1 Introduction

This report sets out the key renewable energy resources in the Western Cape, and uses available information on the conversion technologies to estimate the potential contribution of these resources to the Western Cape's future energy mix. Cost information is then used to indicate investment requirements, and to provide an indication of the 'cost of energy' associated with the different resource and technology combinations. This allows us to present a number of different scenarios for renewable energy contributions to Western Cape energy mix. Preliminary conclusions are drawn about the scope and shape of the significant opportunity available in the Western Cape for the establishment of renewable energy markets and industries. This contributes to the achievement of goals and targets outlined in the Provincial Sustainable Energy Strategy as well as help shape the development of the Environmental Economy Programme as envisaged by the Department of Environmental Affairs and Development Planning.

Given the short/medium term limits associated with development of a large scale renewable energy industry (and given that some Western Cape renewable energy resources may be 'consumed' outside the borders of the province), to the strategy looks briefly at the options for trading of renewable energy, in order to meet the proposed objectives for a more sustainable energy development path as outlined in the Sustainable Energy Strategy.

The primary approach used in selecting the technology/resource mix is that of developing an explicit portfolio – which seeks, especially in the initial years, to develop experience in a range of technologies and resource management environments, in order to minimise the overall risks associated with the energy supply portfolio. This is not unlike the concept of spreading financial investments across a number of different sectors of the stock exchange. It means that a number of industries and opportunities are nurtured and grow – resulting in a high potential for some of them to emerge as significant regional players.

The Investment Case is organized into the following main sections:

- Key demand scenarios
- Resource Assessments (with brief descriptions of key applicable technology)
- Supply scenarios – taking into account the potential for renewable energy
- Key drivers for renewable energy
- Discussion and Conclusions
- Appendixes provide additional information on renewable energy projects and activities as well as biofuel potential.

2 Demand Assessment Summary

Energy demand in the Western Cape has been discussed in some detail in the report ***Demand Side Scenarios and Energy Efficiency Programme for the Western Cape*** which has been completed as part of the Strategy process (Borchers 2007).

Key results are shown in Figure 1and Figure 2. These scenarios are for the 'reference case'. A number of energy efficiency initiatives are proposed in Borchers (2007). These affect both electricity consumption, and the use of other forms such as oil. In some cases interventions result in an *increase* in electricity consumption, but this allows a much bigger saving elsewhere (e.g. the transport modal shift discussed in Borcher 2007 (as passengers move from using diesel and petrol powered vehicles to electricity powered rail).

Opportunities for renewable energy to contribute are in four main areas:

- Passive solar building design, which (amongst other things) makes use of a range of techniques to harvest solar energy for space heating, maximises use of natural light, and to reduce summer air-conditioning requirements,
- Solar Water heating,
- Renewable energy used to generate electricity,
- Use of biofuels

In the future, it is anticipated that hydrogen or similar fuels could be generated from renewable energy – and this could replace fossil fuels in some of the other non-electrical energy arenas. A number of regional governments from around the world are collaborating on these initiatives but these are regarded as too early stage to account for any significant intervention at this stage.

Aspects of improved building design have been included in the energy efficiency scenarios (inclusion of ceiling insulation), and solar water heaters have been modelled as an energy efficiency measure

It will be noted from the above there are few immediately apparent options to significantly substitute renewable energy use for the very significant coal usage indicated in Figure 2. This challenge will need further work in years to come – informed by a detailed understanding of how and where that energy is used.

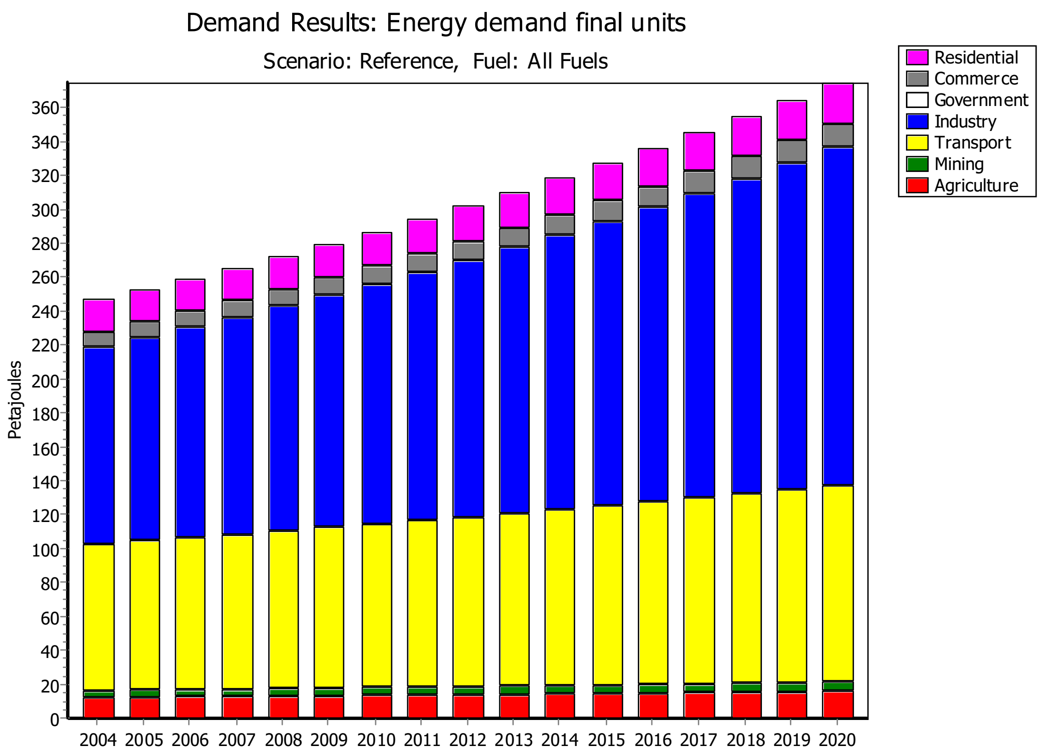

Figure 1 Energy Demand by Sector - reference scenario (see Borchers 2007 for further detail)

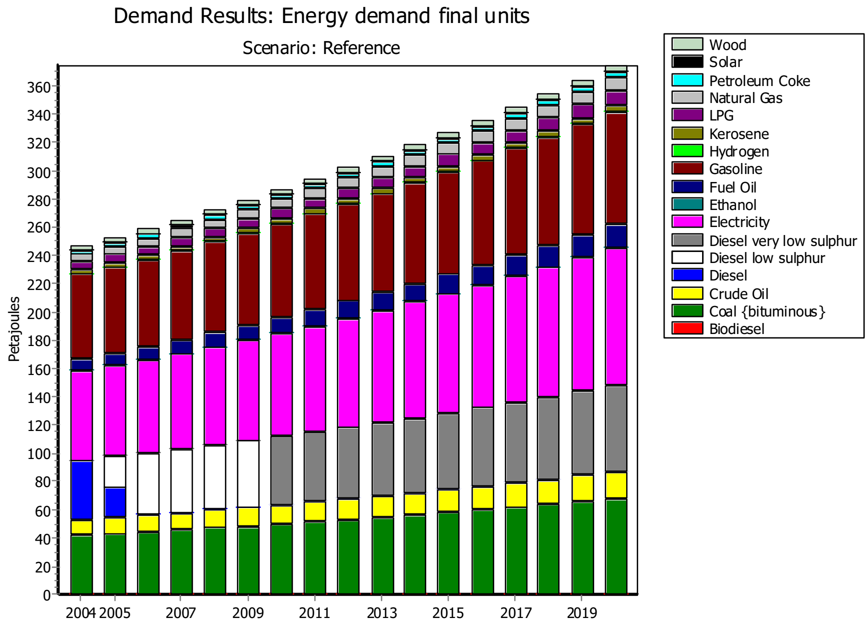

Figure 2 Energy demand by fuel type (Reference Scenario: See Borchers 2007 for further detail)

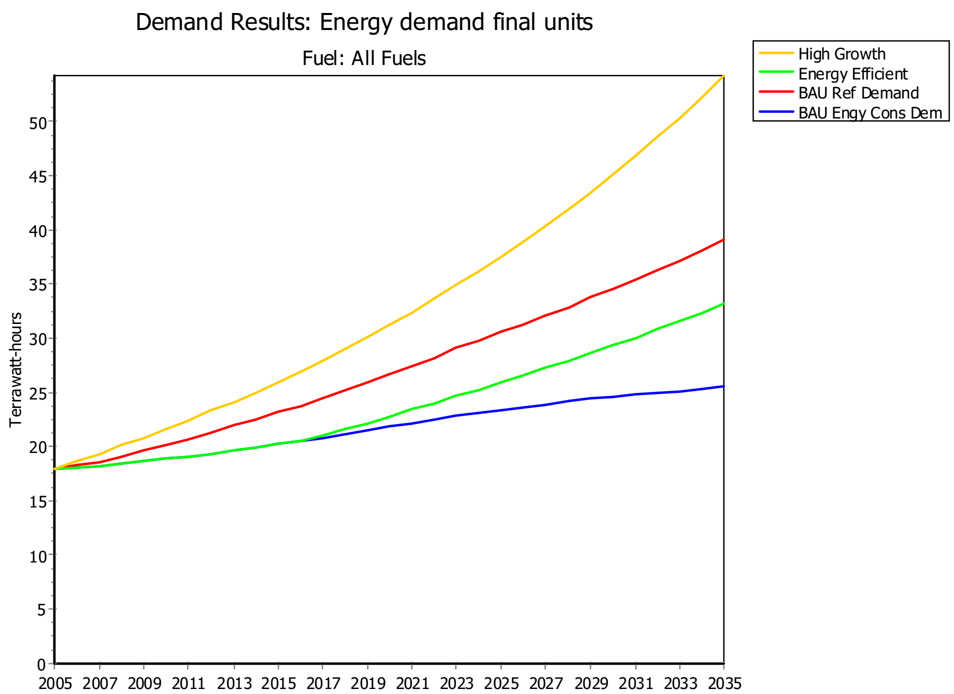

Figure 3 Electricity demand scenarios

Figure 3 shows the electricity sector demand predictions used in the Demand Side Strategy "Reference" case (BAU Ref Demand), and also shows the impact on electricity demand if all the energy efficiency "interventions proposed in the Strategy are implemented (the "Energy Efficient" curve). In both cases the growth curves have been extended from 2023 to 2035, using an annual growth rate of 2.5%. Historical growth in the Western Cape has been of the order of 4% per annum. For illustrative purposes a curve has been added to the graph based on the average growth rate of 3.75% which it is understood is being used by NERSA.[1] (High Growth). This was assumed to continue at 3.75% until 2035 (the NERSA modelling stops at 2025). As illustrated, this would result in demand increasing almost three-fold, and would be extremely difficult to sustain in the longer term.

The last curve on the graph is the so called "*BAU Energy Conscious"* curve. This assumes that the energy efficiency measures proposed in the ***Demand Side and Energy Efficiency programme*** (Borchers, 2007) are implemented. However, *from* 2016, it is assumed that even stronger energy efficiency measures are introduced, so that the rise to 2.8% annual growth rate (as per the "Energy Efficient" scenario) is held back to a more modest 1.5%, and then reduced even further in the years following 2023 (to 1.2%, and from 2028 to 0.8%).

Options for this sort of electricity demand reduction have not yet been identified. However, from an environment and development perspective, it may well be necessary to reduce the rate of electricity consumption growth to these levels or lower if the Provincial Government is to achieve the Sustainable Development objectives outlined in the Sustainable Development Implementation Plan (SDIP) adopted by Government in 2005.

Of interest in these scenarios, is that some sustainable energy promoted measures (e.g. in transport) may actually *increase* electricity consumption, as other forms of energy are substituted with electricity, or as petrol and diesel vehicles change over to electricity. This effect is noted in the modal shift from transport listed by Borchers 2007. The issue is also discussed in Banks and Schäffler (2005, pp 49), where they postulate significant *increase* in electricity demand as some non-electrical services that are currently fossil fuels may be converted to electricity in order to allow for use of *renewable* electricity. These major shifts are 'thought experiments' at present, and thus not discussed in detail in this report.

Subsequent elements of this report focus on the reference demand scenario, and the Energy Conscious Scenario – as these represent the range of the main longer terms options facing the Western Cape.

[1] NERSA is currently undertaking an integrated resource plan development exercise for South Africa. Information is not yet available from this study. However, note that Dr Lisa Woolhouse (lead energy economist for the SA Demand Forecast 2005 to 2025 as part of the NERSA study) in a presentation 15 March 2007, indicated that the average growth rate being modelled for NIRP3 is currently 3.75% up to 2025.

3 Renewable Energy Resource Assessment

3.1 Introduction

The Western Cape is blessed with significant renewable energy resources – and as is shown below there is far more energy available in the natural environment than is required for provincial energy needs.

However, not all this can be harnessed effectively, and in many cases the financial costs of tapping into renewable energy resources is higher than if fossil fuels were to continue being used, assuming the current pricing of electricity in South Africa. However, it is understood that energy prices will change in the medium term reflecting the capital investment needed to sustain the envisaged investment programme by Eskom. In the sections below each of the major resource streams are investigated in order to determine the amount of energy that could be harnessed in the near to medium term using technologies that exist, or have a high probability of being developed, and within cost regimes that are acceptable bearing in mind the portfolio based approach to energy planning advocated in the Sustainable Energy Strategy.

This document does not include a detailed economic analysis of the so called 'external costs' of using fossil fuels (and renewable energy), as this is beyond the scope of the current project. However, it should be noted that climate change related accounting (where CO_2 emissions could carry a significant real cost), as well as more general environmental and risk management concerns can play a significant role in modifying the costs of fossil fuel based technologies, as well as some renewable energy products.

3.1.1 Evolving technologies and industries

Some renewable energy technologies are relatively mature, and have been widely used internationally (and in some cases in South Africa). These include hydro power and direct biomass combustion (for cooking, and in some cases as a boiler feed material).

Others are reasonably mature, but still experience significant technical development as well as industry scale-up changes. Photovoltaic's, Solar Water heaters and wind turbines fall in this class. A range of other technologies are relatively new or under development, but show significant promise and potential. In developing a medium term strategy for the province, we believe it is important to consider the range of technologies.

Evolution in the sector is rapid, international focus on renewables is high, and global and regional climate change imperatives as well as fossil fuel price volatility provide significant incentive for technical and industrial development of renewable energy technologies. This evolving environment means that a slightly different approach to strategic energy planning than many may be comfortable with must be adopted. This is highlighted in the Sustainable Energy Strategy. It is also necessary to consider that the availability and cost of future renewable energy technologies is strongly dependent on how much effort the Western Cape, South Africa and the global community expend on research, development, commercialisation and development of the industries. The optimum future pathway cannot be predicated precisely. Flexibility, risk mitigation and innovation are important elements of required future scenarios.

The ability to plan thoroughly is also constrained by a significant lack in reliable renewable energy resource and market data. Public domain studies of resource have been conducted, and in some cases we have presented new approaches to determining the resource/application area overlay. However, the level of information available is hardly adequate for proper planning and decision making. While some parties (including Eskom and some private sector project developers) have better information on resource in key locations – this has generally not been made available to the project team given the often commercially confidential nature of this information. Primary research into resource availability was also beyond the scope of this initial Investment Case.

3.1.2 Resource classes

In the assessments below, the main methodology used to quantify the renewable energy resource has been presented– in most cases relying on an overlay of physical information (solar radiation, wind speed information) with the land areas suitable for harvesting the resource. This information is then coupled with technical information on the conversion efficiencies to useable electricity, heat or liquid/gaseous fuels. In some cases the resource has been divided into a number of classes as the final cost of energy delivered is significantly dependant on the particular characteristics of the solar, wind or agricultural resource in specific geographic locations.

3.2 Biomass

Biomass has the potential to contribute to Western Cape energy needs through a wide range of resources and conversion processes. At present it is primarily used as a cooking fuel, or for space heating in low-income households.

Biomass is transformed into commercial fuels, in the form of charcoal and briquettes. It can be used to generate electricity, with a range of technical options being available, including direct combustion in boilers, gasification, fluidised bed gasification). Biomass can also be processed into more easily used fuels, such as using biological processes to produce ethanol, or processing plant oils to produce biodiesel and creating a liquid fuel that can be used for transport or cooking applications.

In the long term, there is potential for biomass to provide a high proportion of total energy needs. Lynd et. al. (2003) estimate that the gross (prior to conversion) annual biomass energy production potential for South Africa is about 135 PJ per percent of available non-crop, non-forest, non-wilderness area used to produce energy crops. Thus their base case estimate entailing use of 10% of non-crop, non-forest, non-wilderness land gives an estimated production potential of 1350 PJ. Assuming a conversion efficiency of 25 percent for electricity, this could deliver almost 100TWh, just less than half of South African electricity consumption in 2005. If it were converted to liquid fuels at a conversion efficiency of 50 percent it would provide 675 PJ of liquid fuels equivalent (more than current South African transport fuel requirements). Although the Western Cape is not in the high biomass resource regions, these estimates provide some confidence regarding upper ranges of potential.

Biomass energy production requires extensive farming or forestry activities, and in this context greater biomass use has significant potential for enhanced rural economic activity.

One does however have to take particular cognisance of environmental concerns, as well as economic concerns related to greater use of biomass. These include (Banks & Schaffler 2005, p27)

- Water requirements: South Africa is a water-stressed country and the well-known ‘Working for Water’ programme has actively sought to reduce water-hungry tree infestations in catchment areas.
- Biodiversity: Large-scale monoculture energy crops could have a significant effect on species diversity and land quality.
- Food security: If farmers start to plant energy crops instead of food crops, there is a greater risk of food scarcity, particularly in years of drought. Furthermore, many food crops can be used as direct inputs to biofuels production, with the risk that product will be diverted from food markets to energy markets.

There is already evidence that internationally traded items such as sugar, and maize are trading at higher prices as a result of the demand for ethanol production from these food crops (See DME 2006, b, pg 54).

On the other hand, it should be noted that current processes (such as ethanol production from wheat or maize starch, or oil production from canola) produce significant volumes of oil cakes and other protein rich products that can re-enter the food chain.

Provided that biomass resources are used in a sustainable fashion, the net greenhouse gas emissions in their combustion are zero, as equivalent Carbon Dioxide is extracted from the atmosphere during the growth of the resource. There are however concerns about the fossil fuel inputs required to grow, transport and process biofuels. To this end it is necessary to look at the net energy balance of various biofuels processes (see Table 3), as well as the net Carbon balance.

Figure 4 provides and over view of the biomass resources in the country.

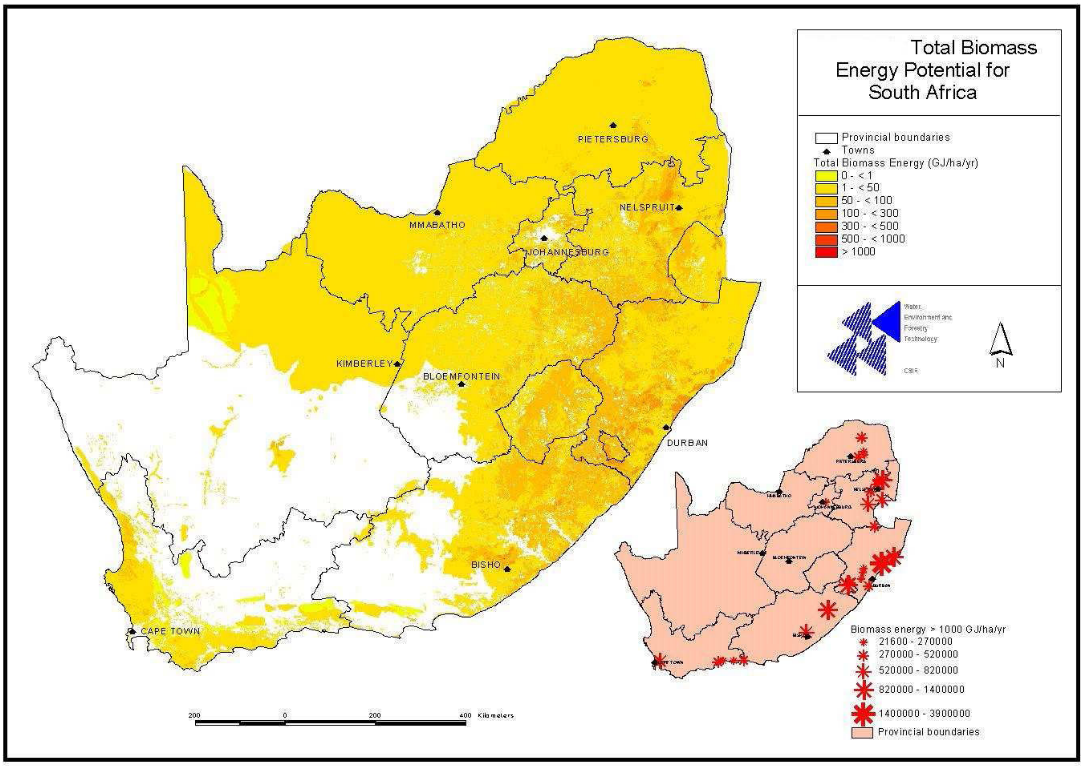

Figure 4 Overview of the National biomass resource in south Africa (DME/CSIR/Eskom 2002)

Key biomass resources are reviewed in the following sections

3.2.1 Fuelwood

Wood is a critical energy resource for poor people, and is widely used in rural areas of the Western Cape, as well as in informal settlements and low income areas. There is little information available on the provincial (or even national use of fuel wood). In a recent review of strategy options (National) Shackleton et al (2004, p.4) noted that:

- The national demand for fuelwood was estimated at 13 million m^3/annum in the mid-1980s and has never been updated since then.
- Fuelwood use is widespread, with over 95 percent of rural households using it to some degree.
- Urban markets are a growing aspect of fuelwood demand.
- Newly electrified and /or urbanised households tend to continue to use fuelwood for a variety of reasons, including its low price or ‘free’ availability, cultural reasons, lack of cash to buy alternatives, lack of cash to buy appliances for other energy forms, general preference, etc. In the longer term, however, per capita consumption tends to decline.
- The gross annual value of demand to the national economy is estimated to be R3 – 4 billion.
- At the local level, demand is highly variable by location, but does tend to be greater in areas with larger biomass resources.
- Estimates of household consumption rates range from 0.6 tonnes per year to more than 7.5 tonnes per year, typically between 3 and 4 tonnes per household per year.

Fuel wood use does lead to high levels of indoor (and in dense settlements outdoor) air pollution, and in several international studies, respiratory infections resulting from inadequate ventilation are regarded as a leading health factor. Western Cape specific data on health impacts is not readily available.

Given the critical importance of fuel wood to large sectors of the population, as well as the health, convenience and environmental aspects of its use as a resource, it is recommended that evolving national strategy work on the area be monitored, and efforts taken to ensure that best practice is adopted in the Western Cape.

Key questions for the Western Cape include:

- Is the resource increasing, or reducing in the province, and what is the impact of the "Working for Water" alien vegetation clearing programmes?
- Is consumption of fuelwood growing or declining?
- Are policies such as the Free Basic Energy having an impact on fuelwood consumption/transitions to more modern fuels?

3.2.2 Biomass for Power Generation

Forest products, and more specifically forest waste can be used to generate process heat and electricity. Processes include:

- Combustion of biomass products as a portion of the feedstock for conventional fossil fuel powered furnaces/boilers to generate heat or to drive steam turbines/electricity generators
- Firing of boilers for steam production/electricity generation using only biomass fuels
- Thermal gasification, and subsequent combustion of the syngas in reciprocating or turbine based power plant.

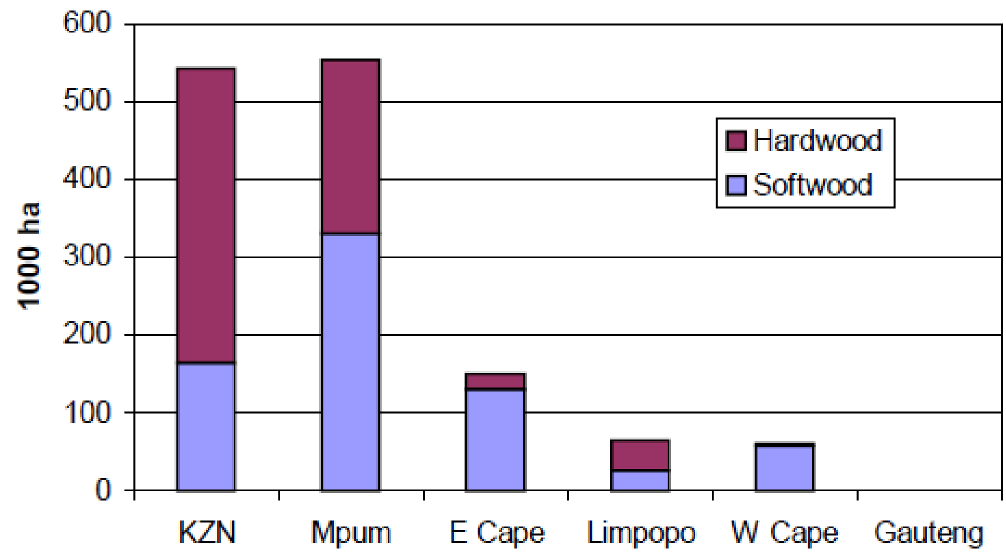

Figure 5 Timber plantation areas by province in 2003 (from DME 2003, p22)

Figure 5 compares the timber plantation areas in the country (DME 2003, p22). From this it can be seen that the Western Cape has comparatively limited resources, compared to the KwaZulu Natal and Mpumalanga.

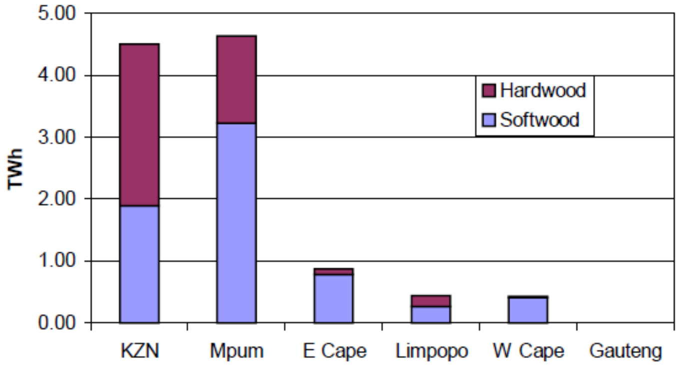

Figure 6 Energy content in forest biomass waste by province (2003, from DME 2003, pg 24)

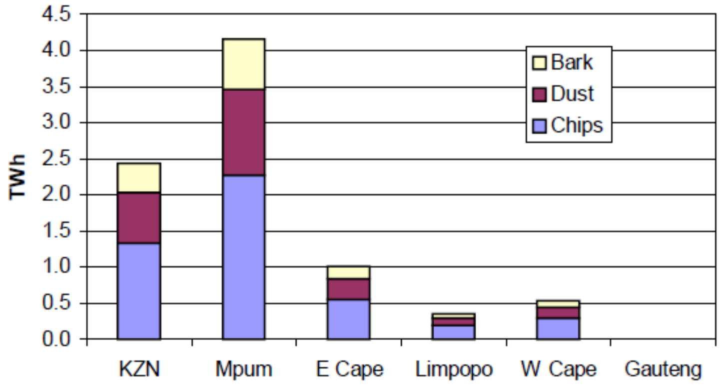

Figure 7 Energy content of sawmill waste by province (DME 2003, pg 27)

Figure 6 and Figure 7 show the estimated energy content of forest biomass waste, and sawmill waste by province in South Africa. This represents about 0.4 and 0.55 TWh of energy respectively. At 25% efficiency (waste in to electricity out), this is equivalent to a 35 MW power plant, operating at a 68% capacity factor. Discussions with Forestry resources experts who have undertaken pre-feasibility studies for power plants located at sawmills indicate that the medium term potential is not much more than about 12 MW electrical (Reynecke, 2007). Two such projects are in advanced stages of planning, see the biomass projects listed in Appendix A).

If trees are grown specifically as energy crops, the potential for energy production could be far higher. This would however mean that the wood is not available for other purposes. The land area under plantations could be increased, but this is not advised, given concerns regarding water resources and other environmental issues. Nevertheless, the so called 'exit policy' whereby active plantation area in the Western Cape is being reduced may need to be reviewed in the light of energy resource concerns.

The cost of electricity produced from biomass is highly dependent on whether the resource is grown as a specific energy crop, or whether it is made available as a by product of other processes. The following table lists cost of energy data for biomass plants. It should be noted that biomass based power generation costs are highly variable. See for example

DME 2003, which has costs in the range of R0.10 to R0.98 for pulp and paper mill power generation, and R0.22 to R0.29 for bagase (Static Financial Cost, Table 67 of DME 2003).

Table 1 Cost information for biomass based power generation

Cap Ex (R / kW)	Fixed OM (R / kW / yr)	Var OM (R / MWh)	Lifetime (years)	Interest Rate	Cost per kWh	Year	Units	Source	Notes
18,667	not stated	not stated	20	not stated	0.37	2006	ZAR	Reynecke	6 MW sawmill waste plant, private sector
23,000	154	22.9	30	8%	0.39	2006	ZAR	ERC 2006	The cost per kWh was derived using 8% discount rate.

Table 16 provides a summary of the key data carried forward from this section into the scenarios presented below.

3.2.3 Biodiesel and Bioethanol

Biodiesel is a vegetable oil derived from crops such as sunflower, soya and canola seed. It can be used in diesel engines and has a similar energy content to that of conventional crude oil-based diesel. In the Western Cape the main feedstock under consideration at present is Canola, which can be grown in a crop rotation cycle with wheat (and in so doing helps to enhance land productivity). At present canola production is drawn from only about 40 000 ha, and many wheat farmers choose to leave land fallow to rest between every third wheat crop, rather than planting canola. However, if canola prices increase sufficiently, this could encourage larger scale production.

Bioethanol can be produced from wheat or other similar high starch crops. It can also be produced from sugar cane (indeed this sugar-ethanol process is one of the most energy positive biofuel options available). Given Western Cape climate and agricultural conditions, the sugar route is not a medium term option – but wheat or wheat like crops do present a significant opportunity. In particular, there are several grades of wheat produced – and the lower grades do not fetch as good a price for food products as high grade wheat. The assumptions used n the scenario development assume that this low grade wheat could be converted to bioethanol.

A resource assessment in provided in Appendix B.

3.2.3.1 Key issues already in place in South Africa

There is extensive debate around a biofuels strategy at present in South Africa. Given the rapid evolution in the policy environment, we do not comment on this extensively in this report. Suffice to say that:

- A draft Biofuels draft strategy has been released (DME 2006b)
- There is existing provision for a rebate on fuel taxes for biofuels.
- There is an existing tax-depreciation write incentive of 50:30:20 , and there are existing fuel levy exemptions.

The draft strategy proposes that (DME 2006b)

- “aims to achieve a biofuels average market penetration of 4.5 % of liquid road transport fuels (petrol and diesel) by 2013 which will contribute 75 % to the national Renewable Energy target.”

- "a scenario of E8 (national basis of 8 % ethanol in petrol, although in reality this would more likely be E10 in 80 % of the petrol), and B2 (national basis of 2 % biodiesel in diesel, although in reality would more likely be B5 in certain diesel supply regions) was examined"

There are a number of key issues related to biodiesel and bioethanol production that need to be given careful consideration in adopting and implementing the strategy. These include:

- job creation potential – biofuels could have significant positive impacts on rural agriculture;
- energy inputs (often fossil, vs energy outputs);
- carbon balance for biofuel production (in some cases biofuels may have significant CO2 emissions);
- water consumption and water scarcity for production of crops as well as processing (particularly important issue in the Western Cape);
- biodiversity implications of large scale mono-crop production;
- technical and standards issues related to biofuels.

There are also still significant areas requiring research, including: selection of optimum crops, investigation of socio-economic impacts, and development of optimum conversion technologies. It should be noted that significant potential exists for far greater us of biomass based fuels if cellulose conversion technologies are developed and become commercially viable (see Lynd et al, 2003).

3.2.3.2 International experience

There is significant international experience of biofuel production, and introduction into the liquid fuel supply mix. For example, Brazil currently produces of 20% of its national liquid fuels requirement through production of ethanol from sugar, and has a target of 50% biofuels contribution to liquid fuel supply. Production is viable at about $35/bbl, although this includes a renewable energy cogeneration incentive of about 10$/bbl (and Brazil has higher base electricity costs than South Africa which gives another $10/bbl effective support). (DME 2006a.)

In the USA there is a significant subsidy in place to support bioethanol production, with an effective subsidy of the order of $ 40 bbl. Europe has set a target of 5.75% by 2010, but incentives are higher, and reach up to $80/bbl (DME 2006a)

According to Remi Burdairon at the conference on Biofuels Markets in Africa (Cape Town. November 2006.) the EU experienced an increase of 184% in the production of Biodiesel between 2004 and 2006.