comprehensive Agricultural Support programme are expected to work in synergy with the Biofuels Industrial Strategy to open opportunities in the new biofuels sector for emerging farmers. The expected growth in agriculture, rural employment and widened enterprise ownership has been disappointing. Policies in the forestry sector have addressed social, economic and ecological challenges.

The Biofuels Industrial Strategy targets a national penetration level of biofuels amounting to 400 million litres per annum. Limited agricultural land and water resources make it unlikely that South Africa will be exporting biofuels. South Africa has not yet started producing biofuels at a large scale. The policies have not made the sector attractive for private investment. Small-scale plants produce biodiesel from waste vegetable oil and some farmers produce biodiesel from sunflower seeds for on-farm consumption. "Working for Energy" is an innovative project and is part of the government's Expanded Public Works Programme focusing on creating green jobs and reducing GHG emissions. It intends to use invasive alien vegetation to generate energy as well as biogas from municipal and household waste.

Mozambique is a fast-developing very poor Southern African countries, with annual growth rates of eight% for the last ten years. About 84% of the people still depend on woodfuels for their energy needs. The country has large energy resources and is already exporting hydroelectricity and natural gas to its neighbours. It is considered ideal for bioenergy production due to its relative abundance of land resources, favourable environmental conditions and low population density.

Mozambique has developed a comprehensive biofuel policy and strategy in 2009 to reduce dependence on imported fuels, to promote rural development through investment in biofuels and to reduce fuel cost to the final consumer without introducing subsidies. The policy creates business opportunities for private local and foreign investors and communities including small and big producers. Mandatory blending and the use of flexifuel vehicles will create a local market. Export to the international market is expected. Blending will be gradually increased from five% in 2009 to above E25 and B75 in 2021. A National Energy Fund will be established to support small-scale producers, infrastructure projects and research and development of new crops for feedstock. International companies have shown interest in the biofuel opportunities in Mozambique and have submitted proposals to grow the feedstock and generate biofuels.

Malawi is a very poor landlocked country and particularly densely populated. Faced with rising import cost of oil after the 1973 oil crisis, the country started to produce and blend ethanol with petrol (E10) since 1982. The local demand exceeds supply because of a shortage of bagasse. An expansion of sugarcane plantations is planned. The sugar and ethanol factories source their cane predominantly from plantations but also from smallholder farms. Malawi intends to produce biodiesel and has started to grow Jatropha. Woodfuels are still the major household fuel used by 98% of the population. The illegal charcoal production and trade is worth US$41 million a year. If the charcoal trade would be well regulated and taxed forests could be regenerated for sustainable charcoal production, more secure rural jobs could be created and government could collect revenue. Malawi's interest is to grow biofuels for the local market first to save on imports of petrol and diesel and to export the surplus.

Biofuel development in Southern Africa is not only influenced by local national policies and markets but also by international markets and biofuel policies and import taxes in the EU and the USA which are the major export markets as well as the established competing biofuel exporters such as Brazil.

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Acronyms used

ASGISA	Accelerated Shared and Growth Initiative for South Africa
EPWP	Expanded Public Works Programme
CASP	Comprehensive Agriculture Support Programme (South Africa)
CEF	Central Energy Fund
CS	Community Survey
CSP	Concentrated Solar Power
COMPETE	Competence Platform on Energy Crop and Agroforestry Systems
DANIDA	Danish International Development Agency
DOA	Department of Agriculture (South Africa)
DOE	Department of Energy formerly
DME	Department of Minerals and Energy (South Africa)
DWAF	Department of Water Affairs and Forestry (South Africa)
EEB	European Environmental Bureau
ERC	Energy Research Centre – University of Cape Town
EU	European Commission
FAO	Food and Agricultural Organisation of the United Nations
FAOSTAT	Food and Agriculture Organisation Statistical Database
FTA	Free Trade Area
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GWh	Gigawatt hours
HDI	Human Development Index
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
Km	Kilometres
LDC	Least Developed Country
NBDP	National Biofuels Development Programme (Mozambique)
NBTT	National Biofuels Task Team (South Africa)
NERSA	National Energy Regulator of South Africa
OECD	Organisation for Economic Cooperation and Development
ProBEC	Programme for Basic Energy and Conservation in Southern Africa
REFIT	Renewable Energy Feed-in Tariff
SADC	Southern Africa Development Community
UNEP	United Nations Environment Programme
USA	United States of America
WMO	World Meteorological Organization

1. Introduction

The oldest source of biomass fuel is wood and for millennia people have used it to cook food. Biofuels - liquid fuels of plant origin - are relatively new and have a number of possible advantages; they improve the security of energy supply, save greenhouse gas (GHG) emissions, create employment particularly in rural areas, and open new export opportunities for developing countries.

There is widespread energy poverty in sub-Saharan Africa and on average only 24% of the population has access to electricity. The vast majority depend on traditional biomass such as fuelwood, charcoal and agricultural residue for their energy needs.

Most farmers in Africa are smallholders, and agricultural growth and poverty reduction will depend on more productive smallholder farming enterprise in the short and medium terms (FAO, 2009). Over the years, large globally integrated companies are entering African agriculture and these companies are advantaged because of greater technical expertise, market knowledge and access to cheaper capital. Smallholders are undercapitalised and are under increasing pressure to adopt new technologies and crops and learn to adapt to market requirements. Larger commercial farms are in a better position to manage risks associated with the adoption of new technologies and crops.

Climate change affects most African countries negatively and the continent is among the most vulnerable regions of the world because of multiple stresses and low adaptive capacity (IPCC, UNEP and WMO, 2007). Some countries have already experienced devastating floods and droughts associated with climate change. Adapting to climate change is estimated to cost Africa 5-10% of GDP and in some African countries climate change could decrease potential crop yields from rain-fed agriculture by a half.

In sub-Saharan Africa the percentage of people living in absolute poverty has decreased from 53.7% in 1981 to 51.2% in 2005, but due to population growth the number of people in absolute poverty has risen from 214 million to 391 million in the same time period (FAO, 2009).

The challenge of the new biofuel industry is to strengthen support for smallholder farmers to be the engine of agricultural growth and poverty reduction in sub-Saharan Africa.

Most African farmers are subsistence farmers and low agricultural productivity is one of the major problems in poor rural areas. It is hoped that biofuels will stimulate agricultural productivity of smallholder farmers not only for the bioenergy crop but also for food production. In the past, cash crops such as tobacco, tea, cotton, were thought to stimulate agricultural productivity and rural development but they generally failed to do so and rural poverty is increasing. The challenge is to make sure that a more suitable agricultural development model is adopted for growing and processing the new biofuel crops including both smallholder farms and plantations of agrobusineses.

Some African nations have seen substantial developments made in their agricultural sector. Government support (finances and policies), increased mechanization, irrigation, improved seed and fertilizer use are some of the reasons behind the success. The gains in agricultural production are outpaced by population growth with the effect that on average there is less food produced per person.

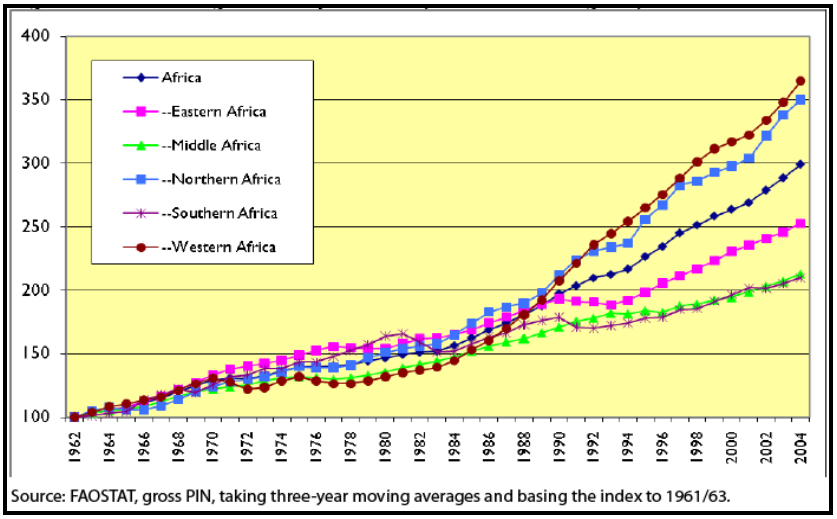


Figure 1: Trend in agricultural production in Africa, 1961/63 to 2003/05 (Wiggins, 2009)

Africa's continued growth in agricultural production is mainly in Western and Northern Africa, with Southern and Middle Africa showing the least progress, well below the average growth rate (see Figure 1). This is particularly disappointing given that a lot of land is available for production in the region; Mozambique for example, only cultivates 10% of its arable land.

This study looks at the opportunities and threats of the old and the new fuels and discusses the circumstances in which wood, charcoal and biofuels can contribute to potential rural development and sustainable livelihoods in three Southern African countries: South Africa, Mozambique and Malawi. The development of biofuels in Africa should not only fill the cars in the industrialised world but should primarily alleviate energy poverty in the country where the feedstock is grown.

In Southern Africa traditional biomass is still the most common energy source and electrification rates are relatively low and range from 9 to 45% (UNDP and WHO, 2009). The exception is South Africa, the economically most powerful country in the region, where electricity and fossil fuels are the major energy sources and about 80% of households have access to electricity (Statssa, 2007).

The agricultural bioenergy potential varies greatly in the region. Namibia, Botswana and South Africa include deserts or large arid regions or parts where rainfall is too low for biofuel crops, while countries such as Zambia, Malawi, Mozambique and the eastern part of South Africa have good agro-climatic potential for them.

The livelihoods of many poor people depend on woodland resources – primarily fuelwood but also other products such as timber, fruit, fodder, medicines, honey, meat and mushrooms. Changing the land-use from woodlands to growing biofuels would deprive poor people of access to traditional food, medicine and other resources.

Given continuing fuelwood use, there is growing concern about the sustainable harvesting of trees and shrubs for fuel. Production of commercial biofuels for transport is still limited in the region. This is about to change as many Southern African countries are planning to grow feedstock and produce biofuels such as ethanol and biodiesel.

The priorities for investing in biofuels are different for industrialised countries and developing countries. While all countries emphasise energy security, industrialised countries prioritise GHG emissions. Agricultural development, job creation and export earnings are far more important than GHG savings for developing countries. Foreign investment in biofuels in Africa is motivated by GHG savings and encouraged for example by the EU biofuel policy which stipulates that 10% of transport fuels must come from biofuels by 2020. There is insufficient land in the EU to grow the necessary amount of biofuels and maintain food crop levels and this drives the investment for growing biofuels in Africa where there is more land and the tropical and subtropical climate is particularly suitable.

Many countries in Southern Africa have large potential for growing biofuel feedstock. Angola, Mozambique, Zambia and Tanzania have low population densities and have favourable soils and climate. So far commercial biofuel production in the region is limited, however. This is about to change as many Southern African countries are planning and have started to grow feedstock with the intention of producing ethanol from mainly sugarcane and biodiesel from Jatropha. Coastal countries such as Mozambique will expand coconut plantations from which they have traditionally exported vegetable oil. There is some concern that African countries will produce and export raw oils and it is important that more steps in the biofuels value chain are localised to add value and to create more jobs.

Sustainability issues of the bioenergy sector have attracted widespread attention in the last years. COMPETE (Competence Platform on Energy Crop and Agroforestry Systems) has published a Declaration on Sustainable Bioenergy for Africa (Janssen, 2009) addressing the opportunities and challenges of bioenergy development from an African perspective. The emphasis is on local sustainable rural development, increasing energy access and income generation and safeguarding land ownership under local land tenure systems. The need for capacity building of decision makers, farmers, extension services, technicians, scientists and researchers is underlined.

Another concern is the food versus fuel issue. The early 2008 rise in global food prices was partially due to the diversion of food to biofuels and raised the public debate on fuel versus food. Since 2005 more studies had been published on the GHG reduction benefits particularly regarding the impact when land use changes from food to energy crops. When all the GHG emissions are included and counted the GHG balance was found to be much less favourable than generally claimed in most biofuel production chains and was neutral or even negative for some biofuel crops.

Three countries, South Africa, Mozambique and Malawi, have been selected for the present study because they are taking different approaches to bioenergy and biofuels in particular. South Africa has developed a biofuels industrial strategy (DME, 2007) including clear social objectives addressing rural poverty and development and this is supported by policies with similar objectives in agriculture and land redistribution. Mozambique has published a biofuels strategy (Republica de Mozambique, 2009) evaluating both plantation and smallholder farming and production activities with the objective to reduce dependency on imported fossil fuels and promote rural development by investing in biofuels. In Malawi, bioethanol development is far ahead of other countries in the region and private companies have produced bioethanol from sugarcane from 1982, since when petrol was blended with 10 percent ehanol. The country has considerable experience in ethanol generation and is now investigating the feasibility of using 100% ethanol for cars. The three countries would compete in the domestic, regional and international biofuel markets. A brief overview of selected indicators in these countries is given in Table 1.

Table 1: Comparative overview of development indicators in South Africa, Mozambique and Malawi *(World Bank, 2009a)*

	South Africa	*Mozambique*	*Malawi*
Population 2007	48	21	14
GNI per capita Atlas $ 2007	5720	330	250
PPP $ 2007	9450	730	760
Life expectancy at birth years 2007	50	42	48
Primary school completion rate % of relevant age 2007	92	46	55
Access to improved water source % 2006	92	42	76
Carbon dioxide emissions per capita metric tonnes 2005	8.7	0.1	0.1
Total debt service % of export 2007	5.9	1.3	..
Internet users per 100 people 2007	8.3	0.9	1.0

2. South Africa

South Africa has limited agricultural land and water resources. Only 14% is arable and about 10% of this land is under irrigation, using 60% of the national water supply. The country has a well developed commercial agricultural sector but smallholder farming in historically disadvantaged areas was neglected during the apartheid era. Since the democratic elections in 1994 changes in agricultural and land policy are addressing the inequality of the past and the policy objective is poverty alleviation and sustainable development. In the last ten years South Africa has become a net food importer.

2.1 Bioenergy resources

Fuelwood is the most widely used solid bioenergy resource available to the poor, particularly to the rural poor, and 20% of the population use it (Statssa, 2007). The major biofuel crops expected to be grown for energy purposes are sugarcane, maize, soya beans, sorghum, canola and sugar beet. The Biofuels Industrial Strategy proposes sugarcane and sugar beet for ethanol production and sunflower, canola and soya beans for biodiesel. Due to food security concerns maize, a staple food crop is excluded for ethanol production in the first five years of the Biofuels Industrial Strategy (DME 2007).

Woodfuel

Fuelwood has received long and in-depth attention, starting with the fuelwood gap theory in the 1970s assuming that fuelwood would be depleted much faster than it could regrow, leading to critical forest degradation. The acute fuelwood crisis did not happen because the harvesting patterns were overestimated and households increasingly added kerosene, gas and electricity to their energy portfolios, reducing the use of fuelwood. But there is a slow and gradual depletion of fuelwood resources in many parts of Southern Africa and this is largely due to commercialization of fuelwood and charcoal.

In South Africa only about 23% of indigenous woodlands remain, while 40% of the land surface could potentially be natural woodlands but have been converted to other land uses such as agriculture, urbanisation, industrial sites and roads (Thompson, 1999). Forests cover only about 0.3% of the land surface (DWAF, 1997) and they are generally well protected and are mostly found on state land or in protected areas (Von Maltitz, 1999).

There are a number of studies on fuelwood use and harvesting and the potential threat of overharvesting fuelwood resources poses serious challenges to sustainable woodland management. Shackleton et al (2004a and 2004b) assess the opportunities and constraints of fuelwood use for poverty alleviation. Nationally the use of wood for cooking has declined from 27% in 1996 to 20% in 2007 (Statssa, 2007). Charcoal – quite common in urban Malawi and Mozambique - is hardly ever used for cooking in South Africa.

Land resources for biofuels

In comparison to other Southern African countries South Africa could just meet blending targets of 4.5% (National Biofuels Task Team (NBTT), 2006) while other countries with lower population densities, more suitable land and climate could not only produce biofuels for domestic consumption but also for export (Von Maltitz & Brent, 2008). Table 3 gives approximate estimates of the land required to meet a 5% (2% for South Africa) biofuels targets for South Africa compared to other Southern African countries.

Table 2: Approximate estimates of the extent of land needed to meet 5% (2% for South Africa), biofuel targets, and total fuel needs based on 2005 petrol and diesel consumption
(from Von Maltitz et al 2008)

	Botswana	*Namibia*	*Tanzania*	*South Africa*	*Mozam-bique*	*Malawi*	*Zambia*
Diesel use per Country per year (IEA 2005) in million litres per year	281	445	667	7 987	381	140	327

	Botswana	*Namibia*	*Tanzania*	*South Africa*	*Mozam-bique*	*Malawi*	*Zambia*
Petrol use per country per year (IEA 2005) in million litres per year	301	325	202	10 289	107	90	210
% of total land area needed to fully meet total transport fuel needs[1]	0.9	0.9	1.2	14.6	0.8	2.3	0.8
% of arable land needed to fully meet transport fuel needs				120	4	4	4
% of available arable land needed to meet total transport fuel needs				589	5	48	6
Land area needed to meet biofuel target s in ha	26 078	38 917		307 375	30 631	13 464	56 286
Estimates of jobs created to meet biofuel targets[2,3]	12 251	18 608	26 399	142 919	15 036	6 261	27 046
Estimates of jobs created to meet total national fuel needs	245 028	372 160	527 980	n/a	300 712	115 802	270 458

There have been plans to develop a soya biodiesel plant in South Africa but Sasol seem to have received insufficient government support and the plan is shelved for now (Bridge, 2004).

Biodiesel from used vegetable oil is being produced and sold from a number of small plants.

Although Eskom supplies most electricity in South Africa, some municipalities are exploring to diversify their energy portfolios and increasingly look at green energy. The City of Cape Town sees itself in the forefront of renewable energy and is exploring the use and application of bioenergy and biodiesel activities (Wilson et al, 2005).

2.2 Use of bioenergy

South African households are switching from traditional energy sources to electricity. Household use of fuelwood declined from 27% in 1996 to 20% in 2007, while animal dung declined from 0.9 to 0.2% (Statssa, 2007). Paraffin was also used less. Electricity use for lighting went up from 58% in 1996 to 80% in 2007 (Statssa, 2007) reflecting a successful national electrification programme. In the same time period, households' electricity use for cooking rose from 45% in 1996 to 59% in 2007 (Figure 2).

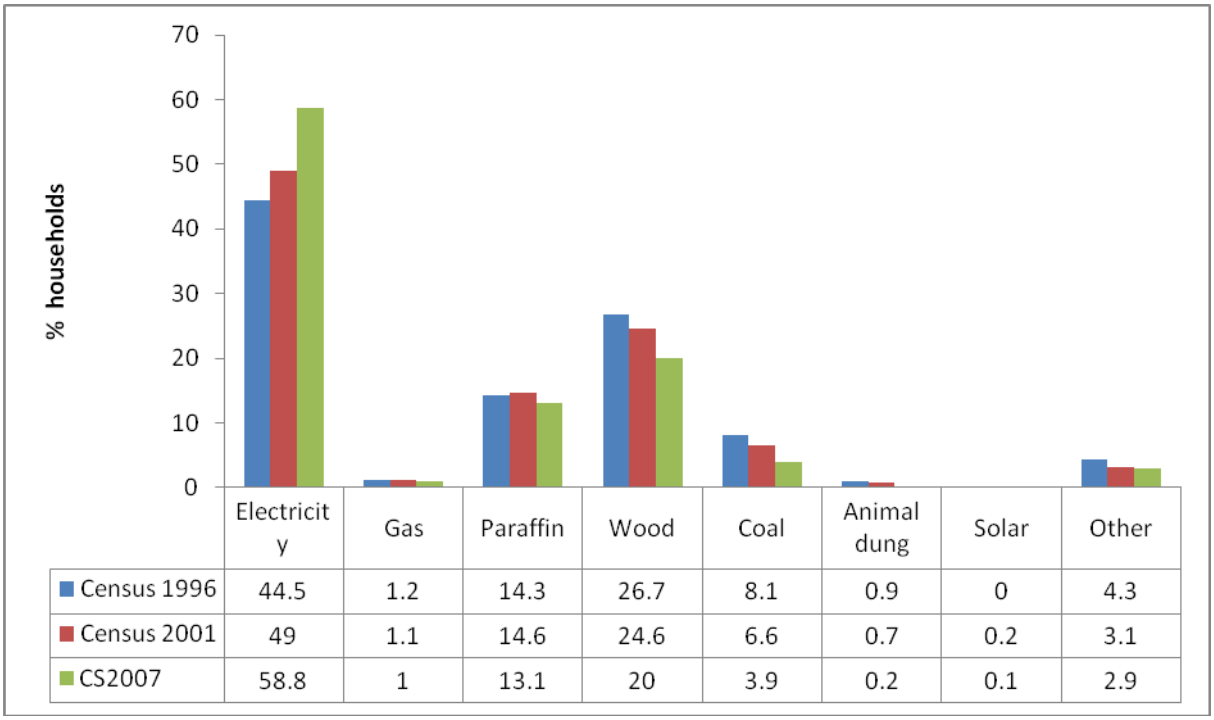
Although poor households have access to electricity they can only use it for lighting and TV. About 80 percent of the population in rural areas still depend on fuelwood as their primary energy source

[1] All calculations based on the production values from the biofuel yield in l/ha from Von Maltitz et al (2008), using sugarcane and Jatropha as feedstock. These values are therefore not linked to specific country level growth conditions and assume suitable land is available.

[2] It is very difficult to estimate total job creation as there are many unknowns, especially for Jatropha. The figures are based on 0.5 job per ha for biodiesel and 0.33 job per ha for sugarcane. Most of the jobs would be low paying labourers' jobs.

[3] These estimates are substantially higher than the 25 000 given in the South African biofuels strategy and Von Maltitz et 2008 attribute the difference to the fact that South Africa uses mechanized farming and that annual crops rather than Jatropha are being proposed i.e.; more capital, fertilizer and fossil fuel but less labour intensive.

(Damm and Triebel, 2008). It is estimated that over two million households concentrated in the poorer provinces Limpopo, KwaZulu Natal, Eastern Cape and North West, are depending on fuelwood for cooking, water heating and space heating.



	Electricity	Gas	Paraffin	Wood	Coal	Animal dung	Solar	Other
Census 1996	44.5	1.2	14.3	26.7	8.1	0.9	0	4.3
Census 2001	49	1.1	14.6	24.6	6.6	0.7	0.2	3.1
CS2007	58.8	1	13.1	20	3.9	0.2	0.1	2.9

Figure 2: Percentage of households using different energy sources for cooking
(Statssa, 2007)

2.3 Review of bioenergy policies

Biofuels do not yet compete with fossil fuels in the market and still need policy support to make them economically viable. Policy can play a major role supporting biofuels that have proven benefits for society and the environment. The biofuel development in Brazil demonstrates that if the right biofuels and policies are selected they can substantially contribute to addressing present and future challenges in energy, environment, food and poverty alleviation. The policy support to biofuels as substitutes for fossil fuel should be given only when they make a positive impact on four important objectives: energy security, greenhouse gas emissions, biodiversity and the sustainability of food supply (Tilman, 2009). In developing countries poverty alleviation is an important additional criterion. For countries with a large proportion of poor people it is an objective at least on a par with energy security.

At the international level biofuel policies in the USA and the EU influence land-use change in developing countries where large areas of unused land and cheap labour are assumed to be available for growing biofuels. In addition many biofuel crops grow better and faster in tropical and subtropical countries than in the industrialised colder countries of the north. Developing countries in Southern Africa with the exception of South Africa have relatively small internal markets for biofuels (Tables 8 and 9) and would grow and process crops for the international market.

At the regional level the Southern African Development Community (SADC) is supporting biofuels development and markets at the regional level (SADC, 2005).

Energy policies in South Africa

The preparation of the renewable energy policy (DME 2003) was preceded by studies on the potential of renewable energy resources and the feasibility of renewable energy generation. The study assessed the impact on GDP, income of low-income households and employment (Table 2).

The largest energy contribution of over 5000 GWh is estimated to come from sugar bagasse. It would also contribute most to the income of poor households and create the highest number of jobs.

Table 3: Macroeconomic impact of renewable energy technologies on GDP, low-income households and employment
(DME 2004)

Resource categories	*GWh*	*GDP (R millions)*	*Low-income households income (R millions)*	*Labour requirement numbers*
Hydro: Large-refurbishment	273	123	16	430
Hydro: Large-inter-basin transfer	526	305	38	1 407
Hydro: Large-ROR-LH	310	180	23	961
Biomass Pulp and paper: Mill 1	65	28	4	76
Biomass Pulp and paper: Mill 2	39	20	3	80
Landfill gas: Micro	191	96	12	443
Landfill gas: Small	160	67	9	237
Landfill gas: Medium	215	89	12	306
Landfill gas: Large	32	13	2	43
Sugar bagasse: Reduced process steam	570	301	39	1 209
Sugar bagasse: Including high pressure boilers	1 483	897	113	3 894
Sugar bagasse: Including tops & trash	3 795	1 840	240	20 214
SWH Residential – High income households	930	578	73	2 589
SWH Commercial – Office & banking space	224	119	15	449
SWH Commercial – Hospitals	267	154	20	646
SWH Commercial – Hostels – Education	581	336	43	1 405
SWH Commercial – Security services	339	196	25	820
Total	**10 000**	**5 342**	**687**	**35 209**

Meyer et al (2008) have modeled the economic feasibility of biofuel production in South Africa and developed different scenarios for the period 2007 to 2015 and concluded that Government support for the local biofuel industry is essential in the early stages of development.

Developing countries such as South Africa face the dual challenge of pursuing economic growth and environmental protection. In South Africa easily accessible local coal reserves dominate energy supply and government support is required to assist generating and disseminating renewable energy.

The government has introduced policies and strategies to support renewable energy, as shown in Table 4, and this support has gradually grown over the years. The REFIT supports a market mechanism to stimulate the renewable energy industry in South Africa to contribute towards the renewable energy target of 10 000GWh by 2013.

Table 4: Relevant renewable energy policies and strategies in South Africa

Author	*Name of policy*	*Objectives related to bioenergy*
DME (1998)	White Paper on the Energy Policy of the Republic of South Africa	Provide support for small- and large-scale applications of renewable energy; promote the development and implementation of standards and codes of practice

DME (2003)	White Paper on the Renewable Energy Policy of South Africa	Additional 10 000 GWh of renewable energy contribution (3% of total) to final energy consumption mainly from biomass, solar and small-scale hydro by 2013.
DME (2007)	Biofuels Industrial Strategy of the Republic of South Africa	Supports biofuel for social development and poverty alleviation
NERSA (2009)	Renewable Energy Feed-in Tariff (REFIT) Phase I and II	Subsidises a feed-in tariff into the national grid for different renewable energy sources

The White Paper on Renewable Energy (DME, 2003) set the renewable energy target to be cumulative 10 000 GWh of final energy consumption by 2013. The major sources are biomass, solar and small-scale hydro. The White Paper also proposed the production of bioethanol and biodiesel for the transport sector. Of particular interest to the GNESD bioenergy study is the Biofuels Industrial Strategy (DME 2007). It seeks to stimulate rural development and reduce poverty in previously disadvantaged areas. The strategy targets to act as a bridge between the first and the second economies and to create jobs in underdeveloped areas where agricultural development was neglected in the past. It aims at a balanced development between emerging farmers and established commercial farming areas to ensure sustainable development for the biofuels industry. Biofuels development would transform rural economies and contribute to the government's Accelerated Growth Initiative (AsgiSA) as well as contribute toward renewable energy goals, energy security and GHG emissions. The strategy intends to achieve a 2% biofuel contribution to the national liquid fuel supply within five years. The proposed crops are sugarcane and sugar beet for bioethanol and sunflower, canola and soya beans for biodiesel. At this relatively low target land availability is not of major concern because 5% of the national diesel demand could be generated from underutilised land in the former homelands. Food security concerns exclude staple food such as maize. Jatropha, an alien species, is excluded under the policy. This strategy appears to be overoptimistic in expecting the emerging farmers to produce 400 million litres of biofuels within the next five years from an almost zero starting base. If the experience of the Land Reform and Redistribution Programme is anything to go by, training the new landowners to become productive framers takes much longer than generally thought. Brazil reported similar experiences in their social biodiesel programme. So far the emerging farmers have not taken up growing feedstock for biofuels.

Commercial farmers do not benefit from the subsidies announced in the first phase (five years) of the biofuels strategy. Commercial farmers also opposed the exclusion of maize for biofuel production. They argued that they could produce 14 million tonnes of maize on average per year exceeding South Africa's annual maize demand of 9 million tonnes by 5 million tonnes. The surplus would then be available for biofuel production and would at the same time stabilize national maize prices.

A criticism directed at the strategy is that the framework is so vague that investors cannot take a decision and feel discouraged to make any investment. According to the Central Energy Fund (CEF) the finer details of the strategy are currently under review.

The National Energy Regulator of South Africa (NERSA) published the Renewable Energy Feed-in tariff (REFIT) Phase I (NERSA, 2009a) in March 2009 and its objective is to promote socio-economic and environmentally sustainable growth, to stimulate the renewable energy market and to support the national target of 10 000 MW of renewable energy by 2013. In the first phase REFIT I proposed low tariff rates which were guaranteed for only 15 years, which is too short for the lifespan of renewable energy capital investment. After a public consultation process of REFIT I and REFIT II, NERSA published a revised REFIT Phase II (NERSA, 2009b). There were substantial changes in the revised REFIT. The tariffs for most technologies were raised (Table 5) and these tariffs are now guaranteed for 20 years.

The REFIT guarantees the price that covers the cost of generation and reasonable profit for electricity supply. Different technologies attract different tariffs (see Table 5). They should be set to provide a reasonable return on investment and they should be long term so that investors can make decisions covering approximately the life time of the technology. So far, no power purchasing agreements under the REFIT have been concluded

Table 5: REFIT Phase I and Phase II
(NERSA, 2009b)

Technology	*REFIT I (R/kWh)*	*REFIT II (R/kWh)*
Concentrated Solar Power (CSP) trough without storage	-	3.14
Large scale grid connected PV systems (>_ 1MW)	-	3.94
Biomass solid	-	1.18
Biogas	0.90	0.96
CSP Tower with storage of 6 hrs per day	2.10	2.31
Wind	1.25	-
Small hydro	0.94	-

The bioenergy sources included in the REFIT are biogas and solid biomass. But biogas from landfills is excluded because anaerobic digestion occurs naturally in landfills and REFIT only supports power plants fuelled by biogas produced in dedicated anaerobic digester systems (NERSA, 2009b). Biomass based entirely on forest wood, plants and residues from agriculture and trees isincluded. The tariff also covers electricity generation from solid fuel (pellets and briquettes) based on the processing of municipal waste. Sugar bagasse, pulp and paper and other mill waste are excluded from REFIT II because they use 'waste products and fuels obtained as an output from industrial processes as a primary source to generate electricity' (NERSA, 2009b).

Eskom will be the sole buyer of electricity under REFIT and is responsible for distributing it. But Eskom has no obligation to buy the REFIT electricity, which reduces the investment security of renewable energy developers (Pegels, 2009).

Agriculture and land policies
There are a number of land and agriculture policies and programmes (seeTable 6) supporting the objectives of reducing poverty and inequality in rural areas and promoting agricultural production in disadvantaged communities. The Land and Agrarian Reform Project and the Comprehensive Agricultural Support Programme are expected to work in synergy with the Biofuels Industrial Strategy to open the opportunities in the new biofuels sector to small and emerging farmers. Agricultural growth is expected to create rural employment and widen enterprise ownership.

Table 6: South African Department of Agriculture policies

Name of policy	*Objectives related to BIoenergy*
Comprehensive Agricultural Support Programme	To support agricultural production by previously disadvantaged farmers
Land Reform and Restitution Programme	To redistribute land to the original owners who were disposed under the racial policies of the previous regimes
Programme for small and emerging farmers	Stimulate agriculture among small and emerging farmers
Water Allocation Reform	To develop fair water allocation to all consumers
Grain Strategy	

Subsidies for agricultural production are generally low in South Africa as compared to industrialised countries (Figure 3). Only four products attract more than 5% producer support. Of these, maize,

milk and sheepmeat are staple foods of the poor and the subsidies are intended to keep their costs down. Sugarcane gets the highest support (28%).

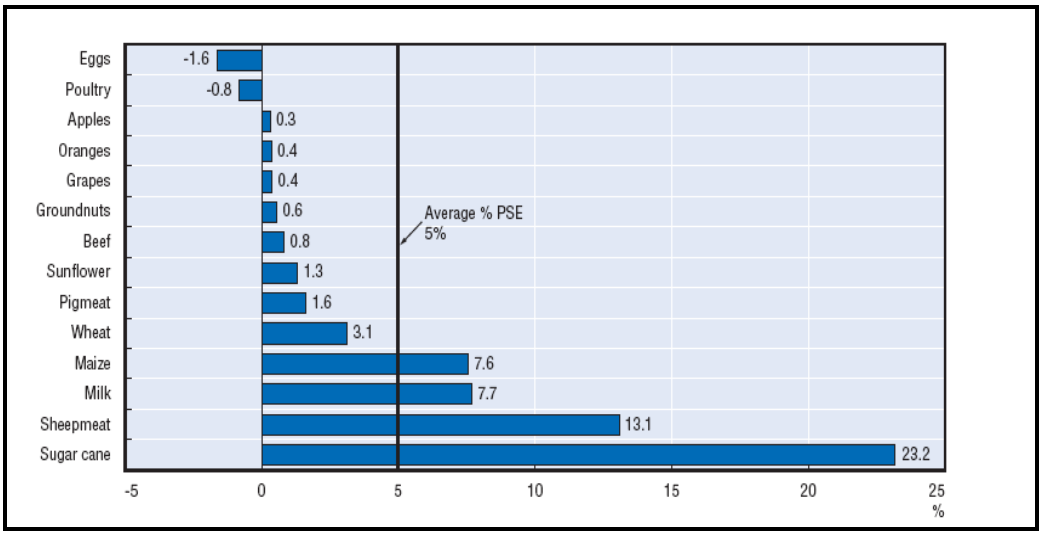


Figure 3: South African producer support estimates by product, 2000-2003 average *(OECD, 2006)*

Forestry policies

About 80% of the rural poor use fuelwood for their household energy needs. The gross national value of fuelwood use is estimated to be R3 billion a year and the value to a household using fuelwood is just under R2000 a year (Shackleton, et al, 2004a).

Comparably to programmes in the energy and agricultural sectors, the Department of Water Affairs and Forestry (DWAF) approved and implemented policies, strategies and programmes to provide that disadvantaged rural people share in the ownership and benefits of these natural resources (see Table 7). They strongly focus on social, economic and ecological challenges.

Table 7: Forestry policies, strategies a and programmes in South Africa
DWAF (2005)

	Focus areas (goals)		
	Social	*Economic*	*Ecological*
State Forest Transfers and Forestry related Land Reform	x	x	
Community Forest Management (woodlands, small indigenous forests and woodlots)	x	x	x
Participatory Forest Management (public and private forests)	x	x	x
Forestry Enterprise Development	x	x	
Broad-based Black Economic Empowerment in the Forestry Sector	x	x	
Forests Products Innovation	x	x	x
HIV/AIDS in the Forestry Sector	x	x	
Fuelwood Energy (carbon-neutral energy production)	x		x
Management of Ecological Services (climate change, soil and water conservation)		x	x
Forest protected Area System Planning (integrated conservation planning and forestry biodiversity hotspots)			x

2.4 Bioenergy markets

The markets for fuelwood, charcoal and biofuels are by the nature of the fuel very different. Transport costs generally limit the distances at which woodfuels can be sold. Fuelwood cannot be

economically sold beyond a radius of about 100 km, charcoal for cooking is sold farther away to places of about 300 km, while liquid biofuels are transported in tankers across the world. Global biofuel demand has a major impact on local biofuel feedstock production.

Fuelwood

In South Africa about 13 million m^3 of fuelwood (9.8 million tons dry mass) are used annually ranging from 0.6 to 7.7 tonnes per household per year, with a mean around 687 kg per person per year and a gross use value per household per month of approximately R165. This would amount to about R3 billion use value per year when considering the 1.53 million rural households in the woodlands (Shackleton, et al, 2004a). It is very difficult to assess how much of the fuelwood is sold and how much is self collected for family use. In South Africa charcoal is not commonly used for household thermal uses.

Biofuels

South Africa is the largest market in the region. The Biofuels Industrial Strategy targets a national penetration level of biofuels amounting to 400 million litres per annum. It is unlikely that South Africa will be exporting biofuels because of limited agricultural land resources.

For regional comparison Tables 8 and 9 give the consumption and production of bioethanol and biodiesel in South Africa Malawi, Zambia, Zimbabwe and Botswana. The projected consumption demand for 2010-2015 is about 300 million litres for South Africa and the projected production is slightly less (Econergy, 2008). Consumption and production for biodiesel are estimated to be approximately the same. A biodiesel demand of about 110 million litres is projected for Malawi, Zambia, Zimbabwe and Botswana for 2010-2015 (Econergy, 2008).

Table 8: Southern African ethanol markets 2006 and projected 2010-2015[4]
(Econergy 2008)

Ethanol 2006 (millions of litres)	*Total consumption*	*Total production*	*Balance*
South Africa	0	0	0
Malawi, Zambia, Zimbabwe, Botswana	18	18	0
Ethanol 2010-2015 (millions of litres)	*Projected demand*	*Projected production capacity*	*Projected balance*
South Africa	280-330	250-300	30
Malawi, Zambia, Zimbabwe, Botswana	105-120	105-120	0

Table 9: Southern African biodiesel markets 2006 and projected 2010-2015[5]
Econergy (2008)

Biodiesel 2006 (millions of litres)	*Total consumption*	*Total production*	*Balance*
South Africa	0	0	0
Malawi, Zambia, Zimbabwe, Botswana	18	18	0
Biodiesel 2010-2015 (millions of litres)	*Projected demand*	*Projected production capacity*	*Projected balance*
South Africa	280-330	250-300	30
Malawi, Zambia, Zimbabwe, Botswana	105-120	105-120	0

[4] Assuming an 8% fuels standard and adequate response in supply.

[5] Assuming a 2% fuels standard and adequate response in supply.

The Southern African Development Community (SADC) Free Trade Area (FTA) came into effect in January 2008 and 85% of all goods including biofuels are trading at zero tariffs. The remaining 15%, mostly fresh food, will have tariff barriers gradually removed by 2012. The FTA will support a regional biofuels market. A certificate indicating that products originate in SADC countries is required for custom duties exemption.

Biofuels investment in Southern Africa will also depend on policies in the EU and the USA and the change in these policies will have an impact on demand from these regions. The changing EU biofuel policies are an example. The EU Biofuel Directive of 2003 set indicative targets for the transport sector at 2% by energy content for 2005, and 5.75% for 2010. Only three out of 25 member states (Austria, Germany and Sweden) reached the 2005 target (see Figure 4). Despite the lack of success of the 2003 policy the EU agreed on a 10% binding target for renewable energy in the transport sector as part of an overall 20% renewable energy target by 2020. The relevant Renewable Energy Directive (2009/28) entered into force on 25 June 2009.

However the target no longer specified that the 10% of renewables in the transport sector have to come from biofuels but can also be from other renewables – allowing for contributions such as electric cars or renewable electricity in railways. This will reduce the demand for biofuels on the global market. As a measure to promote electric vehicles the renewable energy used in these cars will count 2.5 times towards the target. Some countries (Denmark, France, Ireland, Sweden, UK) have already launched plans to follow the electric car route (European Environmental Bureau, 2009).

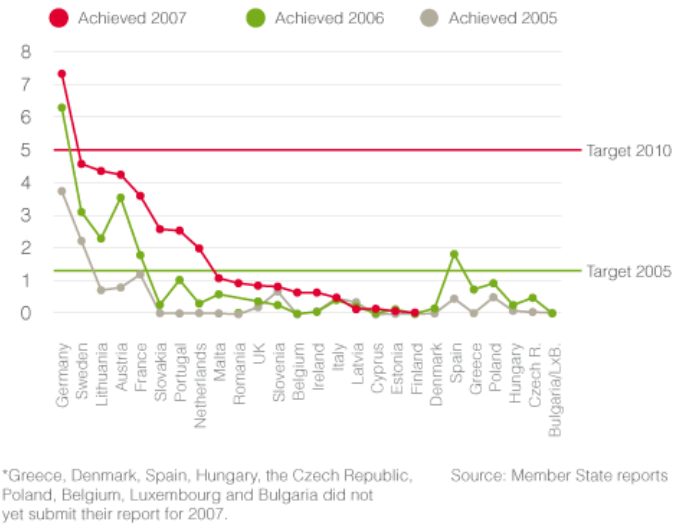


Figure 4: EU biofuel targets achieved by member states in 2005, 2006 and 2007
(European Bioethanol Fuel Association, 2009)

Barriers

There are various barriers to a role for bioenergy in rural development and poverty alleviation.

1. The biofuels industrial strategy does not support the commercial sector to produce biofuels but restricts its support to mainly former homelands and historically disadvantaged communities.
2. The food vs fuel issue: Maize is excluded for biofuel generation but this can have a negative impact on price stability for South African large-scale maize farmers.
3. Agricultural subsidies in developed countries make the biofuel production cost not competitive with biofuels produced in the USA or EU.

4. Tariffs on imported biofuels in the EU and USA are a major barrier to market entry for countries such as South Africa. Imports from LDCs such as Malawi and Mozambique are exempted from import tariffs.
5. South Africa has scarce water resources, limiting the type and amount of crops to be grown for biofuels.
6. Access to and sustainability of fuelwood is of concern because it continues to be a major energy source for the rural poor.

2.5 Major bioenergy programmes in South Africa

Ethanol
Sugar companies produce ethanol from sugarcane on a limited scale for end uses such as alcohol, but not for fuel. Expansion into ethanol for biofuels would require very large investments but the market for such large amounts of ethanol does not yet exist locally and without substantial subsidies South African producers may not be able to compete with the subsidised USA producers and the more cheaply produced bioethanol from Brazil.

Biodiesel
There are small plants in operation using predominantly waste vegetable oil. Some farmers also produce biodiesel from sunflower seeds for their own on-farm use. Sasol had planned a generation plant for biodiesel from soya beans but this project did not go ahead due, it appears, to insufficient support from government.

Gelfuel
Gelfuel was originally marketed as a cooking fuel for camping and outdoor activities. It consists of over 80% ethanol which is produced from sugar beet and bagasse. It is now being promoted as a safe alternative cooking fuel to kerosene in poor communities because it is less inflammable and doesn't spread as quickly as kerosene and thus is expected to reduce fires in poor urban townships.

Working for Energy
This innovative government project is part of the Expanded Public Works Programme, focusing on renewable energy and energy efficiency and creating green jobs supporting development and climate. Skills learned in the Working for Energy Programme are expected to lead to permanent and sustainable jobs. Working for Energy is to supply additional energy through labour-intensive activities. The following are biomass-related activities (Batte, 2009):

- biomass from invasive alien plants and bush encroachment for heat and power generation;
- biogas generation from farm waste;
- biogas generation from municipal solid waste;
- biogas generation from municipal waste water; and
- biogas from household waste.

The programme started work in 2010.

3. Mozambique

3.1 Introduction

Mozambique is one of the poorest countries in the world with a HDI of 0.402 giving the country a ranking of 172 out of 182 countries (UNDP, 2009). About 80% of the labour in Mozambique is employed in the agriculture sector which contributes 25% to GDP and 16% to exports. The Poverty Reduction Strategy suggests that economic growth should be rapid and must be broad-based to include the poor. The economic growth rate for 2001–2010 is expected to be 8% - the highest in Africa. The priority areas are education, health, agriculture, rural development, good governance and sound macroeconomic and financial management.

Many poor Mozambican farmers are particularly vulnerable to the impacts of climate change. Severe droughts and floods create food insecurity. If land use is changed from food to fuel crops these farmers will become more vulnerable to hunger and high food prices. Also, many rural people gather non-fuel products from common property resources such as forests and woodlands which are being converted to biofuel plantations. The loss of these resources will be difficult to compensate for.

Mozambique is potentially an energy-rich country and it already exports hydroelectricity and natural gas to its neighbours. About 20% of the population has access to electricity.

3.2 Review of bioenergy policies

Bioenergy policies in developing countries cannot be looked at in isolation but have to be compared to biofuel policies and targets in developed countries. It is expected that Mozambique and Malawi with small internal markets will look for export markets for their planned biofuel production and the biofuel targets and mandates of other countries such as the EU's and USA's biofuel mandate will influence the amount of land and resources allocated to biofuel production.

Biofuels

The government of Mozambique commissioned a detailed assessment of biofuels in the country focusing on technical, socio-economic and environmental feasibility (Econergy, 2008). The biofuels policy and strategy was published on 21 May 2009 (Republica de Mozambique, 2009). The policy states that the biofuels sector is to contribute to energy security and socio-economically sustainable development. A new National Commission for Biofuels (CNB) will be responsible for the implementation of the biofuel strategy and a National Programme for Biofuel Development will provide financial support for biofuel activities and projects. The objectives of policy are (Mataveia, 2009);

- to reduce dependency on imported fuels;
- to stimulate the sustainable local energy resource use to substitute or complement imported fossil fuels;
- to promote rural development through investment in biofuels;
- to reduce the fuel cost to the final consumer without creating other financial impacts like subsidies; and
- to protect economic development against the high volatility of fuel prices and energy insecurity.

The policy is inclusive and creates business opportunities for private investors and communities including small and big producers. The development of the biofuel sector is planned to be gradual and flexible allowing all stakeholders to develop and fostering institutional capacity.

Mandatory blending and the use of flexifuel vehicles will create a local market. Export to the international market is expected. The action plan for biofuels gives three phases of mandatory blending (Mataveia, 2009):

- Pilot phase (2009-2015): Increase the level of blending up to 10% ethanol (E10) and up to 5% biodiesel (B5).
- Operational phase (2015-2021): E10 and B5 will be available nationwide and if possible blending will be increased to E20 and B20.
- Expansion phase (from 2021): Development of parallel distribution network for blending above E25 and B75 aiming at E100 and B100

The Action Plan will define and delimit areas for biofuel projects and land use maps will be drawn. The National Energy Fund will establish a National Biofuels Development Programme (NBDP) to support small-scale producers, infrastructure projects, and research and development for new crops for feedstock

Land and forestry policies

All land in Mozambique is owned by the state and cannot be sold, mortgaged or pledged (Article 46 of the Constitution of Mozambique). Rights of use can be granted to Mozambicans and foreigners for purposes of economic activities for a maximum period of 50 years, renewable for an equal period of time. Only a few percentage of Mozambican farmers have a formal lease for their land and insecurity of tenure can affect poor people's land rights and access to food resources when land is leased to international companies for plantations.

The Forestry and Wildlife Law 10/99 regulates the harvesting of wood for fuel in two ways. The first is a simple licence for harvesting, and the second is a concession licence. The licensing system is poorly implemented and although fuelwood and charcoal account for 92% of total wood removals, the government collected only US$11 000 per year from 1993 to 2000 in licence fees (SEI, 2001). And there appears to be widespread illegal licensing and illegal wood cutting. (This problem is found in many African countries because most poor people depend on the wood and charcoal trade as their only source of income.) Community level management of forest resources appears to be an effective solution if rights and authority are transferred from the government to the community level. Wood cutting and replanting will then be regulated and implemented at the community level.

3.3 Analysis of bioenergy resource availability

Mozambique is considered ideal for biomass production due to its relative abundance of land resources, favourable environmental conditions, and low population density (Batidzirai, 2006).

Fuelwood and charcoal

Forests cover over 51% of Mozambique. As generally in sub-Saharan Africa, wood is the predominant fuel in rural areas and charcoal is more common in urban areas. About 84% of the population relies on wood and charcoal (UNDP and WHO, 2009). Fuelwood harvesting has lead to forest degradation near the major population centres.

Biofuels

The Mozambican Agricultural Research Institute estimates that 6.5–12.2 million ha are available for expanding agricultural production. Local and foreign producers can get long-term renewable leases or concessions (Econergy, 2008). Suitable agricultural land and sufficient water resources are found particularly in the Centre and North of the country where unemployment is high among the rural population. It will be important to integrate smallholder farmers into the emerging biofuel industry. Sugarcane and sweet sorghum are the proposed feedstock for bioethanol and *Jatropha curcas* and coconut for biodiesel (Republica de Mozambique, 2009). The sugarcane industry in addition to producing ethanol can combust bagasse residues from sugarcane processing for heat and electricity (Batidzirai, 2006).

3.4 Bioenergy markets

Biofuels will supply the national market and substitute fossil fuel imports which are a major drain on foreign exchange. Export to industrialised countries will play a major part in the Mozambican biofuel programme. The biofuel markets are changing rapidly and only general statements can be made. The Ministry of Energy estimates the petrol demand to amount to about 123 million litres in 2010 (Econergy, 2008). This amount would rise to 211 million litres by 2015 assuming an 8% annual growth rate in consumption. With blending levels of 10% it would create a domestic market of 12.3 million litres in 2010 rising to 21 million litres in 2015.

Mozambique's biofuel investment strategies aim at exporting biofuels. The export to industrialised countries is driven by local production cost, biofuel targets in these countries, tariff barriers and competition from other countries such as Brazil. At present production costs in Mozambique are higher than those in Brazil which has a long history of biofuel production and is the second largest bioethanol producer after the USA. In the EU a target of 2% of biofuels was set for 2005 and not achieved. The EU Directive 2003/30/EC set an indicative target of 5.75% (based on energy content) biofuels of all transport fuels by 2010. In March 2007 the European Council approved a binding target of 10% biofuels by 2020. The USA has similar targets. Biofuel production in EU and USA is subsidised. Biofuels produced outside the EU and USA carry import duties when entering these countries.

Mozambique is a least developed country (LDC) and the EU exempts all LDCs from import tariffs for everything except arms. This would offset the cheaper production cost in Brazil but not the subsidies to EU and USA producers. The LDC tariff agreements can change and it is important that Mozambique aims to reduce its production costs.

3.5 The potential of bioenergy for rural development, and some major barriers

Introducing biofuels will bring employment and income but could also lead to food insecurity and land appropriation by large companies. The risk can be reduced if biofuel crops are produced on small-scale family farms as well as on large plantations. Supporting smallholders has the potential to raise their traditionally low agricultural productivity. Sustainable production can have a major impact on alleviating rural poverty and can prevent degradation of the natural environment and the exploitation of cheap labour.

Additional biomass potential comes from forestry residues, timber-processing, and agricultural waste (Batidzirai, 2006). However, there are costs associated with the logistics of recovering logging residues from dispersed forests and collecting and processing of agricultural wastes when compared to collection of waste from a timber-processing production site.

The sustainable production of energy crops does not only open rural areas to employment opportunities, but upgrading land and infrastructure while earning foreign currency. There is a myth that marginal land can be utilized for growing jatropha, but it will not bear a good crop in poor circumstances, needing care, good soils, water and fertilisers to produce an economic yield.

3.6 Major bioenergy programmes in Mozambique

Fuelwood and charcoal

There are several ongoing charcoal projects aiming at improving the efficiency and sustainability of charcoal production and charcoal stoves. PorBEC promotes energy efficient cooking technologies to save on fuels and emissions. Woodstoves are promoted in rural areas and the company Ceramica Termica Ltd produces charcoal stoves for the urban market.

Biofuels

Mozambique has a large area of land not used for agricultural production and the agro-climatic conditions are suitable for growing biofuel feedstocks such as sugarcane and Jatropha. There has been considerable interest from investors and the government had received 21 new biofuel production proposals by 2008 (ActionAid, 2008) to increase Jatropha and sugarcane production. The traditional coconut plantations grown since colonial times for vegetable oil are now being extended for biofuel production. Jatropha seedlings are being raised for biodiesel production in several parts of the country.

3.7 Sustainability and social issues

The government has published a Biofuel Policy and Strategy (Republica de Mozambique, 2009). Mozambique is developing biofuels at two levels; plantations with the assistance of foreign investment, and government-supported smallholders. Foreign investment appears to be readily available for developing biofuel plantations. The biofuel policy strikes a balance to attract the necessary finance for plantations and at the same time supports smallholders so that they can participate, increase agricultural productivity and benefit from the biofuel development. The policy states this objective – but implementation is critical. The implementation of the social biodiesel policy and the industrial biofuels strategy in South Africa have shown that the implementation of biofuel policies that support the poor as active participants is generally more complex than initially anticipated. The poor know their local conditions but they generally have no knowledge of modern farming systems, technology and markets. Involving the poor in growing biofuel feedstock and allowing them to benefit from the new crops requires the development of efficient agricultural extension services and infrastructure in rural areas where the poor live.

Large-scale biofuel programmes will have to produce for export because fuel consumption in Mozambique is low. Biofuels produced in Mozambique have to compete in the world market with

subsidised biofuels from the USA and the EU and biofuels from Brazil where production costs are lower than in Mozambique.

The blending targets set out in the biofuels policy will create a market for biofuel production. Smallholder farmers can grow biofuel feedstock as an additional cash crop and benefit from the income they earn. It is expected that the biofuel crops, particularly the new ones like Jatropha, will be distributed by companies or extension services together with other necessary inputs and training. This can enable the subsistence farmers to apply the new methods to their traditional crops and achieve higher yields as the yield of the staple food crop maize is only 0.9 tons per hectare as compared to 1.7 tons per hectare in Malawi and 2.8 tons per hectare in South Africa (based on data from FAOSTAT 2005 and cited in (Econergy, 2008)). Unemployment in rural areas is 13% as compared to 31% in urban areas and the biofuel sector could contribute to alleviating rural unemployment (INE, 2006).

The land issue may become controversial in cases where smallholders lose their land to plantations owned by international companies. Since only a very small minority of farmers have title deeds traditional landownership has to be recognised by all to avoid land disputes.

4. Malawi

Landlocked Malawi is one of the poorest countries in the world with a Human Development Index value of 0.493, and ranking 160 out of 182 countries studied in the recent UNDP Human Development Report (2009). With a little over 13 million people and a land area of 94 000 square kilometres, Malawi is one of the most densely populated Southern African countries (UNSTATS, 2010). The country's poverty reduction strategy, the Malawi Growth and Development Strategy (MGDS), is a five year plan (2006-2011) that covers a number of areas with the aim of increasing prosperity, reducing poverty and assisting to achieve the Millennium Development Goals (IMF, 2007). The MGDS identifies six key priority areas to help achieve economic growth in the country, one of which is energy generation and supply. To support these key priority areas, the MGDs highlights five broad-based thematic areas including sustainable economic growth, social protection, social development, infrastructure development, and improved governance. A second 5-year strategy is being drafted with input from various ministries to evaluate not only progress to date of the 2006-2011 priorities, but to account for changing priorities approved by Cabinet.

Agriculture contributes 35% of Malawi's GDP and 80% of its export earnings (World Bank, 2008) supporting 85% of the population. About three quarters of agricultural production is on smallholder farms and 40% of these cultivate less than 0.5 hectare. Agricultural exports are mainly tobacco, sugar, cotton, tea, cotton, and corn (CIA, 2010).

There is little unused land for biofuel expansion. Similar to other Southern African countries Malawi has been growing and exporting sugar. However Malawi is the only country in the region producing bioethanol for blending with petrol (E10). The country imports all its fossil fuel supplies. Biomass contributes over 95% of primary energy supply in Malawi (ProBEC, n.d.). Electricity, petroleum products, coal, and other forms of energy account for only 7%. Only 6% of households have access to electricity. Fuelwood and charcoal supply most of this demand. Forests cover about a third of Malawi but are declining at a rapid rate due to agricultural expansion, fuelwood use, commercial charcoal production, curing tobacco, brick making and other uses.

Access to food resources will be critical for the poor when large areas of land and particularly woodland from which traditional food resources were harvested are transformed into sugarcane and Jatropha plantations. An estimated 90 000 people depend on making and selling charcoal from the woodland resources. Women who have no or only weak traditional land rights will be adversely affected by these changes. As already indicated for Mozambique, traditional land rights have to be better recognised and respected.

4.1 Review of bioenergy policies

The objective of the MGDS is to 'reduce the number and duration of blackouts, increase access to reliable, affordable electricity in rural areas and other targeted areas, improve coordination and the

balance between the needs for energy and those of other high growth sectors such as tourism and mining' (IMF, 2007).

The Malawi Land Policy (2002), Forestry Policy (1996), the supporting Forest Act (1997), the Energy Policy (2003) cover man-made plantations, woodlots, natural woodlands as well as harvesting, marketing and utilization of wood (GoM, 2003). Biomass (firewood, charcoal, agricultural and industrial wastes) accounts for 95% of the country's total primary energy supply (GoM, 2003).

It is important to note that laws governing land tenure have allocated 80% of land to customary holding in which private ownership of the land and its resources is prohibited. While individual Malawians have certain rights which allow access to wood resources free of charge, wood that is harvested for commercial purposes are issued a 'stumpage fee.' However, enforcement is weak and illegal harvesting does occur (GoM, 2003).

The government has a series of policies to support renewable energy and particularly the provision of biomass energy, as shown in Table 10.

Table 10: Energy policies and programms in Malawi

Author	*Name of Policy or programme*	*Objectives Related to bioenergy*
GoM	National Environmental Policy	Deals with fuelwood, charcoal and biofuels to prevent further degradation of forests and to minimize the dependence on imported oil.
GoM 1999	National Sustainable and Renewable Energy Programme (NSREP)	Promote the use of renewable energy technologies. Umbrella programme for all renewable energy projects implemented by various donor organisations such as UNDP, Danish International development Agency (DANIDA) and Global Environmental facility (GEF).
GoM 2003	National Energy Policy (NEP)	Supporting Malawi's Vision 2020 and Poverty Reduction Strategy. Reforming and improving energy supply industries.
GoM 2006-2011	Malawi growth and development strategy	Increasing prosperity. Reducing poverty and support for achieving the Millenium Development Goals. Six key priority areas including energy generation and supply
ProBEC	Programme for Biomass Energy Conservation (ProBEC)	Investigation of biomass resources their improvement and conservation
GoM and DANIDA	Danish International development Agency(DANIDA)	Study on Assessment of Alternative Energy Sources in Malawi
Gom and DANIDA	DANIDA II	Renewable energy development energy in malawi
ProBEC	Programme for Biomass Energy Conservation	Improved biomass cookstoves

Fuelwood and charcoal

Malawi's forests and woodlands are under severe stress from overharvesting. The government introduced a tree planting bonus scheme providing cash payments as an incentive for farmers to plant trees, but it was costly to administer and had limited impact (Dewees, 1995). Government recently signed an edict empowering the army to arrest people found making charcoal illegally. These measures have been largely ineffective because when charcoal producers are arrested only their charcoal and tools are confiscated. The charcoal producers are poor and, with no other way of making a living, they return to charcoal making. It is argued that if charcoal production is regulated it could become one of the country's major crops, contributing to the economy almost at the same level as tobacco and tea and provide the incentives for reinvestment in the next cycle of harvest and encourage sustainable use of forest resources. 'If charcoal trade was regulated and taxed, government could raise substantial revenues, using the estimated industry worth of K5.78 billion

(US$41.3 million) per year. Value Added Tax (VAT) alone could generate more than K1 billion (US$7 million) annually in revenue" (GoM, 2007).

Biofuels

The government has supported ethanol production and blending since 1982. There is an installed capacity of 18 million litres of which 95% is used for fuel-ethanol blending and 5% for industrial alcohol (GoM, 2003). It is also considering the expansion of sugar plantations for ethanol production. Malawi's Biodiesel Agricultural Association supports biodiesel development. Jatropha is widely encouraged as feedstock for biodiesel, and several projects growing Jatropha are underway. It is grown by both smallholder farmers and on plantations.

4.2 Bioenergy resource availability

Fuelwood and charcoal

While Malawi's dependence on woodfuel has been thought to contribute to the country's deforestation, the 2003 Energy Policy states that both deforestation and environmental degradation are linked to land clearance for agriculture, urbanisation and infrastructural developments. However the major cause of lass of forests is the conversion to farmlands driven by population growth MARGE 2009). From 1983 to 2007 the population grew by 3.3 percent and land under crops grew by 3 percent. Population growth has expanded almost at the same rate as the land area under crops. Unsustainable harvesting of woodfuels is only around the population centres Lilongwe and Blantyre/Zomba (MARGE 2009). The overall national supply can meet the demand but demand is site specific. Unsustainable woodfuel harvesting is found around the population centres Lilongwe and Blantyre/Zomba.

It is expected that in the next 15 years the demand for commercial fuelwood will rise by 39 percent and the demand for charcoal will increase by almost 100 percent.

Biofuels

Malawi produces ethanol from sugarcane and two plants generate 18 million litres of ethanol per year (GoM, 2003). The use of cane juice is being explored. The Ethco-owned Dwanga plant is in the central Lake Malawi region and the other one owned by the local Press Cane Company is at Nchalo in the southern region. They are both located next to sugarcane plantations and sugar factories of the South African sugar group Illovo.

The plants have a capacity of 16 million litres of ethanol each but produce well below capacity because there is not enough molasses available. A higher ethanol percentage in the ethanol-petrol cannot be met due to underproduction of ethanol. The country expects to expand sugarcane plantations, however, so that the two plants can produce to capacity, and is also exploring blending with other petroleum products and producing gelfuel – a cooking fuel to replace imported kerosene (GoM, 2003).

Malawi is encouraging private-sector Jatropha projects to further diversify its overdependence on liquid fuel imports. Biodiesel production from Jatropha was expected to start in 2009 (Chimwala, 2008).

Malawi is expanding soya production and is trying to attract investment for soya cultivation for soya milk, soya oil and other secondary products.

4.3 The potential of bioenergy for rural development and some major barriers

The Government of Malawi recognises that deforestation is not solely an energy issue. The Energy Policy (2003) states that it can only be resolved in a 'development path that alleviates poverty and increases productivity.' It further states that the greatest potential for poverty reduction is to prioritise rural energy interventions and support public-private investment to increase human capability and transform rural economies.

One of the issues relates to the sustainability of fuelwood and forest resources on which over 95 percent of Malawians depend for their primary energy needs. The state owns the forests and because of high rural unemployment the poor cut trees, make charcoal and sell wood and charcoal illegally.

The unplanned and uncontrolled harvesting leads to forest degradation. Community forest management could regulate tree cutting and replanting, introduce more efficient charcoal making and regulate selling. This would create sustainable employment in rural areas, provide charcoal for cooking and stop and reverse forest degradation. With increasing forest degradation and fuelwood scarcity households will spend more time in fuelwood collection and less time on agriculture. The scarcity of fuelwood will also impact on illegal fuelwood harvesting in national parks.

Biofuel expansion could have an impact on forest land and resources. When forest lands are cleared for biofuel plantations the poor lose access to forest food resources and this affects food security. Women have weak or, often, no landrights and harvesting not only fuelwood but also food and other resources from woodlands contributes to their livelihoods. When woodlands are transformed into biofuel plantations it will impact on women's ability to fulfil their household needs.

Lack of modern farm inputs could decrease expected yields of biofuels. This includes energy for productive uses such as irrigation and mechanical implements for harvesting and processing.

4.4 Major bioenergy programmes in Malawi

Fuelwood

Among the many projects trying to find alternative energy sources to fuelwood and charcoal is the government support for the private firm D & S Gel Fuel Limited which is introducing and marketing gel fuel technology for household heating and cooking.

Improved stoves such as Tech and Rocket stoves using charcoal or fuelwood are energy efficiency programmes supported by the ProBEC.

Biofuels

Malawi has grown and processed bioethanol since 1982 and has blended petrol with 10% ethanol. In the last ten years Malawi's ethanol production has grown from 1 million tons to 18 million tons and continues to increase. About 50% is blended with petrol in Malawi and the other 50% is exported to East and Southern Africa. There are also plans to grow sweet sorghum for ethanol feedstock.

There are a number of biodiesel projects based on Jatropha in Malawi. A consortium of Netherlands-based TNT group together with African investors are setting up a 12 million US$ biodiesel production plant in the capital Lilongwe (Chimwala, 2008).

4.5 Sustainability and social issues

Charcoal production is illegal in Malawi but the government has turned a blind eye on the industry on which about 93 000 people depend for employment as producers, bicycle transporters and roadside urban vendors (Government of Malawi, 2007).

The two ethanol companies in Malawi have sold ethanol to petrol companies over the last 28 years. The demand cannot be met due to shortage of bagasse and there are plans to expand the sugarcane plantations to increase the feedstock for bioethanol. Malawi has no fossil fuel resources and the blending programme has reduced import expenditure on fossil fuel for the transport sector.

The ethanol production from sugarcane plantations and small-scale growers has led to employment among the surrounding communities. When plans for expanding the plantations are undertaken it is important that the smallholders are not locked out of the benefits and plantations do not encroach on smallholders' land. Smallholders and plantations are now growing Jatropha trees as feedstock for biodiesel.

5. Conclusions

Bioenergy is the oldest fuel and wood was the first fuel humans used for cooking. Deforestation due to overharvesting started when populations increased and more recently when rural people harvested wood and made charcoal for selling in the cities. Wood harvesting and charcoal-making have become viable though illegal businesses for rural people in Malawi and these people and their families would starve without these businesses. When wood is cut illegally no trees are replanted, leading to the degradation of forest on which woodcutters depend for their livelihood. Decentralised

community management of forest resources in addition to efficient extension services would make forests a sustainable income and employment source for the rural unemployed and in addition create tax revenue for the government.

Low productivity is one of the major problems of smalholder farmers in Southern Africa. It is expected that biofuels will stimulate agricultural productivity of smallholders. The question then arises what has to be done differently so that problems associated with earlier cash crops (such as tobacco, tea and cotton), which were thought to stimulate agricultural productivity and rural development, will not be repeated.

If biofuels are produced on plantations, policies must be in place to guarantee food security for the local people and implementation must also safeguard the access to food and other livelihood resources which many rural poor collect from common property land. Women have weak land rights and when land tenure changes their continuing access to traditional food resources are further weakened and this puts food security for women and children at risk.

So far there is only limited production of biofuels in Southern Africa. Biofuels are expected to supply the national market in South Africa and substitute fossil fuel imports. In Mozambique where there are large land resources and a suitable climate biofuels, they will not only replace imports but also contribute to export earnings. In Malawi they already replace 10 percent of imported petrol.

The Biofuels Industrial Strategy in South Africa has not achieved to stimulate the biofuels industry because it was too restrictive reserving incentives to emerging farmers who did not take to growing biofuels. A re-evaluation of the strategy is required. In Mozambique the biofuels strategy has attracted offers of investment and it is expected that biofuels will contribute significantly to the national economy. In Malawi energy policies do support bioethanol and the growing of Jatropha for biodiesel and it is expected that biodiesel production is about to start.

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