DEVELOPING A BUSINESS CASE FOR SUSTAINABLE BIOFUELS IN SOUTH AFRICA:

A FOCUS ON WASTE-BASED BIOETHANOL FOR FLEET TRANSPORT IN THE WESTERN CAPE

GREEN CAPE

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TABLE OF CONTENTS

ACRONYMS

BEE	Black Economic Empowerment
BIC	Biofuels Implementation Committee
BRT	Bus Rapid Transit
CBP	Combined Bio-Processing
CEF	Central Energy Fund
DDGS	Dried Distillers Grains with Solubles
DEA	Dept of Environmental Affairs (National) (Formerly DEAT)
DEAT	Dept of Environmental Affairs and Tourism. (National)
DED&T	Dept of Economic Development and Tourism (Western Cape)
DAFF	Dept of Agriculture, Forestry and Fisheries (National)
DoA	Dept of Agriculture (Western Cape) (Also used for former National dept)
DoE	Dept of Energy (National) (Formerly DME)
DME	Dept of Minerals and Energy (National – now DoE)
dti	Dept of Trade and Industry (National)
DWAF	Dept of Water Affairs and Forestry (National – now the DWA and DAFF)
DWA	Dept of Water Affairs (National – now falls under DEA)
EIA	Environmental Impact Assessment
FAME	Fatty Acid Methyl Ester
FAO	Food and Agriculture Organisation
FARE	Future of Agriculture and the Rural Economy
FFA	Free Fatty Acids
FOG	Fats, Oils and Grease
FT	Fischer-Tropsch
GABS	Golden Arrow Bus Service
GHG	Greenhouse Gases
HDSA	Historically Disadvantaged South Africans
IDC	Industrial Development Corporation
IFES	Integrated Food-Energy Systems
ILRS	Imperial Logistics Refrigeration Services
IRT	Integrated Rapid Transit
MFMA	Municipal Finance Management Act
MON	Motor Octane Number
MSW	Municipal Solid Waste

MTBE	Methyl Tertiary Butyl Ether
NEMA	National Environment Management Act
RON	Research Octane Number
SABS	South African Bureau of Standards
SANS	South African National Standard
SARS	South African Revenue Services
SIDA	Swedish International Development Agency
SMME	Small, Medium and Micro Enterprises
TCT	Transport for Cape Town
UCT	University of Cape Town
VOC	Vehicle Operating Company
WCBITT	Western Cape Biofuels Inter-departmental Task Team
WVO	Waste Vegetable Oil

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1 Executive Summary

This study sought to understand the current situation with regard to the biofuels sector in South Africa. Thereafter it focuses in particular on the opportunity to produce bioethanol from waste streams within the Western Cape.

During the course of the study, significant steps were taken by the Department of Energy with regard to the roll-out of the National Biofuels Industrial Strategy. In October, the mandatory blending date was gazetted as being the 1st October 2015. At the same time, the multi-stakeholder Biofuels Implementation Committee was constituted to deal with the outstanding issues requiring resolution prior to this date. Two of the most important matters on which clarity is still awaited are the final biofuel pricing mechanisms and the production incentive scheme. There is also no finality yet on the criteria that will be applied to identify producers that will qualify for production subsidies, as there is no guarantee that the granting of a biofuel manufacturing licence will lead to automatic granting of the subsidies.

It is clear from close examination, that the National Strategy's primary focus is the supporting of rural development and employment creation. Its focus is also only on the production of bioethanol and biodiesel for blending into the national fuel pool at 2% and 5% volumes respectively. It thus makes no provision for waste-based biofuels production, nor for any niche opportunities such as high blend biofuels.

This study has focussed on investigating the potential waste streams in the Western Cape that could be used to produce bioethanol. Findings are that the streams that are sufficiently aggregated, and can most easily be diverted from their current uses to bioethanol production are, grape pomace from the wine industry, citrus pomace from orange juice production, 10% of the total lignocellulosic agricultural wastes and the carbon monoxide component of the off-gases from the steel mill in Saldanha.

Based on these feedstocks, using technologies that are currently commercially proven, it has been determined that a total of 359 million litres/yr of bioethanol could be produced in the Province. Furthermore, if crop-based production is also considered, a further 78 million litres/yr could be produced from small grains, and 12 million litres/yr from Jerusalem artichokes. This further production could be achieved without threatening food security, and while simultaneously creating employment opportunities and stimulating rural development.

On the demand side, current liquid fuel consumption in the Western Cape, including petrol and diesel for transport, and paraffin for household use, amounts to just over 5 billion litres/yr of ethanol equivalent. In other words, the potential bioethanol production, from the waste streams discussed above, could supply over 7% of the annual fuel needs in the Province, and if the crop-based production were to be included, this would rise to nearly 9% of the demand.

However, the development of a biofuels industry in the Western Cape is not without its challenges, and there are numerous factors that need to be considered. In the mid-2000s, the Western Cape Government appointed an inter-departmental task team which examined the potential for such an industry, and found that the national policy and strategy was not conducive to its development. However, in the interim, there have been significant changes on the technical, economic and policy fronts, both nationally and internationally. The current context thus provides both new opportunities, and new challenges.

Despite the changes and advances at the policy level nationally, there is uncertainty as to whether the National Biofuels Industrial Strategy will meet its October 2015 biofuels blending targets, particularly as regards the 5% biodiesel blending level. On the basis of this and the aforementioned, it is concluded that, the business case for biofuels production in the Western Cape merits a detailed re-examination. This investigation should build on the work done by the Province's Dept of Agriculture in the mid 2000s, prior to the finalisation of the National Biofuels Industrial Strategy in 2007.

It is important that this analysis:

- Consider all waste resources as potential feedstocks, including agricultural residues;
- Investigate fully the available biofuel conversion technology options;
- Understand the potential of non-food crops as feedstocks, and the resulting land use change implications;
- Quantify the employment creation and economic multiplier opportunities; and
- Compare and contrast the business case for biofuels for blending versus biofuels as dedicated fuels, as well examine the use of bioethanol as a household fuel.

2 Introduction

This study has its origins in a Swedish International Development Agency (SIDA) sponsored visit by Prof Jim Petrie, of the Western Cape Government's Department of Economic Development and Tourism (DED&T), to Sweden in November 2012, under the auspices of SIDA's Partner Driven Cooperation Programme. This study tour, which included delegates from South Africa and Namibia, focussed on opportunities in "Waste to Energy and Biogas".

Scania CV AB was one of the companies visited on this trip, the focus being their heavy duty vehicles fuelled with biofuels. Scania was at the same time considering an application to SIDA, for funding to conduct a broad feasibility study for bioethanol and other biofuels in South Africa and neighbouring countries.

Prof Jim Petrie and Mr Jonas Strömberg of Scania (Director Sustainable Solutions) agreed to collaborate in a study to ascertain the potential for biofuel-powered fleet vehicles, with a special focus on waste-based bioethanol in the Western Cape. Further discussions with the City of Cape Town, who shared the above interest, resulted in a tripartite agreement to apply for funding to SIDA to support this current study.

This report is thus the product of the SIDA-funded Planning Grant for Cooperation "Developing a Business Case for Sustainable Biofuels in South Africa".

3 National Biofuels Policy and Regulatory Context

It is important to understand the current biofuels policy and regulatory context that pertains in both South Africa and the Western Cape, before investigating the potential for bioethanol production in the Western Cape.

3.1 National Biofuels Industrial Strategy

The National Biofuels Industrial Strategy (DME, 2007) was developed by the Biofuels Task Team, appointed by Cabinet in December 2005. The Task Team's mandate was to develop a national biofuels strategy targeted at creating jobs in the energy-crop and biofuels value chain, and to act as a bridge between the so-called first and second economies in South Africa. The Task Team consisted of members drawn from departments across the full national government.

The final Strategy, approved by Cabinet in December 2007, adopted a short term five-year focus of achieving a 2% penetration of bioethanol and biodiesel into the national liquid fuel supply. Based on the total national fuel (petrol and diesel) pool of about 20 billion litres/yr this would have translated into a blending target of 400 million litres/yr by the end of 2013. This target was revised downward from the 4.5% initially proposed in the draft Strategy, and the 10% proposed in the biofuels industry feasibility study (DME, 2006). This adjustment was made taking into consideration the challenges faced in developing the biofuels industry. However, not even this revised target has been met.

The Strategy proposed sugar cane and sugar beet as the feedstocks for the production of bio-ethanol and sunflower, canola and soya beans for biodiesel production, based on the findings of DME (2006). The exclusion of other crops and plants such as maize was based on the food security concerns while jatropha's exclusion was primarily because of biodiversity concerns. No provision was made in this strategy for fuel production from wastes.

Since the release of the Strategy, according to the DoE (2013), grain sorghum and sugar cane have been adjudged the most appropriate commercial crops for bio-ethanol production, and it is on the basis of the use of these two feedstocks that the, yet to be released, biofuel production incentives have been calculated. Large volumes of these crops are already widely grown, and nationally, it is felt that sufficient experience exists to expand their production. Sugar beet has not been grown on a large scale in South Africa and no long-term, firm information exists on its cultivation costs.

On the biodiesel front the most common feedstocks used worldwide are soya beans, canola and palm oil. In South Africa, again according to the DoE (2013), soya beans and sunflower seed are deemed to be the most appropriate commercial crops, as large volumes of these potential feedstocks are already grown locally and experience is deemed to exist to allow for expansion of production.

The Biofuels Industrial Strategy is strongly focussed on the integration of emerging farmers into the feestock production process, and the involvement of historically disadvanted South Africans (HDSA) all along the value chain and across the participating sectors. It envisages the creation of a reliable market for biofuels to be used as blending components in both petrol and mineral diesel. In the case of petrol, bioethanol can substitute a number of octane boosters currently used by the oil industry.

The Strategy envisages the pegging of the price of bioethanol and biodiesel as blending components, at levels that cover the costs associated with constructing and operating a biofuels plant, cultivation of agricultural feedstock and of transportation. These costs will include an allowance for a return on the installed capital plant, commensurate with the corresponding risk. The Strategy states that the return would be determined in the same way as the revised margin setting approach used to set petroleum products' wholesale margins. This margin will be fixed for a period, but be reviewed regularly according to an agreed formula. It is thus envisaged that the cost of biofuels will be ring-fenced, and remunerated separately, given that they will be blended at the fuel wholesale level.

The Strategy expects that farmers supplying biofuel plants with feedstock, particularly emerging farmers, will organise themselves into co-operatives to maximise benefits and market power and further that they will participate fully or partially in the ownership of the biofuels plants. With its focus on rural development the Strategy envisages that contracts would be signed between farmers' cooperatives and individual biofuel producers, as is currently done in the sugar industry. These contracts would facilitate the sourcing of funding by the farmers from institutions such as the Land Bank, and thus serve to assist in guaranteeing feedstock supply for the duration of the contract.

Perhaps one of the aspects of the Strategy that is given the most prominence in all debates surrounding it, is that of its perceived ability to create jobs in the energy crop production sector and through involvement of rural people in the biofuels value chain, to act as a bridge from the so-called second economy to the so-called first economy. It is on this basis that the development of an industry based on imported feedstock is not supported by the Strategy, except in times of adverse agricultural production, when local producers cannot meet the plant operators' demand.

The last key element of the Strategy is its targeting of those areas of the country that are worst afflicted by poverty and deprivation. It hopes to generate economic activity, and thus explicitly targets feedstock production in the previous homelands, by historically disadvantaged farmers, for support. For this reason, only biofuels producers that have been identified as assisting in meeting these objectives will be supported, and their location will be a condition of the issuing of a biofuels manufacturing licence.

The Strategy has clearly adopted a developmental approach, and as such has excluded niche biofuel production opportunities which make use of waste streams as feedstock, and will as such contribute to the national renewable energy and carbon emissions reduction targets, from any form of government incentives or support.

3.1.1 Biofuels Production Licensing Criteria

The Biofuels Production Licensing Criteria (see Appendix A.1) were established by the Department of Energy (DoE) in 2008 and serve to reinforce the objectives of the National Biofuels Industrial Strategy as outlined in the previous section. These Criteria were drawn up in terms of the Petroleum Products Act, 1977 (Act No. 120 of 1977), as amended. They have been used by the Office of the Controller of Petroleum Products in the DoE to evaluate applications for biofuels manufacturing licences.

The following are the clauses of the Licensing Criteria, and where relevant, they are followed with a discussion of certain key aspects. For ease of reading, the actual text of the Criteria is placed in quotes, and the comments in italics.

"All biofuels manufacturers, including pilot projects, are required to apply for a manufacturing license (sic). Those manufacturing for own use will have to register with the Petroleum Controller and provide annual statistics on what crops they are utilizing, production capacity (how much they are producing) and detailed information of what the products are used for."

"Biofuels production for research purposes will have to provide proof/letter from relevant research institutions. Produce from research projects shall be limited to specified quantities and as such must not be used for commercial purposes."

"All crops used for the production of biofuels must not have negative environmental impacts on South Africa during processing and storage."

COMMENT: *This criterion could be taken at face value, however, in the context of the Licensing Criteria, it needs to be made more explicit, and "processing" and "negative environment impacts" need to be defined, e.g. does "processing" include the cultivation and harvesting of the feedstock crops?*

"The production of feedstock under irrigation will only be allowed in exceptional circumstances and a detailed motivation will have to be provided. Water that is currently used for gainful irrigation will not be considered for a new water license for biofuels production purposes."

COMMENT: *The outright refusal for the granting of an irrigation licence, implicit in the last sentence, appears to contradict the first sentence.*

"In terms of the Criteria as they currently stand, applicants for the manufacture of biofuels must adhere to the following guidelines:"

1. "Crops considered suitable for biofuels are mainly sugar cane, sugar beet, soya beans, sunflower and canola (as contained in the National Biofuels Industrial Strategy)."

COMMENT: *The so-called benchmark feedstocks for bioethanol are now grain sorghum and sugar cane, and all the DoE incentive mechanism calculations have been based on these. On the biodiesel front, soya has been chosen as the benchmark feedstock.*

2. "Maize and jatropha are not permitted as feedstocks for biofuel production."

3. "Feedstock imports are not allowed:
   - Except during periods of adverse agricultural production, when local producers cannot meet the producers needs.
   - In such a case a licensed producer must apply in writing to the Petroleum Controller who will decide whether such a period of adverse agricultural production indeed exists."

COMMENT: *It is assumed that the Petroleum Controller will seek advice from agricultural sector experts.*

4. "Due to difficulties in the availability of certain feedstocks domestically, importation could be allowed for projects at inception stages under certain conditions. Conditions to be considered are:
   - Only those crops where generally there is no adequate domestic capacity or are not grown in South Africa. In addition, the carbon footprint of that crop production must not be negative in the country of origin.
   - Importation only allowed when a detailed phase-in period for import replacement (substitution) and domestic sourcing has been provided.
   - Import replacement and domestic sourcing must be linked to sourcing from emerging farmers from underutilised areas.
   - A detailed account of type(s) of by-products, quantities and potential markets has to be provided. Fair conditions of trade have to prevail so as to manage/avoid market dominance by operator(s) in the local market on the back of imports."

COMMENT: *Overall, this is a confusing criterion, the object of which is not clear, and which could be open to various interpretations, and thus have unintended consequences.*

5. "Feedstock must be cultivated and sourced from the designated areas.
   - A written commitment or contract is required to ensure that feedstock is sourced from emerging farmers from underutilised areas.
   - The use of feedstock from commercial farmers will also require a detailed phase-in plan and period for increased use or evening out of feedstock by emerging farmers from underutilised areas."

COMMENT: *A "Designated Area" is an area designated by the Department of Agriculture, Forestry and Fisheries (DAFF) as underutilised and suitable for the production of biofuel feedstock crops. This is a very prescriptive criterion and, it would seem to be very difficult to comply with. Furthermore, how DAFF will assess land as underutilised is not clear at all. It will also not allow for the use of crops grown in rotation on currently cultivated land.*

6. "During the first phase (2008 – 2013) more priority will be given to commercially proven technologies, while the piloting and demonstration of second generation will be supported only if it is for research purposes."

COMMENT: *Apart from the fact that the timing of the first phase of the Biofuels Industry Strategy will now be different, it is clear that both bioethanol and biodiesel production processes have evolved significantly since the drafting of these Licensing Criteria. In other words, what can be regarded as commercially proven technologies have changed, thus indicating the need for a substantial redrafting of this clause.*

7. "All biofuels products and producers must meet the prescribed SANS specifications and standards."

8. "The utilization of by-products needs to be clearly indicated and a proof of off take agreements need to be submitted."

COMMENT: *It is not clear why this should form a prerequisite for the granting of a production licence.*

9. "An off-take agreement with a local oil company, operator, large commercial undertaking and dedicated operator such as municipalities that will use the biodiesel and bioethanol is required. Mandated upliftment and accommodation of biofuels in the oil industry infrastructure envisaged in the Biofuels Strategy has to be ensured."

COMMENT: *It must be understood that the Blending Regulations refer only to biofuels produced in the country. There will be no need for the importing of biofuels to meet the blend targets if there is insufficient supply nationally.*

10. "Biofuels producers must provide a proof of an agreement or undertaking regarding the blending facilities."

COMMENT: *Again, this is unclear. Compliance with criterion number 9 should ensure this.*

11. "The applicant must provide evidence where it is applicable that it has engaged with other authorities whose approval will be necessary for the manufacturing facility to operate. These will include, but may not be limited to:
    - DoA
    - The dti - International Trade Administration Commission,
    - Department of Land Affairs
    - DEAT
    - DWAF
    - Others"

COMMENT: *This refers to the large number of approvals that are required for biofuel manufacture, many of which are triggered by activities or processes, in biofuel manufacturing, which are regarded as Listed Activities in terms of the National Environmental Management Act (NEMA), as listed in Appendix A.2. As formulated, this is a very open-ended and non-specific criterion. It is conceivable that it could be used for refusal of a licence, or at the very least, its granting being endlessly delayed, as various approvals or authorisations are sought from the relevant authorities. Just for the record, Land Affairs no longer exists.*

12. "In addition to the guidelines above, all other provisions pertaining to the manufacture of petroleum products contained in Petroleum Products Act of 2003 will still apply."

COMMENT: *The Petroleum Products Amendment Act 58 of 2003 has a Schedule 1, which is the Charter for the SA Petroleum and Liquid Fuels Industry.*

On balance, the Licensing Criteria provide an inconsistent list of requirements to be met by applicants. They are at differing levels of complexity, and border on being internally contradictory. It is suggested that they should be reviewed and redrafted to fit more closely with the current situation and realities.

Based on these Licensing Criteria, the following table, released by the DoE, shows the list of companies that have thus far been processed by the Controller of Petroleum Products in terms of the Petroleum Products Act, 1977 (Act No. 120 of 1977). Those that are listed as "Issued" are those that have fulfilled all the requirements of the licensing procedure. Those listed as "Granted" still have matters outstanding, such as, for example, full EIAs etc.

It should be noted that biodiesel producers producing below 300 000 litres/yr, are currently fuel tax exempt, this apparently being motivated by the need to simplify administrative procedures. The National Biofuels Industry Strategy further recommended that the small producers' threshold be raised to 1.2 million litres/yr. However, this provision has as yet not been officially gazetted. These small-scale biodiesel producers, of which there are quite a number dotted all over the country, are not included on the list of licensed producers released by the DoE, but they are registered with the South African Revenue Services (SARS) for recording purposes. It is not clear how many of these there are, as it has proved impossible to find a consolidated list.

Table 1: Status of Biofuel Licences as of October 2013 (DoE)

Company Name	Crop / Feedstock	Capacity (million litres/yr)	Location	Licence status
BIOETHANOL				
Mabele Fuels	Sorghum	158	Bothaville, FS	Issued
Ubuhle Renewable Energy	Sugarcane	50	Jozini, KwaZulu Natal	Issued
E10 Petroleum Africa cc	Sugarcane and other crops	4.2	Germiston, Gauteng	Granted
ARENGO 316 (Pty) Ltd	Sorghum and sugar beet	180 (in two phases of 90 each)	Cradock, Eastern Cape	Granted
TOTAL BIOETHANOL CAPACITY		**392.2**		
BIODIESEL				
Rainbow Nation Renewable Fuels	Soya Bean	288	Port Elizabeth, Eastern Cape	Issued
Exol Oil Refinery	Waste Vegetable Oil	12	Krugersdorp, Gauteng	Granted
Phyto Energy	Canola	>500	Port Elizabeth, Eastern Cape	Applying for licence
Basfour 3528 (Pty) Ltd	Waste Vegetable Oil	50	Berlin, Eastern Cape	Granted
TOTAL BIODIESEL CAPACITY		**850**		

3.2 Mandatory Blending Regulations

In August 2012, the Regulations Regarding the Mandatory Blending of Biofuels with Petrol and Diesel were promulgated, laying out the terms under which bioethanol is to be blended with petrol, and biodiesel with mineral diesel. However, neither a mandatory blending date nor blending levels were stipulated in the Regulations. In September 2013, the commencement date of mandatory biofuels blending was finally gazetted as 1st October

2015, i.e. this is date on which the mandatory blending regulations come into force. However, this announcement neither mentioned the blending levels of the bioethanol or biodiesel, nor the incentives and subsidies needed for biofuel production to begin in earnest.

With the mandatory blending date now set, the National Biofuels Industrial Strategy has to be given life. This in turn will necessitate further careful planning and decision making around a number of strategic, practical and regulatory issues. To this end, the so-called Biofuels Implementation Committee (BIC) has been established by the DoE, with its secretariat in the Central Energy Fund (CEF). The BIC consists of members drawn from across the relevant sectors, ranging from government departments through to the oil companies.

The BIC has already met twice (November, 2013), and has established eight working groups to deal with the outstanding issues that need to be resolved to allow blending to commence in October 2015. These include the biofuels pricing framework, subsidy criteria, logistics, sustainability of feedstock supply, tax and customs excise issues and better coordination of enabling activities between key government departments. It is envisaged that the results of these groups' activities will be released before the end of 2013. However, there are a number of substantive issues that still need to be addressed, and these could take time. For example, all the legislation and regulations governing the petroleum sector are currently under review, and any amendments will be made available for public comment only in mid-2014.

One point that needs to be clearly understood is that mandatory blending does not mean that from the blending date on, the oil companies have to ensure that they have bioethanol blended into their petrol, or biodiesel into their mineral diesel. They are only obliged to take up the biofuel that is available at that time, and is offered to them by producers. Furthermore, if, for example, a 2% bioethanol blending level is required in petrol, as is currently being proposed, this does not mean that there will have to be 2% bioethanol in every litre of petrol that is on sale in the country after 1st October 2015. It will rather mean that there will be a 2% displacement of petrol by bioethanol, across the country as a whole.

3.3 National Biofuels Pricing Mechanism

As a nation, it is felt that there will be an upside to the "greening" of the fuel pool through the introduction of biofuels, which will justify the introduction of subsidies and incentives. In addition macro-economic advantages and societal benefits such as: job creation (mainly through additional agricultural output); energy security (domestic production from local feedstocks); environmental benefits and the meeting of GHG emission reduction goals; rural development; the creation of a readily-accessible market for emerging farmers; and positive balance of payments effects, are also expected to be spin-offs of the biofuels programme.

What is not clear however, is whether the potential environmental impacts are going to be monitored and evaluated in any way, as no specific mention has been made of this in any policy statements or strategic documents to date. If monitoring and evaluation of these impacts were to be required, the question would then arise as to who would be responsible for it, and how would compliance be enforced?

Despite the lack of clarity on these issues, it is on the above premises that the National Biofuels Pricing Mechanism, and related issues are currently being finalised by the DoE, with the assistance of the working groups of the BIC. The Pricing Mechanism will contain the necessary incentives and subsidies to stimulate the development of the biofuels industry. Currently, all renewable energy projects, including biofuels, qualify for an accelerated depreciation allowance of 50:30:20 over three years. Otherwise, the only existing price incentive is a rebate of 50% on the general fuel levy for biodiesel.

Bioethanol, on the other hand, according to the National Biofuels Industrial Strategy, falls outside the fuel tax net and therefore does not attract any general fuel levy. However, there is now some uncertainty about whether this will be the case going forward, as it appears that bioethanol will be taxed together with petrol, after it is blended.

The above incentives have not proven to be sufficient to stimulate major investments in the biofuels sector to date, hence the need to establish a more enabling and supportive fiscal and regulatory framework. The aim of the Biofuels Pricing Mechanism is thus to provide a guaranteed return to biofuels manufacturers, and thereby reduce controllable market risk, and ensure that any investments made are sustainable (Tait, 2013). The departure point for the calculation of the incentive or subsidy is a benchmark reference plant. This approach obviates the need to calculate the subsidy for each individual plant. Thus, efficient manufacturers will be able to beat the benchmark model, and achieve greater returns, while inefficient manufacturers will be penalised.

The collection of the funds for the subsidies will be incorporated into the fuel pricing structure to ensure that the fiscus is neutral, i.e. motorists will pay for the subsidies. As was stated in the 2013 Budget Speech the initial cost of the incentives will be between 3,5 and 4 cents per litre of petrol or diesel, and will be recovered through a levy included in the monthly price determination.

In addition to the abovementioned benchmark reference biofuels plant, specifically in the case of bioethanol, a key element of the Biofuels Pricing Mechanism calculations is its so-called blending value. This value incorporates all the penalties accrued and benefits gained by local petroleum companies if bioethanol is blended with petrol at a specific volume. The blending value is designed to ensure that cost neutrality for the overall petrol pool is maintained.

By way of explanation, in a typical oil refining operation, petrol contains multiple components in an optimised blend, to meet the required petrol specifications. Introducing bioethanol contributes benefits and penalties to the blend pool value. Bioethanol has a significantly higher research octane number (RON), adds oxygen to a blend, contains zero benzene and aromatics, and has low sulphur content, all of which increase its value relative to petrol. It is also a locally-manufactured replacement for high-octane petrol and component imports.

However this enhanced value of bioethanol is diminished mainly by its adverse properties of lower motor octane number (MON) and high volatility. As a result of the high non-linear blending volatility of bioethanol, refineries are forced to exclude other high-value, high-volatility components like butane, pentane and isomerate and produce a so-called blendstock for oxygenated blends (BOB) for use in the petrol-ethanol blending process, once the ethanol content reaches a level where it will affect the overall volatility.

Because of the high volatility and the hygroscopic nature of bioethanol, oil companies will also need to invest in new, separate, fixed roof tanks, advanced fire-fighting systems and enhanced housekeeping and control systems. Special wastewater management systems, receipt, storage, blending and loading facilities, as well as satellite laboratories will be required for depot blending. These additional capital and operating costs have also been considered in establishing cost neutrality.

In the DoE's recently completed study to determine the Bioethanol Blending Value, the value was found to be negative, mainly because of the hygroscopic nature of bioethanol and the cost implications thereof. In other words, the infrastructure capital expenditure and increased operating costs incurred by the blenders result in the bioethanol incurring a penalty. The value has been found to be at its best i.e. least negative, at a concentration of 2% by volume, and to become even more negative with increasing concentration to be worst at 5%, but to improve thereafter to a second best level at 10%. Hence when applying a subsidy scheme, the quantum of the subsidy per litre of blended petrol will correlate with the concentration of bioethanol in the blended petrol, the lowest subsidy level being at a 2% volumetric concentration.

In the case of biodiesel, according to the regulations governing Petroleum Products Specifications and Standards, it can be blended at different concentrations into mineral diesel, from 5% biodiesel (B5) right up to 100% biodiesel (B100).

3.3.1 Biofuels Subsidy Selection Criteria

In addition to the Licensing Criteria, the DoE are also planning to introduce criteria for the eligibility of biofuels manufacturers to receive subsidies. Thus, even though a manufacturer might be licensed to produce biofuels, it will not be a foregone conclusion that they will receive the biofuels subsidies. The proposed criteria have yet to be officially released by DoE, and are under discussion internally by the working groups of the BIC and other affected parties.

The total potential production capacity of the biofuels plants that are currently licensed, as per the earlier table, is over 1.2 billion litres/yr of bioethanol and biodiesel combined. If this potential is realised, it would exceed the envisaged 2% penetration level of biofuels in the national liquid fuel supply (combined petrol and diesel consumption is currently around 20 billion litres/yr), by over 4%.

Given the above potential biofuels oversupply expected during the so-called pilot phase of the Biofuels Industrial Strategy, the DoE is recommending the implementation of subsidy eligibility criteria. Being licensed by the Office of the Controller of Petroleum Products will be the primary prerequisite for eligibility for subsidies. However, awarding of a production licence will not ensure receipt of subsidies.

Qualification for the subsidy scheme will be on a first come first served basis, and be based on actual production and not projected plant capacity. That is, the subsidy payouts will be based on actual litres of biofuels produced and blended. For as long as the penetration remains below 2% the subsidy will be based on a 2% bioethanol concentration in blended petrol. It is envisaged that the subsidies will be applied over the pilot period of ten years, and then be subjected to review.

It is very difficult to make an estimate as to when this 2% penetration target could be reached. Considering the number of licensed entities and the fact that the Biofuels Pricing Mechanism will remove the main obstacle to biofuels production, the DoE is expecting that the target will be achieved in the fourth year from the date of finalising the Biofuels Pricing Mechanism. This incorporates the fact that once the scheme is finalized and announced, it will take about two years to construct the first manufacturing plants, which are not going to produce at their full capacity on their commissioning dates. It is however expected that they will operate at full capacity by their second year of production.

The principles that are going to guide determination of the biofuel manufacturing facilities' eligibility for Government support will include such aspects as:

- Contribution to liquid fuels industry transformation – This will be based on mandatory part ownership by HDSA.
- Facilitation of social inclusion – This will include mandatory part sourcing of biofuels feedstock from small holder and emerging farmers and other HDSA farming entities.
- Protection of agricultural land rights - Prior written consent from land owners to participate in the biofuels programme will be required.
- Positive contribution to rural development – The use of local labour; mandatory sourcing of services from rural SMMEs and co-operatives; and contribution to community initiatives;
- Avoidance of food security threats - Prohibition of diverting commercial farmlands to biofuels feedstock production
- Protection of scarce natural resources - Avoidance of deforestation; and controlled use of water to irrigate biofuel feedstock crops

In order to reduce the regulatory burden for potential role players and to streamline Government processes, it is being proposed that the criteria should also be administered and communicated to stakeholders by the Office of the Controller of Petroleum Products.

It has also apparently been mooted that, where profits made by manufacturers receiving the subsidy are in excess of a 20% return on assets, 25% of the excess portion of such profits should be paid into the State coffers (pers. comm. A Moodaly, November 2013). This clearly resurrects the issue of windfall taxes, and would no doubt also potentially revive the call for Sasol to be subjected to such taxes in the instance of there being large movements in the international oil price. The eligibility for subsidisation of a manufacturer may also be terminated if there is reasonable proof that they have failed to meet their obligations.

As stated at the beginning of this section, the criteria are still under review, and once finalised will be reviewed from time to time in line with changes in the industry landscape as well as the environmental and socio-economic needs of the country. It is however envisaged that there will be a revision of the subsidy mechanism at blending levels above 2% penetration of biofuels, to include stricter criteria for food and water security as well as environmental impact assessments.

3.3.2 Taxes and Levies Relating to Biofuels

Various issues associated with the taxation and levying of biofuels are being discussed by the BIC. SARS' view is that there is legislation currently in place to address the blending of fuel bioethanol into petrol. Said legislation implies that:

- Undenatured ethanol will be transferred, under Customs and Excise control, from distilleries to the blending points;
- The normal volume loss allowances would apply (0.25% storage and 0.25% transport), but losses in excess of this would be dutiable at the full potable ethanol excise duty rate, which is currently R122 per litre; and

- Depots would have to be registered as Vervaardiging/Manufacture (VM) warehouses, if blending is to take place in them.

These regulations are being discussed by the BIC, and hopefully clarity and consistency will emerge between the SARS regulations and the regulations governing blending, to ensure that there are no onerous bureaucratic procedures that will impede an easy integration of biofuels into the national fuel pool. For example, the fuel ethanol producers could be at risk for the R122 per litre excise duty, unless the denaturing of the bioethanol at the distillery is permitted.

As far as the taxes and levies on a so-called high blend bioethanol fuel such as the ED95 (see Overview of Biofuel Use in Fleet Transport) used by Scania are concerned, there are a number of considerations that still need to be clarified. This is because ED95 is a fairly recent development in the country. Biodiesel on the other hand has been produced for some years and is afforded a 50% rebate on the fuel levy, which is currently at R1.98 per litre. The second levy of importance is the Road Accident Fund levy, which is used to compensate people involved in vehicle accidents. This is currently at R0.96 per litre, and would be applicable in the case of both ED95 and B100 (pers. comm. A. Stevens of the Ethanol Producers Association of Southern Africa). Lastly, it is not clear whether high blend bioethanol and B100 would be exempted from paying the Excise Levy, which is currently set at R0.04 per litre.

3.4 Issues Relating to the Introduction of Biofuels

3.4.1 Fuel Standards

SANS 1164 which covers fuel ethanol for blending with gasolines for use as automotive spark-ignition engine fuel, has very recently been released. The following table details the properties required of the ethanol.

Table 2 - Requirements for undenatured fuel ethanol for blending into gasoline

Property	Requirement
Density at 20 °C, kg/m3	Report the density
Ethanol content plus higher saturated alcohols %(mass fraction) min.	98,7
Higher saturated (C3 to C5) alcohols %(mass fraction), max.	2,0
Higher saturated (C4), % (mass fraction), max.	0,5
N-propanol, % mass fraction, max.	1,0
Methanol content, % (mass fraction), max.	1,0
Water content, % (mass fraction), max.	0,30
Inorganic chloride content, mg/kg, max.	6,0
Copper content, mg/kg, max.	0,100
Total acidity (expressed as acetic acid), %(mass fraction), max.	0,007
Appearance	Clear, colourless
Phosphorus content, mg/l, max.	0,15
lnvolatile material content, mg/ 100 ml, max.	10
Sulphur content, mg/kg, max.	10,0
Solvent-washed gum content, mg/100 ml, max.	5,0
Total sulphate, mg/kg, max.	4,0
pHe	6,5 to 9,0
Electrical conductivity, µS/m, max.	300

SANS 1935, the South African Bureau of Standards' (SABS) biodiesel standard was established some years ago as follows:

Table 3 - Requirements for biodiesel

Property	Requirements
Methyl ester content, % mass fraction	>96,5
Density at 15ºC, kg/cm	860-900
Kinematic viscosity at 40ºC, mm2/s	3,5 – 5,0
Flash point ºC	>120
Sulphur content, mg/kg	<10
Carbon residue on 10% distillation residue % mass fraction	<0,3
Cetane number	>51
Sulphated ash content, % mass fraction	<0,02
Water content, % mass fraction	<0,05
Copper strip corrosion (3h at 50ºC) rating	Class 1
Oxidation stability at 110 ºC, h	>6
Acid value, mg KOH/g	<0,5
Iodine value, g of iodine/100g of FAME	<140
Linolenic acid methyl ester, % mass fraction	<12
Polyunsaturated methyl esters, % mass fraction	<1
Methanol content, % mass fraction	<0,2
Monoglyceride content, % mass fraction	<0,8
Diglyceride content, % mass fraction	<0,2
Triglyceride content, % mass fraction	<0,2
Free glycerol, % mass fraction	<0,02

The process has been initiated to have the SABS Fuels Standards Committee consider the formulation of a SANS standard/s for high blend bioethanol fuels such as ED95, for use in modified compression ignition engines (see section on Overview of Biofuel Use in Fleet Transport). The following table details the components that are included in ED95.

Table 4: Components which make up ED95

Component	Content		Type of product	Properties
	% by weight	% by volume		
Ethanol	91,4	92,66	Hydrous	Fuel
Denaturants	2,2 0,4	2,4 0,44	MTBE Iso-butanol	Denaturates the fuel. Some energy contribution.
Ignition improver	5,0	3,6	Poly ethylene derivative.	Ignites ethanol at the max compression.
Lubricant	1,0	0,9	Polymer.	Lubricant and detergent component.
Corrosion inhibitor	90ppm	90ppm	Morpholine	Protects engine and fuel system from iron corrosion.

The comparative properties of ED95 are given in the following table alongside those of mineral diesel and 95 octane petrol.

Table 5: Comparative properties of ED95, diesel and 95 octane petrol

Property	ED95	Diesel	Petrol 95
Density (kg/m3)	810-830	820-845	745
Flash point (°C)	12	>55	> -45
Vapour pressure kPa	5.83	< 0.04	45-70
Cetane number	~10	>51	Octane 95
Sulphur content (mg/litre)	Max 1	Max 10	Max 10
Biofuel (vol %)	>95	<7	5
Energy content (MJ/litre)	21.1	35.7	32.3

The key property to note here is the energy content per litre of ED95 in comparison to that of diesel i.e. ED95 only has 59% of the energy content of diesel, on a volumetric basis. Thus, when used as a fuel in a suitably modified compression ignition engine, you would require 1.69 litres of ED95 to achieve the same power output as that from a standard compression ignition engines fuelled with mineral diesel. Thus in order to provide consumers with equal power for equal money, the price of ED95 should be 59% of the diesel price per litre.

3.4.2 Ethanol Blending, Distribution and Retail Infrastructure

The biggest challenge that is faced in terms of fuel infrastructure, with the introduction of ethanol-petrol blends, is the presence of water. If water contaminates the fuel, the water dissolves into the ethanol and disperses through the tank. Once it exceeds the tolerance level, the alcohol-water mixture will separate from the petrol. Depending upon individual conditions, about 40% to 80% of the ethanol will be drawn away from the petrol by the water, forming two distinct layers. The top layer will be petrol that is a lower octane and perhaps out of specification, while the bottom layer is a mix of water and ethanol that will not burn. This is what is known as phase separation.

Depending on the temperature of the fuel, as little as 0.3% water can cause phase separation. Thus, in a 25 000 litre tank of a 2% ethanol in petrol blend, it takes only about 75 litres of water to cause phase separation. The potential for this occurrence thus requires that petrol oxygenated with ethanol should not be exposed to water during its distribution or use in a vehicle. Because of this requirement, ethanol blends are usually not transported in pipelines, which sometimes contain water. Rather, the ethanol should be added to the transport tanker trucks at the depot, immediately before delivery to service stations.

There are many ways for water contamination of a storage tank to occur:

- water accumulation around the fill gauge manhole
- faulty gaskets
- loose fill caps
- leaky fittings
- leaks in the tank itself.

Most tank gauging systems are not effective at measuring water below 1 cm. Removal of tank bottom water and other contaminants is recommended before introducing an ethanol blend. Most tanks are equipped with a gauge plate under the tank openings, and this can mask as much as 40 litres of water in the bottom of a tank. Also a tilt in the tank's positioning can mask significant quantities of water.

In addition to the water contamination problems, all other equipment also needs to be checked for compatibility with ethanol blends. Equipment such as pumps, nozzles, hoses, and meter seals have been made to be compatible with petrol-ethanol blends for some time now, so it is unlikely that they would need modification. Very old submersible pumps could require replacement of impellers or seals. Fuel retailers also need to determine the type of tank that will be used for storage of their ethanol-petrol blend. Mild steel tanks are completely satisfactory, whereas tanks that are lined with certain epoxy or polyester coatings may not be suitable for ethanol-petrol blends.

Since ethanol blends scour contaminants from the sidewalls and the bottom of a storage tank high-performance dispenser filters have to be used. The storage tank can accumulate a large amount of particulates that are typically mixed with water. Normal dispenser filters will prevent contaminants from reaching a customer's fuel tank, but they will not detect phase separation. It is thus essential that all water is out of the tank and recontamination does not occur before or after adding an ethanol blend to the tank.

It is important to note that once a gasoline-ethanol blend is brought into use, and the fuel distribution system is "dried" to accommodate it, is impossible to then revert to non-blended petrol, as petrol is inherently "wet". It is also important to be clear that the above problems with regard to water contamination of gasoline-ethanol blends do not apply in the case of high bioethanol fuels such as ED95, which already, purposely, contain water.

As far as the storage and dispensing of ED95 is concerned, in Sweden, it is dispensed from purpose-built, above ground tank stations, with a maximum volume of 40 000 litres. These comply with all the necessary environmental, health and safety regulations.

3.4.3 Overview of Biofuel Use in Fleet Transport

Various options exist for the fuelling of fleet transport vehicles, such as buses, delivery trucks and public utilities service vehicles, which generally make use of compression ignition engines. The possible fuels are biogas, biodiesel and bioethanol, each of which has its particular, supply, storage and other logistical advantages and disadvantages.

Biogas is a fuel that can be produced through anaerobic digestion of municipal solid waste (MSW), waste water, and other organic waste streams. After production it requires further processing to remove the carbon dioxide and any hydrogen sulphide it may contain. Thereafter, getting the gas to the customers is best achieved through a piped gas network. If such a network does not exist, the vehicles making use of the fuel should be filled at the point of biogas production. Vehicles using biogas require modifications to their engines, which are spark-ignition, and they will also have to be fitted with a suitable tank.

Biodiesel is a fuel that can fully replace mineral diesel, and requires no modification of the engine. However, a challenge faced by fleet operators, with the introduction of cleaner fuels standards, and increasingly sophisticated post-combustion exhaust clean-up, is that certain vehicle suppliers are not allowing the use of biodiesel, because it interferes with these new technologies. Furthermore, it can be difficult to ensure consistent quality in biodiesel production, and if it is not properly handled, or used within a prescribed time period can be subject to deterioration.

The use of bioethanol in compression ignition engines can either be in the form of a mineral diesel-bioethanol blend known as diesehol, or in the form of a modified, high bioethanol blend fuel, used in a suitably modified compression ignition engine. This latter option is discussed in the following section. Diesehol is a fuel that is still very much under investigation, and has as yet not received widespread acceptance by vehicle suppliers.

3.4.4 Scania Bioethanol-fuelled Engine Technology and ED95 Fuel

Bioethanol, when blended together with an ignition improving additive (see section on Fuel Standards), has been technically proven as a fuel suitable for use in compression ignition engines, despite the conventional wisdom being that is used in spark ignition engines, because of its high octane number. Among others, Scania has been using bioethanol in compression ignition engines since the 1980s with its current commercially-available third-generation version of this engine shown in Fig. 1.

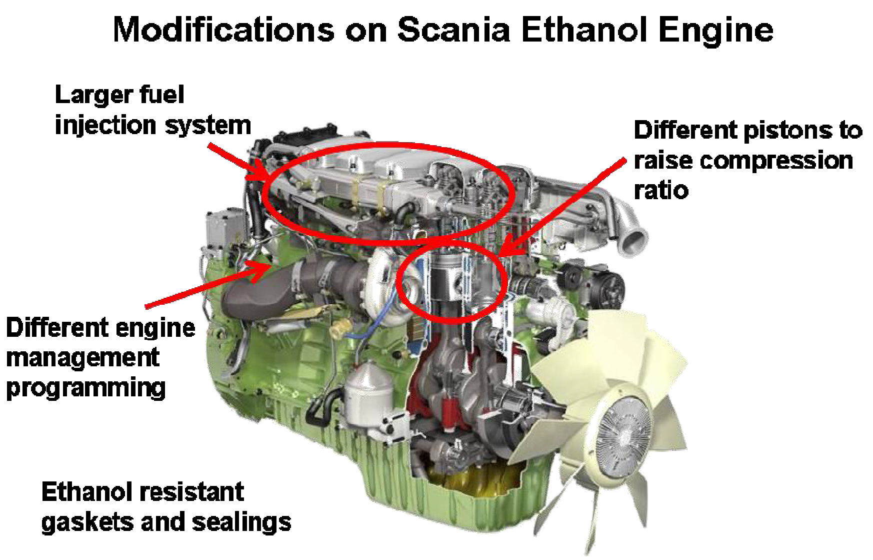

Figure 1: Scania Ethanol-Fuelled Compression Ignition Engine

The Scania bioethanol-fuelled compression ignition engine is based on a standard Scania diesel engine, with the following modifications. A higher compression ratio is used, up to 28:1, to both increase the thermal efficiency and cope with the high octane nature of ethanol. A larger volume fuel injection system is required because of the lower energy content per unit volume of the ethanol fuel in comparison to diesel. Of course, certain gaskets and seals, which are exposed to the ethanol, need to be changed to meet ethanol-resistance specs. In summary, there are some 40 components that are different to a conventional diesel-fuelled compression ignition engine. Finally, the engine management unit has to be programmed to handle the ethanol fuel.

Table 6: Specifications of Scania ethanol-fuelled compression ignition engine

Specification	Details
Model	DC9 E02 270 Euro-5 EEV engine
Fuel	Ethanol ED95
Cylinder displacement	9 litre, 5 cylinder
Max power	270HP (198 kW) at 1,900 rpm
Max torque	1,200 Nm at 1,100-1,400 rpm
Fuel injection system	EDC, PDE Unit Injector
Bore x Stroke	127 mm x 140 mm
Compression ratio	28:1

Scania has commercialised this specially developed ethanol compression ignition engine in their City Bus. In addition to Sweden, Scania ethanol buses have been tested in Brazil, China, Germany, Italy, Netherlands, Norway Spain and UK under the EU FP-7 co-financed project BioEthanol for Sustainable Transport (BEST) and other initiatives. In addition to Scania, SAAB has also worked on an ethanol-fuelled CI-powered passenger car.

The bioethanol fuel used in these engines is the ED95 described in the section on fuel standards. It consists of a blend of 95% by volume of 95% hydrous bioethanol, with 5% by volume of important additives. These effectively modify the nature of the bioethanol, thus making it suitable for use in compression ignition engines. It is important to note that using ethanol in compression ignition engines achieves a much higher efficiency of fuel use than when it is used in a spark ignition engine.

4 The Context for Biofuel Production and Use in the Western Cape

Agriculture is central to the Western Cape's economy, but the Province ranks amongst the most vulnerable to the effects of climate change in the country. Because of its Mediterranean climate and the predicted hotter, drier weather with less but more intense rainfall that climate change is expected to bring, the Province is expected to experience four critical conditions, namely increased incidence of fires, floods, and drought as well as increases in wind speed.

It is thus predicted that the agricultural sector will experience challenges as a result of heat stressing of crops, diminishing water resources and resultant vulnerability of the poor and marginalised groups. However, on the positive side, public and private-sector investments in new sustainable resource use approaches such as renewable energy, energy efficiency, organic farming, zero waste, sustainable aquifer management and waste recycling could transform these threats into significant growth opportunities.

4.1 Biofuels Policy in the Western Cape

Although the production of biofuels has traditionally been associated with crops that are not commonly grown in the Western Cape, in the mid 2000s, in addition to the need for renewable energy, a number of reasons were identified that led to an investigation into the potential for development of a biofuels industry in the Province. The first of these reasons was the clear upwards pressure on the price of crude oil. The movement from less than $30 per barrel in 2003 to close to $140 per barrel in 2008 placed an increased emphasis on the need to find alternative energy sources. (Troskie and Grwambi, 2009)

The second reason for the interest in biofuels was downward pressure on the wheat price, as well as the unfavourable transport differential between Paarl in the Western Cape and Randfontein in Gauteng, which Western Cape farmers had to bear. This prompted efforts to find alternative markets for local produce. The third reason was also closely linked with markets, as domestic and international experience has shown that the chances of success for new entrants into agriculture increase dramatically if they can rely on a secure market. Thus, it was felt, a local biofuels industry could potentially provide significant support to the land reform programme in the Western Cape.

The fourth driver was that, although South Africa is generally a net importer of wheat, the Western Cape as a region is a surplus producer. However, this surplus, which has, over the last couple of decades, consistently been between 200 000 and 300 000 tonnes/yr, is generally in the B3, B4 and Utility wheat grades. These grades attract lower prices, and are primarily sold into the animal feed market. In the light of this, and the other market-related issues outlined above, it would make sense to use this surplus for other, higher-value end-uses, without endangering food security in the Province.

As the result of an approach from GrainSA, an investigation was conducted by the Western Cape Department of Agriculture into the viability of a biofuels industry in the Province, based on local production of winter grains. In the resulting report by Lemmer (2006) it was found that the establishment of a viable industry would lead to a biofuels production plant processing around 290 000 tonnes of small grains, primarily wheat, producing about 104 million litres/yr of bioethanol, and achieving a net margin of R69 million annually. This implied an additional value added of R243 per tonne of wheat. In addition a one-time benefit of a R302 million investment injection, and 150 jobs would result during the construction phase of the plant.

Once the plant was in full production, between 40 and 50 specialised jobs would be created and the backwards and forwards economic linkages would lead to the creation of between 560 and 750 further jobs. However, almost more important is that rain fed agriculture in the cropping areas of the Western Cape would be supported, and the livelihoods of an estimated 7 650 people on the grain growing farms would be secured.

It was also argued that, if approached correctly, such a plant would create black economic empowerment (BEE) opportunities, as well as the opportunity for enhanced BEE at farm level, through the establishment of secure markets for new entrants. In the latter case it was argued that this would allow new entrants to focus on production and gaining of farming experience without being exposed to market vagaries. In addition the waste products from such a plant e.g. dried distillers grains and solubles (DDGS) would replace imported animal feed protein sources such as soya oil press cake, and also provide the opportunity for feedlots to be created next to such a plant. Again this would create BEE opportunities. The Report concluded that a more detailed and in-depth study should follow.

It was clear from Lemmer (2006) that the establishment of a biofuels industry in the Western Cape would potentially support a number of general growth initiatives, and more importantly, targets for rural economic growth, employment creation and equity distribution. As a result, the Economic Portfolio Committee of the Western Cape Cabinet appointed an Inter-Departmental Task Team to further investigate the establishment of a biofuels industry (WCIBTT, 2007).

This Task Team was chaired by the Department of Agriculture and consisted of representatives from the departments of Environmental Affairs and Development Planning, the Premier, Economic Development and Tourism and Transport and Public Works and the Provincial Treasury. Its mandate was to:

- Develop an official provincial response to the Draft National Biofuels Industrial Strategy; and
- Report back to the Economic Portfolio Committee of Cabinet on the future of biofuels in the Western Cape.

As potential feedstocks, the Task Team evaluated winter grains i.e. wheat, barley and triticale for bioethanol production and canola, soya beans and jatropha as biodiesel feedstocks. It was found that all these crops would have a beneficial impact on economic growth and support BEE opportunities, largely through the opening up of alternative and secure contract markets for emerging farmers (WCBITT, 2007). Jatropha was however deemed a non-viable option because of its classification as an invader plant. Furthermore, it was felt that by potentially displacing existing food crops, jatropha could have a negative impact on food security.

The two other potential feedstocks for biodiesel production, canola and soya were found to have a positive ecological footprint, but South Africa was still a net importer of these products. Thus the Task Team focussed only on winter grains meeting all the criteria for economic growth, BEE involvement, positive ecological footprint, food security and availability. It is curious that soya was ruled out by them, as it is essentially being imported for its protein-rich press cake, which would still be available as a by-product, if the oil was being used for biodiesel production.

To identify the potential ideal location of a biofuels plant in the Western Cape, the following criteria were used:

- Adequate availability of suitable dry land production area (Irrigable land and water were considered to be too precious to use for the production of biofuels feedstock and only to be used for food production. For this reason they were not included in the Task Team's study).
- Ecological sensitivity of the area.
- Profitability of production.
- Available infrastructure, roads, silos, etc.
- Proximity of refineries for blending with existing carbon fuels.
- Patterns of fuel consumption within the Western Cape.
- Linkages to Integrated Development Plans of Municipalities.

By applying subjective weightings to the above criteria for the candidate towns, it was found that the most appropriate location of such a plant would be in the Swartland area and, more specifically, somewhere between Malmesbury and Atlantis. The Task Team also confirmed the financial viability, alternative market creation, BEE potential, employment creation and surplus production capacity that were initially identified by Lemmer (2006). The Task Team was concerned that the then current bioethanol production technologies would only create a window of opportunity for between ten and fifteen years. Thereafter it was felt that the next generation of so-called second generation biofuels technology would become the norm and any existing plant or plants would need to be upgraded accordingly.

In addition to the above, and almost more important, were the findings by the Task Team that the development of a biofuels industry in the Western Cape would only succeed if the appropriate policy instruments and institutions were in place. It was felt that a favourable regime for mandatory biofuels blending, production licensing and incentives needed to be in place at a national level, and it was estimated that, if the appropriate provisions identified in the National Biofuels Industrial Strategy were not in place, a provincial subsidy of approximately R100 million/yr would be required to ensure the long-term viability of a biofuels industry producing 100 million litres/yr in the Province[1].

[1] According to Tait (2013) the subsidy per litre of bioethanol produced from grain sorghum will be between R2.00 and R3.00 per litre. This would thus far surpass the R1.00 per litre subsidy shown to be needed in the modelling done by the Western Cape DoA.

In conclusion it was clear from the findings that a biofuels industry in the Western Cape would contribute to National, Provincial and Local Government development policies and strategies, but that it was dependent on:

- The primary objectives of the National Biofuels Industrial Strategy being implemented.
- The nature of the technology employed.
- The nature, type and availability of suitable business partners.

The Task Team's report was presented to the Economic Portfolio Committee of Cabinet on 19 September 2007. At this presentation a number of questions were raised by the Portfolio Committee which required further investigation. These included:

- What is the international experience regarding biofuels with specific reference to its impact on developing countries?
- What would the impact of a biofuels industry be on domestic food security?
- How would the development of a biofuels industry contribute to the provincial renewable energy target?
- How could a biofuels industry be located in the renewable energy strategy of the Province?
- How would the biofuels industry link to the provincial fuel levy?
- What are the international trends regarding the production of biofuels from biomass?
- How vulnerable are existing and near release small grain varieties to climate change?
- What is the carbon balance (ecological footprint) of biofuels relative to that of fossil fuels and other renewable energy sources?
- What is the energy balance of biofuels relative to that of fossil fuels and other renewable energy sources?
- What is the cost per unit of biofuels relative to that of fossil fuels and other renewable energy sources?
- What are the appropriate incentives that provincial government can provide?

However, before the above questions posed by the Cabinet Committee could be addressed, the long awaited National Biofuels Industrial Strategy was released in December 2007. The objectives of this Strategy are laid out elsewhere in this document.

In reaction to the national Strategy, the Western Cape Biofuels Task Team judged that the prescriptions were not conducive to the establishment of a biofuels industry, in the Province, based on existing grain to bioethanol technology. Furthermore, it was determined that there was very limited underutilised or new land that could be brought into production, as dictated by the National Strategy. The available existing agricultural incentives also needed to be oriented towards land reform beneficiaries and were not nearly sufficient to cover the costs associated with the establishment of a biofuels industry. Finally, the high food prices at the time, combined with global shortages of grain led to questioning of the prudence of the Provincial Government providing support for fuel production from grains.

These factors ultimately led to a decision being taken by the Task Team not to proceed with the development of a biofuels industry based on food crops in the Province. It was, however, recognised that second generation bioethanol technologies under development might provide the basis for a viable biofuels industry in the future, and also hold advantages for economic development in rural areas. The next step was thus deemed to be to identify these technologies, and to evaluate them and consider whether they merited future support. However, this step was not followed through, and in 2009, the development of a provincial biofuels industry was essentially placed indefinitely on hold.

It is of interest to note that the Western Cape Department of Agriculture itself is concerned about the lack of alternative markets for the Western Cape's grain farmers, and in 2012, it initiated a study to investigate the potential for the establishment of a beer brewing industry based on micro-breweries (Troskie, 2012). However, following initial studies, this too has not been followed through, and not resulted in any coordinated development.

It is evident that circumstances have changed significantly since 2009 with respect to bioethanol production technologies, macro and agricultural economics, and national and provincial development imperatives. There have also been significant advances at the national level with respect to the biofuels regulatory environment. It is thus suggested that the time has come to thoroughly re-examine the potential for the development of an agriculturally-based biofuels industry in the Western Cape.

4.2 Western Cape Fleet Fuel Demand

4.2.1 Public Transport

Transport for Cape Town - Transport Authority

The Transport Authority, known as Transport for Cape Town (TCT), introduces a new era for public transportation in Cape Town, focussing human and other resources, skills, and finances to deliver a superior service to the citizens and other partners of the City (City of Cape Town, 2013a).

The Transport Authority has been established:

- To be the custodian of all transport matters within the City itself;
- To be the interface with surrounding municipalities and other transport related stakeholders; and
- To be the single point of responsibility for public transport matters for the Cape Town Metropolitan functional area.

TCT, as constituted in terms of the National Land Transport Act (NLTA), is mandated by the Act to fulfil a number of functions to allow it to plan and implement an integrated transportation system in Cape Town. The Constitution of Transport for Cape Town By-law (2013) has assigned the aforementioned functions, roles and responsibilities to various entities, the most important of these being the Cape Town Integrated Rapid Transport (IRT) System.

Cape Town IRT aims to integrate all modal options into a coherent package for the customer and to give priority over private transport. A major component of this system is the Bus Rapid Transit (BRT) system, which comprises a high quality bus-based transport system that delivers fast, comfortable and cost-effective urban mobility with segregated right-of way infrastructure, and rapid and frequent operation.

Implementation of the bus component of the IRT system has been divided into four Phases. Phase 1 focuses on the central city and the corridor towards Blaauwberg, Dunoon and Atlantis. The second phase will provide a more extensive service to the southeast parts of the city, including Mitchells Plain and Khayelitsha to destinations across the peninsula. Phase 3 will incorporate Bellville, Delft, the rest of the northern suburbs and Stellenbosch, and the fourth phase the Greater Helderberg area. The network will ensure that more than 75% of people are within 500m of a high-quality public transport system (Cape Town, 2013b)

MyCiTi Integrated Rapid Transit (IRT) System

The first BRT network component of the MyCiTi IRT was launched in May 2011. The MyCiTi system provides reduced travelling times especially during peak hours due to its dedicated, median busways. The dedicated lanes also reduce operating costs, making fare levels affordable and thereby encouraging a shift from private car use towards public transport. The implementation of the BRT component of the IRT system is designed for integration with other modes of transport, especially rail, the backbone of public transport in Cape Town.

Section 33 MyCiTi Vehicle Operating Company (VOC) contracts

Key to further operational expansion of the MyCiTi system is the awarding of VOC contracts to companies largely formed by affected minibus taxis and scheduled bus operators whose services will be replaced by the new IRT system. On 28 August 2013, the City of Cape Town Council approved 12-year contracts to three new Vehicle Operating Companies (VOCs) to expand the roll out of the BRT to other routes in the city. Section 33 of the Municipal Finance Management Act No. 56 of 2003 (MFMA), requires that City Council be assured that contracts spanning more than three financial years are financially sustainable and will not burden the City's revenue streams for the full duration of the contract. Each VOC will be contracted to provide both trunk and feeder services and the contracts will be paid by way of a fee per kilometre of service provided. The duration of the contracts is meant to correspond with the lifespan of the vehicles, which are to be procured by the City and leased to the VOCs through a financial institution and subsequently transferred to the VOCs at a nominal fee.

VOC Structure and responsibilities

Newly appointed MyCiTi VOCs recently established by minibus-taxi owners' associations and scheduled bus operators, will be tasked with operating parts of the MyCiTi service on the premise that:

- A majority of the current minibus-taxi operators must agree to having their operating licences suspended, and to scrapping their vehicles in favour of a shareholding in one of the VOCs.
- Competing bus companies must give up their subsidies for competing routes.

The VOCs will be responsible for:

- Operating the buses, in accordance with the timetables and routes as stipulated by Cape Town's MyCiTi team;
- Maintaining the buses they are allocated to operate on these routes; and
- Managing the bus depots and staging areas.

Funding MyCiTi sytem operations

The operation of the IRT bus services will be funded through fare and advertising revenue and grant funding from the:

- National Government's Public Transport Infrastructure Grant;
- The Public Transport Network Operating Grant; and
- The Public Transport Operating Grant.

The City will also contribute a portion of its annual rates revenue to the project. A limit of 4% of rates was agreed to by Council but only an estimated 2% of the revenue from rates is expected to be used for the operating costs of the first phase of the 12-year contracts.

Table 8: My CiTi bus system by the numbers

<table>
<tr><td colspan="3">My CiTi buses, model, type and size</td></tr>
<tr><td colspan="2">Phase 1A</td><td>Phase 2 / N2 Express (Initial order only)</td></tr>
<tr><td colspan="2">• 221 x Optare Solo SR (9 m)
• 42 x Volvo B7R (12 m)
• 8 x Volvo B12m (18m)
• 42 x Scania (12m) – In prototype development
• 24 x Scania (18m) - In prototype development</td><td>• 20 x Volvo B9L (12 m low floor) – In production
• 20 x Volvo B9LE (18 m low floor) – In production</td></tr>
<tr><td colspan="3">My CiTi VOCs and their depots</td></tr>
<tr><td>Transpeninsula Holdings</td><td>Kidrogen</td><td>TBART</td></tr>
<tr><td>• Prestwich Street, Cape Town
• Foreshore</td><td>• Stables Depot – Potsdam Rd, Dunoon</td><td>• GABS Depot – Woodstock
• Atlantis Depot</td></tr>
<tr><td colspan="3">Fuelling of the buses (Where? How?)</td></tr>
<tr><td colspan="3">• All buses run on diesel
• Buses are fuelled at their depots
• New depots have e-fuel fitted to the bowser pumps but no devices fitted to the buses.
• VOCs record the fuel manually.</td></tr>
</table>

Table 9: Projected MyCiti monthly diesel consumptions per VOC

VOC	Vehicle Type	No. of Buses	Fuel (1/100km)	Monthly kms*	Litres of Diesel/ month	Total litres/ month
Transpeninsula	18 m Artic	0	61.81	0	0	
	12m Rigid	10	27.72	61 401	17 021	
	9m Solo	80	33.67	235 316	79 241	**96 262**
Kidrogen	18 m Artic	11	61.81	33 509	20 712	
	12m Rigid	28	36.94	128 474	47 462	
	9m Solo	89	26.65	335 848	89 504	**157 678**
TBART	18 m Artic	12	61.81	73 176	45 230	
	12m Rigid	19	31.20	79 098	24 675	
	9m Solo	18	28.54	63 992	18 265	**88 170**
Total				**1 010 816**		**342 110**

* Long-term average monthly kilometres to be travelled when the full Phase 1 is rolled out.

Golden Arrow Bus Services (Pty) Ltd

Golden Arrow Bus Services (Pty) Ltd (GABS) is the largest private bus company in the Western Cape. It operates a subsidised and scheduled bus service throughout the Cape Metropolitan Area on a single comprehensive permit which covers all routes and services. The services are predominately provided under an interim contract with the Western Cape Government's Department of Transport that commenced in April 1997. This contract is currently being extended on a monthly basis, and with the formation of the TCT, the responsibility for its administration will soon pass to this body.

GABS operate 1 073 buses on nearly 400 schedules. A total of 2 269 scheduled routes are served in the Cape Metropolitan Area. The fleet covers 56 million kms, transporting over 39 million passengers, and consuming around 20 million litres/yr of diesel.

The average age of the GABS fleet is 10 years, with 214 of the buses being less than two years old. GABS has around 700 MAN buses in service, accounting for more than two thirds of its fleet. These buses are designed specifically for African conditions and meet Euro 3 operating standards.

Sibanye Bus Services

Sibanye was established as an equal shareholding joint venture company between Siyakhula Bus Services, Abahlobo Bus Services and GABS in 2001. Since then it has successfully operated the Atlantis routes as a subcontractor to GABS, which handed over these routes as part of the company's commitment to the economic empowerment of previously disadvantaged bus operators. Sibanye operates a total of 20 timetables in the area. Sibanye also provides the Jammie Shuttle service for the University of Cape Town (UCT), the service having been designed to ease the traffic congestion and parking space limitations at UCT.

The average age of the Sibanye 78 vehicle fleet is 10 years. The company carries close to 4 million passengers, covers just under 4 million kms, and consumes around 1.35 million litres/yr of diesel.

4.2.2 City of Cape Town and Western Cape Government Fleets

The City of Cape Town operates a fleet of over 6 500 vehicles, which are separated into the Solid Waste Management, Electricity, Water and Sanitation and Corporate fleets. The City of Cape Town's Solid Waste Management Department operates a fleet of 165 19 cubic metre garbage compactors. Each of these covers an average of 10 507 kms/yr, consuming around 9 507 litres of diesel each. This total fleet annual consumption is over 1.56 million litres of diesel.

The Western Cape Government only operates a fleet of passenger vehicles, with all services requiring heavier vehicles being outsourced to the private sector.

4.2.3 Logistics and Distribution Transport

Imperial Logistics Refrigerated Services (ILRS) is a major provider of local delivery services in the Western Cape, providing outsourced services to a number of the major retailers. They operate a fleet of around 260 vehicles, 70% of which are local delivery vehicles, with engines typically in the 250 hp range. Their fleet currently consists solely of Mercedes-Benz vehicles, although they are considering a possible order of 30 vehicles as part of their fleet recapitalisation programme in 2014.

ILRS's past experience with biofuels has not been good. They did at one stage, under instruction from a major client, Woolworths, fuel part of their fleet with a biodiesel blend.

However, poor quality biodiesel resulted in severe damage to a number of their vehicles, and as a result this was discontinued. At the time of writing, this is the status quo and according to Woolworths' logistics management, this will not alter until such time as they can be given confidence with regard to the quality of biofuels in the market. ILRS currently provide 90% of Woolworth's local delivery services in the Western Cape, consuming of the order of 1.2 million litres/yr of diesel.

4.3 Other Potential Uses for Bioethanol

4.3.1 Use of Bioethanol as a Household Fuel

Project Gaia, Inc. based out of Gettysburg, Pennsylvania is a US non-profit organization that is part of a global initiative promoting clean-cooking fuels, particularly alcohol cooking stoves, to the poorest part of the World's population (www.projectgaia.com). Project Gaia's first focus has been on clean-burning stoves because nearly 3 billion people worldwide cook and/or heat their homes using fuels such as wood, charcoal and dung, resulting in a smoky and unhealthy living environment.

Part of the solution has been the CleanCook stove designed by Dometic AB, formerly a division of the Swedish Electrolux Group. It was selected by Project Gaia because of its ease of use, safety and affordability. It burns bioethanol cleanly and is highly efficient. The fuel tanks hold the ethanol in a special adsorptive fibre, so the opportunity for dangerous spills is virtually zero, even if the stove is turned upside down.

This stove is also a big improvement over paraffin and LPG stoves that are the usual alternatives to wood or charcoal stoves. Paraffin is dirty and dangerous. In addition, paraffin, once widely subsidized by developing country governments to promote the move from fuelwood to liquid fuels, is now being widely deregulated, as governments can no longer afford the subsidies. The result of this deregulation is rapidly increasing prices, at a rate of 200% per year or more in many markets. All over Africa, people are moving back from paraffin to fuelwood and charcoal. Even in Brazil, because of price deregulation of LPG, there has also apparently been a move back to fuelwood.

An estimated 20 million South African households rely on solid fuels such as coal and firewood, and they also consume over 700 million litres/yr of paraffin. Because paraffin is often stored in cold drink bottles, it is accidently ingested by up to 80 000 children per year, with 40 000 of them developing chemical pneumonia as a result. Furthermore, as a result of paraffin-related fires, more than 200 000 people are injured or lose their homes and possessions per year.

In 2001, Project Gaia conducted pilot tests uses the Origo 3000 stove, a precursor to the Dometic CleanCook, in eMbalenhle Township, 140 km southeast from Johannesburg with methanol as the fuel. Study results showed that:

- Families liked the stove's appearance and size. Pots fitted properly on it, and the stove stability and the spill-proof fuel canister made it very safe
- Heating power was greater than local paffin stoves.
- Taste and fuel economy were well-rated.
- Best of all, the clean-burning stove neither smelled of paraffin nor stained the pots.

As further funding was not available at the time, the project ended with the pilot. Nonetheless, it is clear that the experience that Project Gaia has gained in larger roll-outs in Ethiopia, Nigeria, Mozambique, Brazil, Haiti and other countries, could well be applied in

South Africa. As Western Cape townships are often affected by paraffin-related fires, it would appear to make sense to explore this possibility in greater detail.

4.3.2 Use of Bioethanol in Agricultural Machinery and Other Engines

In the 1970s and 80s extensive studies were conducted by the sugar industry in KwaZulu Natal on the use of ethanol in tractor engines. The potential for this application should be investigated in the Western Cape. Furthermore, CA Components, a diesel engine manufacturer in Atlantis, has expressed an interest in investigating the development of high blend ethanol-fuelled compression ignition engines.

5 A Review of Biofuel Production Pathways Using Wastes

Regardless of the substantial and material promise of dedicated energy crops, waste has increasingly become the biofuel feedstock receiving the most attention in terms of process development. This has largely to do with waste's ability to answer three of the most pressing problems blocking biofuel production capacity expansion. These are:

- Feedstocks need to be available, as far as possible, at fixed, affordable prices. Waste is sometimes free, sometimes even available with a negative-cost tipping fee, and it is often available on the basis of fixed, long-term supply contracts.
- Ideally feedstocks should not be too dispersed, requiring transport to the process plant, and wastes are generally fairly well aggregated.
- Wastes are less subject to considerations such as indirect land-use change that have plagued energy crops, and they evoke few protests, if any, on the basis of adverse environmental impacts. On the contrary, the use of wastes can often obviate such impacts.

Figure 2 shows the pathways that can be used to convert various feedstocks into biofuels. In this study we have focussed on those that yield bioethanol using wastes as the feedstock. These raw materials would typically be starchy, sugary or lignocellulosic in nature. One of the most researched sources of waste-related feedstock are agricultural and forestry residues, which can be classed as lignocellulosic, as shown in the figure.

5.1 Feedstocks and Processes for Bioethanol Production

A great deal of attention has been paid to so-called advanced second and third generation processes, to produce bioethanol, using waste streams as feedstocks. These processes are at varying stages of development, and a number of those regarded as furthest developed, are briefly described in Appendix B.

These advanced bioethnaol production pathways take lignocellulosic feedstocks, as shown in Figure 2 overleaf, and then subject them to processes such as enzymatic hydrolysis and gasification. In the former case, the resulting sugars are then fermented in the conventional manner to produce bioethanol. In the gasification case, the resulting syngas is then passed into a gaseous fermentation process, where once again bioethanol is produced.

It is of interest to note that several of the companies discussed in Appendix B had intended making Initial Public Offerings in 2013, but they were all withdrawn, citing unfavourable financial market conditions. This demonstrates the unpredictability of the renewable fuels industry, and its ongoing vulnerability to shifts in macro- and micro-economic factors and trends such as, for example, the shale gas boom in the US.

Of possible interest in the context of the Western Cape are the large facilities for cellulosic bioethanol production. Those that have either already been commissioned or under construction, include, Abengoa´s facility in Hugoton, USA (75 million litres/yr), POET-DSM's facility in Emmetsburg, USA, (75 million litres/yr), Beta Renewables' facility in Crescentino, Italy, (40 million litres/yr) and INEOS Bio's Vero Beach facility (24 million litres/yr) (Bacovsky et al, 2013).

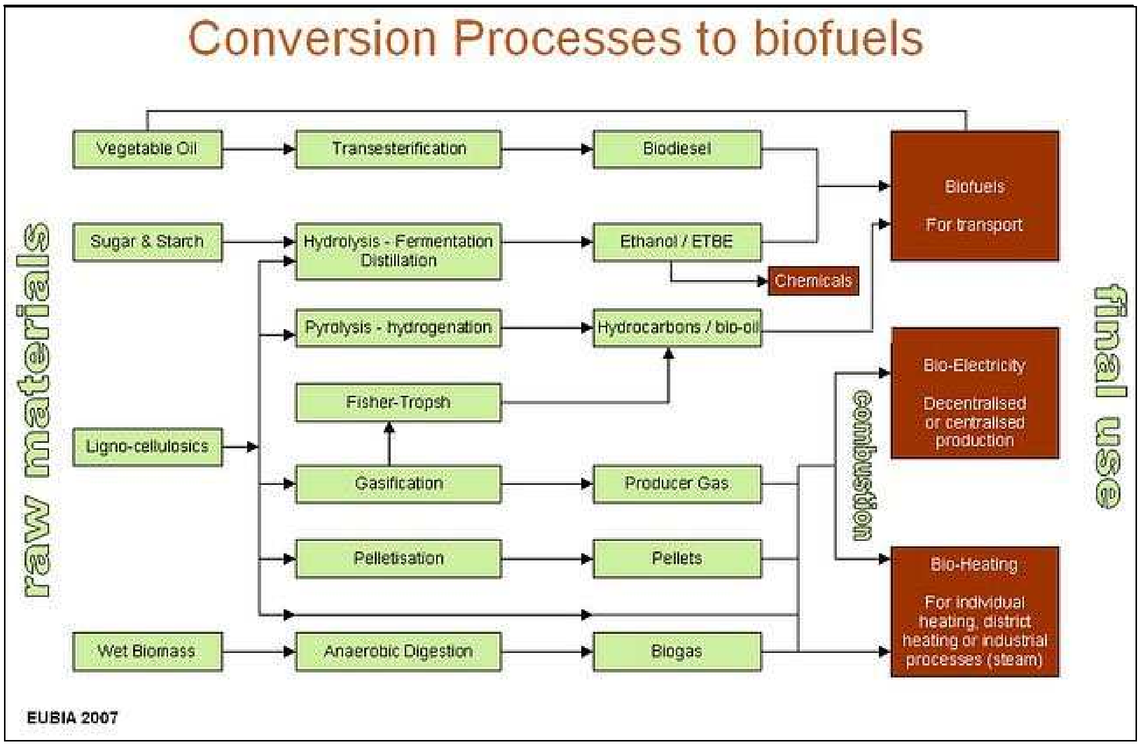

Figure 2: Pathways for the conversion of various feedstocks to biofuels (EUBIA, 2007)

5.2 Feedstocks and Processes for Biodiesel Production

Although this report focusses on bioethanol, this section is included to give an indication of potential paths for the expansion of biodiesel production in the Province.

Given the pricing challenges faced by the production of biodiesel from virgin vegetable oils, a number of processes can take various waste streams and produce clean diesel fuels. Some of these are based on the well-established transesterification process, while others are more innovative in nature, and make use of emerging new technologies.

It is clear when one looks at the price of virgin cooking oils, such as sunflower, canola and soya oil in the retail sector, their price is such that it is impossible to contemplate their conversion into biodiesel. Thus, biodiesel processes using waste streams seem to be the only ones that would currently make financial and economic sense.

5.2.1 Waste Vegetable Oil

There are already a number of companies producing biodiesel from waste vegetable oil (WVO) that is collected from restaurants and fast food outlets. Generally this collection is done by the suppliers of the fresh cooking oil, who then pass it on to the biodiesel producers. As these producers are all small-scale i.e. typically producing under the 300 000 litres/yr level, it is difficult for them to ensure the quality of their product, as they can not afford the necessary quality control laboratory equipment. This has resulted in a number of costly situations arising where customers have suffered engine damage as a result of sub-standard biodiesel being supplied.

It is also understood that there are other challenges faced by the WVO biodiesel industry as a result of competing uses for their WVO feedstock. There is a demand for used cooking oil for use in various animal feed formulations. In addition, there is also apparently a thriving export market for WVO, the destination of which is not entirely clear. Anecdotal evidence suggests that some of it is going to China and India for biodiesel production. It has also been heard that unscrupulous companies are filtering and bleaching the WVO, rebottling it and selling it as "fresh" cooking oil.

5.2.2 Fats, Oils and Grease

As the demand for biodiesel increases and viable WVO, or so-called yellow grease, sources are becoming ever scarcer, entrepreneurs have begun to pursue the conversion of select brown grease resources i.e., free fatty acid (FFA) content >15%, to biodiesel (Ragauskas *et al*, 2013). The attractive features of commercially recovered brown grease are fourfold:

- Lower feedstock cost.
- Large volume of resource available.
- Governmental mandates requiring collection and processing of select brown greases.
- Avoidance of Food vs Fuel concerns while contributing to the development of renewable fuels.

One of the biggest sources of brown grease is the material trapped and recovered in grease inceptors/traps that many commercial food processing centres are mandated to have, in the US and Europe. Grease abatement plumbing devices are usually non-mechanical gravity separation flow-through devices that facilitate the recovery of grease and food solids from aqueous waste streams. Depending on the size of food processing operations, modern building/business codes often require the installation of grease traps or interceptors. Grease interceptors are multi-compartment chamber devices where the aqueous grease containing flow is retained long enough so that grease and some solids can rise to the water surface and most of the solids settle to the bottom.

Historically, this material was collected and landfilled, although other options included land application, compositing, rendering for lubricants/soaps, or incineration. Direct disposal is becoming more challenging due to legislative regulations and overall decreased access to inexpensive landfill options. The two most attractive future applications for grease trap waste are anaerobic co-digestion of the fats, oils and grease (FOG) to biogas, or to use them for biodiesel production. Several companies in the US and Europe are now actively pursuing the conversion of FOG to biodiesel.

The initial processing of FOG requires that prior to esterification of the FFAs, the FOG needs to be screened to remove solids, then degummed, sulphur depleted, and dried. It is clear that the conversion of FOG to biodiesel will be accompanied with a substantial water fraction that needs to be disposed of in an acceptable manner. Hence, co-siting this process alongside a waste water treatment facility is the preferred option.

5.2.3 Lignocellulosic Wastes and MSW

Advances in the development of smaller-scale Fischer-Tropsch (FT) reactors have led to opportunities for the production of clean biodiesel from a variety of lignocellulosic feedstocks, such as crop residues and forestry wastes, and MSW. The process followed is achieved either through the direct gasification of the feedstocks, and then feeding the resultant syngas to the FT reactor to produce the liquid fuels. An alternative path is to first anaerobically digest the biomass feedstock to produce methane in the form of biogas. This gas is first stripped of it carbon dioxide and hydrogen sulphide components, and then reformed to produce the requisite syngas for feeding into the FT reactor.

An example of a project using the solid biomas to liquid fuels process is GreenSky London, Europe's first commercial scale sustainable jet fuel facility, being developed in partnership with British Airways. In 2012, Velocys was selected by project developer Solena Fuels to provide its FT technology. GreenSky London is the first of several waste biomass to jet fuel projects planned by Solena. Through using Solena's plasma gasification process and Velocys' FT process, it will convert 500 000 tonnes/yr of London's MSW, previously destined for landfill, into 50 million litres of low carbon jet fuel, 50 million litres of ultra-low sulphur FT diesel and green naphtha, as well as green power. The project should be fully operational by 2015, and carries a price tag of over R3 billion.

5.3 Food Security and Biofuels Production

In the light of the above, as the Food vs Fuel debate has long been a central issue in all biofuels-related discussions, it important that this be addressed.

The most concise and recognised definition of food security was declared by the FAO at the 1996 World Food Summit (FAO, 2006):

> "Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2006)".

Commonly, the concept of food security is defined as including both physical and economic access to food that meets people's dietary needs as well as their food preferences. It is widely recognized as a complex social problem, and while there is broad agreement that it involves ensuring that everyone has sufficient food for a healthy and productive life, research in the field encompasses a wide range of perspectives, objectives and methodologies.

There are four commonly recognised components, or pillars, that characterise food security, and they are (FAO, 2006):

1. Utilisation, which involves benefitting from a healthy diet with all the nutritional elements human bodies require, lacking any health hazards;
2. Access, which involves people having the resources, economic as well as legal and political, to obtain their food;
3. Availability, which involves matching food supply with demand, through production and distribution; and
4. Stability, which ensures utilisation, access and availability are not compromised by sudden economic or environmental shocks.

There is also an increasing awareness that no single role-player can meaningfully address food insecurity acting in isolation. The complex interactions within and between social, economic and natural systems, that characterise food value chains, call for better communication and collaboration between role-players in the state, business and civil society sectors. Numerous studies have shown that more attention ought to be given in particular to the role of the private sector in ensuring food security: While government leadership is crucial for addressing the implications of the food crisis, business also has a vital role to play in partnership with others to develop and implement innovative responses.

It is against this backdrop that the various biofuel initiatives that are being driven by the private sector in the Western Cape should be evaluated. These efforts are primarily driven by the need to provide farmers with alternative markets, and to assist them in ensuring the sustainability of their operations, thus keeping them on the land, and able to play their role in contributing to food security. Clearly, a viable and sustainable agricultural sector is fundamental to ensuring food security. Furthermore, it is a key provider of employment in the Western Cape, and as such provides households with incomes thus addressing the issue of *access* to food. As was discussed earlier, there is actually a surplus of grains cultivated in the Western Cape, thus implying that, at least in this regard, there is no real threat of food insecurity. Rather, it is the economics of international food trade that cause these market distortions, and prevent food from being accessed by those who might need it.

Another factor that should be borne in mind is that the Food vs Fuel land use challenge can be partly solved with the deployment of Integrated Food-Energy Systems (IFES), simultaneously producing food and energy (PANGEA, 2013). Farming methods combining the production of both food and energy can help rural communities solve two of their main problems, i.e. lack of energy access and food scarcity. There are some to keys to achieving successful IFESs.

Firstly, multiple-cropping systems can be used in conjunction with livestock and/or fish farming. Secondly, using agro-industrial technology to produce renewable energy can integrate the processes by using all of the by-products and feeding them back into the system, thus promoting higher crop yields. Anaerobic digestion for biogas manufacture is an example of one of these technologies.

It should also not be forgotten that energy is needed to produce food, and investment in biofuel and bioenergy production can leverage investment and infrastructure to produce more food, not less. In Africa in particular, many other factors have a much more significant influences on food production and prices, such as lack of food storage, post-harvest losses, climatic and weather extremes and national development policies.

5.3.1 Case Study on the Food Security Impacts of the Cradock Bioethanol Project

A research project conducted by a postgraduate student at the Imperial College in London, based on a case-study approach, performed an assessment of the potential impacts of the proposed Cradock bioethanol project (Besharati, 2012). It focussed on whether food security will be enhanced or damaged by the project. Data collection was characterised by field work in the project area, which consisted primarily of semi-structured interviews with Cradock's population, the project stakeholders and other role players. This was further complemented by observational data and field notes.

A system was developed to quantify scores against indicators, which, in turn, fulfilled criteria towards achieving food security. Fifty interviews were conducted with households residing in underprivileged neighbourhoods, representing a valuable sample of the vulnerable population, and the group most likely to be affected by food security impacts. In addition, secondary interviews were carried out with six farmers, four food retailers, two politicians and four project development personnel, thus collectively offering a multifaceted view. Using interview results and observational records, the baseline scores for food security were established, and a future projection made on the food security impact associated with the project.

It was found that the land committed to plant feedstock will come from existing commercial farms, competing for land currently used to grow crops that are normally used for animal feed. This potential negative impact on the animal feed is expected to be balanced through the introduction of the plant's DDGS by-product into the market, and thus traditional farming activities should become more productive as a result of the investments. The data also showed that no additional stress will be exerted on water resources.

The investigation concluded that villages and subsistence farming are virtually non-existent in the valley. Instead, the vulnerable population obtains its food, mostly sourced from outside the valley, through urbanised retail systems, and thus accesses it through income. Interviews revealed that joblessness and financial stress are considered the biggest threats to food security, with the project promising to boost the local economy and improve these two factors. As a result, the project was found to be very well received by the local community, and overall, the study concluded that it is expected to have a mildly positive effect on food security in the area.

6 Potential for Bioethanol Production in the Western Cape

In this section, various options for bioethanol production in the Western Cape are examined. Although the terms of reference of this study were specifically to investigate the use of wastes as feedstocks, precisely to obviate this issue being raised, the opportunities for agriculturally-based biofuel production in the Western Cape are clearly such that they can not be ignored.

6.1 Waste Streams for Bioethanol Production in the Western Cape

Mahlare and White (2012), researchers from UCT conducted a comprehensive high-level assessment of the availability of waste streams potentially suitable for bioethanol production. Their study focused on the use of carbon-rich waste streams as a feedstock for gasification, and the use of the resultant syngas as a feedstock for a gaseous fermentation process such as those described earlier.

The bulk of the Western Cape's agricultural residues are produced in the Overberg and Boland regions, with the three largest producing areas being Caledon, Ceres and Worcester. This is consistent with the previous results regarding the dominance of fruit and crop-derived wastes in the overall agro-waste mix, since the Boland is a large fruit-producing region, and is particularly notable for its viticulture.

Agriculture wastes differ from typical chemical plant feedstocks in various respects. They are not produced consistently throughout the year, with their production being dependent on the harvest periods, and they are geographically dispersed. Summer harvests dominate the Western Cape agricultural sector, with 54% of waste being generated during the summer months, while winter harvests account for 38% of the yearly waste supply. Only 8% of residues come from perennial crops.

In addition to this seasonality factor, the distribution of the feedstock supply over the season will not be constant either, since most crops (including perennials) will be harvested over a few weeks or months, not throughout a full six-month season. Thus any plant processing agricultural waste would either need to be extremely flexible, being able to easily ramp its production up or down, or it would have to artificially ensure a steady supply of feedstock, for example by pelletizing and storing the wastes.

6.1.1 Field Crop Residues

In Mahlare and White (2012) the quantity of available, dry field crop residues available in the Western Cape was calculated on the basis of accepted waste to produce ratios e.g. tonnes of straw per tonne of wheat harvested. Given the competing uses for these residues and their dispersed nature, only 10% of the total was taken as being available for further processing. Agricultural production statistics were taken from Statistics South Africa (2010). Waste generation ratios and moisture content for the various crop types were taken from numerous sources, the majority coming from Koopmans and Koppejan (1998) or Eisentraut (2010).

Based on the above, it was found that the crop residues could potentially provide the quantities of available dry biomass as shown in the following table.

Table 10: Quantities of dry residues from field crops

Crop	Available residue (tonnes/yr)
Wheat	72 355
Maize	17 114
Barley	14 257
Total	**103 726**

Although only 10% of the residues produced each year are included in the above table, an important factor to bear in mind, are the potential competing uses for these lignocellulosic residues. For example, straw is used both as fodder and bedding for livestock. Furthermore, the retention of straw in the fields is considered an important element of conservation agricultural, which is increasingly prevalent in the Province. The straw is an important source of carbon for the typically carbon-poor soils in the Western Cape, and an important mulching material, which assists in the improvement of the soils' moisture retention ability.

6.1.2 Fruit Industry Residues

Residues generated by the fruit cultivation and processing industry were found by Mahlare and White (2012) to be as shown in Table 11.

Table 11: Quantities of dry residues from fruit cultivation

Crop	Available residue (tonnes/yr) on dry basis
Wine grapes	129 919
Apples	51 953
Pears	25 447
Oranges	14 833
Table grapes	14 202
Peaches	13 932
Lemons	2 749
Naartjies	2 540
Other citrus fruit	1 383
Total	**256 958**

On the face of it, fruit wastes represent one of the largest sources of carbon-rich waste in the Western Cape. However, a detailed study, conducted by fruit industry specialists Blue North Sustainability Practice (Blue North, 2013a), on behalf of Green Cape, found that Western Cape fruit supply and processing chains are relatively efficient, and very little fruit can be classified as true waste. This efficiency is clearly driven by the relatively thin margins faced by the agricultural sector in general.

In summary, the study found that:

- Orchard and vineyard wastes at farm-level are negligible.
- Wet waste from citrus packhouses is negligible.
- Canneries produce little waste, with some being processed in juicing plants.
- Topfruit (apples and pears) packhouses generate fair volumes of wet waste, with the Grabouw region producing 3 400 tonnes and Ceres 2 200 tonnes/yr, relatively evenly spread throughout the year. This waste has no economic value and costs in the region of R180 per ton to remove for dumping. However, this waste is destined to be used increasingly in biogas digesters. Biogas production is a recent development, with the first project under development in the Grabouw region, and another being mooted in Ashton.
- Pomace waste from juicing facilities holds promise for bioethanol production. About 13 000 tonnes are produced from February to July in the Grabouw and Ceres regions. However, again there are competing end-uses for this both as animal feed and as feedstock for biogas digesters.
- Winery waste (stalks and pomace) amount to about 120 000 tonnes in total for the top three regions, but are only available from January to April. Each year, a company called Brenn-O-Kem processes between 30-35 000 tonnes of the grape pomace and wine lees from major wine cellars in the Western Cape. These are trucked to either their Wolseley or Worcester plants where they are processed into valuable products including grape spirit, grape seed extract, cream of tartar and raw materials for the production of tartaric acid. To further enhance the sustainability of their operations, once the extracts have been drawn from both seeds and skins, they are dried, compacted and used as fuel.
- A total of 59 000 tonnes of citrus pomace is available in the Citrusdal/Clanwilliam area from April to September. It currently trades at a value of R 300 per tonne, as an animal feed. As it represents an alternative to maize in animal feeds, its price is linked to maize.

On the basis of the above findings, it would appear that the potential feedstocks with the greatest promise are the 80-90 000 tonnes of winery wastes, and the citrus pomace.

6.1.3 Forestry Residues

The Western Cape plantation area per tree species (in ha) was taken from the (Forestry Economic Services, 2010). The report also provided data on the amount of wood that was pulped during the 2008/2009 period. Yields of forestry waste on a per hectare basis for logging, sawing and pulping of wood were taken from Eisentraut (2010). An availability of 10% of the total residues was again assumed. Given the small size of the Western Cape's forestry industry, it can supply only around 4 500 tonnes/yr of biomass.

6.1.4 Industrial Carbon Monoxide

The carbon monoxide emissions from Exxaro's Namakwa Sands ilmenite smelter were determined on the information from a project design document (Mahlare and White, 2012).

The plant generates two producer gas streams, producing a total of close 70 000 tonnes/yr of carbon monoxide, and just over 1 000 tonnes/yr of hydrogen. In the case of Arcelor-Mittal's Saldanha Steel smelter, its carbon monoxide production was calculated to be in the region of 950 000 tonnes/yr, and hydrogen production was around 13 000 tonnes/yr.

According to LanzaTech (pers. comm. J Gonsky, email on 28 Nov 2013), the annual bioethanol potential from the above two plants using the LanzaTech process would be 22 million litres from Namakwa, and 300 million litres from Arcelor-Mittal. However, Namakwa Sands currently use their smelter off-gas for their process driers, and are currently in the process of commissioning a cogen plant using the remaining off-gases, both of which are less economically attractive than the LanzaTech option.

Arcelor-Mittal's 1.2 million tonne/yr Saldanha steel mill uses Corex/Midrex technology, and thus requires the carbon-rich off-gases as fuel for internal use. In the future, however, the plant could switch to natural gas from Ibubhesi, if and when this comes on stream, and thus free up the off-gases for bioethanol production.

6.2 Crop-based Feedstocks for Bioethanol Production

Although this study is focussed on the use of waste streams as feedstock for bioethanol production, given the importance of the agricultural sector in the Western Cape economy, this needed to be within the broader context of the opportunities offered by a crop-based feedstock approach to bioethanol production.

6.2.1 Ethanol from Grains

In 2008, a consortium consisting of a Swellendam-based animal feed specialist, Sjoerd ten Cate, and three agricultural cooperatives, Cape Agri, Overberg Agri and Central South Co-op, initiated a pre-feasibility study of the potential for the production of bio-ethanol from small grains in the Western Cape (Gorgens *et al,* 2008). The study was funded by PetroSA, who subsequently relinquished all rights to the findings thereof.

The study investigated all aspects of the potential grain-based bioethanol project, including feedstock, agricultural, technical and economic aspects. Small grain feedstocks considered included B3 (non-food grade) wheat, triticale (a hybrid of wheat and rye), malt and feed barley. Plant sizes in the range of 100 000 to 300 000 tonnes/yr of feedstock were considered, with a 200 000 tonnes/yr plant turning out to be the most viable size, producing around 78 million litres of bioethanol.

A key factor which improved the economic performance was found to be the value added to the by-products. More specifically, the inclusion of grain fractionation to isolate fibre from the starch showed promise, with substantially improved economics compared to a conventional starch-to-ethanol plant. The fractionation results in a higher valued DDGS being produced, as it has lower fibre content, making it suitable for mono-gastric animals as well as cattle. The fibre is hydrolysed to produce additional fermentation feedstock. This could be of importance in the future expansion of the production plant, as it provides potential capacity for processing not only this fibre, but also other sources of lignocellulose, such as grain straw.

The study also demonstrated that under preferred scenarios the bioethanol factory would have the option of switching between different potential grain feedstocks, including triticale, wheat B3 and barley. This creates substantial flexibility in the feedstock which would benefit farmers by providing an alternative market for various crops.

The study provided substantial evidence of the agricultural, technical and economic potential for bioethanol production from small grains in the Western Cape.

6.2.2 Ethanol from Alternative Crops

In the Sandveld, potato farmers cultivate a total of 6 600 ha, and as they are faced with a number of challenges, they are interested in finding viable alternative crops. To a large extent this arises from their need to rotate their potato crops on a five-year cycle of one year on and four years off, in order to combat the incidence of nematodes and other pests and diseases. They are thus in a position to consider alternatives for the interim years (Franke et al, 2012).

A possible alternative to be considered are crops such as Helianthus Tuberosus (DAFF, 2011), otherwise known as the Jerusalem artichoke or sunchoke, in a three-year crop rotation system. The Jerusalem artichoke grows in any soil, but prefers light, sandy soil of good fertility, similar to that suitable for potatoes. It does best in temperate climates, to the point of becoming an 'edible weed'. Four to five irrigations may be needed for optimum yields. Regular watering gives the best tuber production, but it can tolerate dry periods. In warmer, more humid areas it can still be very productive. Jerusalem artichokes are propagated from tubers, and the plants are hardy and once established need little attention.

Harvesting the tuber crop is similar to potatoes, with a few exceptions. The potato vine is weak and usually has senesced before harvest, which is in contrast to the continued growth of the strong artichoke stems. Potato tubers separate easily from the stems, while the large mass of artichoke tubers are strongly attached and intertwined with the roots. By adding small chains and increasing agitation, a potato digger can be converted into a Jerusalem artichoke digger. Yields of up to 60-80 tonnes per ha can be achieved, and the bioethanol yield is 0.095l/kg of tuber. If one third of the available potato growing area were to be planted to Jerusalem artichokes, a bioethanol yield of around 12 million litres/yr could be achieved.

This crop could thus be considered as an alternative, to maximise the use of the agricultural infrastructure in the Sandveld, and a bioethanol distillery could be installed at Lamberts Bay. This facility could make use of the waste starch and potatoes from the Lamberts Bay Foods chip factory, which would result in an annual production of 1.3 million litres, and also the Jerusalem artichokes cultivated during the potato fallow periods.

6.3 Socio-economic Impacts of Biofuel Production and Use

Employment Creation

It would appear that very few additional jobs will accrue through the use of already aggregated waste streams for bioethanol production, other than a few hundred skilled and semi-skilled opportunities at the production plants.

The most significant employment opportunities would arise if an agriculturally-based biofuels industry were to be developed in the Province. Based on the numbers presented in Agama (2003) a 100 million litre/yr bioethanol plant using small grains as the feedstock, would provide 3 000 to 4 000 permanent agricultural jobs. Using Lemmer's (2006) figures, however, around 7 000 permanent jobs would be created.

Despite the above difference, what is evident is that a biofuels industry can result in relatively significant employment opportunities, if the feedstock is agriculturally produced. It is also evident, however, that each case should be judged on its own merits, and that a comprehensive audit be done of each aspect of each project. Indeed, it is evident that, in order to administer the proposed biofuels subsidies fairly, the DoE is going to have to develop a standardised employment impact auditing process for the industry.

Emerging Farmer Opportunities
According to the recent FARE (2013) report, globally there is increased recognition of the central role of smallholder farmers in ensuring food security, and there is consensus that supporting emerging farmers through land reform and agricultural development is of critical importance. However, few models for how to effectively deliver this support are available, and evidence shows that most poor black farming households receive little if any support, largely because available resources are directed at better-resourced farmers.

The reality is that supporting smallholder farmers is difficult and requires significant commitment of extension capacity. However, there are an increasing number of initiatives in the Western Cape that bring some hope, and which could be used as possible role models. One such example is Agri Dwala (Pty) Ltd, which was established in March 2006 (AgriDwala, 2013). The company's main initial objective was to rent municipal land around Napier from the Cape Agulhas Municipality for a group of previously disadvantaged people and to assist them in farming it. The group now farms this land and has also bought two farms, tractors, a harvester, a truck, and some pick-ups. The initiative has benefitted significantly from the involvement of two experienced farmers, who are co-shareholders and mentors, Overberg Agri, Pioneer Foods, the Land Bank and DAFF.

A key component for the success of emerging farmers is their integration into the full value chain, from production through processing, marketing and, ultimately, to the consumer. Incentive mechanisms could be developed to encourage commercial enterprises to enter into partnerships with smallholder farmers, to help ensure this market access and transfer of skills. To facilitate this, the dti could, in conjunction with DAFF, encourage the development of cooperatives. Similarly, emerging farmers should be encouraged to cooperate among themselves to become more competitive.

It is clear that the development of an agriculturally-based biofuels industry could well provide some of these elements, and involvement such a relatively secure industry would, to some extent, insulate them from the vagaries of less regulated produce markets.

Health Impacts of Biofuels
The health impacts of using biofuels, particularly in urban environments, are becoming increasingly evident throughout the world. A study conducted in Brazil found that over 12 000 hospitalizations and 875 deaths would be avoided per year in a scenario of total oil and diesel replacement by bioethanol in Greater Sao Paulo (Saldiva et al, 2011). During this period, public coffers would save nearly R1.9 billion as a result of the reduced cost in health care. A more realistic goal, just using bioethanol in the bus fleet, was found to result in the reduction of 1 350 hospitalizations per year due to ailments caused by diesel-generated pollution. This would save more than R3.8 million, and 220 deaths would be avoided per year, equivalent to half the number of deaths from tuberculosis in the region in 2007.

7 Short Term National Biofuel Production Potential

With the long-awaited promulgation of the biofuels blending date, a number of projects that have been in the pipeline should shortly be moving into their implementation phase. It is clear from previous sections that there are a number of issues that will have to be resolved between now and the October 2015 blending date.

7.1 Bioethanol

The most significant of the bioethanol projects are the proposed 158 million litre/yr grain sorghum based Mabele Fuels plant at Bothaville, in the Free State and the 90 million litre/yr Arengo plant at Cradock, in the Eastern Cape. The latter plant, which is to be financed primarily by the Industrial Development Corporation (IDC), was initially going to use sugar beet as its feedstock. However, the low yields obtained during sugar beet cultivation trials have led to the feedstock also being changed to grain sorghum.

The sugar industry is contemplating involvement in bioethanol production. However, the criteria regarding the bringing into production of underutilised land and the sourcing of feedstock from emerging farmers currently present something of a stumbling block, and discussions are ongoing with the DoE.

7.2 Biodiesel

All indications are that, at this stage, there is little prospect of there being any significant production of biodiesel in the near future. Of the two major potential producers listed by the DoE in Table 1, Rainbow Nation Renewable Fuels (RNRF), a subsidiary of National Biofuels Group of Australia, obtained its environmental impact assessment approval and manufacturing licence in 2008. RNRF's proposed R2.5 billion plant is designed to produce over 280 million litres of soya biodiesel, at its site in Coega.

The global financial crisis, however, resulted in the withdrawal of the major shareholder, AIG insurance company of the US, after it was bailed out by the US government. Thereafter, regulatory uncertainty in South Africa further delayed the project. Ian Armstrong, chairman of both the Australian and South African companies, says the project was placed in "hibernation" late in 2012 but still has all approvals and is likely to be rapidly revived once regulatory certainty is achieved. About R100m has been spent on the project so far and it is still apparently highly viable (Payne, 2013)

Phyto Energy, the other major potential producer, is apparently in the process of establishing its canola feedstock supply chain. However, there is scepticism in the agricultural sector that it will manage to grow the quantity of seed that would be required for its operation. Cultivation trials currently running are all over the country, many of them far from the proposed Eastern Cape plant (Payne, 2013)

Phyto Energy's business model has, however, been based on the export of the bulk of its production to the EU. It is not clear what its situation is now, with the recent major changes in Europe vis-à-vis the importing of biofuels, and payment of the subsidies to foreign producers.

8 Potential Bioethanol Production and Demand in the Western Cape

Based on the investigation of potential waste streams suitable for the production of bioethanol in the Western Cape, the following table indicates the volumes that could be produced using commercially-proven, advanced, so-called second generation, technology.

Table 12: Potential Western Cape Bioethanol Production Volumes

Feedstock	**Technology**	**Production Volume (million litres/yr)**
Grape pomace	Enzymatic hydrolysis	24
Citrus pomace	Enzymatic hydrolysis	12
Agricultural residues	PROESA	23
Steel mill CO off-gases	LanzaTech	300
Total		**359**

The above volumes are small in comparison to the liquid fuel demand in the Province, which can be summarised as shown below.

Table 13: Current Western Cape Liquid Fuels Consumption Volumes

Fuel	**Consumption (billion litres/yr)**	**Ethanol Equivalent (billion litres/yr)**
Diesel	1.3	1.9
Petrol	2.3	3.0
Paraffin	0.074	0.103
Total	**-**	**5.03**

From the above, we can see that the potential bioethanol production levels from easily available waste stream represent about 7% of the current liquid fuel consumption in the Province. If we add the further potential of 78 million litres based on small grain, plus the 12 million litre potential production from Jerusalem artichoke, the proportion rises to nearly 9% of the current provincial liquid fuels consumption.

9 Potential Carbon Footprint Impacts

Given that one of the central rationales for the introduction of biofuels is to reduce the carbon footprint of activities that are normally fossil-fuelled, an important part of a biofuels strategy should be to ensure that the fuels being produced do, in fact, contribute to a reduction in carbon emissions. It is important that this analysis follows a recognised protocol such as that laid down by the Roundtable on Sustainable Biomaterials (RSB)

As there is no specific reference made in the National Biofuels industrial Strategy to life cycle analysis of the biofuels production processes or the carbon footprints of the resulting biofuels, it was felt that this study should examine the advantages or otherwise of using waste streams as feedstocks for biofuel production.

A hypothetical bioethanol production process, based on grape pomace, using enzymatic hydrolysis, was modelled for Green Cape by Blue North (Blue North, 2013b). The analysis was conducted from cradle (wine farm) to fuel depot gate (96% bioethanol delivered in Cape

Town) using the Carbon Trust's Footprint Expert Software v4.0. The PAS 2050:2011 methodology was applied throughout the study. The hypothetical process diagram is presented in Appendix C, and a similar process would be applicable in the case of a bioethanol plant based on citrus pomace as the feedstock.

It is important to note that this analysis does not take into account the avoided GHG emissions that would have resulted from disposal the waste stream in a landfill. There is thus every possibility that the bioethanol product might even have a negative carbon footprint, if this additional factor is taken into account. This would of course also apply in the case of other waste streams such as the citrus pomace, and the carbon monoxide from steel manufacture.

Table 14: Carbon Footprint of 96% Bioethanol from Grape Pomace.

Process	Category	Input	Kg CO2e	g CO2e / MJ of Ethanol delivered in Cape Town	% Contribution
Hammer Mill	Raw Material	Grape Skin Pomace	10,463	0.49	3.3%
Hammer Mill	Energy	Electricity	4,950	0.23	1.5%
Pomace Heat Treatment	Raw Material	Water	595	0.03	0.2%
Pomace Heat Treatment	Energy	Electricity	3,484	0.16	1.1%
Cellulose Enzymatic Conversion	Raw Material	Water	1,788	0.08	0.6%
Cellulose Enzymatic Conversion	Raw Material	Enzymes	218,905	10.33	68.5%
Cellulose Enzymatic Conversion	Transport	Incoming	10,878	0.51	3.4%
Cellulose Enzymatic Conversion	Energy	Electricity	9,389	0.44	2.9%
Centrifuge 1	Energy	Electricity	5,983	0.28	1.9%
Fermentation	Raw Material	Yeast	7,272	0.34	2.3%
Fermentation	Transport	Incoming	316	0.01	0.1%
Fermentation	Energy	Electricity	2,052	0.10	0.6%
Centrifuge 2	Energy	Electricity	5,169	0.24	1.6%
Distillation	Energy	Steam	10,951	0.52	3.4%
Transport	Transport	Outgoing	27,308	1.29	8.5%
Total			**319,503**	**15.07**	**100.0%**

Table 14 summarizes the carbon footprint for 96% bioethanol delivered in Cape Town. The enzyme raw material, contributes 65% to the carbon footprint of this fuel, which can be attributed to the very carbon-intensive enzyme production process, with its footprint ranging from 1 to 10 kg CO2e per kg of enzyme product (Nielsen *et al.* 2006). An average of 6 kg CO2e per kg of enzymes was used for modelling in this study. Lignin recovered from the manufacturing process and used as boiler fuel is a major factor contributing to keeping the carbon footprint low.

As is evident from the above table, the model found the total carbon footprint of the bioethanol to be 15.07 g CO2e/MJ of delivered fuel ethanol. This compares favourably with the Silversands sugar beet based bioethanol, used for the Johannesburg bioethanol bus trials, which had a footprint of 18.10 g CO2e/MJ (Tricorona, 2012). Taking diesel, with a carbon footprint of 83.80 g CO2e/MJ, as the reference fuel that the fuel ethanol would be replacing, the grape pomace based bioethanol has a footprint equivalent to less than 18% of that of diesel.

This low footprint demonstrates the advantages of using a waste stream as the feedstock for bioethanol production. It also highlights the savings in carbon emissions that can be achieved by making full use of the waste products from the production process itself, such as the use of the lignin as a process fuel in this case.

10 Conclusions and Recommendations

The short term nature of this project restricted the level of analysis that could be undertaken to answer fully, all the critical questions surrounding the Western Cape biofuels opportunity. It was however, in the timeframe, able to conclude the following:

- The National Biofuels Industrial Strategy is aimed primarily at supporting rural development and employment creation, particularly for emerging farmers, and is focused purely on blending bioethanol and biodiesel into the national fuel pool at 2% and 5% volumes respectively.
- The National Strategy makes no provision for waste-based biofuels production, nor for any sub-national niche opportunities
- Major uncertainties remain on the ability of the National Strategy to meet its expected targets. Whilst the mandatory blending date of October 2015 is now set, there is still no clarity on the final biofuel pricing mechanisms or subsidies, nor on the criteria that will have to be met to qualify for them.
- The business case for biofuels production in the Western Cape, merits re-examination. This should build on the formative work undertaken by the Western Cape's Dept of Agriculture in the mid 2000s, which pre-dated the finalisation of the National Biofuels Industrial Strategy in 2007. As part of this analysis, it will be important to:
    - Consider all waste resources as potential feedstocks, including agricultural residues;
    - Understand fully the potential of non-food crops as resources;
    - Understand the implications for land use change; and
    - Compare and contrast the business opportunities related to biofuels for blending versus biofuels as dedicated fuels.
- Beyond the blending of biofuels into the current liquid fuel pool, there is a need to better understand the Western Cape liquid fuel demand scenarios, including ability to service dedicated transport fleets, such as buses, freight transporters, tractors etc, and to investigate the use of liquid fuels by households.
- The preliminary results of this study show that the production of bioethanol from grape pomace has definite potential. A small scale plant based on this feedstock could serve as the fuel supply for a dedicated fleet transport pilot project. Such a production and consumption project could serve to test and demonstrate the full fuel chain from "farm to wheel", and provide valuable experience in waste to bioethanol production, and the full fuel chain management.

In light of the above, it is recommended that further investigation and activities, building on this study, be pursued to address the following specific questions and issues:

- Given the identified limitations and inconsistencies in the current national biofuels policy, what needs to change to allow for the potential production of biofuels from wastes? The national process should be actively engaged with in this respect, and the Western Cape Government should become involved in the Biofuels Implementation Committee's activities.
- What are appropriate biofuel production scenarios for the Western Cape? This should be informed by a multi-criteria analysis of:
    - All potential feedstocks, i.e. not just primary agricultural products;
    - All technologies, including second-generation innovations; and
    - Markets, including the use of biofuels in uses other than for transport.

As mentioned above, this should build on the analysis undertaken by the Western Cape DoA in the mid 2000s.

- Based on this analysis, what is the business case for the main feedstock and technology contenders?
- Prove the business case/s for selected agricultural wastes, in order to help develop pilot demonstration project/s of adequate capacity. Some initial potential projects were identified within this study, and these now need to be refined, and possible funding sources sought.
- What are the implications for land use management and carbon footprinting of the main contenders for biofuel production?
- Can a Western Cape-based biofuel production sector lead to significant numbers of new employment opportunities?

It is envisaged that further investigation, which could provide considered answers to these questions, would help arrive at an understanding of the genuine potential for biofuels production in the Western Cape, and also assist in moving from an assessment of viability to the implementation of concrete projects.

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Appendices

Appendix A - Compilation of Licensing and Other Regulatory Requirements for Biofuel Production

Appendix A.1 - Criteria for Licences to Manufacture Biofuels

Definitions

Designated area - An area designated by the Department of Agriculture, that is underutilised and suitable for the production of biofuels crops that will supply feedstock to a specific biofuels plant.

Underutilized land - Land that has sustainable agriculture production potential, as determined by the Department of Agriculture, that is not currently fully utilized .

Emerging farmer - A farmer from previously disadvantaged groups that did not have access to markets and/or were engaged in subsistence agricultural activities including those in the former homelands. This includes farmers that acquired land through the land restitution programme

Own use - The manufactured product can only be used by those who manufactured it and is not transferable either commercially or in kind.

Eligibility

All biofuels manufacturers, including pilot projects, are required to apply for manufacturing license. Those manufacturing for own use will have to register with the Petroleum Controller and provide annual statistics on what crops they are utilizing, production capacity (how much they are producing) and detailed information of what the products are used for.

Biofuels production for research purposes will have to provide proof/letter from relevant research institutions. Produce from research projects shall be limited to specified quantities and as such must not be used for commercial purposes.

All crops used for the production of biofuels must not have negative environmental impacts on South Africa during processing and storage.

The production of feedstock under irrigation will only be allowed in exceptional circumstances and a detailed motivation will have to be provided. Water that is currently used for gainful irrigation will not be considered for a new water license for biofuels production purposes.

Applicants for the manufacture of biofuels must adhere to the following guidelines:

1. The crops for the production of biofuels are mainly sugar cane, sugar beet, soyabeans, sunflower and canola (as contained in the biofuels strategy).
2. Maize and Jatropha are not permitted crops from which biofuels may be manufactured.
3. Feedstock imports are not allowed.
    - This can only be supported at times of adverse agricultural productions and when local producers cannot meet the investors demand.
    - A licensee must apply in writing to the Petroleum Controller to decide that a period of adverse agricultural production has commenced.

4. Due to difficulties in the availability of certain feedstocks domestically, importation could be allowed for projects at inception stages under certain conditions.
   Conditions to be considered:
   - Only those crops where generally there is no adequate domestic capacity or are not grown in South Africa. In addition, the carbon footprint of that crop production must not be negative in the country of origin.
   - Importation only allowed when a detailed phase-in period for import replacement (substitution) and domestic sourcing has been provided.
   - Import replacement and domestic sourcing must be linked to sourcing from emerging farmers from underutilised areas.
   - A detailed account of type(s) of by-products, quantities and potential markets has to be provided. Fair conditions of trade have to prevail so as to manage/avoid market dominance by operator(s) in the local market on the back of imports.
5. Feedstock must be cultivated and sourced from the designated areas
   - A written commitment or contract is required to ensure that feedstock is sourced from emerging farmers from underutilised areas.
   - The use of feedstock from commercial farmers will also require a detailed phase-in plan and period for increased use or evening out of feedstock by emerging farmers from underutilised areas
6. During the first phase (2008 – 2013) more priority will be given to commercially proven technologies, while the piloting and demonstration of second generation will be supported only if it is for research purposes.
7. All biofuels products and producers must meet the prescribed SANS specifications and standards.
8. The utilization of by-products needs to be clearly indicated and a proof of off take agreements need to be submitted.
9. An off-take agreement with a local oil company, operator, large commercial undertaking and dedicated operator such as municipalities that will use the biodiesel and bioethanol is required. Mandated upliftment and accommodation of biofuels in the oil industry infrastructure envisaged in the Biofuels Strategy has to be ensured.
10. Biofuels producers must provide a proof of an agreement or undertaking regarding the blending facilities
11. The applicant must provide evidence where it is applicable that it has engaged with other authorities whose approval will be necessary for the manufacturing facility to operate. These will include, but may not be limited to:
    - Department of Agriculture
    - The dti- International Trade Administration Commission,
    - Department of Land Affairs
    - DEAT
    - DWAF
    - Others
12. In addition to the guidelines above, all other provisions pertaining to the manufacture of petroleum products contained in Petroleum Products Act of 2003 will still apply.

Appendix A.2 – Listed Activities in Terms of the Various NEM Acts

National Environmental Management Act (Act No. 107 of 1998)
The NEMA provides the environmental legislative framework for South Africa. The EIA Regulations (GN. R543) were promulgated in terms of NEMA and became effective on 2nd of August 2010. The 2010 EIA Regulations contain three Listing Notices (GN.R544, R545 and R546) of activities that either require a Basic Assessment or Scoping and EIA procedure in order to obtain EA from the competent authority. If activities are listed within Listing Notice 2 a Scoping and EIA process must be undertaken. Activities can be triggered in either of the listing notices or within Listing Notice 1, 2 and 3 and therefore require that the proposed activity be subjected to Scoping and EIA process in order to obtain environmental authorisation.

The following statutes, among others, fall under the NEMA framework legislation:

- Environment Conservation Act (No. 73 of 1989).
- National Water Act (No. 36 of 1998) and National Environmental Management (NEM) legislation, including:
  - NEM: Air Quality Act (No. 39 of 2004) (NEM: AQA);
  - NEM: Protected Areas Act (No. 57 of 2003) (NEM: PA);
  - NEM: Biodiversity Act (No. 10 of 2004) (NEM: BA);
  - NEM: Integrated Coastal Management Act (No. 24 of 2008) (NEM: ICMA);
  - NEM: Waste Act (No. 59 of 2008) (NEM: WA).

List of NEMA EIA activities and competent authorities relating to biofuels production

Activity No.	Description of Activity	Applicability of activity
GN 544 (Listing Notice 1) Basic Assessment process		
13	The construction of facilities or infrastructure for the storage, or for the storage and handling, of a dangerous good, where such storage occurs in containers with a combined capacity of 80 but not exceeding 500 cubic metres	**Activity triggers:** ▪ **Storage occurs in containers (above or underground storage or a combination) with a combined capacity of between 80 cubic metres but less than 500m3.** ▪ **Construction of depots, private or commercial filling stations for the storage and handling of a dangerous good.**
27	The decommissioning of existing facilities or infrastructure, for - (iv) storage, or storage and handling, of dangerous goods of more than 80 cubic metres; (v) but excluding any facilities or infrastructure that commenced under an environmental authorisation issued in terms of the Environmental Impact Assessment Regulations, 2006 made under section 24(5) of the Act and published in Government Notice No. R. 385 of 2006, or Notice No. 543	**Activity triggers:** ▪ Decommissioning of existing facilities or infrastructure, for activities, where the facility or the land on which it is located is contaminated. ▪ Decommissioning of existing facilities or infrastructure, for storage, or storage and handling, of dangerous goods of more than 80 cubic metres **Competent Authority** DEADP or applicability of Section 24 C of NEMA **Relevant authorities:**

	2010.	▪ Department of Water Affairs, section 21 water use licences may be applicable or pollution matters. ▪ Heritage Western Cape if the provisions of section 38 of the National Heritage Resources Act, 1999 (Act 25 of 1999) is triggered. ▪ Western Cape Nature Conservation Board (CapeNature).
28	The expansion of existing facilities for any process or activity where such expansion will result in the need for a permit or license in terms of national or provincial legislation governing the release of emissions or pollution, excluding where the facility, process or activity is included in the list of waste management activities published in terms of section 19 of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) in which case that Act will apply.	**Activity triggers include:** ▪ If expansion of the facility that requires a waste licence as well as a licence or permit ito the NEM: AQA or NWA, this listed activity is triggered. ▪ Assessment must be done on the entire expansion of the facility, including that part of the expansion that deals exclusively with the waste management listed activities. ▪ For example, the expansion requires an atmospheric Emission Licence as well as a Waste Management Licence for re-use or treatment of hazardous waste, applications will be submitted to the District Municipality, DEA&DP (for this activity) and DEA.
42	The expansion of facilities for the storage, or storage and handling, of a dangerous good, where the capacity of such storage facility will be expanded by 80 cubic metres or more.	**Relevant Legislation** ▪ National Water Act, 1998 (Act 36 of 1998) – Section 21 Water Use applications ▪ Heritage Resources Act, 1999 (Act 25 of 1999) Section 38 ▪ Regulations: Petroleum products site and retail licences or petroleum products wholesale licences (Petroleum Product Act, 1977).
48	The expansion of facilities for the refining, extraction or processing of gas, oil or petroleum products where the installed capacity of the facility will be increased by 50 cubic metres or more, excluding facilities for the refining, extraction or processing of gas from landfill sites.	**Relevant Legislation** ▪ Activity regulated ito Minerals and Petroleum Act. ▪ Authorisation required from the Department of Minerals and Energy.
GN 545 (Listing Notice 2) Scoping/EIR process		
3	The construction of facilities or infrastructure for the storage; or storage and handling of a dangerous good, where such storage occurs in containers with a combined capacity of more than 500 cubic metres.	**Activity Triggers** ▪ Includes storage facilities of more than 500 cubic metres ▪ The construction of infrastructure only, directly to do with the facility, prior to the development of the facility will trigger this activity. ▪ **Containers for bio-fuel plants would trigger this activity, depending on the thresholds.** ▪ The conversion (i.e. reuse) of storage facilities not previously used for the

		storage of dangerous goods. **Competent Authority** DEA&DP is the competent authority; competent authority for an application for environmental authorisation, where this activity is applicable, must be determined with reference to Section 24C of the NEMA.
4	The construction of facilities or infrastructure for the refining, extraction or processing of gas, oil or petroleum products with an installed capacity of 50 cubic metres or more per day, excluding facilities for the refining, extraction or processing of gas from landfill sites.	**Activity Triggers include:** ▪ Facilities and associated structures for the **refining of gas, oil and petroleum products related to the manufacture of fuel.** ▪ **Commercial production of green fuels e.g. bio-diesel, oil refineries (plants of any size, where fuel is produced to be sold.)**
5	The construction of facilities or infrastructure for any process or activity which requires a permit or license in terms of national or provincial legislation governing the generation or release of emissions, pollution or effluent and which is not identified in Notice No. 544 of 2010 or included in the list of waste management activities published in terms of section 19 of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008) in which case the activity is regarded to be excluded from this list.	**Activity Triggers** • Construction of new facilities or infrastructure required for any process or activity which requires a permit or license in terms of national or provincial legislation governing the generation or release of emissions, pollution or effluent **Competent Authority** DEADP or identified through Section 24C of the NEMA
6	The construction of facilities or infrastructure for the bulk transportation of dangerous goods - (i) in gas form, outside an industrial complex, using pipelines, exceeding 1000 metres in length, with a throughput capacity of more than 700 tons per day; (ii) in liquid form, outside an industrial complex, using pipelines, exceeding 1000 metres in length, with a throughput capacity more than 50 cubic metres per day; or in solid form, outside an industrial complex, using funiculars or conveyors with a throughput capacity of more than 50 tons day.	**Activity Triggers** • Distance threshold as well as the throughput capacity threshold must be met • Throughput capacity must be more than 50 tons day
GN 546 (Listing Notice 3) Basic Assessment: Activities and sensitive areas per province		
12	The construction of facilities or infrastructure for the storage of a dangerous good, where such storage occurs in containers with a combined capacity of between 30 and not exceeding 80 cubic metres. ▬ Geographical areas in the Western Cape province to which this activity applies, include:	**Competent authority:** ▪ Determined with reference to 24C of the NEMA. ▪ If Minister is competent authority, submit application to DEA. ▪ If MEC is competent authority, submit application to relevant Provincial Department **Relevant authorities include**: ▪ Department of Water Affairs:

(e) i. In an estuary; ii. All areas outside urban areas; iii. Inside urban areas: (aa) Areas seawards of the development setback line or within 200 metres from the high-water mark of the sea if no such development setback line is determined; Areas on the watercourse side of the development setback line or within 100 metres from the edge of a watercourse where no such setback line has been determined.	National Water Act, 1998 (Act 36 of 1998). ▪ Heritage Western Cape: Section 38 of the National Heritage Resources Act, 1999 (Act 25 of 1999) ▪ DEA: Marine & Coastal Management: Integrated Coastal Management Act, 2008 (Act 24 of 2008). ▪ DEADP: Marine & Coastal Management for activities in the coastal protection zone. ▪ Western Cape Nature Conservation Board (Cape Nature). ▪ DME: Petroleum Controller consulted for all commercial sites (i.e. filling stations). ▪ Hazardous Substances Act, 1973 (Act 36 of 1973)

National Environmental Management: Air Quality Act, 2004 (Act 39 of 2004)
The National Environmental Management: Air Quality Act, 2004 (Act 39 of 2004) was gazetted on 24 February 2005 and came into force on 11 September 2005. The NEM: AQA amongst its objectives is to reflect the overarching sustainable development principles in the National Environmental Management Act, 1998 (Act No. 107 of 1998) (NEMA). With regard to industrial emissions, the NEM: AQA provides for the licensing of "listed activities" through an atmospheric emission licence by metropolitan municipalities, district municipalities and provincial environmental affairs departments.

Atmospheric Emission Licence (AEL)
There are two possible 'routes' through which an AEL may be obtained, namely:

1. AEL process running parallel with the EIA process (joint process); and
2. AEL process (carried out without the EIA process).

Thus, the principle route through which an AEL is issued will be via a joint process, run in association with an EIA process.

Joint EIA / AEL Processes
When is it applicable?
The EIA process is further divided into two processes, namely, listed activity that require a full EIA and listed activity that require a basic assessment.

Full EIA	Basic Assessment
Process for applications for an AEL for a new facility which will involve a listed activity. For example, this process is applicable in the following case: Section 37 of AQA: new facility development which involves a listed activity.	Process followed in all applications for a change or amendment to the existing AEL. For example, this process is applicable in the following cases: Section 46 AQA: change to emission rates, raw materials which may increase emissions for the listed activity or activities.

AEL application process
In the above cases the applicant must submit an application to:

- the EIA competent authority for an environmental authorisation; and
- the AEL licensing authority for an atmospheric emission licence.

AEL Competent Authorities

For the AEL process, **the relevant metropolitan municipality or district municipality is the licensing authority**, except in a situation where the municipality has delegated the licensing function to the province, the province has intervened in terms of section 139 of the Constitution or where the municipality is the applicant for an AEL. **In such circumstances, the relevant provincial environmental affairs department is the licensing authority**.

EIA Competent Authorities

For the EIA process, **the competent authority is either the DEA or provincial environmental affairs department depending on the size and nature of the proposed development.**

The development proponent is responsible for hiring a qualified Environmental Assessment Practitioner (EAP) to help with the application process in order to ensure that all necessary applications are applied for from relevant authorities. The table below is a broad activity description of atmospheric emission licence triggers.

Table 1: Potential Biofuels Atmospheric Emission Licence Triggers

CATEGORIES	BROAD ACTIVITY DESCRIPTION
1	Combustion installations.
2	**Petroleum industry, the production of gaseous and liquid fuels as well as petrochemicals from crude oil, coal, gas or biomass.**
3	Carbonisation and coal gasification.
4	Metallurgical industry.
5	Mineral processing, storage and handling.
6	**Organic chemicals industry.**
7	Inorganic chemicals industry.
8	**Disposal of hazardous and general waste**
9	Pulp and paper manufacturing activities, including by-products recovery.
10	Animal matter processing.

Category 2 of the NEM: AQA listed activities relates to the production of gaseous and liquid fuels as well as petrochemical from crude oil, coal, gas and biomass. Subcategory 2.4 regulates the Storage and Handling of Petroleum Products. According to the Petroleum Product Act (Act No. 120 of 1977), a petroleum product is "any petroleum fuel and any lubricant, whether used or unused, and includes any other substance which may be used for a purpose for which petroleum fuel or any lubricant may be used". Refer to the NEM: AQA listed activities for detailed minimum emission standards associated with the storage and handling of petroleum products.

Category 6, sub-category 6.1: Organic Chemical Manufacturing has relevance to the manufacturing minimum emission standards associated with biofuels / ethanol. The sub-category is applicable to the manufacturing of hydrocarbons. The NEM: AQA listed activities provides a detailed minimum emission standards associated with organic chemical manufacturing.

National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008)
NEM: WA is subsidiary and supporting legislation to the NEMA. The Act is a framework legislation that provides the basis for the regulation of waste management. Of relevance to biofuels (ethanol) manufacturing is GN: 718 (July 2009) which comprises a list of waste management activities that have or are likely to have a detrimental effect on the environment and require a licence in accordance with section 20(b) of the National Environmental Management: Waste Act, 2008 (Act No. 59 of 2008).
In respect of Category A: conduct a NEMA basic assessment process as part of the application
Category A activities include:

- storage of waste;
- reuse, recycling and recovery of waste;
- treatment of waste;
- disposal of waste;
- storage, treatment and processing of animal waste;
- construction, expansion or decommissioning of facilities and associated structures and infrastructure.

In respect of Category B: conduct a NEMA scoping and Environment Impact Report (EIR) as part of the application.
Category B activities include:

- reuse, recycling and recovery of (mainly hazardous) waste;
- treatment of (mainly hazardous) waste;
- disposal of (mainly hazardous) waste on land;
- construction of facilities and associated infrastructure.

Table 2: Potential Biofuels Waste Management Licence triggers

Government Notice No. 718 - Category A activity no(s):	Basic assessment - Describe the relevant waste management activity as per the project description:
Category A - Part 2	The storage including the temporary storage of hazardous waste at a facility that has the capacity to store in excess of 31 m3 of hazardous waste at any one time, excluding the storage of hazardous waste in lagoons.
Category A - Part 3	The storage, including the temporary storage of general waste in lagoons.
Category A - Part 7	The recovery of waste including the refining, utilisation, treatment or co-processing of the waste at a facility that has the capacity to process in excess of 3 tons of general waste or less than 500kg of hazardous waste per day, excluding recover that takes place as an integral part of an internal manufacturing process within the same premises.
Category A - Part 10	The processing of waste at biogas installations with a capacity to process in excess of 5 tons per day of bio-gradable waste.
Category A - Part 15	The construction of facilities for activities listed in this schedule.
Category A - Part 16	The expansion of facilities for activities listed in this schedule.
Category A - Part 17	The decommissioning of activities listed in this schedule.
Category A - Part 18	The re-commissioning of activities listed in this schedule.
Category A - Part 19	Temporary closure of operations of activities listed in category B of this schedule.

Government Notice No. 718 - Category B activity no(s):	Scoping and EIA - Describe the relevant waste management activity as per the project description:
Category B - Part 1	The storage including the temporary storage of hazardous waste in lagoons
Category B - Part 2	The recovery of hazardous waste including the refining, utilisation or co-processing of waste at a facility with a capacity to process more than 500kg of hazardous waste.
Category B - Part 4	The biological, physical or physico-chemical treatment of hazardous waste at a facility that has the capacity to receive in excess of 500 kg of hazardous waste per day.
Category B - Part 5	The autoclaving, drying or microwaving of hazardous waste at a facility regardless of the capacity of such a facility.
Category B - Part 6	The incineration of waste at a facility regardless of the capacity of such a facility.
Category B - Part 7	The treatment of hazardous waste in lagoons.
Category B - Part 8	The disposal of any quantity of hazardous waste to land.
Category B - Part 10	The construction of facilities for activities listed in this schedule.
Category B - Part 11	The expansion of facilities for activities listed in this schedule.
Category B - Part 12	The decommissioning for activities listed in this schedule.
Category B - Part 13	The re-commissioning for activities listed in this schedule.

Where to submit applications

Applications for WMLs in terms of section 45 of the National Environment Management Waste Act, 2008 (Act No. 59 of 2008) are **submitted to the national Department of Environmental Affairs in the case of hazardous wastes and the provincial environmental departments in the case of general waste.** The Minister of Water and Environmental Affairs is the competent authority in respect of the following:

- all listed activities listed in both categories of Schedule 1 pertaining to hazardous waste;
- where an applicant is a Parastatal, even if an activity is for a general waste;
- where an activity is for a general waste but is funded by the Provincial Department of Environmental Affairs;
- where the applicant is a national Department; and
- where the activity overlaps between two provinces

Appendix B –Advanced Bioethanol Production Processes

This appendix briefly describes some of advanced bioethanol production processes, which are currently regarded as among the most promising. They are not listed in any particular order of relevance or success, whether actual or expected.

Beta Renewables
Beta Renewables is widely recognised as the leader in practical and cost-competitive use of non-food cellulosic biomass for the production of advanced biofuels and biochemicals. It is a joint venture formed from the Chemtex division of Gruppo Mossi and Ghisolfi and TPG. The company has over 60 years of experience in process development and commercializing hundreds of plants worldwide.

Beta has invested over R2 billion in the development of the PROESA process, which takes biomass, such as energy crops (such as giant reed, miscanthus or switchgrass) or agricultural waste (such as sugarcane bagasse and straws) and turns them into high- quality, low-cost, fermentable sugars. To achieve this, it combines an enzymatic pretreatment process with fermentation, which is typically shorter in duration than other enzymatic hydrolysis approaches, is acid- and alkali-free, and produces minimal by-products. The lignin that is produced is used to provide process heat and generate power to run the plant.

In October 2013, Beta commissioned what is regarded as the world's first commercial-scale cellulosic ethanol facility in Crescentino, Italy, at a cost of R2.1 billion (€140 million). It currently has an annual production capacity of 40 million litres of ethanol, which will be ramped up to 60 million litres, at which point it will be using 270 000 tonnes/yr of cellulosic feedstock, drawn from within a 70 km radius around the plant. The plant's conversion rate is around 220 litres ethanol/tonne of biomass, and it is energy self-sufficient, producing steam, plus 13MW of power from the lignin by-product. It also recycles all its process water.
The PROESA process is feedstock-agnostic, i.e. it can process energy crops, agricultural residues, organic municipal waste, woody biomass, and bagasse, and is competitive against crude oil at a price of as low as USD 70 per barrel. The cost of the fermentable sugars it produces are of the order of R2.80 per kg (20 cent €/kg), with a resultant ethanol cost of around R5.30 per litre (30 cent €/kg). (www.betarenewables.com)

INEOS Bio
Recently, INEOS Bio announced that its Indian River BioEnergy Centre is now producing cellulosic ethanol at commercial scale. This is the first commercial-scale production using INEOS Bio's breakthrough gasification and fermentation technology, for conversion of biomass waste into bioethanol and renewable power. The facility cost more than R1.3 billion and created more than 400 direct construction, engineering and manufacturing jobs during its development.

The BioEnergy Centre is a joint venture project between INEOS Bio and New Planet Energy. The facility has already converted several types of waste biomass material into bioethanol, including vegetative and garden waste, and citrus, oak, pine, and pallet wood waste. It will have an annual output of 30 million litres of cellulosic ethanol and 6 MW of power. The Centre is also licensed to use MSW, quantities of which will be used for bioethanol production at the Centre during 2014. (www.ineos.com)

Fulcrum BioEnergy
In December 2012, Fulcrum BioEnergy announced that it had successfully secured commitments and was proceeding toward closing R1.75 billion in financing to fund construction of its first MSW to low-carbon fuels facility, the Sierra BioFuels Plant. The project is expected to be completed in 2015, and will produce 38 million litres/yr of ethanol. This is achieved by gasification to produce a syngas which is then passed through Fulcrum's proprietary catalytic process to produce ethanol.

Fulcrum's engineering and technology teams have recently made numerous enhancements to this proprietary process. They expect these improvements will dramatically reduce operating costs to less than R2.00 per litre. (www.fulcrum-bioenergy.com)

LanzaTech
The LanzaTech gaseous fermentation process converts carbon monoxide containing gases produced by industries such as steel manufacturing, oil refining and chemical production, as well as gases generated by gasification of MSW, forestry and agricultural residues into fuel and chemical products. Unlike many other gaseous fermentation technologies, this process is flexible with regard to the hydrogen content in the input gas and it also is tolerant of typical gas contaminants.

The carbon monoxide containing gas enters the process at the bottom of the bioreactor, and is dispersed into the liquid medium where it is consumed by LanzaTech's proprietary microbes as the reactor contents move upward in the reactor vessel. The product is withdrawn and sent to the product recovery section, which makes use of an advanced hybrid separation system to recover the valuable products and co-products from the fermentation broth. The water is recovered and returned to the reactor system, thus minimizing water discharge.

In some cases, these products can be used directly as fuel or chemical products. In many cases it is also possible to convert products from the LanzaTech process into common chemicals or 'drop-in' fuels that are normally derived from petroleum. The process thus provides a route from waste gases and solids to valuable fuel and chemical products, reusing carbon along the way to minimize environmental impact.

In 2012, LanzaTech reached key development milestones when it became the first company ever to scale gas fermentation technology to a pre-commercial level. Working closely with its partner in China, Baosteel, LanzaTech successfully operated a facility with an annual production capacity of 3.8 million litres of ethanol. The companies are now planning construction of a commercial facility. The success with Baosteel helped accelerate the development and commissioning of a second, similarly-sized facility with Capital Steel near Beijing. (www.lanzatech.com)

Abengoa BioEnergy
Earlier this year, Abengoa inaugurated its demonstration waste-to-biofuels plant, which is able to treat 25 000 tonnes of MSW from which it will obtain up to 1.5 million litres/yr of ethanol. The demonstration plant, located in Salamanca, Spain, uses waste-to-biofuels technology developed by Abengoa to produce second-generation biofuels from MSW using enzymatic hydrolysis and fermentation. During the transformation process, the organic matter is treated in various ways to produce organic fibre that is rich in cellulose and hemicellulose, which is subsequently converted into ethanol. (www.abengoabioenergy.com)

Coskata

Coskata is a biology-based renewable energy company, whose technology enables the low-cost production of ethanol from a wide variety of input material including biomass, municipal solid waste and other carbonaceous material. To achieve this, it makes use of proprietary microorganisms and patented bioreactor designs.

Recent announcements about Coskata have focussed on its apparent abandoning of biomass as its feedstock in favour of natural gas. However, the company maintains it has always been feedstock flexible, and has now prioritized natural gas owing to the low prices and the attractive funding options. The CEO recently spoke about the abundance of gas almost being a problem, leading to historic price dislocation, and a level of availability that has not been seen for a long time. With Coskata's technology, it is able to achieve a lower ethanol cost on a per litre basis, and a significantly lower overall capital cost because the equipment needed to aggregate and gasify biomass, and then condition the syngas, is appreciably more costly than that required for the reforming of natural gas.

Accordingly, the company now plans to utilize natural gas as its exclusive feedstock for its first several commercial-scale projects. Coskata was already using gas for around one-third of its feedstock needs in its previously planned first commercial project in Alabama. (www.coskata.com).

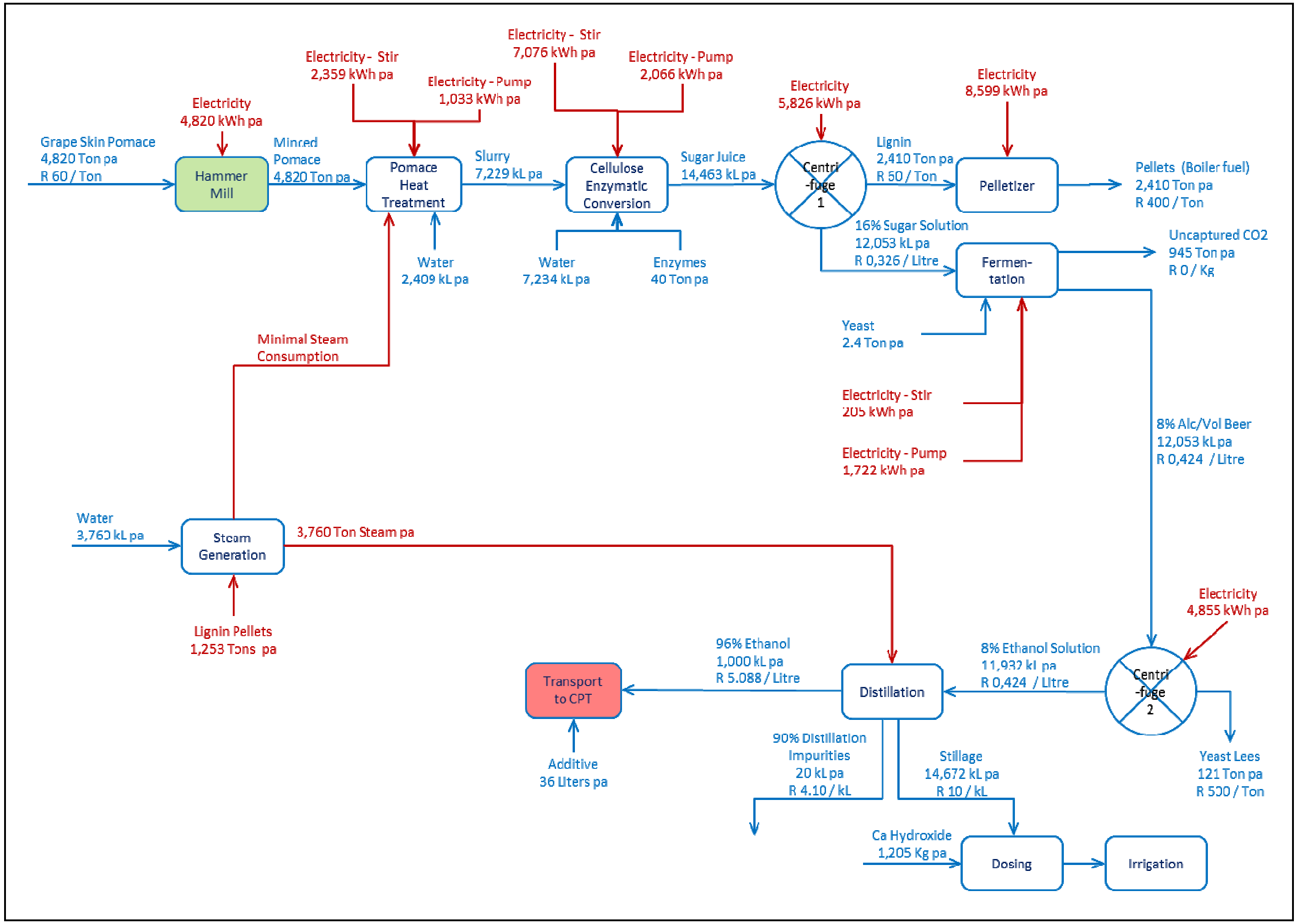
Mascoma

Mascoma's technology is focused on overcoming the key impediment to conversion of cellulose into fuels and chemicals, i.e. cost-effectively accessing of the chemical building blocks locked in cellulosic materials. Typical biomass conversion processes require a collection of saccharolytic enzymes (cellulases and hemicellulases), which first hydrolyze the carbohydrates present in pretreated biomass to sugars, and microorganisms capable of fermenting the liberated sugars into ethanol or other end-products. When the microorganisms simultaneously produce both the necessary saccharolytic enzymes and ferment the liberated sugars to end-products, the conversion process is called consolidated bioprocessing (CBP).

CBP requires the development of genetically-engineered microorganisms, since naturally occurring microorganisms are not capable of simultaneously producing the saccharolytic enzymes and then converting the sugars directly into the desired end-products. In addition, CBP microorganisms need to be able to perform both of these tasks efficiently and rapidly under challenging, industrial processing conditions. Mascoma have developed robust, industrial microorganisms by combining the best qualities of naturally-occurring microorganisms into a single, industrial biocatalyst.

A company started by researchers from the University of Stellenbosch, Stellenbosch Biomass Technologies (SBMT) has been actively involved in the development of CBP, and holds the South African licence for its use (www.mascoma.com and www.sbmt.co.za).

Appendix C – Flow Diagram of the Proposed Grape Skin Based Ethanol Distillery



Appendix D - Workshop Reports

Appendix D.1 – Scoping Workshop

Attendance List - Green Cape Bioethanol Workshop - 23rd August 2013

Name	Institution
Scania	
Jonas Stromberg	Scania
Per Aleby	Scania
Western Cape Government	
Nigel Gwynne-Evans	DEDT
Fernel Abrahams	DEDT
Helen Davies	DEADP
Andre Roux	Elsenburg - Agric
Vanessa Barends	Elsenburg - Agric
Carine van Zyl	Elsenburg - Agric
Leann Cloete-Beets	Elsenburg - Agric
Cabral Wicht	110% Green
City of Cape Town	
Niki Covary	CCT
John Martheze	CCT
James Groep	CCT
Donald Cupido	CCT
Hilton Trollip	CCT
Sivu Jokazi	CCT
Academia	
Johann Gorgens	U of Stellenbosch
Harro von Blottnitz	U of Cape Town
Mamahloko Senatla	U of Cape Town
Private Sector	
Buks Venter	Taurus Distillation
Sjoerd ten Cate	W Cape Ethanol
Orlando Mostert	Tetrox
Wessel Lemmer	Grain SA
Anton Moldan	SAPIA
Schalk Pienaar	Logichem
Green Cape	
Joshua Wallace	Green Cape
Gracia Mungunga	Green Cape
Saliem Fakir	WWF/Green Cape
Anthony Williams	Green Cape

NOTES
Bioethanol Workshop
FRIDAY, 23 August 2013
08h30 – 14h30
River Club

NO	ITEM	ACTION
1	**Welcome** Anthony Williams welcomed and thanked all the stakeholders who made time to attend the workshop and gave a special vote of thanks to the delegates from Scania, Sweden.	
2	**Introduction** **Background** The workshop formed part of a five-month study to investigate the potential for bioethanol production for use as a fleet fuel in the Western Cape, being conducted by Green Cape. Funded by Swedish International Development Agency (SIDA) with Scania, Western Cape Government and City of Cape Town in a business partnership agreement. The study was designed to use waste streams as feedstock, but has since been broadened to look at the use of other feedstocks. **Context of the Study** • National Biofuels Policy and Strategy • National Biofuels Industrial Strategy- 2007 • National Mandatory Biofuels Blending Regulation – 2012 The effective date of the National Mandatory Biofuels Blending Regulations has not been fixed yet for a number of reasons, one of which is that the incentive calculations undertaken by DoE have all been based on grain sorghum as the feedstock. This has understandably raised concerns from the sugar industry, and as a result the DoE has had to delay announcements of its biofuels incentive scheme until such time as the required information is to hand. The pressure is on the DoE as the Minister of Finance has given an undertaking that the incentives will be announced at the mid-term Budget Review in October.	
3	**Agenda Items**	
3.1	**Scania Presentation: Biofuels in heavy duty vehicles** **Jonas Stromberg** 13. Biofuels in heavy duty vehicles project was headed by the Green Product Portfolio at Scania 14. Stockholm started with a demo fleet of 30 buses running on ethanol and have since converted to 100% biofuels in city transportation 15. Ethanol is taxed like diesel in Sweden 16. Presentation made reference to Swedish bioethanol standards and bioethanol certification. 17. Presentation reiterated the importance of doing a pre-feasibility study followed with a pilot demo fleet of 1-5 vehicles to test the potential of running a heavy duty	Presentation to be made available through Green Cape

	vehicle fleet on ethanol within cities. 18. Long term policy on biofuels was also cited as an important deciding factor for continued sustainability of the industry. 19. The minimum capacity required for a viable plant is 1 million litres/yr (which can fuel 20-30 buses, depending on routes) **Presentation: Buks Venter** **Fuel Ethanol Production from Fruit & Vegetable Waste** 1. 5 million tonnes/yr of fruit waste end up in landfills 2. By-products: high value by-products from the fermentation and distillation processes should be investigated in the study. 3. Cost of transporting waste to plant from fruit processing plants. **Presentation: Johann Gorgens** **Cellulosic pulp** 1. Pulping of wood and paper production waste end up in landfills 2. Recognition that too much waste has potential to be used as feed stock 3. A paper sludge pilot project is to be started in several paper mills in South Africa utilizing CBP technology 4. Question raised whether other sources other than paper can be used with CBP technology. It was easy to use paper was the reply **Presentation: Sjoerd ten Cate** **Bioethanol Production in the Western Cape Study** 1. The pre-feasibility study involved Western Cape Ethanol, PetroSA, and University of Stellenbosch. 2. The focus was on creation of another winter grain besides wheat and barley with empowerment potential envisaged for the rural communities – triticale (korog) 3. Target underutilized storage capacity, e.g. George and environs 4. Production of Dried Distillers Grain and Solubles. **Study Business Plan Highlights** 1. Established that Western Cape can produce 200 000 tonnes of grain to ethanol plant 2. The above translates to 78 million litres of bioethanol 3. The implementation of such a project would result in better Western Cape balance of payment, i.e. recirculate money lost to inland and international imports of proteins for animal feeds. **Future of the study** 1. Government should take position on the biofuels industry 2. Regulations for maize were looming but not for wheat, barley or triticale 3. Financing was also cited to be a challenge to the study. The questions raised by the audience were: Energy input (per unit produced)? Original energy source for the plant (e.g. coal)	Biofuels team to conduct investigation

	Key Issues Identified 1. Investigate synergies with the biomass collected from the alien clearing programme (implemented by working for water) 2. There is a need to create a biofuels implementation task team which includes DoE , SAPIA, NAAMSA… 3. Lack of concrete action and direction from government 4. Pricing framework and phasing in approach 5. The 2% mandatory blending requirements could hinder the possibility to create a long term incentives for large scale companies as the 2 industrial facilities (e.g Mabele and Arengo Fuels estimated at a capacity of 250 millions litres) would provide enough bioethanol. 6. The feasibility for higher blends for biofuels should therefore be investigated (e.g. E95, E100)	
3.2	**SWOT analysis of Western Cape Bioethanol Sector in Plenary and focus groups** **Strengths and opportunities** • Provincial state of environment • Green Economy Strategy of the Western Cape has been finalized and is publically available online • Saldanha has been ring-fenced as Special Economic Zone (SEZ) • Industrial symbiosis opportunities • The Western has a strong academia and research capacity • Demands needs local supply • The potential to test Bioethanol in the new fleet of trhe City of Cape Town's 60 new buses (My Citi) • Best distillation expertise and experience in country • Reduction of brown haze from reduced emissions • Introduction of alternative household energy source • Stringent regulation for waste disposal facilities, will also provide an additional incentive for alternative treatment/use of the organic fraction from municipal solid and industrial waste. **Weaknesses** • Limited arable land available in the Western Cape. Further research is needed to address the previous findings of the Department of Agricultire's study which recommends that large scale biofuel crops would not be feasible in the Western Cape • Climate and scale (biodiversity threats and land use threats) • Research on land use change to be done by agricultural and soil scientist • Regulated industry and lack of information on the market segmentation for biofuels • Cost and sustainability of biofuels industry (the main emphasis should be on pricing, perhaps it is engaging with the national biofuels steering committee)	

	• The potential of creating new jobs through SMEs is currently not highlighted enough for the biofuels industry-which might present a threat to large scale roll-out of biofuels • Lack of functionality (independent producers should unite) • Lack of information on the targeted market • Absence of long term policy **Opportunities** • Stimulate Independent fuel producers industry • Transformation of industry • Use of alien vegetation as energy source	
3.3	**Plenary session to map out the way forward** 1. Integrated Energy Strategy- linkages 2. Other biofuels should be included 3. Smaller scale approach to Bioethanol production 4. Assessment of potential market for pure ethanol market 5. Analyse regulatory issues regarding ethanol production from triticale plants 6. Creation of a biofuels consortium needs to be pursued 7. Cape Biotech conference must be revived to create a forum where local companies are given the opportunity to showcase their products and technology 8. Wastes streams potential as feedstock to be investigated, what would be the key issues? 9. Investigate reason behind creation of big soybean plants 10. Investigate gap between already commercially viable vs. those needing incentives 11. Job creation opportunities-political implications to secure support from relevant departments 12. Get Western Cape message to national government level 13. Investigate surplus production in Western Cape 14. Invite financial institutions such Standard Bank and the IDC who have invested in commercial scale facilities 15. Investigate the feasible scale industry opportunities (with and without government incentives) 16. Revive CHEC and collaboration with other universities 17. Engage with national government to investigate the feasibility of establishing an 'Independent Biofuel Producers Programme' similar to the DoE's Renewable Energy Independent Power Producer Programme (REIPPP)	CA in Atlantis produces biodiesel and biogas engines for export market
	General comments	
	Closing Remarks • Anthony Williams thanked attendees for their inputs. • A biofuels draft scoping report based on the input gathered at the workshop to be compiled • Draft report to be disseminated to all stakeholders for comment and further input. • Follow up meeting to be announced during the course of the study	Anthony to disseminate draft report to all stakeholders.

Appendix D.2 – Final Workshop

Attendance List - Green Cape Bioethanol Workshop – 14th November 2013

Name	**Institution**
Sweden	
Marie Bergstrom	Swedish Embassy
Asa Heden	SIDA
Jonas Strömberg	Scania CV AB
Roberto Virgili	Scania CV AB
Per Aleby	Scania CV AB
Western Cape Government	
Helen Davies	DEADP
Jim Petrie	DEDAT
Fernel Abrahams	DEDAT
Goodwell Dingaan	DEDAT
Andre Roux	DoA
Bertus Harmse	DPW
City of Cape Town	
Niki Covary	City of Cape Town
Sivu Jokazi	City of Cape Town
James Groep	City of Cape Town
EDP/CTP	
Lyndon Metembo	FARE
Lisa Kane	SEA - Low Carbon
Industry Associations	
Anton Moldan	SAPIA
Academia	
Riaan de Haan	University of Stellenbosch
Harro von Blottnitz	UCT
Technical Service Providers	
Buks Venter	Taurus Distillation
Ethanol Producers	
Andre Uys	Overberg Agri
Financial	
Jo-Ann Snyman	IDC
Green Cape	
Anthony Williams	Green Cape

NOTES
Bioethanol Workshop
THURSDAY, 14 November 2013
08h30 – 12h30
Belmont Conference Centre

Transport, demand-side
Demand-side management – are there opportunities?

Public education issues – labelling of fuels containing biofuels e.g. E10. Education on effects on older vehicles.

Other models for creating job opportunities through other bioethanol routes

Western Cape's position on cleaner fuels/ smart transport?

Smarter transport – smart contributions to development.

Pilot projects to "learn" new ways of doing things in transport – a long term approach.

Green Building Council – plans to assign points based on "greenness" of goods and services transported to and from the building.

Agriculture
Other models for creating job opportunities through biofuel production routes other than crop-based.

Overberg Agri (Western Cape Ethanol) - 200 000 ha of arable, previously-farmed land has been identified for triticale based project. 700 commercial, emerging farmers. 78 million litres of ethanol and 50 000 tonnes of protein feed.

Future of Agriculture and the Rural Economy (FARE) – looking to diversify the rural economy. Commercialising small farmers.

Overberg Agri – Agri Dwala project to commercialise emerging farmers – Suurbraak, Elim, Napier etc. Yield 27 000 tonnes of grain/yr (www.agridwala.co.za)

Environmental Impact Assessment Impacts (EIA) process for clearing land for agricultural purposes

National, regulatory etc
Exclusionary biofuels strategy – anti-competitive selection criteria in place.

How to get niche opportunities recognised for subsidy support? Non-crop manufacturers cannot obtain licence. What subsidy formulae might be suitable and applicable?

Dti – Green Economy initiatives under IPAP; and DST – BioEconomy Desk
Central Energy Fund (CEF) for funding opportunities

WCG input into the National Biofules Implementation Committee process – NOW. Also interaction with DoE, dti, DAFF etc. (Lyndon Metembo of EDP/FARE has indicated that they would also be able make approaches to DAFF etc)

Provincial level
Import for WCG to engage with municipalities on the agricultural aspects of their municipal spatial development plans, and municipalities have land available.(Do WCG DPW or others have un- or under-utilised land that could be used?)

Innovation
Project-driven activities at University of Stellenbosch: 2nd generation use of triticale bran; low-energy starch hydrolysis through CBP; pilot project on CBP processing of paper sludge waste stream.

WC technology innovation – Biofuel innovation – what are the missing innovation ingredients – HvB to follow up.

Potential pilot studies
CCT is fully supportive of initiative to pilot biofuels in one of their fleet.

GABS and Sibanye to be engaged given that they receive WCG subsidies to provide transport services.

Private waste collection companies – Wasteplan are apparently an innovative company, possible piloting of biofuels with them. HvB to supply contacts.

BRT's i.e MyCiti currently under scrutiny by Treasury for their financial viability.

Look at a key case study on ED 95 ethanol - the more WC biofuels test cases/pilots the better.

Project Driven Activities at Stellenbosch University: Looking at second generation feedstocks; low- energy starch to ethanol through CBP; cellulose enzyme CBP projects. Pilot soon: Use of waste pulp product, paper sludge project-still in lab scale.