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FACTORS INFLUENCING THE SUCCESS OF ETHANOL PRODUCTION FOR USE IN LIQUID TRANSPORT FUELS IN SOUTH AFRICA

Tammy Chetty

A research report submitted to the Gordon Institute of Business Science, University of Pretoria, in partial fulfillment of the requirements for the degree of Master of Business Administration

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ABSTRACT

Against the backdrop of rising fuel prices and increasing demand for transport fuels, coupled with government's imperative to reduce high unemployment levels by developing the agricultural sector to support a bio-fuels sector, it was considered necessary to conduct research to determine the factors that would influence the success of bio-ethanol production for use in liquid transport fuels. The literature review highlighted five key factors that were developed into research questions to establish whether these factors are relevant to the South African context and which are considered more important.

The research was conducted using a combination of face-to-face interviews and telephonic interviews to gather opinions from 16 subject matter experts in the field of bio-fuels. A questionnaire was used to drill down into each of the factors individually, to determine the importance of that factor as it relates to bio-ethanol production.

The findings reveal that the absence of clear and sound government policy poses the biggest hindrance to the establishment of the industry. Furthermore, that agricultural development is a major factor for the success of bio-ethanol production as the industry is dependant on the availability of competitive feed stocks in order to be sustainable. Finally, that job creation is the motivating factor for the establishment of the industry since it addresses a government imperative to reduce unemployment levels in South Africa.

DECLARATION

I declare that this research project is my own, unaided work. It is submitted in partial fulfillment of the requirements of the degree of Master of Business Administration for the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination in any other university.

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Thamaraveni Chetty

13 November 2007

DEDICATION

To my children, Tarshni and Keenan, who supported and encouraged me through late nights and many weekends to complete this research. Thank you for the sacrifices you have made and your understanding to help me and keep me focused.

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- All the participants who gladly gave of their time for the interviews to share their experience and insights.
- To all my friends and colleagues for their support and unfailing confidence in me.

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LIST OF ABBREVIATIONS

ASGISA-SA	-	Africa Shared Growth Initiative – South Africa
BFAP	-	Bureau for FOOD and Agricultural Policy
CEF	-	Central Energy Fund
CEO	-	Chief Executive Officer
COO	-	Chief Operating Officer
EU	-	European Union
GWh	-	Gigawatt hour
Mtoe	-	Million tons of oil equivalent
PM	-	Particulate Matter
RFTO	-	Renewable Fuels Transport Obligation
SAPIA	-	South African Petroleum Industry Association
USA	-	United States of America
VOC's	-	Volatile Organic Compounds

CHAPTER 1. DEFINITION OF THE PROBLEM

1.1. INTRODUCTION

In 1978, Boulding as cited in Heinberg (2005, p1) stated, *"In 1859 the human race discovered a huge treasure chest in the basement. This was oil and gas, a fantastically cheap and easily available source of energy. We did, or at least some of us did – live it up, and we have been spending this treasure with great enjoyment."* Heinberg goes on to state that fossil fuels have transformed our societies and personal lives and wars have been fought to control the inherently non-renewable energy which is therefore limited in supply and not sustainable.

Pahl (2005, p1) argues that the world's oil resources are being depleted and that this is an *"undeniable fact"*. This argument is supported by Demirbas, (2007, p1) who states that conventional energy resources like coal, petroleum and natural gas is *"on the verge of getting extinct."* He further argues that while demand for energy is continually increasing, alternative fuels is the most feasible means to meet the growing demand. Against this backdrop, it has become necessary to develop policies for energy security and invest in the production of alternate sources of energy.

Reijnders as quoted in Demirbas states that bio-fuels, an alternative fuel for the transport sector, offers many benefits like sustainability, reduction of greenhouse gas emissions, regional development, social structure and agriculture and security of supply (Demirbas, 2007). The South African Government has consequently responded by setting a goal of achieving 10 000 GWh (0.8 Mtoe [Million tons of oil

equivalent]) renewable energy contribution to final energy consumption by 2013 (Bureau for Food and Agricultural Policy, 2005).

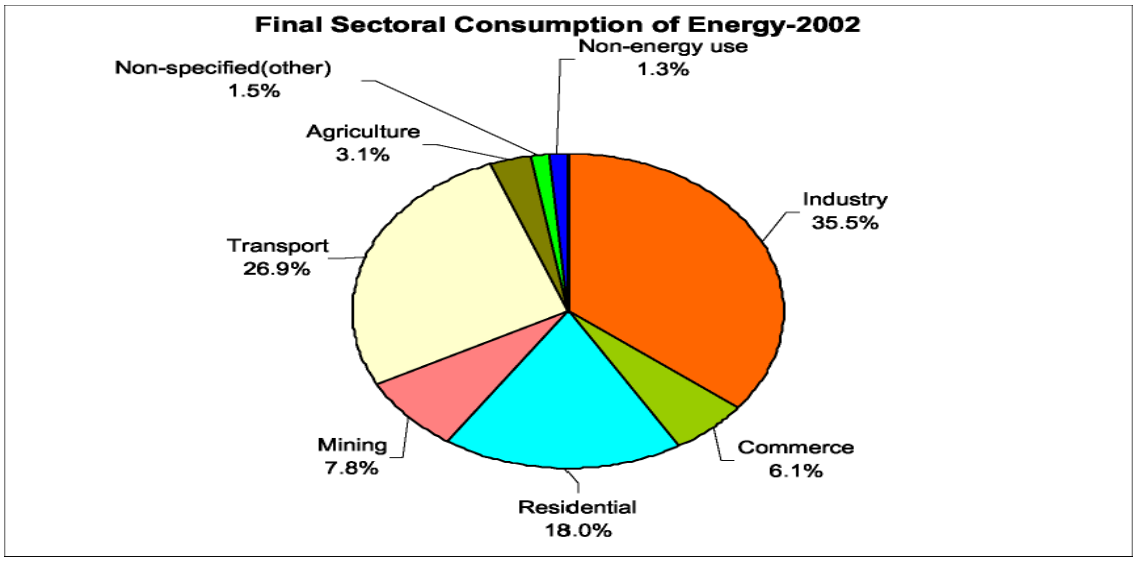
1.2. MOTIVATION FOR RESEARCH

Conn (2006), reports that transportation accounts for approximately 20% of the total global energy consumption.

While countries around the world were slow to respond to warnings relating to energy supply coming under pressure over the next couple of decades, Brazil has successfully developed a bio fuels sector over the last 30 years. In so doing, the country has decreased unemployment, reduced their dependency on fossil fuels, and created economic growth in the country (Hull Aeck, 2005). Hull Aeck further states that currently 70% of all new cars in Brazil run on flexi fuel – a blend of fossil fuels and ethanol.

South Africa lags behind Brazil, Europe and the USA in developing and stimulating an alternate energy industry. The high volume maize industry and the availability of arable land make ethanol production a lucrative source of alternate energy for transportation. In 2002, the transport sector consumed 26.9 % of the total energy consumed in South Africa (Digest of South African Energy Statistics, 2005).

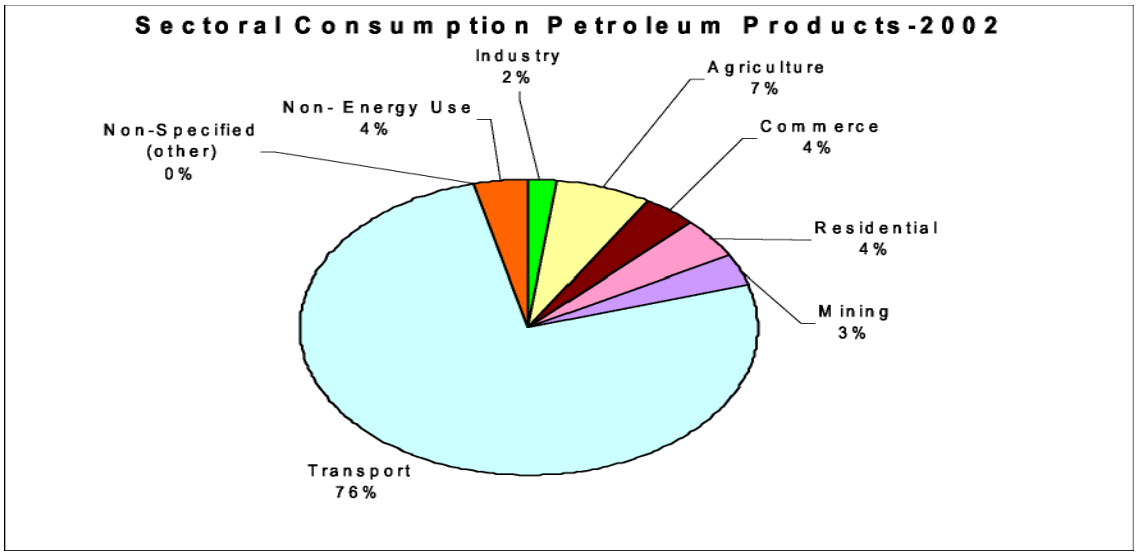
Figure 1-1: Final Sectoral Consumption of Energy - 2002



(Source: Digest of South African Energy Statistics, 2005)

Figure 1-2 below illustrates that in 2002 the transport sector consumed 76% of petroleum products this being mainly petrol and diesel obtained from the Digest of South African Energy Statistics – 2005.

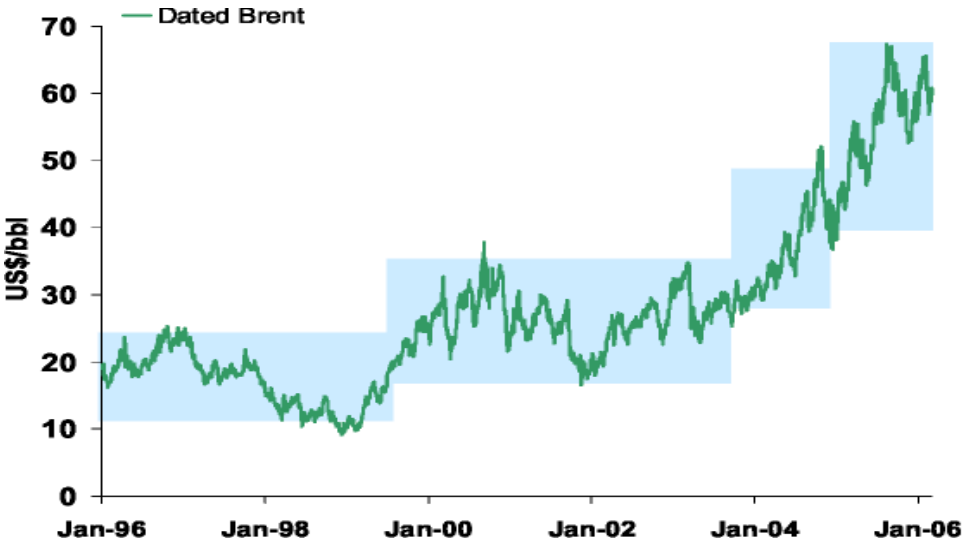
Figure 1-2: Sectoral Consumption Petroleum Products – 2002



(Source: Digest of South African Energy Statistics, 2005)

Energy security is becoming of greater concern since oil prices (depicted in figure 1-3 below) have been rising dramatically over the last few years fuelled by growth in demand and limited supply (Conn, 2006).

Figure 1-3: Crude Oil Prices January 1996 – January 2006



(Source: Conn, 2006)

South African Minister of Minerals and Energy, Hendricks stated that in order for the country to reduce its dependence on crude oil imports it is necessary to promote the growing of bio fuel producing crops by subsistence farmers (Business Report, 2006).

Although regulation has been introduced to stimulate the growth of the bio-fuels industry, there has been slow progress to date. Despite available research and successful case studies like Brazil, debate still looms around issues of food security, commercial viability and sustainability of supply.

1.3. RESEARCH AIM

South Africa, also a developing country facing similar economic issues to that of Brazil, has both the capacity and potential to adapt the Brazilian model to suit the South African environment in order to stimulate growth and sustainability of liquid energy and the agricultural sector through the development of a bio fuels sector, primarily focused on ethanol production. To date little has been done to invest in this sector despite the obvious benefits.

This research seeks to identify the factors that will determine the success of producing ethanol for use in liquid transportation fuels in South Africa.

The research will aim to identify factors for success in the following areas:

- Suitability of ethanol as a liquid transport fuel - will determine the role that ethanol production will perform in securing the supply of liquid fuels for transportation purposes and will include the volume of such contributions.

- Agricultural development – will explore the factors that will support the growth and development of the agricultural sector if an ethanol sector in South Africa were to be established.

- Social impact – will determine the impact the development of a bio-fuels industry would have on food security and employment in South Africa. The report will focus on the factors that will determine the success of such an industry without negatively impacting the issue of food security.

- Environmental Impact – will determine the factors that encourage the success of producing ethanol on a large scale for use in liquid transportation fuels.

- Regulation – will determine what government support and intervention is required to stimulate a bio fuel industry. Factors that will be investigated include legislation and incentive programs.

1.4. REPORT STRUCTURE

Chapter 1 discusses the current global energy debates and provides a compelling argument for the development of a bio-fuel industry in South Africa with ethanol production being the primary focus of this research. Included is the content of this report as well as the expected outcomes for this research.

Chapter 2 reviews literature on the topic of energy as it relates to liquid energy consumption globally and in the South African context. It further outlines the views of experts on bio-fuel as an alternative source of liquid transportation fuels focusing primarily on the factors that will influence the success of developing an ethanol industry for use in liquid transportation fuels.

Chapter 3 discusses the questions that this research aims to address

Chapter 4 outlines the research methodology and criteria used for selection of the population and sample, gathering the data and analysis of the data.

Chapter 5 presents the findings of data collected. The data is presented in a categorized format based on the themes that emerged from the semi-structured interviews that were conducted.

Chapter 6 provides the results of the research as it relates to the research questions posed as well as the literature reviewed.

In the final chapter, Chapter 7, the merits of this research and its limitations are discussed. Recommendations for further research are also recommended.

CHAPTER 2: LITERATURE REVIEW

2.1. INTRODUCTION

Duncan, (2000) states that modern civilization is beholden to energy and therefore without energy, industrial civilization comes to a grinding halt. In 1893, more than a century ago, Henry Adams envisioned that industrial civilization would last for approximately 100 years from 1930 to 2030. His theory was extrapolated to indicate that during the last two decades a series of blackouts will be experienced as a result of a shortage of energy, eventually resulting in electric power grids going down and never coming up again (Duncan, 2005 – 2006).

Literature reviewed indicates that a significant amount of effort and money has gone into researching bio-fuel as an alternate source of energy (McKinsey Quarterly, 2007). Several alternate sources of energy exist, however the most promising of these appear to be the production of ethanol from starch rich agricultural produce for use in liquid transportation fuels. This chapter will explore the literature available on the subject of bio-fuels in order to extract the factors relevant to the successful production of ethanol particularly for use in liquid transportation fuels. The review will focus on the following four areas:

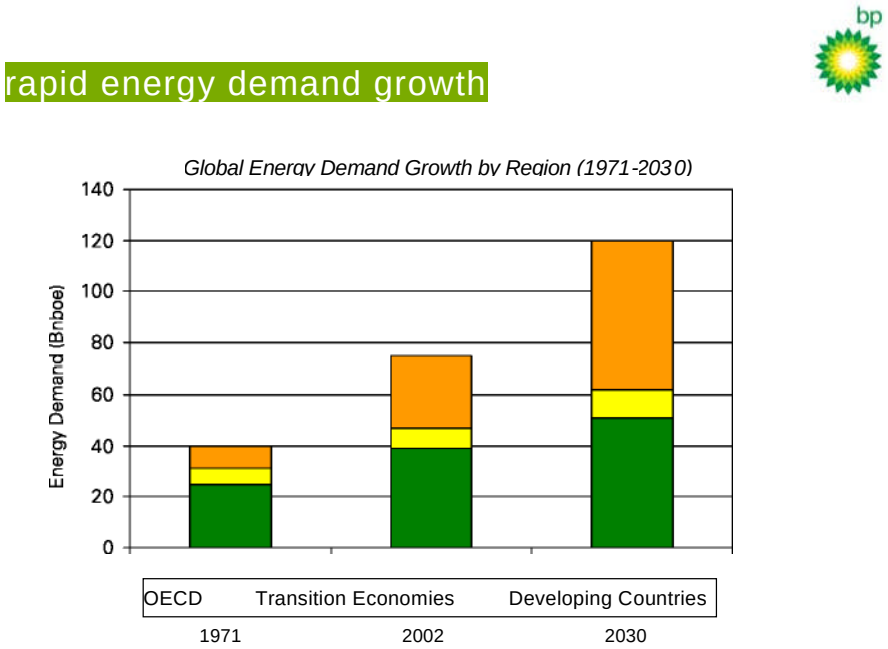
- Agricultural development to support ethanol production on a commercial scale
- Suitability of bio fuels as an alternate source of transport fuels
- Socio – economic factors (environmental, labour, food security)
- Regulatory environment

2.2. GLOBAL ENERGY TRENDS

Agarwal, (2006) states that "*indiscriminate extraction and lavish consumption of fossil fuels have led to reduction in underground-based carbon resources" (p1).*

He further argues that industrialisation and motorization has led to steep increases in the demand for petroleum fuel. According to Wood, Long and Moorhouse (2005) as cited in the Bureau for Food and Agricultural Policy (BFAP, 2005) the demand for crude oil, the main source of petroleum fuel, is estimated to be growing at a rate of 2% compounded annually. They further argue that oil production is *"expected to peak in the year 2037 with a volume of 53.2 billion barrels per day*", (p2).

Figure 2-1: Global Energy Demand Growth by Region (1971 – 2030)



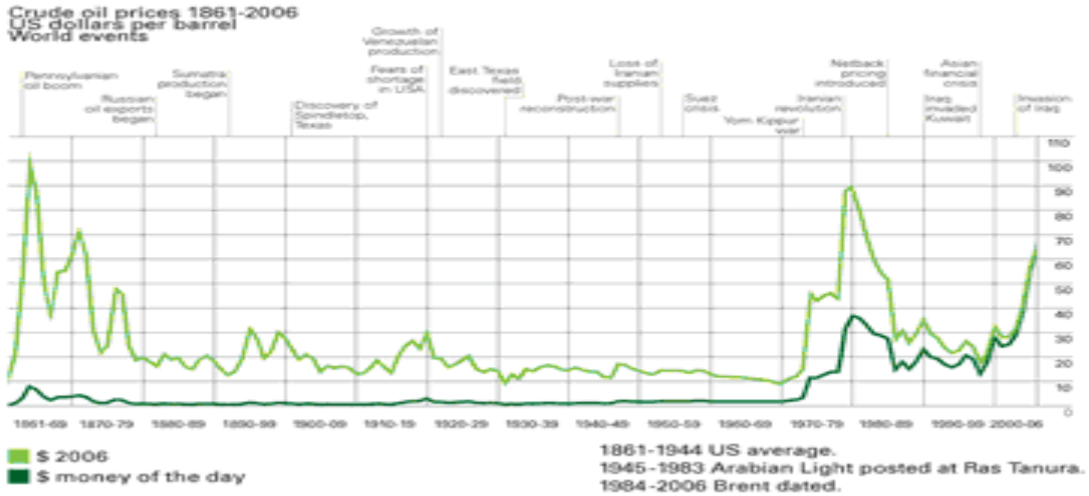
(Source: Conn, 2006)

Conn (2006) confirms that the demand for energy is growing rapidly and states that demand has risen around 15% during the 21st century to date and is

estimated to grow by some 60% from 2002 to 2030. Figure 2-1 above illustrates the demand growth from 1971 and estimates demand up to 2030 for different regions.

Coupled with increased demand has been the steep rise in oil prices reported by BP (2007) trading at an average of $ 65.14 in 2006. This represents a 19% increase over the 2005 average of $ 54.52 making it the 5th consecutive year that prices have risen. In addition, it is reported that two record highs were recorded when oil traded at $ 71.89 and $ 78.82 per barrel in May and August of 2006 respectively. Figure 2-2 below depicts the rise in oil prices from 1861 to 2006. It is evident from the graph below that steep rises in oil prices occurred between 2000 and 2006.

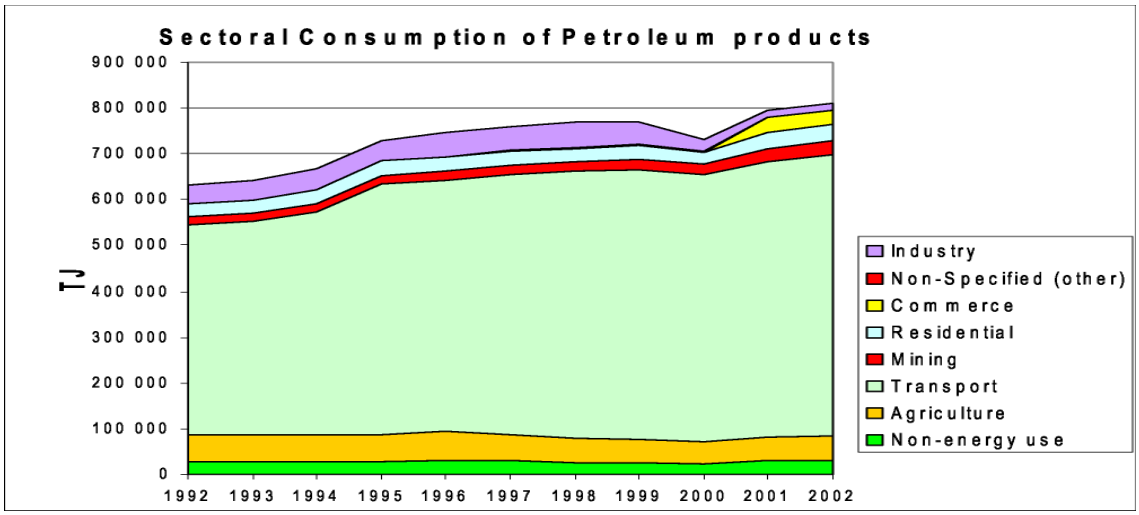
Figure 2-2: Crude Oil Prices (1861 – 2006)



(Source: BP, 2007)

Figure 2-3 below depicts the rapid increase in consumption of petroleum products in South Africa by sector from 1992 to 2002. It is interesting to note the growth of consumption in the transport sector in comparison to the other sectors shown.

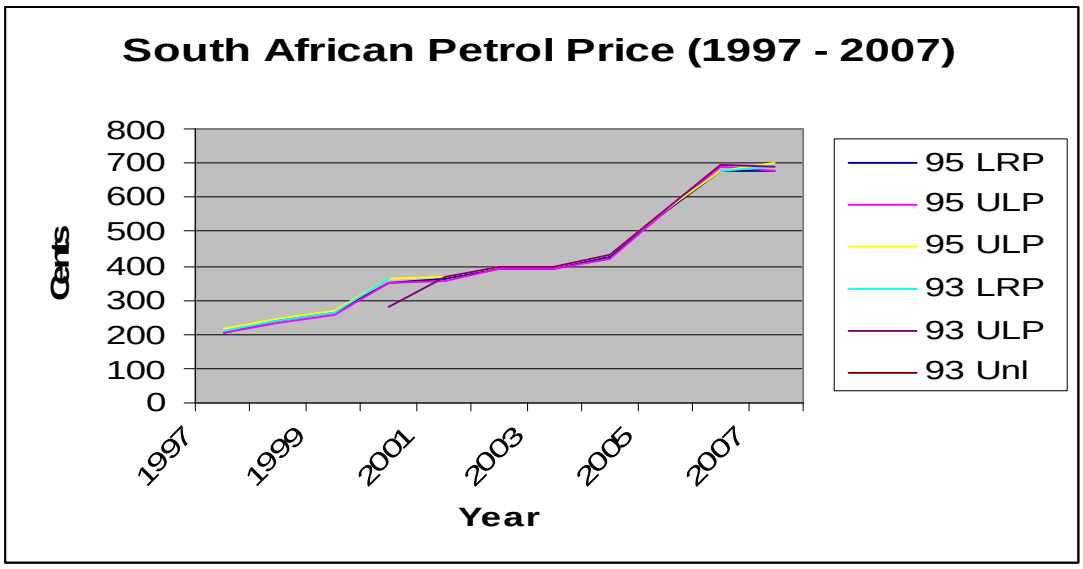
Figure 2-3: Sectoral Consumption of Petroleum Products in South Africa



(Source: Digest of Energy Statistics, 2005)

Figure 2-4 below visually illustrates the rapid rise in the petrol price in South Africa over the last 10 years.

Figure 2-4: Petrol Price in South Africa



(Source: SAPIA, 2007)

The increase in petrol price represents an increase of approximately 250% over a 10 year period from mid 1997 to mid 2007. The above figures illustrate the increasing demand for energy coupled with the steep rise in oil prices and consequently the rapid rise in petrol prices. The argument can thus be made that under the prevailing conditions, producing alternate sources of energy such as bio-fuels becomes more attractive.

2.3. THE BURNING PLATFORM - THE CASE FOR BIO-FUELS

Bio-fuel production was researched and developed shortly after the 1970 oil crisis to decrease dependence on fossil fuels as a source of transport energy. Current trends indicate that a number of countries are committing to reduce dependence on fossil fuels and increase alternate supplies of energy as a result of the impending shortage of oil and increasing oil prices, as well as the damaging effect fossil fuels have on the environment. This is evidenced by the 175 countries that signed the Kyoto Protocol which came into effect in February 2005 committing to reduce carbon emissions and greenhouse gases from the atmosphere in an effort to slow down global warming (Kyoto Protocol, 2005).

Conn (2006), Executive Director of British Petroleum, in an address to the Harvard University Centre for the Environment, stated that the feasibility of bio fuels as a sustainable alternate source of energy could meet four needs: "*it can meet demand; offer security of supply; address climate change and support agricultural activity*". Agarwal, (2006) supports this view by stating that alternative fuels promise a "*harmonious correlation with sustainable development, energy*

conservation, efficiency and environmental preservation and has become highly pronounced in the present context" (p1).

Pahl, (2005) confirms this by stating that bio-fuels are "*produced from domestic feed stocks, reducing the need for foreign oil while boosting the local economy and supporting the agricultural community".*

The case for bio-fuels can further be motivated by: the rapid increase in fossil fuel prices; speculation regarding the forecasted shortages for fossil fuels; climate change as a result of carbon emissions; the need to create employment in rural and underdeveloped areas and the potential to generate a new industry for economic growth (Worldwatch Institute, 2006).

"The establishment and growth of a bio-fuels industry is one possible solution to addressing both the economic and social challenges and is an important contributor to Africa Shared Growth Initiative – South Africa (ASGI- SA), led by the Deputy President. South Africa imports about 60% of its crude oil requirements, which has economic implications in terms of balance of payments as well as vulnerability to rising crude oil prices. Increasing the volumes of ethanol in petrol and increasing the use of bio-diesel would therefore have macro economic benefits for the country. In addition, converting sustenance farmers into cash crop producers to supply the crops or inputs into bio-fuel will start to address the high level of unemployment in the country, particularly in rural areas." (Hendriks, 2006)

It is evident from the Minister of Minerals and Energy's address above that the South African Government has acknowledged the need for and the benefits of establishing a bio-fuels industry.

2.4. WHAT ARE BIO-FUELS?

Bio-fuels are transport fuels manufactured from plant material or other forms of biomass. (Climate Change Capital, 2005) Two forms of bio-fuels can be produced: bio-ethanol, which is produced from crops with high starch content and bio-diesel which is produced from crops that produce vegetable oils. The most common feed stocks currently in production are sugar and maize which are used to produce ethanol.

Agarwal, (2006) describes ethanol as a fuel that can be produced from a variety of crops; however it is mainly produced from sugar and corn in Europe and bio-diesel as a fuel that can be produced from straight vegetable oils, animal fats and waste vegetable oils.

Table 2-1 below lists the common feed stocks available for ethanol and bio-diesel production. It is interesting to note that South Africa grows significant quantities of some of the feed stocks required for ethanol production.

Table 2-1: Potential Feed Stocks for Bio-ethanol and Bio-diesel:

Ethanol	Diesel
Wheat grain	Rapeseed
Sugar beet	Sunflower
Sugar cane	Soybean
Sorghum	Palm oil
Maize / Corn	Jatropha
	Waste vegetable oil
	Waste animal fats

(**Source: Climate Change Capital, 2005)**

The feed stocks used for ethanol production has a variety of properties and therefore each yields a different volume of ethanol. Table 2-2 below lists the volume of alcohol (ethanol) yield per ton of feedstock.

Table 2-2: Ethanol yield per ton of feedstock

Table 1. Average yield of 99.5 percent alcohol per ton**

Material	Gallons	Material	Gallons
Wheat (all varieties)	85.0	Yams	27.3
Corn	84.0	Potatoes	22.9
Buckwheat	83.4	Sugar beets	22.1
Raisins	81.4	Figs, fresh	21.0
Grain sorghum	79.5	Jerusalem artichokes	20.0
Rice, rough	79.5	Pineapples	15.6
Barley	79.2	Sugarcane	15.2
Dates, dry	79.0	Grapes (all varieties)	15.1
Rye	78.8	Apples	14.4
Prunes, dry	72.0	Apricots	13.6
Molasses, blackstrap	70.4	Pears	11.5
Sorghum cane	70.4	Peaches	11.5
Oats	63.6	Plums (nonprunes)	10.9
Figs, dry	59.0	Carrots	9.8
Sweet potatoes	34.2		

(Source: Journey to Forever, 2007)

"Ethanol has been known as a fuel for many decades. Indeed, when Henry Ford designed the Model T, it was his expectation that ethanol, made from renewable biological materials would be the major automobile fuel" – Agarwal, 2006.

The Model T Ford was built to run on ethanol

2.5. BENEFITS OF BIO-ETHANOL

A number of advantages of ethanol exist over conventional fuels. Energy Systems Research Unit (2006) states the following as the most obvious benefits.

- Produced from a renewable source rather than a finite source
- Provides a reduction in greenhouse gas emissions by absorbing carbon dioxide through the growing of crops
- Through blending with conventional fuels the life expectancy of conventional fuels can be extended
- Promotes agricultural growth and thus boosts the economy
- Increases security of supply
- It is biodegradable and therefore less toxic than conventional fuels
- Improves air quality by reducing the amount of carbon monoxide emitted into the air by older engines

- ❖ Easily integrated into the current fuel network and distributed through conventional petrol stations
- ❖ Up to 5% can be blended with petrol without requiring engine modifications
- ❖ It is produced using familiar methods such as fermentation
- ❖ Promotes employment in rural areas

The website, Journey to Forever lists the following benefits of Ethanol:

- *It is a renewable fuel made from plants*
- *It is not a fossil-fuel: manufacturing it and burning it does not increase the greenhouse effect*
- *It provides high octane at low cost as an alternative to harmful fuel additives*
- *Ethanol blends can be used in all petrol engines without modifications*
- *Ethanol is biodegradable without harmful effects on the environment*
- *It significantly reduces harmful exhaust emissions*
- *Ethanol's high oxygen content reduces carbon monoxide levels more than any other oxygenate: by 25-30%*
- *Ethanol blends dramatically reduce emissions of hydrocarbons, a major contributor to the depletion of the ozone layer*
- *High-level ethanol blends reduce nitrogen oxide emissions by up to 20%*
- *Ethanol can reduce net carbon dioxide emissions by up to 100% on a full life-cycle basis*
- *High-level ethanol blends can reduce emissions of Volatile Organic Compounds (VOC's) by 30% or more (VOC's are major sources of ground-level ozone formation)*

- *As an octane enhancer, ethanol can cut emissions of cancer-causing benzene and butadiene by more than 50%*
- *Sulphur dioxide and Particulate Matter (PM) emissions are significantly decreased with ethanol.*

Further to the benefits listed above, a policy dialogue on co-generation and bio-ethanol for Southern Africa, held in Durban in 2004 listed the following advantages:

- ❖ Can help stabilise agricultural sector and sugar markets
- ❖ Sustainable job creation
- ❖ Less dependency on oil imports, reduces need for foreign exchange to purchase oil
- ❖ Low production cost due to established technology and sugar cane market
- ❖ Provides domestic contribution to fuel mix
- ❖ Low net greenhouse gas emissions
- ❖ Octane enhancer
- ❖ Car engine modifications are not necessary up to a 20% blend
- ❖ Mileage performance of petrol/ethanol blend is essentially the same as petrol only
- ❖ About 12kg of sugar cane produce 1 litre of ethanol

It is evident from the above that the benefits and advantages of ethanol are many. It therefore stands to reason that South Africa should develop strategies with haste to promote the establishment of a bio-fuel industry, particularly for ethanol production.

2.6. ETHANOL IN THE GLOBAL ECONOMY

As already established, global demand for crude oil continues to grow. Whilst uncertainty prevails as to when fossil oil reserves are expected to diminish, many environmental and economic factors are encouraging investigation and investment into the production of renewable fuels. Several countries have taken the baton and have initiated programmes and developed policies to encourage the production of bio fuels.

Table 2-3 below, provides a brief overview of ethanol production programmes in several countries around the world. It also states the main feedstock used.

Table 2-3: Ethanol Production Examples Worldwide

Ethanol Production Examples Worldwide		
Location	Feedstock	Ethanol Production
SOUTH AMERICA		
Brazil	Sugarcane	The Brazilian government launched its National Fuel Alcohol Program in the mid-1970s, and by 1980 ethanol use overtook gasoline. Since price liberalization in 1999, ethanol has maintained prices a third lower than gasoline. Brazil is the world's leading ethanol producer and exporter, distilling nearly 4 billion gallons in 2004.
Peru	Sugarcane	In 2002 Peru announced the "Mega-Project," a plan to build up to 20 distilleries and an ethanol pipeline from the interior to the port of Bajovar. Up to 600,000 acres of sugarcane will be planted in forest areas now used for coca leaf production. The government hopes to export 300 million gallons of ethanol by 2010.
Colombia	Sugarcane	From 2006 the use of 10 percent ethanol in fuel will be mandated in cities with populations over 500,000, requiring the cultivation of an additional 370,000 acres of sugar cane and nine new ethanol plants to produce the necessary 260 million gallons a year.

Central America	Sugarcane	El Salvador, Guatemala, Honduras, Nicaragua and Costa Rica project total output to reach 132 million gallons by 2010, enough to allow for a 10 percent ethanol blend in gasoline. Costa Rica, Jamaica and El Salvador export ethanol fuel blends to the United States duty-free under the Caribbean Basin Economic Recovery Act, and are looking to increase exports.
NORTH AMERICA		
United States	Corn	In 2004, 35 million tons of corn (12 percent of the U.S. corn crop) was used to produce 3.4 billion gallons of ethanol. Capacity is expected to top 4.4 billion by late 2005 as 16 new plants come on line. Currently there are 81 plants ranging in size from 1 to 300 million gallons annual capacity, half of which are farmer-owned.
Canada	Corn, wheat, barley	Canada produced 61 million gallons of ethanol in 2004. To meet Kyoto Protocol commitments, the country aims to replace 35 percent of its gasoline use with E10 blends, requiring production of 350 million gallons of ethanol. 7 new plants with total capacity of 200 million gallons are planned under the Ethanol Expansion Program. Ontario, Saskatchewan, and Manitoba are already promoting ethanol through production subsidies, tax breaks, and blending requirements.
ASIA / OCEANIA		
China	Corn, wheat	China is the third largest ethanol producer, with 964 million gallons in 2004. Since 2001, China has promoted ethanol-based fuel on a pilot basis in five cities in its central and north-eastern regions (Zhengzhou, Luoyang and Nanyang in Henan and Harbin and Zhaodong in Heilongjiang province). The Jilin Tianhe Ethanol Distillery, the largest in the world, is producing 240 million gallons per year, and has a potential final capacity of 320 million gallons per year.
India	Sugarcane	Since 2003, India's government has mandated use of E5 in nine states and enacted an excise duty exemption for ethanol. Sugar producers are planning to build 20 new ethanol plants in addition to 10 existing plants, with most located in Uttar Pradesh, Maharashtra and Tamil Nadu. Estimated annual ethanol needs for an E5 blend is 98 million gallons, against actual production of 462 million gallons in 2004 and total capacity of 713 million gallons per year.
Thailand	Cassava, sugarcane, rice	Thailand has mandated a 10 percent ethanol mix starting in 2007, which would boost production from 74 million gallons in 2004 to 396 million gallons. 18 new ethanol plants are being developed, and producers will enjoy several tax breaks. The government calculates an E10 blend would be

		$0.04-0.08 cheaper per gallon than conventional gasoline.
Australia	Grains, sugarcane, sweet sorghum	The Australian government has supported ethanol since 2000 with a range of tax exemptions and production subsidies, aiming to produce 92 million gallons of biofuel by 2010, enough to replace one percent of total fuel supply. 2004 production stood at 33 million gallons.
EUROPE		
EU	Grains, sugar beet	A non-binding directive by the European Commission asks EU countries to meet 2 percent of vehicle fuel demand with biofuels by the end of 2005 and 5.75 percent by 2010. In practice, it is only likely to reach 1.5 percent by the end of 2005, up from 0.2 percent in 2000 and 0.6 percent in 2003. Assuming 3.4 billion gallons of ethanol were produced, some 12.6 million acres of grain and 1.5 million acres of sugar beet would be required. Member states may also exempt biofuels from the tax on petroleum products.
France	Sugarbeet, wheat, corn	France leads the European Union, with ethanol production jumping from 23.4 million gallons in 2003 to 219 million gallons in 2004, and plans to add another 97 million gallons by 2008.
Germany	Rye, wheat	2004 production stood at 71 million gallons. Three new distilleries should bring domestic capacity to nearly 150 million gallons annually, requiring an additional 1.4 million tons of rye and wheat in 2005 - 3 percent of Germany's 2004 grain crop.
Spain	Wheat, barley	In 2004, ethanol production stood at 79 million gallons, up from 55 million gallons in 2003. Total Spanish capacity has been estimated at about 132 million gallons per year.
Sweden	Wheat	E5 blends have been in wide use since 2003 and E85 is now available at some fifty service stations. Ethanol production reached 26 million gallons in 2004, up from 15.8 million gallons in 2003, and Sweden now imports ethanol from Brazil and Spain.
AFRICA		
South Africa	Corn, sugarcane	South Africa's state gas company is a leading producer of synthetic ethanol from coal, but the country is now moving toward crop-based ethanol production. Total ethanol production in 2004 was 110 million gallons. 8 new plants may be built by the end of 2006, enough to produce 320 million gallons of ethanol.
Zimbabwe	Sugarcane	Most gasoline sold in Zimbabwe for the past 20 years has contained 12-15 percent ethanol. Production capacity has exceeded 10 million gallons since 1983, though actual production stood at only 6 million gallons in 2004.

Conversions: 1 gallon = 3.785 litres; 1 acre = .4047 hectares; tons used here are metric tons.		

(Source: Earth Policy Institute, 2005)

Table 2-4 below lists the top five ethanol producers in 2005. It is interesting to note that the top producer globally is a developing country much like South Africa. Both countries are in the Southern Hemisphere with similar climatic conditions, agricultural focuses and a growing demand for fuel.

Table 2-4: Top five fuel ethanol producers in 2005

	Production (million litres)
Brazil	16,500
United States	16,230
China	2000
European Union	950
India	300

(Source: Worldwatch Institute, 2006)

The United States and Brazil are the largest producers of Ethanol in the world, followed by China then by a few European countries as stated in a study conducted by the World Watch Institute (2006). In 2004, Brazil produced 3989 million gallons of ethanol fuel with the United States producing the second greatest quantity in the world at 3535 million gallons (BFAP, 2005). It is further reported that in 2005 China had entered the ethanol market, having built the largest ethanol producing plant in the world.

In 2003, 3 billion gallons of ethanol was consumed by the transport sector in the United States of which 90% was produced from corn (Agarwal, 2006). He further reports that no ethanol is currently produced from sugar and the limited supply of corn cannot meet a significant portion of the fuel demand. As a result, research and development has been commissioned to investigate the possibility of producing ethanol from sugar.

> *"The recent pace of advancement in technology, policy and investment suggest that the rapid growth of biofuel use could continue for decades to come and that these fuels have the potential to displace a significant share of the oil now consumed in many countries. A recent study found that advanced biofuel technologies could allow biofuels to substitute for 37 percent of U.S. gasoline within the next 25 years, with the figure rising to 75 percent if vehicle fuel efficiency were doubled during the same period. The biofuel potential of EU countries is in the range of 20 -25 percent if strong sustainability criteria for land use and crop choice are assumed, and assuming that bioenergy use in non-transport sectors is growing in parallel."* (Worldwatch Institute, 2006)

Based on the evidence above, several countries have initiated strategies and programmes to develop and produce ethanol for use in transport fuels to reduce dependence on conventional fossil fuels and create sustainability for transport fuels in the global economy.

2.7. THE SUITABILITY OF ETHANOL AS A LIQUID TRANSPORTATION FUEL

In a study conducted by Lorenz and Morris of the Institute of Local Self Reliance (1992), as quoted on the website Journey to Forever, it was stated that "the

amount of energy contained in a gallon of ethanol is more than twice the energy used to grow the corn and convert it to ethanol".

Al- Farayedhi as quoted in Agarwal (2006) stated that 20 percent of ethanol can be blended with conventional fuels, requiring no changes to current motor vehicle engines and resulting in no deterioration to the performance of the engines. A similar view is expressed by the Central Energy Fund (CEF) in South Africa, stating that bio-ethanol can be blended at ratios of 10 to 15 percent with conventional fossil petrol without the need to adapt vehicles to use the product (Engineering News, 2005).

Hull Aeck (2005) states that more than 70% of all new cars sold in Brazil run on either petrol or ethanol, while 33% of all transportation fuels used is made of sugar. Demand for bio-ethanol from Brazil has increased with India and China showing interest as reported by the Mail and Guardian (2006).

However, despite market dominance at present Brazil faces challenges to improve transport infrastructure and increase space around its ports to maintain continued and sustainable export growth. South Africa however, has an advantage over Brazil as the transport infrastructure is better developed for export growth, while the country enjoys similar climates and has similar socio-economic conditions.

Agarwal (2006) states that using ethanol as a transport fuel can reduce environmental pollution, strengthen the agricultural sector, create job

opportunities, reduce diesel fuel requirements and as such act as a contributor in extending a major commercial energy source.

The view to diversify South Africa's energy resources is supported by the Deputy President of South Africa as well as the Minister of Minerals and Energy (Engineering News, 2005). As mentioned earlier in this report South Africa's strategy to promote the development of a bio-fuels industry is largely based on it's potential to reduce the country's dependence on fossil fuels, stimulate growth of the agricultural sector, job creation and reduction of harmful greenhouse gases that contribute to global warming.

The Mail and Guardian (2007) reported South Africa's capacity of producing potential ethanol feed stocks as follows:

- Maize – is amongst the most efficient feedstock for ethanol production in terms of its yield and high starch content. South Africa's 2007 production yields is expected to be about 6 million tonnes which provides ample opportunity for expansion since production volumes have fallen to 1920's levels.
- Grain Sorghum – currently produced in the Free State and Mpumalanga provinces have the potential to be expanded to the North West province where temperatures and climate is conducive to growing these crops. The starch content of grain sorghum is about 75% which is relatively high in comparison to other feed stocks.

- Wheat – Although expectations for 2007 yields are around 1.9 tonnes, the starch content is too low to provide an economically feasible basis to produce ethanol.
- Sugarcane – South Africa is among the top 10 producers of sugarcane in the world, however, half of this is exported. Wynne, Deputy Director of Industrial Affairs at the South African Cane Growers Association, stated at a bio-fuel conference in January 2007 that a petrol blend with 4% alcohol could be developed immediately, if the exports were redirected towards ethanol production.

Hendriks (2006) stated that several studies have been conducted indicating that bio-fuels could be produced at a significantly cheaper cost than conventional fuels making bio-fuels a very suitable alternative to conventional fuels particularly for transport (Business Report, 2006).

It is evident from the above that ethanol is indeed a suitable alternative to conventional fuels particularly because of its blending capabilities and the opportunities presented by the current availability of suitable feed stocks; the advantages of creating jobs thus reducing unemployment; stimulating growth of the agricultural sector and reducing the country's dependency on imports of fossil fuels.

2.8. SOCIO-ECONOMIC AND ENVIRONMENTAL FACTORS OF ETHANOL PRODUCTION

2.8.1. Environmental Factors

Environmental concerns have reached significant proportions over the last decade as a result of increased usage of fossil fuels. This has led to global degradation of the environment causing effects such as the greenhouse gas effect, acid rain, ozone depletion and climate change (Agarwal, 2006). The Commission of the European Communities (2005) states that transport is a major cause of greenhouse gas emissions responsible for 26% of all emissions contributing to global warming.

In February 2005 the Kyoto Protocol came into effect with 175 countries signing their commitment to reducing greenhouse gas emissions.

Tofield (2003) states the following environmental advantages of using liquid bio-fuels:

- *Liquid biofuels, bioethanol and biodiesel, provide a key to reversing the continually rising carbon dioxide emissions from road transport;*
- *Near term, biofuels can makes significant and valuable cuts in carbon dioxide emissions as well as other pollution gains;*
- *There will be benefits to soils and biodiversity as well as to greenhouse gas emissions that will occur;*
- *With innovation, yields will increase and processes will become almost zero carbon.*
- *Longer term, biofuels can provide much bigger carbon dioxide savings.*

Studies indicate a great benefit of using ethanol and bio-diesel over conventional fuels (Agarwal, 2006). The major causes of Greenhouse gases are carbon dioxide, carbon monoxide and hydrocarbons. Agarwal argues that although both these renewable fuels emit carbon dioxide, they are environmentally friendly due to their organic origin. Secondly, ethanol and bio-diesel are oxygenated fuels which reduce carbon monoxide emissions into the atmosphere when blended with conventional petrol. Finally, due to the high octane content of ethanol, blending ethanol into conventional fuels will replace other hazardous additives like benzene, leading to reduction or removal of hydrocarbons.

The benefits and advantages from an environmental perspective are many and it is globally one of the main driving forces behind investigation into bio-ethanol production as an alternate source of transportation fuels.

2.8.2. Job Creation

Job creation is cited as one of the most obvious economical and social benefits of ethanol production. To date Brazil leads the world with impressive results both economically and socially. In 2004, Brazil exported 2.4 billion litres of ethanol and the sector employs 500 000 people in sugarcane production and a further 500 000 in ethanol production (Flavin, Hull Aeck, 2005). Skilled workers account for 30% of these jobs, while medium skilled workers account for 10%, the remaining 60% is taken up by unskilled labourers. It is further stated that the average family income of sugarcane cutters is 50% higher than the average family wage in Brazil.

Hendricks (2006) stated that a task team consisting of various departments has been established to promote the production of bio-fuels in South Africa, with a primary focus on shifting subsistence crop farmers to commercial farming (Business Report, 2006). Hendricks further states that the strategy is intended to reduce unemployment in the underdeveloped economy significantly, with the expectation to halve unemployment by 2014, thereby assisting government in its objective of bridging the gap between the first and second economies. Optimistic indications are that South Africa has the potential to create approximately one million jobs in farming and refining if the bio-fuel industry were to be established.

These numbers are consistent with the jobs created in Brazil and therefore it appears to be a plausible strategy for South Africa to follow to reduce the high levels of unemployment and increase sustainability amongst the country's impoverished.

2.8.3. Food Security

Food versus fuel has become a controversial sub-topic of bio-ethanol production. It is argued that energy crops are in competition with food crops for labour, fertilizers and water and thus result in an increase in food prices, which could potentially leave the masses without basic foods.

In a report conducted by the Worldwatch Institute (2006) it is reported that bio-fuels may have an upward effect on the price of agricultural commodities, but that the problem is more complex than it is currently said to be. It is further stated that many of the poorest people are also farmers who will benefit economically from

increased production of feedstock crops as well as involvement in the processing of the ethanol for own use or for commercial use.

The Canadian Renewable Fuels Association (2006) stated that ethanol production from grain will not minimize the country's ability to feed its citizens and still supply the export markets with high quality grains.

"*The world already grows more than enough food to feed everyone. About a billion people now don't have enough food to meet their basic daily needs, but that's NOT because there's not enough food. There's more food per capita now than there's ever been before – enough to make everyone fat. There's enough to provide at least 4.3 pounds of food per person a day: two and a half pounds of grain, beans and nuts, about a pound of fruits and vegetables, and nearly another pound of meat, milk and eggs.*

People starve because they're victims of an inequitable economic system, not because they are victims of scarcity and overpopulation." Journey to Forever (2006).

Whilst the debate continues with both sides having strong arguments for and against the impact of bio-fuel production on food security, it is uncertain if indeed it would have the damaging effects portrayed. In spite of the pessimists, several studies indicate that bio-fuel production could benefit the poor as many of the poor

are farmers or farm labourers who will benefit economically from the stimulation of the agricultural sector and the processing and refining of the produce.

2.9. REGULATORY ENVIRONMENT

Several countries have initiated programmes and developed incentives to support the growth of a bio-fuel industry. Europe has set targets for bio-fuel inclusion in conventional transport fuels. European Union member states are required to achieve 5.75% bio-fuel sales by 2010 (Agarwal, 2006).

Canada has made available $11.9 million for incentives, research and the establishment of industrial scale bio-diesel production plants and included a production goal of 500 million litres of bio-diesel by 2010 in its climate change action plan (Canadian Renewable Fuels Association, 2006).

In South Africa a task team has been established to investigate and determine how lucrative a bio-fuel industry could be (Hendriks, 2006). Key activities that the task team will focus on will be:

- *Identification of resource requirements (land, crops, incentives, human capital, etc.*
- *Feasibility studies for plant construction where required*
- *Long term feedstock supply aspects and farmer outreach activities*
- *Cost benefit analysis, to determine optimal use of land, water, etc.*

- *How to move farmers from subsistence farming to commercial farming, including what support they might need such as agricultural extension services and advanced farming methods*
- *Dealing with issues such as land tenure, reform and usage*
- *Protecting vulnerable participants, such as farmers from food price vulnerability, oil price drops and currency fluctuation.*

Flavin and Hull Aeck (2005) state that the following factors need to be taken into consideration to achieve renewable energy goals:

- The creation of supportive policy and institutional frameworks linked to rural development initiatives and other social objectives.
- Promotion of private sector involvement.
- Level the playing field between conventional fuel and bio-fuel particularly where costs are concerned.
- Nurture micro-enterprise to mitigate risks for potential investors.
- Integrate projects around local needs and capacity.

It is evident from the above that several countries are well advanced in terms of their bio-ethanol strategies and programmes. Clearly, South Africa is still at the starting blocks. While Brazil initiated their programmes over 30 years ago, the South African government only expressed its interest to explore bio-fuels late in 2005 (Engineering News, 2005).

2.10.THE CURRENT STATUS OF BIO-ETHANOL PRODUCTION IN SOUTH AFRICA

Despite rising oil prices, climate changes and high unemployment South Africa has yet to acknowledge the benefits of developing a bio fuel sector. The Financial Mail (2005) stated that the only bio-fuel production currently taking place is conducted by farmers, producing bio-diesel, on a small scale for their own use.

Several projects are currently underway to support the bio-ethanol industry. Hendriks, (2006) stated that a pilot project in Cradock in the Eastern Cape has commenced to grow beet for the ethanol industry (Business Report, 2006). Evergreen Biofuels, a bio-diesel project in Mpumalanga, has plans to build a refinery to produce bio diesel from maize and soya beans (Business Report, 2005).

Several studies have been conducted by the South African agricultural industry associations regarding the surplus capacity of certain agricultural produce with the capability to be converted to bio-fuels. A study conducted by F O Licht (2005) indicates that if South Africa redirected 50% of sugar exports (equal to 10.5 million tons) to bio-fuel production it would generate 840 million litres of ethanol. F O Licht further indicates that a surplus capacity of 3 million tons of maize can be converted to 1.2 billion litres of ethanol.

The employment and atmospheric benefits are significant and has the potential to boost economic growth significantly. The current ports and roads infrastructure is an advantage South Africa has over Brazil. If sufficient investment is channelled

into the development of this sector, South Africa has the potential to exceed the volumes produced in Brazil. Furthermore, high unemployment serves as an opportunity to ratchet up the agricultural production capacity to meet increasing demand for ethanol as other countries endeavour to reduce their dependence on fossil fuels.

An ethanol plant initiated in Bothaville in the Freestate was expected to start production of ethanol in the second half of 2007 with the expectation to produce 155 million litres per annum (Engineering News, 2005). The area was identified as an ideal location for ethanol production, given the large quantities of maize produced in that province. However, media reports indicate that the project has since been placed on hold.

Despite interest shown by government and investors since early 2005, other than the ethanol production plant partially established in Bothaville, no other plant has yet been established. As a result production of bio-ethanol has still not materialised.

2.11.CONCLUSION

Although several South African studies have been conducted to determine the potential for a bio-fuels industry no research has as yet been conducted to determine the factors necessary to establish and promote such an industry.

The one project that did initially take off the ground has come to a grinding halt implying that despite the obvious benefits as stated earlier in the report of producing ethanol for use in transport fuels, several factors congruently are key to the success of establishing the sector. While several reports, in the literature review, state some of the factors that will contribute to the success of an ethanol industry, no published report could be found that holistically identifies or addresses these factors specifically where it relates to South Africa. This report is aimed at addressing that gap in the current research available.

CHAPTER 3: RESEARCH QUESTIONS

Researchers use broad or central questions in qualitative studies so as not to limit the inquiry (Cresswell, 2003). The following research questions will be explored to determine the factors that contribute to the success of bio-ethanol production particularly for use in liquid transportation fuels.

Research Question 1: Is bio-ethanol a suitable alternate source of energy for transport purposes in South Africa?

Research Question 2: How does bio-ethanol production stimulate growth of the agricultural sector?

Research Question 3: What impact will bio-ethanol production have on socio-economic factors such as job creation and food security?

Research Question 4: How does the use of bio-ethanol as compared to conventional petrol reduce environmental degradation?

Research Question 5: What regulatory support is required to establish a sustainable bio-ethanol industry?

CHAPTER 4: RESEARCH METHODOLOGY

4.1. INTRODUCTION

This chapter covers the methodology used to conduct the research. This study was intended to determine the factors that enhance the success of bio-ethanol production for use in transport fuels in South Africa. Firstly, the research problem was formulated based on an extensive literature review that was conducted. The literature review further assisted in formulating the research questions and providing structure and content to the questionnaire used to collect the data. Several methods were used to secure interviews and gather the data. The questionnaire was used in one-to-one interviews with 5 subject matter experts to collect relevant data to answer the research questions. Where subject matter experts were not available the questionnaire was completed via telephonic interviews with a further 11 subject matter experts. Quantitative methods were used to present and analyse the close ended questions while qualitative methods were used to analyse the open ended questions. The data is presented in chapter 5 in a tabled format.

4.2. RESEARCH DESIGN

Since the study was exploratory in nature, extensive document research was conducted to substantiate the development of key arguments. Thereafter semi-structured interviews were conducted as outlined by Welman and Kruger (2001) to collect data to answer the research questions. Qualitative research was conducted by interviewing subject matter experts on the topic of bio-ethanol

production. These interviews have addressed the research questions outlined in Chapter 3 of this report. This is substantiated by Saunders, Lewis and Thornhill (2003, p378) who state that through "*qualitative analysis one has the ability to draw significant distinctions from those that result from quantitative analysis and also provides a basis upon which to analyse the data meaningfully*".

A questionnaire was developed using both open ended questions as well as closed ended questions. The benefit that this questionnaire presented was to maintain a semi-level of structure during the interviews by gaining insights and uncovering new issues through in-depth discussions as described by Jancowicz (2000) while at the same time gaining input on areas highlighted by the literature review with closed ended questions. The questionnaire is attached as appendix 1 for reference purposes.

4.3. POPULATION OF RELEVANCE

The population of relevance consists of subject matter experts who have been involved in research on the topic of bio-fuels, have an interest in the bio-fuels topic or been involved in the development of the draft strategy on bio-fuels for South Africa. The size of the population is unknown since no data is available. However, sources were gathered from existing literature and from references obtained from these sources.

The criteria used to select the respondents were as follows:

- Individuals needed to have knowledge about bio-fuels in South Africa

- Individuals needed to be involved in either research on bio-fuels, development of the South African bio-fuels strategy or involved in a bio-fuels project.

Details of the respondents are attached in appendix 2.

4.4. SAMPLING

Non-probability purposive sampling or judgement sampling has been chosen for the purpose of conducting this research. Welman and Kruger (2001) state that non probability sampling is used when the probability that certain members of the population may have no chance of being included in the sample. Welman and Kruger *(p. 63)* also state that when using purposive sampling "*researchers rely on the experience, ingenuity and / or previous research findings to deliberately obtain units of analysis in such a manner that the sample that they obtain may be regarded as representative of the relevant population".* Since the purpose of this study is to obtain the opinion of experts to substantiate the findings of the literature review and ascertain if these arguments are true for South Africa, this sampling technique is appropriate.

During the interviews, five of the respondents were asked to identify suitable individuals from the relevant population that could be interviewed based on their knowledge and expertise on the topic of bio-ethanol. As a result the snowballing effect, as outlined by Welman and Kruger (2001), was used to increase the size of the sample and obtain as many contacts for interviews as possible.

In all instances the respondents occupied senior positions in the organisations they represented. In some instances the most senior official was unable to supply the information requested and elected another official occupying a senior position to participate in the interview. A breakdown by function of the interviewees is presented in table 4-1 below.

Table 4-1: Number of interviewees by position held in the organisation

Position	Number interviewed
President	1
CEO	3
Director	4
Senior Manager	5
Middle Manager	3

Interviews with respondents who agreed to participate were secured by means of telephonic or email contact.

4.5. DATA COLLECTION

Data was collected by conducting one-on-one or telephonic semi-structured interviews with key individuals and subject matter experts who were identified from the literature review to have the knowledge to answer the research questions. Semi structured interviews may be useful in extracting additional information for which there is no specific question in the questionnaire (Welman and Kruger, 2001). Additional respondents were referred by the first 5 interviews conducted.

Each respondent was contacted telephonically or via e-mail to outline the objectives of the research and to secure an interview. A follow up e-mail was sent

to each respondent to confirm the date and time of the interview and to provide the themes that would be explored when the interview takes place. All interviews took place at the respondent's place of work or telephonically whilst the respondent was at work. The responses to the questions posed were recorded manually during the interview and later transcribed onto excel spreadsheets. Key comments and responses were captured.

4.6. RESPONSE RATE

A total of 50 South African contacts were extracted from the literature review. All of these were contacted for an interview. Only 5 face-to-face interviews were granted from this source. An additional 19 contacts were obtained from the first 5 interviews. Of these 11 telephonic interviews were granted. A total of 16 interviews were thus secured and conducted.

4.7. DATA ANALYSIS

Welman and Kruger (2001) state that content analysis can be used to systematically analyse "*unstructured interviews in order to report in a quantitative way in addition to making qualitative analysis of the essence of the contents of such an interview"(p 195)*. It therefore stands to reason that since this study will be conducted by means of semi-structured interviews, content analysis will be used to extract themes and categorise the data into a format that can be used to derive recommendations in a systematic order to answer the research questions in chapter 3 of this report.

The data from the close ended questions once categorized was transferred onto an excel spreadsheet to enable reporting the data in a quantitative manner. Tables were developed to present the data in chapter 5. Answers from the open ended questions were analysed using quantitative methods and presented in chapter 5 under the themes that emerged.

4.8. INFLUENCING FACTORS AND LIMITATIONS OF THE RESEARCH

The following research limitations have been identified in conducting this study:

- The sample size may be considered too small to be regarded as representative, as demographic factors were not considered when choosing the sample.
- The data analysis may be subjective due to the nature of the research method and the inexperience of the interviewer in this field.
- Welman and Kruger (2001) advise that the interviewer needs to be trained to conduct research. Despite the interviewer being familiar with the contents of the questionnaire, in this instance the interviewer had not received training prior to conducting the interviews.
- Since consumers of conventional petrol were not interviewed for their opinion on the use of bio-ethanol it is believed that the report may be biased to industry opinion only.
- Only one respondent from the Agricultural sector was interviewed which may prove to be too small a sample to be representative of that sector.

CHAPTER 5: RESULTS

5.1. INTRODUCTION

Chapter 5 reports the results of the data collection process in terms of the responses received from the interviewees to questions posed during the interviews.

Semi-structured interviews were conducted with industry experts in the field of bio-fuels. The interviewees were selected based on their knowledge and experience of the topic. The questionnaire was divided into seven sections with close-ended and open-ended questions designed to elicit information to answer the five research questions outlined in chapter 3.

The responses are presented firstly by profiling the interviewees and then presented to address each of the research questions stated in Chapter 3.

5.2. PROFILE OF THE SAMPLE

Section 1 of the questionnaire was used to obtain the organizational information of the interviewees. Appendix 2 details the list of the interviewees, their contact details and the organizations they represent.

Section 2 of the questionnaire was designed to obtain a profile of the interviewees. A breakdown of the organizational position of the sample is presented in Chapter 4 in Table 4-1.

Table 5-1 below shows the number of interviewees per industry as an indication of the representation of the various stakeholders.

Table 5 – 1: Number of Interviewees by industry

Industry	Number of interviewees
Bio-fuel Producers	4
Government / NGO's	4
Oil Companies	4
Agriculture	1
Service Providers	1
Investors	2

Bio-fuel is a relatively young industry in South Africa. Table 5 – 2 below shows the experience of the interviewees by the number of years in the bio-fuels industry.

Table 5 - 2: Years of experience of interviewees

Number of years of experience	Number of Interviewees
Less than 2 years	4
2 to 4 years	5
5 to10 years	4
More than 10 years	3

Table 5 – 3 below shows the responses of the interviewees when asked what their interest in bio-fuels is. The responses were categorized as illustrated.

Table 5 – 3: Interviewees expressed interest in bio-fuels (16)

Interest in Bio-fuels	Number of responses
Work related interests	8
Project related interests	3
Personal Interests	3
Agricultural interests	2

Section 3 of the questionnaire addresses the suitability of bio-ethanol as a liquid transport fuel. Section 4 analyses the degree to which bio-ethanol production influences agricultural development. Section 5 evaluates the social impact of bio-ethanol use as it relates to food security and job creation. Section 6 addresses the environmental impact of bio-ethanol use. Finally, section 7 addresses the regulatory environment. The results of the above sections are reported in a format so as to address the research questions under analysis, these being:

Research Question 1: Is bio-ethanol a suitable alternate source of energy for transport purposes in South Africa?

Research Question 2: How does bio-ethanol production stimulate growth of the agricultural sector?

Research Question 3: What impact will bio-ethanol production have on socio-economic factors such as job creation and food security?

Research Question 4: How does the use of bio-ethanol as compared to conventional petrol reduce environmental degradation?

Research Question 5: What regulatory support is required to establish a sustainable bio-ethanol industry?

5.3. RESEARCH QUESTION 1: IS BIO-ETHANOL A SUITABLE ALTERNATE SOURCE OF ENERGY FOR TRANSPORT PURPOSES IN SOUTH AFRICA?

The suitability of bio-ethanol as a transport fuel was initially addressed at a broad level and then narrowed down to blending capability; factors that contribute to the success of bio-ethanol production and factors that contribute to the development of the industry. Table 5 – 4 below presents the responses by the number of times a response was cited. This format of presenting the responses is used throughout the remainder of chapter 5 unless stated otherwise.

Table 5 – 4: Suitability of bio-ethanol as a liquid transport fuel (16)

	Yes	No
Frequency of response	14	2

The two respondents that did not view bio-ethanol as a suitable alternative to conventional petrol stated that they believed bio-ethanol to be an additive or extender of conventional petrol.

The table below shows the frequency of responses relating to the blending capability of bio-ethanol into conventional petrol ranked from highest suggested blending capability to lowest suggested blending capability.

Table 5 – 5: Blending capability of bio-ethanol into conventional petrol (16)

	Up to 15%	Up to 10%	Up to 8%
Blending capability	1	14	1

It is interesting to note that of the 16 responses 14 stated that bio-ethanol could be blended with conventional petrol at a 10% blending capability. Of these nine commented that the reasons were related to the motor vehicle manufacturing industry that will only honour warranties on engines at bio-ethanol blends up to 10%. The interviewee that stated that blends could only be accommodated up to

8% commented that the altitude in South Africa would cause a vapour lock which would affect engine performance.

The eight factors listed below were identified from the literature review as being the factors that could likely contribute to the success of bio-ethanol production. Interviewees were asked to rate each of the factors according to their level of importance in contributing to bio-ethanol production. The number of responses for each degree of importance is shown in the table below ranked by the sum of the responses for VERY IMPORTANT and CRITICAL FACTOR.

Table 5 – 6: Factors that contribute to successful bio-ethanol production (16)

Factor	Very low importance	Low importance	Average importance	Very important	Critical factor
Availability of feedstock in South Africa	0	1	0	4	11
Facilitates job creation	0	1	1	4	10
Strengthens the agricultural sector	0	2	2	3	9
Reduces dependency on fossil fuels	1	2	3	4	6
Reduces environmental pollution	1	2	3	4	6
Cost competitiveness of bio-ethanol	2	2	3	4	5
Extender / blending capabilities	3	0	5	3	5
Modifications to engines not required at blends up to 10%	1	1	6	2	6

One of the interviewees commented that other important factors that need to be considered are energy security and the balance of payment concerns relating to energy security. This report did not specifically identify those factors and therefore no questions relating to these were asked.

Interviewees were asked their opinions on what they believe are the most important factors that contribute to the development of a bio-ethanol industry in order to compare the responses to those identified from the literature in Table 5 – 6 above. Seven of the interviewees offered less than 5 factors. The responses are ranked by frequency or response.

Table 5 – 7: 5 Most Important factors contributing to the development of the bio-ethanol industry (16)

Factor	Frequency of response
Competitive feedstock from South African Agricultural Sector	7
Government Support and incentives	7
Investment	6
A defined price for the product	6
An effective supply chain from the field to the motor vehicle	5
Job creation	5
Appropriate processing Technology and knowledge	4
A defined market for the product	3
Environmental issues	3
Development of rural agricultural communities	2
Available Land	2
Food security	2

Respondents were asked to mention and comment on any current bio-ethanol projects being established that they believe will be successful. The following list of projects was mentioned as well as the feedstock identified for processing.

Table 5 – 8: Bio-ethanol projects currently being established in South Africa (16)

Project	Feedstock
Ethanol Africa - Bothaville	Maize
Hoopstad Project	Maize
Makhatini Project - Mpumalanga	Sugarcane
Cradock Project	Sugarbeet
Pongola Project	Sugarcane
Industrial Development Corporation Project - Ogies	Maize

The respondents stated that the above projects are still in the initial stages of development and none have yet started production of ethanol. Further that the projects are likely to fail if the factors for successful production listed in Table 5 – 6 and Table 5 – 7 above are not met.

5.4. RESEARCH QUESTION 2: HOW DOES BIO-ETHANOL PRODUCTION STIMULATE GROWTH OF THE AGRICULTURAL SECTOR?

First the research attempted to determine if the interviewees believe that ethanol production will stimulate growth in the agricultural sector. Once this was established, interviewees were asked to confirm where and how the agricultural

sector would be impacted, secondly which feedstock presented the greatest opportunity for ethanol production in South Africa and finally what the most important factors for successful agricultural production would be.

Table 5 – 9: Agricultural growth (16)

	Yes	No
Bio-ethanol production will stimulate the growth of the agricultural sector	15	1

All, but one of the interviewees believe that bio-ethanol production in South Africa will stimulate the growth of the agricultural sector. The interviewee that affirmed a growth impact on agriculture indicated that growth in the agricultural sector would be stimulated in the areas listed in table 5 - 10 below which were extracted from the literature review. The responses to this question are ranked by the frequency of the response.

Table 5 – 10: Growth effect of bio-ethanol production on the agricultural sector (15)

Impacted areas	Frequency of response
Higher production volumes	15
Increase in feedstock prices	14
New markets for feedstock	14
Improved Technology	13
Higher contribution to GDP	13
Available land put to better use	13
Skills development	13
Increased investment in agriculture	13

The data below is presented by the highest number of citations for MOST EFFICIENT and then VERY EFFICIENT. Some feed stocks were ranked lower due to availability in South Africa despite the ability to produce higher yields of alcohol. Two interviewees were unable to answer the question due to a lack of knowledge of the feedstock. A further 3 interviewees only ranked sugarcane and maize due to a lack of knowledge of the other feed stocks.

Table 5 – 11: Feedstock ranked by a combination of energy and price efficiency and then availability (14)

Feedstock	Least efficient	Very low efficiency	Low efficiency	Average efficiency	Very efficient	Most efficient
Maize	1	0	1	2	6	4
Sugarcane	0	0	0	1	3	10
Sugarbeet	3	2	2	1	3	0
Grain Sorghum	3	1	3	2	2	0
Sweet Sorghum	1	4	4	2	0	0
Wheat	3	4	1	3	0	0

The factors listed below were cited as the most important factors for successful agricultural development as it pertains to bio-ethanol production. The responses were grouped and then ranked by frequency of response.

Table 5 – 12: Factors for successful agricultural development (16)

Factor	Frequency of response
Utilisation and availability of underdeveloped land	7
Funding for agriculture	7
Government support in respect of incentives and regulation	7
Location of a defined market	7
Improved technology	5
Availability of water	4
Defined price for the product	4
Skills development	3
Drought resistant cultivars	1
Uptake of by products by agricultural companies	1
Resolve land ownership issues	1
Logistics and infrastructure	1

The research next attempted to establish the impact that bio-ethanol production would have on socio-economic factors which forms the content of the third research question.

5.5. RESEARCH QUESTION 3: WHAT IMPACT WILL BIO-ETHANOL PRODUCTION HAVE ON SOCIO – ECONOMIC FACTORS SUCH AS JOB CREATION AND FOOD SECURITY?

The research attempted to firstly, determine the impact of bio-ethanol production in South Africa on job creation at a 10 % blending rate. Secondly, to determine the impact on food security as it relates to food prices and the availability of basic foods.

Table 5 – 13: Number of jobs created at a 10% blend rate (15)

	10 000 to 50 000	50 000 to 100 000	100 000 to 250 000	250 000 to 500 000	500 000 to 1000 000
Number of jobs created	6	5	2	0	2

One respondent chose not to answer the question due to a lack of knowledge.

Interviewees were then asked to state the percentage of jobs that would be created in each of the categories listed in Table 5 -14 below.

Table 5 – 14: Percentage of jobs created according to skills level (16)

	Skilled workers	Semi-skilled workers	Unskilled workers
Mean percentage	11%	22%	67%

The following definitions were used to define the level of skills of workers in the questionnaire:

Skilled workers – managers, supervisors, technicians, etc.

Semi-skilled workers – drivers, machine operators, etc.

Unskilled workers – farm workers, etc.

The research then attempted to determine if the creation of the stated number of jobs would influence the establishment of the bio-ethanol industry.

Table 5 – 15: Job creation influences establishment of ethanol industry (16)

	Yes	No
Frequency of response	16	0

Three interviewees stated that they believed that job creation would be the main driver for the establishment of the bio-ethanol industry since it is a government imperative.

The main beneficiaries of the jobs created are believed to be the rural unemployed since most jobs will be created in the agricultural sector which is largely rurally based.

Table 5 – 16: Main beneficiaries of the jobs created (16)

	Rural unemployed	Urban unemployed
Mean percentage	80%	20%

To determine the impact of bio-ethanol production on food security, interviewees were first asked to state whether bio-ethanol production would have a negative effect on food security and then asked questions to ascertain what that impact would be and whether a negative impact could be controlled through the introduction of regulation.

Table 5 – 17: Does bio-ethanol impact food security negatively? (15)

	Yes	No
Frequency of response	6	9

One respondent chose not to answer the question above to a lack of knowledge on this aspect.

The following comments were given by the interviewees that believe that bio-ethanol production will impact food security negatively.

Table 5 – 18: Negative impact of bio-ethanol production on food security (6)

Impact	Frequency of response
Increases prices of basic food stocks internationally	1
Shortage of food and fuel as a result of both competing for the same commodity	1
Opportunity to leverage food supply	1
Food will be diverted to fuel unless additional plantings take place	2
Government support is needed to reduce food security issues	1
Prices of basic foods will rise until there are market corrections	1

The comments listed in the table below were recorded from the interviewees with a YES response.

Table 5 – 19: Positive impact on food security (9)

Impact	Frequency of response
An increase in feedstock prices results in an increase in production which will result in an oversupply	3
Under-utilised land can be put to plantings which will increase	3

food supply	
The choices of feedstock for ethanol production can be limited to non-edible types which will not impact food supply	1
Capacity exists in South Africa to produce sufficient feedstock for food supply and ethanol production	1
Job creation creates access to food	1
Increased feedstock production facilitates food security	1
By-products of ethanol production can be used in the food industry	1

Responses in the table below are presented by the frequency of response per ranking.

Table 5 – 20: Impact of ethanol production on food prices and availability of basic foods (15)

Impact	Very low impact	Low impact	Average impact	High impact	Critical impact
Food price increase	3	5	2	3	2
Availability of basic foods	8	2	2	0	3

One respondent chose not to answer the question.

The table below shows the frequency of the response, when interviewees were asked if utilizing under-developed land to plant feedstock for ethanol production would have a positive effect on food security. One respondent chose not to answer due to the economic complexity of the question.

Table 5 – 21: Impact of utilizing under-developed land on food security (15)

	Yes	No
Frequency or response	13	2

The table below indicates the responses of the interviewees when asked if food prices need to be regulated to ensure food security. One interviewee stated that the answer is economically complex and that supply and demand will regulate food prices.

Table 5 – 22: Regulation of food prices to ensure food security (15)

	Yes	No
Frequency of response	1	14

When asked whether the establishment of the bio-ethanol sector would be positively influenced if food security could be guaranteed the interviewees responded as outlined in Table 5 – 23 below.

Table 5 – 23: Impact of guaranteed food security on the establishment of the bio-ethanol industry (16)

	Yes	No
Frequency of response	14	2

Although the majority of respondents believe that the establishment of the bio-ethanol sector will be positively impacted if food security can be guaranteed they stated that they believe that food security could not be guaranteed. Although, when asked if food security needs to be guaranteed in order to establish the bio-

ethanol industry the responses were almost an equal split as can be seen in Table 5 - 24 below.

Table 5 – 24: Does food security need to be guaranteed to establish the bio-ethanol industry (15)

	Yes	No
Frequency of response	8	7

The research then aimed to establish if bio-ethanol use would reduce environmental pollution and contribute to a healthier environment. This is covered in the fourth research question.

5.6. RESEARCH QUESTION 4: HOW DOES THE USE OF BIO-ETHANOL AS COMPARED TO CONVENTIONAL PETROL REDUCE ENVIRONMENTAL DEGRADATION?

First the research aimed to establish if road transport is a contributor to environmental pollution and whether the use of bio-ethanol in transport fuel will reduce the effect on the environment. The responses are presented in Table 5 -25 and Table 5 – 26 below.

Table 5 – 25: Road Transport is a contributor to environmental pollution (16)

	Yes	No
Frequency of response	16	0

It is interesting to note that all the respondents agreed that road transport is a contributor to environmental pollution.

Table 5 – 26: Use of bio-ethanol in transport fuel will reduce environmental pollution (16)

	Yes	No
Frequency of response	15	1

The NO respondent commented that at a 10% blend rate, there will not be a significant reduction in environmental pollution. The 15 YES responses ranked the 6 potential areas of impact, which were extracted from the literature review, in Table 5 -27 below.

Table 5 – 27: Impact of bio-ethanol use on the environment (15)

Contributors to environmental pollution	Very low impact	Low impact	Average impact	High impact	Critical impact
Reduction of Carbon Dioxide and other greenhouse gas emissions	1	1	4	1	8
Reduction in acid rain	3	2	1	3	6
Slow down ozone depletion	3	4	2	3	3
Benefits to soil and biodiversity	3	3	3	4	2
Provide bigger carbon savings	2		5	4	4
Replaces hazardous additives in conventional petrol	2	1	3	5	4

One interviewee did not answer the question due to a lack of knowledge in the field of environmental pollution.

5.7. RESEARCH QUESTION 5: WHAT REGULATORY SUPPORT IS REQUIRED TO ESTABLISH A SUSTAINABLE BIO-ETHANOL INDUSTRY?

Since bio-ethanol production would be included in a bio-fuels strategy in South Africa, interviewees were asked broad questions around the current regulatory environment of the bio-fuel sector rather than limited to ethanol. Opinions were then requested on what needs to be done from a government perspective to establish the industry.

When asked if the South African government has delivered on its strategy to facilitate the establishment of the bio-fuels industry the interviewees responded as indicated in Table 5 – 28 below.

Table 5 – 28: South African Government's delivery on strategy (16)

	Yes	No
Frequency of response	1	15

Interviewees were asked what the 3 actions are that the South African government would need to take on an urgent basis in order to establish the bio-fuels sector. The responses were categorized and are ranked by the frequency of response in the table below.

Table 5 – 29: Urgent Actions to be taken by the South African Government to establish the bio-fuels sector (15)

Actions	Frequency or response
Finalise and approve the national bio-fuels strategy that addresses the concerns of all stakeholders	11
Clarify what government support will be available for all stakeholders	7
Regulate mandatory blending	4
Analyse the implications of the establishment of a bio-fuels sector	3
Funding support	3
Introduce regulation to ensure supply of feedstock for fuel production	3
All relevant government departments should collaborate to facilitate the establishment of the sector	2
Clarify food security issues	2
Infrastructure and logistics support	2
Regulation on captured fleet systems	1

Table 5 – 30 lists the responses of the interviewees when asked what should form part of the policy framework for the bio-fuels sector. The responses were categorised and are ranked by frequency of response.

Table 5 – 30: Policy framework considerations (16)

Suggested inclusion in the policy framework	Frequency of response
Government support (incentives, subsidies, tax relief)	13
Mandatory blending targets	9
Regulation for importing and exporting of feedstock - tariffs	7

A defined price and quality for the product	6
Social issues (job creation, food security)	5
A defined market for the product	3
Licensing framework	3
Land management policy	2
Regulation to encourage sourcing of feedstock from emerging farmers	2
Environmental sustainability issues	1

Table 5 – 31 below lists the stakeholders mentioned by the interviewees when asked who the most important stakeholders in the industry are. The data is ranked by the frequency of response.

Table 5 – 31: Stakeholders (16)

Stakeholders	Frequency of response
Government	16
Oil companies	16
Agricultural sector (farmers, farm workers)	13
Investors	8
Consumer	5
Primary and secondary suppliers and service providers	4
Bio-fuel Producers	3

The following factors were mentioned by the interviewees as being the main reasons holding back the establishment of the bio-fuel industry

Table 5 – 32: Factors delaying the establishment of the sector (16)

Factors	Frequency of response
Lack of sound and clear government strategy and policy framework	15
Access to funding	5
Vested interests and political agendas	2
Food security	2
Reluctance from oil industry for off-take	2
Knowledge	2
Availability of water resources	1

In order to establish the most critical factors necessary to establish the bio-ethanol industry, interviewees were asked to rank a set of factors extracted from the literature review. The responses are presented by the frequency per ranking of each factor in Table 5 -33 below.

Table 5 – 33: Most important factors to establish the bio-fuels industry (16)

Factors	Least Important	Less important	Average importance	Very important	Critical factor
Creation of supportive policy and institutional framework			1	1	14
Public sector involvement	2	3	1	10	
Leveled playing fields for conventional petrol and bio-fuels	10	1	3	2	
Integrated projects around local needs and capacity	4	8	4		
Identification of resource requirements		5	7	2	2

To gauge which factor is the most important for the establishment of the bio-ethanol industry in South Africa, the key themes of the research questions of this report were presented to the interviewees to be ranked according to importance. The responses are presented in Table 5 -34 below by frequency of response for each ranking.

Table 5 – 34: Factors that play a significant role in the establishment of the bio-ethanol industry (16)

Factors	Least importance	Less important	Average importance	Very important	Critical factor
Suitability of Ethanol	6	3	2	3	2
Agricultural development	1		7	7	1
Socio-economic factors	1	5	7	2	1
Environmental factors	7	7		2	
Regulation	1	1		1	13

All the results reported in Chapter 5 above are analysed and discussed in depth in the next chapter.

CHAPTER 6: DISCUSSION OF THE RESULTS

This chapter briefly summarises the profile of the interviewees and then analyses the data presented in Chapter 5 in conjunction with the literature reviewed in chapter 2. The analysis is presented to address each of the research questions stated in chapter 3.

6.1. DISCUSSION OF THE INTERVIEWEES PROFILE

In summarizing the profile of the interviewees there are a few points that need to be noted. Due to the limited size of the population in South Africa, the sample was deliberately targeted at subject matter experts, to add merit to the research. The seniority level of the interviewees (Table 4 – 1), is of the highest ranking order in each organization with the requisite knowledge on the bio-fuels topic therefore adding further credibility to the research.

To add even further credibility to the sample and in order to gauge the extent of knowledge, interviewees were asked for their number of years of experience in bio fuels and their interest in the bio-fuels industry (Table 5 – 2 and Table 5 – 3). Since the South African bio-fuels industry is fairly young and production of bio-ethanol has not yet begun, it is worth noting that the experience of the interviewees are significant, more especially where experience is greater than 5 years, which is the case for 44% of the sample. Further credibility can be attributed to the fact that 69% of the sample have work or project related interests in bio-fuels indicating that the interviewees have more than intellectual interests involved.

The sample was further analysed according to the industry that the interviewees represent (Table 5 – 1) to ensure that all identified stakeholders in the industry are represented. When comparing Table 5 – 1 with Table 5 – 31 that reports the interviewees' opinions on who the most important stakeholders in the industry are, then it is evident that this research obtained the opinion of only one representative from the agricultural sector. Although attempts were made to interview more representatives from the agricultural sector, only one representative was available. However, it is worth noting that although the sample has only one representative from agriculture, two interviewees expressed an agricultural interest in bio-fuels. When comparing the two tables, further cognisance is taken that consumers of transport fuels were not interviewed and this research therefore does not include their opinion. Analysis of the data may therefore be biased towards other stakeholder opinions.

The first research question attempted to determine if bio-ethanol is a suitable alternative for transport fuels in South Africa. This research question is addressed below.

6.2. RESEARCH QUESTION 1: IS BIO-ETHANOL A SUITABLE ALTERNATE SOURCE OF ENERGY FOR TRANSPORT PURPOSES IN SOUTH AFRICA?

In attempting to establish the suitability of bio-ethanol as a transport fuel, the extent to which South Africa has the capacity to blend ethanol into current transport fuels and what factors will contribute to the establishment of a bio-ethanol production industry were considered.

The results show that 14 of the 16 respondents believe that bio-ethanol is a suitable alternative to conventional petrol (Table 5 – 4). This is evidenced and supported by the great strides made in Brazil to convert transport fuel usage from conventional fossil fuels to bio-ethanol fuel (Hull, 2005). Hull further states that 33% of all transportation fuels used in Brazil are made from sugar confirming the suitability of bio-ethanol as a transport fuel.

Two respondents stated that bio-ethanol is best described as an extender or additive to conventional petrol given that current South African motor vehicles cannot run on 100% ethanol. This view was also expressed by the other 14 respondents, who believe that over time ethanol and bio-diesel could become the main transportation fuels as in the case of Brazil.

The results indicate that 14 of the 16 respondents believe that a blending capability of up to 10% can be accommodated in conventional petrol, without compromising the guarantees on motor vehicle engines and without requiring any changes to current motor vehicles (Table 5 – 5). This view is similar to that of Agarwal (2006) who states that ethanol can be blended with conventional petrol at blends up to 20% requiring no changes to motor vehicle engines and having no impact on engine performance. The difference in the blending capacity obtained from this research and that of Agarwal can be attributed to the altitude differences in South Africa as mentioned by one respondent and also to the need to obtain the approval of the motor vehicle manufacturers to protect motor vehicle owners.

Of the eight factors that contribute to successful bio-ethanol production (Table 5 – 6), the results of this research indicate that the critical factors that will increase success is: the availability of feed stocks; the fact that bio ethanol production will strengthen the agricultural sector and that it will facilitate the creation of jobs. The results also show that two other very important and / or critical factors are the reduction in environmental pollution and reduction in dependency on fossil fuels. These findings almost mirror the statement made by Minister of Minerals and Energy (Engineering News, 2005) and are also supported by a policy dialogue on co-generation and bio-ethanol held in Durban (2004), in which it is stated that bio-ethanol production will reduce dependency on oil imports and that car engine modifications are not necessary at blends up to 20%. It can therefore be concluded that these findings are in line with those of Government and stakeholders in the industry.

The results of this research also indicate that the five most important factors that contribute to the development of a bio-ethanol industry (Table 5 – 7) are:

- Competitive feed stocks from the South African agricultural sector
- Government support and Incentives
- Investment
- A defined price for the product
- A defined market for the product

It is interesting to note that availability of feed stocks are regarded as a critical factor that contributes to the success of bio-ethanol production as well as the most frequently mentioned factor that will contribute to the development of the bio-

ethanol industry. This factor appears to be unique to South Africa since it did not appear as a critical factor in the international literature reviewed. This finding could be attributed to the fact that South Africa is currently undergoing land claim issues that could impede agricultural production, especially where available under-utilised arable land could be utilised to grow feed stocks for ethanol production and more especially because arable land represents only 10% of land in South Africa. By implication, land issues could represent a significant problem as it reduces the extent of land put to plantings and therefore will impact the availability of feed stocks.

The next most frequently mentioned factor that could contribute to the development of the bio-ethanol industry is Government Support and Incentives. While several projects that have been identified for bio-ethanol production were mentioned by the interviewees (Table 5 – 8), they believe that these projects will not materialise unless the factors for success listed in Table 5 – 6 and Table 5 – 7 are met. All interviewees reported that the projects are doomed to fail if government support and incentives are not put into place. Agarwal (2006), (Canadian Renewable Fuels Association, 2006) and Hull Aeck (2005), state that government support and incentives are necessary to propel the industry into existence.

From the findings of this research and in conjunction with the literature review, it can be established that bio-ethanol is a suitable transport fuel at blends up to 10%, however several factors need to be taken into consideration for the industry to be established and successful, these being:

- Competitive feed stocks need to be available from South African Agriculture
- Government Support and Incentives are required
- The establishment of the industry should be accompanied by job creation

6.3. RESEARCH QUESTION 2: HOW DOES BIO-ETHANOL PRODUCTION STIMULATE GROWTH OF THE AGRICULTURAL SECTOR?

Research question 2 sought to establish the growth effect that a bio-ethanol industry would have on agriculture and which factors need to be considered for successful agricultural development as it pertains to bio-ethanol production.

Energy Systems Research Unit (2006), the website Journey to Forever and Pahl (2005) state that bio-ethanol production can grow the agricultural sector and thus boost the economy. 15 of the 16 interviewees confirmed this view (Table 5 – 9) and an overwhelming majority conveyed that the growth will be impacted in all of the areas listed in Table 5 – 10. This is largely consistent with the findings in the literature review since all of the impacted areas listed in the questionnaire were drawn from different references.

The most common feed stocks cited by the interviewees as being efficient from a price and energy perspective as well as being the most readily available in South Africa is sugarcane followed by maize. These two feed stocks are also the most commonly utilised feed stocks for ethanol production in the world. Brazil, Peru, Columbia, Central America, India and Zimbabwe produce ethanol for transport purposes exclusively from sugarcane while the USA, Canada, China and France

use corn (known as maize in South Africa) to produce ethanol (Earth policy Institute, 2005). This represents the greatest opportunity for South African agriculture since South Africa at present feedstock production levels is a net exporter of both maize and sugar. However, this situation may change if land claim issues continue and the population continues to grow at the current rate.

Interviewees listed the utilsation and availability of under-developed land; funding for agriculture; government support in respect of regulation and incentives and the location of a defined market for the produce, as the most important factors for successful agricultural development as it pertains to bio-ethanol production.

It is interesting to note that some of the factors identified for successful bio-ethanol production are similar to those identified for agricultural development. Government support and incentives is a common factor for the first two research questions while utilsation and availability of underdeveloped land can be linked to the availability of competitive feed stocks as another. Since both of these factors appear to require government intervention, it can be deduced that for the development of the agricultural sector to support a bio-ethanol production industry, government support and incentives will be required. During the discussions with the interviewees, government support was defined as inclusive of defining the market for the feed stocks as well as for bio-ethanol, which reinforces the role that government has to play in both industries.

It can therefore be concluded that the development of a bio-ethanol industry will stimulate the growth of the agricultural sector. However, Government support and

incentives; the availability of underdeveloped land to grow competitive feed stocks; location of a defined market and funding for agriculture are the most important factors that need to be in place in order for the growth of the agricultural sector to materialise.

6.4. RESEARCH QUESTION 3: WHAT IMPACT WILL BIO-ETHANOL PRODUCTION HAVE ON SOCIO – ECONOMIC FACTORS SUCH AS JOB CREATION AND FOOD SECURITY?

This research question attempted to address the impact that bio-ethanol production will have on job creation and food security. The issue of job creation is first addressed followed by food security.

The research reports that 15 respondents believe that jobs will be created if the bio-ethanol industry is established (Table 5 – 13). However, the number of jobs varies significantly between 10 000 and 1 million jobs. 11 of the 15 responses fell between 10 000 and 100 000 jobs. This result differs from that of Minister Hendricks (2006) who stated that approximately 1 million jobs could be created in farming if the bio-fuel industry were to be established. Interviewees commented that government was far too optimistic about the number of jobs that could be created and that they preferred to err on the side of caution. Government's optimism could be based on the number of jobs created in Brazil as a result of the bio-ethanol industry which is equal to 1 million jobs (Flavin, Hull Aeck, 2005). It must be noted though, that Brazil has been producing ethanol for over 30 years and have thus developed both their agricultural sector and their bio-ethanol sector over time and as a result have created the 1 million jobs over a long period of time.

Since it is the South African Government's imperative to promote the production of bio fuels with a primary focus to create jobs, predominantly in the rural areas by shifting subsistence farmers to commercial farmers (Business Report, 2006), it was important to establish the view of the interviewees in terms of who the main beneficiaries of the jobs would be (Table 5 -16) and which skills level would most benefit from the jobs created (Table 5 – 14). A comparison was done with the jobs created in Brazil by skills level as reported by Flavin and Hull Aeck (2005) to that of this research report, as indicated in the table below.

Table 6 – 1: Comparison of jobs created according to skills level

Skills level	Flavin, Hull Aeck (2005)	This Research Report (2007)
Skilled Workers	30%	11%
Semi-skilled workers	10%	22%
Unskilled Workers	60%	67%

The greatest disparity in the responses from this research to those of Flavin and Hull Aeck are in the categories of skilled workers and semi-skilled workers. This can be attributed to the fact that South Africa has higher levels of employment amongst skilled workers and semi-skilled workers. Some of the jobs created in these categories could be filled by workers who are transferred from one industry to another rather than new unemployed recruits. The number of jobs to be created for unskilled labour in this report is slightly higher by comparison but not significant since it is the larger portion of the total jobs created.

The interviewees further implied that the main beneficiaries of the jobs created will be the rural unemployed at 80% over the urban unemployed at 20%. This could be due to the interviewees' belief that job creation influences the establishment of the bio-ethanol production industry particularly in South Africa (Table 5 -15). If job creation is a critical factor in establishing the industry and the majority of South Africa's unemployed are rurally based, then by inference Government's primary focus is well placed in terms of focusing on job creation amongst subsistence farmers.

The research next attempted to determine the impact bio-ethanol production would have on food security. Interviewees that believe that bio-ethanol production will have an impact on food security were somewhat optimistic that measures could be put in place to combat a negative impact on food security. Comments related to the bio-ethanol industry creating an opportunity to leverage food supply through increased plantings of feed stocks and that although basic food prices may rise as a result of food and fuel competing for the same commodity (Table 5 – 20), market forces of supply and demand will come into play to normalise food prices. This view is confirmed by the Worldwatch Institute (2006), who argue, that the price of agricultural commodities will have an upward effect, but that the problem is more complex than it appears to be and that the poorest people are also farmers who will benefit from increased production. 9 of the 16 respondents are in agreement with the Worldwatch Institute and stated that bio-ethanol production will have a positive impact on food security as well as that job creation creates access to food (Table 5 – 17).

Despite sugar and maize surpluses, many of South Africa's poor still go hungry highlighting the point made on the Website Journey to Forever (2006) that *"people starve because they are victims of an inequitable system, not because they are victims of scarcity and overpopulation"*. 13 of the 15 respondents inferred that utilising under-developed land would have a positive effect on food security (Table 5 – 21).

The research further shows that 14 of the 15 respondents believe that if food security could be guaranteed, it would positively influence the establishment of the bio-ethanol industry (Table 5 – 23). Of these 8 respondents believe that food security needs to be guaranteed to establish the bio-fuels industry while the other 7 felt that it is not necessary (Table 5 – 24). However, 14 of the 15 respondents do not believe that food prices need to be regulated to ensure food security (Table 5 – 22). The research did not establish if any other means could ensure food security other than the regulation of food prices. It can therefore not be concluded how food security can be guaranteed. It is interesting to note that food security has been a widely debated issue around the broad topic of bio-fuels, yet the world's leading ethanol producing countries did not introduce regulation to address the issue.

It can thus be inferred from the findings that while food security remains an issue that may need to be addressed and by some means guaranteed, regulation is not the means by which it should be ensured, although, many inferences were made that job creation amongst the unemployed could be the solution in that it creates access to food.

The key themes that emerged in the analysis for research question 3, is that job creation is a critical factor in South Africa to motivate and promote the establishment of the bio-fuels sector. Further that the impact that bio-ethanol production will have on job creation is a positive one although the extent of this cannot be conclusively or scientifically established. Mixed responses still exist around whether bio-ethanol production will have a positive or negative impact on food security, although job creation may address the food security issue positively. Job creation and food security appear to have a linked relationship in facilitating the establishment of the bio-ethanol industry.

6.5. RESEARCH QUESTION 4: HOW DOES THE USE OF BIO-ETHANOL AS COMPARED TO CONVENTIONAL PETROL REDUCE ENVIRONMENTAL DEGRADATION?

This research question attempted to address the impact that bio-ethanol production will have on the environment and if this is an important factor in the establishment of the industry. The Commission of the European Communities (2005) states that transport is a major cause of greenhouse gas emissions responsible for 26% of all emissions contributing to global warming. All the respondents in this research confirmed that road transport is a major contributor to environmental pollution (Table 5 – 26) and all but one respondent agrees that the use of bio-ethanol in transport fuels will reduce environmental pollution (Table 5 – 27).

Tofield (2003) and Agarwal (2006) state the following benefits of using bio-fuels:

- Reduces carbon dioxide emissions and other greenhouse gas emissions
- Benefits soil and biodiversity
- Reduction in acid rain
- Slows down ozone depletion
- Provides bigger carbon savings
- Replaces hazardous additives in conventional petrol

Respondents in this research rated reduction in carbon dioxide emissions and other greenhouse gases and the reduction in acid rain as the factors that would have the most benefit if bio-ethanol was used in transport fuels. The other benefits appear to take a longer time to materialise and were therefore rated lower. Tofield and Agarwal's research does not specify which benefits materialise over the short or long term and therefore while respondents believe that the above are potential benefits, the impact on the environment in South Africa will be restricted in the short term to the two mentioned above with the highest rating.

Interestingly, most other bio-fuel producing countries have promoted the production and use of bio-fuels in transport fuels as a result of environmental degradation and after signing membership to the Kyoto Protocol. Clearly, evident from the findings in this research is the fact that while there are definite environmental benefits of using bio-ethanol in transport fuels, this is not a key factor for the establishment of the industry as is evident in Table 5 – 34 which shows that the environment was ranked as the least important factor in establishing the bio-fuel industry in South Africa.

6.6. RESEARCH QUESTION 5: WHAT REGULATORY SUPPORT IS REQUIRED TO ESTABLISH A SUSTAINABLE BIOETHANOL INDUSTRY?

Regulatory support and incentives have surfaced several times in the results as a factor that will influence the success of bio-ethanol production in South Africa. This research question sought to establish if the South African Government has delivered on its strategy and what kind of regulatory support and incentives are required.

Despite media coverage and briefings on government's intention to promote the bio-fuels industry (Hendricks, 2006; Business Report, 2006) 15 of the 16 interviewees stated that government has not delivered on it's strategy to promote the bio-fuels industry (Table 5 -28) and that the reason for this is due to the fact that government has not yet finalised and approved the national bio-fuels strategy or clarified what government support will be available (Table 5 – 29). These two actions were highlighted by the interviewees as the most urgent actions that government needs to take to establish the bio-fuels sector.

Not surprising then that 15 of the 16 interviewees stated that the main cause for the delay in the establishment of the bio-fuels industry is the lack of a sound and clear government strategy and policy framework (Table 5 -32). Interviewees stated the following points, most frequently, as being those that should form part of the policy framework in order for the policy to facilitate the establishment of the industry:

- Government support in the form of incentives, tax relief and subsidies to both the ethanol producers and the farmers

- Mandatory blending targets
- Regulation for importing and exporting of feed stocks, preferably in the form of tariffs
- A defined price and quality for the bio-ethanol
- Social issues such as job creation and food security

When these requirements are compared with what is being done in other countries, then they do not appear to be far fetched since, the Brazilian ethanol programme and the USA programme legislated and regulated many of the above to promote the establishment of their ethanol programmes. Canada has made available $11.9 million for incentives and research to establish the bio-diesel industry (Natural Resources Canada, 2004). In addition, Canada has already introduced production subsidies, tax breaks and blending requirements.

In the European Union, member states are allowed to exempt bio fuels from the tax on petroleum products, while in Thailand and India several tax breaks are enjoyed (Earth Policy Institute, 2005). In Australia, since 2000, the government has introduced a range of tax exemptions and production subsidies to facilitate the production of 92 million gallons of bio fuel by 2010. It can therefore be deduced that government support in the form of incentives, import and export tariffs, tax relief and mandatory blending requirements are key considerations for an enabling policy.

To conclude the research findings on regulatory support, it was established from the responses of the interviewees, that the creation of a supportive policy and

institutional framework, as well as public sector involvement (Table 5 – 33), as suggested by Flavin and Hull Aeck, (2005), are the most important factors to establish the bio-fuels industry.

In order to create a ranking of the factors identified in this research, the key concept in each the five research questions were posed to the interviewees as factors that play a significant role in the establishment of the bio-ethanol industry (Table 5 – 34). The responses, by frequency, ranked regulation as being, by far the most critical, followed by development of the agricultural sector, then by socio-economic factors, then suitability of ethanol and finally by environmental factors. It is interesting to note that the interviewees felt that all of the above would play a significant role although some like regulation and agricultural development are critical and very important respectively. Once again, an interesting observation is that environmental factors are considered the least important in establishing the bio-ethanol industry.

To conclude, the key theme emerging from the fifth research question is the lack of government support in the form of incentives, tax relief, tariffs and mandatory blending requirements. These can be addressed through the introduction of sound regulation and clear policy on government's strategic intent on the establishment of the bio fuels industry.

CHAPTER 7: CONCLUSION

7.1. INTRODUCTION

Chapter 7 integrates the key findings of this research report, offering recommendations for stakeholders and suggesting future research, identified, in this project.

The gap that this research attempted to address relates to the factors that influence the success of bio-ethanol production for use in liquid transport fuels in South Africa. The research tested five factors that were identified from the literature reviewed, which could influence the success of bio-ethanol production in South Africa. The key themes and findings from each of these research questions are integrated with the literature in this section.

7.2. INTEGRATION

7.2.1. SUITABILITY OF BIO-ETHANOL

The Minister of Minerals and Energy is reported as stating that South Africa has a need to diversify its fuel resources and reduce dependency on fossil fuels as a result of the increasing price of crude oil and the rising demand for transport fuels.

With current import levels of crude oil at around 60 percent of usage, the production of ethanol presents the opportunity to diversify fuel resources, reduce dependency on fossil fuels and further to address the high levels of unemployment in the country.

The suitability of ethanol in South Africa can be seen from the fact that the predominant feed stocks for ethanol production, maize and sugar, are produced in large quantities in South Africa. In table 2 - 3 it was established that 16 countries globally are either already producing large volumes of bio-ethanol or have firm plans to produce ethanol for transport purposes in the very near future. Further to this, it was established that these countries use an ethanol blended fuel and in some instances, as in Brazil, both a blend and ethanol in its pure form are used for transport purposes.

The findings of this research indicate that ethanol is indeed a suitable fuel for use in transport fuels but that in the short to medium term it can be introduced into the transport fuel network only as an extender of conventional fuel at blends up to 10 percent. However, bio-ethanol being a suitable transport fuel appeared to be a minor factor in the establishment of a bio-ethanol industry and factors such as government support and incentives as well as the availability of competitive feed stocks were cited as far more important.

7.2.2. AGRICULTURAL DEVELOPMENT

It was also established in Chapter 2 that bio-ethanol production has many benefits. Conn (2006), Agarwal (2006) and Pahl (2005) agree that bio-ethanol production will stimulate growth of the agricultural sector. The findings of this report concur. However, limitations cited are once again factors such as weak government support and lack of incentives as well as the availability of underdeveloped land to grow feed stocks.

7.2.3. SOCIO-ECONOMIC FACTORS

The South African government declared that its primary motivation for establishing a bio-fuels sector is the opportunity that it presents to create jobs in light of the currently high unemployment levels. According to government, unemployment could be halved by 2014 if a bio-fuels industry were to be established. Brazil has created one million jobs over the last 30 years through the establishment of a flourishing bio-ethanol industry which the South African government believes it can replicate. The opinion of the majority of the interviewees of this report is that jobs will be created but they are far less optimistic about the number. However, they do agree that job creation is the main driver of the establishment of a bio-fuels industry.

Food versus fuel remains a highly debated topic as it relates to bio-fuel production. The literature highlighted that there are compelling arguments for and against using food crops to produce fuel. Those that are against, argue that bio-fuel production using food crops will increase food prices, potentially leaving the masses without basic foods. Those for, argue that there is more than enough food grown on this planet and yet there are approximately 1 billion people who do not have access to food and this as a result of not having the means to buy food, rather than because of a shortage of basic foods.

This report indicates that food security is indeed a topic that needs to be addressed and that measures need to be put in place to ensure that bio-ethanol production does not result in a shortage of basic foods, but it is not foreseen as a critical factor for the success of bio-ethanol production. It is further suggested that

job creation is a possible means of addressing food security issues in that employment creates the means to gain access to food.

7.2.4. ENVIRONMENTAL FACTORS

The literature indicates that 175 countries pledged their support to improving the environment by signing the Kyoto Protocol and introducing targets to reduce environmental pollution. While the literature highlighted that environmental factors are the main drivers for the establishment of bio-fuel production in other countries, this report clearly indicates that environmental factors play the least important role in the establishment of a successful bio-ethanol industry. Although all participants in this research agreed that transportation is amongst the biggest contributors to environmental pollution, they believe that other critical factors such as regulation, agricultural development and job creation play a more significant role in the establishment of a bio-ethanol industry.

7.2.5. REGULATION

On the topic of regulation it is clear from the literature that all of the countries that have successfully established a bio-ethanol industry were supported by government. This support is largely in the form of tax relief, subsidies, mandatory blending targets and import and export tariffs. In addition to the above incentives, many of these governments also made funds available for research and development, thereby playing the role of the enabler in the establishment of the industry.

The key findings of this report indicate that government has been slow to respond with a clear and sound policy covering aspects relating to the promotion of the industry. The report further indicates that the following key considerations should form part of the policy:

- Mandatory blending targets
- Subsidies
- Tax relief
- Import and export tariffs for feed stocks as well as bio-ethanol

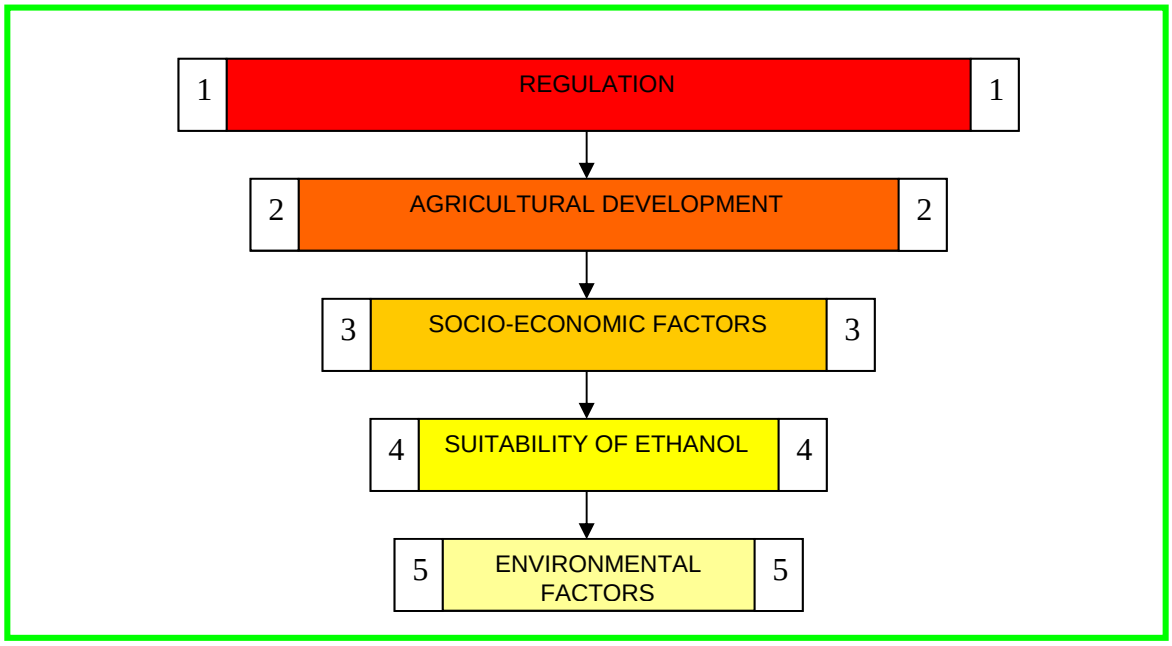
When reviewing the findings of this research a clear theme that emerged is the lack of a sound and clear government strategy and policy framework, which impedes the establishment of a bio-ethanol industry in South Africa. Agricultural development and job creation, which were identified as key factors for establishing a bio-ethanol industry, are both dependent on government policy and regulation. It therefore can be concluded that all other factors hinge on government communicating a policy outlining these aspects and further, indicating what other government support will be available.

7.3. RECOMMENDATIONS

The following recommendations derived from a review of the key themes identified in this report are aimed at the stakeholders involved in the industry.

This report highlighted a ranking of the key factors, which has been developed into a model (figure 7 – 1 below) illustrating a sequence in which these factors need to be addressed in order to establish the bio-ethanol industry successfully.

Figure 7 – 1 Factors by sequence to be addressed



To successfully establish a bio-ethanol industry in South Africa the priority is for government to develop and communicate a sound and clear strategy; one that covers policy on mandatory blending targets, incentives, tariffs and other government support such as funding for research and development.

The next imperative is to develop the agricultural sector through identifying available arable land that can be utilised for the cultivation of the competitive feed stocks required to produce bio-ethanol. It is recommended that government speed up the issues relating to land claims in order to facilitate the availability of land.

Job creation was identified as a strong motivator for the establishment of the bio-fuels industry; the sooner government can promote the establishment of the industry the sooner can the jobs be created. This will address the high unemployment levels as well as provide the means for access to food.

While the suitability of ethanol has been established, the government policy needs to address issues around quality of the ethanol that should be produced for transport purposes as well as mandatory blending targets which will ensure take up of the bio-ethanol into the mainstream fuel distribution channels.

Environmental factors were identified in this report as the least important of all factors in South Africa, however, caution should be exercised that this factor is not down played as it has consequences to the voluntary participation in the Kyoto Protocol and also presents carbon trading benefits that could benefit other mainstream industries in the country.

It is evident that although a definite sequence exists for enabling the bio-ethanol industry, all factors are dependent on government communicating the appropriate regulation to facilitate the establishment of the industry.

7.4. FUTURE RESEARCH IDEAS

The issue of food security, remains inconclusive. Although job creation has been identified as a possible solution, uncertainty prevails around the extent to which bio-fuel production can create a food security problem. A future possible research

option would be to analyse the impact, in greater detail, that bio fuel production will have on food security and to investigate possible means to prevent this from becoming a hindrance to the establishment of the industry.

Another possible research option would be to determine the number of jobs that could be created if the industry were to be established. Factors that can be investigated are the number of jobs per additional hectare planted by crop type and also the number of jobs created per million litres of ethanol produced.

7.5. CONCLUSION

In conclusion, this research has highlighted the factors that will influence the success of bio-ethanol production in South Africa, particularly for transport purposes. Moreover, it has contributed to the knowledge base of the bio-ethanol industry; reinforcing international theories and opinions as well as highlighting issues which are unique to South Africa.

In addition to adding to the knowledge base, it is hoped, that this research will add value for all stakeholders in speeding up the establishment of the bio-ethanol industry in South Africa.

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APPENDICES

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

RESEARCH QUESTIONNAIRE APPENDIX 1

Date of Interview:

Factors Influencing the Success of Bio-ethanol Production for use in Liquid Transportation Fuels in South Africa

SECTION 1: ORGANISATIONAL INFORMATION

1. Registered Name of Company/Organisation:
2. Nature of Business:
3. Telephone Number:

SECTION 2: INTERVIEWEE INFORMATION

4. Name:
5. Designation:
6. Years of experience with bio-fuels:
7. Interest in bio-fuels:

SECTION 3: SUITABILITY OF BIOETHANOL AS A LIQUID TRANSPORT FUEL

8. Is bio-ethanol a suitable alternative / extender to conventional petrol? Yes / No
9. What percentage of bio-ethanol can be blended with conventional petrol without requiring modifications to current motor vehicle engines?.....
10. Rate the following 8 factors that contribute to the success of establishing a bio-ethanol industry in terms of importance. 1 = very low importance 2 = low importance; 3 = average importance; 4 = very important; 5 = critical factor
    a. Cost competitive of bio-ethanol versus conventional petrol ……..
    b. Extender / blending capabilities ……..
    c. No modifications required to motor vehicles at blends up to 10% ……..
    d. Reduces environmental pollution ……..

e. Strengthens the agricultural sector ……..

f. Facilitates job creation …….

g. Reduces dependency of fossil fuels …….

h. Availability of feed stocks in S.A. ……...

11. In your view what are the 5 most important factors that contribute to the development of a bio-ethanol industry?

a. .....

b. ……..

c. ……..

d. ……..

e. ……..

12. List any major projects currently being established to produce ethanol that you believe will be successful if the above factors are taken into account.

……

……

……

……

……

SECTION 4: AGRICULTURAL DEVELOPMENT

13. 1. Do you believe that bio-ethanol production will stimulate the growth of the Agricultural Sector? Yes / No

14. If Yes – In which of the following ways?

a. Higher production volumes

b. Improved technology

c. Higher contribution to GDP

d. Available / under-utilised land put to better use

e. Skills development

f. Increased investment in Agriculture

g. Increase in feedstock prices

h. New markets for feedstock

15. Rank the following feedstock in terms of price efficiency, energy efficiency and availability to produce ethanol in South Africa?

    1 = most efficient; 2 = very efficient; 3 = average efficiency; 4 = low efficiency;

    5 = very low efficiency; 6 = least efficient

    a. Maize

    b. Sugarcane

    c. Sugar beet

    d. Grain Sorghum

    e. Sweet sorghum

    f. Wheat

16. What are the 3 most important factors for successful agricultural development as it pertains to bio-ethanol production?

a. ……..

b. ……..

c. ……..

SECTION 5: SOCIAL IMPACT OF BIOETHANOL USE

17. How many jobs will be created if a bio-ethanol sector were to be established at a 10% blending rate?

    a. 10 000 – 50 000

    b. 50 000 to 100 000

    c. 100 000 to 250 000

    d. 250 000 to 500 000

    e. 500 000 to 1000 000

18. How will the jobs created be split according to the categories listed below

a. Skilled workers (managers, supervisors, technicians, etc)…….%

b. Semi-skilled workers (drivers, machine operators, etc)…….%

c. Unskilled workers (farm workers, etc)……..%

19. In your opinion, does the creation of this number of jobs act as a factor for the establishment of a bio-ethanol industry? Yes / No
20. Who do you believe will be the main beneficiaries of the jobs created? If both, what is the percentage split?
    a. Rural unemployed ……%
    b. Urban unemployed ……%
21. Does bio-ethanol production impact food security negatively? Yes / No
22. Why?.....

    .....

    .....
23. On a scale of 1-5. 1 = very low impact; 2 = low impact; 3 = average impact; 4 = high impact; 5 = critical impact. What impact will it have on:
    a. Food prices
    b. Availability of basic foods
24. Will utilising underdeveloped land increase food security? Yes / No
25. Do food prices need to be regulated to ensure food security? Yes / No
26. If food security can be guaranteed, in your opinion, will this influence the establishment of a bio-ethanol sector positively? Yes / No
27. In your view does food security need to be guaranteed to establish a bio-ethanol industry? Yes / No

SECTION 6: ENVIRONMENTAL IMPACT OF BIOETHANOL USE

28. In your view is road transport a huge contributor to environmental pollution? Yes / No
29. Will the use of bio-ethanol in transport fuel reduce environmental pollution? Yes / No
30. On a scale of 1-5 rate the following in terms of their contribution to a healthier environment if bio-ethanol were used in transport fuels.

1 = very low impact; 2 = low impact; 3 = average impact; 4 = high impact; 5 = critical impact

a. Reduction of carbon dioxide and other greenhouse gas emissions …...
b. Reduction in acid rain …...
c. Slow down ozone depletion …...
d. Benefits to soil and biodiversity …...
e. Provide bigger carbon savings …...
f. Replaces hazardous additives in conventional petrol …...

SECTION 7: REGULATION

31. Has the South African Government to date delivered on its strategy to establish a bio-fuels industry? Yes / No
32. What are the 3 actions in your view the SA Government needs to take urgently to establish a bio-ethanol sector?
    a. ……
    ……
    b. ……
    ……..
    c. ……
    ……
33. What should form part of the policy framework?.....
    .....
    .....
    .....
    .....
34. Who are the most important stakeholders in this industry?.....
    .....
    .....
    .....

35. What are the factors holding the establishment of this industry back?.....
.....
.....
.....

36. Which factors do you believe to be the most important in establishing the bio-fuels industry? Rank them 1-5

1 = Critical factor; 2 = Very important; 3 = Average importance; 4 = Less important;

5 = Least important

a. Creation of supportive policy and institutional frameworks ……..
b. Private sector involvement ……..
c. Levelled playing fields for conventional and bio-fuels ……..
d. Integrate projects around local needs and capacity ……..
e. Identification of resource requirements ……..

37. Which factors listed below in your opinion can play a significant role in the establishment of a bio-ethanol industry? Rank them 1-5

1 = Critical factor; 2 = Very important; 3 = Average importance; 4 = Less important;

5 = Least important

a. Suitability of ethanol ……..
b. Agricultural development ……..
c. Socio-economic factors ……..
d. Environmental factors ……..
e. Regulation ……..

38. Can you refer me to a few key individuals in your network that would be able to answer these questions?

LIST OF INTERVIEWEES **APPENDIX 2**

FULL NAME:	***COMPANY:***	***CONTACT DETAILS:***
Dr Adrian Wynne *Director*	*South African Cane Growers Association*	*031 508 7200*
Andrew Makinete *President*	*South African Biofuels Association*	*011-621 6002* *082 457 2282*
Anton Moldan *Environmental Advisor*	*SAPIA – Cape Town*	*021-419 8054*
Avhapfani Tshifularo *Pricing and Taxation Advisor*	*SAPIA*	*021-4198057* *083 3128 047*
Derek Lake *Consultant*	*Sasol*	*011-441 3111* *082 800 6515*
Vinesh Moodley *General Manager*	*D1 Oils*	*082 085 7692*
Erhard Seiler *CEO*	*South African Biofuels Association*	*011-486 2775* *082 449 1166*
Johan Hoffman *CEO*	*Ethanol Africa*	*082 455 8871*
Julia Kupka *Analyst: Manaufacturing*	*ABSA*	*011-350 6409* *Julia.kupka@absa.co.za*
Natalie Naidoo *Manager: Compliance and Projects*	*Sasol Oil*	*011-889 7812*
Adam Mostert *Manager Biodiesel*	*Sasol*	*011-3442160* *082 803 5394*

Philip Bouwer *Director*	*Sterling Waterford Securities*	*021-674 6591* *083 658 5100*
Desmond Padyache *Marketing Director*	*Siyanda Biodiesel*	*dkpadiachey@telkomsa.net* *084 556 2026*
Roshney Dayal *Chief Operating Officer*	*Siyanda Biodiesel*	*011-445 2451* *083 453 5156*
Stefan Schutte *Project Engineer*	*Peter George Bailey International (PGBI)*	*011-8083841* *sschutte@pgbi.co.za*
Sibusiso Ngubane *Commercial Manager*	*Central Energy Fund (CEF)*	*011-280 0339* *082 413 0475*

APPENDIX 3: SUMMARY OF RESULTS

(Each company is randomly positioned and not in alphabetical order as per list in Appendix 2)

	COMPANY NUMBER	1	2	3	4
	SECTION 1: ORGANISATIONAL INFORMATION				
1	**Number of Interviewees by Industry:**				
	Bio-fuel Producers				
	Government / NGO		√		√
	Oil Companies			√	
	Agriculture	√			
	Service Providers				
	Investors				
6	***Years of experience with bio-fuels:***				
	Less than 2 years	√			
	2 to 4 years				√
	5 to 10 years		√	√	
	More than 10 years				
7	***Interest in Bio-fuels:***				
	Work related interests		√	√	√
	Project related interests				
	Personal interests	√			
	Agricultural interests				
	SECTION 3: SUITABILITY OF BIO-ETHANOL AS A LIQUID TRANSPORT FUEL				
8	Is bio-ethanol a suitable alternative / extender to conventional petrol? Yes / No	No	Yes	Yes	Yes
9	What percentage of bio-ethanol can be blended with conventional petrol without requiring modifications to current motor vehicle engines?				
	Up to 15%		√		
	Up to 10%	√		√	√
	Up to 8%				
10	Rate the following 8 factors that contribute to the success of establishing a bio-ethanol industry in terms of importance. 1 = very low importance; 2 = low importance; 3 = average importance; 4 = very important; 5 = critical factor	1 = very low importance 2 = low importance; 3 = average importance; 4 = very important; 5 = critical factor			
	a. Cost competitive of bio-ethanol versus conventional petrol	1	4	5	3
	b. Extender / blending capabilities	1	3	1	3
	c. No modifications required to motor vehicles at blends up to 10%	1	3	4	3

d. Reduces environmental pollution	3	1	4	4
e. Strengthens the agricultural sector	2	3	3	4
f. Facilitates job creation	5	3	4	5
g. Reduces dependency of fossil fuels	5	2	4	3
h. Availability of feedstock's in S.A.	5	5	2	5

11 In your view what are the 5 most important factors that contribute to the development of a bio-ethanol industry?

a) Competitive feedstock's from South African Agricultural Sector	√			√
b) Government Support and incentives			√	√
c) Investment		√		
d) A Defined price for the product	√	√	√	√
e) An effective supply chain from the field to the motor vehicle	√		√	
f) Job creation		√		
g) Appropriate processing Technology and knowledge	√			
h) A defined market for the product				√
i) Environmental issues				
j) Development of rural agricultural communities				
k) Available Land				
l) Food security			√	

12 List any major projects currently being established to produce ethanol that you believe will be successful if the above factors are taken into account.

Projects - Feedstock				
Ethanol Africa - Bothaville - Maize		√		
Hoopstad Project - Maize				
Makhatini Project - Mpumalanga - Sugarcane		√		
Cradock Project - Sugarbeet				
Pongola Project - Sugarcane				
Industrial Development Corporation Project - Ogies - Maize		√		

Section 4: Agricultural Development

13 Do you believe that bio-ethanol production will stimulate the growth of the Agricultural Sector? Yes / No

	Yes	Yes	Yes	Yes

14 If Yes – In which of the following ways?

a. Higher production volumes	√	√	√	√
b. Improved technology	√	√	√	√
c. Higher contribution to GDP	√	√	√	√
d. Available / under-utilised land put to better use	√	√		√
e. Skills development	√	√	√	√
f. Increased investment in Agriculture		√	√	√
g. Increase in feedstock prices	√	√	√	√
h. New markets for feed stocks		√	√	√

15 Rank the following feed stocks in terms of price efficiency, energy efficiency and availability to produce ethanol in South Africa?

6= least efficient
5 = very low efficiency;
4 = low efficiency;
3 = average efficiency;
2 = very efficient;
1 = most efficient

6 = least efficient
5 = very low efficiency;
4 = low efficiency;
3 = average efficiency;
2 = very efficient;
1 = most efficient

a. Maize	2	2	1
b. Sugarcane	1	1	2
c. Sugar beet	4	6	
d. Grain Sorghum	6	4	
e. Sweet Sorghum	5	5	
f. Wheat	3	3	

16 What are the 3 most important factors for successful agricultural development as it pertains to bio-ethanol production?

a. Utilisation and availability of underdeveloped land			
b. Funding for agriculture			
c. Government support in respect of incentives and regulation	√	√	√
d. Location of a defined market	√	√	√
e. Improved technology	√		
f. Availability of water			√
g. Defined price for the product	√	√	
h. Skills development			
i. Drought resistant cultivars			
j. Uptake of by products by agricultural companies			
k. Resolve land ownership issues			
l. Logistics and infrastructure		√	

Section 5: Social Impact of bio-ethanol use

17 How many jobs will be created if a bio-ethanol sector were to be established at a 10% blending rate?

a. 10 000 – 50 000	√	√	
b. 50 000 to 100 000			√
c. 100 000 to 250 000			
d. 250 000 to 500 000			
e. 500 000 to 1000 000			

18 How will the jobs created be split according to the categories listed below

a. Skilled workers (managers, supervisors, technicians, etc)…….%	10%	5%	5%	5%
b. Semi-skilled workers (drivers, machine operators, etc)…….%	20%	10%	30%	5%
c. Unskilled workers (farm workers, etc)……..%	70%	85%	65%	90%

19	In your opinion, does the creation of this number of jobs act as a factor for the establishment of a bio-ethanol industry? Yes / No	Yes	Yes	Yes	Yes
20	Who do you believe will be the main beneficiaries of the jobs created? If both, what is the percentage split?				
	a. Rural unemployed ……%	98%	80%	90%	100%
	b. Urban unemployed ……%	2%	20%	10%	0%
21	Does bio-ethanol production impact food security negatively? Yes / No		Yes	Yes	No
22	Why? Response from the interviewees with a **YES** response.				
	An increase in feedstock prices results in an increase in production which will result in an oversupply	N/A	√	√	N/A
	Under-utilised land can be put to plantings which will increase food supply	N/A	√	√	N/A
	The choices of feedstock for ethanol production can be limited to non-edible types which will not impact food supply	N/A			N/A
	Capacity exists in South Africa to produce sufficient feedstock for food supply and ethanol production	N/A			N/A
	Job creation creates access to food	N/A			N/A
	Increased feedstock production facilitates food security	N/A			N/A
	By-products of ethanol production can be used in the food industry	N/A			N/A
22	Why? Response from the interviewees with a **NO** response.				
	Increases prices of basic food stocks internationally	N/A	N/A	N/A	
	Shortage of food and fuel as a result of both competing for the same commodity	N/A	N/A	N/A	√
	Opportunity to leverage food supply	N/A	N/A	N/A	
	Food will be diverted to fuel unless additional plantings take place	N/A	N/A	N/A	
	Government support is needed to reduce food security issues	N/A	N/A	N/A	
	Prices of basis foods will rise until there are market corrections	N/A	N/A	N/A	
23	On a scale of 1-5. 1 = very low impact; 2 = low impact; 3 = average impact; 4 = high impact; 5 = critical impact. What impact will it have on:	1 = very low impact; 2 = low impact; 3 = average impact; 4 = high impact; 5 = critical impact.			
	a. Food prices		4	2	1
	b. Availability of basic foods		1	2	1
24	Will utilising underdeveloped land increase food security? Yes / No		Yes	Yes	No
25	Do food prices need to be regulated to ensure food security? Yes / No		No	No	No

26	If food security can be guaranteed, in your opinion, will this influence the establishment of a bio-ethanol sector positively? Yes / No	No	Yes	Yes	Yes
27	In your view does food security need to be guaranteed to establish a bio-ethanol industry? Yes / No		No	Yes	No

Section 6: Environmental Impact of bio-ethanol use

28	In your view is road transport a huge contributor to environmental pollution? Yes / No	Yes	Yes	Yes	Yes
29	Will the use of bio-ethanol in transport fuel reduce environmental pollution? Yes / No	Yes	Yes	Yes	No
30	On a scale of 1-5 rate the following in terms of their contribution to a healthier environment if bio-ethanol were used in transport fuels.				
	1 = very low impact; 2 = low impact; 3 = average impact; 4 = high impact; 5 = critical impact	1 = very low impact; 2 = low impact; 3 = average impact; 4 = high impact; 5 = critical impact			
	a. Reduction of carbon dioxide and other greenhouse gas emissions		3	5	1
	b. Reduction in acid rain		2	4	1
	c. Slow down ozone depletion		2	2	1
	d. Benefits to soil and biodiversity		3	1	4
	e. Provide bigger carbon savings		3	1	3
	f. Replaces hazardous additives in conventional petrol		4	1	3

Section 7: Regulation

31	Has the South African Government to date delivered on its strategy to establish a bio-fuels industry? Yes / No	No	No	No	No
32	What are the 3 actions in your view the SA Government needs to take urgently to establish a bio-ethanol sector?				
	a. Finalise and approve the national bio fuels strategy that addresses the concerns of all stakeholders	√			√
	b. Clarify that government support will be available for all stakeholders	√	√	√	√
	c. Regulate mandatory blending				
	d. Analyse the implications of the establishment of a bio fuels sector		√	√	
	e. Funding support				
	f. Introduce regulation to ensure supply of feedstock for fuel production	√			
	g. All relevant government departments should collaborate to facilitate the establishment of the sector.			√	

h. Clarify food security issues				√
i. Infrastructure and logistics support		√		
j. Regulation on captured fleet systems.				

33 What should form part of the policy framework?

Government support (incentives, subsidies, tax relief)		√	√	√
Mandatory blending targets			√	√
Regulation for importing and exporting of feedstock - tariffs	√	√		
A defined price and quality for the product	√			
Social issues (job creation, food security)				√
A defined market for the product	√		√	
Licensing framework		√		
Land management policy				√
Regulation to encourage sourcing of feedstock from emerging farmers				
Environmental sustainability issues			√	

34 Who are the most important stakeholders in this industry?

Government	√	√	√	√
Oil Companies	√	√	√	√
Agricultural Sector (Farmers, farm workers)	√	√	√	
Investors	√	√		√
Consumer		√	√	
Primary and secondary suppliers and service providers	√			
Bio fuel Producers		√		√

35 What are the factors holding the establishment of this industry back?

Lack of sound and clear government strategy and policy framework	√	√	√	√
Access to funding		√	√	
Vested interest and political agendas				
Food security				
Reluctance from oil industry for off-take				
Knowledge				√
Availability of water resources				

36 Which factors do you believe to be the most important in establishing the bio-fuels industry? Rank them 1-5

5 = Least important; 4 = less important; 3 = average importance; 2 = very important; 1 = critical factor

1 = critical factor
2 = very important
3 = average importance
4 = less important
5 = least important

a. Creation of supportive policy and institutional frameworks	1	1	1	3
b. Private sector involvement	1	2	4	2
c. Levelled playing fields for conventional and bio-fuels	5	4	5	5
d. Integrate projects around local needs and capacity	4	5	3	4
e. Identification of resource requirements	3	3	2	1

37 Which factors listed below in your opinion can play a significant role in the establishment of a bio-ethanol industry? Rank them 1-5

5 = least important; 4 = less important; 3 = average importance; 2 = very important; 1 = critical factor

1 = critical factor
2 = very important
3 = average importance
4 = less important
5 = least important

a.	Suitability of ethanol	5	5	2	1
b.	Agricultural development	2	3	3	3
c.	Socio-economic factors	3	2	4	5
d.	Environmental factors	4	4	5	4
e.	Regulation	1	1	1	1

38 Can you refer me to a few key individuals in your network that would be able to answer these questions?

APPENDIX 3: SUMMARY OF RESULTS

(Each company is randomly positioned and not in alphabetical order as per list in Appendix 2)

	COMPANY NUMBER	5	6	7	8
	SECTION 1: ORGANISATIONAL INFORMATION				
1	**Number of Interviewees by Industry:**				
	Bio-fuel Producers		√		√
	Government / NGO'			√	
	Oil Companies	√			
	Agriculture				
	Service Providers				
	Investors				
6	***Years of experience with bi-fuels:***				
	Less than 2 years		√		
	2 to 4 years				√
	5 to 10 years				
	More than 10 years	√		√	
7	***Interest in Bio-fuels:***				
	Work related interests		√	√	
	Project related interests				
	Personal interests	√			√
	Agricultural interests				
	SECTION 3: SUITABILITY OF BIO-ETHANOL AS A LIQUID TRANSPORT FUEL				
8	Is bio-ethanol a suitable alternative / extender to conventional petrol? Yes / No	Yes	Yes	Yes	Yes
9	What percentage of bio-ethanol can be blended with conventional petrol without requiring modifications to current motor vehicle engines?				
	Up to 15%				
	Up to 10%	√	√	√	√
	Up to 8%				
10	Rate the following 8 factors that contribute to the success of establishing a bio-ethanol industry in terms of importance. 1 = very low importance; 2 = low importance; 3 = average importance; 4 = very important; 5 = critical factor	1 = very low importance 2 = low importance; 3 = average importance; 4 = very important; 5 = critical factor			
	a. Cost competitive of bio-ethanol versus conventional petrol	3	2	5	3
	b. Extender / blending capabilities	5	1	3	5

c. No modifications required to motor vehicles at blends up to 10%	5	5	3	4
d. Reduces environmental pollution	2	5	5	5
e. Strengthens the agricultural sector	2	5	5	5
f. Facilitates job creation	2	5	5	5
g. Reduces dependency of fossil fuels	3	4	5	4
h. Availability of feed stocks in S.A.	5	4	5	5

11 In your view what are the 5 most important factors that contribute to the development of a bio-ethanol industry?

a) Competitive feed stocks from South African Agricultural Sector	√		√	
b) Government Support and incentives		√		√
c) Investment	√			√
d) A Defined price for the product	√		√	
e) An effective supply chain from the field to the motor vehicle	√	√		
f) Job creation			√	
g) Appropriate processing Technology and knowledge				√
h) A defined market for the product				
i) Environmental issues		√		
j) Development of rural agricultural communities			√	
k) Available Land				√
l) Food security				

12 List any major projects currently being established to produce ethanol that you believe will be successful if the above factors are taken into account.

Projects - Feedstock

Ethanol Africa - Bothaville - Maize				
Hoopstad Project - Maize				
Makhatini Project - Mpumalanga - Sugarcane			√	
Cradock Project - Sugarbeet			√	
Pongola Project - Sugarcane			√	
Industrial Development Corporation Project - Ogies - Maize			√	

Section 4: Agricultural Development

13 Do you believe that bio-ethanol production will stimulate the growth of the Agricultural Sector? Yes / No

No	Yes	Yes	Yes

14 If Yes – In which of the following ways?

a. Higher production volumes	√	√	√
b. Improved technology	√	√	√
c. Higher contribution to GDP	√	√	√
d. Available / under-utilised land put to better use	√	√	√
e. Skills development	√	√	√
f. Increased investment in Agriculture	√	√	√

g. Increase in feedstock prices		√	√	√
h. New markets for feed stocks		√	√	√

15 Rank the following feed stocks in terms of price efficiency, energy efficiency and availability to produce ethanol in South Africa?

6 = least efficient
5 = very low efficiency;
4 = low efficiency;
3 = average efficiency;
2 = very efficient;
1 = most efficient

6 = least efficient
5 = very low efficiency;
4 = low efficiency;
3 = average efficiency;
2 = very efficient;
1 = most efficient

a. Maize	2	1	3	1
b. Sugarcane	1	2	1	3
c. Sugar beet	6		2	5
d. Grain Sorghum	4		4	2
e. Sweet Sorghum	5		5	6
f. Wheat	3		6	4

16 What are the 3 most important factors for successful agricultural development as it pertains to bio-ethanol production?

a. Utilisation and availability of underdeveloped land	√	√		
b. Funding for agriculture		√		
c. Government support in respect of incentives and regulation			√	
d. Location of a defined market			√	√
e. Improved technology	√	√		
f. Availability of water	√			
g. Defined price for the product			√	
h. Skills development				√
i. Drought resistant cultivars				
j. Uptake of by products by agricultural companies				
k. Resolve land ownership issues				√
l. Logistics and infrastructure				

Section 5: Social Impact of bio-ethanol use

17 How many jobs will be created if a bio-ethanol sector were to be established at a 10% blending rate?

a. 10 000 – 50 000	√	√		
b. 50 000 to 100 000				√
c. 100 000 to 250 000			√	
d. 250 000 to 500 000				
e. 500 000 to 1000 000				

18 How will the jobs created be split according to the categories listed below

a. Skilled workers (managers, supervisors, technicians, etc)……%	2%	30%	30%	10%

b. Semi-skilled workers (drivers, machine operators, etc)……%	5%	20%	50%	40%
c. Unskilled workers (farm workers, etc)……..%	93%	50%	20%	50%

19 In your opinion, does the creation of this number of jobs act as a factor for the establishment of a bio-ethanol industry? Yes / No	Yes	Yes	Yes	Yes

20 Who do you believe will be the main beneficiaries of the jobs created? If both, what is the percentage split?

a. Rural unemployed ……%	100%	80%	70%	75%
b. Urban unemployed ……%	0%	20%	30%	25%

21 Does bio-ethanol production impact food security negatively? Yes / No	Yes	No	Yes	No

22 Why? Response from the interviewees with a **YES** response.

An increase in feedstock prices results in an increase in production which will result in an oversupply		N/A	√	N/A
Under-utilised land can be put to plantings which will increase food supply		N/A		N/A
The choices of feedstock for ethanol production can be limited to non-edible types which will not impact food supply	√	N/A		N/A
Capacity exists in South Africa to produce sufficient feedstock for food supply and ethanol production		N/A		N/A
Job creation creates access to food		N/A		N/A
Increased feedstock production facilitates food security		N/A	√	N/A
By-products of ethanol production can be used in the food industry		N/A		N/A

22 Why? Response from the interviewees with a **NO** response.

Increases prices of basic food stocks internationally	N/A	√	N/A	
Shortage of food and fuel as a result of both competing for the same commodity	N/A		N/A	
Opportunity to leverage food supply	N/A		N/A	
Food will be diverted to fuel unless additional plantings take place	N/A		N/A	√
Government support is needed to reduce food security issues	N/A		N/A	
Prices of basis foods will rise until there are market corrections	N/A		N/A	

	On a scale of 1-5. 1 = very low impact; 2 = low impact; 3 = average impact; 4 = high impact; 5 = critical impact.	1 = very low impact; 2 = low impact; 3 = average impact; 4 = high impact; 5 = critical impact.			
23	What impact will it have on:				
	a. Food prices	5	2	2	4
	b. Availability of basic foods	5	2	3	1
24	Will utilising underdeveloped land increase food security? Yes / No	No	Yes	Yes	Yes
25	Do food prices need to be regulated to ensure food security? Yes / No	No	No	Yes	No
26	If food security can be guaranteed, in your opinion, will this influence the establishment of a bio-ethanol sector positively? Yes / No	Yes	No	Yes	Yes
27	In your view does food security need to be guaranteed to establish a bio-ethanol industry? Yes / No	Yes	Yes	Yes	Yes

Section 6: Environmental Impact of bio-ethanol use

28	In your view is road transport a huge contributor to environmental pollution? Yes / No	Yes	Yes	Yes	Yes
29	Will the use of bio-ethanol in transport fuel reduce environmental pollution? Yes / No	Yes	Yes	Yes	Yes
30	On a scale of 1-5 rate the following in terms of their contribution to a healthier environment if bio-ethanol were used in transport fuels.				
	1 = very low impact; 2 = low impact; 3 = average impact; 4 = high impact; 5 = critical impact	1 = very low impact; 2 = low impact; 3 = average impact; 4 = high impact; 5 = critical impact			
	a. Reduction of carbon dioxide and other greenhouse gas emissions	3	3	5	5
	b. Reduction in acid rain	5	1	5	5
	c. Slow down ozone depletion	3	1	5	3
	d. Benefits to soil and biodiversity	1	2	2	4
	e. Provide bigger carbon savings	3	4	5	5
	f. Replaces hazardous additives in conventional petrol	1	3	5	5

Section 7: Regulation

31	Has the South African Government to date delivered on its strategy to establish a bio-fuels industry? Yes / No	No	No	No	No

32	What are the 3 actions in your view the SA Government needs to take urgently to establish a bio-ethanol sector?				
	a. Finalise and approve the national bio-fuels strategy that addresses the concerns of all stakeholders	√		√	√
	b. Clarify that government support will be available for all stakeholders	√			
	c. Regulate mandatory blending			√	√
	d. Analyse the implications of the establishment of a bio-fuels sector				
	e. Funding support				
	f. Introduce regulation to ensure supply of feedstock for fuel production				√
	g. All relevant government departments should collaborate to facilitate the establishment of the sector.	√			
	h. Clarify food security issues				
	i. Infrastructure and logistics support				
	j. Regulation on captured fleet systems.			√	

33	What should form part of the policy framework?				
	Government support (incentives, subsidies, tax relief)	√	√		√
	Mandatory blending targets			√	
	Regulation for importing and exporting of feedstock - tariffs	√	√		√
	A defined price and quality for the product				√
	Social issues (job creation, food security)		√	√	
	A defined market for the product	√			
	Licensing framework				
	Land management policy				
	Regulation to encourage sourcing of feedstock from emerging farmers			√	
	Environmental sustainability issues				

34	Who are the most important stakeholders in this industry?				
	Government	√	√	√	√
	Oil Companies	√	√	√	√
	Agricultural Sector (Farmers, farm workers)	√		√	√
	Investors		√		
	Consumer				
	Primary and secondary suppliers and service providers	√		√	
	Bio-fuel Producers		√		

35	What are the factors holding the establishment of this industry back?				
	Lack of sound and clear government strategy and policy framework	√	√	√	√
	Access to funding				√
	Vested interest and political agendas	√			√
	Food security	√			

Reluctance from oil industry for off-take				
Knowledge				
Availability of water resources	√			

36 Which factors do you believe to be the most important in establishing the bio-fuels industry? Rank them 1-5

5 = Least important; 4 = less important; 3 = average importance; 2 = very important; 1 = critical factor

1 = critical factor
2 = very important
3 = average importance
4 = less important
5 = least important

a. Creation of supportive policy and institutional frameworks	2	1	1	1
b. Private sector involvement	4	2	2	2
c. Levelled playing fields for conventional and bio-fuels	3	5	5	5
d. Integrate projects around local needs and capacity	5	4	4	4
e. Identification of resource requirements	1	3	3	3

37 Which factors listed below in your opinion can play a significant role in the establishment of a bio-ethanol industry? Rank them 1-5

5 = least important; 4 = less important; 3 = average importance; 2 = very important; 1 = critical factor

1 = critical factor
2 = very important
3 = average importance
4 = less important
5 = least important

a. Suitability of ethanol	1	2	5	5
b. Agricultural development	5	3	2	2
c. Socio-economic factors	3	4	3	3
d. Environmental factors	4	5	4	4
e. Regulation	2	1	1	1

38 Can you refer me to a few key individuals in your network that would be able to answer these questions?

APPENDIX 3: SUMMARY OF RESULTS

(Each company is randomly positioned and not in alphabetical order as per list in Appendix 2)

	COMPANY NUMBER	9	10	11	12
	SECTION 1: ORGANISATIONAL INFORMATION				
1	**Number of Interviewees by Industry:**				
	Bio-fuel Producers				
	Government / NGO				
	Oil Companies		√	√	
	Agriculture				
	Service Providers				√
	Investors	√			
6	***Years of experience with bio-fuels:***				
	Less than 2 years		√		√
	2 to 4 years	√		√	
	5 to 10 years				
	More than 10 years				
7	***Interest in Bio-fuels:***				
	Work related interests		√		√
	Project related interests			√	
	Personal interests				
	Agricultural interests	√			
	SECTION 3: SUITABILITY OF BIO-ETHANOL AS A LIQUID TRANSPORT FUEL				
8	Is bio-ethanol a suitable alternative / extender to conventional petrol? Yes / No	No	Yes	Yes	Yes
9	What percentage of bio-ethanol can be blended with conventional petrol without requiring modifications to current motor vehicle engines?				
	Up to 15%				
	Up to 10%	√		√	√
	Up to 8%		√		

10 Rate the following 8 factors that contribute to the success of establishing a bio-ethanol industry in terms of importance. 1 = very low importance; 2 = low importance; 3 = average importance; 4 = very important; 5 = critical factor

1 = very low importance
2 = low importance;
3 = average importance;
4 = very important;
5 = critical factor

a. Cost competitive of bio-ethanol versus conventional petrol	4	4	2	4
b. Extender / blending capabilities	4	5	4	3
c. No modifications required to motor vehicles at blends up to 10%	5	3	5	3
d. Reduces environmental pollution	3	2	5	3
e. Strengthens the agricultural sector	5	4	5	5
f. Facilitates job creation	5	5	4	5
g. Reduces dependency of fossil fuels	2	1	5	3
h. Availability of feedstock's in S.A.	4	5	4	5

11 In your view what are the 5 most important factors that contribute to the development of a bio-ethanol industry?

a) Competitive feedstock's from South African Agricultural Sector		√		√
b) Government Support and incentives		√		
c) Investment			√	
d) A Defined price for the product				
e) An effective supply chain from the field to the motor vehicle		√		
f) Job creation				√
g) Appropriate processing Technology and knowledge				
h) A defined market for the product		√	√	
i) Environmental issues			√	√
j) Development of rural agricultural communities				
k) Available Land				
l) Food security		√		

12 List any major projects currently being established to produce ethanol that you believe will be successful if the above factors are taken into account.

Projects - Feedstock

Ethanol Africa - Bothaville - Maize		√		√
Hoopstad Project - Maize		√		
Makhatini Project - Mpumalanga - Sugarcane				
Cradock Project - Sugarbeet				
Pongola Project - Sugarcane				
Industrial Development Corporation Project - Ogies - Maize				

Section 4: Agricultural Development

13	Do you believe that bio-ethanol production will stimulate the growth of the Agricultural Sector? Yes / No	Yes	Yes	Yes	Yes
14	If Yes – In which of the following ways?				
	a. Higher production volumes	√	√	√	√
	b. Improved technology	√	√		√
	c. Higher contribution to GDP			√	√
	d. Available / under-utilised land put to better use	√	√	√	√
	e. Skills development	√	√	√	
	f. Increased investment in Agriculture	√	√	√	√
	g. Increase in feedstock prices	√	√	√	√
	h. New markets for feedstock's	√	√	√	√
15	Rank the following feed stocks in terms of price efficiency, energy efficiency and availability to produce ethanol in South Africa?				
	6 = least efficient 5 = very low efficiency; 4 = low efficiency; 3 = average efficiency; 2 = very efficient; 1 = most efficient	6 = least efficient 5 = very low efficiency; 4 = low efficiency; 3 = average efficiency; 2 = very efficient; 1 = most efficient			
	a. Maize		1	2	2
	b. Sugarcane		2	1	1
	c. Sugar beet		4	5	
	d. Grain Sorghum		6	3	
	e. Sweet Sorghum		3	4	
	f. Wheat		5	6	
16	What are the 3 most important factors for successful agricultural development as it pertains to bio-ethanol production?				
	a. Utilisation and availability of underdeveloped land	√		√	√
	b. Funding for agriculture	√	√	√	
	c. Government support in respect of incentives and regulation		√		
	d. Location of a defined market				
	e. Improved technology	√			√
	f. Availability of water				
	g. Defined price for the product				
	h. Skills development			√	
	i. Drought resistant cultivars				√
	j. Uptake of by products by agricultural companies		√		
	k. Resolve land ownership issues				
	l. Logistics and infrastructure				

Section 5: Social Impact of bio-ethanol use

17	How many jobs will be created if a bio-ethanol sector were to be established at a 10% blending rate?				
	a. 10 000 – 50 000		√		
	b. 50 000 to 100 000	√			√
	c. 100 000 to 250 000				
	d. 250 000 to 500 000				
	e. 500 000 to 1000 000			√	
18	How will the jobs created be split according to the categories listed below				
	a. Skilled workers (managers, supervisors, technicians, etc)……%	5%	20%	10%	10%
	b. Semi-skilled workers (drivers, machine operators, etc)……%	15%	20%	20%	40%
	c. Unskilled workers (farm workers, etc)……..%	80%	60%	70%	50%
19	In your opinion, does the creation of this number of jobs act as a factor for the establishment of a bio-ethanol industry? Yes / No	Yes	Yes	Yes	Yes
20	Who do you believe will be the main beneficiaries of the jobs created? If both, what is the percentage split?				
	a. Rural unemployed ……%	80%	60%	70%	75%
	b. Urban unemployed ……%	20%	40%	30%	25%
21	Does bio-ethanol production impact food security negatively? Yes / No	No	No	No	No
22	Why? Response from the interviewees with a **YES** response.				
	An increase in feedstock prices results in an increase in production which will result in an oversupply	N/A	N/A	N/A	N/A
	Under-utilised land can be put to plantings which will increase food supply	N/A	N/A	N/A	N/A
	The choices of feedstock for ethanol production can be limited to non-edible types which will not impact food supply	N/A	N/A	N/A	N/A
	Capacity exists in South Africa to produce sufficient feedstock for food supply and ethanol production	N/A	N/A	N/A	N/A
	Job creation creates access to food	N/A	N/A	N/A	N/A
	Increased feedstock production facilitates food security	N/A	N/A	N/A	N/A
	By-products of ethanol production can be used in the food industry	N/A	N/A	N/A	N/A

22	Why? Response from the interviewees with a **NO** response.				
	Increases prices of basic food stocks internationally				
	Shortage of food and fuel as a result of both competing for the same commodity				
	Opportunity to leverage food supply				√
	Food will be diverted to fuel unless additional plantings take place				
	Government support is needed to reduce food security issues	√			
	Prices of basis foods will rise until there are market corrections			√	
23	On a scale of 1-5. 1 = very low impact; 2 = low impact; 3 = average impact; 4 = high impact; 5 = critical impact. What impact will it have on:	1 = very low impact; 2 = low impact; 3 = average impact; 4 = high impact; 5 = critical impact.			
	a. Food prices	3	3	4	2
	b. Availability of basic foods	5	3	1	1
24	Will utilising underdeveloped land increase food security? Yes / No	Yes	Yes	Yes	Yes
25	Do food prices need to be regulated to ensure food security? Yes / No	No	No	No	No
26	If food security can be guaranteed, in your opinion, will this influence the establishment of a bio-ethanol sector positively? Yes / No	Yes	Yes	Yes	Yes
27	In your view does food security need to be guaranteed to establish a bio-ethanol industry? Yes / No	No	Yes	No	No

Section 6: Environmental Impact of bio-ethanol use

28	In your view is road transport a huge contributor to environmental pollution? Yes / No	Yes	Yes	Yes	Yes
29	Will the use of bio-ethanol in transport fuel reduce environmental pollution? Yes / No	Yes	Yes	Yes	Yes

30 On a scale of 1-5 rate the following in terms of their contribution to a healthier environment if bio-ethanol were used in transport fuels.

1 = very low impact; 2 = low impact; 3 = average impact; 4 = high impact; 5 = critical impact

1 = very low impact;
2 = low impact;
3 = average impact;
4 = high impact;
5 = critical impact

a. Reduction of carbon dioxide and other greenhouse gas emissions	3	5	5	5
b. Reduction in acid rain	4	5	2	3
c. Slow down ozone depletion	4	4	2	2
d. Benefits to soil and biodiversity	4	3	4	2
e. Provide bigger carbon savings	3	3	5	4
f. Replaces hazardous additives in conventional petrol	4	2	4	4

Section 7: Regulation

31	Has the South African Government to date delivered on its strategy to establish a bio-fuels industry? Yes / No	No	No	No	No

32 What are the 3 actions in your view the SA Government needs to take urgently to establish a bio-ethanol sector?

a. Finalise and approve the national bio-fuels strategy that addresses the concerns of all stakeholders	√	√	√	√
b. Clarify that government support will be available for all stakeholders				
c. Regulate mandatory blending			√	
d. Analyse the implications of the establishment of a bio-fuels sector	√			
e. Funding support			√	
f. Introduce regulation to ensure supply of feedstock for fuel production		√		
g. All relevant government departments should collaborate to facilitate the establishment of the sector.				
h. Clarify food security issues	√			
i. Infrastructure and logistics support				√
j. Regulation on captured fleet systems.				

33 What should form part of the policy framework?

Government support (incentives, subsidies, tax relief)	√	√		√
Mandatory blending targets		√	√	√
Regulation for importing and exporting of feedstock - tariffs				
A defined price and quality for the product		√	√	√
Social issues (job creation, food security)				
A defined market for the product				
Licensing framework	√			√
Land management policy				

Regulation to encourage sourcing of feedstock from emerging farmers	√			
Environmental sustainability issues				

34 Who are the most important stakeholders in this industry?

Government	√	√	√	√
Oil Companies	√	√	√	√
Agricultural Sector (Farmers, farm workers)	√	√	√	√
Investors			√	
Consumer	√	√	√	
Primary and secondary suppliers and service providers				√
Bio-fuel Producers				

35 What are the factors holding the establishment of this industry back?

Lack of sound and clear government strategy and policy framework	√	√	√	√
Access to funding				√
Vested interest and political agendas				
Food security				√
Reluctance from oil industry for off-take			√	√
Knowledge				
Availability of water resources				

36 Which factors do you believe to be the most important in establishing the bio-fuels industry? Rank them 1-5

5 = Least important; 4 = less important; 3 = average importance; 2 = very important; 1 = critical factor

1 = critical factor
2 = very important
3 = average importance
4 = less important
5 = least important

a. Creation of supportive policy and institutional frameworks	1	1	1	1
b. Private sector involvement	2	3	2	5
c. Levelled playing fields for conventional and bio-fuels	5	2	5	2
d. Integrate projects around local needs and capacity	3	5	4	3
e. Identification of resource requirements	4	4	3	4

37 Which factors listed below in your opinion can play a significant role in the establishment of a bio-ethanol industry? Rank them 1-5

5 = least important; 4 = less important; 3 = average importance; 2 = very important; 1 = critical factor

1 = critical factor
2 = very important
3 = average importance
4 = less important
5 = least important

a.	Suitability of ethanol	3	4	2	4
b.	Agricultural development	2	3	3	2
c.	Socio-economic factors	4	1	4	3
d.	Environmental factors	5	2	5	5
e.	Regulation	1	5	1	1

38 Can you refer me to a few key individuals in your network that would be able to answer these questions?

APPENDIX 3: SUMMARY OF RESULTS

(Each company is randomly positioned and not in alphabetical order as per list in Appendix 2)

	COMPANY NUMBER	13	14	15	16
	SECTION 1: ORGANISATIONAL INFORMATION				
1	**Number of Interviewees by Industry:**				
	Bio-fuel Producers	√	√		
	Government / NGO				√
	Oil Companies				
	Agriculture				
	Service Providers				
	Investors			√	
6	***Years of experience with bio-fuels:***				
	Less than 2 years				
	2 to 4 years				√
	5 to 10 years	√	√		
	More than 10 years			√	
7	***Interest in Bio-fuels:***				
	Work related interests		√		
	Project related interests	√			√
	Personal interests				
	Agricultural interests			√	
	SECTION 3: SUITABILITY OF BIO-ETHANOL AS A LIQUID TRANSPORT FUEL				
8	Is bio-ethanol a suitable alternative / extender to conventional petrol? Yes / No	Yes	Yes	Yes	Yes
9	What percentage of bio-ethanol can be blended with conventional petrol without requiring modifications to current motor vehicle engines?				
	Up to 15%				
	Up to 10%	√	√	√	√
	Up to 8%				

10 Rate the following 8 factors that contribute to the success of establishing a bio-ethanol industry in terms of importance. 1 = very low importance; 2 = low importance; 3 = average importance; 4 = very important; 5 = critical factor

1 = very low importance
2 = low importance;
3 = average importance;
4 = very important;
5 = critical factor

a. Cost competitive of bio-ethanol versus conventional petrol	5	5	1	5
b. Extender / blending capabilities	5	5	4	3
c. No modifications required to motor vehicles at blends up to 10%	5	5	2	3
d. Reduces environmental pollution	5	5	4	4
e. Strengthens the agricultural sector	5	5	4	5
f. Facilitates job creation	5	4	4	5
g. Reduces dependency of fossil fuels	5	5	4	5
h. Availability of feedstock's in S.A.	5	5	4	5

11 In your view what are the 5 most important factors that contribute to the development of a bio-ethanol industry?

a) Competitive feedstock's from South African Agricultural Sector			√	
b) Government Support and incentives		√	√	
c) Investment	√	√		
d) A Defined price for the product				
e) An effective supply chain from the field to the motor vehicle				
f) Job creation	√			√
g) Appropriate processing Technology and knowledge	√	√		
h) A defined market for the product				
i) Environmental issues				
j) Development of rural agricultural communities	√			
k) Available Land				√
l) Food security				

12 List any major projects currently being established to produce ethanol that you believe will be successful if the above factors are taken into account.

Projects - Feedstock				
Ethanol Africa - Bothaville - Maize	√	√	√	√
Hoopstad Project - Maize				
Makhatini Project - Mpumalanga - Sugarcane	√		√	√
Cradock Project - Sugarbeet			√	√
Pongola Project - Sugarcane			√	
Industrial Development Corporation Project - Ogies - Maize			√	

Section 4: Agricultural Development

13	Do you believe that bio-ethanol production will stimulate the growth of the Agricultural Sector? Yes / No	Yes	Yes	Yes	Yes

14	If Yes – In which of the following ways?				
	a. Higher production volumes	√	√	√	√
	b. Improved technology	√	√	√	√
	c. Higher contribution to GDP	√	√	√	√
	d. Available / under-utilised land put to better use		√	√	√
	e. Skills development	√	√		√
	f. Increased investment in Agriculture	√	√		√
	g. Increase in feedstock prices	√	√		√
	h. New markets for feed stocks	√	√	√	√

Rank the following feed stocks in terms of price efficiency, energy efficiency and availability to produce ethanol in South Africa?

6 = least efficient
5 = very low efficiency;
4 = low efficiency;
3 = average efficiency;
2 = very efficient;
1 = most efficient

6 = least efficient
5 = very low efficiency;
4 = low efficiency;
3 = average efficiency;
2 = very efficient;
1 = most efficient

15	a. Maize	6	2	4	3
	b. Sugarcane	1	1	1	1
	c. Sugar beet	3	6	2	2
	d. Grain Sorghum	2	3	6	5
	e. Sweet Sorghum	4	4	3	4
	f. Wheat	5	5	5	6

16	What are the 3 most important factors for successful agricultural development as it pertains to bio-ethanol production?				
	a. Utilisation and availability of underdeveloped land	√			√
	b. Funding for agriculture	√	√		√
	c. Government support in respect of incentives and regulation		√	√	
	d. Location of a defined market			√	
	e. Improved technology				
	f. Availability of water		√		√
	g. Defined price for the product			√	
	h. Skills development	√			
	i. Drought resistant cultivars				
	j. Uptake of by products by agricultural companies				
	k. Resolve land ownership issues				

	l. Logistics and infrastructure				

Section 5: Social Impact of bio-ethanol use

17	How many jobs will be created if a bio-ethanol sector were to be established at a 10% blending rate?				
	a. 10 000 – 50 000				√
	b. 50 000 to 100 000		√		
	c. 100 000 to 250 000	√			
	d. 250 000 to 500 000				
	e. 500 000 to 1000 000			√	
18	How will the jobs created be split according to the categories listed below				
	a. Skilled workers (managers, supervisors, technicians, etc)……%	5%	10%	5%	10%
	b. Semi-skilled workers (drivers, machine operators, etc)……%	20%	20%	10%	30%
	c. Unskilled workers (farm workers, etc)……%	75%	70%	85%	60%
19	In your opinion, does the creation of this number of jobs act as a factor for the establishment of a bio-ethanol industry? Yes / No	Yes	Yes	Yes	Yes
20	Who do you believe will be the main beneficiaries of the jobs created? If both, what is the percentage split?				
	a. Rural unemployed ……%	95%	70%	80%	60%
	b. Urban unemployed ……%	5%	30%	20%	40%
21	Does bio-ethanol production impact food security negatively? Yes / No	No	Yes	Yes	No
22	Why? Response from the interviewees with a **YES** response.				
	An increase in feedstock prices results in an increase in production which will result in an oversupply	N/A			N/A
	Under-utilised land can be put to plantings which will increase food supply	N/A	√		N/A
	The choices of feedstock for ethanol production can be limited to non-edible types which will not impact food supply	N/A			N/A
	Capacity exists in South Africa to produce sufficient feedstock for food supply and ethanol production	N/A		√	N/A
	Job creation creates access to food	N/A	√		N/A
	Increased feedstock production facilitates food security	N/A			N/A
	By-products of ethanol production can be used in the food industry	N/A	√		N/A

22	Why? Response from the interviewees with a **NO** response.				
	Increases prices of basic food stocks internationally		N/A	N/A	
	Shortage of food and fuel as a result of both competing for the same commodity		N/A	N/A	
	Opportunity to leverage food supply		N/A	N/A	
	Food will be diverted to fuel unless additional plantings take place	√	N/A	N/A	
	Government support is needed to reduce food security issues		N/A	N/A	
	Prices of basis foods will rise until there are market corrections		N/A	N/A	
	On a scale of 1-5. 1 = very low impact; 2 = low impact; 3 = average impact; 4 = high impact; 5 = critical impact.	1 = very low impact; 2 = low impact; 3 = average impact; 4 = high impact; 5 = critical impact.			
23	What impact will it have on:				
	a. Food prices	1	5	1	2
	b. Availability of basic foods	1	5	1	1
24	Will utilising underdeveloped land increase food security? Yes / No	Yes	Yes	Yes	Yes
25	Do food prices need to be regulated to ensure food security? Yes / No	No	No	No	No
26	If food security can be guaranteed, in your opinion, will this influence the establishment of a bio-ethanol sector positively? Yes / No	Yes	Yes	Yes	Yes
27	In your view does food security need to be guaranteed to establish a bio-ethanol industry? Yes / No	No	Yes	No	Yes

Section 6: Environmental Impact of bio-ethanol use

28	In your view is road transport a huge contributor to environmental pollution? Yes / No	Yes	Yes	Yes	Yes
29	Will the use of bio-ethanol in transport fuel reduce environmental pollution? Yes / No	Yes	Yes	Yes	Yes

30 On a scale of 1-5 rate the following in terms of their contribution to a healthier environment if bio-ethanol were used in transport fuels.

1 = very low impact; 2 = low impact; 3 = average impact; 4 = high impact; 5 = critical impact

1 = very low impact;
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5 = critical impact

a. Reduction of carbon dioxide and other greenhouse gas emissions	5	5	2	4
b. Reduction in acid rain	5	5	1	4
c. Slow down ozone depletion	5	5	1	4
d. Benefits to soil and biodiversity	5	5	1	3
e. Provide bigger carbon savings	5	4	1	4
f. Replaces hazardous additives in conventional petrol	5	5	3	4

Section 7: Regulation

31	Has the South African Government to date delivered on its strategy to establish a bio-fuels industry? Yes / No	No	No	No	Yes

32 What are the 3 actions in your view the SA Government needs to take urgently to establish a bio-ethanol sector?

a. Finalise and approve the national bio-fuels strategy that addresses the concerns of all stakeholders		√		√
b. Clarify that government support will be available for all stakeholders	√		√	
c. Regulate mandatory blending	√			
d. Analyse the implications of the establishment of a bio-fuels sector				
e. Funding support		√	√	
f. Introduce regulation to ensure supply of feedstock for fuel production				
g. All relevant government department should collaborate to facilitate the establishment of the sector.				
h. Clarify food security issues				
i. Infrastructure and logistics support				
j. Regulation on captured fleet systems.				

33 What should form part of the policy framework?

Government support (incentives, subsidies, tax relief)	√	√	√	√
Mandatory blending targets	√		√	√
Regulation for importing and exporting of feedstock - tariffs		√	√	
A defined price and quality for the product	√			
Social issues (job creation, food security)		√		√
A defined market for the product				
Licensing framework				
Land management policy				√
Regulation to encourage sourcing of feedstock from emerging farmers				
Environmental sustainability issues				

34 Who are the most important stakeholders in this industry?

Government	√	√	√	√
Oil Companies	√	√	√	√
Agricultural Sector (Farmers, farm workers)	√		√	√
Investors	√	√	√	
Consumer				
Primary and secondary suppliers and service providers				
Bio-fuel Producers				

35 What are the factors holding the establishment of this industry back?

Lack of sound and clear government strategy and policy framework	√	√	√	
Access to funding	√			
Vested interest and political agendas				
Food security				
Reluctance from oil industry for off-take				
Knowledge		√		
Availability of water resources				

36 Which factors do you believe to be the most important in establishing the bio-fuels industry? Rank them 1-5

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2 = very important
3 = average importance
4 = less important
5 = least important

a. Creation of supportive policy and institutional frameworks	1	1	1	1
b. Private sector involvement	2	4	5	2
c. Levelled playing fields for conventional and bio-fuels	3	5	3	5
d. Integrate projects around local needs and capacity	5	4	4	3
e. Identification of resource requirements	4	3	2	4

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1 = critical factor
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3 = average importance
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5 = least important

a.	Suitability of ethanol	3	5	4	5
b.	Agricultural development	2	1	3	2
c.	Socio-economic factors	4	3	2	3
d.	Environmental factors	5	2	5	4
e.	Regulation	1	4	1	1

38 Can you refer me to a few key individuals in your network that would be able to answer these questions?