

An industry analysis of the South African biofuels industry

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KEYWORDS

Renewable energy, biofuel, biodiesel, bioethanol, biofuel industry, biofuel industrial strategy, energy crops, rural development, waste vegetable oil, renewable fuel sources, ethanol fuel gel, sustainability, job creation and government policy.

ABSTRACT

Biofuels have been used as an energy source for heating and cooking since the beginning of time. However, recent changes in the demand for energy, and in particular, renewable energy, have spurred the growth of liquid biofuel industries in developed countries. Many developing countries, including South Africa have the potential to produce biofuels with benefits extending into the economic and social spheres. Despite government commitments and targets, the South African biodiesel and bio-ethanol industries have stalled in the starting blocks. This research aims to assess the reasons why.

South Africa does not have the climate to compete with Brazil in bio-ethanol production and the scope for bioethanol is limited by environmental factors. However our neighbours show significantly more promise in this area. Biodiesel production is more likely to be commercially viable due to the country's ability to grow oil crops and the need for the by-products.

Despite the availability of land for cultivation of energy crops, the required technology and suitable infrastructure, progress has been slow. Uncertainty, high risk and misdirected government interventions have hampered investment in the sector and those involved in biofuel projects are very negative about the government's ability to stimulate the industry. Consequently, they are looking towards importing feedstock material and exporting the biofuel. This will create a limited number of jobs, but will be energy and carbon negative, and will not aid rural development.

Currently there is no medium or large scale virgin oil to biofuel producer operating in the country and the start-up dates for projects are beyond 2013. The WVO biodiesel industry has grown rapidly in the last five years but is limited to small scale operators with limited benefit potential.

With the exception of Brazil, other world leaders in biofuels are facing heavy criticism and the mechanisms used to initially boost the industry have very limited application in South Africa. The benefits of biofuel production in South Africa are plentiful and align well with social need and development goals.

TABLE OF CONTENTS

Acknowledgements	ii
Keywords	iii
Abstract.....	iii
List of figures	vi
List of tables	vii
List of abbreviations and acronyms	viii
 CHAPTER 1: ORIENTATION AND PROBLEM STATEMENT	 1
1.1. INTRODUCTION	1
1.2. CAUSAL FACTORS	3
1.3. OBJECTIVES OF THE STUDY	4
1.3.1. Primary objectives.....	4
1.3.2. Secondary objectives.....	4
1.4. SCOPE AND DEMARCATION OF THE STUDY	5
1.5. RESEARCH METHODOLOGY	5
1.6. DIVISION OF CHAPTERS	6
1.7. CONCLUSION	7
1.8. CHAPTER SUMMARY	7
 CHAPTER 2: LITERATURE STUDY	 8
2.1. INTRODUCTION	8
2.2. BIOFUELS	8
2.2.1. Biodiesel	8
2.2.2. Bio-ethanol.....	10
2.2.3. Second generation biofuel	12
2.3. GLOBAL OVERVIEW	13
2.3.1. The world leaders	13
2.3.2. The SADC situation	16
2.4. LOCAL OVERVIEW	17
2.4.1. Political.....	17
2.4.2. Economic	19
2.4.3. Social	20
2.4.4. Technological.....	21
2.4.5. Legal	22
2.4.6. Environmental	23

2.5.	BIOFUELS INDUSTRIAL STRATEGY	23
2.6.	SOUTH AFRICAN PROJECTS	25
2.6.1.	First generation liquid bio-fuel projects	25
2.6.2.	Waste vegetable oil diesel producers	28
2.6.3.	Projects currently on hold or discontinued	29
2.6.4.	Second generation bio-fuel research	30
2.7.	CONCLUSION	30
2.8.	SUMMARY	31
CHAPTER 3: RESEARCH METHODOLOGY AND FINDINGS		31
3.1.	INTRODUCTION	31
3.2.	THE PROCEDURE AND SCOPE OF THE QUALITATIVE RESEARCH	31
3.2.1.	Sample size and group	32
3.2.2.	Survey Instrument	32
3.2.3.	Description of the sample	35
3.2.4.	Discussion of results	35
3.3.	ECONOMIC EVALUATION	40
3.3.1.	Cost-Capacity	41
3.3.2.	Operating costs	41
3.3.3.	South African Data	43
3.4.	CONCLUSION	44
3.5.	SUMMARY	45
CHAPTER 4: CONCLUSIONS AND RECOMMENDATIONS		46
4.1.	INTRODUCTION	46
4.2.	STATE OF THE SOUTH AFRICAN BIOFUELS INDUSTRY	46
4.3.	REQUIREMENTS AND RECOMMENDATION	50
4.4.	RECOMMENDATIONS FOR FURTHER STUDY	52
4.5.	CONCLUSION	53
4.6.	SUMMARY	53
REFERENCES		55

LIST OF FIGURES

Figure	Page
Figure 1: General conversion process for bio-diesel from vegetable oil	9
Figure 2: Ethanol production from dry-grain milling.....	10
Figure 3: Global biofuel production from 2000 to 2008	14
Figure 4: Index of crude oil, ethanol, corn and gasoline prices in the US	15
Figure 5: Closed-loop recycling management of agricultural oil-mill-based biodiesel plant ..	20
Figure 6: Location of South African bio-fuel projects.....	25
Figure 7: Canola trial plots planted at Nywara (Eastern Cape)	27
Figure 8: Comparison of production cost of bio-diesel for the reference concepts	43

LIST OF TABLES

Table	Page
Table 1: Questionnaire	34
Table 2: Effect of component costs on the operation cost of a bio-diesel plant	42
Table 3: Raw material costs and production costs.....	42
Table 4: Raw material costs and production costs in SA Rands – 2008 values	43
Table 5: Production costs based on Amigun at al model and latest SA prices	44
Table 6: Enabling factors for biofuel production	46
Table 7: Lessons from world leaders	49
Table 8: Suggestions for improvement	50

LIST OF ABBREVIATIONS AND ACRONYMS

ASGI-SA	Accelerated Shared Growth Initiative for South Africa
BEE	Black Economic Empowerment
BIS	Biofuels Industrial Strategy
CEF	Central Energy Fund
CO ₂	Carbon Dioxide
CSIR	Central Science and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
DME	Department of Minerals and Energy
DRDLR	Department of Rural Development and Land Reform
DTI	Department of Trade and Industry
EDD	Economic Development Department
EIA	Environmental Impact Assessment
EREOI	Energy Returned Over Energy Invested
EU	European Union
IDC	Industrial Development Corporation
FCI	Fixed Capital Investment
GHG	Greenhouse Gas
FFA	Free Fatty Acid
NMMU	Nelson Mandela Metropolitan University
PJ	Petajoule (measure of energy)
RE	Renewable Energy
RNRF	Rainbow Nations Renewable Fuels
SAA	South African Airways
SABA	South African Biofuels Association
SADC	Southern African Development Community
SAPIA	South African Petroleum Association
SANS	South African National Standards
SBSA	Sugar Beet South Africa
SBMT	Stellenbosch Bio-mass Technologies
UN	United Nations
USA	United States of America
WVO	Waste Vegetable Oil

CHAPTER 1

ORIENTATION AND PROBLEM STATEMENT

1.1.INTRODUCTION

Globally, climate change, volatile oil prices and an increasing demand for energy have created a need for alternative energy sources (Amigun *et al.*, 2011:1360). In particular this can be coupled to the large growth in renewable energy generation (Sebitosi & Pillay, 2008:3312).

Renewable Energy (RE) is energy from sources which will not become depleted over the course of time and which can be sustainably derived from energy flows through the earth's ecosystems. These include wind, solar and hydro power as well as carbon sources which can be harvested and replaced at the same interval. Carbon can be harvested in a variety of ways and in gaseous, liquid and solid forms. The most basic use for solid biomass is the domestic burning of wood and coal for cooking and heating, but this only makes up 5.3% of total primary energy supply (Statistics South Africa, 2012). The industrial use of bio-fuels in Southern Africa has been limited to small-scale applications using residual products such as bagasse and waste wood for energy generation (Johnson and Matsika, 2006:42).

Biofuel refers to liquid and gaseous fuel predominantly produced from biomass which is suitable for use in the transport sector (Demibras, 2008:2106). Biogas is most commonly created by the fermentation or anaerobic digestion of materials such as manure, food waste, sewerage and rotting plant materials. The gas, which contains methane can be captured and used as a fuel source. This study focuses on liquid biofuels and thus excludes biomass and biogas.

Liquid forms of bio-fuels are derived from carbon crops and include bio-ethanol and bio-oil. Bio-ethanol may be used as a pure fuel source or blended with mineral petrol (gasoline) in a range of ratios which cater for different applications. Bio-ethanol can also be used to manufacture other fuels such as bio-fuel gel for use in stoves or as a rocket propulsion agent. Bio-oil can be further processed to make bio-diesel, which once again may be used on its own or blended with mineral diesel.

The manufacture of bio-ethanol starts with the agricultural cultivation of a starch or sugar rich crop. The most commonly used crops are sugar cane and maize (corn), sorghum, wheat and cassava (Johnson & Matsika, 2006:45). After harvesting the crop, glucose, which is created by the plant during photosynthesis, is fermented to form ethanol. This ethanol is an alcohol which can be used for combustion in a piston engine, thereby replacing petrol.

Similarly, the most common method for the production of biodiesel relies on the production of oil rich plant based nuts and seeds. Soya, sunflower, jatropha and canola are commonly used virgin feedstock material. The seeds are milled or pressed to extract the oil before biodiesel can be made. The residual material after the oil extraction is a protein rich cake, and this by-product is a valuable and popular animal feed. Waste vegetable oil (WVO), also known as yellow grease, can also be used for bio-diesel manufacturing. An alcohol and catalyst are added to the oil to facilitate transesterification of the glycol to glycerine and triglycerides. This process is elaborated upon in chapter two. The triglycerides form the basis of the bio-diesel and glycerine can be sold as a by-product. In Southern Africa, the use of liquid biofuels is restricted to isolated small-scale operations (Johnson and Matsika, 2006:42).

In the developing world, and specifically Africa, energy sufficiency and security of supply have been identified as key drivers for socio-economic change (Amigun *et al.*, 2010:1361). South Africa requires more energy to fuel economic growth and job creation but already has a heavy carbon foot print. (Sebitosi & Pillay, 2008:3315) Thus, renewable energy seems likely to be a solution to many problems simultaneously. Since the transport sector is a key consumer of energy, liquid bio-fuels must be considered a priority.

The South African government has identified the need to investigate and promote renewable fuel sources since it published the White Paper on Energy Policy in 1998 (DME, 1998:14). Various commitments, regulations and strategies have been tabled since then culminating in the Biofuels Industrial Strategy of December 2007.

In 1998 the "White Paper on Energy Policy" stated that "South Africa has neglected the development and implementation of renewable energy applications, despite the fact that our renewable energy resource base is extensive and many appropriate applications exist." (DME, 1998:79) Many more recent publications argue that the situation has not improved. (Ashton, 2012; DTI, 2011a:148; Roelf, 2012; Sebitosi & Pillay, 2008:3312).

Many researchers have calculated that due to South Africa's relatively low petrol and diesel prices, expensive grain production costs and low yields, a biofuels industry will not be sustainable without substantial government intervention and subsidisation. (Amigun *et. al*, 2008:705; Winkler, 2005:34; Sebitosi & Pillay, 2008:3313) Research, (Winkler, 2005:34) policy support, governance, guidelines (Gao *et. al*, 2010:493; Johnson & Matsika, 2006:45) and education (Sebitosi & Pillay, 2008:3313) will also be required.

South Africa has set compulsory blending targets but, given the current situation has no hope of meeting any such targets (Ashton, 2012). Reasons for the lack of growth in the sector include a political environment which is not conducive to the accelerated growth of a bio-fuels industry. (Sebitosi & Pillay, 2008:3312). The department of Trade and Industry (DTI) attributes the lack of growth in the South African biofuels industry to complex regulatory issues (DTI, 2011a:148) as well as a lack of investment, limited commercial viability and a negative image of the industry due to the fuel versus food debate (DTI, 2011a:148; Roelf, 2012).

Despite South Africa most likely not meeting the current target of 2% blending, the DTI proposes increasing the target to 10% over the next ten years (DTI, 2011) The South African Petroleum Industry Association (SAPIA) has concerns regarding the pricing of the biofuels and whether a sufficient quantity can be produced to meet the blending requirements. (Roelf, 2012)

The South African context needs to be compared to that of leading biofuel producing countries such as the USA, Germany and Brazil in order to determine the reasons for lack of growth in the sector. Areas for consideration include political, economic, social, technological, legal and environmental factors.

1.2. CAUSAL FACTORS

The causal factors for the study are listed in brief below:

- There is a growth in the demand for energy and particularly liquid fuels in South Africa.
- The crude oil price is volatile and South Africa is an importer of large quantities of crude oil.
- South Africa has a surplus of maize but does not use this for ethanol production.
- South Africa is a net importer of soya and other oil cakes as animal feed.

- There is high unemployment, particularly in rural areas which may benefit from a biofuel industry.
 - Rural development is a priority for the South African government.
 - The South African government has made commitments towards the increased use of renewable energy and biofuel.
 - The technology and infrastructure for the manufacture of biofuel is readily available in South Africa.
 - Many large scale projects for the manufacture of bioethanol and biodiesel have been initiated but either discontinued or severely delayed.
- South Africa's neighbouring countries have a climate which is highly suited to bioethanol and biodiesel production.

1.3.OBJECTIVES OF THE STUDY

The objectives of the study are split into primary and secondary objectives.

1.3.1. PRIMARY OBJECTIVES

The primary objective of the study is to determine whether it is feasible for a bio-fuels plant to operate in an economically viable and sustainable manner given the current opportunities and constraints present in South Africa.

1.3.2. SECONDARY OBJECTIVES

In order to achieve the primary objective, a number of secondary objectives have been formulated:

- To describe the current requirements for the operation of a bio-fuels plant in South Africa. This requires research into the legislation which must be complied with.
- To identify and describe initiatives currently underway in the South African bio-fuels industry both those supported by government as well as independent commercial ventures.
- To investigate the stumbling blocks which have prevented the industry from developing at the global rate as well as the causes of the delays which plague specific projects.
- To consider the economic factors and financial feasibility of a bio-fuel plant in South Africa.

1.4. SCOPE AND DEMARCATION OF THE STUDY

The scope of this dissertation is limited to the study of liquid bio-fuels, namely bio-diesel and bio-ethanol and the manufacture thereof in South Africa. It therefore excludes bio-gas.

The focus of the study is predominantly on the first-generation bio-fuels technologies as these are the most likely to realise into commercial ventures at this time. Second-generation technologies are briefly mentioned as they may have an impact on the industry in future. Bio-mass as a fuel source and the collection of bio-gas are excluded from this study. While these are important aspects of a renewable energy plan, they provide greater opportunities for heating and electricity generation than for the transport sector.

In order to understand the context of the problem and for comparative purposes, a global overview is presented in the literature study. Furthermore, due to a number of factors such as the easing of trade restrictions, climate considerations and the mandate of the Southern African Development Community (SADC), it is necessary to mention South Africa's neighbouring countries and analyse the current trends and possible future bio-fuels developments in the region.

1.5. RESEARCH METHODOLOGY

Information was gathered from a variety of sources during this study. In order for the information to be up to date and relevant, it was necessary to use both academic and non-academic literature including newspaper reports, press reports and government publications.

In order to gain first-hand information from industry players, telephonic interviews were set up and recorded. This was necessitated by the fact that these independent entities are mostly private companies and information regarding their operations are not publically available. Furthermore, the qualitative approach allows for small changes during the course of the questioning thus being able to extract the most information possible. The small sample size of operating and planned bio-fuels manufactures and the vast differences in scale between the entities does not lend itself to a generic questionnaire or statistical analysis.

1.6.DIVISION OF CHAPTERS

This dissertation consists of four chapters each of which is briefly described below:

- **Chapter 1: Orientation and problem statement**

This chapter introduces the dissertation by giving a broad overview of biofuels and the South African industry. It guides the reader through the purpose of the study and its relevance in the context of the energy requirements of the country. The objectives of the research are explained as well as how these objectives intend to be met through a brief discussion of the research methodology.

- **Chapter 2: Literature study**

The second chapter is a study of available literature related to the research. Literature sources consulted include academic works such as journal articles as well as media articles and web resources due to the need for recent and commercial information. The literature study consists of four parts. The first part focuses on biofuels. Thereafter a global overview is given with particular reference to the industry leaders and the South African Development Community (SADC) region. The third part looks at the South African industry in terms of political, economic, social, technological, legal and environmental factors. Lastly, the projects and plants under construction and in operation in South Africa are described.

- **Chapter 3: Research Methodology and Findings**

The research methodology for the qualitative study is explained as well as the reason for this choice of instrument. The findings are presented and results between the different groups of respondents are compared. An economic evaluation, using a model developed by another research is validated with current data.

- **Chapter 4: Conclusion and Recommendations**

In the final chapter of the dissertation, the findings of the research are compared to those found in the literature study. The barriers hampering the development of a biofuels industry in South Africa are detailed. The benefit of a biofuels industry are revisited so that suggestions for the accelerated growth of the industry can be made. Lastly, areas which require further study are identified and listed.

1.7. CONCLUSION

Biofuels have been used as an energy source for heating and cooking since the beginning of time. However recent changes in the demand for energy, and in particular, renewable energy, have spurred the growth of liquid biofuel industries in developed countries. Many developing countries, including South Africa have the potential to produce biofuels with benefits extending into the economic and social spheres. Despite government commitments and targets, the South African biodiesel and bio-ethanol industries have stalled in the starting blocks. This research aims to assess the reasons why.

1.8. CHAPTER SUMMARY

In summary, biofuels were introduced and the production of biodiesel and bio-ethanol was explained. The benefits of biofuels were considered and the South African industry was explored. Causal factors for the development of a biofuels industry were given. In order to assess the feasibility of operating a liquid biofuel plant in the current South African environment, the scope and methodology for a study of the industry is outlined. A road map for the rest of the dissertation is presented.

In chapter two, literature is studied to further the understanding of biofuels and the local manufacture thereof.

CHAPTER 2

LITERATURE STUDY

2.1.INTRODUCTION

Developed countries have identified that renewable fuel sources are required to retard the use of fossil fuels, reduce the dependence on crude oil and conserve the environment. Biomass and biogas were briefly discussed in chapter 1 but are excluded from this study. Biodiesel and bioethanol are the most commonly used liquid biofuels as they provide a substitute for mineral petrol and diesel used in the transport sector. Second generation biofuel technology is in its infancy but shows great promise for the future. The use and manufacture of biofuel is currently very limited in South Africa.

This literature study looks at how biodiesel and ethanol are made, why countries such as Germany and the USA have such successful biofuel industries and why South Africa does not. Available information on proposed large scale biofuel projects, as well as some smaller WVO to biodiesel plants operating in South Africa is gathered.

2.2.BIOFUELS

Biofuels are viewed as an important renewable energy source for a number of reasons. They are easier to commercialise than other renewable energy sources due to their ease of substitution, equivalent performance and ability to be blended with mineral fuels (Amigun *et al.*, 2006:690). And with transport fuels making up 30% of the energy consumption of South Africa (DME, 2007:6) the market is large. Small scale biofuel plants have higher productions costs, but economies of scale for biofuel manufacture have less of an impact than those for electricity generation and it is possible to operate biodiesel and bio-ethanol plants of all sizes in a safe and sustainable way.

2.2.1. BIODIESEL

Bio-diesel can be produced from oil bearing crops such as jatropha, palm oil, soya, canola, rapeseed and sunflower. The choice of feedstock material is most dependant on which plants are suited to the climate where they will be grown. Secondly, the oil content of the plant is important for maximum efficiency. Lastly the value of the residual oil cake product is considered since this provides a parallel income stream. The first step in the

process is to extract the oil from the seed. Different beans, nuts and seeds require different pressing processes. The oil is then used for diesel production while the waste cake residue can be sold as a livestock feed. The most common process for bio-diesel production is via physical-chemical transesterification (Amigun *et al.*, 2008:5; Girard & Fallot, 2006:99) which is depicted in the figure below. In this process, an alcohol, for instance methanol, reacts with the triglyceride found in oils in the presence of a catalyst. The result is alkyl-esters (the fuel part) and glycerine.

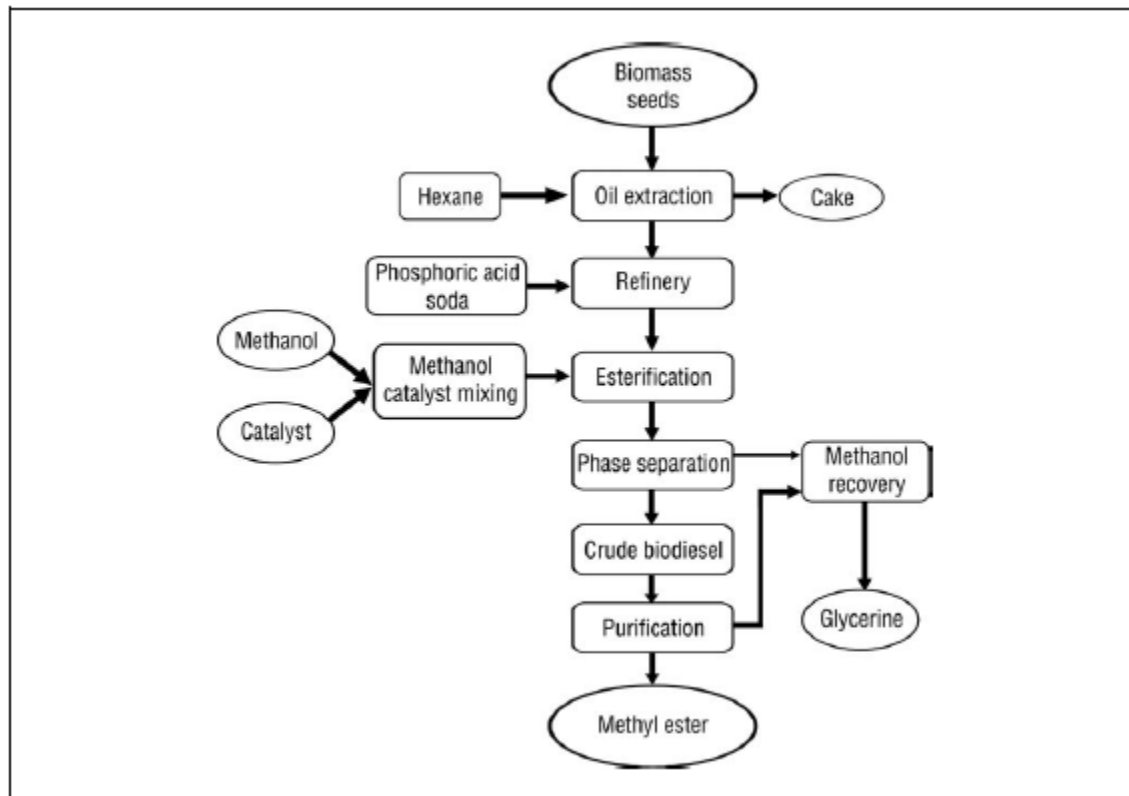


Figure 1: General conversion process for bio-diesel from vegetable oil (Source: Girard & Fallot, 2006:101)

Any oil or fat which contain triglycerides can be used to make biodiesel. These include the vegetable seed oils mentioned previously such as canola, sunflower, soya, jatropha, peanuts, rapeseed and palm oils. Animal fats and waste products may also be used but additional pre-treating is required such as acid esterification in order to break down the free fatty acids which would otherwise interfere with the catalysts required for esterification. (Girard & Fallot, 2006:94) Rapeseed is the most commonly used feedstock material for bio-diesel in Europe as it is suitable for cultivation in the colder northern hemisphere.

Diesel can also be produced by other technologies such as the gasification and fuel synthesis of the Fischer-Tropsch process or hydrogenation of bio-crude oils but is far more complicated and not commonly used. (Amigun *et. al*, 2008:5) These technologies are discussed further in §2.2.3.

Bio-diesel has similar properties to petroleum diesel and can substitute petroleum diesel in many instances. It also has good lubricating characteristics and has a lower freezing point than petroleum diesel, making it “cold-proof” and sought after in Europe and Northern America during the winter months. Additionally, after combustion, the exhaust emissions from bio-diesel are lower in carbon monoxide, hydrocarbons and sulphur than those from petroleum diesel (Nelson & Schrock, 2006:584). Due to the high viscosity of biodiesel produced from WVO, a winterisation additive may need to be added. (Food Processing Africa, 2008)

It is commonly believed that bio-diesel cannot be produced from virgin plant material in Southern Africa at competitive costs without subsidies or government intervention (Amigun *et. al*, 2008:5; Johnson and Matsika, 2006:45). However the production of biodiesel from WVO is economically viable (Food Processing Africa, 2008). This process requires some specialised equipment, such as the reactors which split the triglycerides and glycerol. But small to medium sized plants which operate on a batch method can be purchased locally.

2.2.2. BIO-ETHANOL

Bio-ethanol can be blended with petrol or used on its own in specialised applications. Traditional food crops such as sugar cane, sugar beet, maize, sorghum, cassava and wheat can all be used to make bio-ethanol. (Johnson & Matsika, 2006:45)

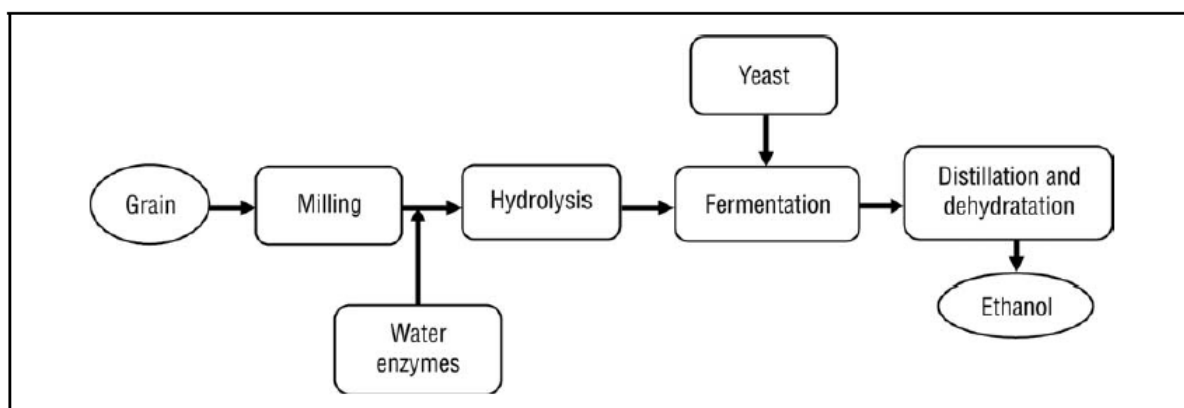


Figure 2: Ethanol production from dry-grain milling (Source: Girard & Fallot, 2006:97)

Sugar cane is the preferred feedstock in countries such as Brazil due to the favourable energy balance and low production cost (Johnson & Matsika, 2006:45) and has been used commercially since the 1970s. The limiting factors for the production of sugar cane are soil quality, rainfall and climate (Girard & Fallot, 2006:94). The South African government has identified sugar cane as the best feed stock for bio-ethanol (Esterhuizen, 2009) but the area suitable for cultivation is limited to frost free coastal areas which have high rainfall.

Sweet sorghum is a variety of sorghum that has been optimised for sugar fermentation and requires less water and can handle more cold than sugar cane (Woods, 2001:31). Trials in Zimbabwe yielded 60 fresh weight ton of above-ground biomass per hectare in 120 days growth. The resulting 46 ton of fresh weight stems can produce 3000 litres per hectare of anhydrous ethanol. However its suitability for the production of ethanol has not been proven in large scale industrial plants and the production costs are likely to be far higher than sugar cane as it has a lower yield. (Girard & Fallot, 2006:94)

Maize is the largest feedstock material for bio-ethanol worldwide as it can be grown in Northern hemisphere countries where the climate is not suitable for sugar cane. 90% of the United States of America (USA)'s ethanol production is from maize (Girard & Fallot, 2006:94) However, bio-ethanol from maize has a worse energy balance and in cases where the factory is fired by coal, both the energy and carbon balance may even be negative. Maize has an EROEI (Energy returned over energy invested) of between 0.8 (more energy used than returned) and 2.3. Maize produces in the vicinity of 1,600 litres of ethanol per hectare and requires a minimum rainfall of 500mm per annum.

Arguments against the use of maize for bio-ethanol extend beyond the food security concerns. South Africa's erratic rain fall and consequent fluctuations in grain production, water required for both the production of the crops and the conversion process, which can use up to 3 litres of water per litre of ethanol produced, and the capital costs required to build the distilleries are all concerns.

Sugar beet has become the latest bio-fuel feedstock of choice in South Africa, with the Cradock Ethanol Project choosing to use sugar beet and sweet sorghum as its raw material. Tests conducted by international consultants on sugar beet grown on 200ha in the Great Fish River Canyon in the Eastern Cape show the highest yield per hectare in the world (Engineering News, 2006). Reports claim that sugar beet, which usually only grows to 1kg in Europe grows as large as 13kg in the Eastern Cape (Kings, 2012). Sugar

beet can be planted in rotation with other crops, thus minimising the effect on food security concerns. Alternatively, two crops per year can be produced on the same land. However, the EREOI of sugar beet is less than two and its use as a fuel source may be questioned (Ashton, 2012). A North West province company planted a crop of sugar beet in 2009 and was the first to use it for the manufacture of bio-ethanol. 110 litres of ethanol were produced per ton of beet with crop yields of 110 ton per hectare, thus 11,000 litres per hectare (compare to maize's 1,600). It requires 550mm of rain per annum. (Siversands, 2009)

An ethanol based gel fuel can be substituted for paraffin, wood, gas, coal or charcoal as a cooking fuel. 2001 statistics show that 21,4% of South Africans use paraffin and another 20,5% are using wood for cooking (Statistics South Africa, 2005:24), which theoretically could be replaced with gel biofuel. Johnson and Matsika (2006:45) agree and estimate that as much as 30% of the cooking fuel in Sub-Saharan Africa could be substituted by gel fuel in future. This not only has environmental benefits but also significant safety and health benefits. (Siversands, 2012).

Another blended variant of ethanol known as ED95 consists of 95% ethanol and 5% ignition improver. This has been produced by the Swedish company SEKAB and successfully used in the adapted diesel engines of bus fleets in Sweden. Recently, it has been manufactured by Siversands in South Africa and is being tested on a Scania bus as part of Johannesburg's Metro Bus fleet. (Siversands, 2012). In the next step, a further 20 busses will be commissioned in Johannesburg to run on the hydrolysed ethanol which is of a particularly high quality. (Food Processing Africa, 2011)

Currently the most popular and in the opinion of many the only sustainable and profitable bio-fuel manufacturing for South Africa at the present time (Food Processing Africa, 2008) is the conversion of WVO into bio-diesel. As cooking oil is reused the free fatty acid (FFA) content increases making it unsuitable for further human consumption. In the past, this oil was then filtered and sold to unsuspecting users or added to pet food. (Biogreen, 2010b) However a number of companies have started to collect this WVO and through a reaction process convert it into bio-diesel.

2.2.3. SECOND GENERATION BIOFUEL

The term second generation biofuel is used very loosely to include a multitude of renewable energy sources. Some include second generation bio-refineries, such as those based on bioprocesses including pyrolysis, Fisher Tropsch, and other catalytic processes

which make more complex molecules to produce biodiesel and bio-ethanol in this definition. (Naik *et al.*, 2009:578). These refineries essentially use the same raw materials as the first generation plant albeit in a more efficient manner. Another example uses the anaerobic digestion of biomass to create biogas whereafter the CO₂ is scrubbed from the cooled gas resulting in liquid methanol which can be stored and transported more easily than the unrefined biogas (Naik *et al.*, 2009:578).

More strictly speaking, second generation biofuels should be carbon neutral and should not use excessive amounts in energy in their creation. The energy output should be higher than that of first generation biofuels which would use the same resources (land, water). The edible part of food crops should not be used. Lignocellulosic materials such as bagasse, wood chips and agricultural residues can be used to manufacture advanced biofuels through hydrolysis and fermentation (biochemical) or through gasification (thermo-chemical) (Sims *et al.*, 2010:1570).

More radical research includes the use of algae to convert CO₂ into organic bio-oil and the production of isobutanol through yeast fermentation instead of methanol.

Second generation biofuel technologies are still in their infancy both locally and internationally. Governments such as those of Japan, USA, Canada and Germany are financially supporting research into second generation biofuels (Sims *et al.*, 2010:1571). A number of private companies such as Chevron, BP, Shell and Exxon are doing their own research and development. South Africa also has some academic projects underway including an algae CO₂ conversion project and these are elaborated upon in §2.5.4.

2.3. GLOBAL OVERVIEW

2.3.1. THE WORLD LEADERS

Brazil has been the world leader in bio-ethanol production since the 1980s, producing over 500 Petajoules (PJ) or 500×10^{15} Joules of biofuel in 2008. However, the USA has recently overtaken it as can be seen in figure three.

As mentioned in §2.2.2, the Brazilian climate, ability to cultivate sugar cane and production methods are the most efficient in the world. They have also passed the test of sustainability due to the electricity which is created from the bagasse, thus making the conversion energy negative (DME, 2007) (Sims *et al.*, 2010:1570). Additionally Brazil has

been able to reach oil self-sufficiency by producing an equivalent of 160,000 barrels of crude oil through its ethanol production. (Amigun *et al.*, 2006:696)

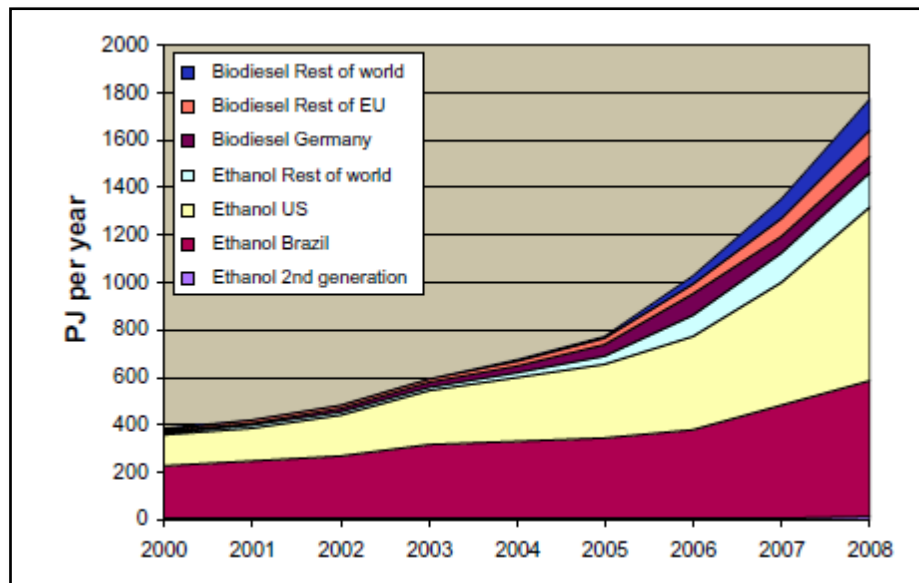


Figure 3: Global biofuel production from 2000 to 2008 (Source: Sims *et al.*, 2010)

The USA is converting 30% of its maize into ethanol for blending with petrol. (Ashton, 2012) It has received a lot of criticism for using maize which has a low energy conversion rate and has been blamed for global maize shortages, the increase in maize prices and wasteful use of food resources (DME, 2007; Gao *et. al.*, 2010:489). In contrary, some evidence shows that other factors such as widespread drought and extremely low maize prices in the past contributed to the shortage and that the growth in the US biofuels industry is coincidental (Sims *et al.*, 2010:1570).

The relationship between gasoline prices, ethanol prices and grain prices seen in figure four has strengthened during the last decade (Wisner, 2009).

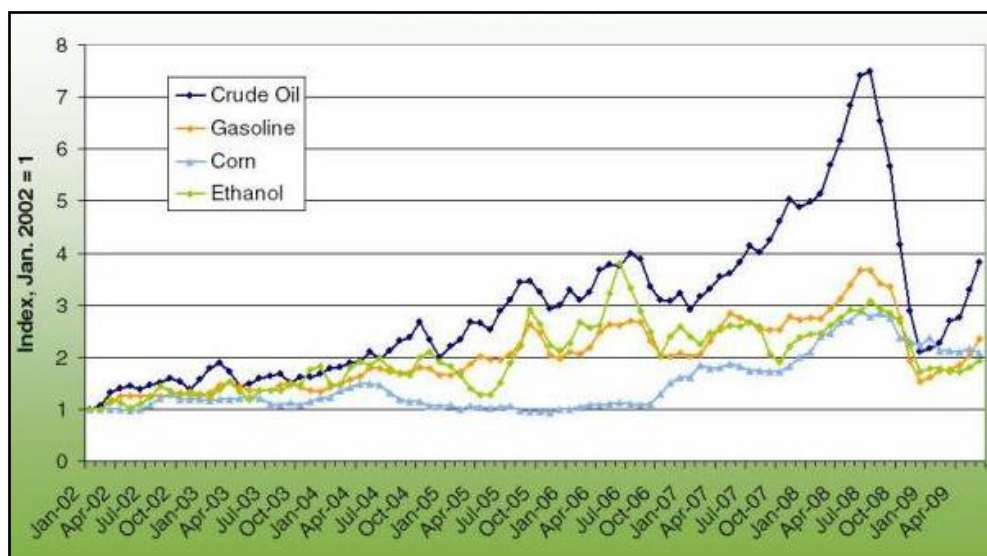


Figure 4: Index of crude oil, ethanol, corn and gasoline prices in the US (Source: Wisner, 2009)

This is based on data from the US but since both grain and crude oil are traded globally, other countries will have a similar relationship depending on their gasoline manufacturing and agricultural capability. This relationship means that there is a certain margin available above the grain price for the ethanol manufacturer to convert the grain to fuel and make a profit. During the first quarter of 2009, the relative corn price was higher than the gasoline price and the profits of ethanol producers would have declined. But the US, like many European countries, has rebates, incentives and subsidies in place to support both the farmers and the ethanol manufacturers to bridge the gap. (Johnson & Matsika, 2006:47)

The USA has always subsidised farmers in some way or another. The initial justification for this was to aid households by keeping food prices low while still making farming profitable. In 2000, subsidies reached an all-time high when US\$25,7 billion was paid in subsidies to farmers, making up 47% of farm income. (Washington Post, 2006). Amid budget cuts and criticism from the World Trade Organisation, the USA has reduced subsidies to farmers slightly in the last decade. The USA also supports the ethanol industry with subsidies in order to reduce the dependence on imported crude oil; to utilise the surplus maize production and to buffer the US ethanol producers from cheaper Brazilian ethanol imports. Subsidies reached a maximum in excess of 85c (US) per gallon (approximately R1,97 per litre) totalling US\$7,3 billion (Washington Post, 2006).

In Europe, an EU directive of 2003, defined indicative targets for transport fuels from biogenic and other renewable energy sources as 2% by 31 December 2005 and 5.75% by 31 December 2010 for all EU Member States. (EU, 2003) Germany has been the

forerunner in achieving this. In 2004, Germany exempted biofuel from CO₂ emissions tax and the industry grew rapidly, quickly reaching 5% of the total fuel usage. In 2006, Germany used 28,200,000 tons of diesel for transport fuel, 21,800,000 tons of petrol, 2.5 million tons of biodiesel, 1,080,000 tonnes of plant oil and 480,000 tons of bioethanol. (Burgermeister, 2007) However in 2007, a tax was introduced on biofuels and some plants cut back on production despite a simultaneous mandated 5% blending of all diesel in Germany. With the price of rapeseed oil, which is used for over 70% of Germany's biodiesel production increasing and taxes likely to continue to rise – the outlook of the German biofuels industry is bleak and its sustainability is questionable. In light of this, the German government is supporting second generation biofuel research. (Sims *et al.*, 2010:1571).

In Sweden, biofuel has grown to the second largest source of energy (Amigun *et al.*, 2006:696). Subsidies ensure that biofuel is 30% to 40% cheaper for the motorist than the mineral equivalents and a range of other benefits such as exemption from congestion tax in Stockholm, free parking bays and reduced vehicle licencing fees have resulted in a rapidly growing fleet of E85 vehicles. Large filling stations and all new filling stations are required to stock at least one form of biofuel. Even liquor confiscated by customs officials is taken to a refinery to be converted into ethanol. (Johansen, 2007) Yet, Sweden imports most of its ethanol from Brazil and Italy, questioning the carbon footprint of the initiatives.

2.3.2. THE SADC SITUATION

Sub-Saharan Africa has been identified as having the largest potential for bio-energy creation due to the large areas of underutilised land, current low productivity and sub-tropical climate where photosynthetic efficiency is higher (Johnson & Matsika, 2006:43). Countries such as Malawi, Zambia, Zimbabwe and Tanzania have average sugar cane yields in excess of 100 t/ha, in comparison to Brasil's yield of 74 t/ha and thus have enormous potential for bio-ethanol production (Johnson & Matsika, 2006:44). These SADC countries also have sufficient rainfall. Regional conflict and a lack of infrastructure, particularly transport to the ports for export from land locked countries has stunted the growth of the sugar industry in these countries, but increase the benefit of bio-ethanol production. Subsidised sugar production in the EU and US have also distorted sugar prices in the past (Johnson and Matsika, 2006:45).

Economic integration of the SADC region can see all SADC countries benefitting from the favourable bio-ethanol production conditions in countries such as Malawi, Zimbabwe, Zambia and Mozambique.

Zimbabwe began a programme of ethanol-blending in the 1980s but this was halted due to severe droughts and a lack of government support. (Johnson and Matsika, 2006:47). Currently blending of bio-ethanol into petrol is not mandatory in Zimbabwe and as such their ethanol plant has been idle since February 2012 due to a lack of local market. In September 2012, the Confederation of Zimbabwean Industries called for mandatory E10 blending by no later than December 2012. (Biofuels Digest, 2012)

Principle Energy is busy establishing a large scale sugar cane to bio-ethanol plant in the Dombe region of Mozambique. The plans include planting 23,000 hectares of sugar cane in an area where soils are rich and which has irrigation potential. 65 million gallons of ethanol can be generated a year as well as 13MW of electricity from the bagasse.

There are also plans for large scale bio-fuel production in Malawi. Bio-Energy Resources Limited have plans for the 2016 start-up of a plant which will initially produce 111,000 litres of vegetable oil from jatropha for diesel. The scope is to ramp up to 29 million litres of oil with the involvement of 130,000 small scale farmers in the next five years. Malawi is also researching ethanol for use in vehicles and actively promoting bio-fuels as an alternative to the imported fossil fuels. (Food Processing Africa, 2011b)

In many SADC countries potable ethanol is produced for export and use in beverages.

2.4. LOCAL OVERVIEW

2.4.1. POLITICAL

Research has concluded that it is necessary to have government support in order to promote the introduction and growth of renewable energy technologies (Girard & Fallot, 2006:93). The growth rate of such technology is responsive to the energy policy guidelines as well as the social goals of a country (Winkler, 2005:27). The current level of development, socio-economic factors and environmental factors play a role in determining what forms of support the government may employ (Sebitosi & Pillay, 2008:3314) and initiatives include:

- Investment cost reduction;
- Public investment;

- Market facilitation and
- Tax relief

The driver for political will is social pressure. In many instances, mostly in Europe, lobby groups have persistently applied pressure on the government in order to change their policies to be in favour of renewable energy. This social pressure created the market demand which drives the development of bio-energy. (Gao, Zhao & Wang, 2010:488) In South African, there is no credible pro-environment civil movement exerting such pressure. (Sebitosi & Pillay, 2008:3313) In isolated cases, such as countries wanting to become part of the European Union (EU), external pressure has brought about change in terms of RE policy, It is not likely that external pressure, either from organisations such as the United Nations (UN) or countries to which South Africa exports products will be strong enough to bring about the required change. Locally, typical African problems such as severe poverty, low-levels of investment, poor infrastructure, and socio-economic factors such as health care, education and food security are high on the priority list for Sub-Saharan governments. Consequently, topics such as biofuels have a low priority and receive little attention (Johnson & Matsika, 2006:44).

The government has identified key success drivers for a sustainable RE industry in its White Paper (South Africa, 2008) but when one compares the progress made with the objectives set out in the papers then it appears that the government lacks the will and the capacity to move forward with RE (Sebitosi & Pillay, 2008:3313). The White Paper published in 1998 calls for a strategy to be developed within the next 5 years (DME, 1998), but the Biofuel Industrial Strategy was published only in 2007 (DME, 2007) and is still criticised for not addressing all of the requirements particularly in terms of costing and compensation.

Good data and information relating to the manufacture and use of energy and fuels is not effectively collected or made available to the public (Sebitosi & Pillay, 2008:3313). This can mainly be attributed to the secrecy and government control of the industry during the Apartheid years. This lack of data makes decision making in both the public and private sectors difficult and hampers investment in the sector.

Despite a certain amount of deregulation, shared infrastructure and the monopoly of the SA fuel industry by a few large players, make entry into the market difficult. Newcomers to the industry will require significant assistance in order to effectively compete or sell their products to the major players for blending purposes (Sebitosi & Pillay, 2008:3314).

In summary, the South African political environment is not conducive to the accelerated growth of a bio-fuels industry (Sebitosi & Pillay, 2008:3312).

2.4.2. ECONOMIC

Macro-economic benefits for South Africa include reduced dependency on imported fuels as well as a buffer against the price volatility thereof, improved flexibility in terms of off-grid supply and moving fuel production closer to the user. (Winkler, 2005:30; Johnsson & Matsika, 2006:44) The labour intensive industry will create jobs (DTI, 2011) and rural livelihoods can be created (Johnsson & Matsika, 2006:44). Musango *et al.* (2011:6939) list local job creation as a key positive impact of large scale bio-diesel production.

Biofuels, biodiesel in particular have another significant benefit to South Africa in that the by-product of the oil extraction is a protein rich cake or meal which is used as an animal feed. Currently South Africa is a net importer and in 2007, 812 000 tons of soya oil cake were imported. These by-products are often not quantified and included in the income streams of the project, but should be included as they can influence the profitability of the project. (Musango *et al.* 2011:6939)

By exporting “cold-proof” diesel which can be sold at a premium in Europe and reducing the imports of animal feed oil cakes, South Africa can improve its trade deficit on condition that the feed stock material can be grown locally.

The direct costs associated with the production of bio-fuels include the feedstock costs, transport costs and conversion costs (Johnson and Matsika, 2006:48). Feedstock costs are dependent on the type of feedstock (eg. maize, sugar cane or soya), farming methods and input costs such as diesel and fertilizer. Transport costs are incurred while moving the feedstock to the factory. The distance from the fields to the factory plays the most significant role. Production costs include labour, energy (electricity and heating costs), administration and the cost of capital.

Co-products generated in the production of the bio-fuels can be used internally or sold to provide the factory with another income stream. Examples include bagasse from sugar which can be used for heating and soya oil cake which can be sold as an animal feed.

The South African Petroleum Industry Association (SAPIA) has concerns regarding the pricing of the biofuels as well as whether enough will be available to meet the blending requirements. (Roelf, 2012)

The Industrial development Corporation (IDC) has a number of development funds which can support investment and provide funding for the biofuels industry, these include the Green Energy Efficiency Fund, the support programme for industrial development and the risk capital development fund. Depending on the individual requirements, loans or grants may be allocated to stimulate new businesses. Factors influencing eligibility include black or women ownership, job creation potential, energy use, level of innovation and competitiveness in the industry. (IDC, 2012)

2.4.3. SOCIAL

A bio-fuel plant which is located close to an agricultural area and which incorporate an oil-mill has many benefits for the community. The closed loop model shown below illustrates how a self-sufficient rural economy can be created by incorporating crop production, livestock farming and energy generation as well as the fuel plant.

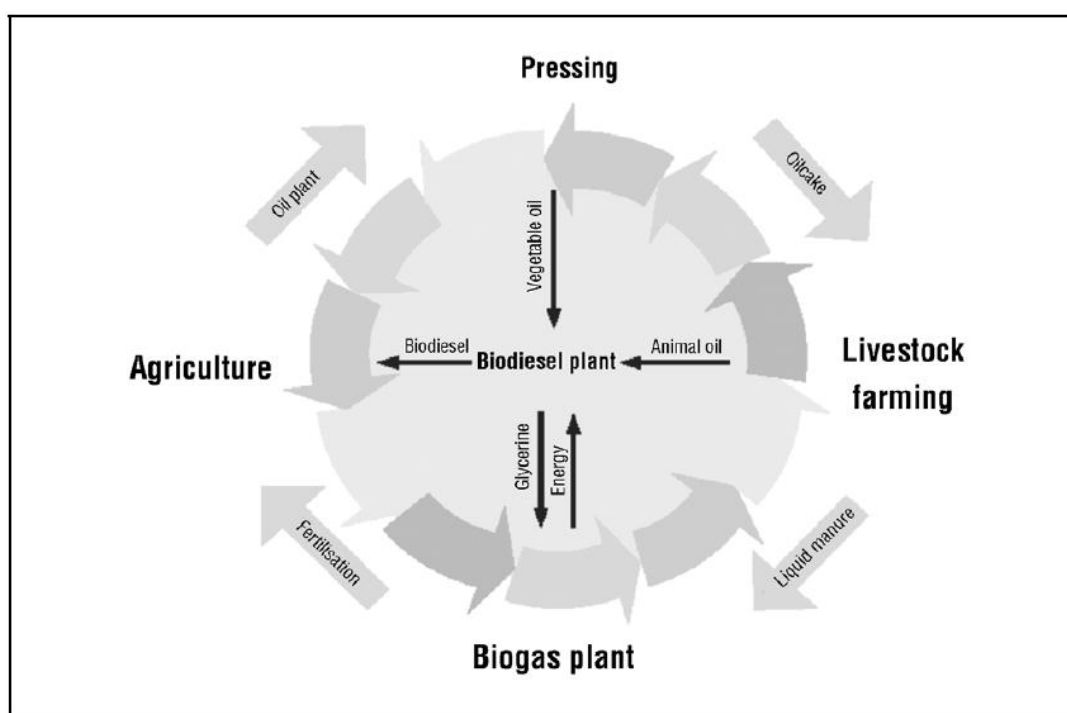


Figure 5: Closed-loop recycling management of agricultural oil-mill-based biodiesel plant (Source: Amigun et. al. 2008:11)

This type of process will provide the rural stimulation, employment and wealth creation (Amigun et. al. 2008:11) as desired in the Industrial Strategy (DME, 2007).

Ashton (2012) attributes the delays to the emerging farmers tasked with growing the sugar beet who have not been successful. Chris Hani Municipality's executive major, Mr

Koyo complained to the Rural Development and Land Reform Minister Gugile Nkwinti that the 13 farms encompassing 8000ha which were earmarked for redistribution and cultivation of the sweet sorghum and sugar beet required for the Cradock plant, were being unfairly distributed to city dwellers who were not utilising the land (Radebe, 2012). The valuation of the farms purchased caused some problems and not enough land has been purchased through the willing buyer / willing seller principle (Radebe, 2012). 3500ha of land must still be purchased. (Rodgers, 2012). Land which has been purchased is lying unused and the expensive irrigation infrastructure is not being maintained.

In the case of the Coega project, Musango et al. (2011:6939) determined that the community required to use their previously fallow land in the Transkei and Ciskei for canola production had previously had bad experiences with crop production and had a bad perception of the bio-diesel crops. Making a change from subsistence farming to harvesting a product for commercial gain requires education, mentorship and promotion.

Existing commercial farmers have been excluded from the benefits proposed by the Strategy for Bio-Fuels (DME, 2007). This has limited the use of grains and especially sugar cane for bio-fuel production (Esterhuizen, 2009), as all projects not only need to make economic sense for the conversion plants but also have to establish new farms which is proving to be much more challenging than the actual conversion process.

Since the raw materials used for the production of bio-fuels are mainly grain and oil crops, an increase in bio-fuel production will inevitably affect food security (Gao *et al.*, 2010:490).

2.4.4. TECHNOLOGICAL

The technology required for first generation biofuel production is mature and readily available, (DME, 2007:17) even in South Africa. South Africa also has a well-established fuel industry with a history of innovative success. The IDC and the Council for Scientific and Industrial Research (CSIR) as well as the CEF have groups which concentrate on renewable energy and biofuels.

Second generation biofuel research is already underway at South African universities such as NMMU and Stellenbosch.

South African Airways (SAA) stated that it aims to use 50% aviation bio-fuels by 2020. It hopes that this policy shift will spark local production. (Biofuels Digest, 2012b)

2.4.5. LEGAL

Biofuel producers need to obtain a licence from the Petroleum Products Controller before they may operate. Conditions of the licence include: crop selection and availability, environmental standards including the restriction of water usage quality standards. (DME, 2007). At the time of writing, the application process for such a licence had not been updated to incorporate biofuels.

South Africa has set compulsory blending targets but given the current situation has no hope of meeting any such targets (Ashton, 2012). The DTI attributes the lack of growth in the South African biofuels industry to complex regulatory issues (DTI, 2011) as well as a lack of investment, limited commercial viability and a negative image of the industry due to the fuel versus food debate (DTI, 2011; Roelf, 2012).

Improved regulations and better cooperation between government departments have been identified by the DTI as key aspects in order to accelerate the growth. (DTI, 2011) Sebitosi and Pillay (2008:3315) also list bickering between state departments such as the DME and the Department of Science and Technology and administrative anomalies as serious stumbling blocks. Roak Crew, chief executive at SBSA said that the industry will not be sustainable without mandatory blending of biofuels (Roelf, 2012). Neil Morris, chairperson of the board responsible for the construction of the Cradock Ethanol plant blames the slow promulgation of regulations and uncertainty over price support structures for the delays in construction of the plant. (Radebe, 2012). While some legislation has been promulgated, there is still a back-log of outdated policies and regulations in many departments that need to be revised in order to reduce the bureaucratic barrier to the construction and operation of bio-fuel plants. (Sebitosi & Pillay, 2008:3315)

Despite South Africa most likely not meeting the current target of 2% blending, the DTI proposes increasing the target to 10% over the next ten years (DTI, 2011)

Many changes are required in legislation in order to facilitate the growth of the biofuels industry. Rentia van Tonder, head of Green Industries at the IDC has stated that a lack of blending regulations is a factor in the delays experienced by many plants including the IDC's proposed Cradock plant (Kings, 2012).

The Department of Energy committed to finalising the mandatory blending regulations by the end of 2012 (Roelf, 2012), and in August 2012 the regulations regarding the mandatory blending of biofuels with petrol and diesel were published in the Government

Gazette. The regulations include mandatory blending of a minimum B5 diesel and a B2 – B10 ethanol-petrol blend. Oil companies must buy all available biofuel until this target is reached. Quality standards are mandated but the pricing structure is not mentioned. (DE, 2012)

2.4.6. ENVIRONMENTAL

3 171 million hectares of land are currently utilised by commercial farming in South Africa. Of this, 2 699 million hectares of maize will be planted in 2012, a figure which has decreased by 21% from the 3 429 million hectares of maize planted in the year 2000 (SA Grain, 2012:30). Despite the dramatic increase in the area under soya beans in the last twelve years to 472 000 hectares (SA Grain, 2012:30), there is still a 7,5% decrease in the total area cultivated. Reasons for the decline include an increase in the use of agricultural land for mining purposes in Mpumalanga.

The DTI has also identified water scarcity as a limiting factor for the growth of the bio-fuels industry (DTI, 2011)

The potential air-pollution and greenhouse gas (GHG) reduction has localised health benefits as well as earning credits under the Kyoto Protocol's Clean Development Mechanism and can help South Africa to meet its Renewable Energy Targets (DTI, 2012). With the US Department of Energy listing South Africa as the 7th highest emitter of GHG per capita in the world (Sebitosi & Pillay, 2008:3314), it is likely that more pressure will be exerted on South Africa to make some progress in this area despite its status as a developing country.

While trading in carbon emissions has been possible in South Africa since 2004, it has had very little impact so far. This presents an opportunity which can be better exploited.

2.5. BIOFUELS INDUSTRIAL STRATEGY

The 2007 publication of the "Biofuels Industrial Strategy" presents the government's approach to biofuels and the creation of such an industry. This is the road map which many people eagerly awaited, hoping that it would provide clarity on a number of points mentioned in the previous sections.

The mandate which was given to the task team appointed to compile the strategy document has only one objective being "to create jobs in the energy-crop and biofuels value chain" (DME, 2007:3). From this the objectives of the strategy are briefly listed:

- Address poverty and economic development
- Promotion of farming in former homelands
- Uplift previously disadvantaged areas and communities to become commercial farming areas.
- Reduce poverty through rural development and income earning opportunities
- Contribute towards the achievement of renewable energy goals. (DME, 2007:4)

The penetration level target was reduced to 2% over 5 years (up to 2012) from the initial target of 4,5% published in the draft strategy. (DME, 2007:20) 2% blending of bio-fuels before 2013 equates to about 400 million litres a year (Roelf, 2012)

Energy-crop production is limited to the following plants: sugar cane, sugar beet, sunflower, canola and soya beans (DME, 2007:3) In the case of drought or crop failure, the energy crops can still be redirected to the food market (DME, 2007:4). Furthermore, only historically disadvantaged farmers, growing crops in the former homelands will qualify for support. (DME, 2007:13) The manufacturing licencing conditions will include the location of the projects in order to ensure that they are located close to such farmers. Fixed price contracts between the oil companies and biofuels producers will make provision that the crops are grown in the areas designated for development. (DME, 2007:18)

An investor incentive was proposed that will benefit projects until the 2% penetration limit is reached. (DME, 2007:20) Furthermore, licences will only be issued to those who assist in reaching this target. Biodiesel is exempted from 50% of the fuel levy (approximately R0,53 per litre) and bioethanol from 100% of the fuel tax (approximately R1,21 per litre). The pricing of biofuel will be fixed at a level of a 2% saving to the motorist while the oil price is above US\$65 per barrel. However the pump price of petrol-bioethanol blends will not be regulated.

It is not recommended to mandate the uptake of biofuel at this stage. (DME, 2007:19)

The strategy acknowledges that government support is required in the development of farming on previously underutilised land. No new plans are in place for this, but farmers can seek assistance from the existing support mechanisms offered by the Departments of RDLR and Agriculture. Projects are also expected to support emerging farmers. (DME:2007,14)

The biofuels uptake and blending must use the existing infrastructure but negotiations with the oil companies were not finalised at the time of the strategy. (DME, 2007:22) The proposed blending ratios are B2 biodiesel and B8 bioethanol (DME, 2007:12,21) The SANS standards make provision for up to a 5% biodiesel blend and a 10% ethanol blend. (DME, 2007:22)

2.6. SOUTH AFRICAN PROJECTS

Plans for a number of bio-fuel projects have been put in place in South Africa in recent years, but to date there are no commercial production units in operation (Musango et al, 2011).



Figure 6: Location of South African bio-fuel projects (Source: Google Earth, 2012)

2.6.1. FIRST GENERATION LIQUID BIO-FUEL PROJECTS

2.6.1.1. Ethanol Africa

Ethanol-Africa was founded by GrainSA and the SA Biofuels Association (SABA) and in 2006 intended to build a number of maize to bio-ethanol plants. Advanced planning for such a plant with the capacity of 470,000 litres per day of ethanol from 1125t maize in Bothaville was halted by the 2007 government ruling prohibiting the use of food crops for bio-fuel. This is despite an annual surplus of 3 – 4 million tonnes of maize. The group is in the process of investigating the use of sweet sorghum as an alternative feedstock. However as they will not qualify for the incentives offered by the government, the commercial feasibility of the project is still being evaluated.

2.6.1.2. Siyanda bio-diesel

Sasol, the state-owned Central Energy Fund (CEF) and Siyanda, a black empowerment enterprise (BEE) formed a joint venture in 2006 to build a bio-diesel from soya plant. Sasol applied for a temporary rebate on the import duty on 600,000 tons of soy beans in order to get the plant operational. The International Trade Administration Commission approved this in order to jump start the bio-fuels industry (Esterhuizen, 2009), however the rebate grace period expired in 2011 before the plant was built. Sasol and the CEF have since withdrawn from the project. CEF stated that the economics behind the project were not favourable (CEF, 2007) but Siyanda has continued with the plans and will start construction on the 100,000 tons per annum plant near Newcastle in February 2013. Soya will be imported initially as emerging farmers ramp up their production in the surrounding areas (Siyanda, 2012)

2.6.1.3. Phyto-Energy

Projects involving canola for bio-diesel in the Eastern Cape under the umbrella of the Accelerated and Shared Growth Initiative for South Africa (ASGI-SA) and the Eastern Cape Department of Agriculture have been earmarked as a way to boost employment and economic growth in previously disadvantaged regions. (Musango et al, 2011) Canola, a winter crop, could be produced on the same land as maize, a summer crop, alleviating food security concerns. Despite the fact that the EREOI of canola is between one and two and the input costs are likely to far exceed the selling price of the diesel (Ashton, 2012).



Figure 7: Canola trial plots planted at Nywara (Eastern Cape) (Source: Fouche, 2012)

PhytoEnergy Group of companies was founded in 2004 and has plans for a canola to bio-diesel plant in the Eastern Cape. It is working in conjunction with the Department of Trade and Industry (DTI) the Economic Development Department (EDD), the Department of Agriculture, Forestry and Fisheries (DAFF) and the Department of Rural Development and Land Reform (DRDLR). By aligning its objectives with those of government it has secured financing and support from the DTI. It is also behind the scheduled start up date of 2011 (Esterhuizen, 2009) but has planted 50ha (PhytoFarming, 2012) of the proposed 5000ha of canola in the former Transkei and Ciskei. Construction of the 400,000 tons per annum factory is planned to commence in 2012 and be completed in 2014. (DTI, 2010) The plant will be located in the Coega Industrial Development Zone, which is an industrial estate geared for easy transport and export. The diesel produced by the project will be exported to Europe where it can be used as a “cold proof” fuel.

2.6.1.4. Rainbow National Renewable Fuels

Rainbow Nations Renewable Fuels (RNRF), owned by the Australian company National Biofuels Group, plans to build a 1,000,000 tons per year soya to diesel plant in the Coega Industrial Development Zone. This is more than three times the current South African production of soy beans. An investment to R2,1 billion (DTI, 2011) is required to produce 250,000 ton of soya oil with 800,000 tons of soya oil cake as a by-product. 288 million litres of bio-diesel a year can be generated with glycerine as a byproduct. (Esterhuizen, 2009) The energy intensive plant requires 48MW of electricity. Initial plans were for commissioning in late 2009 with soy beans being imported at first and later being sourced from South Africa (Hill, 2008). Plans were adjusted for a September 2012 start-up (DTI, 2011) at 50% capacity. R1,7 billion of the R2,1 billion investment to be made by RNRF in order to create 130 direct jobs has qualified for tax rebates granted by the DTI. (DTI, 2011)

2.6.1.5. Cradock Arengo 361

Another Eastern Cape project involves cultivating sugar beet for bio-ethanol. Cradock Ethanol plant also known as Arengo 361 which is owned by the Industrial Development Corporation (IDC) and Sugar Beet South Africa (SBSA) of which the Eastern Cape government is a 74% stakeholder (Engineering News, 2006) after the Central Energy Fund (CEF) pulled out (Schneider, 2011). Initial plans were for construction to start on a R1,3 billion production facility in 2009 (Hill, 2008) but these have been delayed to start up

in October 2012 (CEF, 2010) and more recently to start up in May 2014 at 50% capacity. (DTI, 2011) 8000ha of sugar beet and sweet sorghum will be grown by emerging farmers on redistributed land near Cradock and processed to 90 million litres of bio-ethanol (CEF, 2010). It has also qualified for tax allowances based on it being in the priority sectors of the IPAP. 167 jobs will be created at the processing facility while the upstream agricultural development will contribute 2500 jobs (Radebe, 2012). In December 2011, Arengo calls for tenders to supply 70% of the 230,000 tons of sorghum required, with only 30% of the sorghum coming from the emerging farmers in the start-up phase. The second phase will utilise the locally grown sugar beet. In July 2012, a spokesperson for the IDC said that the project had not yet been approved by the board. (Radebe, 2012)

2.6.1.6. Silversands Ethanol

Silversands Ethanol is a private commercial venture in Lichtenburg the North West province which is growing sweet sorghum to make ethanol based fuel gel. (Food Processing Africa, 2011) They also planted a trial crop sugar beet in 2009 which was successfully used in the manufacture of their gel fuel which is used in safety stoves and household geysers. The company has since changed his crop production to Syngenta tropical beet, a variant of sugar beet (Food Processing Africa, 2011) Silversands is also the first company in South Africa to produce E95 ethanol based fuel for testing in a Scania bus operated by Johannesburg Metro. (Silversands, 2012)

2.6.2. WASTE VEGETABLE OIL DIESEL PRODUCERS:

2.6.2.1. First In Spec

First In Spec Biofuels is based in Richardsbay, Kwa-Zulu Natal. They aim to be the first bio-diesel production company in South Africa by converting waste vegetable oil (WVO) to diesel. (First In Spec, 2012) 15 million litres of waste oil per month has been secured for importation from countries such as India, Canada and Australia where the price of WVO is lower than in South Africa (Harcourt, 2009), the company hopes to secure a partner to fund the R250 million project. (Donahue, 2009). The business is strongly geared against the price that WVO can be obtained for as well as the transportation cost thereof. The transportation also affects the carbon footprint of the project negatively. (Harcourt, 2009)

2.6.2.2. Bio-diesel Centre

Biodiesel Centre is another company using WVO to produce bio-diesel. It has three plants in Johannesburg, Cape Town and Durban and collects WVO from fast food outlets. Production is limited by the quantity of oil it can collect, with between 80,000 and 100,000 litres being made per month at each of the three sites. (Food Processing Africa, 2008) The bio-diesel is blended at a 5% ratio or 20% ratio with normal diesel and is used in trucks such as those belonging to Woolworth's distribution centre. (Esterhuizen, 2009) Biodiesel Centre's own fleet operates on 100% diesel from WVO.

The founder of Biodiesel Centre also markets equipment for the production of biodiesel. This equipment operates on a batch principle and is locally manufactured. It costs approximately R400,000 for a plant capable of producing 60,000 litres per month and requires three operators. (Food Processing Africa, 2008)

2.6.2.3. Greentech Biofuels

Greentech Biofuels is a Port Elizabeth based company that is also using WVO for the production of diesel. It retails its product as a B50 blend consisting of 50% bio-diesel and 50% mineral diesel. (Greentech Biofuels, 2012)

2.6.2.4. Biofusion

Biofusion has developed its own manufacturing method for the conversion of WVO to diesel. They operate in East London and have licenced other companies such as Greentech Biofuels to use their technology. (Greentech Biofuels, 2012)

2.6.2.5. Biogreen

Biogreen, also based in Port Elizabeth, has been converting WVO into diesel since 2009. Similarly to the other producers it is collecting WVO and its main clients are supermarket retail chain fleets. In 2010, Biogreen planned to open another plant in Johannesburg. (Biogreen, 2010)

2.6.3. PROJECTS CURRENTLY ON HOLD OR DISCONTINUED:

The IDC and CEF had three projects in the pipeline in July 2009. These included the Cradock project discussed above as well as a Hoedspruit sugar cane to bio-ethanol plant with a capacity of 100 million litres per annum. The third plant was to be situated in Pondoland making use of the underutilised farming areas of Kwa-Zulu Natal and the

Eastern Cape for sugar cane. This would have a capacity of 150 million litres per annum. The combined projects had a budget of R3,2 billion and could supply enough fuel to realise the 2% blending requirement. (Esterhuizen, 2009) The IDC is waiting to see if the Cradock plant is successful before approving the next two projects.

2.6.4. SECOND GENERATION BIO-FUEL RESEARCH:

2.6.4.1. Stellenbosch Biomass Technologies

Stellenbosch Biomass Technologies (SBMT) has secured rights to commercialise technology which produces cellulosic ethanol from non-edible plant material for Southern Africa. They endeavour to raise R80 million to build a semi-commercial pilot plant capable of 150 000 litres of bio-ethanol per year (Schneider, 2011).

2.6.4.2. InnoVenton

InnoVenton, The Nelson Mandela Metropolitan University's (NMMU)'s institute of chemical technology has a pilot project which uses marine algae to convert Carbon Dioxide (CO₂) into bio-fuels. It hopes to find industrial partners which can feed CO₂ off-gasses into their sea water algae plant. (Donahue, 2009)

2.7. CONCLUSION

Biodiesel and bioethanol can be manufactured in small or large scales wherever the raw materials required are available. With the exception of the Brazilian bioethanol from sugar cane industry, the economic viability and sustainability of first generation biofuel industries is questionable. Second generation biofuels may provide better solutions in the long term, but are currently in the research and development stages. In the USA and EU, agricultural and biofuel subsidies have sparked rapid growth in the industries.

The South African context does not look positive with government not having the political will, social need or economic stimulus to support the industry despite apparent benefits to rural development and the environment. Technology and infrastructure is available to enable a biofuel industry. A handful of large scale first generation plants have been planned with the aim of exporting their product but these have all been delayed. A niche manufacturer of fuel oil gel and some WVO converters are in operation.

2.8. SUMMARY

Literature shows that while much research is being done into some aspects of biofuel production, there is also much scepticism hanging over the industry. In the next chapter, qualitative research is done to verify the findings from the literature study and to assess whether sustainable biofuel production is possible in the current environment.

CHAPTER 3

RESEARCH METHODOLOGY AND FINDINGS

3.1. INTRODUCTION

In chapter two, the current state of the local and global bio-fuels industries was outlined. Chapter three focuses on the research methodology required to meet the objectives described in chapter one and then discusses the results obtained during the study.

3.2. THE PROCEDURE AND SCOPE OF THE QUALITATIVE RESEARCH

As described in chapter two, the South African bio-fuels industry is still in its infancy. A limited number of organisations have dared to venture into the sector which is plagued by unknowns and high risks. In addition to the limited number of industry role players, there is also vast diversity among the different business units. **For this reason, quantitative research is not possible and thus a qualitative survey instrument was chosen.**

Furthermore, the industry is very dynamic with changes in policy affecting the viability and sustainability of projects on an on-going basis. The volatile commodity prices also affect the financial sustainability of the projects on a daily basis. This means that only the most recent information is relevant and historic data quickly becomes obsolete. This also affects the choice of survey instrument used.

Lastly, there are no large scale bio-fuels plants which are presently in operation, once again making the analysis of historic actual data impossible. For this reason, projected

data for the projects using current pricing is compared to academic data obtained from German plants in operation.

The scope of the research is broken down into two components:

- Qualitative research consisting of a questionnaire applied to all the current operators in business and with plans to enter into the business soon. The open ended questions address factors relating to the slow progress made in the industry, stumbling blocks, and perceived potential of the industry.
- Secondly a model developed by Amigun *et al.* (2008) which predicts the costs of Bio-diesel production using German data is updated with the latest prices and assumptions in order to gauge the financial viability of a South African project. This continues in §3.3

3.2.1. SAMPLE SIZE AND GROUP

The sample of the South African bio-fuels producers consists of the complete population as identified in §2.5. This sample can be broken down into three groups namely:

- Large scale projects in progress, delayed and discontinued;
- Plants currently in operation using virgin material and
- Small to medium scale waste oil to bio-diesel producers.

The grouping of the sample is important as the information which can be obtained from each group varies. The first group of five projects is mostly likely to provide insight into the constraints, frustrations and challenges encountered in the industry. The second group, which consists of only one business, has achieved success along the complete value chain, but in a niche market. The last group, also consisting of five projects is not concerned with agricultural production and energy crops, but only focusses on the refinement process through to the marketing and blending. They can provide information regarding the market characteristics and the extent of the demand for the product.

3.2.2. SURVEY INSTRUMENT

As discussed previously, this study does not lend itself towards the objective approach of a quantitative study and a qualitative approach is required and has thus been chosen by the author. The subjective nature of the qualitative approach is suitable for collecting the opinions and thoughts of the managers of the various businesses and projects being assessed. This also enables a deeper understanding of the dynamics of this developing

industry. The downside to this method is that statistical establishment of reliability and validity is sacrificed.

A questionnaire was compiled in order to give the research structure and allow comparison between the respondents. However most questions are broad and open ended in order to allow for the most information possible to be captured during the interviews and to allow the interviewer to delve deeper into certain issues. This approach is also necessitated by the varied circumstances of the respondents. Furthermore it was decided that the questionnaire would be applied in interview format to allow for clarification and on-going interpretation.

Due to the geographic dispersion of the respondents, the interviews were conducted telephonically. These conversations were recorded for later reference and analysis. After a brief introduction – the following questions were put to the respondents:

Table 1: Questionnaire

Question	Objective
1. Briefly describe your bio-fuels business / proposed project.	Verify the information obtained during the literature study to ensure that it is up to date and still correct. Validate assumptions.
2. What feedstock material do you use / plan on using? Why was this chosen and how do you plan to procure the raw material?	Consider the agricultural implications of the project and how it may fit into the governments' policy. Determine why some projects plan to import raw feedstock material.
3. If project is delayed – what is the main reason for your project being behind schedule? If project was not delayed – how has your project managed to stay on schedule?	Gain further insight into the challenges identified in §2.4
4. How do you plan to market your fuel and to whom? Is the lack of clarity	Challenge the statements made by various parties regarding the cause of the delays in

regarding the blending and pricing hampering the industry?	getting an industry off the ground in §2.4.1
5. In your opinion – how does the South African bio-fuels industry compare to that of the global leaders such as Germany and Brazil?	Compare the local industry to the global overview.
6. Do you believe that South Africa has the social drive and political will to support a bio-fuels industry?	Identify whether South Africa's abundant social problems are in fact overshadowing the need for bio-fuels development despite the apparent future benefits and intrinsic solutions which such industry development may offer to many other problems such as poverty, unemployment and poor health.
7. Under what circumstances is it financially and economically viable for you to produce bio-fuels? Do you qualify for the government rebates and tax incentives? And are these determining factors in the profitability of your project?	Discover what the industry profitability indicators and constraints are and whether or not it is required to have financial support from government?
8. What are the biggest barriers to a sustainable South African bio-fuels industry?	Identify common problems and themes including possible technological, legal and environmental problems.
9. Is there anything else which you would like to add?	Open a platform for further discussion and for the respondent to list any other issues which he feels may contribute to the industry or its problems.

The interviews were concluded by thanking the respondents for their input and time.

Many inconsistencies were found between the current status of the projects and the situation reported in the articles, media and on the company websites. Despite the most recent information being used, changes have still occurred in the recent past. Due to the respondents being private companies, they are not obliged to publically share their project updates and recent information.

What was disappointing to find is that the Silversands E95 ethanol metro bus pilot project was successfully completed but that the plant has since closed down while the company waits for Johannesburg Metro Municipality to purchase the proposed 70 Scania busses. Should this continue as planned, Silversands will then plant the feedstock crops required and restart their plant to produce the ethanol at a new site near Sannieshof. This means that **there are presently no commercial virgin material to bio-fuel plants in operation in South Africa.**

2. What feedstock material do you use / plan on using? Why was this chosen and how to you plan to procure the raw material?

Objective: Consider the agricultural implications of the project and how it may fit into the governments' policy. Determine why some projects plan to import raw feedstock material.

Here the two groups of respondents showed their differences with the respondents in group 1 citing many different challenges but agreeing that it must be possible for South Africa to produce oil crops and convert them into bio-fuel in a profitable manner while the group 3 respondents unanimously felt that it is not economically viable to produce feedstock crops in South Africa and that WVO is currently the only profitable route.

Mr Fouche of Phyto-Energy defended their choice of locally produced canola as a feedstock crop for the following reasons:

- Canola has a higher oil content than other crops such as soya.
- The oil cake produced by extracting the canola oil is very palatable and a better animal feed than sunflower oil cake which is high in fibre.
- Canola can be grown as a winter crop in rotation with maize, and thus large areas which were previously used for wheat production or lay dormant in winter can be cultivated without affecting food security. The area may be as high as three million hectares of which one million hectares are located in the Eastern Cape near the proposed plant.

- Bio-diesel produced from canola oil is cold-proof and suitable for export to Europe.
- Many local communities have expressed interest in producing canola but require financial assistance and government support.

Mr. Matthews of Silversands explained that sugar beet was presently the best feedstock material for dry land Highveld production of ethanol but that sweet sorghum was still being researched and may prove easier to cultivate in the future.

The group 3 WVO biodiesel producers have challenges of their own. According to Mr. Nyiri of First In Spec, as much as 36 million litres of WVO are produced in South Africa each year but most of this is used to produce animal feed and for other questionable purposes. Hence their decision to import as much as 70% of the 14 000 tons of oil which is required each month from countries where the use of WVO is better legislated and controlled. The availability of WVO is a limiting factor for most of the respondents.

3. If project is delayed – what is the main reason for your project being behind schedule? If project was not delayed – how has your project managed to stay on schedule?

Objective: Gain further insight to the challenges identified in §2.4

Most respondents denied that their projects were significantly behind schedule – this is probably since the plans and schedules keep changing. Mr. Matthews of Silversands is waiting for the Johannesburg Metro bus service before their project can continue.

4. How do you plan to market your fuel and to whom? Is the lack of clarity regarding the blending and pricing hampering the industry?

Objective: Challenge the statements made by various parties regarding the cause of the delays in getting an industry off the ground in §2.4.1

The respondents unanimously said that the uncertainty regarding blending and pricing were causing the industry to stall. There is no incentive for the large petroleum companies who need to blend and distribute the biofuel to make an effort in implementing standards or procedures. The blending of the fuel is seen as an inconvenience. Furthermore, the South African motor association and other stakeholders need to sign off on the use of the biofuels but are reluctant to do so until they can be assured that the biofuel which is produced will comply with the required standards. The

transportation, blending and enforcement of standards relating to biofuel all cost money and no one in the South African industry is prepared to pay for it. It is seen as highly unlikely that the government will pass this bill onto the motorists.

All of the large scale projects intend to export their diesel. In this way they avoid the fuel levy totally instead of the current 50% exemption (DME, 2007). They also do not have to wait for the blending to come into practice.

The local WVO biodiesel producers are selling their diesel directly to clients who blend it with mineral diesel themselves. They are targeting an environmentally conscious minority who are willing to put up with some inconvenience.

The bio-ethanol fuel gel which Silversands produces has many advantages over paraffin fuelled lamps and stoves. However consumers are not aware of the benefits of the product and the low income segment of the population using paraffin is very cost sensitive and not safety conscious. Intervention in terms of subsidies, education and cooperation is required at a municipal level in order to promote the use of the fuel oil gel.

5. In your opinion – how does the South African bio-fuels industry compare to that of the global leaders such as Germany and Brazil?

Objective: Compare the local industry to the global overview.

6. Do you believe that South Africa has the social drive and political will to support a bio-fuels industry?

Objective: Identify whether South Africa's abundant social problems are in fact overshadowing the need for bio-fuels development despite the apparent future benefits and intrinsic solutions which such industry development may offer to many other problems such as poverty, unemployment and poor health.

Question 5 and 6 were mostly answered together as the most prominent response to the difference between South Africa and the global biofuels leaders such as Germany relate to government, politics and society. Respondents replied that society was uneducated with respect to the benefits of biofuels. This results in no political drive to propel government to facilitate the required changes quickly or effectively. While government has been quick to make commitments which gain popularity with the international community, all respondents indicated that they could not see a biofuel blend in

widespread use any time soon if ever. None of the respondents anticipate that the 2% (DME, 2007) mandatory blending target will be met.

A group 3 respondent added that an agricultural based biofuels industry would never be possible without the subsidies to farmers and manufacturers which countries such as Germany introduced.

A more positive respondent highlighted that the European biofuels industry has actually reached its maximum capacity according to the land available for the cultivation of energy crops and that countries such as South Africa which have large areas of underutilised land can now export to Europe.

7. Under what circumstances is it financially and economically viable for you to produce biofuel? Do you qualify for the government rebates and tax incentives? And are these are determining factor in the profitability of your project?

Objective: Discover what the industry profitability indicators and constraints are and whether or not it is required to have financial support from government?

The respondents all have business plans which allow for them to operate profitably. However as described in previous questions, their plans do not include selling any biofuel into main stream South African use at this stage. The group 1 and 2 respondents have plans to make use of the tax relief incentives offered by the DTI but are reluctant to include these in their business plans as the uncertainty is high and they are not sure that they will actually receive the proposed benefits.

8. What are the biggest barriers to a sustainable South African bio-fuels industry?

Objective: Identify common problems and themes including possible technological, legal and environmental problems.

All respondents indicated that they foresee no technological problems since the technology for biodiesel and bioethanol conversion has been in use on other countries for a long time. Infrastructure was also not cited to be a problem with the two respondents who plan to be based in Coega had many good things to say about the infrastructure in the area. One respondent stated that South Africa has first world infrastructure but third

world mentality. Environmental Impact Assessments are in the advanced stages for most of the larger projects and no major risks to the environment have been identified.

All respondents saw Government as the biggest barrier to a biofuels industry and added the social and political unwillingness discussed under question five and six to the problem.

Uncertainty regarding regulations, blending, pricing, standards and time frames add to the high risk nature of the industry which is hampering investment which is another barrier which was mentioned numerous times. From funding for farmers to encourage the cultivation of energy crops, right through to the funding of the blending and marketing of biofuels, financial constraints are a barrier throughout. Foreign investment in projects such as those of Phyto-Energy and First In Spec is only possible due to the foreign off take agreements which they have in place. Investors view the industry as very high risk due to the enormous uncertainty hanging over the industry as a whole.

9. Is there anything else which you would like to add?

Objectives: Open a platform for further discussion and for the respondent to list any other issues which he feels may contribute to the industry or its problems.

No new themes were added by the respondents and they continued to lament the poor state of the industry and the unlikelihood that it would change. Despite this, the respondents who based their business plans on importing raw materials or exporting the biofuel all said that should the South African environment change, their plants would be ready and willing to use local feedstock or supply the local market as long as the prices were in line with their international contracts.

3.3. ECONOMIC EVALUATION

Amigun *et al.* (2008) predicted the costs of bio-diesel production in Africa by learning from Germany. In the article the cost-capacity was calculated for a bio-diesel plant as well as the operating costs. Four different scenarios incorporating various stages of the value chain were assessed in order to calculate the production cost of bio-diesel given certain assumptions and using data obtained from operational German plants.

Assumptions are validated using the most current available data specific to South Africa from each of the calculations.

3.3.1. COST-CAPACITY

Fixed Capital Investment (FCI) is compared to the capacity of a plant in Europe in order to determine a cost-capacity factor (n) for bio-diesel production to understand economies of scale. This is important in this study as the plant size in South Africa varies from some very small scale and domestic plants (which do not form part of the study) to large industrial plants. Capital cost is not only important due to the budgeting and feasibility studies for the erection of a plant but the availability and cost of capital are limiting factors for many businesses in South Africa. Thus the initial outlay and its relationship with the operational costs of the plant are critical components when determining the sustainability of a bio-diesel production unit.

Amigun *et.al* (2008:8) uses the widely used logarithmic function given by the equation:

$$C_1 = C_2 \times \left(\frac{Q_1}{Q_2}\right)^n \quad (1)$$

Where C_1 and C_2 are the costs associated with plants of different capacities Q_1 and Q_2 with n being the cost-capacity factor. From data collected in Germany, n was determined to equal 0,89 which is higher than the average of 0,6 and indicated that the cost of erecting larger bio-diesel plants as opposed to a smaller plant has less of a economy of scale benefit than other comparable projects.

Since no assumptions are made which are likely to have changed in the last four years and all data is based on European research – this factor can still be used.

3.3.2. OPERATING COSTS

Amigun *et al.* (2008:8) defines four different models of plants which use different feedstock and enter the value chain at different points – these are:

- I. Agricultural bio-diesel plant which includes the cultivation of rape seed.
- II. Industrial bio-diesel plant which uses virgin bio-oil as feedstock.
- III. Industrial bio-diesel plant which purchases feedstock material and includes an oil mill.
- IV. A multi-feedstock bio-diesel plant which makes use of waste vegetable oil (WVO)

Groups I – III correspond with groups 1 and 2 in §3.2 and Group IV corresponds with the WVO converters of group 3.

Amigun *et al.* (2008:14) excludes the effect of government subsidies as these vary throughout Europe. This should also initially be applied in South Africa as the conditions which must be met in order to qualify for the incentives may not be met in all cases and may change in future. The research makes provision for the sale of by-products such as the glycerine and oil cake where applicable.

Table 2 shows that the model which uses virgin bio-oil as feedstock as the highest relative raw materials input cost while a WVO or mixed source plant has the highest percentage of operating costs. Table 3 shows Amigun *et al.* (2008)'s productions costs based on raw materials listed with their prices in Europe in 2008.

**Table 2: Effect of component costs on the operation cost of a bio-diesel plant
(adapted from Amigun *et al.*, 2008:15)**

Model	Raw Material	Operating Cost	Capital Costs
II	0.844	0.116	0.040
III	0.807	0.131	0.062
IV	0.660	0.210	0.130

The biofuels industrial strategy (DME, 2007) quotes a ratio of 0.70 for raw materials, and 0.15 each for operating and capital costs. The increase in the capital cost component of the South African figures can be attributed to the higher cost of capital, due to higher interest rates and higher investment risk in South Africa.

Table 3: Raw material costs and production costs (adapted from Amigun *et al.*, 2008:15)

Model	Raw Material	Price (€/t)	Cost of production (€/l)
I	Rape seed own production	200	0.65
II	Rape seed outsourced production	220	0.63
III	Clean oil	600	0.73
IV	Yellow grease	300	0.49

These results shown in table 2 and table 3 are depicted graphically in the figure shown below. The WVO plant (model IV) has by far the lowest production cost. Once the by-product sale is discounted from the production costs of the oil-mill plants, they become

more profitable than the stand alone plant. This makes sense since the stand alone plant will need to pay the oil mill a higher premium so that they can also make a profit percentage.

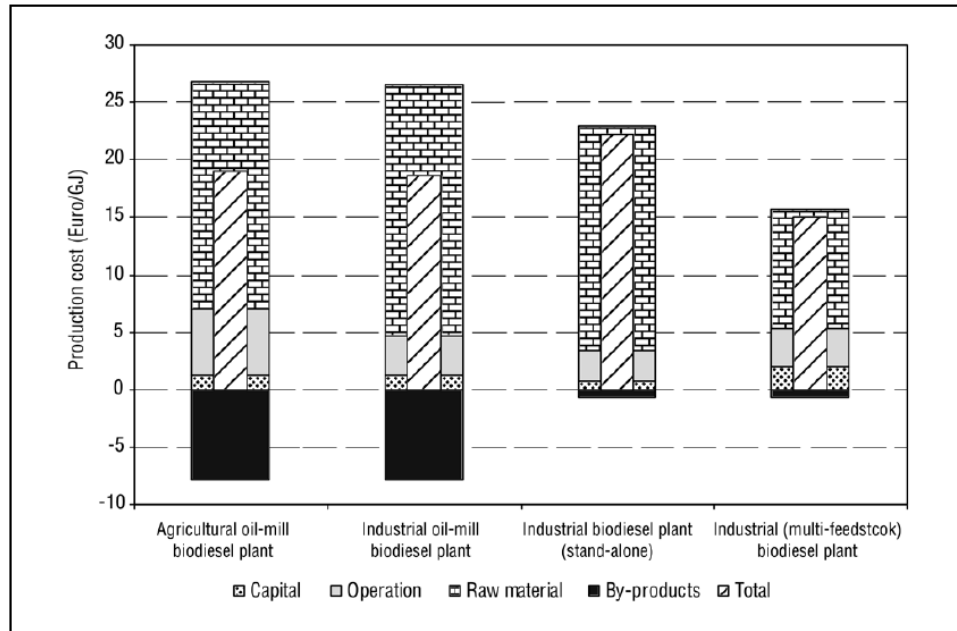


Figure 8: Comparison of production cost of bio-diesel for the reference concepts (Source: Amigun *et al.*, 2008:14)

3.3.3. SOUTH AFRICAN DATA

Assuming a linear relationship between the raw material, operating and capital costs and the production cost of the biodiesel and using the proportional factors calculated by Amigun *et al.* (2008:14) as shown in table 2 – the cost of production can be estimated for 2012 production at South African prices. The oil cake income has not been increased in line with the feedstock material as this scaling factor is not available. An exchange rate of R11,50 = €1,00 was used to convert the data to South African rand.

Table 4: Raw material costs and production costs in SA Rands – 2008 values

Model	Raw Material	Price (R/t)	Cost of production (R/l)
I	Rape seed own production	2300	7.475
II	Rape seed outsourced production	2530	7.245
III	Clean oil	6900	8.395
IV	Yellow grease	3450	5.635

Assuming all other factor pricing stays the same and only adjusting for the latest oil seed prices, the table below estimates the production costs without the benefit of higher oil cake prices.

Table 5: Production costs based on Amigun at al model and latest SA prices

Model	Raw Material	Price (R/t)	Cost of production (R/l)
II	Soya bean outsourced production	5600*	14.66
III	Clean oil soya	9840**	11.28
IV	Waste cooking oil	3000***	5.15

* Grain SA SAFEX 31 October 2012 Randfontein.

** Grain SA SAFEX CBOT Oil contract 16 Nov

*** R3 / litre as quoted by a WVO collector.

Soya and canola have very similar prices per ton and the production costs will be in the same region. The oil prices in South Africa are relatively high since the current oil production capacity in South Africa is low. Table five shows that at a cost of production of above R11,00 per litre, model II and model III are not economically viable options since this price is already higher than the pump price of mineral diesel. Model I is excluded since it is difficult to determine the producer price of energy crops. Model IV which utilised WVO is more likely to be profitable.

3.4. CONCLUSION

The South African biofuel industry consists of a small number of projects in the development phase and some WVO to biodiesel converters. Uncertainty, high risk and government interventions which are not aimed at economic development, but rather at the spin-offs which industry development will create such as rural job creation, are hampering investment in the sector. Despite the availability of land for cultivation of energy crops, the required technology and suitable infrastructure the industry has stalled. Most senior officials involved in biofuel projects are very negative about the government's ability to stimulate the industry and are looking towards imports and exports. This will create a limited number of jobs, but will be energy and carbon negative and will not aid the rural development goals in any way.

The economic evaluation shows that biofuel plants do not need to be very large to be profitable since the cost-capacity factor is higher than most other industrial projects. The

very crude calculation done shows that without significant government subsidisation, the production price of virgin biodiesel is too high for production to be economically viable under the current conditions.

On-going delays and set-backs will result in South Africa not meeting the 2012 2% blending target.

3.5. SUMMARY

Telephonic interviews were conducted with senior officials at the identified biofuel operators. All of those interviewed were eager to share their time, opinions and view of the industry. The results obtained in the study showed some contradiction with the literature study, particularly in smaller details. However, the responses were unanimous in nearly all areas. The most popular and profitable area of development is for WVO conversion. The last chapter summarises the state of the industry, where after suggestions are made to improve the situation.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

4.1. INTRODUCTION

In chapter two, the scope of the biofuels industry was evaluated from literature. The framework in which a plant must operate was defined by considering the government's strategy. Chapter three uses input from those attempting to function within this framework in order to gauge the effect that the political, economic, social, technological, legal and environmental situation in South Africa has on the industry. The last chapter brings the previous chapters together, culminating in requirements for improvement, recommendations and suggestions for further study.

4.2. STATE OF THE SOUTH AFRICAN BIOFUELS INDUSTRY

Literature provides a clear list of which factors are required to stimulate the growth of a biofuels industry. The table below lists the requirements, facilitators and enabling factors which were identified in the literature study as necessary for the development of a sustainable biofuel industry in the first column. The second column evaluates whether these have been accomplished both from a legislative and policy perspective from the biofuels industrial strategy (BIS) as well as what the industry players perception thereof as determined during the qualitative research. An assessment is given of how well each factor has been accomplished.

Table 6: Enabling factors for biofuel production

Requirements from literature compared to actual	
Enabling factor	Degree of accomplishment
Government support: Investment cost reduction Public investment	The IDC has a number of financing and grant options available to fund private projects. Funding may be limited if there is not BEE. The CEF and IDC have invested in some projects. Private entities still list obtaining financing as a

Market Facilitation	<p>delaying factor and have looked offshore for investment.</p> <p>Mandatory blending from August 2012 can be viewed as market facilitation but the efficiency thereof will lie with the oil companies and other stakeholders who form a vital link in the supply chain and their willingness to cooperate.</p>
<p>Tax relief</p> <p>Assessment: GOOD</p>	<p>Tax relief is available and some projects have already been granted such relief by the DTI.</p>
<p>Energy policy guidelines</p> <p>Assessment: LIMITED</p>	<p>The BIS provides a number of guidelines but these relate more to rural development than to the biofuel industry development. Many interviewees and writers attribute problems to unclear guidelines specifically relating to pricing. Blending and quality requirements have been formulated.</p>
<p>Alignment to the social goals of the country</p> <p>Assessment: GOOD</p>	<p>The BIS provides a clear indication of how well a biofuel industry could aid job creation, poverty alleviations and rural development.</p>
<p>Social pressure</p> <p>Assessment: POOR</p>	<p>Currently social pressure levels in South Africa are high, but these relate to salaries, housing and service delivery. No social pressure is being applied to promote biofuels.</p>
<p>Political will</p> <p>Assessment: POOR</p>	<p>Since there is little social pressure for the government to stimulate the use of biofuels, the political will has been identified as being very low both in literature and by industry role players, who identified it as possibly the biggest stumbling block.</p> <p>The mandate and objectives of the BIS also show a political will to receive the benefits of a biofuel industry without providing practical support which is likely to encourage rapid growth.</p>
<p>Market demand</p> <p>Assessment: POOR</p>	<p>The only market demand identified for the biofuels in South Africa is the supermarket retail chains that are using biodiesel blends and some other smaller private clients. Motorists have not demanded biofuel, this is likely due to a lack of education, concerns over the cost thereof and current more urgent issues such as e-tolling.</p>

Commercial viability Assessment: LIMITED	Commercial viability of biodiesel and bioethanol production is questioned in literature. In the BIS it is calculated that biofuels may be profitable with oil prices higher than US\$65 per barrel. Prices above this threshold seem likely to continue. Some respondents agreed that virgin plant material to biofuel production is not economically viable in South Africa. Those busy with the large scale projects believe that it can be commercially viable but only if the fuel is exported. WVO biodiesel has good commercial viability both for local use and for export.
Cooperation between government departments. Assessment: POOR	This was deemed poor both in literature and by those in industry. The delays experience by large projects, particularly the Cradock project, which has many departments involved, is believed to be mainly due to poor cooperation between local, provincial and national government departments.
Mandatory blending Assessment: LIMITED	Despite the BIS (2007) not encouraging mandatory blending, it has been legislated in August 2012. Industry is sceptical as to whether oil companies will make an effort to comply due to the lack of clarity regarding pricing and the increased logistics and administration involved. It is not clear how this will be policed.

In the next table, additional factors which other countries have used to stimulate the biofuel industry are added and the practicality thereof in the South African context is debated from the BIS and the industry responses.

Table 7: Lessons from world leaders

Aspect	South African implications
Education – the US, Brazil and EU educated the public and motorists regarding the benefit of biofuel.	This has not been done on a large scale in South Africa. It is not a priority in the BIS. Other education such as health and safety are likely to receive greater priority.
Use of excess crop production. Sugar cane in Brazil and corn in the US.	This has been outlawed due to food security concerns and the possible backlash which could cause prices to rise.
Very large agricultural subsidies (EU and US)	South Africa has very little subsidisation in place with the exception of the agricultural diesel rebate. The BIS states that this is not likely to change any time soon.
Subsidisation of biofuel producers.	Provision for this has been made in terms of reduced (biodiesel) and eliminated (ethanol) fuel levies for biofuel for a limited time. This provides some relief but not to the same extent as the US or EU.
Tax relief and other benefits to encourage motorists to convert to vehicles which use biofuel. Germany and Sweden. Brazil.	This has not been proposed in South Africa. It is not likely since high blend ratio fuels have not been considered and the blend ratios mandated are suitable for most vehicles. Vehicle taxes, licencing and parking rates are also lower in South Africa, making it difficult to make these substantial.
Government purchasing of biofuel vehicles.	The only case in South Africa to date is the Johannesburg Metro's plan for 70 E85 ethanol powered busses. This would provide exposure to biofuels as well as open doors for other similar ventures.

The literature study and qualitative research identified that while there are significant benefits for South Africa to develop a biofuels industry, and that these benefits align with

key focus areas of government, the industry has not grown. These benefits are listed below:

- Reduced dependency on crude oil
- Improve trade deficit
- Buffer price volatility of crude oil and exchange rate fluctuation
- Improved flexibility
- Move production closer to the user
- Job creation
- Rural development
- Local animal feed production (reduction of imports)
- Create self-sufficient rural economies
- Reduction in pollution
- Health benefit of reduced pollution
- Meet renewable energy targets
- Foreign investment
- Export of fuel (improve trade deficit)

4.3.REQUIREMENTS AND RECOMMENDATION TO IMPROVE THE OUTLOOK OF THE INDUSTRY

The enabling factors and the assessment thereof from table six in §4.2 are repeated below with suggestions for improvement:

Table 8: Suggestions for improvement

Enabling factor	Suggestion for improvement
Government support: Investment cost reduction	The IDC has good programs in place but has many limiting factors which make it difficult for the typical South African entrepreneur or farmer to access the funds. Reducing some requirements, for instance BEE could favour other requirements such as job creation.
Public investment	South Africa could start a government owned and operated biofuel plant in order to stimulate feedstock production as was done in Brazil and some US states. The current BIS which

<p>Market Facilitation</p> <p>Tax relief</p> <p>Assessment: GOOD</p>	<p>limits feedstock cultivation to previous homelands will mean that this project will face the same challenges as the private projects. Thus it is rather suggested that the limitations on feedstock production areas be revised as this could assist the industry as a whole without jeopardising food security. Alternatively government can invest more heavily in agricultural reform mechanisms in the areas allocated to energy crop production.</p> <p>Lastly, the state can make the industry more attractive to already established companies in the fuel industry such as Sasol, Chevron and BP who have all been involved with their own research into biofuels. The BIS does not encourage this type of industry expansion at all.</p> <p>Strict enforcement of mandated blending is required as well as monitoring to ensure that the monopolising oil companies do not disadvantage the producers.</p> <p>Tax relief can be extended to the emerging farmers tasked with cultivating the feedstock crops.</p>
<p>Energy policy guidelines</p> <p>Assessment: LIMITED</p>	<p>Guidelines require clarification with regards to: New timeframes and objectives (since the 2012 objectives will not be met). Pricing mechanisms and transparency. Penalties and procedures for policing non-compliance.</p> <p>A trust relationship must be established between the industry and the government as previous sudden decisions have made investors and operators scared that legislation may change suddenly leaving their plants unable to operate profitably.</p>
<p>Alignment to the social goals of the country</p> <p>Assessment: GOOD</p>	<p>The benefits of biofuels align well with the social goals – but a road map is required to bridge the two. The BIS does not sufficiently achieve this as it focussed on the results of a successful biofuels industry and not how South Africa can achieve this in the near future. It should be revised to incorporate commercial farmers and appeal to entrepreneurs.</p>
<p>Social pressure</p> <p>Assessment: POOR</p>	<p>Social pressure will result in market demand and encourage changes political will. Social pressure can be stimulated by</p>

Political will Assessment: POOR	education regarding the benefits of biofuels and the benefits of a biofuel industry. Only a small percentage of South African voters own motor vehicles, so the scope is limited.
Market demand Assessment: POOR	
Commercial viability Assessment: LIMITED	Commercial viability can be encouraged by the supply of reasonably priced, locally available feedstock material. Commercial farmers are key in achieving this. Mentorship and other assistance of developing farmers, can be a prerequisite for commercial farmers wanting to supply biofuel feedstock. This will ensure that the previously disadvantaged farmers are uplifted, while security of supply is guaranteed to the refinery. Partnerships can be formed between old and new farmers, reducing the burden on the state and the refining companies. An import tax on oil cake destined for animal feed will have benefits in stimulating oil crop production, providing feedstock oil to the refineries, reducing imports and burden on the road and rail infrastructure from the ports. Most crop production areas are located close to livestock production areas.
Cooperation between government departments. Assessment: POOR	This must be viewed as a priority. The task teams already in place must facilitate communication, cooperation and alignment of goals.
Mandatory blending Assessment: LIMITED	Policing of the regulations, pricing, transparency and time frames must be added to the regulations recently promulgated.

4.4. RECOMMENDATIONS FOR FURTHER STUDY

The following areas will benefit from further study:

- Feedstock crop selection in particular for the different regions of South Africa and for crops which are suitable to be grown in labour intensive, dry-land situations where land may be arid or have been dormant for long periods of time.
- Second generation biofuel technology.
- How South Africa can benefit from the bioethanol potential of the other SADC member countries and how this can best be stimulated and utilised.

- Advanced study into how biofuel production could affect food security in South Africa as the current theory is based on speculation.
- Further study into the economic and financial feasibility of plants of varying size, location and technology.
- Quantification of the export market for biofuel in order to stimulate production for export.
- Suggestions for cooperation between commercial and new farmers to aid the one without disadvantaging the other by studying the partnerships and mentorship schemes which are working well at the moment.

4.5. CONCLUSION

The biofuels industry has stagnated despite some good interventions by government. The BIS is misdirected and has not improved investor confidence or provided a road map for the growth of the biofuel industry. The exclusion of commercial farmers from the BIS provides a number of challenges and problems. There is a low level of trust and cooperation between stakeholders in the industry which makes cooperation difficult and it hampering the ability of the industry to grow.

With the exception of Brazil, which South Africa cannot copy due to climate and land differences, other world leaders in biofuels are facing heavy criticism and the mechanisms used to boost the industry have very limited application in South Africa.

The benefits of biofuel production in South Africa are plentiful and align well with social need and development goals. Commercial viability remains questionable.

4.6. SUMMARY

Chapter four has brought the previous chapters together and evaluated the scope and status of the South African biofuels industry in terms of academics, policy and industry opinion. The enabling factors were listed and assessed and recommendations were made for possible improvement areas. The benefits of a biofuel industry to South African society were reiterated.

South Africa does not have the climate to compete with Brazil in bio-ethanol production and the scope for bioethanol is limited in environment, however our neighbours show significantly more promise in this area. Biodiesel production is more likely to have commercial viability due to the country's ability to grow oil crops and the need for the by-

products. Some progress has been made in government policy, but much work is still to be done in order to streamline the industry and create growth.

Currently there are still no medium to large scale virgin oil to biofuel producers in the country and no project has an imminent start up. Hopefully some projects will now start meeting their milestones as they move from the feasibility to the construction phases. The WVO biodiesel industry has grown rapidly in the last five years but is limited to small scale operators. It is hoped that this industry will get a foot in the door for the larger feedstock plants as this is where the benefits for the country lie.

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