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Biofuel production in South Africa: the games, the cost of production and policy options

by

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Declaration

I, Thomas Bernhard Funke hereby declare that the dissertation

Biofuel production in South Africa: the games, the cost of production and policy options

being submitted by me for the Dcom degree in Agricultural Economics at the University of Pretoria is my own work and that the dissertation has not been previously submitted by me for a degree at this or any other tertiary institution.

Signature: Date: 23 October 2010

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Abstract

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The production of biofuels in South Africa has evolved very slowly and at present there are only a handful of plants producing some derivative of biofuel. The lack of commitment from government and the utter information distortion under which the current policy framework was developed have largely contributed to the current state of affairs. The manner in which the current policy framework was formulated based on the available information has impacted negatively on the development of the industry and it is hypothesised that had a better and more comprehensive analysis process been followed, the framework would be of such a nature that the industry could be sustainable in the long run. The study examines the policies and policy development process that have taken place in other biofuel producing countries and investigates the various policy instruments that are in use in these industries. The study further explores the interactions of industry role players at both government and producer level while attempting to explain the factors that could have caused their deviation from the rational and expected path of strategies and actions. In both games, each at a different level, the resultant Nash Equilibrium changes and prevailing strategies indicate that it is not in the role player's interest to commit to the industry. The government departments involved in formulating the biofuel policy seem to be uninformed and hence choose a low support route while oil companies

consistently choose not to invest in capacity and biofuel refiners find their Nash Equilibrium at high levels of investment. A decision tree is formulated to conduct an in-depth review of the current level of profitability of proposed and current projects with specific reference to current legislation. The decision tree unpacks the current economic environment in the industry and identifies various factors that are crucial to the long-term development and growth of the industry. Based on this comprehensive survey of the industry and a detailed comparison of various production costs, together with the design of the game theoretic framework, a conceptual policy framework is designed and it is proposed that this replaces the current biofuel strategy. The new policy framework establishes its sustainable structure based on facts, detailed figures and existing project information. The framework is based on a more sustainable policy structure that combines elements of rural development with the economics that are required in order for the industry to be sustainable in the long run. Unlike the official government biofuels policy, the Industrial Biofuels Strategy, this proposed policy framework takes the industry's and role players' requirements into account and is designed in such a way that government targets and goals are accomplished. It is hypothesised that the implementation of this comprehensive policy framework will assist in the establishment of a successful and sustainable biofuels industry.

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Chapter 1

Introduction

1.1 Background

In the energy sectors of the world there is a fear that sooner or later fossil fuel reserves could potentially dry up, leaving the world with the predicament of an energy shortage and extremely high energy prices. The concept of 'Peak Oil' has in recent years received a fair amount of attention and refers to the future decline in world production of crude oil and to the accompanying potentially calamitous effects (Holland, 2006). In the world of energy economics there seem to be two distinctive schools of thought. The one school professes that oil production is nearing or has peaked and that only 55% of all total oil resources are still to be discovered (Holland, 2006; Hart & Skrebowski, 2007). The other school of thought is that of the so called 'economists' who believe that human ingenuity will bring about alternative sources of energy to replace energy gained from fossil fuels (Kerschner and Hubacek, 2006; Hamilton, 2008).   Sharing this thought sequence are energy economists such as Smil (2003) who argue that eventually, the presence of finite quantities of minerals in the Earth's crust will become irrelevant, as our effort to extract these resources will cease long before we approach their physical global exhaustion and with oil prices having tested $147/bbl in June 2008, and likely to do so again in future, alternatives may well come into the spotlight, sooner rather than later. Smil (2003) further argues that this will occur as the cost of creating new reserves through exploration and development becomes too high, resulting in the discontinuation of these industries which will in turn play an important role in the development of an alternative. It is partly due to this concern that alternative means of energy production have been explored since the 1970s. More recently, the strive to produce alternative energy

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sources, such as biofuels, in other words fuels from agricultural commodities, has been the focus in various countries. The complications involved in the production of biofuels highlights the importance of considering the various aspects of policies and various policy options, if a country is in the process of implementing these fuels as a source of alternative energy. It is therefore crucial that policy makers, biofuel producers, farmers, blenders and end consumers all take factors such as the economic feasibility of production, environmental sustainability in terms of land use and greenhouse gas impacts, food security, the status of its energy efficiency as well as the impact on developing the rural economy, into consideration.

The experience from the US policy process has shown that the correct measures are indeed necessary to create and sustain such an industry, especially in times when the plant's profitability comes under pressure. At present, biofuel legislation in the US supports the industry extensively. Biofuel producers receive a tax credit to the value of 52 US cents per gallon, a blending mandate of 10.21 % for 2009 was set, and the local industry enjoys trade protection in the form of an import tariff to the value of approximately 57 US cents per gallon (De Gorter & Just, 2010).

A similar situation exists in Europe where an extensive policy framework has been developed to assist the industry. In June 2010, the European Union (EU) is implementing a package which is referred to as the "20/20/20" goals for 2020. The package aims to achieve a 20 % reduction in greenhouse gas emissions from the EU's 1990 levels, a 20 % improvement in energy efficiency compared to current forecasts for 2020 and a 20 % share for renewable energy in the EU energy mix; of which a minimum 10 % target for renewable energy should be consumed in the transport sector and this in turn should be achieved by all Member States (United States Department of Agriculture (USDA), 2009). As a result of the extensive goals set out by the "20/20/20" package, the EU needs to have some form of import

protection in place. Consequently, a number of tariffs and duties have been implemented. These include, among others, a 6.5 % rate plus a provisional anti-dumping duty on 99 % biodiesel (B99), and € 19.2/hl and € 10.2/hl on un-denatured and denatured ethanol, respectively. The EU policy framework is, however, slightly different from that of the US in that the main focus is on long-term sustainability, from sustainable sources, with as little impact on Indirect Land Use Change (ILUC) as possible. This means that by the end 2010, the European Commission will have developed a concrete methodology on calculating the indirect land use, which will enable them to assess the situation as well as the impact of their policies (USDA, 2009).

The South African policy process has followed a more erratic and unclear route with respect to setting up its own interests in the development of renewable energy with various legislative guidelines being written to establish critical targets. Early research on the biofuels topic was conducted by Ortmann and Niewoudt (1987) and Ortmann (1987) largely focussing on the sugar industry and the production of ethanol and various price schemes that could support the production of ethanol. In May 2001, the former Department of Arts, Culture, Science and Technology completed an audit on the transport fuels sector and found that this sector offers the largest energy-saving potential through the improvement of vehicle efficiencies. The audit further found that biofuels should enjoy greater interest and that the level of government support in the industry should be determined. After becoming a Kyoto Protocol signatory in 2005, biofuels received more commitment with projects being allowed to apply for carbon emission reduction credits via mechanisms such as fuels switching. In addition, the National Treasury approved an increase in the fuel levy exemption for biodiesel from 30 % to 40 %, while SARS allowed a 100 % exemption for small biodiesel producers (Department of Minerals and Energy (DME), 2007). In 2005, the Department of Science and Technology also led a Biodiesel Joint Implementation

Committee which in turn conducted a detailed examination and found that government support of the industry can be justified due to the social and environmental benefits. The National Treasury further approved a Renewable Energy Capital Subsidy Scheme, providing a 16.7 c/l subsidy for bioethanol and 27.3 c/l for biodiesel up to a maximum of R20 million. During 2006, national standards were developed together with the South African Bureau of Standards and the Department of Science and Technology while further regulations, gazetted under the Petroleum Products Act, included a specific allowance for biodiesel additions. The South African National Standards (SANS) has also finalised its fuels standards and these are in line with those of Europe, the United States of America (US) and Japan (DME, 2007). In 2006, the first draft of the National Biofuels Strategy was submitted to Cabinet after which the final version was approved during December 2007 and at present counts as the main legislation in place to strategically guide the industry.

It, however, became clear that the approach followed by government and its reasons for interest in this new industry varied widely from other interested role players, which included farmer groups, producer organisations, potential financiers and oil/petroleum producing companies. Famer groups and producer organisations had an interest in the industry as a result of extremely low maize prices during 2004 and 2005. The idea behind ethanol production was to create an alternative maize market and, in so doing, process the surplus production, which at the time was the main cause for the low prices.

Lobby groups, consisting of mostly local farmers, agro processors, finance houses and oil companies, were formed and attempted to assist the Department for Minerals and Energy (DME) in drafting a biofuels strategy. One of the DME's aims was to meet renewable energy quotas and goals as set out in the White Paper for

Renewable Energy in 1997. The strategy planning process and the development of the policy debate commenced smoothly and various lobby groups had different targets and strategies in mind. Farmer interest groups, such as Ethanol Africa, a company poised to become the leading maize-to-ethanol producer in South Africa, attempted to swing opinions in such a way so that maize would be included as one of the agricultural commodities that could be used for biofuels. Oil refineries, on the other hand, had no interest in supporting biofuels development as they faced supply risks and would have to incur costs for the adaptation of their equipment and processes. Other interested parties, such as South African commercial banks and other international finance institutions, also attempted to give their input by influencing the policy development process through the publication of various articles and by being involved in the establishment of the South African Biofuel Association (SABA). The many interests and actions from lobbyists in the industry together with the confusion of critical policy variables on the part of the government resulted in a disparity among stakeholders. The result of the debate was a strategy of no commitment. In turn, many proposed projects were halted or discontinued and the question that arises is, if such disconnect among stakeholders exists, are the South African agricultural, agro processing and energy sectors ready to cooperate and work towards a common goal in the establishment of such an industry? The study investigates whether the establishment of a biofuels industry in South Africa has merit and, if so, what policy options should be in place in order to make the establishment of such an industry possible.

1.2 Problem statement and justification for research

In times of high oil prices and dwindling supplies of fossil fuel reserves, the production of biofuels can assist the economy in being less dependent on the use of fossil fuels, more environmentally friendly, a market to the agricultural sector and an

additional source of employment. In the US, the additional impacts of the Renewable Fuel Standards (RFS) have been estimated at reducing oil imports by 2 billion barrels, creating more than 200 000 new employment opportunities, increasing household income, adding to the gross domestic product and creating new investments to the value of US$ 6 billion (Renewable Fuels Association, 2006). In Europe, the production and use of fuel derivatives from agricultural produce and forests is today viewed as a new frontier in energy supply. In a context of action against climate change, the carbon emissions efficiency of some energy crops has emerged as a promising and powerful alternative to the use of fossil fuels (Swinbank, 2009). The strategic positioning of agro fuels as a tactic in combating climate change or as an energy and development strategy is, however, complicated by various factors. These include a lack of consensus on how to deal with the emerging flows of trade and investments as well as the ensuing trade-offs in the allocation of implicated resources with respect to land, capital and the workforce. Adding to the dilemma is an ill-equipped regulatory framework, both in countries of production and internationally, as well as a deficiency in science and metrics to demonstrate the effects (Swinbank, 2009).

In South Africa, the production of biofuels faces similar issues that raise a number of questions regarding its ability to be a sustainable source of energy in the long term and not to have its relevance relegated to use in a niche market. These issues include questions on the economic feasibility of production, environmental sustainability, effects on food security, energy efficiency of the fuel and the beneficial development of the rural economy, including the creation of jobs due to an increased demand for energy crops. All these factors play an equally important role with regard to biofuel's overall importance as an alternative energy source in the economy and need to be understood if correct policy measures are to be put in place. History has shown that an industry cannot be developed if the correct policies are not in place

and experiences from other nations, such as the US and the EU, suggest that the establishment of the biofuels industry is largely dependent on the way in which the policy framework has been set out and designed, in order to develop and shape the industry. But even a well-developed programme and policy framework comes with its complications. De Gorter and Just (2007a) mention that even the US policy has its controversy surrounding it with the implementation of an import tariff of 54 US cents per gallon, which, together with a 51 US cents per gallon subsidy that US ethanol producers receive on ethanol, means that foreign producers need to produce ethanol at US$ 1.05 per gallon cheaper if they wish to compete. All such combinations of policies achieve is that they add "water" to the tax credit and contradict goals of improving the environment, reducing reliance on oil and oil imports and diversifying energy sources (De Gorter & Just, 2007 a). Thus, the question arises whether such an industry should be in place in South Africa and, if so, what type of policy framework for the development of the industry will be important to address the various issues related to the industry.

Historic development of the biofuels industry in various countries has shown that the success of the industry, especially in its developing phases, is largely dependent on how the policy development process was handled and who was involved in the process. In Brazil, for example, a major agreement with the state-owned oil company, Petrobas, various major car manufacturers and sugar processors resulted in a proactive approach being followed. This ensured that on the supply side there was a constant stream of ethanol sufficient to satisfy the mandate, while on the demand side, the agreement with the large automobile manufacturers ensured that there was a constant production of vehicles, capable of running on 100 % ethanol (Cordonnier, 2009).

The proactive policy approach ensured both that the policy framework was based on calculated risk and a relatively smooth transition of the industry. Thus, the availability of detailed and accurate information in order to shape the policy framework for such an industry is of extreme importance. If such a process is not followed or properly researched, this will in all likelihood result in the failure or non-existence of the industry. According to the Foreign Agricultural Service (FAS, 2009 a) of the United States Department of Agriculture, "There is still no workable biofuel project from virgin material in South Africa, this despite many policy statements, plans for projects, debates, workshops etc. over the past couple of years. The blame of this lack of biofuel production is largely directed at the morass of government inaction, lack of policy determination and the threat to food security. This despite South Africa being a net exporter of food, both in maize and sugar, in most years and having more than enough land available to accommodate agricultural production for both food and fuel". It should, however, be noted that the area under maize and sugar production is decreasing, which in turn could have an impact on the South African ability to maintain its net food exporter status (Bureau for Food and Agricultural Policy (BFAP), 2009 a). In fact, the inaction by government and the lack of policy determination can be partly directed at various role players consulted during the policy development process. It can be argued that these role players used information to favourably advance their strategic positioning in the industry. This, in turn, has often been part of the confusion and overwhelming information presented to policy makers during different stages of the decision making and policy forming process. As a result, the policy design process of the Industrial Biofuels Strategy of South Africa has been flawed and distorted in many aspects which have ultimately had the effect of a "non-commitment" policy being designed and implemented.

A number of flaws that existed during the policy development process need to be addressed and these include the consultation process with stakeholders and the use

of feedback from these sessions. The focus on achievement of targets mentioned in the white paper framework, concrete and structured guidelines, as well as commitment from government in terms of achieving these and the use of accurate and independent research in assessing and developing a structured policy framework and achieving a distinct level of sustainability throughout the policy, is also of extreme importance. It is unwise to assume that a successful policy can be developed and implemented if the development process is based on inaccurate and biased information.

To the author's knowledge, two reports have been published commenting on the government's current Industrial Biofuels Strategy. The Bureau for Food and Agricultural Policy (2007) and Lemmer, Makanete and Kupka (2007) clearly layout the implications of the strategy on the overall agricultural market and emphasise that, in order for the industry to become sustainable in the long term, the entire policy framework needs to be drastically amended; although how it should be amended and what policy instruments should be included and to which degree is not clear. Chapter 2 of this study reviews various strategies, policies and policy instruments that are in use in other countries. It is the aim of the study to build on the knowledge and experiences gained from the first policy development process and to further explore the factors that played an important role in the first process, as well as the actions and reactions of various role players. This is achieved by means of employing various versions of game theoretic models to the situation. Based on the backdrop of the industry and its current state, the second aim of the study is to deal with the question surrounding the use of biofuels in South Africa and whether such use and production should even be considered. The third aim and final contribution of the study is to provide an accurate and comprehensive biofuels policy framework for the South African industry. It is further proposed that this framework replaces the

current government's strategy and, in so doing, develops a concrete foundation from which further development can take place.

1.3 Statement of hypothesis

Favourable climatic conditions for biomass or agricultural feedstock production are not the only requirements that have a positive impact on biofuel production in an economy. In the study, it is hypothesised that:

If the appropriate policy development process is followed and the relevant information framework is available, then the correct policy framework can be put in place, which in turn has the potential to create a successful and sustainable industry.

The hypothesis is based on two arguments. On the one hand, there is the Brazilian ethanol industry which offers a rich and detailed case history of a government-backed programme which resulted in rapidly and exponentially increasing levels of ethanol production (Cordonnier, 2009). The Brazilian case has been an example in policy development and incentives as it has achieved what it terms a sustainable industry with as little as possible government support. It is hypothesised that if the correct policy framework is in place and if this is based on a solid fundamental policy framework, an industry such as the biofuels industry can successfully be established and developed. It is also hypothesised that in the long run, an industry based on these foundations can achieve the goals that its policy framework was strategically set out for, such as replacing a significant portion of fossil fuels in the country's transport sector. Apart from the percentage of imported fuel that can be replaced and the positive impact that biofuels will have on greenhouse gas emissions, a successful biofuels industry will also have a positive impact on rural development and value additions in the agricultural sector. On the other hand, there is the South

African example where the lack of biofuel production is largely directed at the morass of government inaction, lack of policy determination and the threat to food security. The government strategy is also mentioned as one of the major constraints in the development of a viable biofuel industry in South Africa (Foreign Agricultural Service, 2009 a). The available information supports the argument that biofuel production is largely dependent on the policy framework that is in place, and if this framework is based on information that has not been clearly researched, structured or strategised but rather is based on existing rumours, concerns and assumptions as put forward in the media and other sources of information, it can lead to poor decision making and a scathing of the industry. The methodology that will be used to test this hypothesis is discussed in the following section.

1.4 The general objectives

The policy development process in other countries has indicated that by following a process of good and accurate, structured research, informed decision making can take place. This in turn has the ability to ensure the design and development of an accurate and feasible policy framework which can achieve the objectives that it has set out and pave the way for the development of an industry. The main research question the study therefore wants to address is to understand why the South African policy on biofuels has followed a particular route and achieved an undesirable and confused outcome and how could this have been prevented?

It is the objective of the study to illustrate tools with which an accurate process of policy development can be followed; indicating the important role players at each level of the policy development process and their roles within the industry, and what policies need to be in place in order for such an industry to function optimally. The study further aims to develop a policy framework which is in line with various

governmental targets, taking into account the variables that are important in developing an industry that functions optimally, contributes to achieving certain environmental goals, enhances the agricultural sector and assists government in achieving its rural development goals.

It is therefore the general objective of the study to give constructive input to the debate on biofuels in South Africa by taking into account actions by role players, changes in variables, policy developments in other countries as well as the projects that are currently successful. By taking stock of these facts and factors it will be possible to determine what needs to change in order for the industry to become successful and sustainable in the long term. The general aim is therefore to analyse the current state of affairs and to explore what needs to change in order for the industry to develop and become sustainable.

1.4.1 The specific objectives

The general objective will be attained by means of the following specific objectives:

1.) Review past and present literature on biofuel development processes in various countries. Review the various biofuel policy instruments implemented and utilised in order to achieve various policy goals and review the current state of affairs in countries that have already implemented these policies in order to determine their success.

2.) Apply game theory in order to model role player interactions within the policy development process and to design a model that captures all interactions at governmental and industry level.

3.) Conduct a complete industry review in terms of proposal projects by means of a decision tree framework. Establish an accurate data base of the cost of

production, current profit levels and future capacity available, with specific focus on long-term sustainability.

4.) Develop a policy framework capable of facilitating the development of a sustainable biofuels industry based on a policy development process which includes the use and analysis of accurate and independent data, concise and accurate research and analysis, extensive consultation with international and local experts as well as lessons learnt from mature biofuel industries.

1.5 Methods and procedures

The objectives of the study are to understand and test the underlying factors that influence biofuel production. On the one hand, there is the policy development and implementation process which shapes and determines the way that the industry and other interested role players react to the incentives as set out by governmental departments and policy makers. In addition to analysing the reactions of the role players to this policy development and implementation process, a decision tree analysis framework has been developed in order to determine the current state of affairs in the industry.

Game theory and game theoretic simulations are used to determine the Nash Equilibrium at which the various role players should find themselves, given rational decision making and strategies. The existing games are then modified in order to explain why role players find themselves in their current states and the modified variables that are implemented to achieve these outcomes are dissected and reviewed in detail. Two games are simulated at different levels in the industry, one at government level between various governmental departments, and one at producer level representing the game among the industry stakeholders.

The industry review is conducted by means of a decision tree analysis. The methodology involves an in-depth review of preferential areas of production in terms of legislation. The first level of the analysis takes EU regulations as well as those set forth by the South African government into account. The second level in the decision tree framework analyses the supply security of the proposed energy crops in terms of commodity availability at a national and regional level. Decisions at this level focus specifically on the availability of the crop and its price dynamics based on the preferential areas of production. The third level analyses the overall biofuel plant profitability based on a financial biofuel plant level model, developed by the author and members of the Bureau for Food and Agricultural Policy, based on the production process data from leading biofuel technology providers, such as Praj Industries ltd and Lurgi GMBH. This data is verified and reconciled with business models and actual data from the various active projects. The fourth level of the analysis rates each one of the projects in terms of its success rate based on the current economic environment and gives a clear indication as to which projects could be sustainable in the long term if the correct policy measures are in place. The fifth level concludes the analysis.

The methods used and conclusions drawn from the analysis are employed to give a precise and solid base to the formulation of the new policy framework. The hypothesis is further tested based on the developed framework and conclusions drawn as to the success of its implementation.

1.6 The outline of the study

The study is presented in a total of six chapters. Chapter 1 gives an exact overview of the topics to be discussed with specific focus on the hypothesis, objectives and outcomes that are to be achieved with this research. Chapter 2 unravels the policies

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that are in place in various other countries and discusses them in detail. This provides a precise overview of what has been done in other parts of the world in terms of policy instrument implementation and focuses on what can be done in the South Africa biofuels industry. Chapter 3 represents the game theoretic simulation between the various governmental departments on a rational level. The chapter takes the first game one step further and develops an explanation as to why, currently, the strategies are uncoordinated in terms of the goals that they would want to achieve. The game provides an excellent insight into how government actions have been unfocused and irrelevant. Chapter 4 focuses on the political stance that the various energy role players would take in order to achieve their respective goals. In this chapter, game theory is used to simulate action and strategies of the oil industry and the biofuel producer, based on the current policy framework in place. Chapter 5 analyses the economic feasibility of producing biofuels in the South African market and considers the legislation that is in place, the competitiveness of producing crops purely for energy use and the biofuel plant profitability that needs to be taken into account for the project to be sustainable in the long run. The chapter focuses on different methods of production based on the experiences drawn from the various case studies. A number of South African projects are taken into consideration and analysed within a decision tree framework. Chapter 6 concludes and summarises the dissertation with a policy framework capable of replacing the current Industrial Biofuel Strategy. The framework is designed based on a comprehensive policy development process and, if implemented, can assist the government in improving their targets and the biofuel industry in becoming a long-term sustainable contributor to the South African energy supply mix.

Chapter 2

Policy Use and Development in World Biofuel Production

2.1 Introduction

The rise in crude oil prices during the middle of 2000 together with concerns about greenhouse gas abatement and energy security has resulted in a sharp increase in biofuel production and related policy measures (Hertel, Tyner & Birur, 2008). These biofuel production support policies have been at the forefront of a debate concerning the various spin-off effects of these policies, such as increasing food prices and a consequent decline in the use of the commodities for domestic feed, other industrial uses and even exports. This has been found to be the case in the US (Tokgoz, 2007; Tyner & Taheripour, 2007) while in the EU it is expected that the implementation of the EU biofuel directive will have an enormous impact on the demand for biofuels feedstock and consequently result in a substantially larger trade deficit (Banse, van Meijl, Tabeau, & Woltjer, 2007; Tokgoz, 2007). It is, however, important to note that various countries and governments have implemented biofuel support programmes in order to support the respective industries; and often the aims of these policies are to assist the industry in it primary development. Governmental policy briefs often mention specific time frames during which these policies will be in place and aim at discontinuing the extensive support of the industry, hoping that enough has been done to create a sustainable base for such an industry.

This chapter introduces the various policy instruments that have been used all over the world in order to establish and promote the development of biofuels industries. The chapter focuses on various policy instruments that have been employed and explores how these instruments function. In addition, the chapter explores the policy

development process and how it has been adapted in various countries in order to achieve certain goals and further develop the industry. The instruments and development processes are reviewed with specific reference to various countries and their implementation.

2.2 Biofuel policy instruments

Biofuel policy instruments have been in use since the first biofuel programmes and evidence dates back as far as the 1920s when ethanol was first used as a petrol additive in Brazil. It was, however, only in 1931 that fuel produced from sugar cane was officially blended with petrol (Food and Agricultural Organisation (FAO), 2008). In 1975, Brazil launched the Proalcool (Programa Nacional do Álcool) which required a mandate for the consumption of ethanol in the local fuel mix and by 1980 the program required the industry to produce 3.5 million litres of ethanol per annum (Cordonnier, 2009).

Ethanol policies were also common in other countries and the US established the Energy Policy Act of 2005 which, under a new Section of the 211(o) of the Clean Air Act, created the Renewable Fuel Standard (RFS) programme. Under the programme, a number of objectives are sought to be achieved, which include (1) the expansion of the applicable volumes of renewable fuel; (2) the separation of the renewable fuel volume requirements into four categories, namely cellulosic, biomass biodiesel, advanced biofuel and total renewable fuel; (3) changes to the definition of renewable fuels and criteria for determining which if any of the four renewable fuel categories a given renewable fuel is eligible to meet; (4) expansion of the fuel pool subject to the standards to include diesel and certain non-road fuels and expansion of the obligated parties to include refiners, certain blenders, and importers of those

fuels; and (5) inclusion of specific types of waiver and EPA generated credits for cellulosic biofuels (Environmental Protection Agency, 2008).

The EU also has its own biofuel policies in place focusing strongly on redirecting its current goals of achieving a blending target of 5.75 % for biofuels in the total transport fuel mix. The EU has moved towards a more realistic policy position and is aiming at achieving a package termed the "20/20/20" goals in which it aimed at achieving a 20 % reduction in greenhouse gases, a 20 % improvement in energy efficiency compared to current forecasts and a 20 % share of renewable energies in the EU energy mix, of which a percentage share of 10 % must be the minimum target of renewable energy reached in the transport fuel sector (Foreign Agricultural Service, 2009 c).

A wide variety of biofuel policies are in place throughout the world and, among others, blending mandates, tax credits, producer subsidies and import protection seem to be the most commonly used. The implementation of these policies is, however, more complex than one would think and research has indeed indicated that often, the welfare impacts of biofuel policies can be rather large and, even when biofuel policies are used in concert with one another, their impacts can be contradictory and result in a reversal of their policy impacts (De Gorter & Just, 2010).

2.2.1 Blending mandates

A blending mandate is often structured over a period of time and requires that biofuel blenders attain certain targets in terms of the percentage of biofuels which need to be blended into the local transport fuel mix. A blending mandate is normally measured in liquid quantities but expressed in percentage terms of the total transport fuel mix, bio-ethanol with reference to consumption of petrol or gasoline and biodiesel with

reference to consumption of diesel in the specific market. Blending mandates have the function of creating an artificial demand for the products, in other words, a vertical demand curve, forcing the fuel industry to take up required quantities of biofuels, regardless of the price at which they are selling. Blending mandates therefore force an uptake of the fuel into the local market.

Table 2.1 gives a short summary of biofuel targets and mandates that have been initialised throughout the world and specific targets that these countries aim at achieving.

Table 2.1: Biofuel blending mandates and targets, 2008 – 2020

Country	Targets
Brazil	*Mandatory blend of 20-25 % anhydrous ethanol with petrol, minimum blend of 3 % biodiesel, increasing to a 5 % by the end of 2010.*
Canada	*5 % ethanol in petrol by 2010 and 2 % biodiesel in diesel by 2012.*
China	*15 % of transport fuel needs to be renewable by 2020.*
France	*7 % biofuels by 2010 and 10 % by 2020.*
Germany	*6.75 % biofuels by 2010, 8 % in 2015 and 10 % in 2020.*
India	*Proposed blending mandates of 5-10 % for ethanol and 20 % for biodiesel.*
Italy	*5.75 % biofuels in 2010 and 10 % blend in 2020.*
South Africa	*8 % voluntary mandate.*
UK	*5 % target for biofuels by 2010 and 10 % by 2020.*
US	*9 billion gallons by 2008 rising to 36 billion gallons in 2022 of which 21 billion gallons from advanced biofuels.*
EU	*10 % biofuels of transport fuels by 2020.*

Source: FAO, 2008

In the US, the Energy Policy Act of 2005 introduced the Renewable Fuels Standard (RFS) which in turn mandated that all transport motor fuel in the US be sold, containing renewable fuels to the volume of 7.5 billion gallons (28.38 billion litres) by 2012, after which this percentage content was to be maintained. The Energy Independence and Security Act of 2007 (EISA) established more ambitious targets,

stipulating a volume of 9 billion gallons of renewable fuels for 2008 and an increase of this to 36 billion gallons (136 billion litres) by 2022, of which 22 billion gallons (83.27 billion litres) should be covered by advanced biofuels (FAO, 2008). Figure 2.1 clearly defines the provisions that have been made in order to boost biofuel production levels. Within the framework of the EISA, the general term of biofuels has been broken down into four categories, which include conventional, cellulosic, biodiesel and other advanced biofuels, all of which are then included at certain rates depending on their longer term availability. As the Act stands at present, sub-mandates that have been included are biodiesel production, which should reach 3.7857 billion litres by 2012, and cellulosic ethanol production, which should reach levels of 3.7857 billion litres by 2013 and seven times that volume by 2018 (EISA, 2007). The term "advanced biofuels" refers to biofuels that reduce greenhouse gases and are therefore considered to be green, while the term "conventional biofuels" refers to biofuels that are being produced under current conditions. The Act polices the blending of biofuels by requiring blenders to show their Renewable Identification Numbers (RIN) in order to prove that they actually meet their share of the national mandate (FAPRI, 2008). Blenders can also trade in RINs in order to meet the mandate. If blenders have not met their mandate targets, they will be able to buy additional RINs from blenders who have exceeded their share (FAPRI, 2008).
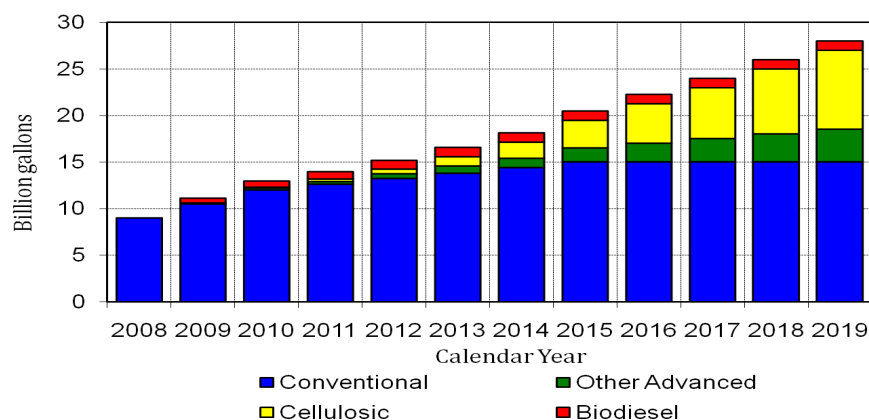
Figure 2.1: Increase in mandate as required by the Renewable Fuel Standards (RFS), 2008 – 2019
Source: EISA, 2007

The EU's biofuel legislation consists of three main Directives that govern the industry. The 2003/30/EC is the first pillar and its function is to promote a biofuels market in the EU by encouraging biofuel use in competition with less costly fossil fuel use. The Directive has set a reference target of 2 % biofuel consumption for 2005 and 5.75 % for the 31st of December 2010. It obliges member states to set national indicative targets which they should aim to achieve, even though the strategy that is used to achieve the targets is left entirely up to them (FAO, 2008). In March 2007, the European Council in Brussels reaffirmed its position in terms of the Renewable Energy Roadmap. It demonstrated that a 20 % target for the overall share of energy from renewable resources and a 10 % share target for renewable energy in transport would be appropriate and achievable objectives. Further, the framework which includes mandatory targets should offer the industry longer term stability, which it needs in order to reduce the EU's dependence on imported fossil fuels as well as to boost the use of new energy technologies (European Commission, 2008).

In 2008, Germany, France, Italy, the UK and Austria were the largest biodiesel consumers in the EU. The increases in consumption that made these nations the largest consumers of biodiesel were largely driven by the increases in the mandates of the various member states. It is, however, evident that the mandates cannot always be fulfilled and Table 2.2 indicates by just how much the actual EU consumption is currently lagging behind. In 2010, it is expected that the biodiesel share of total diesel consumption will only be approximately 4.80 % compared to the 5.75 % that is required in terms of the mandate.

Table 2.2: Estimated EU biofuel consumption, 2006 – 2010 (ktoe*)

	2006	2007e	2008e	2009f	2010f
Biodiesel	4170	5460	6000	7610	8960
Pure vegetable oil	915	620	415	190	200
Bioethanol	945	1350	1700	2055	2570
2nd generation biomass liquids	0	0	5	10	10
Total biofuels	6030	7430	8120	9865	11740
Biofuels as a % share of total transport fuel	2.06 %	2.49 %	2.68 %	3.21 %	3.75 %

*ktoe: 1000 tons of oil equivalent, e = estimated, f = forecast
Source: USDA, 2009

Brazil has one of the oldest and most successful biofuel programmes in the world and at present, ethanol blending in Brazil is mandated between 20 % and 25 %. The year 1993 was marked as one of the most significant in Brazil's ethanol programme when the local biofuels industry was significantly boosted by the government mandating that 22 % of anhydrous ethanol be added to all petrol distributed at retail petrol stations (FAO, 2008). The mandates are established by the Inter-Ministerial Board for Sugar and Ethanol and the mandate can range between 20 % and 25 %. During 2006, for example, the mandate was reduced from 25 % to 20 % due to ethanol shortages and higher prices. This reduction was just temporary and was increased in November 2007 to 23 %. In June 2007, the blend was again increased to the original 25 %, which was mainly as a result of a higher than expected harvest and availability of ethanol (Foreign Agricultural Service, 2007 a). The increased availability of ethanol in the local market through the Proalcool programme has increased the demand for flex fuel vehicles and in 2010, it is expected that nearly one third of the entire fleet will be made up of flex fuel vehicles (Foreign Agricultural Service, 2007 a). Biodiesel, on the other hand, is a minor industry in Brazil and policy incentives are far more recent. In 2005, a biodiesel law was established which requires that minimum blending requirements are 2 % in 2008 and increase to 5 % in

2013.   This policy is further supported by the "Social Fuel Seal" programme, providing income tax incentives for biodiesel producers who support small family farm enterprises in poor regions (FAO, 2008).

Argentina has been slower in welcoming the use of biofuels in its market but recently a mandate has been put in place which by law requires the use of biofuels with an obligatory mixture of 5 % ethanol in gasoline and 5 % biodiesel in the local diesel supply (Foreign Agricultural Service, 2007 b). At present, the policy framework is still unclear and cumbersome and many interested parties feel that these first have to be defined before an extensive development of such an industry can take place.

The use of biofuels in China has been extensively researched by the government and 2005 was the deadline at which E10 was to be made available throughout the regions of the Heilongjiang, Jilin, Liaoning, Henan and Anhui provinces, centrally through gradual introduction of E10 to six cities in the Hebei province, seven cities in the Shandong province, five cities in the Jiangsu province and nine cities in the Hubei province (Foreign Agricultural Service, 2006).

Even though it seems that the biofuel strategy in China has been carefully planned and laid out, there are still differing opinions regarding the respective policies. The Ministry of Agriculture does not, for example, participate in the promotion of biofuels as it feels that food security of the population is a more important issue. Interestingly, on the demand side, the state has nearly total control of the entire fuel market. At present, approximately 95 % of all fuel stations are owned and what is sold there is regulated by the state. As such, the policy in place is solely focused on achieving the goals as set out by the government and therefore it does not seem likely that demand for E10 will be influenced at all by the consumer, especially not in the short to medium term (Foreign Agricultural Service, 2006).   It thus seems that the government of China understands the critical aspects of implementing a biofuel

program but also understands that there are benefits to be derived from choosing this route and developing such a sector.

2.2.2 Tax credits and incentives

Tax credits are common policy instruments that are used in the biofuel policy framework. Tax credits are given to blenders for each litre of biofuel that is blended into the fuel mix with the other fuels (FAPRI, 2009). Tax exemption instruments represent a means for stimulating the demand for biofuels and these are among the most widely-used instruments that can dramatically affect the competitiveness of biofuels (FAO, 2008).

Various countries use tax credits and other incentives in order to make biofuel production more financially feasible. The US in its 1978 Energy Tax Act provided an excise tax exemption for alcohol fuel blends at 100 % of the petrol tax, which at the time translated into 4 US cents per gallon (1 US¢/l). In 2004, the Job Creation Act of 2004 introduced a Volumetric Ethanol Excise Tax Credit of around 51 US cents per gallon (13 US¢/l) for ethanol blenders and retailers. The 2005 Energy Policy Act extended this policy until 2010 and includes biodiesel which qualifies for a US$ 1.00 per gallon (26 US¢/l) tax credit and biodiesel from waste grease which in turn qualifies for a tax credit of 50 US cents per gallon (13 US¢/l) (FAO, 2008). The 2007 US Farm Bill reduces tax credits for maize ethanol, which was previously at 51 cents per gallon to 45 US cents per gallon (13 US¢/l to 11 US¢/l) but focuses on the production and support of cellulosic ethanol by introducing a tax credit of US$ 1.01 per gallon (26 US¢/l) (FAO, 2008).

The EU has an Energy Taxation Directive which has the function to control and set the minimum rates of taxation applicable to energy products when used for motor, heating or electricity purposes. The objective of the directive is to reduce distortions of competition between energy products and it encourages more efficient use of energy in order to reduce the dependence of imported energy products and limit greenhouse gas emissions (Swinbank, 2009). There are two good examples in the EU as to how the taxation rates are being applied and, in recent times, even reversed due to their impacts on the market. In the United Kingdom (UK), the incentive from the Energy Taxation Directive was used to stimulate the industry by allowing an abatement of 20 pence per litre of ethanol and biodiesel for road transport, which the government has promised to maintain until at least 2010 (HM Government, 2009). The conditions for obtaining this tax reduction are strict in that the producer needs to pay the appropriate duty to the HM Revenue and Customs and, only after proving that the fuel indeed complies with the definition and sufficient tests have been carried out to prove this, will the tax rebate be allocated (Swinbank, 2009). Germany, on the other hand, has always showed good support for renewable energies and, as a result, B100 was for a long time completely exempt from any duty. In 2004, this duty concession was extended to include other fuels, such as B5, which in turn had an expanding impact on the market (Swinbank, 2009). The introduction of mandatory blending rates has led to a reduction in the tax relief for biofuel producers and it is planned that the relief will be completely phased out by 2012. This entails that the biofuel duty will increase from a level of € 0.09 per litre in 2007 to the full € 0.45 per litre in 2012 (Agra Europe, 2006).

It is interesting that some countries, such as Germany and even France, are moving into a policy framework of taxing biofuel production when mandates are in place, while others, such as the UK and the US, are attempting to make the industry more

profitable by increasing incentives by improving the tax incentives for biofuel producers.

2.2.3 Import tariffs and protectionism

Import tariff protection is a critical policy when an infant industry is being developed and these measures are widely used to protect the domestic agricultural and biofuels industries as well as to support local prices and provide an incentive for domestic production (FAO, 2008).

Tariff protection varies widely across the world with countries changing their tariff applications as needed. Table 2.3 gives a clear representation of those nations that have some form of import tariff in place. Among these nations are those that are establishing their markets but are still vulnerable to imports.

Table 2.3: Import tariffs applicable in various countries, 2007

Country or country grouping	Applied MFN tariff	Exceptions/Comment
Australia	5 % + AUS$ 0.38/litre	US,NZ
Brazil	0 %	Reduced from 20 % in 2006
Canada	CAN$ 0.0492/litre	FTA partners
Switzerland	SWF 35/100 kg	EU, GSP
US	2.5 % + US$ 0.54/gallon	FTA partners, CBI partners
EU	€ 0.192/litre	EFTA, GSP

Notes: Tariff rates on 1 January 2007.
MFN=Most Favoured Nation, FTA=Free Trade Agreement, EFTA=European Free Trade Association, GSP=Generalised System of Preferences, CBI=Caribbean Basin Initiative
Source: FAO, 2008

Biofuel imports to the US are subject to a tariff of US$ 0.54/gallon (14.3 US¢/l) and an ad valorem duty of 2.5 %, and the countries that are exempt from this are the FTA partners of the US as well as the CBI members, which include the 24 Caribbean countries; among others, Costa Rica, Dominican Republic and Haiti (United States Trade Representative, 2009). This has resulted in nearly 33 % of all the Brazilian ethanol exports in 2006 destined for the US market being diverted via the Caribbean

in order to avoid the tariff. Rules of origin issues were avoided by dehydrating Brazilian ethanol in the Caribbean from a hydrous content of 5 % to 1 % (De Gorter & Just, 2007 a).

The EU has also evolved to include stringent import protection measures for some types of biofuels and most notably ethanol, which at present is subject to a 45 % ad valorem tariff; whereas the import duties on other imported biofuels, such as biodiesel and vegetable oil are much lower (Swinbank, 2009). At present, bioethanol is traded as either undenatured or denatured with an MFN tariff rate of € 19.20 or € 10.20 per hectolitre, respectively. The most recent ethanol imports that entered the EU were duty free under three main trade schemes, which included super GSP, Everything but Arms (EBA) as well as the Cotonou Agreement for ACP States all with zero or no quantitative restrictions (Commission of the European Communities, 2006). Biodiesel, on the other hand, faces an MFN import tariff of 6.5 % but there have been reported cases where the product will be imported as a vegetable oil rather than biodiesel; as a result, it enjoys far lower import duties with palm oil for technical and non-food industrial use entering the EU free of import duty and crude soybean oil with a tariff of 3.2 % (Swinbank, 2009). The level of tariffs for bioethanol is to be negotiated and could face reductions under the Doha Agreement on Agriculture but since biodiesel has not been included under the existing agreement it has a rather uncertain WTO status, so any tariff reductions would probably be agreed to in the non-agricultural market access negotiations (Swinbank, 2009).

In short, there are two trade policy dilemmas that need to be mentioned. On the one hand, it becomes evident that if the use of biofuels is encouraged in one jurisdiction but not in another, by either tax rebates or subsidies, then there will be an incentive for producers to ship biofuels to the economy where they can take advantage of

these concessions. As a result, the policies of developed countries are likely to encourage the imports of biofuels which could have been utilised more efficiently in the country of production. This might result in the countries that cannot compete with the generous concession that the developed countries are offering to export biofuels to nations where these can be attained, forcing them to import higher volumes of fossil fuels (Swinbank, 2009). The second trade policy dilemma that Swinbank (2009) refers to is "[b]y granting tariff concessions on the import of products from some countries, but not from others, in the context of GSP, economic partnership agreement (EPA), etc., trade distortions are introduced into the global economy that the preference receiving nations are keen to see maintained". He further suggests that the correct way of dealing with this issue would be to slowly wean recipients off their dependence on protected markets by having the importing nations reduce their MFN tariffs and as a result open up their markets.

2.3 The biofuel policy development process

Biofuel policy development processes have taken place in many different forms and ways with some countries pursuing goals of energy independence, job creation, increases in household income, reduction in oil imports, thereby creating a cleaner and more environmentally friendly energy sector. Other countries pursued strategies related to biofuel production in order to secure the local market against erratic oil price volatility and by implementation, bolstering the success of agricultural industries. In Brazil, for example, the *Proalcool* program safeguarded the largely privately-owned sugar industry (Cordonnier, 2009).

The Brazilian ethanol experience dates back to the early 1930s, when ethanol was first blended into the local petrol supply. The next big development in the industry did however occur together with the establishment of the *Proalcool* programme in 1975.

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The *Proalcool* programme was established in a time of great flux in the sugar industry. With extremely high oil and petrol prices at the time, the government took action to stabilise sugar prices and reduce the negative impacts that high oil prices had on the Brazilian economy. A proactive approach was followed in order to secure success of the programme and in 1974, a year before the implementation of *Proalcool*, it was ensured that enough alcohol production plants had been converted to ethanol distilleries with an overall production capacity of 625 million litres per annum (Cordonnier, 2009). In addition to developing the production capacity of ethanol prior to the implementation of the mandate, the Brazilian government brokered an agreement with the large automobile manufacturers in order to ensure that there was a constant production of vehicles capable of running on an E100 blend.

In 1979, a major agreement was reached between the two parties which created a protocol that defined the aims of mass producing ethanol-only vehicles (Cordonnier, 2009). Following the correct policy development process and making sure that measures on both the demand and supply side are in place has made the Brazilian ethanol program one of the most successful biofuel policies in the world. The programme was so successful that by 1985, the mandate was raised to 10.7 billion litres. This was achieved by the production of a number of new distilleries, increasing the capacity available and by signing the protocol with the car manufacturers resulted in 85 % to 90 % of all new cars being solely powered by ethanol. The Brazilian ethanol programme has, however, not been without its problems. The subsidies and tax incentives provided to the industry, following the 1979 agreement, proved problematic as they were based on the assumption that oil prices could remain high in the long run. The 1986 collapse of the oil price and the elimination of subsidies proved problematic for the industry as rising sugar prices led to a scarcity of ethanol (FAO, 2008). Over time, the government incentives of the industry were dismantled

and in 1990, the Sugar and Ethanol Institute was discontinued. This led to the gradual transfer of production, distribution and sales activities to the private sector which responded by diminishing the use of hydrated ethanol in the fuel mix. The maintenance of the blending mandate did, however, still offer some form of support to the industry (FAO, 2008).

The American approach to the policy development process for biofuels was somewhat different. The first idea of biofuels and implementation thereof also started in the early 1970s, when the first and second oil shock prompted US policy makers to investigate agriculture as a potential of supplying feedstock for energy production. The process even went as far as passing legislation to encourage the production of renewable energy and fund research of developing ethanol, biodiesel, solar, wind power and by-products (Duffield, 2006). In addition to searching for alternative means of producing energy, the US Government also set standards and developed policies aimed at conserving energy. US households became more energy efficient, US farmers consumed 25 % less energy between 1978 and 1993, energy efficient building standards were put in place and government vehicle fleets were required to purchase renewable fuels for their vehicles (Duffield & Collins, 2006). US energy concerns did, however, become more of an issue again in the late 1990s and by 2001, uncertain energy supplies and homeland security concerns triggered policymakers to intensify their efforts in order to secure long-term energy resources.

The policy development process for biofuels in the US commenced in all earnest in 2000 when the USDA directed farm policies at energy production with the provisions made in the USDA's FY 2000 Appropriations Act. This Act and the Commodity Credit Corporation Bioenergy Programme (CCC) were initiated to firstly stimulate demand and secondly alleviate crop surpluses, which were contributing to low crop prices and having an impact on resultant low farm income levels (Duffield & Collins,

2006). The government further initiated other Acts and programmes, such as Title III of the Agricultural Risk Protection Act of 2000 which aimed at agricultural and energy secretariats to cooperate and coordinate the policy development process in order to promote the research and development leading to the production of bioproducts. It was, however, not until the initiation of the 2002 Farm Bill that the USDA received any funding regarding its energy development capacity. A number of policies in the 2002 Farm Bill were aimed at stimulating research of biofuels and, in so doing, developing the capacity and knowledge of the industry to its fullest extent. Programmes such as the Federal Biobased Product Procurement Preference Programme (FB4P), the Biodiesel Fuel Education Programme, the Renewable Energy Systems and Energy Efficiency Improvement Programme and the Value Added Grant Programme (VAGP) all aimed at supporting biofuel initiatives and processes either through grants or loans with the long-term goal of generating extensive research capacity, improving understanding of biofuels and addressing a wide range of biomass production issues and biorefinery production processes (Duffield & Collins, 2006). Various papers mention that the renewable energy sector as well as the agricultural sector did help in shaping the framework of the current legislation and this becomes clearly visible when analysing the long-term nature of the legislative policies, such as the scope of the Renewable Fuel Standards (RFS).

The EU has always imported vast amounts of oil in order to fuel its transport system, which, in turn, is almost completely dependent on oil. Most of the oil is imported from nations with some forms of political instability and therefore supply security has always been a major issue. Biofuels in the EU had become of interest in the 1990s. This interest became more serious in 2001, and in 2003, the Commission brought forward a legislative proposal in the form of the biofuels directive, Directive 2003/30/EC on the promotion of the use of biofuels and other renewable fuels for transport, and Article 16 of the energy taxation directive titled Directive 2003/96/EC

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restructuring the Community framework for the taxation of energy products and electricity (Commission of the European Communities, 2006). The Commission approached the topic and use of biofuels in a very cautious manner expressing its intention with respect to biofuels as contributing to meeting climate change commitments, promoting it as an environmentally friendly security of supply and the overall promotion of renewable energy resources (Commission of the European Communities, 2006). A part of the cautiousness with respect to achieving the renewable energy directives is that various targets had been set during the early phases of the programme in order to establish if actual achievement of biofuel targets was indeed possible. It was only later recognised that a strong system of targets, or perhaps even mandatory ones, were indeed necessary in order to ensure that the targets as set out by the directive could actually be achieved. The objectives of the EU Directive on biofuels are also supported by measures under the CAP or Common Agricultural Policy. The idea behind this was to break the link between payments made to farmers and the particular crops they produce and as a result the programme allows these farmers to take advantage of new market opportunities such as those offered by biofuels. Farmers could now use the previously set aside land to cultivate non-food crops and could claim an energy crop credit which is available to all member states. The EU did however set "cross compliance" criteria which make payments to farmers conditional with respect to complying with environmental legislation and other sustainability standards (Commission of the European Communities, 2006).

In the EU the achievement of renewable energy, especially in terms of biofuel targets, proved to be the greatest challenge. The targets set out by the EU included an interim target of 2 % share of the market for petrol and diesel in 2005 and a 5.75 % target set to be achieved in 2010. The targets proved difficult to achieve and in 2005, only 2 out of 21 member states accomplished this, with Germany leading the

way and achieving 3.8 % and Sweden also achieving a target of 2.2 %. It was interesting that the Commission mentions that the lack of obligations or requirements for member states to take "appropriate steps" to achieve the required targets in 2005 definitely had a role to play in the low compliance rate (Commission of the European Communities, 2006). According to the Commission, future targets are also not likely to be fully achieved with, at that time, various models depicting various shares that biofuels will hold with respect to fossil fuels. In various analyses models were consulted with the PRIMES model depicting a share of 3.9 % in 2010 and the Green X model depicting a share of around 2.4 % (Commission of the European Communities, 2006). In 2009, *The Directive on the Promotion of the Use of Energy from Renewable Sources* was adopted by the Council and is to be implemented in 2010. The Directive varies strongly from the previous one in that it is more substantial and stricter with respect to the targets that need to be achieved. The Directive, for example, sets out that each Member State is required to ensure that the share of energy from renewable sources in all forms of transport in 2020 is at least 10 % of final consumption of energy in transport in that Member State. The Directive further states that expectations are that first generation biofuels will be used to meet these standards, but a compromise has been reached which states that a double weighting of 2 will be given to second generation biofuels in meeting the 10 % target, while renewable electricity used in road transport will be given a weighting of 2.5 (Swinbank, 2009).

The policy development process in the EU has also taken the impact that such mandates and other support measures may have on other agricultural sectors in other parts of the world into account. The directive has therefore gone one step further to include a framework that regulates the production of bioenergy material and forces producers to ensure that their production processes are sustainable in the long run. Article 17 of the European Parliament's first reading set a number of

sustainability standards. These criteria have committed the Commission to producing biennial reports on social sustainability, the impact on "the availability of foodstuffs at affordable prices" and land use rights (Swinbank, 2009). These include:

- Greenhouse gas emission saving of at least 35 %, deferred until April 2013 for installations in operation in January 2008, increasing to 50 % in 2017 and 60 % for new installations operative from 2017.

- Not produced on land with "recognised high biodiversity value" in or after January 2008.

- Not produced on land with "high carbon stock" in January 2008.

- The Commission shall report every two years on the impact of social sustainability in the Community and third countries of increased demand for biofuel, and on the impact of EU biofuel policy on the availability of foodstuffs at affordable prices, in particular, for people living in developing countries, and wider development issues. Reports shall address the respect of land use rights.

2.4. Rethinking biofuel policies

The link between the biofuel policy implementation process and factors such as higher food prices, indirect land use, and deforestation have been analysed in detail by various researchers. However, alternative sources of energy, energy independence, development of the rural economy and foreign currency savings have also all been used as arguments by various government and lobbyists, in order to gain support for energy from agricultural feedstock. Sparked originally by an upward trend in energy prices, alternative sources of energy and diversification of the local energy supply are deemed as vital mechanisms if economies wish to survive future bouts of extremely high energy costs. In order to establish an industry, some form of support mechanism needs to be in place, especially if the industry is still in its infancy and at risk from other more competitive economies.

The policies and legislation that support biofuel industries have not gone without criticism. Arguments that various support policies have not reached their desired goals and have in fact had a negative influence on the economy have been very common, especially in the EU. Reports, such as the Gallagher Review, are one of the examples in which biofuel supporting policies are criticised. The Gallagher Review, for example, labels the EU biofuel target, which aims to include biofuels by as much as 10 % of the total transport fuel mix by 2020, as extremely high and even unattainable. The review further proposes a strong revision of targets so that the negative impact that biofuels have on food price inflation is curbed. Others, however, argue that this is not necessary, since countries such as Germany and France are already well on their way in terms of obtaining their set targets and can thereby contribute to a more energy secure environment (Hart, 2008).

The arguments that implementation of programs for biofuels have indeed led to higher international food prices have been widely researched. Various reports by renowned research institutes have looked at these issues. These institutes include the World Bank, the Organisation for Economic Cooperation and Development (OECD)/the Food and Agricultural Organisation (FAO), the International Food Policy Research Institute (IFPRI) as well as the United States Department of Agriculture (USDA), all of who concluded that biofuel production did have some form of impact on food prices. The results that these institutions put forward did, however, vary drastically. The World Bank, for example, estimated that the biofuel policies in developed countries had a 75 % share in the increasing global food price index between January 2002 and February 2008, while the OECD/FAO estimated the share in the increasing food prices as being around 42 % for coarse grains, 34 % for vegetable oils, and 24 % for wheat, while IFPRI put its estimates of the impacts closer to 39 % and 21 % to 22 %, for maize, rice and wheat, respectively (Mitchell,

2008; OECD, 2008; von Braun, 2007). The USDA had the estimate with the lowest finding, putting the impact of maize ethanol on food prices at no more than 4 % (Westhoff, 2008). Higher prices did seem to be the most logical occurrence, since a higher demand for a commodity results in a drawing down of stocks and therefore a relative scarcity. Higher agricultural commodity prices do also have some positive aspects. Schmidhuber (2006) argues that higher real prices in agriculture, possibly caused by an increasing demand for commodities from biofuels, will have numerous effects on rural areas, rural industries and food security. He further argues that higher prices will help revitalise rural economies, reduce poverty, raise overall incomes in rural areas, create employment opportunities and help in creating a global renaissance for agriculture. Schmidhuber (2006) does however caution that any biofuels policy should be developmental in nature and in so doing help ensure that the growing use of bioenergy in the rural communities results in poverty reduction and hunger alleviation.

In economics, it is unusual that a single factor would be the sole reason for an action, as in most instances, factors are usually subject to some form of correlation. This is particularly true for commodities, as evidence indicates that the ever-increasing oil price prior to June 2008 resulted in the increase of prices of other minerals, such as gold and platinum, as well as prices of agricultural products, such as coarse grains and oilseeds (Oilworld, 2008). Higher oil prices and concerns over future energy reserves as well as local concerns over inflation resulted in increased searches for alternative energies, among which biofuels are an alternative. Governments then attempted to speed up the biofuel production processes by supporting the industry with policies such as mandates, subsidies and tax incentives and, by doing so, this linked the energy and agricultural sectors even more strongly. Increasing oil prices then increased agricultural commodity prices, and the more the oil price rose the more realistic it seemed to support the research and development of alternative

energies. Higher food prices fuelled fears of high local price inflation and, as a result, some governments imposed export restrictions on agricultural commodities destined for the international market, which in turn added to the already undersupplied world market and put upward pressure on prices. In addition to export restrictions in, for example Argentina and Thailand, some parts of the world experienced extreme droughts which even further restricted international availability. Given these events, it might seem unrealistic to shift all the blame onto biofuels, as other variables were just as much the cause. It was, however, perhaps the use of policies, be it in a restrictive or supportive sense, which fuelled the severe changes in commodity correlations and created artificial shortages, even though local inflation rates might not have been threatened.

Government policies have, to a large extent, played a part in driving food price inflation. However, it needs to be remembered that these were implemented on the basis of higher international commodity prices, including raw materials, such as oil and other minerals. In a state of anxiety, governments around the world reacted quickly to higher commodity prices by implementing policies that would protect their economies more from the higher price scenarios that played out in other parts of the world. Protective policies, such as price controls and export restrictions, are then perhaps not the best options that governments should resort to in order to prevent price escalations.

The policies that can be implemented to deal with the overall impact of severe price escalation can be categorised into three different "time" zones, namely the short term, the medium term and the long term. In the short term, governments should deal with the crisis immediately. In other words, if humanitarian aid was required before the price surge then efforts to deal with it during such a time should be increased dramatically. Food aid schemes can be implemented differently, with

some of the options being direct cash transfers to the poor, food for work programs as well as school feeding programs (Mitchell, 2008). In the medium term, attempts should be made to increase the purchasing power of poor food buyers in the affected countries, and this fundamentally requires an improvement in the growth and development of these countries' economies. It could, therefore, well turn out that the best method of dealing with these situations would be to directly invest in agriculture and to stimulate economic activity (OECD, 2008). In order to achieve this type of stimulation within the economy and within the agricultural sector, factors such as an improvement of the basic governance system, infrastructure, technology, health, education and macroeconomic policy should be dealt with. In addition to this, policies that restrict trade and distort market movements are equally undesirable. In the short term, export taxes and embargoes may bring relief to the domestic consumers, but this is short lived, as in the medium term they create a shortage in the international market that will increase prices even further (OECD, 2008). In fact, these border protection mechanisms burden the poor consumers more severely as they add an additional cost to already higher food prices making the local food price situation even worse. On the other hand, cutting back on these regulatory measures impacts severely on the government's fiscus, which in turn, have an impact on the government's overall wealth as well as its ability to implement improvements on local projects. One school of thought that focuses more on the longer term is that the most competitive producers should be given the opportunity to respond to these prices by making use of their competitive advantage. The feeling is that this can be achieved primarily by finding a quick and ambitious conclusion to the Doha Round of negotiations at the WTO (OECD, 2008).

Higher food prices are a clear burden to poor net purchasers of food, but they also present an opportunity to stimulate food grain production and enhance the contribution of agriculture to medium-term growth. In addition, investments into

agriculture by governments, private sector and donors are also generally helped by higher agricultural commodity prices (Mitchell, 2008). Is the argument that medium-term policies are non-beneficial to developing countries not contradictory in nature? On the one hand, higher food prices result in hasty actions by governments and the implementation of protective policies, which in turn, not only have negative impacts on international commodity prices but also on domestic prices and therefore do more harm than good in the medium to long term. On the other hand, agriculture has lacked any significant investment mainly due to it being a low growth industry with little or no expansion potential, mainly due to lower producer prices. Was this the reason then and not the cause of the biofuel development in the US and Europe? Another policy used to counter the problem of over production and lower prices was the grain buffer stock policy in the 1970s and 1980s. This policy had the objective of taking grain out of circulation in years of lower prices and would release this grain back into the market in years of higher prices. High fiscal costs, together with difficult management and governance issues, made the benefits that this policy had on household food security unconvincing (Mitchell, 2008). Creating an alternative demand for grains therefore seemed to be a better solution and could in fact bring with it increased benefits for the rural community. Can it then not be argued that biofuels do indeed hold some form of opportunity for developing countries, rather than a threat? Is this not the place and time during which the use of biofuels as an additional market should be exploited by governments and members of rural communities in developing countries? As mentioned previously, investment in agriculture by means of infrastructure, technology, governance structures and education can improve the competitiveness and functioning of the sector and with that improve the situation of the rural communities (OECD, 2008). So perhaps biofuels are an opportunity to invest and ensure that there will be positive returns from such investments.

2.5 Conclusion

The development of biofuel production has been successful in many parts of the world, in both developed and developing countries. China, Brazil and Argentina are, together with a few other countries, among those in the developing world where biofuel production is taking place and developing, both on a small and large scale. At present, Brazil is the world's second largest ethanol producer, with approximately 22.03 billion litres produced in 2008, and the world's biggest ethanol exporter, trading approximately 3 809 million litres in 2008 (FAPRI, 2008). Biofuel development has also taken place in China, making it the second largest exporter, trading approximately 442 million litres and producing around 1.6 billion litres in 2008. In addition to the biofuel production that is already in place, China's ethanol production is set to expand dramatically within the next couple of years, once all the projects that are underway come into production. In terms of biodiesel production, it is projected that developing countries such as Indonesia, Argentina and Brazil will become major world players. Indonesia, where the main oil source is palm oil, is expected to achieve an output of 400 million litres by 2010 while production in Brazil is expected to reach 2 billion litres by the same year. Argentine biodiesel production is also expected to increase to 1.1 billion litres by 2010; and from there on increase at a far slower rate (FAPRI, 2008). Both South American countries are using soybean oil as their major feedstock, due to its availability and the local expertise that have mastered its production.

Biofuel development in the first world has also developed rapidly, with the US and the EU contributing the most to the overall quantities produced and also having to blend most of the ethanol produced. The US is at present the world's largest ethanol producer with 42.35 billion litres produced in 2008, while the EU also produced some 4.88 billion litres domestically. Both these countries are extremely large ethanol

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consumers and, in most years, ethanol consumption, due to mandates, outweighs ethanol production, and hence the remaining quotas need to be imported. In 2008, ethanol net trade in the US amounted to 1.6 billion litres while net trade in the EU amounted to approximately 250 million litres (FAPRI, 2008). Projections indicate that ethanol production in these countries will not be able to keep up with demand/mandates and hence these markets will have to rely increasingly on the biofuel exporters for supply. In terms of biodiesel production, both these countries are already dominant producers. Biodiesel production in the US is already close to 2 billion litres but is expected to decline as human consumption of soybean oil becomes more profitable, while biodiesel production in the EU reached 5.8 billion litres in 2008 and is expected to increase further as biofuel targets need to be met (FAPRI, 2008). The main source of vegetable oil for biodiesel production in the EU is rapeseed oil and the Member State with the largest production is Germany. Policy reforms and lower oil prices could well signal a movement away from biofuel in the short term, but in the longer term alternative energy production, be it in different forms, could well be a necessity to consider. There is always the hope that the second generation, cellulose to ethanol technologies, will become viable, but at present, the costs of production are just too high and therefore uneconomical.

The biofuel policy development process in various countries has also not gone without its challenges. In Brazil, the *Proalcool* programme offered price stabilisation and had also in the past stabilised prices and made the industry rather dependent on its existence. In following the correct approach, the government created a market by ensuring an uptake of the ethanol from the government-owned oil company *Petrobas* and also brokering a deal with automakers in order to ensure that the Brazilian consumer was able to consume the product directly. The US has followed a somewhat different approach. Farmer groups, lobbyists and other agricultural interest groups among others had a strong role to play in shaping the framework of

the current policy. The government implementation of the programme at first resulted in relatively high economic profits being realised and the implementation of the Renewable Fuel Standards (RFS) offered a very healthy cost-to-income ratio, which in turn resulted in a considerable expansion of the industry, and sooner rather than later the blending wall was reached. Increasing the national blending amount to anywhere above 10 % is a challenge as the lack of compatibility with the vehicle fleet can and will cause problems in the market's ability to use the additional biofuel. Either way, the RFS calls for additional expansion in the quantities of biofuels produced, which is bound to cause some concerns in the future. The EU approach to biofuels has been more cautious. At first, targets were implemented, which in turn were not binding, but with higher oil prices and individual commitment by certain member states, for example Germany, certain quantities of biodiesel were produced. However, a lack of direction in terms of structured biofuel mandates has led to a lack of commitment from various other Members and the latest Directive does indicate that this has changed, and more commitment is sought in order to achieve future goals. The EU has also taken a stance on indirect land use and sustainability criteria and has made provision that in case the adaptation of blending mandates and the creation of a market will have further reaching impacts than just the local developments, a set of sustainability criteria has been put in place in order to curb and control these effects.

The policy development process for a new and infant industry is one of commitment, learning, further development and refinement. Brazil has shown that the correct approach can lead to a sustainable industry. The US has shown that the implementation of a policy can be profitable at first but if the market is not quick enough to adapt problems can occur. The EU has shown that a cautious approach is reasonable but not sustainable and that solid goals and objectives need to be in place. In a few instances, there have been policies that did not have the desired

outcomes. Targets were not reached and environmental goals were not obtained; but why did this occur? Could it be that the policy development process was strongly influenced by lobby groups, either pro or anti biofuels, environmental groups with concerns regarding climate or food aid groups concerned about the impact of the policy process on food aid availability?

Chapter 3 explores the first set of factors in the South African context that could have had an impact on the policy development process. These include the choices that the government had to take in its decision-making process with respect to the risks that it was facing as well as the influence that it was receiving from other parties; all of which had or desired some form of stake in the industry. The interaction of the governmental departments responsible for the policy development process is portrayed by a simple game theoretic model in which payoffs and strategies are analysed. The game portrays the payoff that the role players should have obtained and this game is rerun to illustrate, by use of the Z variable, the point at which the various governmental departments currently find themselves.

Chapter 3

Game theory: Government games

3.1 Introduction

Biofuel production in South Africa seems to be profitable, even without government intervention, provided certain innovative approaches are followed (Matthews, 2009). Without such innovations and applications, such as vertical integration in the supply chain and the penetration of a non-transport fuel market, it seems that government support will be required if the industry is to develop at all. The Department of Minerals and Energy (DME), with its new name the Department of Energy (DoE), was tasked to develop and propose a strategy that could assist the government in developing such an industry and in addition achieve a number of other political goals in the process. These goals, among others, included rural upliftment and development through better market access and higher prices as well as meeting renewable energy targets as set out in the White Paper on Renewable Energy in 2003. The achievement of these goals has proven to be somewhat more complicated as other governmental departments also hold a stake in the agricultural industry and they too have goals to fulfil which are not necessarily in line with those of the other departments. Governments, however, also take a risk when they adopt a specific set of new policies. On the one hand, the government runs the risk of implementing a policy that comes at a too high cost, which in turn can have a severe financial impact on the greater economy due to welfare costs to the consumer and higher food prices. On the other hand, the government runs a risk of not achieving anything by implementing a policy that is not significant enough. As a result, the government achieves nothing other than frustration of role players, inefficiency in the market and a lack of rural development. Such a variable needs to be taken into consideration when modelling the game as it has been perceived that such a variable

has had a definite impact on the current situation that is being played out in the South African biofuels industry.

The question that comes to mind is how did the 'other' government departments, namely the Department of Agriculture, Fisheries and Forestry (DAFF) and the Department of Land Affairs (DLA), react to the proposed biofuels policy? The DAFF took a stance on food security and reacted to it by showing its concerns. It therefore did not embrace the policy and countered it by choosing to argue that food security was at risk if it was implemented. The DLA, on the other hand, continued to pursue its task of implementing land reform and restitution and rejected active participation in the policy debate process out of fear that it would negatively impact on its transformation goals that it wants to achieve.

The aim of this chapter is therefore to develop a game theoretic model that explains the reasons why the three government departments all with a stake in agriculture have reacted as they have to the Industrial Biofuels Strategy[1] (IBS) of the DoE. The game is sequential as DAFF and the DLA have only taken a stance on the issues after the IBS was released. Sets of policy alternatives are represented thereafter which could assist the industry in becoming a self-sustained enterprise within the agro-processing sector.

3.2 Game Theoretic Applications

Game theory or a strategic game represents a form of interaction between decision makers which in turn are often referred to as players. Each one of the players in the game has a set of possible actions, which he or she would like to follow. A strategic

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[1] The Industrial Biofuels Strategy refers to the governmental action plan that has been released in order to regulate the development of the industry in South Africa. From here on it will be referred to as the IBS so as to not create confusion with the terminology used in game theory.

model captures the interaction between the players by allowing each player to be affected by the actions of all players and not only by his or her own action. Each player has specific preferences about the action profile, which in turn represents the list of all the players' actions (Osborne, 2004).

Game theory models vary widely, depending on the context in which they are used. The structure of the interaction between various government departments, in the section that is to follow, can best be represented by a stylised sequential game with complete information. The structure of this game refers to a model in which two moves take place of which the second move involves a simultaneous move between the two remaining players. It is important to note that in a game of complete information the player's payoff functions are common knowledge. In addition, each player within the model also has perfect information about the history of the game, meaning that the player with the move knows the full history of the play of the game thus far (Gibbons, 1992). In order to understand what actions players will choose in a strategic game it is assumed that each player will choose the best for him, which in turn depend the other players' actions. The knowledge of what is best is derived from previous experiences in the game and it is assumed that the past experience is sufficiently extensive that the player will know how the other player will behave. Even though experience is assumed, players view the game in isolation and attempt not to take cognisance of how the other players will behave, the actions that they face nor does the one player expect her actions to affect those of the opponent (Osborne, 2004).

Thus, each player chooses her action according to the model of rational choice, given the belief about the other players' actions and in addition, every player's belief about the other players' actions is correct. These two components give rise to the Nash equilibrium, which is an action profile a^* with the property that no player i can

do better by choosing an action different from a_i*, given that every other player j adheres to a_j* (Gibbons, 1992; Osborne, 2004).

Game theory has been used extensively in the explanation of decision making, political motives and strategies as well as in economic applications. Authors such as Nash (1950), Ohndorff (1966), Borch (1967), Coddington (1967), Snidal (1985), Rasmusen (1990), Fundenburg and Tirole (1991) and Myerson (1991) have dedicated large parts of their academic careers to such game theoretic applications. The background to this specific application, however, stems from the work conducted by Snidal (1985), North and Weingast (1989), Barkema and Kelly (1991), Frank and Henderson (1992), Gibbons (1992; 1997), Horowitz, Just and Netanyahu (1996), Weingast (1997) and Osborne (2004). In their article, North and Weingast (1989) analyse the constitutions and commitments from 17th century England. The authors largely investigate the theory of credible commitments and reputation and in their analysis the sovereign's reputation forms a large incentive for him not renege. It is also mentioned that this approach has recently been formalised in models of modern game theory. The similarity between the role of the Department of Energy (DoE) in developing incentives in the Industrial Biofuels Strategy and the sovereign in the article, with respect to his commitments to his nation, becomes clear. Not only does either party want to build a solid and reputable image but also would like to create a sense of certainty amongst its colleagues that once he has made a move, he will not change or renege on his commitment. This similarity of these situations represented concluded that game theory might well be an appropriate application for such this specific analysis. Since the development of biofuel policies in South Africa have fallen under the control of the Department of Energy's control since 2003, it became clear that the DoE would be a first mover in the game and that a stylised sequential move game with perfect information be an appropriate fit for the modelling of the game (Gibbons, 1992; Osborne 2004). In Weingast (1997) a game theoretic

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approach is followed to model the problem of political officials' respect for political and economic rights of its citizens with reference made to the seventeenth century England, studied by North and Weingast (1989). A two stage model is developed emphasising the two independent impediments that the state faces, with the first stage studying the coordination problem resulting as a result of the sovereign's transgressions, while the second stage embeds the problem in a political context. The sequential model developed by Weingast (1997) thus illustrates well how the challenge of being the first mover in a game can be captured, which in the article referred to the sovereign's choice of transgressing. Again the similarity with the DoE became evident as the choice of strategy would also impact on the other players in the game. The second stage of the game in the Weingast (1997) article is an induced subgame. In this game, players A and B, who in turn represent two groups of citizen, are both directly affected by the actions of their sovereign. The sovereign therefore has an interest to anticipate his payoff based on the actions of his citizens, which in this case are limited to acquiesce or challenge. Amongst the citizens, A and B, it is also important for each one to anticipate how the other group will react and again similarities to the situation in the South African government are identified. For instance, the Department of Land Affairs (DLA) can expects its land reform projects to be more successful if the Department of Agriculture, Forestry and Fisheries (DAFF) focuses on rural development rather than if the focus is on food security, in which case policies on development take a back seat compared to policies related to trade and marketing of agricultural commodities.   Since the role of cooperation and coordination amongst government departments is also an extremely important function in this framework, articles by Barkema and Kelly (1991) as well as Frank and Henderson (1992), who apply game theory to the cooperation and coordination amongst producers, processors and consumers in the food supply chain, have also been considered as background information.

An investigation into the relevance of game theory as the appropriate application for this kind of research was supported by Snidal (1985) who mentions that game theory can be applied across a wide range of politics and that it offers a tool of expanding the rational actor models beyond the restrictions of the realists perspective to a more complex world where the concern is more an issue of cooperation rather than an issue of conflict, which in turn also indicates that game theory is appropriate to use. The fact that game theory is most applicable to problems involving contracts, cooperation and public goods, indicates that it is can also be appropriately used in the field of agricultural economics (Horowitz *et al*, 1996). Gibbons (1997) and Osborne (2004) provide the appropriate theoretical framework from which the format of such a game can be developed and it is from their work that the appropriate framework for the game is selected.

3.3 The Department of Energy

In November 2003, the DoE released a document in the Government Gazette titled the "White Paper on the Renewable Energy Policy of the Republic of South Africa". The document recognises that it is vital to invest an equitable level of national resources in renewable technologies, given their potential with respect to investments in other energy supply options. The document recognises the need for a certain percentage of the national energy demand to be met in the form of renewable energies and sets the DoE's goals on 10 000 Gigawatt Hours (GWh) of renewable energy contribution to final energy consumption by 2013, which should be produced mainly from biomass, wind, solar and small-scale hydro. The document further states that this energy is to be utilised for power generation and non-electric technologies such as solar water heating and biofuels. The document envisaged renewable energies to make up approximately 4 % of the projected energy demand for 2013, in other words, a total of 1667 megawatt (DME, 2003).

In December 2007, the DoE released its IBS in which it outlined the road map for biofuel production in South Africa. The goal of this IBS was to steer biofuel production into the right direction, i.e. one of self-sustained development. In addition, the IBS aimed at creating a policy environment in which the production of biofuels could occur without too much intervention and regulation. It was also hoped that the policy would generate enough investments so that the renewable energy goals, as set out in the white paper on renewable energy, would be met and achieved. Many industry role players felt that the IBS did not offer enough incentive to go ahead with multi billion Rand investments. The sugar industry, for example, is sceptical to consider an ethanol investment even though it might make economic sense when taking the feed-in tariff into account. Cutts (2009) commented that the main reason why the sugar industry would not invest in ethanol production is due to the non-existent ethanol uptake mandate, which in turn does not secure an off-take market. In addition, a relatively low level of import tariff for ethanol and a lack of import tariff for biodiesel also create an insecure environment as there is a strong possibility that cheap ethanol from Brazil might enter the country and take over the market share. Other biofuel investors rated the licence application process as being a main factor of concern. This is especially true for regions where location of the plant is determined by former homeland areas and as a result of ineffective government policies, agriculture within these areas is made up of uneconomical, subsistence farming practices. This means that farmers in those regions would by no means be able to supply feedstock to the biofuels plant even if prices were at above market levels. The failure of extension policies and their implementation by DAFF and the neglect of infrastructural development have strongly contributed to the failure of biofuel production developments in the specific areas.

With the White Paper on Renewable Energy in mind, together with the 10 000 GWh target to be achieved by 2013, it seems reasonable to assume that the DoE would prefer to see a development in biofuels rather than none at all. The resultant payoffs that they receive from pursuing an active biofuels policy are therefore greater than the payoff that they receive from a policy that results in less active developments. The DoE as the first mover in the game therefore, rethinks the current strategy and pursues one that offers greater returns for them, in terms of reaching their targets.

3.4 Department of Agriculture, Fisheries and Forestry

The Department of Agriculture, Fisheries and Forestry (DAFF) is, in the IBS, quoted as being one of the major stakeholders in the biofuel development initiative. In the IBS, the role of DAFF is portrayed as supporting the development of feedstock supplies through its existing support programmes, such as the Comprehensive Agricultural Support Programme (CASP), by increasing local agricultural production (DME, 2007). In addition, agricultural development on underutilised land will be prioritised for feedstock production and CASP will be steered in such a way that this is prioritised.

International developments in 2008 have resulted in the views on biofuels changing somewhat. The surges in international oil prices, together with a host of other factors, resulted in higher farm commodity prices as inputs and the demand for biofuels increased (Westhoff, 2008). Some countries reacted to this by restricting exports or reducing import barriers and, as a result, local prices were slightly reduced while international market prices increased further (Westhoff, 2008). In South Africa, concerns were raised due to the higher food price inflation with the National Agricultural Marketing Council (NAMC) reporting a food price inflation figure of 16.1 % in January 2009 and an overall year-on-year inflation index of 8.1 % for 2008

(NAMC, 2009). The hype that biofuels caused food price inflation to spike may have been one of the reasons why DAFF has taken a backward stance on the issue and has tried focusing its policies on the food security aspect, rather than on agricultural development. It is strange that DAFF would not support a situation with higher food prices but from previous occurrences in 2002 it became clear that an unexplained rise in food prices caused a major concern in government and raised issues as to how well agriculture is being managed. It is somewhat ironic as both food security and agricultural development go hand in hand and both of these aspects can only be dealt with sufficiently if, and only if, there is sufficient investment in the sector. To date, the DAFF's investment in the sector has been very small and it can be argued that the lack of action as well as the inefficiency of its policy and development programs have put South Africa's food security more at risk than if they had actively supported the initiative by the DoE on developing an additional off-take market for agricultural commodities.

In order for DAFF to achieve its goals on food security and rural agricultural development, it is important that the correct policies are first in place. Basic assumptions made with respect to the stance of agricultural development already indicate that if DAFF plays an active part in the biofuel industry's development process, economic conditions will improve, which in turn can help it to achieve the rural development and with that food security goals in the sector.

3.5 Department of Land Affairs

The Department of Land Affairs (DLA) focuses on the creation of vibrant, equitable and sustainable rural communities (Department of Rural Development and Land Reform, 2009). The mission of the DLA is to facilitate integrated development and social cohesion through participatory approaches, in partnership with all sectors of

society. In other words, the DLA's role is to uplift the rural communities and ensure that they are sustainable and vibrant, and that they can continue their daily lives in an economically sustainable manner.

The process of Land Reform is, however, not always successful. A 2008 survey by the University of the Western Cape's Institute for Poverty, Land and Agrarian Studies (PLAAS) indicates that the land reform programme in South Africa is suffering from severe difficulties. The survey found that just one project out of the 128 surveyed is producing a sustainable profit. A call to pair the claimants with commercial operators, often the previous land owners, is seen as one of the only ways in which these projects can become commercially viable. The report further indicates that support by government is inadequate and that in most instances "many, if not most" projects still do not receive the support they need to use the land productively (Institute for Poverty, Land and Agrarian Studies, 2008). This means that the support programmes, such as CASP and the Micro-Agricultural Finance Initiative of South Africa (MAFISA), are not as efficient as they should be as these projects are showing such a low success rate in terms of profitability and sustainability. It therefore seems that additional support and control is required if the land reform projects are to be successful.

According to the DLA, it is not mandated to offer post-settlement support to any of the land redistribution projects. However, at the current high rate of project failure it is surprising that the DLA would not want to be part of the process. If the DLA took an active role in ensuring success with the projects then surely the process would be viewed as positive and the DLA would be seen as succeeding in its role as a facilitator and mentor. It is for this reason that the DLA would embrace a biofuels initiative with strong incentives from the DoE, as this would spur on investment in the sector and if managed correctly could benefit many land reform projects, taken into

account that the mentorship role is not neglected. With such developments in place, the DLA's role would become easier as it could claim a successful land reform programme without suffering expending vast amounts of resources on securing this success. DLA's correct anticipation of DAFF's strategy is also vital as a higher focus on rural development by DAFF would inadvertently result in a higher success rate amongst the DLA's land reform projects. DLA's optimal strategy would thus be to require a rural development focus by DAFF and a high investment in biofuels by DoE. Higher profitability in agriculture automatically generates a wealthier rural community. This theory is also strongly backed by Schimdhuber (2006) as he argues that higher agricultural prices will have a positive impact on rural household incomes. Without such additional investments, the current programme will continue to fail. However, a low investment strategy for biofuels would mean that the DLA would move into an insecure environment in which the success of land reform projects is again subject to, amongst other factors, the profitability of the agricultural sector. It is thus in their best interest to not support a low investment strategy as it would probably not make a huge difference for them in achieving their goals and in addition bring uncertainty in an already insecure environment.

3.6 The Model

A sequential, stylised game is used to represent the interaction between the different government departments. The model represented here has similarities to those developed by Weingast (1997), Barkema and Kelly (1991) and Frank and Henderson (1992). The reason why the game has been structured in such a way is to capture what has occurred in the South African sector and why the various departments find themselves in their current positions. The purpose of the game is to show that the rural development and self-sustainability goals can be better attained, by both DAFF and the DLA, resulting in higher payoffs for them, if the DoE engages in a strong

incentive-driven IBS. There are some limitations to game theoretic models and these include its limitations as a basis for estimation as well as the risk of oversimplification. Furthermore, Horowitz *et al* (1996) found that game theoretic concepts are widely used implicitly, meaning that many models are analysed without drawing on the game theoretic underpinnings such as the standard moral hazard model of contracts.

The game features three players, each representing government departments that interact with the prospect of achieving their missions as set out by their respective strategies, as represented by Figure 3.1. If the two players that react to the strategies of the DoE and decide to support a strong investment in biofuels, then their individual payoffs are far higher, as they have only to play a facilitating role and not spend too much funding on development, as the incentives in the market take care of this. If, however, the DoE decides to pursue a strategy with far lower incentives, it means that the governmental departments shift their focus and become more concerned with other developments worldwide; and as a result, neglect the mission they have in the local economy. Their payoff is thus expected to be lower as their expenses increase and their success rate with projects diminishes.

DoE

High Inv Biofuel strategy   *Low Inv Biofuel strategy*

DAFF   **DAFF**

Food secure / *Rural development*   *Food secure* / *Rural development*

DLA   **DLA**

Support   *Reject*   *Support*   *Reject*   *Support*   *Reject*   *Support*   *Reject*

$$\begin{pmatrix} P_{E1} - C_A \\ v_1 - c_1 \\ v_2 - c_{4A} \end{pmatrix} \begin{pmatrix} P_{E1} - C_A \\ v_1 - c_1 \\ v_2 - c_{4A} \end{pmatrix} \begin{pmatrix} P_{E1} - C_A \\ v_1 - 0 \\ v_2 - c_{4B} \end{pmatrix} \begin{pmatrix} P_{E1} - C_A \\ v_1 - 0 \\ v_2 - c_{4B} \end{pmatrix} \begin{pmatrix} P_{E2} - C_B \\ v_1 - c_2 - c_3 \\ v_3 - c_5 \end{pmatrix} \begin{pmatrix} P_{E2} - C_B \\ v_1 - c_2 - c_3 \\ v_3 - c_5 \end{pmatrix} \begin{pmatrix} P_{E2} - C_B \\ v_1 - c_3 \\ v_3 - c_5 \end{pmatrix} \begin{pmatrix} P_{E2} - C_B \\ v_1 - c_3 \\ v_3 - c_5 \end{pmatrix}$$

Figure 3.1: Game theory model, government game

There is a cost involved for the DoE in implementing its IBS and this cost is lower in the case of the low investment strategy compared to the high investment strategy. The cost of the low investment strategy is therefore represented by C_B while the cost of the high investment strategy is C_A, where $C_A > C_B > 0$. Even though the cost is higher in the high investment strategy, the overall benefit and payoff that the DoE receives as a result of achieving its renewable energy targets is far greater than under the low investment strategy. The final payoff that the DoE receives under the high investment strategy is thus P_{E1} which represents the benefit received from national government when achieving its 2013 goals, while P_{E2} represents the benefits that are received from not achieving the 2013 goals, where $P_{E1} > P_{E2} \geq 0$. The total payoff is thus represented by $P_{E1} - C_A$ for the high investment strategy and $P_{E2} - C_B$ for the low investment strategy, where $P_{E1} - C_A > P_{E2} - C_B \geq 0$ and $C_A > C_B$.

As the DoE is the first mover in the game, DAFF and the DLA react based on the biofuels investment strategy that the DoE has followed. Under a high investment strategy, DAFF benefits more than under a low investment strategy as the costs of

investment are far lower with most of the rural development aspects being taken care of by the market and indirectly by the DoE's investment in biofuels. The payoffs for DAFF are thus as follows, $v_1 - c_1$ for securing food security under a high investment biofuels strategy and $v_1 - 0$ for improving rural development under a high investment biofuel strategy, where $v_1 > 0$. Investments in biofuels result in a far higher cost to DAFF as the department has to finance most of the development costs within the industry. Under the low investment in biofuels strategy, DAFF incurs a few more costs when it attempts to secure food supply in the country as this means protecting borders against cheap imports and improving rural development. As a result, their total payoff under a low investment strategy would be $v_1 - c_2 - c_3$, while focusing on rural development alone would be somewhat cheaper with a total payoff of $v_1 - c_3$. The total payoff for the high investment strategy $v_1 - 0$ is larger than the investment under the low investment strategy $v_1 - c_3$, as c_3 is larger than 0.

The DLA's strategy with respect to the strategy that is followed by the DoE is slightly different. This follows from the fact that it is at present not at all succeeding with its land reform programme, even with the significant amounts of money spent on purchasing farms according to the willing buyer/willing seller principle. Their strategy would thus be to support agricultural development in South Africa by any means possible with the hope that mentorship programmes, either through companies or other commercial farmers, will be the order of the day. If this occurs, the DLA's potential payoffs will be high as the success rates among redistributed farms increases dramatically, helping it to prove that land reform can be successful. If there is only a low investment strategy for biofuels, then the emphasis on a successful land reform programme falls on the DLA, which to date has struggled to achieve any rate of success with its projects (Institute for Poverty, Land and Agrarian Studies, 2008). The DLA's payoffs under a high investment strategy are thus $v_2 - c_{4A}$ with v_2 being the benefits that it receives from success in the land reform process and c_{4A} the cost

that it incurs in the land purchasing process, where $v_2 > c_{4A} > 0$. The success rate of reforming farms under a strategy where DAFF focuses on food security is slightly less than a strategy where DAFF focuses on rural development. Therefore, DLA incurs a cost of c_{4B} when the focus is on rural development and under that strategy money is saved, so $c_{4A} > c_{4B}$, as DAFF funds also support the DLA projects. Under the low investment strategy, the benefit that the DLA receives is very low as its success rate is almost 0 which is unfavourable to DAFF as such a low success rate impacts on the nation's food security status. In addition, the DLA has huge costs to cover as the various farms need to be purchased, and with a low success rate it is viewed that these funds are being wasted. The payoff structure is thus $v_3 - c_5$, where $v_3 < 0 < c_5$.

Given the structure of the benefits that the various governmental departments would receive from investing and supporting a high incentive biofuels strategy, it seems a bit confusing as to why they would opt not to take this route. The case for failure of other departmental programmes does seem to rest with the decision by the DoE to follow a low investment strategy, which at the time of writing the strategy, in 2007, was perhaps an over-cautious approach. Since then, international developments in agricultural commodity prices have caused concern for food security throughout the world and this together with a concern of the financial viability of biofuels world-wide have made a high investment strategy even more unlikely. The irony of the situation is that with a lack in investment and huge inefficiencies in the government, it is highly unlikely that the farmers who need the support the most will get it and as a result they might never be lifted out of their poverty trap.

3.7 The Game

It becomes clear from the investigations and from the reasoning in Section 3.6 that none of the governmental departments is currently at the Nash Equilibrium[2] (NE) in the game. It is the aim of this section to explore where exactly the NE finds itself and why it would be to the advantage of the different departments to move toward those points.

The game indicates that there is a clear NE and, theoretically, that should be the point at which all players in the game should not want to deviate from. The actual equilibrium at which all the government departments would receive maximum payoffs, be these in terms of recognition or measured in success, is if they follow this terminal history: (HI Inv BFS, Rural Development, Support). At both endpoints on this terminal, the agricultural sector, commercial and small scale, will benefit most; as an incentive to spur on the development of an additional agricultural processing industry far surpasses any current agricultural development programmes. In addition, renewable energy targets are met at a time when South Africa needs to show the world that it is serious about reducing its carbon footprint and that it wants to adhere to the guidelines laid out in Copenhagen in 2009.

The game tree in Figure 3.2 indicates just how crucial the governmental policies are in ensuring stronger economic development in the South African agricultural sector. A low investment strategy for biofuels results in almost no rural development and also does not improve the food security situation, as a strain on development and an unsuccessful land reform programme are having negative impacts on agricultural production in South Africa. In addition, the DoE does not meet any of its renewable energy targets and this will result in South Africa being seen as a strong polluter in

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[2] A strategy profile from which no player wishes to deviate, given the other players' strategies.

the developing world. It should however be mentioned that the low investment biofuel

strategy does represent a safer strategy to follow, for the DoE as it will cost very little

to implement and if the industry takes off, the DoE will be seen as having achieved its

targets with very little additional government spending.

DoE

High Inv
Biofuel Strategy

Low Inv
Biofuel Strategy

DAFF

Food secure

Rural development

DLA

Support

Reject

Support

Reject

$$\begin{pmatrix} P_{E1} - C_A \\ v_1 - c_1 \\ v_2 - c_{4A} \end{pmatrix}$$
$$\begin{pmatrix} P_{E1} - C_A \\ v_1 - c_1 \\ v_2 - c_{4A} \end{pmatrix}$$
$$\begin{pmatrix} P_{E1} - C_A \\ v_1 - 0 \\ v_2 - c_{4B} \end{pmatrix}$$
$$\begin{pmatrix} P_{E1} - C_A \\ v_1 - 0 \\ v_2 - c_{4B} \end{pmatrix}$$

DAFF

Food secure

Rural development

DLA

Support

Reject

Support

Reject

$$\begin{pmatrix} P_{E2} - C_B \\ v_1 - c_2 - c_3 \\ v_3 - c_5 \end{pmatrix}$$
$$\begin{pmatrix} P_{E2} - C_B \\ v_1 - c_2 - c_3 \\ v_3 - c_5 \end{pmatrix}$$
$$\begin{pmatrix} P_{E2} - C_B \\ v_1 - c_3 \\ v_3 - c_5 \end{pmatrix}$$
$$\begin{pmatrix} P_{E2} - C_B \\ v_1 - c_3 \\ v_3 - c_5 \end{pmatrix}$$

Nash Equilibria

Figure 3.2: Game theory application, original government game

The NE situation in Figure 3.2 seems to be the best option for all the governmental

departments. When following this strategy, the DoE achieves part of its renewable

energy goals and even though the investment in the sector is more expensive than

under the low investment strategy, its effects are further reaching. DAFF, for

example, does not have to invest any money in rural development as the strategy

spurs on investment and this in turn develops rural areas while food security is far

less of an issue with increased agricultural productivity and better infrastructure. The

DLA also benefits substantially from this situation as an increase in the demand for

agricultural commodities improves rural development and with that the new farm owner's rationality with respect to the degree of mentorship that needs to take place so that the farming enterprise becomes economically profitable. With this type of investment, there is a strong possibility that the profitability of land reform farms can increase and that the success rate of farms will improve. It is therefore optimal for all these departments to pursue such a strategy as the developments within the market should take care of most infrastructural adaptations.

The Nash Equilibrium thus holds when $P_{E1} - C_A \geq P_{E2} - C_B$, $V_1 - 0 \geq V_1 - C_1$, $V_1 - 0 \geq V_1 - C_2 - C_3$, $V_1 - 0 \geq V_1 - C_3$ and $V_2 - C_{4B} \geq V_2 - C_{4A}$ and $V_2 - C_{4B} \geq V_3 - C_5$. It is only under these conditions that the government departments find themselves with satisfactory payoffs and as a result would not wish to divert from these strategies.

This means that if all of the variables mentioned in the game are correct and that if all the players are making rational decisions, then they should end the game at the NE. The lack of investment, development and success of the South African biofuels industry has, however, shown a different picture. At present, circumstances are somewhat different in that the DoE has not followed a high investment strategy, DAFF is largely concerned with Food Security and not acting in terms of rural development and DLA is showing a complete failure in its land reform programmes and has in the past years achieved a less than 1 % rate of success (Institute for Poverty, Land and Agrarian Studies, 2008). This suggests that the game theory representation of this situation is lacking in some instances as one would expect the governmental departments to behave differently in order to achieve the outcome represented in Figure 3.2. It seems as if a cost or risk variable is included when the government has chosen the path of a lower investment strategy. This risk variable is perhaps the most important factor affecting the way that the government departments, especially the DoE, have responded to the calls of the industry. The

following game represents this clearly and indicates just how large the impact of this variable has been on the policy directions that have been followed.

3.8 The Game - replayed

The variable z has been included in the game to represent a risk that the government has opted not to take in terms of the development and support of the industry, as represented in Figure 3.3. The z variable represents a critical uncertainty parameter made up of a number of aggregated factors including an unclear, confused information flow from various role players, uncertainty, the resultant high costs of attaining a licence as well as the uncertainty that the role players face in promoting a policy; which in turn could impact on the consequences that they will face from both the public and other government departments. In other words, it represents a situation in which the government would risk the consequences of making large and important uninformed decisions.

The variable z is included only under the high investment biofuel plan, meaning that this is the only time that the government really runs the risk of supporting an investment on which it has not had the most reliable and accurate information. It is represented as a cost to the government at all levels and as a result has an impact on how these parties react. What needs to be kept in mind is that the NE changes as their respective payoffs change.

DOE

High Inv
Biofuel Strategy

Low Inv
Biofuel Strategy

DAFF

DAFF

Food secure

Rural development

Food secure

Rural development

- - - - - - - - - - **DLA** - - - - - - - - - -   - - - - - - - - - - **DLA** - - - - - - - - - -

Support *Reject* *Support* *Reject* *Support* *Reject* *Support* *Reject*

$$\begin{pmatrix} P_{E1} - C_A - z \\ v_1 - c_1 - z \\ v_2 - c_{4A} - z \end{pmatrix} \begin{pmatrix} P_{E1} - C_A - z \\ v_1 - c_1 - z \\ v_2 - c_{4A} - z \end{pmatrix} \begin{pmatrix} P_{E1} - C_A - z \\ v_1 - 0 - z \\ v_2 - c_{4B} - z \end{pmatrix} \begin{pmatrix} P_{E1} - C_A - z \\ v_1 - 0 - z \\ v_2 - c_{4B} - z \end{pmatrix} \begin{pmatrix} P_{E2} - C_B \\ v_1 - c_2 - c_3 \\ v_3 - c_5 \end{pmatrix} \begin{pmatrix} P_{E2} - C_B \\ v_1 - c_2 - c_3 \\ v_3 - c_5 \end{pmatrix} \begin{pmatrix} P_{E2} - C_B \\ v_1 - c_3 \\ v_3 - c_5 \end{pmatrix} \begin{pmatrix} P_{E2} - C_B \\ v_1 - c_3 \\ v_3 - c_5 \end{pmatrix}$$

Nash Equilibria

Figure 3.3: Game theory application, modified government game

The Nash Equilibrium in Figure 3.3, with the inclusion of the z variable, thus holds when $P_{E2} - C_B, \geq P_{E1} - C_A - z$, $V_1 - C_3 \geq V_1 - 0 - z$, $V_1 - C_3 \geq V_1 - C_1 - z$, $V_1 - C_3 \geq V_1 - C_2 - C_3$ and $V_3 - C_5 \geq V_2 - C_{4B} - z$, $V_3 - C_5 \geq V_2 - C_{4A} - z$. It is only under these conditions that the government departments find themselves with satisfactory payoffs and as a result do not wish to move from their respective strategies.

The outcome of the new game indicates that the *z* variable does indeed play an important role in the final outcome. Adding z to the equation results in the NE shifting from its previous location at a relatively successful situation with a strong focus on biofuels, rural development and a success rate in land reform, due to support of the strategy, to a terminal mode where DoE follows a relatively low investment strategy, DAFF attempts to focus on rural development and DLA sees a moderate failure rate of its land reform projects, due to the rejection of the strategy and a resultant lack of investment in the sector.   The outcome represents the current situation in the

industry and interestingly enough these results re-emerge in interviews with industry stakeholders. Chapter 5, more specifically Table 5.9, and Chapter 6, Section 6.3, aim at capturing some elements of the z variable in detail and concerns relating to these are represented in which in turn means that the variable z needs to be investigated in closer detail.

3.9 Conclusion

The success of agricultural and rural development is usually dependent on the governmental policies that are in place. These policies are usually aimed at supporting the sector but there have been various instances where such policies have actually been destructive. In this game, an agricultural processing sector is depicted which has the ability to process agricultural commodities, take up surplus supply and, as a result, spur on rural development due to higher prices and a larger market. There are however, various inefficiencies within the sector, mostly at government level, that hinder expansion and are keeping this new and exciting industry dormant.

The game theoretic approach that has been followed in this chapter indicates that the various governmental departments are indeed finding themselves at a NE in the market due to a risk variable, termed variable z. The goals that they have set out to achieve in their strategy and policy papers are far from being realised, their current attempts at achieving these goals are failing miserably and the potential that this will change without them taking a new and reformed approach to the situation is highly unlikely. The question that remains to be answered is why this is actually the case and why these inefficiencies exist within this sector; and whether the idea of producing biofuels is actually worth pursuing. From the game theoretic model, it becomes clear that the production in the biofuels industry could have further reaching

effects which could in turn support the agricultural sector and help spur on investment in rural development and infrastructure without costing the government too much money. It is just a matter of having the correct policies in place?

Chapter 4

Game theory: Industry investment decisions

4.1 Introduction

Biofuel producers in the US, the EU and in many other countries strive to influence policies to such an extent in order to make the production of biofuels economically viable within their economic system. The theory to explain the way in which such role players behave has been extensively researched and, to a certain extent, explained by use of game theory.

Game theory can be applied and used in many different situations and such games often appear where they might not be expected. Consider the role players of the biofuels industry in South Africa as an example. It can be argued that the releasing of the Biofuels Industrial Strategy by the Department of Minerals and Energy (DME), later named Department of Energy (DoE), in December of 2007 made them, that is, the government, a first mover. In general, a first mover is characterised by anticipating the reactions of later or second movers. Within the framework of this game and taking the available information into account, it seems that the government did perhaps over estimate the reactions of the market participants. The government, with the available information, did perhaps anticipate the industry to develop at a modest pace, but instead the industry did not develop at all. Within the framework of game theory, this brings to mind the concept of strategic commitment in order to gain the first mover advantage. In other words, the government had to implement some form of assurance that it could or would not just amend or change the strategy so that the later movers in the game realise that the first mover cannot go back on decisions even if it wanted to. It is now up to the other players in the game, namely oil refineries, potential biofuel producers, and farmers to establish themselves with

the national strategy in mind. In this instance, it can be argued that the release of the strategy, and its conditions, has set many of the rules and constraints within which the other players will play their games. One of the main assumptions that has been made is that all players attempt to position themselves so that their payoffs and strategic position within the industry is maximised.

This chapter explores the actions and the possible positioning that the different players in the biofuels industry want to take up, given the set of rules governing the industry. The first section reviews the Biofuels Industrial Strategy issued by the DME and discusses what the strategy means for the different industry players. In the second section, a game theoretic model is developed in which the interactions of the various players are tested against one another, given the rules laid down by the DME. The "biofuels industry development game" in South Africa discusses the calculations of the payoffs, the game's structure, the actions and strategies, and lastly, the outcome of the game. Based on the results of the game, the concept of vertical integration is explored as an additional strategy, which in turn, could positively benefit the industry.

4.2 Application

Game theory can be described as the conceptual and mathematical tool for the study of interaction among parties or players with conflicting interests. The interaction of biofuel stakeholders has been researched in various countries and in particular in the USA where farmers often have a stake in the ethanol plant in the form of a cooperative. Altman, Sanders and Boessen (2006) found that the industry supply chains are likely to develop more quickly if the trading partners, for example the producers and processors, desire the same type of relationship. On this topic Sexton (1984) developed a game theoretic model that solves the membership size, clarifies

the role of membership policy, postulates the approach to cooperative finance and specifies a criterion for decision making. The model captures the forward and backward link and interaction in the marketing chain well with respect to cooperative formation. The game theory model of cooperative formation is a modification of the standard cooperative formation model which in turn supports the use of game theory for such interactive representations. Cooperative structures might however only represent the interaction which farmers and biofuel producers experience in their business relationships (Sexton, 1984). The interaction between the biofuel producers, which could include farmers, and the oil refiners is one which is may incorporate elements of trust, willingness to engage in business activities and build future cooperation. The theory that trust and cooperation cannot be viewed in isolation and how this concept can be represented with game theory is further developed by van Witteloostuijn (2003). He makes reference to the Luhmanian definition of trust which states that a party's expectations that the other will not behave opportunistically in the face of the beneficial opportunity to do so implies that without a conflict of interest, the issue of trust is irrelevant. He further states that concepts of cooperation and trust are closely linked meaning that cooperation is non-opportunistic that is facilitated by an atmosphere of trust. In his article he sets up a game of trust, which in turn is fight for dominance between trustworthy and untrustworthy sources.

The following game thus takes traditional game theory concepts such as the static or simultaneous move game with perfect information, as presented by Gibbons (1997) and Osborne (2004) into account but also incorporates elements of the work done by Sexton (1984), van Witteloostuijn (2003) and Altman *et al* (2006).

4.3 The Biofuels industry development game

Section 4.3.1 discusses what the Biofuels Industrial Strategy entails while section 4.3.2 explains the different goals that the various players in the game would want to achieve. This helps with the understanding of the payoffs as well as the formulation of the payoff function, as depicted in Section 4.4.

4.3.1 The rules of the game

The rules of the game: The Government

The government has a number of goals that need to be achieved and most of these are defined within its Biofuels Industrial Strategy. This means that they have the opportunity to establish their position within the industry by creating a set of rules that will help them to achieve their objectives. Failure in achieving their objectives is also a possibility, as this would mean complete non participation or non establishment within or of the industry.

The strategy is aimed at achieving a number of goals; these include attracting investment into rural areas, promoting agricultural development, and import substitution of foreign oil which should result in balance of payments savings. Other factors also mentioned as key issues are adding to the renewable energy pool in order to create cleaner energies, adding downward pressure to crude oil prices, and creating a more energy secure environment.

The strategy has a set of primary objectives and these are to realise economic development in rural areas by creating a downstream market for the agricultural commodities produced in these areas. In order to achieve this objective, the government intends to regulate the geographic location of biofuel production plants, as well as the type of agricultural commodity used as an input in the production

process. The crops that have been proposed include sugar-based commodities for bioethanol production, such as sugar cane and sugar beet, sunflowers, canola and soybeans for biodiesel. Maize and jathropa have been excluded for the five-year pilot period, since the use of these commodities could have a negative impact on food security and environmental conditions within the country.

In the Biofuels Industrial Strategy, the government proposes various methods through which it aims to achieve the aforementioned objectives and ultimately plans to develop a biofuel sector. The policy tools that the government plans in utilising include a fuel levy exemption scheme, farmer cooperatives and their direct participation in the running of biofuel refineries, quantity control through the issuing of licences, and encouragement of the use of biofuels in the fuel mixture currently produced by the existing refineries.

Rule 1: Fuel levy exemption

Retail fuel prices in South Africa are currently the function of a number of taxes and levies aimed at covering the cost of maintenance and the upgrading of road and logistical infrastructure, as well as profit margins and crude oil prices. These taxes and levies are adjusted every year to keep up with the impact that inflation has on the overall industry. BFP stands for the Basic Fuel Price and represents the import parity price of the refined product. In other words, BFP is the price at which one litre of refined fuel is delivered at Durban harbour without any taxes or profit margins being added. Various other taxes and costs are added to the price, namely transport, delivery and pipeline costs, road accident fund, custom-and-excise duty, equalisation fund and slate levies, and wholesale and retail margins. The strategy proposes the reduction of the fuel tax as a support mechanism to the biofuel industry, the idea being that a lower tax rate on biofuels will increase their competitiveness with fossil fuels and in so doing make them more viable.

The proposed reduction in the fuel levy reduces the fuel tax by 100 % for bioethanol and 50 % for biodiesel. This will drop the biofuels price by between 7 % and 14.8 % below conventional fossil-based petrol and diesel. Since April 2007, fuel tax has totalled R 1.21 per litre for petrol and R 1.00 per litre for diesel, but from April 2008 the amount increased to R 1.27 per litre for petrol and R 1.05 per litre for diesel.

According to the Biofuels Industrial Strategy, the fuel levy tool plays a very important role in the indirect subsidisation process. The strategy proposes that the current biodiesel fuel levy exemption be increased from its current level of 40 % by 10 percentage points to 50 %. It also proposes that the fuel levy exemption on bioethanol be increased to 100 % as ethanol gel could be a substitute for illuminating paraffin, which currently carries no levy. This would translate into R 1.20 per litre and R 0.52 per litre support for bioethanol and biodiesel, respectively, in 2007. The tax exemption would augment the support for biofuels and would translate into R 1.26 per litre for bioethanol and R 0.55 per litre for biodiesel in 2008 (DME, 2007). In 2009, this would translate into R1.44 per litre and R0.64 per litre support for bioethanol and biodiesel, respectively.

Rule 2: Licence allocation

According to the strategy, the main focus of rural development will be on the former homeland areas in South Africa, especially those neglected under the apartheid system. It is hoped that these initiatives will stimulate development in rural areas and reduce poverty by creating sustainable income earning opportunities.

As poverty alleviation and the generation of economic activity in the former homelands are the strategy's most important objectives, it becomes clear why only those agricultural products grown in the former homelands for energy use will qualify

for support, and why only the biofuel plants that can assist in achieving the abovementioned targets will be supported and qualify for a manufacturing licence. Thus, the department that ultimately issues the licence will, to a large extent, control the location of biofuel plants and their operating conditions (DME, 2007). It is important to note that should this be the case, sugar cane for ethanol production will then be excluded from any benefits, as almost all the current industry's production areas fall outside the former homelands and as a result do not qualify for support. This could have an impact on the various targets that are to be achieved.

The government plans to increase agricultural production in order to support biofuel investments by using existing support programmes such as the Comprehensive Agricultural Support Programme (CASP). CASP is expected to prioritise those aspects of production that will enhance effective cropping for biofuels, and in so doing make the supply of feedstock to the biofuels industry more reliable and efficient.

Rule 3: Contracting and mandates on biofuels

According to the strategy, the specifics of the biofuel uptake still need to be negotiated with the oil industry. These include maximising efficiencies, reducing costs and ensuring that fuels adhere to the correct standards, thus allowing them to be sold and used as standard quality fuel. The South African Bureau of Standards (SABS) has recently established a working group among relevant stakeholders to finalise possible future regulations for a biodiesel quality management procedure to be applied in South Africa. These regulations don't affect the biodiesel product standard, but rather the quality assurance process.

The strategy recommends that biofuels be sold on a contract basis, and bought at a price that will ensure the long-term viability of both the biofuels refining and feedstock

growing processes. The contract will come with an obligation to use approved crops grown only in designated areas, such as the former homelands, with the guarantee that crops will be bought at a given price, regardless of the price of crude oil. On the other hand, the price at which biofuel producers buy crops should be comparable with the price that processors pay for crops destined for the food sector, in other words, a market-related price.

The strategy suggests that mandatory biofuels uptake can only be guaranteed once there is security in the supply of biofuels. It is at this stage of the bargaining process that both biofuel suppliers and oil refineries will enter into off-take agreements. In other words, the oil company will submit a claim to a certain slate account for the value of biofuels bought. During the initial phases of production, the mandating of biofuels is not favoured. It is instead suggested that biofuel producers be enabled to reduce their prices and, through this initiative, parties who are traditionally supplied by the oil companies are able to purchase fuel directly from the biofuel producers. The strategy further examines the concept of selling petrol containing bioethanol at a deregulated price to facilitate off-take.

The strategy envisages that costs and logistics should be minimised to optimise efficiency. To achieve this, existing oil refineries closest to the biofuels plants should be utilised. Furthermore, biofuels should be blended in accordance with the South African National Standards (SANS), which currently limits biofuel content to 5 % for diesel and approximately 10 % for petrol. This would ensure that the appropriate quality blends of biofuels are produced (DME, 2007).

In summary, government has set out a number of rules that "govern" the structure and actions taken by players within the game. These rules can be broken down into

three main sections and they focus on fuel levy exemption, licence allocation and rural development, as well as contracting and mandates.

4.3.2 Players in the game

In the development of a new industry, role players will often jockey for position in order to ensure that they receive the best possible payoffs within the rules in which the industry is being developed, i.e. the rules of the game. It has been the case in various industries that individual players within same sector of the economy will act differently in order to further their own achievements. For the purpose of this game, the individual players in the biofuels industry have been grouped and collectively represent the views of their respective sections. Player 1, oil refiner, represents the oil industry, Player 2 represents the biofuel producers and Player 3, represents the farmers, of whom the reactions are taken into account. These in turn represent the feedstock producers as a sector. It is acknowledged that by integrating the behaviour of individual players, some form of interaction or conflict among players within the specific group is lost; which could potentially detract from the outcome's achievements.

Player 1: The oil refineries

The oil refining industry in South Africa is an extremely large player in the liquid energy market with only four major refineries controlling the entire market. In addition to this, the fuel industry is highly regulated and the fuel prices are set once a month depending on the over or under recovery that has been incurred as a result of oil price and exchange rate fluctuations. A highly regulated fuel industry, in this instance, means that oil refineries have one player to adhere to and, in this case, it is the government. The actions taken by the oil industry therefore depend directly on the goals and regulations set out in the Biofuels Industrial Strategy, given the strategic

commitments by the government and the government's anticipation of how the industry is going to react to the implemented strategy. This in turn substantiates the fact that the government is indeed a first mover in this game.

The oil refineries have one major goal, namely that of ensuring stable and high profits given the rules that have been laid down by the government. In addition to adhering to these set rules, the oil refineries also need to be balanced in their actions, and this includes maximising their own profit by managing income and expenses, but also managing good public relations by means of positive public perceptions about the industry and the individual companies. Negative public perceptions can have a negative impact on income and expenses in the short and long run. Thus, oil refineries are in a situation in which they don't want to avoid biofuels, since this will create possible negative public and government perceptions that oil refineries don't care about the environment. On the other hand, the oil companies need to ensure that they can buy biofuels as cheaply as possible to ensure high and stable profits. Since oil refineries control the fuel market, they have bargaining power to influence biofuel blending policy as well as biofuel pricing policy to some extent. Based on this argument, it is assumed in the study that the oil refining industry along with the rules laid down by the government are the two key players that will negotiate blending and pricing policies of biofuels.

Player 2: The potential biofuel producers

The biofuel producer in this game is assumed to be an independent entity, not necessarily a farmer cooperative, although this could prove to be beneficial, with the sole aim of making as much profit as possible from processing agricultural feedstock into biofuels. The actions of the biofuel producer, as with those of the oil refineries, are governed by a set of rules and laws laid down in the Biofuels Industrial Strategy. In their case, these rules refer to the issuing of a licence in order to produce the

product, the tax rebate and other support that is made available to them as well as the regions in which they may purchase feedstock for biofuel production. These rules govern the actions that the biofuel producers may take with respect to farmers, the producers of their primary feedstock, rather than their type of negotiations with the oil refiners. The negotiation that the biofuel producers will have with oil refiners focuses on the profit margin that they need to maintain in order to stay in business. This means that the way the ethanol price is determined is extremely important, as is the quantity that the oil refiners are willing to or will need to accept given the rules laid down by the government. It can therefore be argued that the ethanol price as well as the ethanol mandate or voluntary blending rate, are of the highest importance to these two players.

If the biofuel producer is a sole entity and not an institution run by farmers, then he will need to negotiate not just with the oil refiners but also with the farmers in order to maintain, or achieve the best possible price for the feedstock that needs to be purchased. The biofuel producer has a set of options that he can follow in order to achieve this. These include contracting with the farmers for a specific quantity of their produce at a specific price, purchasing the feedstock on the open market, or forming a cooperative by vertically integrating the processing facility with the group of farmers – and in so doing, creating a combined interest in the company's financial performance. Vertical integration can also have its drawbacks in that the company will be run by a group of individuals, the farmers, who might have ulterior motives in addition to securing the profitability of the biofuel production plant.

Player 3: The farmers (commercial and emerging)

In the case of the farmer, the assumption is made that the goal is the same for both a commercial and an emerging farmer, namely to produce feedstock for biofuel production in order to maximise profit.

The goal of the farmer is to sell high quality produce at the highest possible price and at the lowest possible cost to ensure profits. If the farmer has a choice, he or she would want to earn a price higher than the market price and preferably earn a stable price to be less exposed to risk. In short, the farmer wants to earn as good a price as possible with a minimal amount of risk. The implication is that farmers would want to lobby biofuel producers into buying feedstock under a contract growing scheme, which pays above-market related prices on a regular basis. For the purpose of this exercise, the actions of farmers need to be kept in mind in order to understand the strategies that drive the biofuel producers. The farmers will therefore only affect the outcome of the game indirectly.

4.4 The model

In reality, many strategic situations contain elements of both simultaneous and sequential move games (Osborne, 2004). That is what the model in the chapter will attempt to capture, as the actions and strategies of two players in the game depend on either the laws laid down by the Department of Energy or the impact that the nature player has on the local industry. The link between the game set out in Chapter 3 and this simultaneous move game is made by the laws that govern the biofuels industry, as set out in the Industrial Biofuel Strategy. A nature player is a participant in a game who selects strategies randomly, based on some predetermined probability distribution rather than based on a set of payoffs. The introduction of a nature player simply allows for the introduction of uncertainty or randomness into the game (Shor, 2008). In this case, the nature player will take the form of the price of inputs and outputs used in the production of biofuels, for example the feedstock or biofuel price.

The game is a very simple representation of the situation and it is based on the "rules of the game" as established within the framework of the Industrial Biofuels Strategy with the addition of the nature player. A history of higher commodity prices and higher oil prices influences the actions and strategies that both the biofuel producers and the oil refiners choose. The strategies chosen depend on a range of issues, some relating to the biofuels strategy but most a matter of economic profitability; while the payoffs are calculated as a function of input and output prices as well as the implementation of certain policies as additional rules.
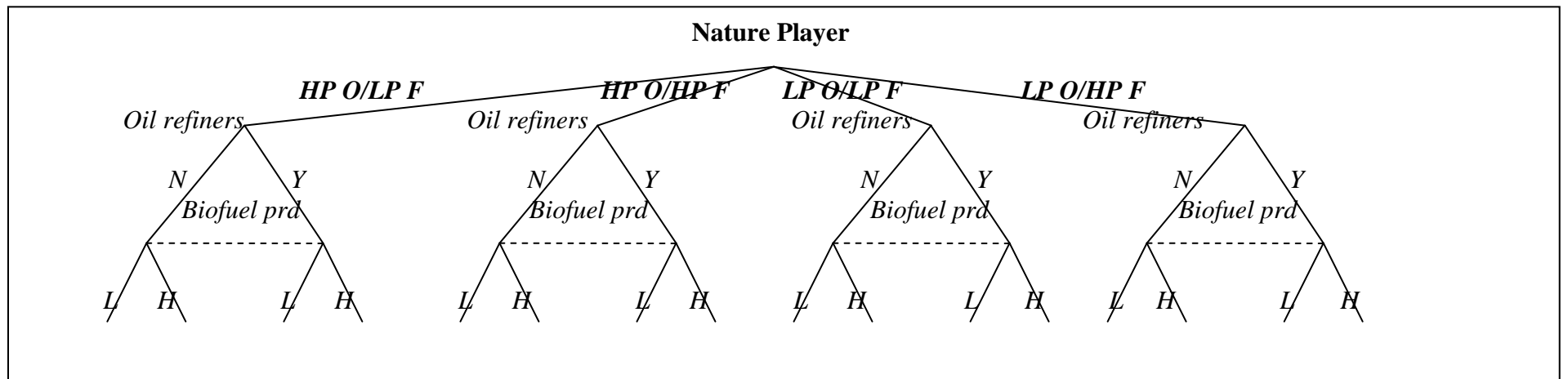
Figure 4.1: Model 1, The biofuels industry development game
* HP O: High oil price, LP O: Low oil price, HP F: High feedstock price, LP F: Low feedstock price, N: No investment, Y: Investment, L: Low investment, H: High investment

The game as depicted in Figure 4.1 represents four possible combinations, in which 2X2 matrix games are depicted as a result of the "nature player" and other forces, beyond the control of the players in the game. In this instance, these include a variation in the oil price and feedstock price with different combinations. The payoffs for both the biofuel producers, represented by the Biofuel Cost and Profit function (*BFCAP)*, and the oil refiners, represented by Oil refiners Cost and Profit function (*OCAP)*, are calculated, based on functions that take the occurrences based on the set of factors and the combinations that the nature player has "chosen" for each strategy, into account. The payoff functions are:

$$BFCAP = \alpha P_{ET} + (\beta(f/2)) - \theta(M)$$

and

$$OCAP = \frac{\theta(M) - \alpha P_{ET} - (\beta(f/0)/2)}{\gamma}$$

Where α is a coefficient of either 1 or 0.5 times the ethanol price P_{ET}, which in this instance is either 3 or 5, depending on a high or low oil price scenario. (β(f/2)) is the full implementation of the tax credit and, in this instance, either 1 or 0.5 is selected for f depending on the need for biofuels by the government. A full implementation of the tax credit under low feedstock prices results in stronger government incentives and gives β and f a value of 1, while a lack of interest and concern regarding the impact on food security under high feedstock prices results in lower government incentives with β and f receiving values of 0.5. θ(M) is a factor that represents the chance of a high feedstock price and in the case of South Africa with its relatively marginal climate, the chance of a high feedstock price or a smaller crop over time has been estimated to be a possible outcome. The factor representing the chance of a higher feedstock price has a value of 0.3 compared to the value of the factor of a low feedstock price, which has a value of 0.2. In the case of OCAP, the oil producer capacity, γ is a variable that becomes 0 when the nominator is positive and is 1 when the nominator is negative, as it is not expected that oil refiners will reap direct

positive payoffs from installing additional capacity to handle biofuels but will rather incur no cost, especially with the current strategy that is in place.

4.5 The game

In accordance to the game tree depicted in Figure 4.1, the biofuel producers and oil refiners are rational and play off against each other in order to achieve their highest possible payoff, given the circumstances that occur as a result of the scenario created by the nature player. It should, however, be noted that these numbers are largely used for illustrative purposes and that they represent the ordinal relations among the payoffs rather than particular cardinal values. The Nash Equilibria within the various sub-games are thus conditional on certain ordinal relationships holding true.

4.5.1 High oil price, low feedstock price

In the instance of a high oil price and a low feedstock price, the returns on investments for biofuel producers are expected to be optimal. A high oil price should in most instances result in a higher biofuel price while a low feedstock price would serve as a lower priced input on the production side.

Table 4.1: The high oil price, low feedstock price game

		Oil Refiners			
		Y (Acceptance)		N (Rejection)	
Biofuel Producers	High investment	4.5	-4.5	**2.5**	**-1**
	Low investment	1	-4.5	0	0

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The best strategy for the biofuel producers, as represented in Table 4.1, would be to follow a high investment as, in such a situation, the payoff function indicates that they will be able to make maximum profits. The oil refineries will, however, be a bit reluctant to invest a lot of money if they are not certain that the industry will be able to support the quantity required by them and if a high oil price, low feedstock price scenario is indeed sustainable in the long term. If they do accept the investment cost, their short-term payoff will be the lowest as they will have to put up with additional development cost. On the other hand, if the game is repeated in a second period this might be a different scenario. The best payoff for the oil refineries would be to reject the idea of biofuels while a high investment strategy would pose the best possible payoff for the biofuel producers. The Nash Equilibrium is represented by the grey area in the table.

4.5.2 High oil price, high feedstock price

The second nature scenario is the instance in which the oil price reaches a high level, as does the price of feedstock. This puts additional pressure on oil refiners, so that they can find an alternative market for energy as fear of a shortage emerge, while a high feedstock price has a negative impact on the profit margin of the biofuel producer and hence impacts on the producer's strategy of whether to invest in additional production capacity.

Table 4.2: The high oil price, high feedstock price game

		Oil Refiners			
		Y (Acceptance)		N (Rejection)	
Biofuel Producers	High investment	2.5	-2.25	**1**	**-1**
	Low investment	1	-2.25	0	0

Table 4.2 shows that investing in the biofuels industry in the time of a high oil price and a high feedstock price may be a challenge for biofuel producers as their margins will already be squeezed and they might not be able to make high investments. Such a situation will benefit the oil refineries as they are in a position to make abnormal profits as a result of the high oil prices because they can use the high feedstock prices as a reason not to invest in additional capacity. The Nash Equilibrium is again represented by the grey area in the table.

4.5.3 Low oil price, low feedstock price

The third nature scenario takes place in circumstances in which the oil price and the feedstock price both drop to a low level. These circumstances offer a relatively profitable environment for the oil producers as they will not have to contend with the research and development of alternative energies due to the relative availability of oil. On the other hand, biofuel producers will reconsider developing biofuel plants due the limited potential return on investment and this is represented in Table 4.3.

Table 4.3: The low oil price, low feedstock price game

		Oil Refiners			
		Y (Acceptance)		N (Rejection)	
Biofuel Producers	High investment	4.5	-2.25	**1**	**-1**
	Low investment	2.5	-2.25	0	0

The low oil price/low feedstock price scenario benefits both parties as both face a situation of lower input costs. The biofuel producers will have to weigh up their options, as a lower oil price means a lower price for the biofuel that they produce but a lower feedstock price means that they can benefit from purchasing their inputs at a lower cost. In addition, biofuel producers as well as farmers will intend on taking advantage of a low feedstock price scenario, as an alternative off-take market will need to be found for feedstock in order to make it more profitable. At a low oil price, oil refiners will be reluctant to invest in alternative energy as they do not face an immediate shortage of oil. In a case in which they would invest in such an industry, their total increased capacity would be kept lower than as is the case in Sections 4.5.1 and 4.5.2.

4.5.4 Low oil price, high feedstock price

The fourth nature scenario takes place in an environment where biofuel expansion does not seem to be an option due to the profitability of the industry. Low oil prices together with high feedstock prices put extra strain on the biofuel producers and in addition relieve any obligation that the oil refiners might have felt towards supporting such an industry.

Table 4.4: The low oil price, high feedstock price game

		Oil Refiners			
		Y (Acceptance)		N (Rejection)	
Biofuel Producers	High investment	2.5	-2.25	**0**	**0**
	Low investment	1	-2.25	**0**	**0**

The low oil price/high feedstock price game has a set of two Nash Equilibria. In Table 4.4, the profit margin of the biofuel producer will be put under pressure, as a high input cost together with a low output price results in a lower overall profit margin. The BFP will therefore be tempted to either invest only a little or to not invest at all should the oil refiners choose to not accept biofuels and expand capacity. In addition, a low oil price scenario results in oil refineries not investing too heavily in research and development due to sufficient supply and does not cause too much of a long-term concern. The Nash Equilibrium is therefore at the point where there is no investment from oil refiners to increase capacity and a very low if any investment in additional biofuel capacity from the biofuel producers themselves. Interestingly enough, this is an actual depiction of what has been occurring in the industry of late. The two role players are strategically positioning themselves under the rules laid out by the government and, under the current circumstances; it seems that a rejection of additional capacity, together with low individual small-scale investment in biofuel production, is the order of the day.

4.5.5 Discussion of the game

It seems that the industry, with its current structure, shows that players have no desire to work together in achieving a common outcome but would rather settle for strategies which result in little or no biofuel production in the form of transport fuels for the local market. Instead, producers are opting to either focus their production on the export market or to be innovative in their approaches and target markets other than the market for renewable transport fuels. One would expect that if the economics of a scenario make sense, oil refiners would accept a high cost in order to create a sustainable strategy for future development. In short, it is perhaps not the economics of blending biofuels into the current mix that result in oil refineries leaning away from production but rather the rules of the game the govern their role as well as the controlled and oligopolistic structure that the oil refiners have in the industry. Changes in the rules of the game, such as the enforcement of a mandate, would alter their payoff structure as a non compliance with legislation and could see refiners facing even higher costs. The following section takes the z variable as discussed in Chapter 3 into account as part of the explanation as to why the producers are currently not engaging the industry with high value investments. The inclusion of this variable in the payoff structure of the biofuel producers should represent their actions more clearly.

Apart from the changes in the rules of the game, a change in the structure of the industry could perhaps also alter the way in which the players perceive the direct costs that they incur in expanding their capacity. The following section explores the possibility of vertical integration with the help of previously researched literature in this specific context.

4.6 The Game – new version

The outcome from the simple version of the game in Section 4.5 of this chapter is not completely suited to represent what is actually happening in the South African biofuels industry. The simple version of the game has been slightly adapted in order to make it more realistic, slightly more complex and more representative.

In order for a company to start producing biofuels in South Africa, it needs to comply with a number of licensing criteria. The criteria are rather stringent and state that: "All biofuel manufacturers, including pilot projects, are required to apply for manufacturing licences". Those manufacturing for own use will have to register with the Petroleum Controller and provide annual statistics on what crops they are utilising, production capacity and detailed information of what the products are used for" (DME, 2007). The licensing criteria add various other requirements, such as the environmental impact of crops used, the use of feedstock produced under irrigation, the type of crops that may be utilised, restrictions on imports of feedstock, who the feedstock must be sourced from with emerging farmers taking precedent over the market, the standards to be obtained by biofuel producers, as well as proof of off-take agreements between biofuel producers and oil companies which need to be submitted (DME, 2007).

The criteria mentioned above therefore set the scene for a market in which a number of costs of monetary and institutional value have to be incurred prior to the start of the production process. In other words, a number of criteria need to be fulfilled and adhered to before the manufacturer can start with the production process. The variable z in Chapter 3 is partly captured within this cost of compliance criteria as the lack of good information available in the legislation drafting process has resulted in strict and unrealistic criteria being brought in as part of the regulation. The total cost

of compliance, represented by variable σ, therefore includes the government's risk factor variable z as well as the cost of other criteria that need to be adhered to in order to register as a biofuel manufacturer. Taking the current payoff structure into account, the biofuel manufacturer derives a payoff from the following formula:

$$BFCAP = \alpha P_{ET} + (\beta(f/2)) - \theta(M) + \sigma$$

The current biofuel policy shows that the governmental compliance costs of becoming a biofuels manufacturer are far higher if the owner is planning to invest in a larger production plant than if he were to only invest in a very small-scale plant for private consumption. The South African Revenue Service, for example, allows for a 100 % exemption for small biodiesel producers, producing less than 300 m^3 or 300 000 litres per annum (DME, 2007). The σ variable therefore needs to have a different relative value depending on the choices that the biofuel manufacturer is making in terms of the investments and also in terms of the market that he is attempting to access.

$$\sigma = \Pi ethanol_{exports} - CoC_{includingZ} + \Pi ethanol_{non-transport}$$

Where, $\pi_{ethanol\ exports}$ represents that profits that are made from supplying an international market with the biofuel commodity, for example the EU, while the $CoC_{including\ Z}$ represents the cost of compliance with the governmental licensing procedure. This includes z, as well as other costs that the biofuel producers are incurring, including risks related to higher value investments. $\pi_{ethanol\ non-transport}$ represents the profit that is made from following an innovative approach and converting the biofuel product into a more processed item, such as ethanol gel for heating and cooking purposes. The value of σ will change depending on the actions taken by the oil companies and ultimately on the government legislation.

4.6.1 High oil price, low feedstock price

The first game includes a scenario in which the oil price is high and the feedstock price is low, as presented in Table 4.5. Higher profits would dictate larger investments in the long run and, in theory, this would be the investment strategy that the biofuel industry would follow. On the other hand, the oil refineries are expected to be rather indifferent to the situation, depending on the government strategy imposed.

Table 4.5: High oil price, low feedstock price game

		Oil Refiners			
		Y (Acceptance)		N (Rejection)	
Biofuel Producers	High investment	1.5	-4.5	5.5	-1
	Low investment	0	-4.5	**6**	**0**

Under this scenario, payoffs for biofuel producers are far higher if the oil refineries reject any commitment to the programme, as they are forced to be innovative and, in so doing, either see a future in the export market but rather follow a high investment strategy or, alternatively and more likely, keep a low key and focus on a different market serving different products, such as the paraffin market. The Nash Equilibrium would therefore include a low investment strategy by the biofuel producers together with a rejection of the biofuel programme by the oil refiners.

4.6.2 High oil price, high feedstock price

The second game includes a scenario in which high oil prices and high feedstock prices dominate the industry. This results in lower profit margins in the local market,

especially in the transport fuel sector, and as a result, biofuel manufacturers focus on other markets where profits are expected to be higher. This includes markets such as the EU and others which are not transport related, such as the paraffin market. With σ taken into account, the payoff structure of the biofuel manufacturer changes and so too does his strategy, as shown in Table 4.6, below.

Table 4.6: High oil price, high feedstock price game

		Oil Refiners			
		Y (Acceptance)		N (Rejection)	
Biofuel Producers	High investment	-0.5	-2.25	4	-1
	Low investment	0	-2.25	**6**	**0**

In this game, the Nash Equilibrium is found at a low investment for biofuel producers and a non-commitment from local oil refiners. The less profitable macro environment for biofuel production impacts severely on the investments made by the biofuel industry, and perhaps even more so under a commitment from the oil refiners than in a situation where the oil refiners are not committed. Under the NE, biofuel producers make better returns by focusing on the production of alternative products as well as the production of biofuels for other markets and hence the greater payoffs.

4.6.3 Low oil price, low feedstock price

Low oil and low feedstock prices have an interesting effect on the payoff structure of the biofuel producers. The theory shows that biofuel producers will be indifferent to investing large amounts of capital or lower amounts of capital as their payoffs after taking the cost of compliance into account will be similar. The Nash Equilibrium

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does, however, fall into the same strategy as the previous game with biofuel producers opting to produce either for the export or alternative use market, as shown in Table 4.7.

Table 4.7: Low oil price, low feedstock price game

		Oil Refiners			
		Y (Acceptance)		N (Rejection)	
Biofuel Producers	High investment	1.5	-2.25	4	-1
	Low investment	1.5	-2.25	**6**	**0**

The oil producers seem to have a dominant strategy in that their lowest costs or highest payoffs that they incur are related to rejecting any involvement in terms of blending biofuels. It therefore does not matter what they do or what strategy they follow, or for that matter which strategy the biofuel producers follow; the oil refiners will always choose not to get involved with the blending of biofuels.

4.6.4 Low oil price, high feedstock price

The low oil price, high feedstock price scenario offers the lowest returns to biofuel producers. Paying a high cost for inputs and receiving a relatively low return affects profitability and in turn influences long-term sustainability. Longer periods of such price relationships may result in biofuel producers opting not to produce at all and therefore close down the factories or alternatively look for commodities other than the ones used originally in the production process.

Table 4.8: Low oil price, high feedstock price game

		Oil Refiners			
		Y (Acceptance)		N (Rejection)	
Biofuel Producers	High investment	-0.5	-2.25	3	0
	Low investment	0	-2.25	**6**	**0**

Table 4.8 shows the low oil price and high feedstock price scenario and indicates that it offers biofuel producers virtually no payoffs in the transport fuel sector. Returns from investing in alternative markets such as exports are profitable but with the low oil price returns are also limited. The most profitable option under this scenario is to invest in markets that are not directly related to transport but rather to other uses.

4.7 Vertical integration and contracting in the biofuel supply chain

It is expected that the process of vertical integration within the South African biofuel industry will be difficult and it is the aim of this section to explore the reasons for this. The concept of vertical integration to be discussed within this section can be two-fold, as it can either take place higher up in the chain, between oil refiners and biofuel producers, or lower down in the chain, among the biofuel producers and the farmers.

The development of a new energy industry, with a completely different structure to any other energy sector, requires processors and blenders to establish entirely new fuel procurement strategies. From an organisational point of view, there are many key relationships that need to be developed, especially those between biomass producers and processors which are indeed critical to the development of the agro-bioenergy industry (Altman & Johnson, 2008). It is also a question of how these

relationships will develop in order to benefit the industry. Altman, Sanders and Boessen (2006) found that the industry supply chains are likely to develop more quickly if the trading partners, for example the producers and processors, desire the same type of relationship. For instance the partnership between farmers, with all the necessary equipment, and the processor of a flexible, low asset specific production plant, should see a spot market for the feedstock develop quickly. Similarly, a highly asset specific production plant in an area where farmers would have to invest in new biomass production technology could result in a long-term supply contract emerging between the two parties.

4.7.1 Farmer – processor relations

Altman *et al.* (2006) mention that in the potential biomass industries producers and processors are indeed independent. However, once an investment is made, they become bilaterally dependent on each other's actions. Altman *et al.* (2006) further state that physical asset specificity becomes an issue for the processor, especially when the processing technology is not flexible with respect to quantity, quality and type of feedstock. In this instance, it might be beneficial for them to consider alternative procurement strategies, such as long-term contracts, vertical coordination and even vertical integration, instead of purchasing feedstock on the spot market. It seems that flexibility in technology, with respect to quantity, quality and even type of crop, is the key to success as that this would allow them to make use of more flexible procurement strategies, such as purchasing on the spot market and being able to switch production processes to accommodate the use of the cheapest feedstock.

Now that it has become clear that vertical integration between farmers and biofuel producers is indeed an option, it needs to be narrowed down into questions so that the relevance of integration, in this scenario, can be determined. In short, there are

three main aspects that need to be considered by the parties involved in such an industry and especially if they are considering integration or contracting to be a viable alternative (Altman, *et al.* 2006). The first question is that of flexibility. How flexible is a plant at adapting to different production processes based on the type of feedstock used? The more flexible the process is, the bigger the options of procurement become. The second question is whether processors will be entering an area where the farmers already own and manage the necessary equipment in order to serve the industry. In the case of South Africa and where rural development is a major goal of this industry, the factor of agricultural mechanisation, for example, becomes a serious issue. The third and final question that Altman *et al.* (2006) find relevant is whether the biomass production techniques, in other words, the specific development of human assets, can be expected from the industry. Again, for the South African example, this becomes extremely relevant as the transfer of knowledge to managers and farmers of rural small holder agricultural production areas will play a vital role in the ability of these biomass producers to physically honour their long-term commitments of supplying the bio-energy industry. An analysis of these issues will help to determine if low cost spot markets develop or if the industry evolves long-term supply contracts or even cooperatives, which in turn entail a much higher administrative cost (Altman, *et* al. 2006).

The question "Is vertical integration between farmers and biofuel producers indeed an option?" depends largely on the "rules of the game" that govern the industry. At present, licence allocation by the government is bound by specifics in that "only agricultural products grown in the previous homelands by historically disadvantaged farmers will qualify for the support. Only biofuels plants that have been identified to assist in achieving the initial target will be supported and their location will be a condition of the issuing of a manufacturing licence. The plants will be located throughout the country depending on the investor's choices and also as per the

conditions of licences" (DME, 2007). This means that allocation of licences is bound to relatively marginal agricultural land that is not only neglected by years of subsistence farming and under-development, but also plagued by a lack of infrastructure on farm mechanisation and knowledge. It is probably a reality that strong alternative energy investments in such rural communities will generate jobs and uplift the general welfare of the region. The more pressing issue, however, is focused on the business relationship and whether such investments will receive sufficient support from these communities in order to successfully conduct their biofuel processing. With such uncertainty, it seems logical to invest in vertical integration and in order to achieve economic success, a statement by Altman *et al.* (2006) comes to mind, "…in the potential biomass industries producers and processors are indeed independent, however, once an investment is made, they become bilaterally dependent on each other's actions".

4.7.2 Biofuel processor – oil refiner relations

The concept of flexibility and variation does not apply to the oil refineries. If one uses the degree of flexibility as an indicator of physical asset specificity then one can imagine that once oil refiners have accepted the move towards biofuels and once they have incurred the necessary cost to upgrade their facilities, there is only one option and that is to source biofuels and blend them. The quality of ethanol that the refineries source will be of vital importance to them, as they not only have to ensure an adequate blend of ethanol within their fuel mixture but also the correct quality; as a failure to adhere to these might cause further public relations problems for the company's image. Upgrading their facilities so as to include ethanol in their fuel mixture is very asset specific. Once refineries have upgraded, there is little that they can do with these facilities other than to blend biofuels and therefore the sustained availability of the product is crucial to their operations. Their asset specificity is so

strong that it would only make sense if they actually had either long-term contractual arrangements with reliable biofuel producers who could also supply the required volumes, or alternatively have contractual arrangements with Brazilian ethanol producers who could deliver but in so doing, refineries would give up the partial share of the tax rebate, as stated in the rules of the game, as the rebate is only "applicable to biofuels produced in the approved region". It then seems rather obvious why refineries are reluctant to engage in biofuel blending until either the rules of the game force them into doing so or the biofuel industry becomes big enough to ensure acceptable returns, through long-term contracting, on their capacity investments. Until such time, the oil refineries will remain reluctant to the concept of blending biofuels.

4.8 Implications, conclusions and limitations

Game theory and game theoretic models do have their limitations. It is the aim of this analysis to capture the interaction of the players in the industry and thereby explain their behaviour. The model and the model assumptions capture the essential features of the interaction between the players rather well. A drawback is that the magnitudes of the payoffs were estimated based on theory and do not specifically represent true costs, as these are in any case very difficult to quantify in an industry that has barely been established. A further critique of the model is that the variable σ could be far greater and more complex than anticipated here meaning that the impact of the additional government costs included within the σ coefficient could have a far greater impact on the industry than what has been captured here.   The game theoretic approach does, however, provide a good tool when it comes to developing a framework which captures actions and strategies of role players in the industry.

It seems that relations among stakeholders in the biofuel industry are as important to its success as the economics governing it. The "rules of the game" that have been laid down to govern this industry not only impact on how the industry develops but also impact on how the various players within the industry see their chances of success and hence, how they line up their strategies.

The game in which the oil refiners and biofuel producers size up against each other, given the strategies of the nature player, indicates that the losses, at least in the first period, are unacceptable to the oil refiners. This is especially true under the circumstances in which the oil price is high and the maize price is low, resulting in maximum profit for biofuel producers, compared to the extremely high costs incurred by the oil refiners. The Nash Equilibria are constantly reached under circumstances where the biofuel producer would like to follow a high investment strategy and the oil refineries reject any voluntary form of involvement with the industry. In fact, under the first game, the oil refiners had a dominant strategy which meant that they did not want to invest in biofuels regardless of the strategy that the biofuel producer sought. In the more complicated version of the game, the strategy of the oil refiners remained the same as policies for them did not change, biofuel producers also changed their strategies as they opted for lower investment strategies due to the complications associated with the CoC variable. One important fact is that the game takes place assuming that both parties, the biofuel producers and oil refiners, are independent entities.

To conclude, it seems that the Industrial Biofuels Strategy, as laid out by the South African Department of Minerals and Energy, does not provide the oil refiners with enough incentive to fully support the uptake of biofuels. Taken this fact into account, there seems to be an opportunity for local producers to participate in the international market, given the differences in costs of production and prices in both local and

international context (BFAP, 2008). Locally it does, however, seem clear that the proposed cost-to-benefit ratio does not offer enough of an incentive and hence, the oil producers are better off not accepting the fuel into their operations; which is especially true in the current context. Changes in policies together with changes in the structure of the biofuel supply chain are definitely required to have a positive impact on the use of biofuels in South Africa.

Chapter 5

Decision tree: South African biofuel case studies

5.1 Introduction

The economic feasibility of biofuel production is the key factor when it comes to the establishment, growth and long-term sustainability of the industry. Changes in commodity prices on both the input and output side of the supply chain have a direct influence on the economic feasibility of such projects. In the US, ethanol margins have been declining since 2006 as plant operating and expansion costs are rising, which has resulted in some plants slowing or even halting expansions (Collins, 2008). It seems that the relative shift in input and output price levels has contributed significantly to this. Collins (2008) further argues that without the tax credit and the Renewable Fuels Standards (RFS) mandate, which help maintain production and capacity, ethanol prices would be likely to decline to their energy equivalent value to gasoline. This would result in some ethanol plants having negative margins and reducing capacity use or ceasing operation, while the corn price would be expected to decline. It therefore seems that policies, economic expansion as a result of feasibility, and long-term sustainability go hand in hand.

This chapter attempts to contribute to the debate on the economic feasibility of biofuel production in South Africa, taking the implications of policies and the long-term feasibility and sustainability into consideration. This is achieved by compiling an in-depth review of current biofuel projects which are either in operation or in the planning phase. The biofuel projects are assessed based on a decision tree framework. The individual projects are evaluated based on a five-level decision tree, which includes preferential areas, supply dynamics, plant profitability, and overall ratings, followed by a summarised discussion and conclusions. This chapter further

fulfils various objectives of the study in that it illustrates some of the tools that can be used in order to assist in an accurate policy development process with respect to the requirements of various role players in the industry. In addition, the chapter aims to satisfy the third specific objective in the provision of a complete industry review with respect to proposed projects, the development of an accurate database on cost of production, current profit levels that can be achieved and future capacity that is available. The focus is largely on the South African situation but experiences from other countries are also taken into consideration and used as benchmarks. The chapter further adds substance to a debate which up to now has been largely based on ideologies and experiences from the developed world.

5.2 The South African biofuels industry

Biofuels and the prospect of creating an additional demand for commodities, especially maize, in 2004/05 created huge excitement within the agricultural sector. Plans to build four maize-to-ethanol plants in South Africa, in order to absorb any surplus in maize production, were commissioned and finance institutions were approached in the hope that these projects would materialise. Coincidently, these plans were commissioned right at the time when a bumper maize crop was harvested (2004 – 2005), maize prices were trading at export parity levels, and stocks rose to more than three million tons. However, economic conditions in the agricultural sector turned unfavourable and, together with the rise in steel and other production costs, projects such as these became unfeasible. In addition to the economic climate that hampered finalisation of such projects, investments in the industry have been severely hampered by strict government legislation with respect to licensing as well as unfavourable market conditions and a lack of investor confidence within the sector. Concerns over food security and crop failures as well as a lack of off-take market commitments are just some of the factors that have had a negative impact on

the overall investor confidence within the industry. Nevertheless, there are some projects that have received the required support from government and are in the planning phase prior to implementation. The following section will discuss the details of each one of these projects in detail.

5.2.1 Canola for biodiesel in the Eastern Cape

Biodiesel can be produced from any type of vegetable oil by converting the triglyceride oil to methyl esters in a transesterification process that yields glycerine as one of the by-products. The oilseeds that are commonly used for this process include oilseed rape or canola, soybeans and sunflowers. The Eastern Cape in South Africa has been the focus of many biofuel projects, largely due to the notion that it is relatively underdeveloped and that it could, potentially, be seen as having a huge potential for agricultural development. Areas, especially those included under the former homeland scheme, are of extreme interest as these will be favoured when it comes to the allocation of petroleum producer licences (DME, 2007). Recent developments in the Eastern Cape have seen a project that is being administered and managed by the Phyto-energy group of companies in South Africa. The project is located in the vicinity of East London and aims at producing rapeseed-based biodiesel for the export market. The aim of the project seems to promote oilseed rape as a worthwhile crop within a rotation because of the benefits for the crops that follow on in the rotation. Phyto-energy has recently launched various canola production trails in the Eastern Cape of South Africa in order to determine if the crop can be successfully cultivated in the region and what yields could potentially be produced (Fouche, 2009). The project aims at being able to source its required feedstock from the surrounding areas and, in so doing, be able to supply its production plant with sufficient raw material so that it can produce biodiesel all year round.

5.2.2 Soybeans for biodiesel in the Eastern Cape

In Argentina and the US, soybeans are commonly used as a feedstock source for biodiesel production. The reason for choosing the Eastern Cape as an area of interest and a favourable location is mainly due to the legislation favouring production in the underutilised, former homeland areas (DME, 2007). The company that is running the project in the area is Rainbow Nations Renewable Fuels Pty (Ltd) and it is largely owned by the National Biofuels Group Pty Ltd in Australia. Key facts concerning the project are that the plant will be a 1 million ton soybean-to-biodiesel production facility with an annual output of approximately 800 000 tons of soybean meal and 250 000 tons of soybean oil, which in turn could be transformed into approximately 288 million litres of biodiesel (RNRF, 2009). The project is located in the Coega Industrial Development district and also aims at sourcing at least some of the feedstock from the surrounding area. In addition, the plant is located at the harbour which makes the access to the deep sea markets relatively affordable.

5.2.3 Ethanol gel production from maize and sugar beet in the North West Province

Ethanol production from maize is a well-developed industrial process in the US, where approximately 9.7 billion gallons of ethanol have been produced during the 2008 – 2009 marketing year (FAPRI, 2009). Due to the food security concern, it has been proposed that maize as a feedstock for ethanol production should be excluded from the South African biofuels industrial strategy (DME, 2007). There is, however, a loophole in the strategy. The production of ethanol for fuel requires the producer to obtain a licence in terms of the Petroleum Products Act of 2003. Ethanol gel production does, however, not require such a licence and hence the production of this type of product has been a success. At present, approximately 1 million litres of

ethanol gel are produced by one plant annually and most of the maize that is used to produce this ethanol is sourced from the surrounding former homeland area. In this area, most of the land is community owned and leased by the ethanol producer, creating a stable model in which both parties benefit. The Distiller's Dried Grains with Solubles (DDGS) that is produced from ethanol is then used as a feed ingredient for cattle on the farm. The ethanol producer has also started experimenting with the use of sugar beet in the production of ethanol gel and has achieved remarkable yields. This specific producer is one of the first successful sugar beet producers in South Africa.

5.2.4 Ethanol production from sugar cane in KwaZulu-Natal

Brazil has dominated ethanol production from sugar cane since the 1970s. In 1975, the *Proalcool* program was initiated and at present, the Brazilian ethanol industry requires almost no support from the government, apart from a mandate which requires that local petrol contains between 20 % and 25 % ethanol (Cordonnier, 2009). In South Africa, ethanol production from sugar is a definitive possibility given the estimated production costs of the process (BFAP, 2007). It does, however, seem that a lack of commitment from the government, in terms of mandatory blending rates, is hampering the industry the most. According to the Industrial Development Corporation, there is a development of an ethanol sugar cane plant in progress in the Makatini Flats in northern KwaZulu-Natal. Preliminary planning indicates that the plant is based on a 280 million litre per annum ethanol plant and has the capacity of consuming an estimated 3.5 million tons of sugar cane per annum. A by-product of the process is electricity which, in turn, can be sold back into the national electricity grid, once the feed in tariff scheme is finalised by the national electricity supplier, ESKOM.

5.3 A descriptive feasibility assessment

The following analysis, as represented in Figure 5.1, is based on a decision tree framework that is used as part of a top down analytical method. Levels 1 to 5 contain detailed research with respect to various aspects of the feasibility of the various projects, and at each one of these levels the individual projects are scored based on their overall suitability and, more importantly, survivability. The decision tree helps to draw a conclusion based on the overall facts and figures that have been made available to the general public.
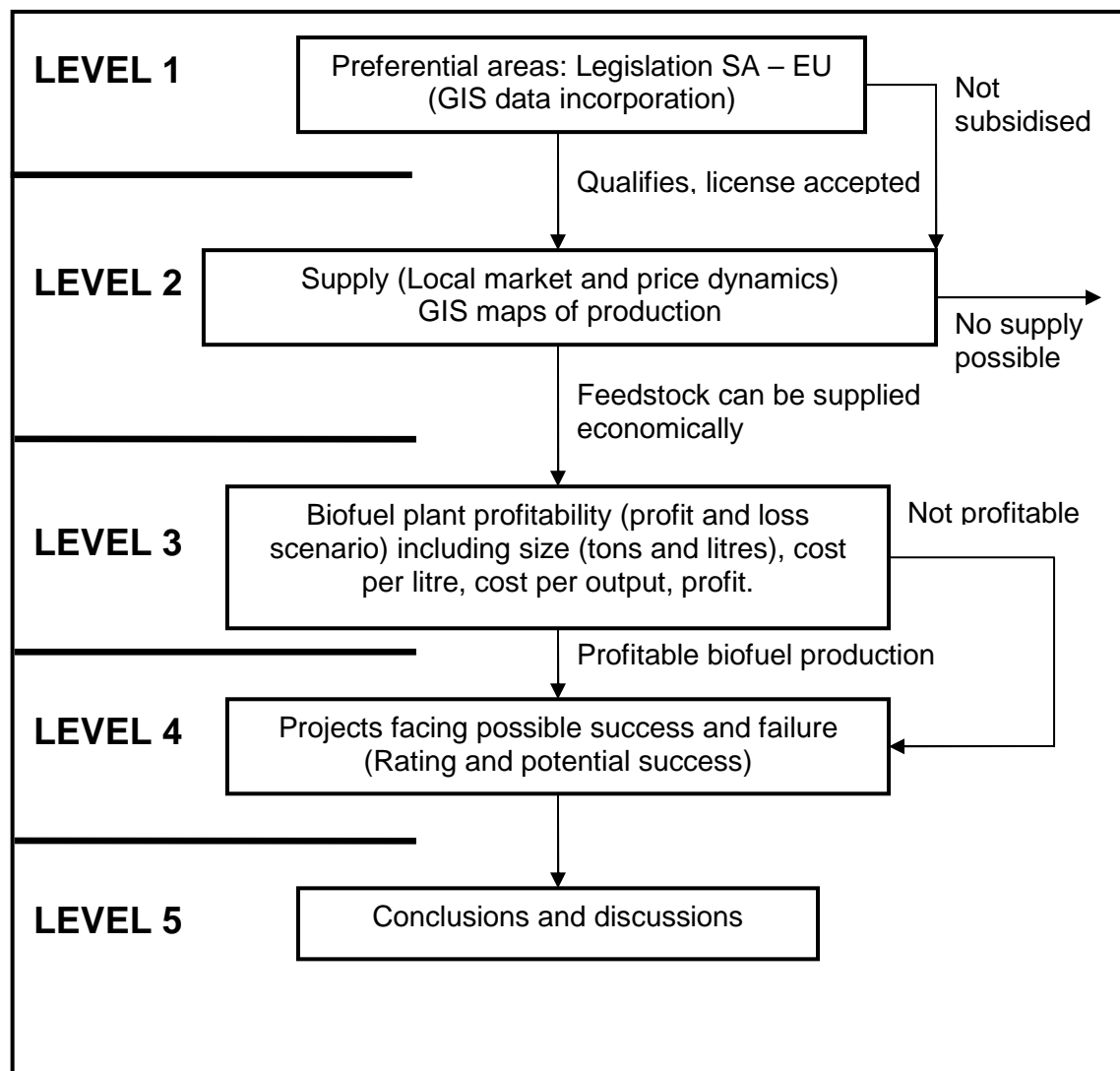

Figure 5.1: Structure of decision tree for biofuel project analysis

Level 1 describes the areas that are of interest with respect to legislation in South Africa as well as the EU. The determination of these areas is based on a rigorous assessment process during which the various biofuel support as well as "sourcing of sustainable biofuels" policies area are analysed. Production of local biofuels within these zones could in future have a preferential trade advantage within the sustainability criteria as set out by the latest and possibly also future European biofuel legislation.

Level 2 analyses the production-side dynamics that the various biofuel production projects are bound to face. This analysis focuses on the different commodities that are proposed to be used for biofuel production as well as their existing markets and future impacts that this additional demand could have on the industry. Price impacts and the resultant impact on demand and supply are backed up with arable land capability analyses, which is especially relevant for areas where lesser intensive crop production, mainly small-scale subsistence agriculture with relatively poor yields, takes place at present.

Level 3 focuses on the overall profitability of the various biofuel production projects given two future scenarios and relevant responses within the industry. Assumptions with respect to government involvement, in order to achieve rural development goals, have also been made based on the framework of existing policies. Biofuel policies have many political objectives, among the most prominent are to reduce oil use, local air pollution, traffic congestion, and CO_2 emissions (De Gorter & Just, 2009). Biofuel policies are also often cited as a means to improve farm incomes, reduce the tax costs of farm subsidies and enhance rural development (Rajagopal & Zilberman, 2007). It is therefore vital that these factors are assessed and their impacts incorporated when an analysis of the industry is conducted.

Level 4 decides which one of the mentioned projects face a possibility of not being commercially viable and should perhaps consider alternative options with respect to their overall strategic and business planning models. Dangers and complications are highlighted and represented while alternative policy options are considered and reference is made to Chapter 5, where these are discussed.

Level 5 concludes the chapter and summarises issues of supply and profitability.

5.4 Level 1: Preferential areas of investment: South African and European Union legislation

The legislation in both South Africa and the EU share similar characteristics in that both are relatively area specific, with respect to where biofuels should preferably be cultivated.

South African legislation

The South African strategy does, however, focus more on the rural development aspect and stresses the fact that "The National Biofuels Industrial Strategy is driven largely by the need to address issues of poverty and economic development". It is further stated that "The Strategy targets areas of South Africa that are worst hit by poverty and deprivation". The areas in South Africa where rural poverty is a dominant factor in everyday life are those areas neglected by the government of the past. The so-called former homeland areas feature strongly in the Strategy as it is clearly states that "…only agricultural products grown in previous homelands by historically disadvantaged farmers will qualify for the support", and in addition, "Only biofuel plants that have been identified to assist in achieving the initial target will be supported and their location will be a condition of the issuing of the licence". In other words, the government aims at only supporting those projects that are presumed to

have a beneficial impact on the overall economic well being of farmers and communities in the area. Figure 5.2 represents the location of these areas within South Africa, which can from henceforth be rated as areas of high priority for the South African government.

The ten former homeland areas were distributed throughout South Africa, with Bophuthatswana in the North West province, Kwandebele in Gauteng, and Lebowa, Gazankulu and Venda being located in the Limpopo province. The purple areas represent the KwaZulu-Natal homeland located in the KwaZulu-Natal province, while the Transkei and Ciskei were both situated in the Eastern Cape.
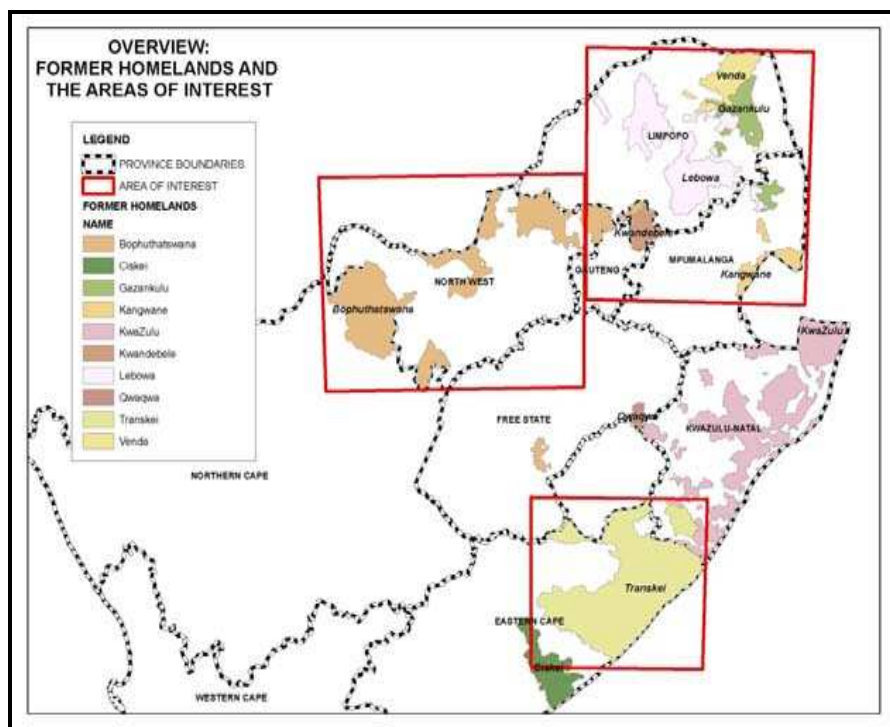
Figure 5.2: Former homeland areas of South Africa

European Union legislation

The EU legislation is not so area-specific but European law makers have been sensitive with respect to the secondary impacts caused by their biofuel legislation. Hence, the proposed legislation by the European Parliament focuses on the

prevention of secondary impacts caused by an increased demand for vegetable oil or other raw materials that are being used in the biofuel production process. The legislation also promotes the idea of producing biofuel feedstock on land that is not in direct competition with food resources, such as marginal, abandoned and degraded land (Hennenberg, Dragisic, Haye, Hewson, Semroc, Savy, Wiegmann, Fehrenbach and Fritsche, 2008). The legislation is structured on a protectionist point of view and strongly discourages the cultivation of virgin, biodiverse and natural grassland. In fact, it has even been proposed that benefits and potential preferential trade agreements are offered to companies that conform to these criteria (Hennenberg, *et* al. 2008). The legislation aims at curbing the negative impacts that have resulted due to the increased demand in blending mandates for vegetable oil and ethanol in developed countries such as the US and the EU (Oilworld, 2009).

The EU Directive on the promotion of the use of energy from renewable sources (RES) from 2008 directly addresses the use sustainability criteria by prohibiting the production of biomass from land with high biodiversity value. The criteria are defined in four categories, namely primary forests and other wooded land and wetlands; highly biodiverse grassland; areas designated by law or by the relevant competent authority for nature protection purposes; and areas for the protection of rare, threatened or endangered ecosystems or recognised species.

In addition, the EU seeks to indirectly reduce pressure on biodiversity by promoting the use of severely degraded or heavily contaminated land and the use of waste and residuals to produce biofuels. Furthermore, there is a strong focus on the protection of carbon-rich areas (continuously forested areas and wetlands) and peatland, while the raw materials that are cultivated in the EU must be produced in accordance with general agricultural requirements and standards of the EU (not relevant for South Africa) and the sustainability scheme requires that cultivation practices outside the

EU need to be monitored only, but they can be specified by voluntary bilateral and multilateral agreements with third countries – indirect land use will be monitored.

In addition to the above mentioned regulators and their criteria, the European Commission has also included a set of sustainability criteria that needs to be met in Article 17 of the Green Package that has been adopted by the European Parliament (European Parliament, 2008). The criteria that are of importance to the South African situation are highlighted and discussed in the section below (Article 17 of the Green package).

- Irrespective of whether the raw materials were cultivated inside or outside the territory of the Community, energy from biofuels and other bioliquids listed in the following points shall be taken into account only if they fulfil the specific sustainability criteria. This should be measuring compliance with the requirements of this Directive concerning national targets, measuring compliance with renewable energy obligations and eligibility for financial support for the consumption of biofuels and other bioliquids.

- However, biofuels and bioliquids produced from waste and residues, other than agricultural, aquaculture, fisheries and forestry residues, need only fulfil one sustainability criterion set out in Paragraph 2 in order to be taken into account for the purposes listed under the above-mentioned points. Namely that the greenhouse gas emission saving from the use of biofuels and other bioliquids shall be 35 %. With effect from 2017, the greenhouse gas emission saving from the use of biofuels and other bioliquids shall be 50 %. After 2017, it shall be 60 % for biofuels and bioliquids produced in installations whose production has started from 2017 onwards. Furthermore, biofuels and other bioliquids shall not be made from raw material

obtained from land with high biodiversity value, that is to say land that had one of the following statuses in or after January 2008, whether or not the land still has this status. The primary forest and other wooded land, that is to say forest and other wooded land of native species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed, the areas designated by law or by the relevant competent authority for nature protection purposes, the areas for the protection of rare, threatened or endangered ecosystems or species recognised by international agreements or included in lists drawn up by intergovernmental organisations or the International Union for the Conservation of Nature. This is applicable unless the evidence is provided that the production of that raw material did not interfere with those nature protection purposes. If highly biodiverse natural grassland, that is to say grassland that would remain grassland in the absence of human intervention and which maintains the natural species composition and ecological characteristics and processes or if highly biodiverse non natural grassland, that is to say grassland that would cease to be grassland in the absence of human intervention and which is species-rich and not degraded, unless evidence is provided that the harvesting of the raw material is necessary to preserve its grassland status.

- Biofuels and other bioliquids shall not be made from raw material obtained from land with high carbon stock, that is to say land that had one of the following statuses in January 2008 and no longer has this status. The wetlands, that is to say land that is covered with or saturated by water permanently or for a significant part of the year, the continuously forested areas, that is to say land spanning more than one hectare with trees higher than five metres and a canopy cover of more than 30 %, or trees able to reach these thresholds. The land spanning more than one hectare with trees higher than five metres and a canopy cover of between 10 % and 30 %, or trees able

to reach these thresholds, unless reliable evidence is provided of the carbon stock of the area before and after conversion.

- Biofuels and other bioliquids taken into account for the purposes referred to in Paragraph 1 shall not be made from raw material obtained from land that was peatland in January 2008, unless it is proven that the cultivation and harvesting of this raw material does not involve drainage of previously undrained soil.

- The Commission commits itself to report every two years to the European Parliament and the Council on the impact on social sustainability in the Community and in third countries of increased demand for biofuel, the impact of EU biofuel policy on the availability of foodstuffs at affordable prices, in particular for people living in developing countries, and wider development issues.

- Reports shall address the respect of land use rights. They shall state, both for third countries and member states that are a significant source of raw material for biofuel consumed within the Community, whether the country has ratified and implemented specific Conventions of the International Labour Organisation.

- Those reports shall state, both for third countries and member states that are a significant source of raw material for biofuel consumed within the Community, whether the country has ratified and implemented the Carthagena protocol on biosafety and the Convention on International Trade in Endangered Species of Wild Fauna and Flora.

- The first report shall be submitted in 2012. The Commission shall, if appropriate, propose corrective action; in particular, if evidence shows that biofuel production has a significant impact on food prices.

Legislation with respect to the South African projects

The South African biofuel legislation and licensing criteria is relatively clear as to what the project needs to include if it wishes to be approved by the then Department of Minerals and Energy (DME) today known as the Department of Energy (DoE). The perhaps single most important issue is that crops are to be sourced from designated areas, as per definition, "…an area designated by the Department of Agriculture that is underutilised and suitable for the production of biofuel crops that will supply feedstock to a specific biofuels plant". The licensing criteria further states that import replacement and domestic sourcing of feedstock must be linked to emerging farmers from underutilised land and per definition these are "A farmer from previously disadvantaged groups that did not have access to markets and/or were engaged in subsistence agricultural activities including those in the former homelands as well as farmers that acquired land through the land restitution process". Underutilised land is also defined within the framework as "… land that has a sustainable agricultural production potential, as determined by the Department of Agriculture, that is, not fully utilised". In addition to specifying areas that are of relevance to biofuel production, the legislation also states that the importation of such crops is not supported but, under difficulties of availability of certain feedstock domestically, such exceptions could be made under certain conditions. The irrigation of crops is also not allowed except under exceptional circumstances and supported by a detailed motivation. Water that is currently used for gainful irrigation will therefore not be considered for a new water licence for biofuel production (DME, 2007).

In short, the legislation, both locally and in the EU is very specific about what can and what cannot be done if the crop is destined for the production of biofuels and in the EU case, if the crop is destined for consumption within the Union. Figure 5.3 has been developed to illustrate the areas in which the various criteria for these regions have been taken into consideration. The criteria that have been included in the GIS map is based on a methodology that cancels out various factors, such as erosion, areas high in biodiversity, urban areas, and conservation areas, but includes land that is degraded and underutilised. It is also important to note that all these areas have been defined by the land capability index, which splits land that is capable of good agricultural production from land that has no potential (Schoeman, van der Walt, Monnik, Thackrah, Malherbe & Le Roux, 2002). In addition to the criteria that are important when it comes to producing agricultural/biofuel crops with having a minimal negative impact on the already vulnerable environment, it is important that these projects are situated within the former homeland areas or at least in areas that benefit emerging farmers. The areas on the map have specifically been included as part of the former homeland areas, due to the complications of the land reform process.
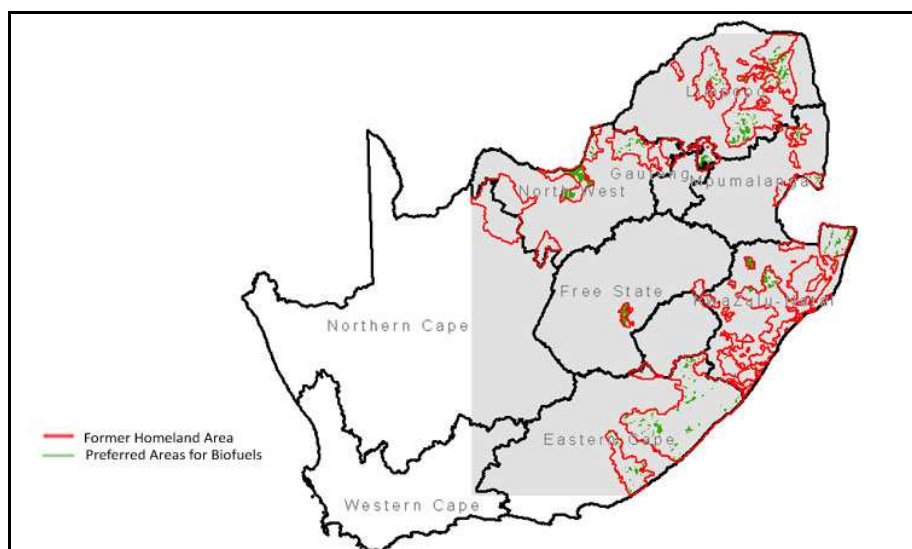
Figure 5.3: Preferred areas for biofuel production
 Source: Funke, Prussat, Schuffenhauer and Ferreira, 2009

Figure 5.3 indicates the areas that are of interest and are also the most preferred areas to invest in with respect to the different legislations. The areas within the red boundaries are most preferred in terms of South African legislation, while the areas coloured in green are the most preferred in terms of the EU legislation. In order for the various projects to score high ratings in the developed decision tree, they need to preferably source their material from inside these allocated regions.

Table 5.1: Rating of projects in South Africa

Description	Region	Rating (water)	Rating (imports)	Rating (location)
Canola biodiesel	Eastern Cape	Approval – dry	Approval – local	Approval - good
Soybean biodiesel	Eastern Cape	Approval – dry	Approval – imports**	Approval - good
Maize/Sugarbeet ethanol	North West Province	Approval – dry	Approval – local	Approval – limited*
Sugar cane ethanol	KwaZulu-Natal	Approval – dry/irrigation	Approval - local	Approval – good

* due to limited homelands in the area
** imports necessary due to shortage of supply in country

In conclusion, it seems that there is a trend for projects to be located in and also to incorporate the former homeland areas within their strategic planning for success, these are represented in Table 5.1. There are, however, a few projects that could potentially run into complications if certain criteria are not met such as sugar cane production could potentially be dependent on irrigation; soybean production could potentially be dependent on imports.

5.5 Level 2: Supply and local market price dynamics

Local supply and demand as well as price dynamics have an extremely important role to play in the economic sustainability of any industry. The infant biofuels industry in South Africa is no different. The South African legislation is strongly focused on the upliftment and development of the rural economy with specific focus on the

development of areas such as the former homelands and other farms that have changed ownership through the land restitution process, in other words, emerging farmers. In some instances, sourcing feedstock from these areas can prove to be challenging as small-scale farmers are often on the brink of being food insecure and extremely vulnerable to weather conditions. In general, there has been a decline in productivity and the absence of local industries has forced workers onto the labour market, yet the general economy has not expanded sufficiently to absorb these individuals (Ndwandwa, 2004). As a result, it can be argued that the South African legislation on biofuels does perhaps put potential biofuel producers at financial risk. A lack of local commodities means that companies are forced to source the goods on the international market at higher import parity prices. It is based on this that the policies imposed by the government are extremely important and hence should be carefully developed so that they achieve the goals that they aim to satisfy. Level 2 of the decision tree investigates the local supply, demand and price dynamics of the various commodities that are to be used in the production processes of the various projects. GIS data in the form of the national land capability classification system will be used to determine whether the areas of relevance are capable of producing crops economically.

5.5.1 Canola in the Eastern Cape

There is very little canola produced in South Africa and the crop that is produced is mainly planted as a winter crop in rotation with wheat in the southern Cape region. In the 2008 – 2009 marketing season, a total of 30 800 tons of canola was produced on a total of 34 000 hectares (National Crop Estimates Committee, 2009). Farmers generally use canola as a crop in an 11-year rotation system, which is planted as a legume within this cycle.

Although the cultivation of canola in South Africa is a positive development for the biodiesel project, the quantities produced are a concern. Consequently, either large amounts of imports need to enter the country, which in terms of canola is not really an option due to its weight-to-volume ratio, or local production would need to increase in order to secure an adequate supply of the feedstock. In addition, the location where the biodiesel plant has been planned is also not a traditional canola-producing area and hence an analysis of climatic conditions, both temperature and rainfall, would have to be done in order to determine whether production can physically be achieved there.

Canola is not traded on the South African Futures Exchange and hence prices are determined as part of a proxy of the commodities value. The Protein Research Foundation (PRF) reports prices with respect to the value that the feedstock has for various livestock. Full-fat canola has a high value in the pork industry and hence is expected to sell at the total price, while in the poultry industry it has 94 % of the value and hence has value that is discounted by 6 % to that in the pork industry.

Weather determinants

The water that is required to produce canola differs from region to region due to other external factors that have an influence. On average, it is estimated that 400 mm to 550 mm of precipitation are required in the plant growing season. There have, however, been areas in other parts of the world where a rainfall of 325 mm – 350 mm has been adequate due to sufficient soil moisture (Canola Council of Canada, 2008 a).

Canola is a cool season crop and it grows best at above 12 degrees Celsius and below 30 degrees Celsius. The optimum temperature for canola growth has been estimated to be at around 21 degrees Celsius in Canada, while in Australia research indicated that 25 degrees Celsius is optimal. If the temperature exceeds the optimum level temperature, the rate of growth is slowed until the maximum temperature is reached at which all growth stops (Canola Council of Canada, 2008 b).

Research indicates that at below 10 degrees Celsius there is progressively poorer seed germination and emergence. It has also been proven that sustained low temperatures damage the seed embryo which in turn damages the seed embryo and reduces germination and growth (Canola Council of Canada, 2008 b).
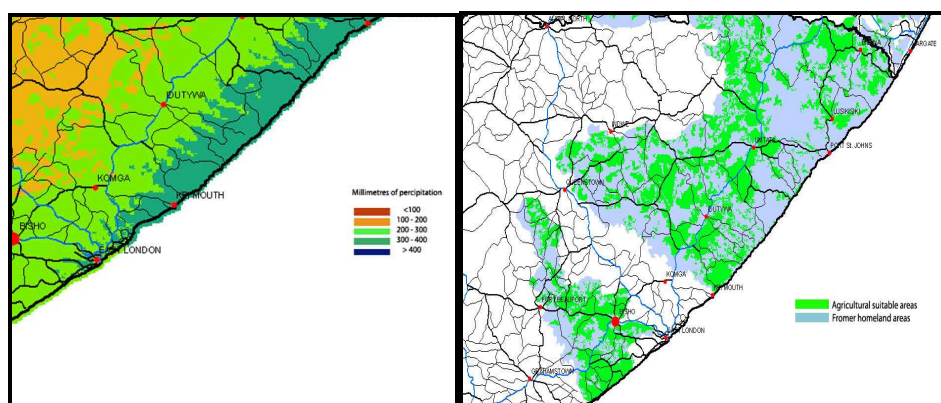
Regional suitability

As discussed, canola requires an average annual rainfall of 400 mm to 550 mm and a temperature range of between 12 degrees Celsius and 30 degrees Celsius. A temperature range of both above and below the given band results in progressively poorer development characteristics of the canola crop (Canola Council of Canada, 2008 b). In South Africa, canola is only planted in the Western Cape and is mostly part of an 11-year rotation cycle. A typical rotation cycle will be structured as follows with the aim of managing moisture, weeds as well as the use of Nitrogen. The crop rotation cycle is an 11-year cycle and consists of grazing for six years, wheat for one year, barley for one year, canola or oats for one year, wheat for one year, barley for one year and then back to pasture for six years. Since production in the Western Cape is small yet relatively successful, a plan has been developed to produce the crop in other parts of the country and perhaps even to export the oil/diesel to the European market. The Foreign Agricultural Service of the United States Department

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of Agriculture also queries the suitability of producing canola in the Eastern Cape province, since the entire crop of 30 000 tons is produced in the Western Cape.

The use of GIS data gives a clear general picture of the climate and soil suitability for the region. In order to ascertain whether the area is indeed suitable for canola production, a set of GIS information was taken into consideration in order to estimate whether the climatological factors, such as temperature, rainfall and land capability do in fact suit agricultural production in the area.

Figure 5.4 indicates the winter rainfall averages as well as the suitability of soil for agricultural uses, respectively.   Figure 5.4 clearly shows that rainfall averages between 300 mm and 400 mm per annum if extrapolated from the month of June. Precipitation data from the South African Weather Service indicates that the average rainfall for the months of June and July is around 40 mm to 47 mm, while the annual average for the East London region is closer to 900 mm (Weather SA, 2009).


Figure 5.4: East London winter rainfall and soil suitability
Source: Funke, et al. 2009

Temperature in the East London region is very mild. The average daily maximum for the winter months is around 21 degrees Celsius and the minimum temperature is

above 10 degrees Celsius, which is therefore within the range that is required for successful cultivation as is represented in Figure 5.5.
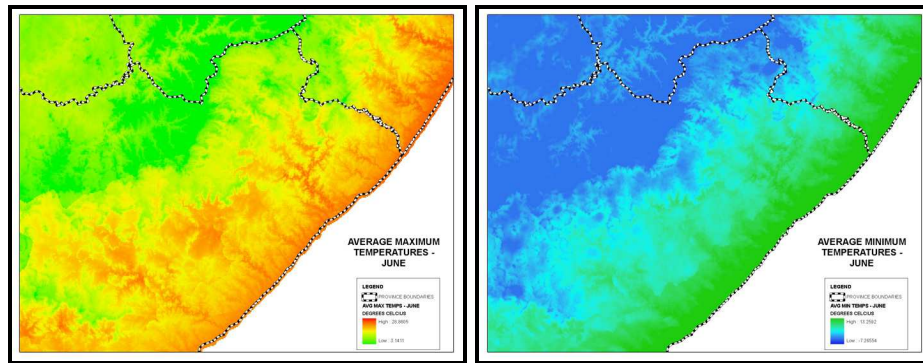
Figure 5.5: Average max/min temperatures for Eastern Cape in June
Source: Funke *et al*, 2009.

Findings

Preliminary analyses indicate that canola production in the Eastern Cape could be possible given the ranges of temperature and rainfall in the region. Soil capability analyses also indicate that the theoretical potential for yields in the region is high with the green area on the map representing the areas that are indeed capable of good potential agricultural production. The factors that could potentially hold back the successful cultivation of canola is a lack of knowledge, machinery and technology in production methods. If the project is to assist farmers and farming communities in the region to successfully cultivate the required 500 000 hectares under canola (Foreign Agricultural Service, 2009), then an alternative model to agricultural production in the areas would have to be developed and employed if this is to be a success.

5.5.2 Soybeans in the Eastern Cape

During the past couple of years, South African soybean production has ranged widely from 205 000 tons in 2007, 282 000 tons in 2008, to 507 000 tons in 2009 (Oilworld,

2009). In addition, it is expected that local production could even turn out to be as high as 1 million tons, given the slightly higher returns that farmers are receiving for soybeans compared to maize and other crops (Oilworld, 2009). Typically, soybeans are produced in the traditional maize producing regions such as KwaZulu-Natal, Mpumalanga, the Eastern Free State and under irrigation in the Northern Cape. The main production areas in South Africa are Mpumalanga with approximately 48 %, KwaZulu-Natal with 22 %, the Free State with 10 %, the Limpopo province with 8 % and the North West province with 7 % of total production (Schulze & Maharaj, 2006). Of the total soybean production, 15 % is under irrigation with the main irrigated areas being in the Limpopo province with 34 %, the North West province with 32 % and in KwaZulu-Natal with 19 % (Statistics South Africa, 2002). The total area under soybean cultivation is, on average, around 200 000 hectares with net imports of soybeans ranging from 119 000 tons in 2007 to a mere 11 000 tons in 2008. The South African feed industry is a net importer of soybean cake with local quantities demanded being around 1.1 million tons of which 980 000 tons are imported from markets such as Argentina (BFAP, 2009 a).

As South Africa is a net importer of soybeans, and especially soybean cake, there is some concern that producing biodiesel from such a sought after commodity will indeed have a negative impact on the country's balance of payments. As mentioned, the location of the plant in the Coega Industrial Development Zone near Port Elizabeth is optimally situated in terms of servicing the export market. The proposed size of the processing facility might prove to be an issue as it is geared towards consuming around 1.36 million tons of soybeans and in the process producing 288 million litres of biodiesel, which in turn equates to 1.088 million tons of soybean cake, enough to supply the entire local market.

Soybeans are currently traded on the South African Futures Exchange but prices are generally linked to the international market due to the fact that the price in the market generally trades at import parity. This means that prices are very closely linked to the international market and especially to exchange rates and other cost variables.

Weather determinants

Soybeans are planted in November and December and ideally require a mean annual precipitation of above 700 mm with more than 450 mm falling during the growing season. Soybeans are relatively resistant to very high and very low temperatures but optimum growth takes place between 20 degrees Celsius and 30 degrees Celsius, with growth rates decreasing when daily maximum temperatures are above 35 degrees Celsius and below 18 degrees Celsius. In addition, the plant is extremely sensitive to day length and especially to the interaction between day length and temperature. The plant has a medium tolerance to frost and it can grow in wide varieties of soil; given that it is not too sandy or too poorly drained (Schulze & Maharaj, 2006).

Regional suitability

There are a number of studies that have been conducted in order to determine the area suitability of soybean production in South Africa (Blignaut & Taute, 2009). Schulze and Maharaj (2006) show that the highest soybean yields should be attained in the north-eastern parts of the Eastern Cape, the moister inland areas of KwaZulu-Natal, western Swaziland, and eastern Mpumalanga but generally decreasing towards the west. Figure 5.6 indicates these potential soybean areas but shows that the areas surrounding Port Elizabeth are completely excluded from any potential activity.
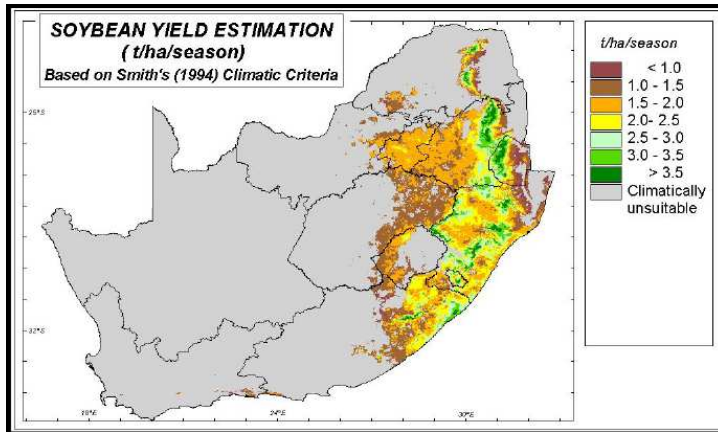
Figure 5.6: Soybean potential in South Africa
Source: Schulze and Maharaj, 2006

Findings

The general climate in the Eastern Cape seems to favour soybean production but this adheres more to the north-eastern part than it does to the south. The study by Blignaut and Taute (2009) indicates that the available area for the production of soybeans is not as big as depicted by Schulze and Maharaj (2006), but rather closer to 1 million hectares after taking all other variables, such as urban areas, slopes and soils that are not suited for agriculture into account.   Nevertheless, soybean production seems to be an option in these areas but again it needs to be stressed that the correct cultivation, production systems and techniques need to be employed if such quantities are to be produced successfully. A similar model to that of dealing with the canola production dilemma would have to be employed if production is to be successful.   Commercial farmer – small-scale farmer relationships could be enhanced to achieve this, the plant could get directly involved with the community and assist them with the production of the crops; or alternatively, the plant could lease the land from the communities and continue with its production practices, as would be the case in a commercial farm set up. At this stage, it seems unlikely that farmers in the area will be able to produce commercially in order to meet the additional demand for soybeans.

5.5.3 Maize production in South Africa

South Africa has always been a relatively large maize producer, producing an average of 9.788 million tons over the past ten seasons with the second largest maize harvest taking place in 2010 with a total of 13.317 million tons being produced. The average yield has shown substantial improvements during the past few years, largely due to advances in technology and less cultivation in marginal areas. Maize production has seen a steady increase in yields, from an average of below 3 tons per ha for the period 1994 – 2006, to an average yield of 4.28 tons per ha for the period 2007 – 2010 (BFAP, 2010). This effectively means that the same amount of maize can be produced on far smaller area, thus making South Africa more efficient. The average domestic use of maize during the past 13 years was 7.9 million tons per annum, of which the feed industry consumed 3.57 million tons and an average of 3.8 million tons went to human consumption. The price of maize is extremely volatile as it is traded on the futures exchange; but it averaged around R 1800 per ton during 2008, an increase of R 800 per ton from its nominal ten-year average level. In essence, the maize price trades between its import and export parity band, which in turn is influenced by the size of the crop, the exchange rate and world price (BFAP, 2010).

South Africa is a net exporter of white maize, trading an average of 980 000 tons during the past ten years, while yellow maize is imported more regularly. Over the ten-year average, South Africa has imported 425 000 tons of yellow maize per annum while it has only exported 275 000 tons into the international market. The South African feed industry requires approximately 3.3 million tons of yellow maize per annum (BFAP, 2010).

At present, yellow and white maize are traded on the South African futures exchange and recently, a link to the Chicago Board of Trade (CBOT) has also been created. Due to the relatively large harvest of maize that South Africa has recently experienced, white and yellow maize prices are trading at or close to export parity and as a result, the maize industry directly benefits from a weakening in the currency, changes in international markets and legislation affecting food prices, such as ethanol policies in the United States of America.

Weather determinants

Maize is mainly planted in mid-October to mid-December and ideally requires between 450 mm – 600 mm in the growing season with its optimal rainfall being around 600 mm. Maize is not frost resistant and requires a frost-free period of 120 – 140 days to prevent damage to the plant (Schulze & Walker, 2007). Its temperature requirements are a January temperature of more than 19 degree Celsius with an optimal temperature of around 24 degrees Celsius. Temperatures of above 32 degrees Celsius directly affect the yield of the plant. Constant distribution of rainfall is crucial for good yield formation especially during the flowering season, when soil water stress reduces yields more than during other growth stages. The crop prefers a relatively deep well-drained soil with both light and heavy textured soils reducing yields, particularly in drier areas (Schulze & Walker, 2007).

Regional suitability

Figure 5.7 indicates that maize production is generally limited to the eastern half of the country with the planting dates making a difference in the yields that can be achieved. In addition, the type of hybrid that is planted also makes a difference in that short or long season hybrids might be more or less susceptible to weather conditions, depending on the weather pattern at the time. It seems that the average

dry land yields can be achieved in KwaZulu-Natal (3.9 tons per ha) and Mpumalanga (3.4 tons per ha), while the yields under irrigation are highest in the Northern Cape (6.76 tons per ha) and the Western Free State (6.3 tons per ha) (Schulze & Walker, 2007). Evidence from the industry does, however, indicate that KwaZulu-Natal and Mpumalanga have significantly improved their yields in the past four years and that average yields are perhaps higher than suggested. It is well known that these areas do have a number farmer's clubs that boast with yields higher than ten tons per ha.
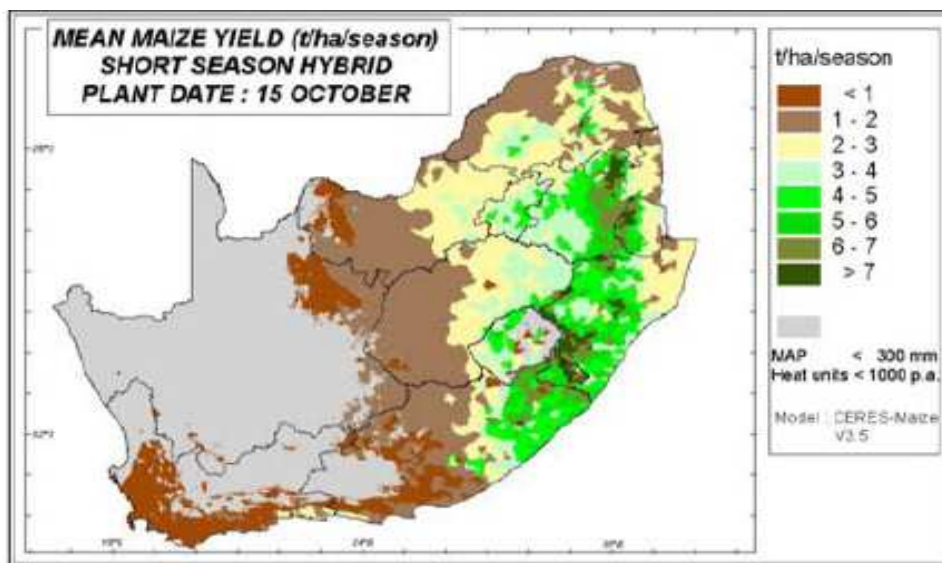
Figure 5.7: Maize potential in South Africa, short season hybrid
Source: Schulze and Walker, 2007

Findings

The climate in eastern Mpumalanga and KwaZulu-Natal seems to favour dryland maize production more than the climate in the Free State. It is interesting that areas in the northern part of the Eastern Cape are also relatively well suited for maize production. The maize sector is one of the only industries in South Africa that has consistently, over time, managed to increase its yields as a result of improvements in technology. Better hybrids and more suited maize cultivars have managed to give the industry the opportunity of excluding the more marginal soils from production and

focusing on higher potential soils, thereby also increasing yields and keeping the country at a level of being a net exporter.

5.5.4 Sugar cane production in South Africa

Sugar cane production in South Africa is relatively constant and the area where it is grown is relatively limited due to area constraints such as urbanisation, climate and environmentally protected areas. South Africa as a whole produces and crushes around 20 million tons of sugar cane; with the largest harvest in the past ten years being produced in the 2000 – 2001 season, when a total of 23.8 million tons was crushed. On average, the South African sugar industry produces over 2.2 million tons of saleable sugar with the highest amount of sugar produced being close to 2.8 million tons during the 2002 – 2003 season (South African Sugar Association, 2009).

South Africa is a net exporter of sugar and in 2008 – 2009 exported approximately 820 000 tons to international destinations. International exports have historically always been higher than 1 million tons but have declined in recent years to lower levels due to lower overall crops, which in turn has largely been attributed to a lack of reinvestment. Yields of sucrose in sugar cane have increased to a slightly higher plateau of 13 %, while the yield of sugar cane per hectare has declined slightly from its higher levels. On average, the tons of cane that are required to produce a ton of sugar have declined slightly to a level of 8 tons, while previously they were closer to 10 tons (South African Sugar Association, 2009). It does, however, not seem realistic to think that the South African sugar industry would decline to a level where no exports surplus would be available. In fact, it seems that the revenues that are to be earned in the export market have been lower than what is optimal and as a result the industry has started to commit itself to finding alternative, higher value uses for its

industry products, of which ethanol could be one of them. However, in order for such alternative revenue generating processes to come into existence the correct policy framework needs to be in place (Cutts, 2009).

At present, the price of sugar is determined by a formula that the industry applies. The division of proceeds is made up of the total proceeds from the sale of sugar and molasses on the local and export market. After the deduction of industrial charges the net divisible proceeds are shared between growers, millers and refiners in terms of the fixed divisions as mentioned in Clause 166 of the Sugar Industry Agreement. In order to provide a price on a constant basis, a provisional recoverable value price is declared monthly which is applied to all cane delivered to date, while a final RV price for the season is declared in March of each year (South African Cane Growers' Association, 2009). The RV price recognises the factors that influence the quality of the cane delivered. These are the effects of Sucrose % cane, Non-sucrose % cane and Fibre % cane on sugar production. The RV formula is represented by RV % = S-dN-cF where S is sucrose % cane delivered, N is non-sucrose % cane delivered, F is Fibre % cane delivered and d and c are the relative values of sucrose lost from sugar production per unit of non-sucrose, taking into account the value of molasses recovered per unit of non-sucrose and the loss of sucrose from sugar production per unit of fibre, respectively. The South African Cane Growers' Association estimates the d and c factors to be around 0.42 and 0.02 respectively, indicating a higher importance of non-sucrose on cane quality relative to fibre. The c factor is calculated annually based on three season rolling averages, while the d factor is calculated monthly and is based on a three season rolling average and current sugar and molasses price estimates (South African Cane Growers' Association, 2009). The cane quality or RV % cane is increased by increasing the maturity, freshness and cleanliness of the cane that is delivered to the mill. Table 5.2 highlights some aspects that add to better quality sugarcane.

Table 5.2: Factors affecting the quality of delivered cane

| Increased Maturity of Cane	Increased Freshness of Cane	Increased Cleanliness of Cane
General husbandry	Burning frequency	Topping height
Cutting cycle, age of cane	Road system and zones	Base cutting
Varieties	Type of haulier and mill yard	Reducing soil
Soils and aspect	Deterioration times	Reducing trash
Ripeners		
Irrigation		

Source: South African Cane Growers' Association, 2009

Weather determinants

Sugar cane ideally requires a total rainfall of between 1100 mm and 1500 mm per annum. Rainfall during critical periods of the growing cycle is very important as high rainfall during the harvest season leads to poor juice quality, encourages vegetative growth, formation of water shoots and increases tissue moisture. The optimum temperature for sprouting of stem cuttings is 32 degrees Celsius to 38 degrees Celsius as growth slows down below a temperature of 25 degrees Celsius, reaches a plateau between 30 degrees Celsius to 34 degrees Celsius, and is again reduced at a temperature of above 35 degrees Celsius. All growth of the plant practically comes to a halt when the temperature is higher than 38 degrees Celsius, which in turn leads to a reduced rate of photosynthesis and increased respiration. For ripening of the crop, relatively low temperatures of between 12 degrees Celsuis and 14 degrees Celsuis are desirable, since this has a severe impact on the reduction of the vegetative growth rate and enrichment of sucrose in cane (Netafim, 2009). It has been proven that higher temperatures revert sucrose into fructose and glucose may occur as a result of a higher rate or photorespiration, leading to a lower accumulation of sugars.

Regional suitability

Sugar cane is successfully cultivated in three regions in South Africa. The northern regions, which include Mpumalanga at Komatipoort and Pongola in northern KwaZulu-Natal, are mostly under irrigation while central KwaZulu-Natal, the midlands as well Pondoland in the Eastern Cape are mostly rainfed. South African sugar production is generally dependent on the availability of water and the suitability of the climate in the region (South African Sugar Association, 2009). The northern parts of the production area are under irrigation as the annual rainfall levels are not high enough to sustain rainfed sugar cane production, while the areas closer to the sea, KwaZulu-Natal and Pondoland, have a higher average rainfall and are therefore able to sustain non-irrigated production. Rainfall data suggests a similar situation with annual rainfall for the Mpumalanga sugar cane producing area averaging around 600 mm per annum while the average rainfall for the central and southern KwaZulu-Natal region varies between a minimum of 800 mm to a maximum of more than 1200 mm per annum. Figure 5.8 represents areas where rainfall is sufficient for sugar cane cultivation.
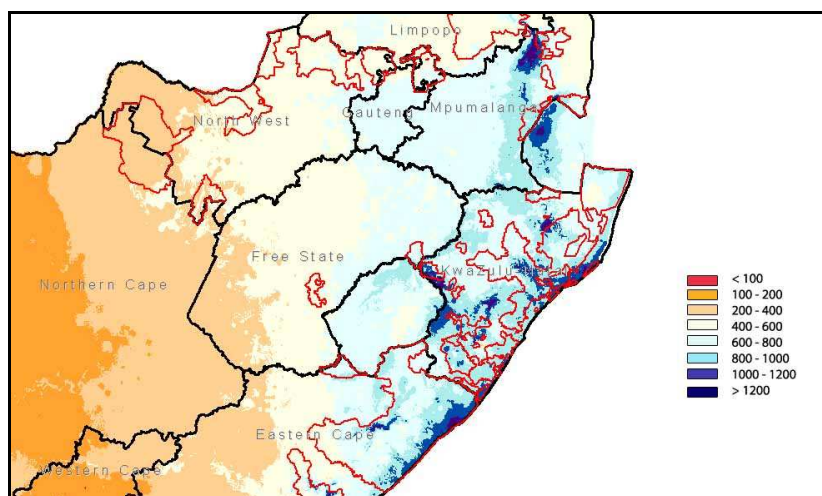
Figure 5.8: Average rainfall in KwaZulu-Natal
Source: Gers, 2009

Findings

Sugar cane and sugar production in South Africa are controlled by the Sugar Industry Agreement. Prices are determined by means of a formula where the actual quality of the sugar cane with respect to sucrose and fibre are taken into consideration. The recoverable value serves as a price that the industry role players receive for the cane that they deliver, given its quality and value. During March of each year, the final RV price is worked out and the income of the cane growers is adjusted according to the final value. The total income that the industry earns is divided according to the division of proceeds of the Sugar Industry Agreement and this is divided on a 64 % to 36 % basis between growers and millers, respectively.

The South African climate and rainfall is a limiting factor when it comes to the expansion of the sugar cane industry. High annual rainfall is generally limited to the Eastern Seaboard, while the subtropical climate is also relatively limited to that area. That results in the total area that has ever been successfully cultivated under sugar cane are limited to around 500 000 hectares (South African Sugar Association, 2009). An expansion of the local industry therefore does not seem to be a feasible option.

5.6 Level 3: Analysis of the profitability of biofuel plants in South Africa

5.6.1 Introduction

All over the world, it seems that biofuel production needs some form of intervention in order to become economically viable. This is especially true for the commodities that are not necessarily the best options for biofuel production, such as maize and wheat. The conversion rates of sugar cane and sugarbeet to ethanol are far greater, making it a far better option with respect to bioethanol production at 85 litres of ethanol per

ton of material for sugar cane and beet, compared to the average of 380 litres of ethanol per ton of maize and wheat. It is important to note that the per hectare conversion rate is important as sugar cane and beet harvests range from 60 tons to 130 tons per hectare, while dryland maize usually has an average yield of 4.8 tons per hectare in South Africa (BFAP, 2010). Bioethanol is mainly produced in Brazil and the US, while biodiesel is produced mainly in Europe and other parts of the world, such as Malaysia. History has also shown that production of biofuels in these countries did at some stage require and receive or is still receiving some form of government intervention. These interventions are discussed here in detail.

In the US, maize is used to produce ethanol and in recent years, the US has become the largest ethanol-from-grain producer in the world. In order to make ethanol production viable, the government has introduced the following policy measures as part of the Renewable Fuel Standards (RFS). An ethanol blender's tax credit of $ 0.45 per gallon, an ethanol specific tax credit of $ 0.54 per gallon and various quantities that need to be produced and blended in order to achieve the goals that are set out by the RFS (FAPRI, 2009). The revised quantities that are required to be produced are 11.1 billion gallons in 2009, 12.95 billion gallons in 2010, 13.95 billion gallons in 2011, 15.2 billion gallons in 2012, 16.55 billion gallons in 2013, 18.15 billion gallons in 2014 and 20.5 billion gallons in 2015 (Environmental Protection Agency, 2008). This refers to the total renewable fuels requirements which include cellulosic ethanol or second generation ethanol, biomass based diesel and advanced biofuels.

In Brazil, on the other hand, ethanol production received support when the National Alcohol Program was launched in the early 1970s, when petroleum deficiencies forced Brazil to find an alternative fuel. Brazil was innovative in turning to ethanol from sugar cane as a source of an alternative fuel. This initiated the development of

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the Brazilian ethanol industry, mostly through government support and control. Currently, ethanol production is regulated by government decree and every year, the actual percentage is determined by the Alcohol Inter-ministerial Committee which is comprised of representatives from the Ministry of Agriculture, Finance, Mines, Energy and Industrial Development and Commerce (Cordonnier, 2009).

The EU and its commission moved towards achieving greenhouse gas reduction targets by the year 2020. The 'Renewable Directive' of the European Commission has included a binding target of 10 % for the transport sector which has to be made up of renewable fuels compared to the final consumption of energy in the transport sector for each Member State in 2020 (European Commission, 2008). In addition to the above stated objectives, the leading committee on Industry, Transport and Energy has agreed to differentiate a target for 2020, with a 6 % target of renewables coming from conventional fuels, while the remaining 4 % will be made up of advanced biofuels or other options of renewable transport, such as electricity and hydrogen (European Commission, 2008). In terms of subsidies, farmers could claim a coupled payment of € 45 per hectare, subject to a maximum area of 2 million hectares across the EU-27, if they grew energy crops. The areas claimed for the first three years fell short of this but in 2007, claims were submitted for approximately 2.84 million hectares meaning that all claims had a reduction coefficient of 0.70337 (Swinbank, 2009).

In South Africa, the Industrial Biofuels Strategy by the Department of Minerals and Energy has also implemented some form of support which the industry can claim if they have been granted a production licence. The benefits that are of application to the industry role players include a 50 % fuel levy reduction for biodiesel and a 100 % fuel levy reduction for bioethanol, which in 2009 amounted to roughly 150 cents per litre for bioethanol and 68 cents per litre for biodiesel (South African Petroleum

Industry Association, 2009). Apart from the reduction in the tax levy, no other support is given to the role players in the industry. The Department mentions a voluntary blending ratio of 2 % for biodiesel and 8 % for bioethanol, but no fixed blending mandate, and as a result of this there is no forced off-take market. In other countries, such as the US and the EU, there is a strong movement towards protecting the local industry. This is again not evident in the South African strategy as there is no mention of any import restriction – even though this is an industry seriously threatened by the international market.

All over the world, it has become evident that the correct policies need to be in place so that the biofuel industry can become sustainable and independent; Brazil is a perfect example. This level of the decision tree investigates whether this can be achieved in the South African case with perhaps a different set of policies as well as the question of whether, given the effect of different policies, the industry will become more profitable in the long term.

5.6.2 Biofuel plant profitability – existing information

The profitability of a biofuel plant is measured in cents per litre and its relative profit margin with respect to its biofuel production. In biofuel production, profitability of the enterprise depends largely on the biofuel plants' overall strategy with respect to the purchases of raw materials necessary for ethanol production. In order to remain profitable, the production plant needs to be sure that it is sourcing raw materials at the lowest possible price in order to sell its products at the highest possible margin and receive the best possible return. Researchers have indicated that biofuel production has had some form of impact on the prices of agricultural commodities; mostly internationally.

Production costs, as can be imagined, are not well documented due to their sensitive nature. In addition to the general lack of data, there are a number of other factors that have an influence on the profitability of the enterprise. The size of the plant, the process, energy efficiency and so forth all play an important role. There are a number of different technologies that also have different cost implications for the company, but the ones that the study focuses on are the ones that have already been mentioned by the various projects or are already in use with the various projects. These technologies include the dry milling process for maize to ethanol gel, the standard sugar cane-to-ethanol conversion process, and for biodiesel, both canola and soybeans, standard conversion methods are taken into consideration.

According to a study conducted by the Bureau for Food and Agricultural Policy (BFAP, 2008), the production costs for the different technologies of the various commodities are calculated by taking the following into account. These production costs are the cost of the raw feedstock, the variable costs in the production process, the capital costs in the production process and, in some cases, the income that is received from the sales of the by-product. All of these together give the total cost that is incurred when producing a litre of biofuel, be it biodiesel or bioethanol. The ratios and costs of production are presented in Table 5.3.

Calculations are as follows:

Cost of feedstock (domestic price per ton/extraction rate * 100)

+ Biofuel variable costs (variable cost per ton of feedstock/extraction rate * 100)

+ Biofuel capital costs (capital cost per ton of feedstock/extraction rate * 100)

= Total cost of biofuel (SA cents per litre)

Table 5.3: Production costs of biofuels

Commodity	Extraction rate litres	Capital costs (c/litre biofuel)	Variable costs (c/litre biofuel)	Income from by-product (c/litre biofuel)	Feedstock costs (c/litre biofuel)
Sugar cane[1]	81.36 *l* ethanol	71.76 *c/l*	124.14 *c/l*	-	265.81 *c/l*
Maize[2]	402.32 *l* ethanol	70.96 *c/l*	125.34 *c/l*	(121.81 *c/l*)	441.42 *c/l*
Sorghum	370 *l* ethanol	70.96 *c/l*	125.34 *c/l*	(96.50 *c/l*)	449.20 *c/l*
Sunflowers	398.5 *l* biodiesel	94.10 *c/l*	95.00 *c/l*	(240.05 *c/l*)	1281.70 *c/l*
Soybeans	194.1 *l* biodiesel	94.10 *c/l*	137.20 *c/l*	(1464.02 *c/l*)	2291.83 *c/l*

[1] Assuming that no by-product, such as electricity produced from bagasse, is sold back into the grid.

[2] Cost of ethanol gel production is equal to that of ethanol fuel with an additional 100 cents per litre for thickening.

Source: Bureau for Food and Agricultural Policy, 2008

As there is no formally traded ethanol price or biodiesel price in South Africa, it is complicated to determine whether the production plants in question will produce a profit, given the estimate of their production costs. The Bureau for Food and Agricultural Policy estimates the prices by solving it in a system of equations. Prices with respect to ethanol are determined by taking the petrol price into consideration as well as its energy value and the price it is expected to trade at, 95 % of the petrol price in the case of ethanol and 100 % in the case of biodiesel. This means that without a mandate in place the price of bioethanol is expected to be slightly lower than the prices of petrol due to its lesser energy value, while in the case of diesel the price of biodiesel is expected to be slightly higher than the price of fossil diesel (BFAP, 2008).

What is of extreme importance to the long-term existence of biofuel plants is under which condition these can actually survive and remain profitable. Oil and feedstock prices change rapidly in this environment and it is vital for production plants to realise the risk that this holds for their overall profitability. In order to illustrate this, the production costs have been re-checked with the members of the various industries in order to determine their accuracy.

5.6.3 Bioethanol production costs – actual comparisons

An investigation into the various biofuel production methods has shown that there are a few business models that can be profitable under most scenarios. It seems that the key to profitable biofuel production lies in both sides of the spectrum, i.e. improving yields of ethanol per hectare of feedstock harvested and obtaining the best possible price for the product and by-product during sales. If these are not achieved, then it seems that the margins within the production process are too volatile, given the dependence on the price of the agricultural commodity as well as the price of oil.

Ethanol – ethanol gel production

Ethanol gel is produced from pure hydrous ethanol, which has its source in maize and/or sugar beet and is produced by adding a thickening agent to the ethanol after production. The gel is then packed into manageable quantities. The production process is standard although a special production facility of 1 million litres per annum has been constructed on site. Plans are underway to expand the current production facility to 4 million litres, all of which is driven by a higher demand for ethanol and ethanol gel due to an excellent marketing strategy and accurate identification of a market with high potential and higher returns.

A comparison of production costs indicates that the estimated costs as reported by the Bureau for Food and Agricultural Policy are very similar to the actual figures of the ethanol gel company. The cost comparison is presented in Table 5.4.

Table 5.4: Cost comparison for 2009

2009	Units	BFAP	Ethanol gel company
Total capital expenditure	*SA c/l ethanol*	79.02	250
Total variable expenditure (incl. feedstock)	*SA c/l ethanol*	378.87	434
Total costs	*SA c/l ethanol*	457.89	684
Gross revenue	*SA c/l ethanol*	649.50	1257.55
Net returns (ex factory)	*SA c/l ethanol*	*191.61*	*573.55*

Source: Bureau for Food and Agricultural Policy, 2009

Capital expenditure costs are higher for the ethanol gel company due to smaller economies of scale. The BFAP figures quote a 140 million litre ethanol plant while the ethanol gel company is based on 1 million litres per annum. The variable costs of production include the cost of the feedstock but in both instances different maize prices were used as a base. The BFAP figures are based on an average maize price of R 1 000 per ton, while the ethanol gel company's figures are based on the same price but with an addition which includes 100 cents per litre for the thickening of the ethanol into gel. This results in the total costs for the conventional ethanol plant, BFAP figures, being 226 cents per litre less expensive than the ethanol gel production plant.

The difference in profitability does show when a comparison is made between the two gross revenues. The BFAP (2009) figure, based on the basic fuel price of the Department for Minerals and Energy, shows a slight profit margin of 191 cents per litre of ethanol, including an additional revenue of 188 cents per litre for the sale of DDGS to the feed industry. The ethanol gel company, on the other hand, bases its strategy on not entering the fuel market but rather on competing with paraffin for cooking fuel. The difference in this strategy is that the company then references its price not to the basic fuel price, but rather to the price of paraffin which, in 2009, averaged around R 12 per litre. In addition, a DDGS by-product is also produced and this adds an additional 188 cents per litre to the overall revenue (BFAP, 2010). A higher price in a non-transport fuel industry results in a far greater profit margin when market access is gained successfully. Government regulations, safety requirements and a market of largely poor communities are just some of the challenges faced when entering a market such as this. Product acceptance and lower production costs result in a market penetration strategy and are perhaps the key factors that should be considered if market share is to be gained successfully.

The production of sugar beet in the ethanol process improves the overall efficiency of the plant and with that the overall, long-term profitability. Sugar beet is able to grow in temperate climates and is known to achieve up to a yield of 80 tons per hectare when cultivated on dry land with a sugar yield of around 15 % (Jewitt, Wen, Kunz and van Rooyen, 2009). When sugar beet is planted under irrigation, yields improve and reach approximately 120 tons per hectare, which results in an ethanol yield of approximately 80 litres per ton of beet and a total of 9 600 litres of ethanol per hectare. This is an ethanol yield efficiency improvement of 2.5 times when compared to maize production under irrigation at a yield of 10 tons per hectare, and there is a further saving in terms of inputs, as far less fertiliser and pesticides are applied in order to achieve such yields (Matthews, 2009). In addition to the better yields that are achieved and the large savings in input costs, the pulp that remains after the production process can also be utilised as an animal feed and is beneficial in terms of its starch and mineral content (Jewitt, *et al.* 2009). For the ethanol gel company, it means that if it is to source its own feedstock for its production process, 2.5 times less area needs to be planted in order to achieve the same capacity, or alternatively the current production capacity can be expanded 2.5 times and the plant will still be able to run at full production.

Ethanol – sugar cane ethanol production

Ethanol production from sugar cane takes place mainly in Brazil, the world's second largest producer and the world's largest exporter of ethanol fuel. During 2008, Brazil's ethanol production reached 24.5 billion litres, which amounts to approximately 37.3 % of total world consumption (Renewable Fuels Association, 2009). To produce ethanol from sugar cane is a conventional technology which is readily available and used commonly, including in South Africa. In 2008, ethanol

from sugar cane production reached approximately 15 million litres, most of which is destined for the industrial and pharmaceutical markets (BFAP, 2010).

Ethanol production from sugar cane requires the building of a plant that is solely geared and used for this purpose. Industry specialists estimate that the total cost of production for such a plant, in capital costs, amounts to approximately R1.3 billion (in 2009 Rands) and requires an internal rate of return of approximately 10 % in order to be economically feasible. The capital expenditure figures and the variable costs of production per litre of ethanol are very much in line with those of the Bureau for Food and Agricultural Policy (BFAP, 2008). In 2009, BFAP estimated that the capital expenditure for a 100 million litre ethanol plant was around 376.04 SA cents per litre while the variable costs are estimated at 127.54 SA cents per litre, including a weighted average cost of capital of 14.5 % and a total cost of sugar cane at a price of R 277 per ton (BFAP, 2010). A comparison with the industry revealed that the BFAP capital cost figures were 9.75 % lower and the variable cost figures were around 55.5 % higher than those of the industry.

In addition to the conventional set up of a sugar ethanol refinery, an electricity generation capacity has been included as part of the overall production process. The overall process has been refined with the help of engineers from Steinmüller Engineering in order to make the cost of production and returns on investment as accurate as possible. The electricity generation is based on a 70 ton per hour bagasse throughput, with a Net Calorific Value (NCV) of 133712.3 kilojoules/second, an 80 % boiler efficiency based on NCV and a 24 % steam cycle efficiency. The plant and boiler thus have an overall electricity generating capacity of 641 MWh and it is assumed that the boiler will run at 100 % capacity for 20 hours per day and 7 months per year, as generation depends largely on bagasse availability. The cost of including such a set up is quoted at R 45 million with a straight line depreciation

schedule over 20 years and an interest rate of 10 % per annum, which roughly translates into an additional cost of 4.73 SA cents per litre of ethanol produced. It if further assumed that the plant has its current electricity cost included in its variable cost figure and it is therefore free to sell all electricity that is generated back into the grid. Viability of following such a process will depend on returns that are being offered in the market by the energy regulator as well as the cost of purchasing electricity from the national supplier, ESKOM.

There are a number of factors that need to be considered within this setup. These include the phases within the design of the plant. In other words, the extent to which the plant is going to produce ethanol and from which materials. Will the plant only utilise the cane and the juice extracted from the cane or will it also make use of C-molasses? Secondly, if the plant is geared to co-generate electricity at the plant, will the plant be able to sell this excess electricity back into the grid? If this is the case, then the plant will be able to earn additional revenue of 118 SA cents per kilowatt hour, of which it can supply its own electricity, mitigating an opportunity cost. The amount that the plant will earn is, however, largely dependent on the decision that the National Energy Regulator of South Africa (NERSA) takes with respect to the generation of electricity from private suppliers, suppliers not regulated by the state-owned monopoly, ESKOM. A high kilowatt output per annum amounts to a good return and can improve overall profitability.

The location of the plant is also an important factor that needs to be considered. Not just is it important to place the plant strategically so that the distance to the market is close enough so as to not impact on its viability, it is also important that the ethanol plant is able to source all its feedstock from within a radius of 80 km, otherwise the transport of the cane becomes a barrier. In recent years, South Africa's area under sugar production has declined due to areas being developed for residential purposes

and farms changing ownership, due to land reform programmes, which in turn have an overall impact on the productivity of this industry (Cutts, 2009). This has resulted in some mills doing away with delivery quotas and allowing farmers to deliver as much cane as is physically possible, in order to keep running at full capacity (Stolz, 2009). It seems illogical to place an ethanol plant within the same feedstock sourcing radius as a sugar production mill, unless the sugar mill is already operating at overcapacity and physically constrained due to its processing capabilities. The estimated costs of production are presented in the Table 5.5 below, together with the prices and extraction rates used in the assumptions.

Table 5.5: Cost of production of sugar cane ethanol for 2009

2009	Units	BFAP	Industry
Gross Revenue (ethanol)	*SA c/litre*	462	462
Gross Revenue (electricity)	*SA c/litre*	158.8	158.8
Gross Revenue (incl. ethanol and electricity)	*SA c/litre*	**620.8**	**620.8**
Total cost of production	*SA c/litre*	503.58	498.7
Total cost of production (with electricity generation capacity)	*SA c/litre*	508.32	503.42
Net Return (w/o co-generation)	*SA c/litre*	**-41.6**	**-36.7**
Net Return (with co-generation)*	*SA c/litre*	**112.52**	**117.4**
Ethanol price (BFP without rebate)	*SA c/litre*	462	462
Sugar cane price	*SA R/ton*	277	244
Extraction rate	*Litres per ton*	81.36	81.36

* National Energy Regulator of South Africa, feed in tariff of 118 SA cents per kwh.
Source: BFAP, 2009

Conclusion – ethanol

Ethanol production for transport fuel in South Africa, as in any other part of the world, is dependent and related directly to the degree of government support that it receives. Lower oil prices and related lower fuel prices (BFP) are too volatile to create a sound foundation for the long-term sustainability of the industry. As a result, an alternative means of income generation needs to be integrated within the industry in order for it to be profitable in the long term. In the case of the ethanol gel company, a movement away from conventional transport fuels to a cooking fuel base

has indeed proven to be sustainable, while in the case of sugar cane ethanol production, co-generation of electricity seems to be the solution to a more sustainable business plan. If the ethanol gel company focused on the transport sector, lower oil prices would result in unsustainable profits; while if co-generation does not take place in the sugar cane-to-ethanol plant, then there is a high probability that at current fuel prices, net returns can be negative.

In addition, the Industrial Biofuels Strategy also lends very little support to the industry and it seems that the criteria for support from the programme are too strict and unrealistic. In the case of the sugar cane-to-ethanol case study, benefits from the strategy were refused and a licence was not granted even though the company has around 3 000 black small-scale growers who would directly benefit from such a development. This contradicts the strategy and should carefully be reconsidered if the industry, and especially a profitable project, is to be designed and developed.

5.6.4 Biodiesel production costs – actual comparisons

The factor most influencing the profitability of the biodiesel industry seems to be its direct competition with the human food market. During periods of low crude oil prices, vegetable oil fetches a far better price in the human market than what would be the case if it were to fetch a price somewhere close to the BFP for diesel. During periods of high crude oil prices, one would expect this situation to be more profitable, but in fact vegetable oil prices rise with crude oil prices and hence profit margins get squeezed and production is less profitable. It therefore seems that the key to a profitable biodiesel industry lies within value addition of materials previously seen as waste, such as waste oil, and the production of high value by-products. It is clear that the production of biodiesel alone at a facility will not return any profits and that a different business model needs to be in place if it is to be successful.

Biodiesel production – soyoil versus soy biodiesel

Table 5.6 represents the production costs when producing biodiesel clearly indicate that larger profits are to be made in the food oil market. The production of oil together with the production of oil cake clearly makes this industry the most profitable vegetable oil processor. It does, however, show that overall profits could not be achieved if oil were to be purchased as a raw material with biodiesel as the final product. In order to achieve further profits, food oil producing companies should engage into buy-back contracts with their respective customers. This would entail them having the right to buy back the used cooking oil from their customers at the market price, ranging from R 2 to R 4 per litre, depending on market conditions (Sidler, 2009).

Table 5.6: Cost of production soy oil versus biodiesel, 2009.

BREAK-EVEN: 2009	Units	Soy oil	Biodiesel
Cost of soybeans[1]	SA c/litre	1499.14	1499.14
Variable costs	SA c/litre	102.70	135.62
Capital costs (WACC = 14.75 %)	SA c/litre	44.64	101.80
(-) Income from soycake (by-product)	SA c/litre	-1430.35	-1430.35
Total costs per litre of product	*SA c/litre*	**216.13**	**306.21**
Product plant price	SA c/litre	781.302	613.24[2]
Diesel price at plant (BFP)	SA c/litre	-	455.54[3]
Net returns	SA c/litre	565.17	307.03[4]

1. Cost per litre of soyoil and biodiesel, respectively.
2. Modelled biodiesel price (BFAP, 2010).
3. Basic fuel price for fossil diesel.
4. Net returns based on the biodiesel price.

Source: Bureau for Food and Agricultural Policy, 2009

The 2009 break-even analysis takes into account various soybean and soybean cake prices. The figures in the Table 5.6 above are based on a soybean seed price of R 2 990 per ton, a soybean cake price of R 3 470 per ton and a crude oil price of US$ 74/bbl. A further assumption is that the biodiesel price trades slightly higher than the current diesel price due to preferential treatment that the product could possibly

achieve from the government if it fulfils all the licensing requirements. If this is, however, not the case, biodiesel is likely to trade at a similar price as diesel, which in turn affects overall profitability and reduces the net returns to 149.33 SA cents per litre. A very important aspect here is that biodiesel production needs to be an activity of the business together with the production of oilcake. If this is not the case, then costs are far greater than profits, even at higher crude oil prices (BFAP, 2010).

Biodiesel production – canola oil versus canola biodiesel

Very similar principles apply to the process of producing biodiesel from canola oil as is the case when biodiesel is produced from soy oil. The main difference is however that canola is produced even less in South Africa than soybeans and as a result it impacts on the viability of producing biodiesel from it, as supply of the commodity might prove to be an issue. The costs of production are presented in Table 5.7, below.

Table 5.7: Cost of production canola oil versus biodiesel

BREAK-EVEN: 2009	Units	Canola oil	Biodiesel
Cost of canola[1]	SA c/litre	806.58	854.97
Canola oil variable costs	SA c/litre	102.70	122.0594
Canola oil capital costs (WACC = 14.75 %)	SA c/litre	44.64	101.80
(-) Income from canola cake	SA c/litre	-342.43	-342.43
Total costs per litre of canola oil	SA c/litre	611.49	736.40
Product plant price	SA c/litre	625.042	613.24[2]
Diesel price at plant	SA c/litre	-	455.54[3]
Net returns	SA c/litre	13.552	-123.16[4]

1. Cost per litre of canola oil and biodiesel, respectively.
2. Modelled biodiesel plant price.
3. Basic fuel price of fossil diesel.
4. Net returns for biodiesel based on the wholesale price of biodiesel.
Source: Bureau for Food and Agricultural Policy, 2009

The costs of producing canola oil and biodiesel are not as profitable as in the case of soybeans. This is due to a number of factors that have an influence on the profits that are to be made from canola processing. Very important is the price of canola,

relative to its value in the feed industry, as cake. According to Duke (1983), the use of canola cake in livestock feed should be limited due to its toxicity. Canola contains goitrogenic L-5-vinyl-2-thiooxazolidone, which induces goitre growth in animals that consume large quantities of this cake. In addition, the consumption of canola has also been linked to poisoning syndromes in animals, affecting respiratory, digestive, nervous, and urinary systems (Duke, 1983). The break-even analysis in Table 5.7 is based on an oil extraction rate of 38 % for canola seed as literature suggests that oil contents of canola seed are around 40 % (Canola Council of Canada, 2008 a). The producer price of canola that was used in the estimation is averaged at R 3 065 per ton for 2009 (BFAP, 2010), while the cake price has been adjusted to an average value of 75 % of soybean cake at an average 2009 price of R 2 602 per ton. The costs of production indicate that there is a clear difference in the level of profitability between producing canola oil for human consumption and processing canola oil for biodiesel production, based largely on prices that would be received at the sales level within the different industries. The variable costs of production for biodiesel are higher than for human consumption as more chemicals need to be added and there is a slight loss due to refining and quality issues in the process; while on the capital side, production costs are also higher for biodiesel as the capital outlay required is more expensive.

Profitability in the human oil sector again outweighs the profitability in biodiesel production sector due to the input/output price ratio. As vegetable oil prices are linked to crude oil prices and since South Africa is trading at the higher end of the price parity band, especially in terms of canola oilseeds, profitability is not necessarily expected to improve as prices rise. A further value addition mechanism needs to be added to the business plan in order to make the company financially viable.

Biodiesel production – waste oil feedstock

The production of biodiesel from waste or used oil is a concept that has already enjoyed attention in the US. In the process, the most common way of producing biodiesel is to transesterify triacylglycerols in vegetable oil or animal fats with an alcohol in the presence of an alkali or acid catalyst. Methanol is the commonly used alcohol in this process, due in part to its low cost. The products, Fatty Acid Methyl Esters (FAME), are called biodiesel and include glycerine as a by-product. Alkali-catalysed transesterification has been most frequently used industrially, mainly due to its fast reaction rate (Zhang, Dubé, Mclean & Kates, 2003). Sodium hydroxide or potassium hydroxide is the usual alkali catalyst. In contrast, acid-catalysed transesterification has received less attention because it has a relatively slow reaction rate. Nevertheless, it is insensitive to free fatty acids in feedstock oil compared to the alkali-catalysed system. The typical acid catalyst used in the reaction is sulfuric acid (Zhang, *et al.* 2003).

Biodiesel from waste oil production is thus a process whereby used oil is filtered and transformed, by alkali-catalysed transesterification, into biodiesel. From an economic point of view, this process indicates that due to its low input cost nature, it could be far more viable than the conventional idea of biodiesel production. Low input costs, due to the relatively cheap price of used cooking oil together with the cost of the facilities bring the total production costs in South Africa to around 430 SA cents per litre, as presented in Table 5.8.

Table 5.8: Cost of production: waste oil biodiesel, 2009.

BREAK-EVEN 2009	Units	Waste oil biodiesel
Cost of waste oil	SA c/litre	250
Biodiesel variable costs	SA c/litre	50
Biodiesel capital costs (WACC = 14.75 %)	SA c/litre	135.90
(-) Income from glycerine	SA c/litre	- 5.35
Total cost per litre of biodiesel	SA c/litre	430.55
Biodiesel price at plant	SA c/litre	613.24
Diesel price at plant (BFP)	SA c/litre	455.54
Net returns	SA c/litre	182.69

Source: Biodiesel centre, 2009

Therefore, producing biodiesel from waste oil on site, in addition to producing cooking oil from soybeans, seems to be the most profitable business set up. With a relatively cheap cost of purchasing waste oil, at 250 SA cents per litre, and a return from glycerine at 5 SA cents per litre, the total net returns for a waste oil biodiesel production plant come to 182 SA cents per litre. These then add to the base profits that are being achieved from the production of soyoil and soycake, bringing the total net return to 565 SA cents per litre of soyoil, including soycake and 182 SA cents per litre of biodiesel produced as shown in Table 5.8.

Conclusion

Biodiesel production from vegetable oil with only glycerine as a by-product does not make economic sense in South Africa. The cost of the vegetable oil is often too high and as a result it cannot compete economically with the price of fossil diesel. This is not only the case under a low crude oil price scenario, but also under a higher oil price scenario, as agricultural commodity prices and prices of fossil fuels seem to have a higher correlation, at higher levels (Binfield, 2009). The key to producing these fuels in an economically sustainable manner should therefore shift from a purely fuel-based approach to one that incorporates various industries as these can together achieve the best returns. Oil for human consumption seems to deliver the best returns if it is produced in conjunction with oil cake. This entails that a plant

should not only be able to refine oil but also be able to press seeds and produce oilcake. In addition, a plant should aim at signing purchase back agreements with various customers in order to ensure a constant stream of waste or used cooking oil, which in turn can be used to produce biodiesel. In this way, net returns can be maximised and all processes can be utilised to the fullest extent.

5.7 Level 4: Projects facing possible success or failure

5.7.1 Introduction

Sections 5.5 to 5.6 of the study have discussed the possible biofuel production facilities that are currently in production or are in the planning and development process. From the investigations, it again becomes clear that the success of facilities that are geared towards the transport fuel industry is largely driven, at least during the infant phases, by government involvement in terms of blending mandates, tax support programmes, import tariffs, regulations and electricity purchase agreements. Success of projects is, however, not solely limited to the degree of government involvement. There are companies and business options out there than can be successful without any involvement from government. The case of the ethanol gel production company is just one of the examples that does substantiate this. It seems that product innovation and the means of adapting the business through innovation can result in success within this sector.

5.7.2 Possible success, possible failure

Innovation and a focus on possible alternatives appear to be one of the main drivers that can result in success within the industry. It seems to be the concept of diversifying the business' activities so as to not be exposed to too much risk from a specific sector. A lack of such diversification has shown clearly that at low oil prices

there is too much risk involved and this in turn can result in a low chance of economic success.

Table 5.9: Status of various projects in South Africa.

Project	Commodity	Status	Level of government support	Success/failure	Conditions/risk
Ethanol	Sugar cane	On paper	0	Success – gov. dependant	Feed in tariff, ethanol mandate
Ethanol	Maize/sugarbeet	In operation	0	Success	No government involvement
Biodiesel	Soyabeans	On paper	Possible	Success – gov. dependant	High cake prices, low veg. oil prices
Biodiesel	Canola	On paper	Possible	Failure	High veg. oil prices, low returns on cake
Biodiesel	Waste oil	In operation	0	Success	Low waste oil prices
Combination (oil/biodiesel)	Waste oil/soyabeans	On paper	0	Success	Diversification of risk, returns based on two industries

The information provided in Table 5.9 indicates that various projects, which have not reached operational status, face a chance of failure if the required action by the government does not take place.

Ethanol projects

The ethanol production project from sugarcane will for example not reach the construction phase if the feed in tariff for renewable electricity is not imposed and altered to include electricity from bagasse and if there is no off-take market for the ethanol that they produce, in other words a blending mandate. Thus, without such legislation being imposed, production from this project is not expected to take place.

The ethanol gel production company is at present the only commercially successful biofuel production plant in South Africa. Good market identification and a movement towards an alternative market have resulted in commercial success and a self-sustaining business enterprise. The movement away from transport fuels as the

main target market has improved the company's reference price and has made its business plan more sustainable. This project has shown that commercial production of bioethanol can be a viable alternative in South Africa.

Biodiesel projects

Biodiesel production from soybeans and canola face a market-driven risk in South Africa. In the case of soybean biodiesel, profits are positive at low oil prices as this is largely driven by high returns from the oil cake. This will only be viable if there is a market into which the biodiesel can be sold, at a profitable price. Without an enforced mandate and a market for the commodity, it is highly unlikely that such investments will be made; as better returns, of almost 200 SA cents per litre, can be realised in the food oil production industry.

Canola biodiesel faces a similar problem in that returns within the food sector are positive, and greater, whereas this is not the case when the production of biodiesel is being considered. Relatively high costs of production in terms of canola oil, together with lower returns with respect to the oil cake and a lower availability of the feedstock, due to limited production, make canola biodiesel the least profitable option in biodiesel production. Perhaps concrete ties with the EU and preferential trade agreements with respect to biodiesel trade could result in the financial success of this project. However, local sourcing of the feedstock as well as production of the feedstock in preferred areas (see Figure 5.3) would have to be carefully completed if such milestones are to be reached. Firstly, preferential areas of production could create further problems for production as this will limit the production areas to certain fields, which in some instances could be some distance apart. Secondly, the distance between the country of origin, South Africa, and the EU is far, resulting in a further cost that has to be considered when estimating profit margins.

Waste oil biodiesel seems to be the most logical source for biodiesel production as the product does not really have a more profitable alternative use. Purchasers of used cooking oil therefore have two alternative options available to them: to either refine the oil again and re-sell it into the poorer communities as low grade oil or to process it into biodiesel. With low costs of production and the more profitable pay-off/opportunity cost, it seems that producing biodiesel from waste oil could indeed turn out to be the more profitable alternative. There are, however, constraints with respect to the volumes of waste oil that can be sourced. Sourcing of waste oil is a highly competitive market as there are many entrepreneurs trying to access this sector in order to make good returns (Sidler, 2009). It is therefore important that steps are taken to ensure a constant source of oil, firstly by introducing buy-back agreements with new oil buyers, and secondly by approaching food chains and securing purchasing agreements with the various branches. It is crucial that these sourcing strategies make economic sense as the biodiesel production plant needs to be in production and it will prove uneconomical if production needs to be halted due to a lack of material. Success of this enterprise is therefore dependent on how well the sourcing strategies are executed and at what price the product can be sourced.

The biofuels industry

Success of the individual projects depends largely on the input cost/output price calculations but also on the actions and regulations that the government will take in order to make these projects more plausible. Regulations that add to inefficiencies in the marketing system of biofuels will negatively impact on the industry. The fact that the sourcing of feedstock from only specific groups of individuals, when those are already being neglected by a lack government support in the rural areas, is mandatory for projects to qualify for official licences in terms of the Industrial Biofuels Strategy, makes this strategy by government somewhat contradictory. In addition to the strict regulations that govern the sourcing of feedstock, there is a lack of

commitment on the demand side of the supply chain. So even if manufacturers adhere to all that is required on the supply side, they will be unable to sell their fuel locally, as fossil fuel manufacturers are not at all obliged to take up any of the biofuel that is being produced. It then becomes unclear as to how the industry is expected to survive or to be established if there is a strong lack of commitment from the various governmental institutions that are actually required to support the industry and guide it in becoming self sustainable. A clear shift in strategy needs to take place before sustainability is a possibility.

5.8 Level 5: Conclusion and discussion

Biofuel production in South Africa is driven by a number of variables, all of which have a direct impact on its sustainability and economic viability. By using the decision tree approach as a framework, various impact levels that influence current biofuel projects in South Africa have been extensively analysed and conclusions drawn based on the information provided.

Legislation

Legislation governing the production of biofuels in South Africa and for use in the European market is two-fold. In South Africa, the focus of the legislation has its basis in rural development and economic upliftment of the rural poor, while in the EU, legislation is largely based on ensuring that the biofuels that are blended into the mix are indeed produced in a sustainable manner. Some of the case studies under consideration do meet these criteria, while others do not, yet this seems not to be a determinant that ensures the project's profitability. In fact, two or possibly three of the projects that will probably not qualify for government support are the ones that show the most profitable figures, while there is serious doubt when considering the projects that do qualify. Perhaps the view of the South African legislators misses the

point and perhaps this is the reason as to why almost no biofuels production is taking place locally and even less improvements in rural development is being achieved with the help of these projects. Perhaps the focus of the governmental policies should take economic success into account before determining what the focus should be on. These issues will be discussed further in Chapter 6.

European legislation, on the other hand, seems to have formed the new benchmark in the developed world. A relatively strong focus on the "greenness" of the fuel together with a concern of the way that it is produced, forms part of a legislative background that seems to be one with a view on responsibility and long-term sustainability. Europe's view is that it is becoming more dependent on energy imports, and therefore energy security and higher prices, could become serious threats. Therefore, investments in energy efficiency, renewable energies and new technologies will prove to have wide-reaching benefits and will contribute to the EU strategy on growth and jobs (European Commission, 2008). In terms of the impact on the South African projects, it seems that these should attempt to adapt themselves to the requirements of this market, if it is part of their business strategy to access it.

Supply

The supply response to an additional demand for agricultural commodities is largely driven by the area's ability to convert to production of that commodity, if it is possible and more profitable. Profitability plays an important role as areas geared for farming use their limited resources to produce specific commodities, based on the expected net returns. In terms of agricultural commodities that are either being used or proposed to be used for bioethanol production, South Africa's supply is sufficient. South Africa is a net exporter of maize and sugar cane and therefore sourcing these

commodities for alternative uses, from a purely supply perspective, should be market related, with the exception of sugarbeet.

Biodiesel production faces a more import-driven scenario in which most prices are largely bound to import parity, due to "shortages" in supply. Even though soyabean production is increasing strongly, largely driven by higher yields, South Africa is still expected to remain an oilcake and vegetable oil net importer for the foreseeable future (BFAP, 2010). The production of canola is, on the other hand, not expected to increase that strongly due to the limitation in cultivatable area in which it is planted, i.e. certain areas in the Western Cape and possibly some areas in the Eastern Cape. Potential areas in the former homelands and especially the Eastern Cape face challenges that have a restraining impact that is just as severe as limitations in favourable weather conditions. The lack of cooperation and commitment in ensuring successful farming practices, together with a complete lack in infrastructure and the appropriate know how, are just some of the main factors that need to be considered. Without the business addressing these factors in the area, successful supply of the commodity to the enterprise will surely be severely affected.

Profitability of the projects

The profitability of the various projects depends largely on the input/output price ratios that can be achieved. Biofuel production has been known to receive subsidies, be it in the form of tax credits, mandates and import tariffs, from governments in various countries around the world (Westhoff, 2010). It is often argued that without such support mechanisms, these projects would be doomed to failure and could never become self sustainable. It is therefore assuring to see that some of the proposed projects in South Africa are indeed self sustaining even without any financial support from the government or any government institution. At present, the most profitable project, based on its unique approach to the marketing of its product,

is ethanol gel produced from both maize and sugarbeet, while the project that is expected to be second most profitable and which serves both the electricity and transport fuel markets, is ethanol from sugar cane, given the proposed size of the plant in KwaZulu Natal and the electricity feed in tariff of 118 SA cents per kwh.

A 2010 – 2020 outlook for bioethanol projects, with current legislation, as stated in the Industrial Biofuels Strategy 2007 is far less promising. In Figure 5.9 the oil equivalent break-even levels for large scale maize and sugar to ethanol projects have been calculated. The difference in oil price and the oil price equivalent of the different projects is an area of concern and reinforce the point that the government strategy needs to be altered if large scale production of bioethanol is to take place. Figure 5.9 takes only the current fuel levy exemption as stated in the Industrial Biofuels Strategy of 2007 into account.
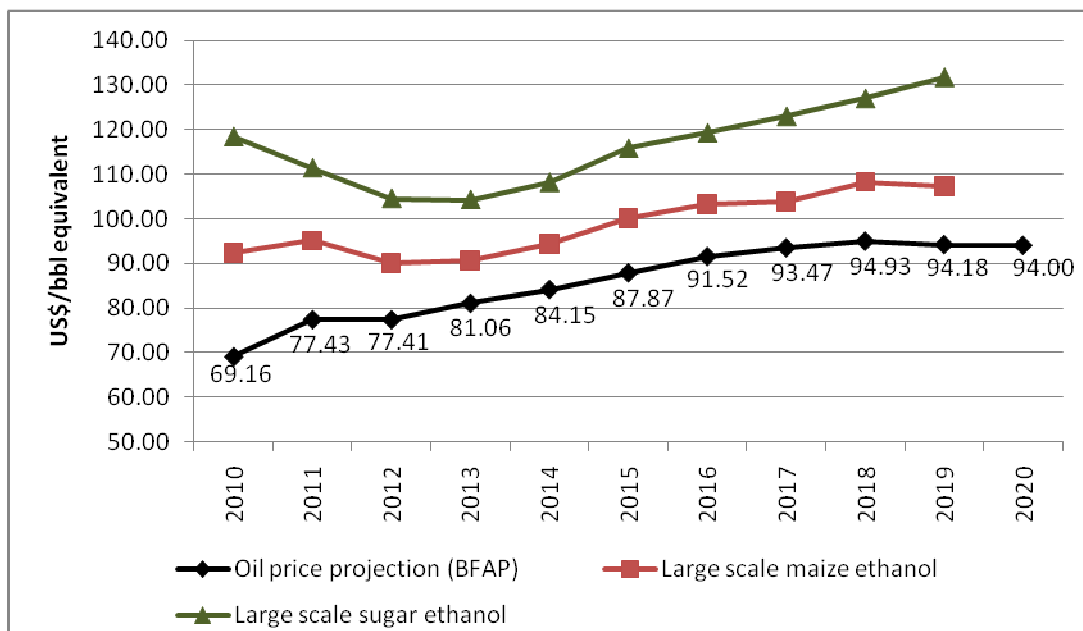
Figure 5.9: Oil price equivalent break-even levels of large scale maize and sugar ethanol production.
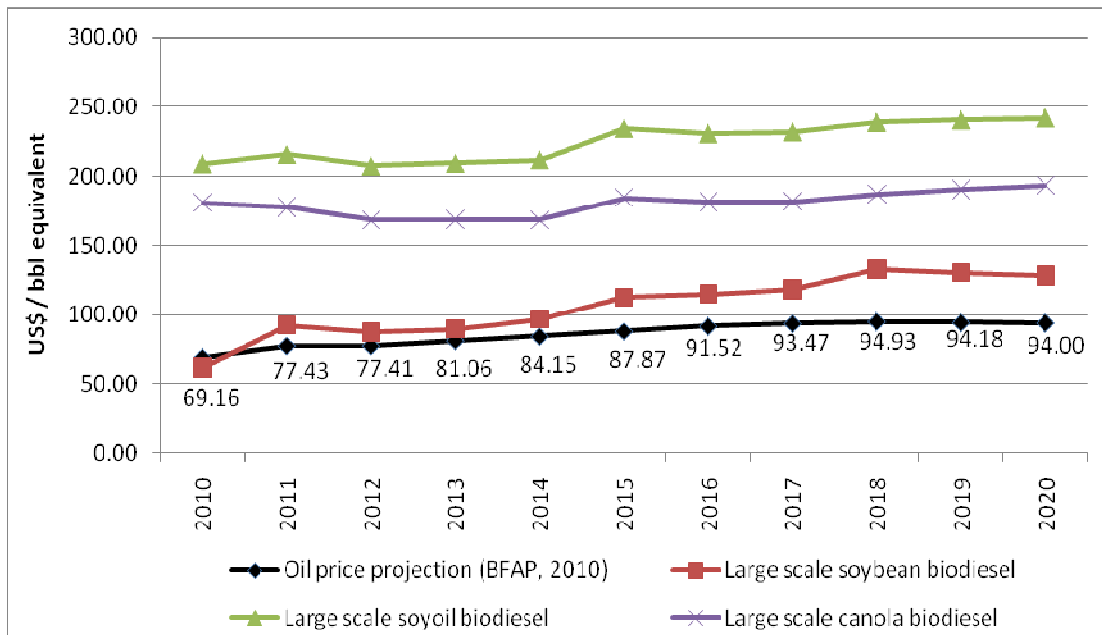Source: BFAP, 2010.

World commodity prices are reaching a new level and as a result costs of production also seem to have shifted (BFAP, 2009). It is however important to note that the oil price is not the only variable in the profitability calculation that plays an important role. In the case of sugar, the price of that the industry can earn on the international market is the actual benchmark (Cutts, 2011). If the international raw sugar price, the New York No.11, reaches an oil equivalent value larger than reflected by the total cost calculation in the local market, then the logical approach for the local industry would be to produce sugar for trade in the international market and not for local ethanol production. This would however only apply to a local market producer whose operation produces both sugar and ethanol as opposed to an ethanol only producer would not be take part in the sugar (Cutts, 2011). In order for sugar to ethanol only projects to be viable an additional revenue source is required. Electricity co-generation from fibre will have to be added as an additional revenue stream if these projects are to have any chance of becoming economically viable. Ethanol from maize is less complex but could potentially also see competition from other uses, such as feed and human consumption, and therefore have an impact on the profitability of its operations. This will apply especially in years of lower maize harvests. Care should also be take in considering Figure 5.9 as it indicates that maize ethanol is viable at lower oil prices, compared to ethanol from sugar cane. There are a number of reasons for this. Firstly, the BFAP (2010) assumes normal rainfall in maize producing areas and an average crop of 11 million tons, resulting in carry-over stock of 2.2 million tons and thus export parity prices. In addition it is assumed that the Dried Distillers Grain with Solubles (DDGS) trades at approximately the same price as maize, as long the market is not flooded with supply. The sales of DDGS are an additional revenue stream for the ethanol plant and thus make it more profitable. The outlook on commodity prices is represented in Figure 5.10.
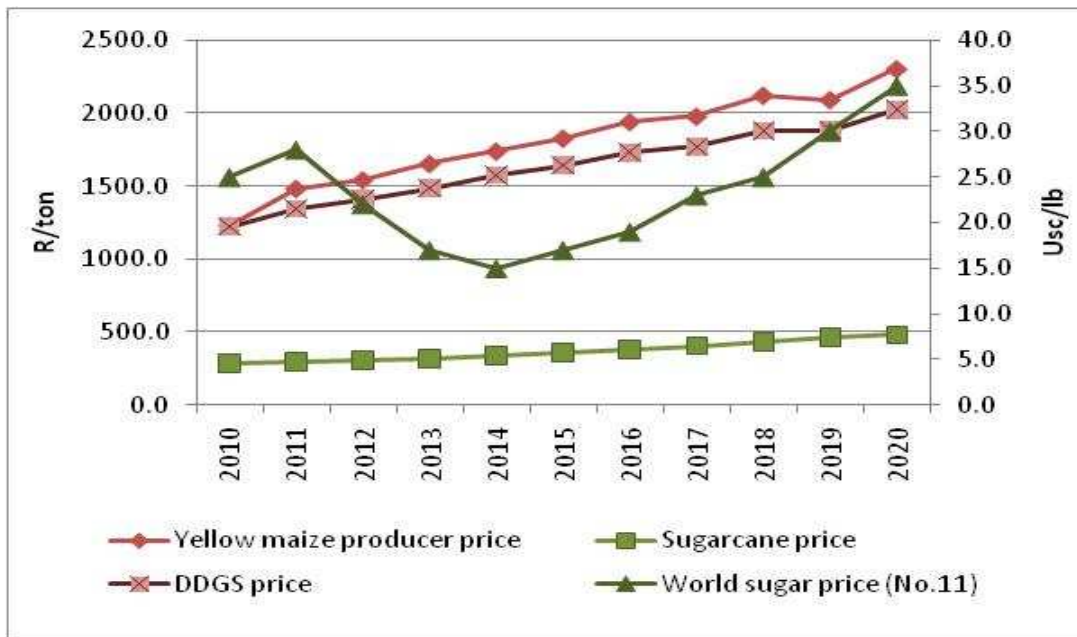
Figure 5.10: Outlook on SA and International Commodity Prices.
Source: BFAP, 2010.

Current conditions in the biodiesel market set soya-based biodiesel as the most profitable fuel from vegetable oil. However, based on competition in the vegetable oil market, it is perhaps wise to only consider biodiesel in a secondary form, i.e. produced from waste oil. Canola biodiesel fares the worst with negative profits and a constraint on the supply side of the marketing chain. The oil equivalent break-even levels of the soybean, soyoil and canola biodiesel are represented in Figure 5.11 below.

Figure 5.11: Oil price equivalent break-even levels of large scale soybean, soyoil and canola biodiesel production plants.
Source: BFAP, 2010.

Figure 5.11 indicates that only large scale biodiesel production from soybeans is likely to be the most profitable form of biodiesel in the foreseeable future. The reason for this is again that approximately 65% of the revenue generated in such a plant is earned from the sale of high value soybean cake to the feed market. It is therefore necessary that a biodiesel plant should incorporate this function. Section 5.6.4 indicates that profits that are to be made in the market for human consumption far outweigh those to be made in biodiesel and thus it is likely that this production will not occur. Large scale biodiesel production from canola faces similar profitability issues as those of pure soyoil production as the revenue generated from a relatively lower value feedstock does not support the operation's profits sufficiently. The BFAP (2010) outlook on oilseed prices indicates a similar up trend, driven largely by the increasing demand for oilseeds worldwide. The outlook on the price of canola and soybean oil indicates why producers of vegetable oil will predominantly be supplying the food market. With current incentives in place, it is expected that the price of biodiesel will be far below that of vegetable oil.
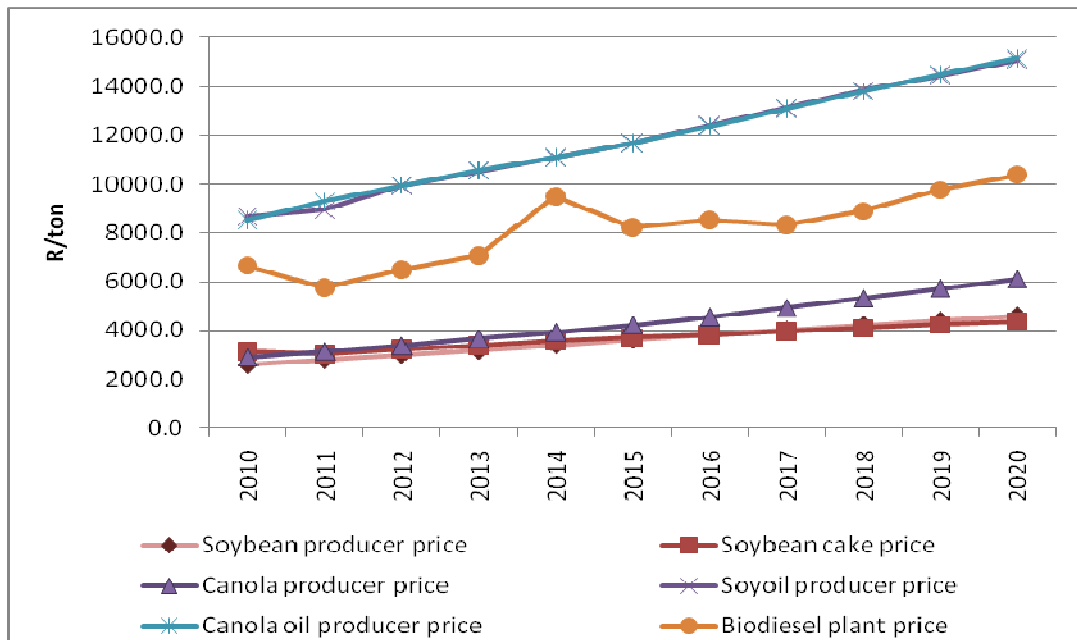
Figure 5.12: Outlook on oilseed prices in South Africa.
Source: BFAP, 2010.

Biofuel projects therefore seem to be most profitable in the current South African environment if they form part of an alternative source of energy solutions. The production of biofuels needs to have at least one alternative product coming out of the process apart from the fuel itself; be it a by-product in the form of an animal feed, renewable energy in the form of electricity or itself as part of a secondary process, such as the conversion of waste oil. In South Africa, this could especially be the case as the lack of government commitment to the industry has forced entrepreneurs into finding alternative applications for their products which in turn has forced them to be more innovative and committed. A lack of commitment has, however, also resulted in certain projects failing to make the cut and perhaps never being able to get off the ground, meaning that the overall benefit to the community would be non-existent.

5.9 Conclusion

The decision tree analysis clearly shows that the production of biofuels in South Africa can take place economically. Agricultural production is sufficient and skills in most areas are sufficient in order to ensure a secured supply of feedstock for most processes. The government has even gone as far as drafting a policy that specifically focuses on the production and use of biofuels and attempts to create an environment in which the production and use of these fuels can achieve industry sustaining levels. The South African Industrial Biofuels Strategy does, however, lack commitment, incentives and direction to such an extent that a severe lack of development within the industry hardly seems surprising. The strategy demands biofuels to be sourced from areas where development of agricultural practices has been neglected for the past 20 years or from farmers and communities which have recently received ownership of land through the land restitution program. This is a worthwhile attempt at improving rural development but with a lack of support mechanisms in place to promote farming in these areas, the success of this seems highly unlikely. A poor level of infrastructure in terms of roads, fencing and farming equipment, together with an extension officer to farmer ratio often exceeding 900 to 1, it seems that the various government departments have directly or indirectly been responsible for the lack of development in this industry. On the demand side, the strategy has been just as poorly thought out. A voluntary blending option, suggesting the use of biofuels as an addition to the fuel mix, has hardly put any oil refinery under pressure; nor has the lack of a clear incentive as to what the industry can expect to receive for its fuel once it adheres to the previously mentioned requirements. Again, this lack of direction has resulted in the most successful projects sourcing alternative markets and competing with products where markets are less regulated and more flexible. The result is that the government might not achieve its renewable energy target of 10 000 GWh of energy equivalent by 2012 and, more importantly, might be

faced with serious energy problems if it does not conform to the market and accept that there are indeed alternative and greener solutions available.

Chapter 6 summarises the findings and discusses a revised policy framework capable of replacing the current biofuels strategy by taking accurate and concise information into account. In this chapter, a set of policy instruments are designed and documented in order to take the entire policy development process into account capable of providing the correct structures in order to ensure that the development and growth of the industry is optimally supported.

Chapter 6

Policy options and conclusion

6.1 Introduction

Biofuel production in South Africa has been under consideration, with the Department of Minerals and Energy publishing the formal strategy of the South African government in December 2007. The strategy is strict in its regulation and states that biofuel producers need to comply with various procedures and adhere to specific regulations before they are able to receive an official licence from the government. In addition to these requirements, the biofuel producer needs to have various procurement strategies in place, which are often far beyond the scope of the project and as a result add unnecessary risk to their operations if upstream supply fails to materialise. In addition to supply issues, the national strategy does not offer these producers enough clarity with respect to incentives, as too much confusion and self-centred focus within the individual departments has resulted in individual as well as overall visions and missions being blurred. This research has reiterated that any infant industry requires various policy support tools in order to become economically feasible and self sustainable.

It is the aim of this chapter to summarise the contents in the framework of the study as well as to show which policy mechanisms DoE, DAFF and DLA can put in place in order to ensure that individual departmental goals are achieved by means of cooperation. Thereafter, the chapter concludes with a summary of the dissertation as well as world developments, the results from the game theory applications, local production cost analyses and possibilities for future research.

6.2 Recap and summary

In times of high oil prices, dwindling oil supplies and a high cost of oil extraction, biofuels can be a source of alternative energy. Concerns and uncertainty over oil supplies have forced governments to look for alternative options, and since 2005, there has been a strong increase in world biofuel production. At present, the largest producers include the US, Brazil, Germany/EU and China, all of whom have or are currently making use of substantial policy intervention in order to establish and support their respective renewable energy initiatives.

In South Africa, the idea of introducing biofuels as part of the total fuel pool has been discussed, debated and strategised but the development in the industry has proven difficult, and it is obvious that there are quite a few factors, such as the national biofuels strategy, hampering the establishment and expansion of the industry. The research question that remains is thus whether South Africa should have a biofuels industry and if so, can this industry assist the economy in being less dependent on the use of fossil fuels, more environmentally friendly, a market for agricultural commodities and an additional source of employment?

A concise literature review has shown that the policy development process is perhaps the most important aspect in creating a sustainable and efficient industry. The Brazilian government, for instance, has been extremely successful at developing the industry and the respective policies in such a way that they complement each other and an odd 40 years later, the industry is so self sufficient that the level of government support barely exists. It should, however, be noted that Brazil is the exception. The levels of support and role player involvement in the biofuel industry in other countries are extremely high. In the US and the EU, large amounts of resources have been spent on supporting the industry as various energy,

environmental and development goals have been set out which are required to be met. This means that support of the industry is necessary if these are ever to be achieved. It is, however, not just the current biofuels policy that is of interest and importance but also the entire policy development process. In Brazil, negotiations and agreements with automobile manufacturers and the sugar cane industry had been concluded before the actual policy was legislated. In the EU and the US, an extensive research and consultation process, with numerous reports and research articles being written on what the likely impact of policies could be, was conducted based on the legislation. The goal of this is to avoid unintended consequences. In South Africa, however, this has not been the case. In fact, the policy development process has been very different and there is a complete disconnect between the government and the industry. The complications and inadequacy of the current policy framework has been mentioned by numerous researchers (BFAP, 2008; Funke, Strauss & Meyer, 2009) and it seems that the cause of this lies in the process of establishing the current policy framework, which in turn has been characterised by confusion, a morass of government inaction and a lack of policy determination (FAS, 2009 a).

In Chapter 3, a simple game theoretic simulation is designed and gives a clear indication that production of biofuels is being seriously hampered by a lack of government involvement but more importantly, a lack of government commitment to the successful implementation of the strategy. The game theoretic illustration indicates that at present, the various governmental departments find themselves in situations which are furthest from their desired Nash Equilibria. In other words, they are failing in achieving their own goals and strategies; which in turn could be much easier achieved if the various departments coordinated their moves and reacted objectively to the decisions taken by their colleagues. For instance, DAFF could well have been far better off in terms of its rural development goals if its activities

coincided with those of DoE, just as the DLA could benefit far more with its land reform program if DAFF would actually focus more on achieving its rural development goals. Instead, DAFF's actions are hampering the development of an additional off-take market for agricultural products with concerns over food security and a failed extension officer support programme. It is interesting that governmental organisations are extremely inefficient; and furthermore, it seems that the achievement of their own goals is not even of interest to them. Reasons for this could be largely political in that various political regimes have strategies and goals that they wish to achieve in order to stay in control. Nevertheless, there are a few alternative policy options that the governmental departments can change and alter in order to better achieve their goals.

A further basic game theory application, designed to model the policy development process in South Africa, indicates that the optimal mode of conduct in the industry is to not invest if there are no incentives to do so. The oil refineries would incur a higher cost due to the adaptations that need to be done to existing facilities, while the biofuel producers face an increasing risk with respect to investment in an industry that will lack a market in which the industry can sell its products. In fact, not reacting to the actions of the "nature player" seems to yield most Nash Equilibria!

An investigation into the physical ability of the South African industry to produce biofuels, in accordance with the strategy, also yielded some interesting results. The research conducted revealed that the production of feedstock for biofuels is definitely not an issue, nor are the direct costs of production a concern. The maize industry, for example, has steadily increased the yield per hectare to such an extent that in the past ten years, eight out of ten times more maize has been produced than has been consumed. In addition, those years had large carry-over stocks preceding them and as a result no shortages were experienced. The South African sugar industry has

followed a similar trend and has only once in its existence been forced to import sugar due to domestic shortages. The biodiesel feedstock situation is different in that traditional feedstock supply is less than what is needed for consumption, but again the implementation of the correct policy framework could well serve as a development tool. A national mandate of a 8 % ethanol blend would require that a total of 877 million litres be produced which would require 2.1 million tons of maize, if solely produced from maize, or 10.7 million tons of sugar cane if this was the only feedstock used. A 2 % biodiesel blend relates to 159 million litres of biodiesel, which in turn would require 820 thousand tons of soybeans or canola, which would be extremely difficult to achieve with South Africa's limited agricultural potential.

It therefore seems that alternative options for a biodiesel blend would have to be found, not just because of the limited feedstock supply but also the opportunity cost that these commodities face with respect to their use in the human/food market. It seems that under specific circumstances, the industry could even be self sustainable with limited government interference, given the assumption that there is in fact a market to sell the fuel other than using it for own consumption. If this is not further investigated by the government and action taken, existing biofuel production businesses might be forced to look towards alternative markets when it comes to selling their products. Such innovations already exist and focus on markets other than the transport fuel market and perhaps this is the necessary innovation needed to propel the industry to self sufficiency. This aspect also became evident in the game theory application in which the σ variable, which is a variable that represents payoffs from various innovative product application processes, depicted the manner in which the biofuel producer responded after having reacted to the current biofuel strategy of the South African government. An example of this is ethanol gel production for cooking purposes, while in the biodiesel developments it seems that the best and most profitable model focuses on producing oil for the food market as a

main product and cake for feed as a by-product. In addition, a buy-back agreement of used oil will further improve the viability of the firm which in turn can be processed into biodiesel; as a result adding value to a product that would previously have fetched a far lower price as used cooking oil in the poorer areas of South Africa. It therefore seems that the key to making profits does not lie in the traditional production of biofuels for transport fuel, especially if there is no blending mandate, but rather in innovation and locating markets that offer the best returns.

6.3 Issues with South African legislation and alternative policy options

Every country that has incentivised the blending of biofuels into the current fossil fuel mix needed to be sure of the policy direction that it was following as well as the goals that it wanted to achieve with this incentive. In the late 1970s, the government of Brazil entered into negotiations with the automobile manufacturing sector which secured an agreement that defined the aims of the sector in terms of producing mass volumes of ethanol-only vehicles. Continued support to the industry, as was the case in Brazil through the *Proalcool* program, has had substantial consequences and now, 30 years later, the government is able to adapt quickly and initiate changes, modified programs and mandates in order to match new economic realities (Cordonnier, 2009). It seems that the Brazilian ethanol industry is well on its way to becoming self sufficient and benefits the country to such an extent that one quarter of all fuel sold, is locally-produced ethanol. This, in turn, was made possible by the uniqueness of the Brazilian authoritarian political system which was an excellent example of the successful guidance to the establishment of an industry in times of favourable economic conditions (Cordonnier, 2009). It has, however, been proven that the welfare effects of a biofuel policy can be relatively large and that in instances where biofuel policies are used in combination with each other, the effects can be

contradictory and even reversed. Therefore, it is crucial that these impacts are clearly analysed and understood (De Gorter & Just, 2010).

In South Africa, the focus may need to be somewhat different. The production of biofuels can form part of the local fuel mix but the long-term goal of the various policies should focus on creating a market, which often does not exist in rural communities. Households in the former homeland areas, who have been earmarked as one of the groups that should supply the biofuels industry with agricultural commodities, were traditionally allocated very small areas of arable land and, according to Lyne and Nieuwoudt (1991), access was further constrained by the absence of efficient land markets. This has partly resulted in the concept of small-scale agriculture in South Africa being laden with subjectivity and as a result has been associated with non-productive and non-commercially viable agriculture (Northord, 2004; Simbi, 1998). The problem lies not in their inability to respond to higher prices or a larger demand of the commodity but rather due to the fact that there is a small or in some instances a non existent market which they can respond to. Food availability for example is linked to food production through processing, delivery and consumption, in addition to other issues such as the socio-economic importance of affordability and accessibility to and of food and the financial vulnerability of food producers and food producing regions (Lopez, 2002). In other words, an increase in the production of food leads to greater availability of food and agricultural commodities which in turn impacts on the economic growth in the domestic and international markets (Lopez 2002; Misselhorn, 2006). Generating an income can therefore provide greater access to more and other varieties of food and also provide cash for use in other areas of the economy such as small enterprises and manufacturing, which in turn help reduce poverty and food insecurity (Everatt & Zulu, 2001). A creation of such a market could assist them in getting out of the poverty trap. The following is therefore proposed:

Blending mandate

The Bureau for Food and Agricultural Policy (BFAP) has conducted a number of studies in which the authors attempt to identify the correct blending mandate levels for biofuels in South Africa. In a policy brief in 2007, BFAP made a recommendation of increasing the blending mandate from the recommended voluntary level mentioned in the Draft Strategy. BFAP (2007) proposed that the government implements a 2 % biodiesel blending level and an 8 % bioethanol level, which it gradually phases in over time by increasing the level with 2 % per annum until the full blend is reached. A further study by BFAP in 2008 analysed the Industrial Biofuel Strategy and recommended that a blending mandate be implemented which has very similar characteristics to the recommendations in 2007. Current research and investigations have confirmed the findings by BFAP (2007; 2008).

A blending mandate is vital to the development of the industry but care needs to be taken when such an instrument is being considered. Firstly, a blending mandate is not relevant if none of the commodities can be supplied locally and need to be imported; nor should a blending mandate be in place if the market does not have the desire or the ability to use the mandated quantities of the product. The implementation of a mandate needs to be coincided with some form of take up scheme not just in the form of commitment from oil refineries and changes to their ability but also from the consumer market; as otherwise, the market could be saturated in a relatively short period of time with the result that complications such as blending walls and physical limits inhibit growth of the sector. The promotion of production and importation of flex fuel cars, capable of running on an E85 blend, is perhaps one of the easiest means of achieving such structures. An alternative option to introducing ethanol in the local market can be achieved by using the fuel as an

additive. Estimates in 2003 indicated that the market for ethanol as an oxygenate can be as high as 12 000 barrels per day (521.2 million litres per annum), which roughly translates into a 5 % ethanol blend. According to a report by Graboski (2003), agricultural feedstocks including maize, cassava, sugar and molasses have the potential of providing this ethanol. The report further mentions that up to 30 000 barrels of ethanol per day can be produced from different feedstocks without impacting on food security. At present, South Africa purchases Methyl tert-butyl ether (MTBE) as it does not have adequate supplies of producing it locally, while much of the ethanol used for oxygenation is produced synthetically from coal. This means that it could be in the interest of the government to invest in greener technologies, such as bioethanol, in order to reduce the water pollution impacts that have been known to be caused by the use of MTBE (Graboski, 2003).

The blending mandate is the most important policy in the entire industry in that it establishes a market. All countries that make use of biofuels have some form of blending mandate in place and it is with this mandate that the industry can be established. Examples that come to mind are the US with its *Renewable Fuel Standards* program, Brazil with its *Proalcool* program and the EU with its *20/20/20* principles. In the South African situation, it has been proven that a voluntary mandate does not achieve any form of market development. The game theoretic application illustrates this rather well as the oil refiners in the industry development game always opt to reject the biofuel policy, if they are not forced to consider it otherwise. In the actual research, this theoretic behaviour is substantiated and comments from industry experts also substantiate this point. Cutts (2009), for example, substantiates this point and emphasises that the industry can only function if an off-take agreement is established and if oil refiners are forced to accept the fuel in order to meet government requirements.

The government is thus faced with two possible options with regard to the volume of the blending mandate. Firstly, a mandate should be imposed and slowly phased in over time in order to give the industry time to react. It is proposed that the biodiesel mandate is kept constant at a 2 % national blend and phased in at 0.5 % intervals. It is vital that if biodiesel is implemented the correct incentives are in place in order to support the projects that have been specifically designed to produce feedstock for these purposes. A 2 % biodiesel blend amounts to 159 million litres. The situation for ethanol is different in that an 8 % national blend can be accommodated given the feedstock availability in South Africa. The blending requirement for ethanol is an initial 2 % and increased at 2 % intervals until a national level of 8 % has been reached. Further increases in blending requirement can be imposed at later stages but from the BFAP (2008) research, an 8 % level seems to be feasible level. A 2 % blending mandate translates into approximately 220 million litre increments with a final level of 891 million litres and the equivalent of approximately 6 average-sized ethanol plants. If this mandate is split equally between the maize and sugar industries, this would require 1.1 million tons of maize (21 % of total yellow maize production) and 5.47 million tons of sugar cane (29 % of total sugar cane production) (BFAP, 2010). BFAP (2008) estimated that the impact of a 10% ethanol mandate can have an upward price impact of between 7% and 10% on the producer price of maize. A higher demand on sugar cane will also impact on the demand for the commodity in the industry and thus an increase the price of cane can also be expected. The magnitude of the increase will largely depend on the notional sugar price at that time but an increase of up to 10% can be expected (BFAP, 2008). It is envisaged that various industries can take part in ethanol production based on their respective profitabilities; and if this is split between maize and sugar, the risk of over committing in one sector and thereby threatening a shortage in the short term, is minimised.

The second option that exists for the government is to look towards ethanol as an additive for petrol at a mandate of approximately 5 %. This requires an approximate production of 550 million litres and the benefit to the government is that this is less of a risky option as there are alternatives should the biofuels industry fail to supply the required quantities. It is, however, vital that coordination and cooperation within the fuel sector takes place as it is crucial for the local development of the industry and this needs to take place effectively in order for the implementation of the policy not to result in any serious market inefficiencies.

It is therefore proposed that a national blending mandate of a maximum value of 8 % be established for bioethanol. This should be phased in over a dedicated period of time in order to give the industry time to adjust and to make sure that the industry can meet these targets. In terms of the biodiesel industry, it is proposed that a mandate of 2 % be imposed in all blends of diesel, again on a national basis over a designated period of time. National refers to the overall blend in South Africa, which means that areas of surplus fuel may blend higher percentages, which in turn offsets shortages in other regions. The mandate is regulated by forcing fuel suppliers to prove that their total supply of fuel does contain the required blend of biofuel.

Tax incentives

A biofuel market will not be developed if the correct policy instruments are not in place. Tax incentives are among the most widely used instruments and can dramatically affect the competitiveness of biofuels with respect to other energy sources and their overall competitiveness (FAO, 2008). The fuel levy or tax exemption has been designed to compensate biofuel producers and can translate into an incentive for production. What is, however, crucial is that the benefits of the exemption are indeed passed onto the producer. If biofuels have a tax exemption of R 1 per litre, the fuel can sell at the same price as fossil fuels but earn the producer

R 1 more revenue per litre, if its production is indeed cheaper. The key is that the tax incentive is large enough to make biofuels competitive with fossil fuels at current cost. This gives regulation and transparency to the industry which is similar to the current structure in the fuel industry. It is therefore recommended that the current levels of 50 % tax exemption for biodiesel be increased to 100 %, while the 100 % tax exemption for bioethanol be maintained. In 2008 – 2009, current tax exemption levels would result in an effective support of R 1.35 per litre for biodiesel and R 1.50 per litre for bioethanol. In terms of government revenue, the tax exemption would result in a net revenue forfeit of R 215 million with respect to biodiesel and an R 1.34 billion revenue forfeit with respect to bioethanol. These support measures are relatively small when compared to the other cost components in the industry and in all likelihood these will be recouped through the sales to the consumer. In addition, this tax exemption would allow the government to reach some of its renewable energy goals as set out in the white paper and it is further estimated that the additional developments in the agricultural sector would create jobs and assist in various governmental departments in reaching their rural development goals faster and more easily.

The mechanism of how the tax credit functions perhaps needs to be revised as it seems that the tax credit incentive or benefit could easily be withheld from the biofuel producers. In addition, the competition with exporters of the commodity will influence the competitiveness of the local industry to its detriment. The situation can easily turn into one in which the local industry is negatively affected due to imported biofuels entering the country without an import tariff being applied to them and blenders still receive a tax credit for blending these fuels into the local mix. Clauses, such as the local use of biofuels for blending purposes, and the allocation of tax credit based on the country of origin status will have to be defined and enforced.

Experiences from other biofuel industries have indicated that tax credits can also be lowered as these industries mature. In Germany for example, the biodiesel industry has always enjoyed far lower taxes than the fossil diesel sector. As a result, an increasing volume of biodiesel was mixed into the fossil fuel mix which eventually led to a relatively large amount of lost tax revenue. As a result of the lost revenue, the total amounts of tax credits have been reduced and a stance has been taken on the leniency of lower tax rates on biofuels. Further developments have been the implementation of a mandate; which at the end of its period in 2015 will be as high as 8 %, with a minimum blending level of 4.4 % for biodiesel and 3.6 % for petrol. Again, the mineral oil industry can only use fuels that have been approved by legislation, i.e. sustainable biofuels from rapeseed, soya or palmoil.

It is proposed that biofuels in South Africa are completely exempt from fuel tax, with 100 % tax rebate for both biodiesel and bioethanol. The tax exemption should be reviewed after a certain time period in order to make sure that it is still required and that the industry can indeed not survive without the exemption.

Import tariff

The import tariff protection is vital for an industry which is in its infant stage of development. Depending on the level and rate of policy implementation, import protection is crucial. Policy development history has indicated that import protection is crucial during the initial phases of the industry's development, while during the latter phases and with increasing local competitiveness the level of protection can and should be scaled down. Two major players in the world market have indicated this exact process and have completely ceased or started a reduction in their level of import protection. Brazil, for example, reduced their level of protection from 20 % to 0 % from March 2006 onwards, while the US is also in the process of reducing tariff protection from the current level of 2.5 % and 54 US cents per gallon to 45 US cents

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per gallon from 2011 onwards (FAO, 2008; De Gorter & Just, 2010). Depending on the level of mandate and the rate at which it gives the industry time to respond, it is extremely important that the correct level of policy protection is in place. In a report, BFAP (2007) recommended that the government set initial import restrictions of 35 % ad valorem in order to initiate the early development of the sector. Once the strategy has been achieved and economies of scale have been reached, model results indicate that the level of production can be maintained. It is vital that the industry maintains its competitiveness internationally. This is especially true from a technological point of view as second generation biofuels, once successful, could potentially have a serious impact on the overall sector; and by constant reductions in import tariff protection, the local industry will have to adapt to the developments. Arguments against using biofuel policy incentives are that these may be contradictory and as a result may cause opposite impacts of what they originally intended to achieve if these are being used in concert (De Gorter & Just, 2010). Environmental impacts may be offset by import tariffs if fuels with a greater negative CO_2 balance are supported and protected compared to those that have clear environmental advantages. The reasons for protection of the biofuels industry are obvious. In the American example, an import tariff is imposed to offset the tax credit, this has the result that significant gains to the Brazilian exporters would be offset as gains from the tax credit are reversed by the implementation of the import tariff (De Gorter & Just, 2007 a). Tariff protection is, however, one of the most important policy instruments; and if it is not in place, then the industry will be largely subject to imports from the other markets. The trade-off that the government faces is therefore most important.

It is extremely important that the experiences of other countries be taken into consideration with regard to the implementation of an import tariff. Data and figures from the BFAP (2008) analysis reveal that potential biofuel production can be

profitable in South Africa. However, when the local price of ethanol is compared to the landed price in Durban harbour, it becomes evident that the landed price of ethanol is slightly less than the local price; and as a result, domestically-produced ethanol would struggle to compete. South Africa does already have an import tariff for ethanol legislated and at present the level of protection is R 3.17 per litre of ethanol produced which is added to the ethanol price.

Further, in order to achieve successful implementation the coordination and implementation of the respective policies need to be well timed. The reason for this is to ensure that the industry is prepared and established before it is ready to compete. A similar framework was followed by Brazil during its infant stages.

As import protection is crucial to the development of an industry it is proposed that biofuels are subject to import tariff protection at least for the initial period. Import tariff protection for bioethanol should be maintained at the present level of R 3.17 per litre, and should not be abolished or reviewed until the industry has been established. The case for biodiesel is different as the focus should be on vegetable oil. With South Africa already being a net importer of vegetable oil, it seems that tariff protection should be focussed on biodiesel and not on imported vegetable oil, which might well form the initial base for local production.

Licensing and regulatory procedures

The current situation in South Africa is such that the industry is severely struggling in its development process. This is due to the fact that the legislation has strict criteria that regulate the approving of licences (Department of Minerals and Energy, 2007). These regulations are spread over a wide field and require manufacturers to register with the Petroleum Controller even if the fuel that is produced is consumed for own use. In addition, the legislation requires producers to adhere to a set of guidelines

ranging from the crops that may be used in the process to the restriction of agricultural commodity imports, domestic sourcing from emerging farmer groups, adherence to proven and already existing technologies as well as standard specifications (Department of Minerals and Energy, 2007). Without such a licence, it would be illegal for a company to start producing certain quantities of biofuels as they would be contravening the Petroleum Products Act of 2003. Licences are of importance to any industry but should be set up in such a way that they benefit the industry through regulation and control. In Europe, for example, production and policies have been refined and have changed in such as way that it can move towards achieving goals which it perceives as being sustainable and realistic enough so that renewable energy can actually have a long-term role in achieving these goals. The 2010 package is based on the 20/20/20 principles, setting goals that greenhouse gas emissions should be reduced by 20 % from 1990 levels, a 20 % improvement in energy efficiency, and a 20 % share of renewable energy in the EU energy mix with a minimum share of 10 % for renewable energy use in the transport sector, which in turn must be achieved by all member states.

The proposed legislation goes one step further and defines certain criteria that are relevant specifically for biofuels, i.e. the 10 % target. Firstly, biofuels need to meet certain sustainability criteria, one of which means that biofuels need to reduce GHG emissions by at least 35 % with respect to fossil fuels in 2010. This reduction needs to improve to 50 % in 2017 and be at least 60 % for any new installations, meaning that inefficiency will in the long run negatively impact on the production process. Second generation biofuels also have an advantage over conventional technologies in that they qualify for a double tax credit while renewable electricity use in cars falls into much the same league, earning a factor of 2.5 and in so doing assisting the member states in achieving their goals faster (USDA, 2009). In short, if biofuels are not being produced in a sustainable way, reducing greenhouse gas emissions, not

having negative impacts on the environment, in terms of Indirect Land Use Change (ILUC), and if their production cannot adapt and become more efficient; in other words, reducing green house gas emissions according to specifications, it seems that there will not be any room for these plants to be in operation in the long term. In addition, provisions are also made for regulating imported biofuels and, more specifically, assessing the conditions under which these were produced, transported and processed, with a strong emphasis on maintaining current criteria set forth in the EU legislative framework.

A special case in the EU that specifically worked with this new legislation was Germany; where, for example, proposals have been heard in which the government allocates licences based on technologies that reduce carbon emissions and more importantly allocates various licences to specific technologies that are better geared towards reducing these greenhouse gases and achieving the climate change goals (USDA, 2009). In this way, the best projects with the most potential receive the licences and have a greater chance of making a difference. In South Africa, licensing should also be broken down according to various categories and should perhaps focus on achieving these goals by coordination and cooperation among departments.

It is thus necessary for the South African government to approach the biofuels industry and its development with milestones instead of strict regulations that are set out but have no concrete timelines in which they need to be achieved. In South Africa, it is estimated that to a certain extent the market and its requirements can fulfil part of the regulatory role of the process.

Licensing and regulatory procedures form an important part of the biofuels industry. These should, however, not negatively impact on the growth and development of the sector. First and foremost, it is therefore proposed that biofuel producer licences can

be granted if biofuel producers prove their fuel compliance with respect to SABS standards and that upon presentation of such evidence registration with the National Petroleum Regulator can take place. Licences should further require that producers adhere to all safety and labour requirements as set out by the South African government. It is, however, proposed that regulations on the sourcing of feedstock with respect to farmer groups, location of the production facility and use of the type of feedstock be revised and amended to include all types of agricultural commodities depending on the financial profitability of biofuel production.

Counter cyclical support measures

A variable subsidy, which for example is inversely related to oil prices can reduce the risk of a loss to venture capitalists, but often comes at a lower cost to government when compared to a fixed subsidy (Tyner, Taheripour and Perkins, 2010). The mentioned support mechanism builds on the ideas of Tyner *et al* (2010) but with specific focus on development from within the industry and not a direct support mechanism from government. It is acknowledged that prolonged periods during which this mechanism is triggered will impact on its sustainability. The current South African government does have a strong free market strategy and thus it is highly unlikely that a direct subsidy would be approved.

The slate account mechanism is not completely clear as the strategy states that: "As per estimated production for a period, monies will be collected from the petrol pump to cover the sale and paid into a dedicated "slate account". It is then envisaged that oil companies submit claims against the slate account with proof that a sale did occur between the respective biofuel producer and themselves (DME, 2007). Questions arise as to the amount dedicated to the slate account; whether this amount will change and if so, when and by how much; and whether the amount required to support the biofuel producers will also change according to variations in the

producers' economic circumstances. Furthermore, there is a flaw in the system in that oil companies are in control of the slate account fund. This means that it is at oil companies' discretion if the biofuel producers receive any kind of funding from this support mechanism. If oil companies do not have a stake in the production of biofuels, their interest to support the industry will be minimal, which could in turn be an area of potential conflict. The mechanism should work differently in that oil refineries and biofuel producers should be subsidised for their use and production of biofuels based on the success of fuel that they achieve, given the mechanism of a voluntary mandate. In doing this, there is an incentive for them to promote the use of the fuels and encourage their acceptance. In addition, biofuels should trade based on their supply and demand, meaning that fuel retailers with higher volumes of fuel sales will be rewarded more as they have a higher turnover rate. As the conditions of a voluntary and normal blending mandate are completely different, it is vital that the goal of what needs to be achieved is clearly understood. It is also important that biofuels should receive some form of support mechanism in times of lower profit margins; while in times of high and extraordinary profits, due to feedstock/output price relations, biofuel producers and oil refiners should be obliged to look after future interests in order to make the future of the industry more sustainable.

It is therefore proposed that instead of the slate account, which is a cost to the consumer at all times, an insurance concept is designed and implemented, which in turn has a counter cyclical effect in terms of its support function. By implementing this both the parties, i.e. the biofuel producers and oil refiners, insure themselves against future uncertainties in supply and blending of the fuel. The mechanism that is being proposed to replace the slate account works as follows. During times of high oil prices and relatively low commodity prices, a tariff from fuel sales is administrated by a regulatory authority, such as the South African Petroleum Industry Association (SAPIA) and saved into an investment account in order to build up a substantial

reserve. In profitable times of high returns, a provision is made by means of collecting a specific amount of the sales price. During times when the blending of biofuels is not profitable, funds can be drawn from this account in order to increase the total returns and act as a type of buffer and thereby assist the industry in surviving.

It is proposed that the slate account mechanism be replaced by a Counter Cyclical Support Mechanism (CCSM). The CCSM has a fund which receives a certain portion of the price from all sales of fuel that are blended with biofuels. This takes place in times when the industry is profitable, which is determined by an input/output price relationship. The CCSM is triggered once the ratio becomes less than a certain value either due to changes in fuel or commodity prices and once triggered biofuel producers will be able to claim a certain amount from this fund depending on the severity of the ratio's 'deficit'. The exact trigger for the CCSM will have to be determined based on the size of the industry and the use of feedstock. It is proposed that this mechanism is controlled centrally and that the support mechanism is calculated into the sales price. A portion of the proposed tax rebate can be used to make up the contribution to this fund. The outlook shows that the CCSM will be activated at different oil price levels for different commodities. These will have to be updated on a monthly basis in order to determine accurate levels.

6.4 Conclusion

Biofuel production has not taken place on any significant scale in South Africa and the biofuel industry has not yet developed into one which can be seen as being sustainable in the long run. In fact, the South African biofuels industry is struggling to get off the ground and has been characterised by a lack of policy direction and inaction by government, which has largely been the result of a poorly executed policy

development process. The lack of production has occurred despite research with respect to the physical biofuel production possibilities, both in terms of the supply of feedstock and their costs of production, showing that such an industry can indeed be sustainable and productive in the long term. The question that arises is why then has this been the case?

In order for any biofuels industry to be established efficiently, a concrete set of policy variables need to be in place which in turn support its structure. The Brazilian example comes to mind in which the industry structures on both the demand and supply side were in place before the biofuel legislation was implemented (Cordonnier, 2009). In the US, the initial incentives were extremely high and as a result the industry developed at a rate which many felt was unsustainable, nevertheless, there was development. Thus in summary, history has shown that in order for a biofuels industry to develop successfully, as was the case in Brazil, the US, the EU and in many other developed and developing countries, a correct set of policy variables needs to be in place. The policy development process and the resultant policy framework play an extremely important role in the future enhancement and development of such an industry. This is, however, largely dependent on the types of policies and whether they have been successfully implemented.

In order for these policies to be successfully managed and implemented, it is vital that the various governmental departments do indeed coordinate their actions and their overall effectiveness in achieving specific goals, as these will form a key part in the policies' success. The background to this research takes cognisance of the fact that each government department taking part in the biofuel industry game had specific goals which it intended achieving as part of its strategic framework. The Department of Energy (DoE), for example, had to keep the goals of its renewable

energy framework as set out in the White Paper in mind. The Department of Agriculture, Forestry and Fisheries (DAFF) has food security and rural development set as its main priorities, while the Department of Land Affairs (DLA) has to achieve a high rate of transformation and subsequent success in the land reform programmes; otherwise the departments face the risk of losing face within the structures of national government, the country and international community as a whole. If these goals were of such importance to the individual departments and if these goals could be more easily achieved by implementing a high investment biofuels strategy, why was this not done? The introduction of the z variable in Chapter 3 illustrates this quite clearly. Uncertainty, misinformation and a perceived risk, among other variables, have resulted in a cautious, low incentive approach with respect to policy implementation in the industry. This has resulted in a shift of the original Nash Equilibrium to a situation where individual government role players are not achieving their goals. Since the DoE is the first mover in the overall game, its anticipation of how the industry would react to the implementation of the biofuels strategy should have resulted in a first mover advantage. In actual fact, it seems as if the z variable had a major impact on the biofuel investment game and as a result has also shifted the Nash Equilibrium within that framework. It seems that in order for biofuel producers to be successful, a move towards innovation was necessary. The revenue from these innovations is, in turn, depicted by inclusion of σ.

A detailed analysis of current and future biofuel projects in South Africa reveals that in most cases overall profitability is not the greatest concern. Industry and BFAP bioethanol production data, for both maize and sugar cane, reveal that the production can take place profitably if the intention is to use the fuel in the transport sector. The picture for biodiesel production is different and data reveals that overall profitability is of concern as more profitable markets exist elsewhere, for example in the food industry. Thus it is unlikely that a move towards producing fuel will result, given the

current circumstances. Interviews with various stakeholders in the industry suggest that the factors most hampering the development of the sector are not necessarily cost-related but instead have their presence in the current policy environment. Unreasonable regulatory and compliance procedures, the absence of an off-take market, the uncertainty of future policy direction and the non-existence of counter cyclical support measures have all contributed to the dormant status of the industry.

The proposed changes to the original strategy can contribute to various government departments achieving their specific goals. The DoE, for example, can meet part of its renewable goals by making provisions for the successful long-term development of the biofuels industry. The supply of an 8 % ethanol blend and 2 % biodiesel blend together with co-generation of electricity at various sugar-ethanol plants will provide the DoE with a relatively large and stable source of renewable energy, which it will be able to write off against the proposed 10 000 GWh. As a result of the implementation of the mandate, overall profitability of farming operations in all of the involved sectors is expected to be boosted by higher returns and additional income streams, contributing to rural development and food security. Net returns of up to R 1.91 and R 1.17 per litre of fuel ethanol can be expected, depending on the macro economic conditions that prevail at the time, which in turn mean higher income levels for farmers and job creation benefits to rural communities. The direct spin-offs, as a result of the biofuel policy implementation, assist DAFF in achieving its goals of making agriculture sustainable, creating a food secure environment and promoting rural development.

Research from the Bureau for Food and Agricultural Policy (BFAP) (2009 b) has indicated that higher commodity prices spur on higher agricultural investment levels, be it an expansion in area planted or a movement to more profitable commodities. The goals that DLA wants and has to achieve are largely focused on the successful

implementation of its land reform programmes, with respect to transformation and successful implementation. At present, the department has been struggling with achieving these goals and as a result has found itself in an unfavourable and vulnerable strategic position. It has become clear, as mentioned in a report by Institute for Poverty, Land and Agrarian Studies (2008), that due to the failure of the land reform process, the way in which the land reform process is conducted needs to change. Higher investment levels in agriculture and rural communities will spur on the interest in successful and profitable farming practices and as a result it will be easier for land reform beneficiaries to become economically sustainable. The more profitable environment will in turn spur on growth and development within this part of the agricultural sector. It has become evident that some action needs to be taken in the agricultural sector in order to make its outlook more sustainable in the long term. This includes value addition and the only way this can be achieved, with respect to biofuels, is by means of a solid policy framework. In fact, it seems that if this specific biofuel policy is implemented, the various departments, DoE, DAFF and DLA, could achieve their goals and strategies by means of coordination and cooperation.

The current industry developments based on the biofuel strategy indicate that biofuel production in South Africa cannot and will not take place without an effective policy and strategy in place. It seems that at present, the lack of clarity on the implementation of the strategy coupled with a severe lack of commitment from the government, especially DoE, with respect to blending targets, achieving of its own White Paper targets and policy direction, is the industry's main drawback. It is, to a certain extent, this lack of focus on growth and commitment together with reluctance to commit financially to the industry that has resulted in the growth of this industry being hampered. Policies would have to be adjusted in order to accommodate the requirements of the industry, as without such adjustments development and growth will be unobtainable. Alternative policies that have been analysed include a firmer

commitment towards achieving strategic goals and making sure that these are also in place and focusing on development within the rural economies. Instead of causing disinvestment with laws and regulations, financial commitment to the industry can be used to accelerate growth and create new opportunities within the agricultural sector.

The risk to food security can be managed and mitigated by the fact that higher growth and larger agricultural investments can eventually lead to higher levels of agricultural production and sustainability, which in turn can be of a benefit to food security in the country. This point is emphasised by BFAP (2009 b) which states that lower prices result in lower profitability and as a result, quantities produced decline. Higher prices have an impact on food price inflation, yet it can be said that the agricultural sector and the rural economy benefit from such a situation through the supply response. On the one hand, higher volumes result in a food surplus and exports. However, on the other hand, higher food prices have an impact on their affordability, especially among the poor. The key argument is therefore not food security or availability, but rather the price associated with it. In recent years, the South African market has been trading at export parity, especially in maize. This means that maize was trading at its cheapest possible price, given international prices, exchange rates and local market developments. The export parity price is a result of the country producing large quantities of products with the result that high carry-over stocks were the order of the day. A mandate and resultant increase in demand for commodities will change this, in that prices trade higher. With this in mind, it is important to remember that many experts have mentioned that the low price of maize in South Africa is not sustainable in the long run and this could perhaps be a more threatening environment to the South African consumer. In addition, other renewable energy targets can be reached which in turn create an image of environmental responsibility for South Africa. This should, however, be achieved by environmentally conscious means, as European legislation on the

sustainable production of biofuels already requires this if biofuels are to enter and compete in the European market. In fact, the quest for sourcing sustainable biofuels is so serious that the EU would eventually like to offer compliant producers a price premium for their products.

The proposed policy alternatives for the biofuels industry can be implemented and it is envisaged, by researchers and industry experts alike that this framework can develop an industry which is capable of being sustainable in the long run. The implementation and maintenance of a mandate, tax incentive and import tariff together with the counter cyclical support mechanism have the potential of supporting all aspects of the industry. The implementation of the support mechanism in periods of low returns makes the business environment within the industry sustainable and profitable. It should, however, not be forgotten that these support and policy measures come at a cost and these need to be estimated. In the proposed legislative framework, it is envisaged that the tax rebate be kept in place and increased for biodiesel, which is not largely different from what is in place at present. The maintenance of the import tariff will result in a higher local price of bioethanol and the implementation of the mandate forces producers to take up biofuels into their local supply. However, the changing environmental legislation in the light of global warming, a failing land reform program and a continuous decline in agricultural land under cultivation could well have far greater implications; and the development of the biofuels industry with respect to these policy incentives seems to be a relatively cheap price to pay.

Long-term profitability and sustainability of the industry is the key to developing an environment in which such an industry can function in a sustainable manner. However, the industry alone cannot be sustainable if the environment in which it is expected to function is in complete disarray. Effectiveness and efficiency within

regulatory bodies together with efficient completion of tasks are of utmost importance to the development of a sustainable business environment.

The implementation of the policy framework and the possible impacts that these specific policies could have on the industry will have to be monitored once the strategy is implemented. Future research will have to focus on welfare impacts on taxpayers as a result of the policies, while reactions and adaptability of the industry to the business environment will also have to be looked at. A detailed investigation of the production costs in the industry will also play an important role if questions regarding the profitability in the industry arise.

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