AN ASSESSMENT OF THE FINANCIAL VIABILITY OF SCALING UP ETHANOL PRODUCTION IN MALAWI

MASTER OF ARTS (ECONOMICS) THESIS

By

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DECLARATION

I, the undersigned hereby declare that this thesis/dissertation is my own original work which has not been submitted to any other institution for similar purposes. Where other people's work has been used acknowledgements have been made.

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Signature

Date

CERTIFICATE OF APPROVAL

The undersigned certify that this thesis represents the student’s own work and effort and has been submitted with our approval.

Signature: ____Date:__________________

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ABSTRACT

Malawi's dependency on fuel imports, combined with unstable local currency and fluctuations in world fuel prices poses a threat to short term macroeconomic advancement. Malawi has been using biofuel for transport since 1982. Currently an E20 policy is in place where petrol from the pump station is sold as a blend of 20 percent ethanol and 80 percent gasoline. Consequently, the Government of Malawi is looking at further promoting the use of biofuel in order to substitute fossil fuels. This study explored the viability of scaling up the use of ethanol to higher blends. Specifically the study built on two financial models to establish the viability of ethanol production from molasses and sugarcane respectively. Study results show that molasses ethanol production is viable but is not practical as it requires huge land holding for irrigated cane growing and in essence increased sugar production. An estimated minimum of 432,000 tonnes of molasses would be required to produce ethanol that will enable petrol vehicles to run on E100. Sugarcane ethanol production on the other hand, despite being heavy on initial capital requirement, has proved to be viable. The issue of land remains dominant in both scenarios. It was established that the cost of feedstock is a major cost in the whole production process. In that regard, results also show that the production of ethanol is highly sensitive to the cost of molasses and sugarcane. Although study results suggest viability in ethanol production, the practicality of using molasses to scale up production of ethanol is questionable. This is on account of limited availability of the feedstock, more so because the sugar industry runs as a monopoly currently. The option of sourcing the molasses from neighbouring countries presents a reasonable opportunity however sustainability will be crucial since efforts to promote biofuels have been deployed across the continent**.** The sugarcane ethanol production despite being better off on land usage requires huge financing which is compounded by the high cost of capital in the country. To make it sustainable there is need for government to harness the macroeconomic environment which will boost the business confidence and enable more players in the sugar and ethanol market to work in association (especially on irrigation infrastructure) so as to benefit from the economies of scale.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

AA	Anhydrous Alcohol
APM	Automatic Price Mechanism
ERA	Energy Regulation Act
ETHCOL	Ethanol Company Limited of Malawi
EDVP	Ethanol Driven Vehicle Project
E20	Ethanol 20 percent blends with 80 percent gasoline
FFVs	Flexible Fuel Vehicles
IBLC	In Bond Landed Costs
IRR	Internal Rate of Return
LF&G	Liquid Fuel and Gas
MERA	Malawi Energy Regulatory Authority
MK	Malawi Kwacha
NPV	Net Present Value
OEPNU	Office of Energy Policy and New uses
PIL	Petroleum Importers Limited
PCL	Press Corporation Limited
PSF	Price Stabilization Fund
RS	Rectified Spirits
USD	United State Dollar
USDA	United States Department of Agriculture

CHAPTER ONE

INTRODUCTION

1.1 Background

The interest in biofuel development has grown over the years as an alternative to fossil fuels. Conventional fossil fuels have been discredited on account of price volatilities, declining oil supplies, environmental unfriendliness and the over dependency on imported fuel. This has forced most developing countries to search for alternative energy sources, and particular emphasis has been on biofuels. Over the years, biofuels have been encouraged in most low income and predominantly fuel importing countries. However, intensive land and water requirements, competition from unconventional fossil fuel and the perceived high cost of production have been of so much concern about the adoption of biofuels and have posed a big threat to the advancement of biofuels across the world.

A growing number of countries are adopting biofuel promotion policies in order to reduce over dependency on imported fuels. Various blends have been deployed by different countries. The largest producer and consumer of Biofuels is the United States of America (USA) after overtaking Brazil in 2005. The two produce both biodiesel and biofuel and account for over 85 percent of total biofuel production (Renewable Fuels Association, 2015). Whereas the United States is well known for corn ethanol production, Brazil is well known for sugarcane ethanol production.

Figure 1 below is a demonstration of the global ethanol production by country. The USA has consistently increased ethanol blends on gasoline forcing the country to engage in increasingly large scale ethanol production resulting into ethanol accounting for more than half of total biofuel production in the world. The steady increase in production has been attributed to the existence of a favourable institutional framework that includes federal mandates, subsidies and incentives which includes tax credits and import tariff for unrefined oils among others. A total production of 15 billion gallons of biofuel in 2015 was produced and is targeting a total of 36 billion gallons by 2022.

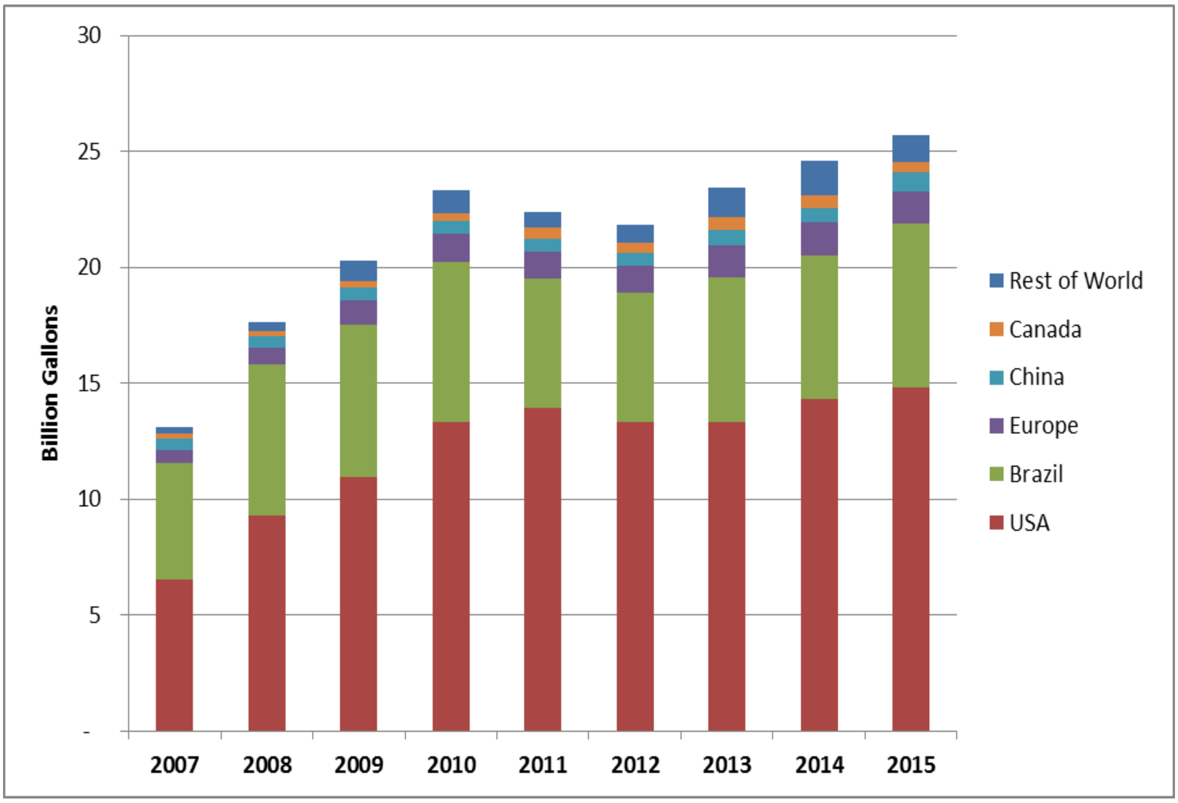

Figure 1: Global Ethanol Production by Country/Region and Year

Source: www.afdc.energy.gov/data

Brazil on the other hand uses sugarcane for biofuel production which is considered the most efficient energy balance (Baddeley, 2003). It has been argued that the success of the ethanol industry in Brazil is on account of government intervention, large land holdings for growing of sugarcane not to mention the most advanced green transport programmes that the country is known for. The use of ethanol as an alternative to petrol in Brazil depicts mixed movements. Recently, the government played a key role in boosting this alternative by increasing mandatory blend of ethanol in petrol from 25% to 27.55%, reintroducing the levy on fossil fuel and remove subsidies on petrol.

In Africa, the biofuel industry is not very well developed. Several countries are initiating specific policies to promote biofuel production in a bid to reduce the importation of fossil fuels. In 2006, an association called the Pan-African Non-Petroleum Producers Association (PANPP) was formed aiming to exchange information, share knowledge, and cooperate on the development of biofuels in Africa. This association was endorsed by the African Union (AU) as an integral part of the sustainable energy strategy for the continent. The endorsement was stimulated by the conviction that biofuels development can drive economic growth in Africa. The body called for conceited efforts from member countries to develop an enabling policy and regulatory frameworks and guidelines to develop biofuels in Africa. However, it can be rightly argued that so far the fruits for the initiative are not yet clear. For example in Zimbabwe, despite government's decision to enforce a mandatory E15 policy, the sole ethanol producing company has consistently failed to meet demand on account of unfavourable weather conditions. Although the company had ambitions of pleading with government to increase the blending mandate to E-20, the Zimbabwean government has been forced to reduce the blending mandate to E10 due to its failure to meet the blending requirements. In Mozambique on the other hand, about 30,000 hectares of land was allocated to sugarcane plantation for large scale biofuel production. However the project was cancelled due to funding problems from the producing company. (Zenebe et al, 2014)

Malawi has over 34 years' experience with sugarcane ethanol production and is the only African country that has consistently used liquid biofuels for transport for an extended period i.e since 1982 (Jumbe & Johnson, 2010). In a bid to reduce the exposure to the dependence of fossil fuels and to promote the development of ethanol, the Malawi government adopted a blend of ethanol and gasoline in the 1980s and further to that in 2004 cabinet directive was issued to look for alternatives to imported fossil fuels, from which ethanol was ranked as the best option. The country is currently operating an E-20 policy where petrol is blended with 20 percent ethanol for consumption by economic agents. This is an upgrade from an initial E-10 policy. Meanwhile, a policy awaits implementation which aims to consider the option of running vehicles exclusively on ethanol. Through this arrangement, a conversion kit will be required to be installed in the normal petrol engine in order to enable the vehicle to use either 100 per cent ethanol fuel, petrol or any mixture of ethanol and petrol according to consumer preferences (NCST, 2016).

It is argued that the implementation of this policy will have a positive bearing on the Malawi economy particularly as it will reduce the importation of petrol thereby enabling the government to save on the hard earned foreign exchange. In addition to that, because transportation accounts for a substantial part in most businesses, it has been extremely difficult for economic agents to plan or budget due to fuel price volatilities. It is believed that the use of ethanol, which is locally produced in the country as an alternative source of fuel will take out the negative effects of price volatilities that come with fuel import.

However as it has been seen in the cases of USA and Brazil, ethanol production is associated with intensive land requirements, perceived high cost of production and low calorific value which renders the arguments about competition from petrol valid. From the African experience on the other hand, land issues, weather conditions and financing are critical in biofuel promotion and ought to be taken into serious consideration. As we stand, the E-20 blending requirement has in some cases not been honoured due to inadequate ethanol supply.

1.2 Problem statement

Malawi depends on imports for its fuel requirements. However, increases in world fuel prices and local fuel demand has led to rapid increases in the country's expenditure on fuel imports. According to Petroleum Importers Limited (PIL), the value of the country's oil imports has been rising in recent years ranging from USD 5 million to USD 10 million per month translating into an annual import bill of USD 60 million at the minimum and USD 120 million at maximum. This expenditure translates to about 18% of the country's official foreign exchange reserves on fuel imports. With this background it can be argued that fuel imports are a weighty yoke for the country's economy. It is due to this realization that, as a matter of policy, the Government of Malawi is placing high priority on promoting biofuels in order to partially (short run) and totally (long run) offset imported fuel in the urge to achieve energy security and affordability. The Malawi government is looking at the option of implementing a policy through which motor vehicle users will choose whether to use ethanol as a standalone fuel (E-100) or a blend of petrol and ethanol in any ratio.(NCST,2016).

Looking at the current petrol consumption pattern, Malawi demands an average of 9 million litres per month, translating to 108 million litres per annum. At the moment, this amount is required to be blended at 80 percent petrol and 20 percent ethanol. Under normal circumstances this means 27 million litres ethanol was required to be blended with the amount of petrol imported. However, figures from Malawi Energy Regulatory Authority (MERA) indicate that the combined annual total volume of ethanol produced for 2015 was 18 million litres which was probably used to blend 72 million litres of petrol leaving 36 million litres of petrol to be sold at filling stations in its unblended state.

With this background, it is crucial to investigate the possibility of scaling up production and how feasible this could be especially considering that the current production which is solely for blending purposes is not able to meet the demand. Empirical evidence in Tanzania (Frohberg, 2007) and Ethiopia (Zenebe et al, 2006) suggest that biofuel production at a large scale is quiet viable and can compete with fossil fuels despite its perceived high cost of production. For Malawi whereas ethanol production may be viable, it is not clear whether scaling up of production from E20 to E100 will be feasible. This study therefore will build the knowledge gap in that regard by assessing the feasibility of scaling up ethanol production in Malawi.

1.3 Objectives of Study

Main Objective

The main objective of this study is to explore the feasibility of scaling up ethanol production in Malawi.

Specific Objectives

- Investigate the viability of scale up of ethanol production using molasses in Malawi.
- Investigate the viability of scale up of ethanol production using sugarcane in Malawi
- Establish the sensitivity of ethanol scale-up to various variables.

1.4 Study Hypothesis

The study explores the feasibility of ethanol scale up in Malawi. The study therefore is guided by the following three null hypotheses;

i. S*caling up ethanol production using molasses as feedstock is not viable*

ii. *Sugarcane scale up of ethanol is not viable in Malawi*

iii. *Ethanol scale up is not sensitive to cost of feedstock and inflation*

The justification of this study is that it will form a basis for policy consideration and will contribute to the knowledge gap since bio ethanol is a new phenomenon and there has not been much empirical work on the subject

1.5 Study Road Map

This study therefore is outlined as follows; Chapter Two explains the institutional and legislative framework of the energy sector in Malawi, and gives an overview of the ethanol market in Malawi with reference to the fuel sector as a whole; Chapter Three describes literature review and Chapter Four presents the methodology used in this study and Chapter Five presents a discussion of results and finally Chapter Six outlines study conclusion, policy recommendations and study limitations.

CHAPTER TWO

INSTITUTIONAL AND LEGISLATIVE FRAMEWORK OF THE ENERGY SECTOR IN MALAWI

This chapter discusses the institutional and legislative framework of biofuels in Malawi with reference to the energy sector in general. The chapter is organized as follows; section 1 gives the background: section 2 outlines of the legislative environment of the energy sector in general; section 3 reviews the institutional and policy framework of the Liquid Fuels and Gas (LF&G) and finally section 4 specifically tackles issues of pricing for biofuels with reference to fossil fuels.

2.1 Background

The energy supply system in Malawi is dominated by biomas accounting for over 80% of total demand. Biomas together with the other compositions which include electricity, LF&G, coal and other renewable components have been aggregated into one policy document called the National Energy Policy (NEP) which, other than providing an operational framework for the sector, aims to guide the development of energy, supply, use, distribution and pricing (NEP, 2003). The document was formulated to achieve energy efficiency, encourage private sector participation in energy supply and to modernize the energy sector by reducing dependence on biomas.

2.2 Energy Legislation in Malawi

Over the years, the energy sector in Malawi has reported significant legislative and institutional transformation. Initially, government was at the centre of everything only to privatise the whole structure leaving government with the regulatory role which entails policy formulation and governance. Meanwhile, the Ministry of Energy and Mining is at the top of the hierarchy through the Department of Energy Affairs and the Malawi Energy Regulatory authority comes in as a regulator. (NEP, 2003)

Prior to 1999, Petroleum Control Commission (PCC) was mandated to be the regulator and sole importer of petroleum products in Malawi. During that time the commission was responsible for both bulk importation of fuel for sale to suppliers and at the same time to carry out regulatory function to all petroleum related products. The statutory body was liberalized to pave way for the private sector into the oil supply leaving the body with the regulatory role. To maximize on economies of scale, oil suppliers formed a consortium, called the Petroleum Importers Limited (PIL). The formation of PIL was on the recommendation from the World Bank, IMF and the government of Malawi and was confined with the mandate to bulk import petroleum products on behalf of all existing oil supply companies.

In 2000, PCC was dissolved due to allegedly administrative challenges that hit the commission. This rendered the regulatory function void, leaving PIL to undertake bulk importation of fuel on behalf of suppliers. It was realized that the regulatory gap brought inadequacy and cost inefficiency in the institutional framework of the petroleum industry and generally of the energy sector in Malawi. In view of that, government established a sector wide regulator called the Malawi Energy Regulatory Authority (MERA) which unlike PCC strives to be independent, coherent, transparent and efficient as a regulatory body. MERA regulates all the energy players in the country in collaboration with the Department of Energy and both entities report to the Ministry of Energy and Mines.

In 2011 government established yet another statutory corporation within the energy sector, called the National Oil Company of Malawi (NOCMA). The establishment was in response to the 2011/2012 massive fuel shortages, which stir the need for the country to have fuel reserves. The formation of NOCMA was stimulated by the realization that the profit making oil importing companies (PIL and other oil players) would not be so keen to hold fuel reserves because this is believed to tie down capital. Other than aiming to achieve energy security through strategic fuel reserves, NOCMA was mandated to spearhead oil exploration in Lake Malawi, initiate pipeline construction and manage biofuel development. The coming in of NOCMA has been controversial as it is argued to have displaced the functionalities of the private owned PIL. The legislative arm of government through a parliamentary committee on natural resources, energy and mining fought this arrangement with the thinking that the involvement of government in fuel importation may bring inefficiencies in the process, but supported the involvement of the private entity (PIL) for bulk importation of fuel. This recommendation by the committee was made with reference from neighbouring countries. Meanwhile both NOCMA and PIL are involved in the fuel importation with cost recovery guaranteed by the automatic fuel pricing mechanism while government is working to amend the fuel import regime aimed at achieving both efficiency and energy security. (NEP, 2003)

2.3 Institutional and Policy Framework for LF&G

The Liquid Fuel and Gas in Malawi comprises fuel and gas products and is mainly petrol, diesel, paraffin, ethanol and gas. Technically, any LF&G is defined to comprise two principal parts, the upstream (exploration, production and refining) and the downstream (Supply logistics and marketing).

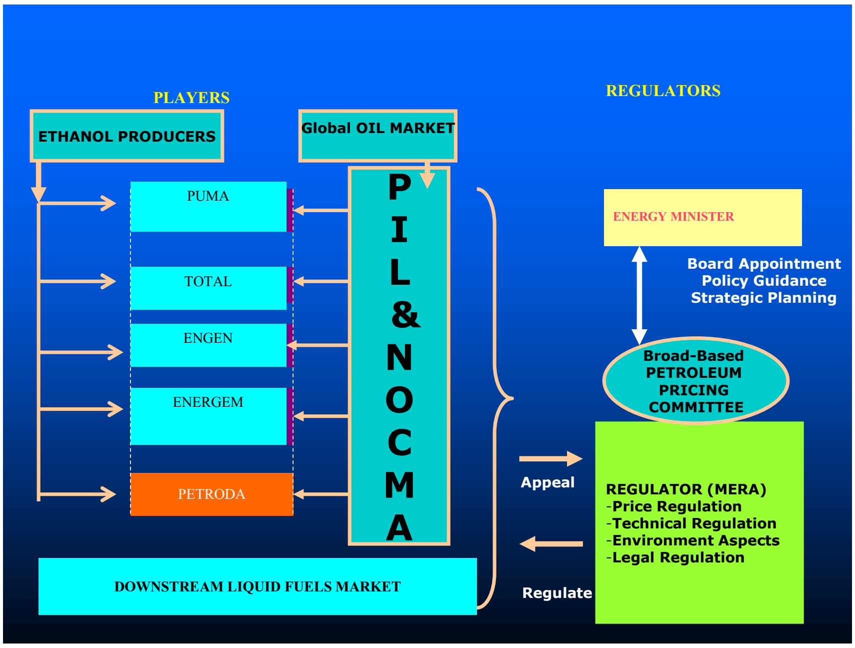

Figure 2: The Energy Structure

Source: National Energy Policy (2003)

Much concentration in terms of policy and legislation has been on the downstream since Malawi imports over 90% of its fuel requirements. In order to ensure efficiency, the downstream separates the LF&G into the following market segments: supply/import currently undertaken by PIL and NOCMA; wholesale by PIL and NOCMA; Retail – Oil Players; Storage – NOCMA; haulage/distribution –

Transporters; guided by Government's policy of diversifying routes and modes of transport: 20% Dar Corridor, 50% Nacala Corridor and 30% Beira Corridor (National Energy Policy 2003). This separation, according to the policy document, is also essential to augment competition, uphold equity, curb collusion, and to empower locals for poverty reduction.

The biofuel industry in Malawi is governed by the Energy Laws (2004); Energy Regulation Act (ERA) and Liquid Fuels & Gas Act (LF&G). The Energy Regulation Act establishes MERA with the mandate to regulate biofuel industry where as LF&G Act stipulates the creation of a favourable condition for new entrants; restriction of biofuel production; Mandatory blending of ethanol with petrol (E20) and none for diesel; production process which includes blending, extraction, conversion, importation, transformation, transportation, storage and distribution of biofuels.

In an initiative to develop the biofuel policy, with the aim of harmonizing all policies related to biofuel so as to effectively govern the industry, a Biofuel Advisory Council and Biofuels Association of Malawi were established. Kalowekamo (2013) outlines the following policy instruments as being vital in the biofuel industry in Malawi;

- Fiscal policy regime : levies, tax exemption on equipment, tax holidays
- Regulatory: biofuel pricing, blending levels, standards
- Marketing: establishment of outlets for biofuel
- Public awareness & capacity building in the biofuels industry

2.4 Pricing

The fuel pricing regime in the country was changed from the Targeted approach to an Automatic Pricing Mechanism (APM) in 2000 through which fuel prices at the pump are triggered by external variables i.e. changes in the in-bond landed cost (IBLC) and the value of the Malawi Kwacha against the US Dollar. This pricing is revised on a plus or minus 5% trigger limit which is reviewed by a board committee; the Petroleum Pricing Committee (PPC) on monthly basis. (NEP, 2003)

Ethanol on the other hand, despite being locally produced is currently charged as a percentage of petrol at an average of MK 5.00 less of petrol prices. According to the

Malawi Energy Regulatory Authority (MERA), the pricing of ethanol is currently under review. A new pricing model has been submitted to the Ministry of Finance by the producing companies but details about the model have not yet been disclosed. Consumers have expressed concern over the pricing of Ethanol as it is evident that ethanol has a low calorific value of about 30% as compared to gasoline, hence releasing less thermal energy per unit volume when involved in combustion process. Stakeholders are hoping that the pricing will take this into consideration.

2.5 The Ethanol Market in Malawi

This section gives a brief analysis of the ethanol market in Malawi with reference to the fuel market in general. The chapter further assesses the critical issues in biofuel development. Finally, the chapter presents three case studies to learn from; for USA, Brazil and Africa.

2.5.1 Fuel Consumption in Malawi

Transportation in Malawi is viewed to be fundamental to economic growth and development. The sector contributes about 55% of costs of production and ranks as the third most dominant sector (6.6%) in the Consumer Price Index (CPI); being third from Food (50.2%) and Housing and Water (14.7%). At the centre of transportation in Malawi is fuel. The three major fuel types used in Malawi are Petrol, Diesel and paraffin. Over the years, diesel has been dominating the fuel consumption basket seconded by petrol. (PIL Report, 2015).

Current consumption trend indicates that petrol is blended with ethanol in the 80-20 ratio whereas diesel is consumed as it is. Because Malawi is a developing nation, it is estimated that fuel consumption will keep rising. According to MERA, the estimated annual petrol requirement for the country is 320 million litres by the year 2020. Maintaining the blending ratio of 20:80 (ethanol/ petrol), an estimated 64 million litres[1] of ethanol will be required to meet the demand for blending in 2020. On the other hand, with a 10% target of vehicles running on 100 percent ethanol (through importation and conversion of existing vehicles), then the total ethanol requirement is

[1] If 320m = 100% then 20% = 64m

estimated at 32 million litres[2]. Increasing the proportion of vehicles running as flexi to 20% by the year 2021 for example, then ethanol requirements for the increased usage is estimated at 64 million litres. To meet these targets, it is therefore required to increase ethanol production from the current 18 million to 32 million litres by 2020 and then to 64 million litres by 2021. It will also be required to increase plant production capacity from 32 million litres to 64 million litres by 2021. The above analysis assumes 100% use of ethanol and disregards the blending mandates.

2.5.2 Ethanol Consumption and Production

A wide variety of feed stocks are used to produce ethanol across the world. Practically, ethanol is made from crops which contain starch such as food grains, and tubers, such as potatoes. Other than that, crops rich in sugar like sugar beets, sugarcane, and sweet sorghum can also be used for the production of ethanol. Food processing by-products such as molasses, cheese whey, and cellulosic materials including grass and wood, and agricultural and forestry residues can also be processed to ethanol. In Malawi, the sugarcane ethanol production started in 1982 and the oligopolistic industry currently has two players. The Ethanol Company Limited (ETHCOL) situated in Dwangwa was the first company to enter the market followed by PRESSCANE in 2004. They are both subsidiaries of Press Corporation Limited (PCL) – a local holding company in Malawi, and they both source the molasses from ILLOVO – the only sugar producing company in Malawi at the respective plants.
Ethanol production has been steadily increasing from a total combined annual volume of 12m in 2012 to over 18m in 2015. The two producing companies are currently both operating a 18 million plant capacity. This implies that they jointly are operating at 50 percent below capacity. Despite ETHCOL being the pioneer producer, on average the company contributes about a quarter to total production.

From table 1 below, it can be clearly shown that ethanol production has been way below demand. In 2013 for example total petrol consumed was about 108 million Litres whereas ethanol production/ consumption stood at 12.9 million Litres. Considering the 80-20 blending mandate, this amount can only blend 51.6 million

[2] 10% of 320m = 32m

litres[3], leaving 57.2[4] million litres unblended. It can therefore be argued that the balance was consumed as 100% petrol. To satisfy the 80-20 blending mandate, about 11.4[5] million litres of ethanol and 45.76[6] million litres of petrol would be required. In essence, this means about 24.3[7] million litres of ethanol was required in 2013 to blend 97.36 million litres of petrol in order to meet petrol demand requirements.

Table 1:Ethanol Production and Consumption in Litres

Year	Presscane	Ethcol	Total	PETROL Consumed	Required Ethanol (With 20-80 Blend)	Total Ethanol Deficit
2013	9,806,757	3,133,948	12,940,705	108,851,586	24,340,000	11,399,295
2014	11,781,045	2,858,814	13,547,217	108,904,094	24,480,000	10,932,783
2015	14,671,520	3,499,381	18,170,901	133,103,654	30,260,000	12,089,099

Source: Malawi Energy Regulatory Authority, own computation using MERA DATA

Annual production from both plants is targeted at 54 million litres in 2016- which will only be achieved after the 27 million litres plant upgrade and assuming production at 100 percent capacity. Production of ethanol has always been limited by availability of molasses since there is only one guaranteed source of the feedstock – ILLOVO (the only sugar producing company in Malawi).

The current setup of sourcing molasses from ILLOVO alone poses another challenge by which the ethanol producing companies do not produce in the first two months of the year. During these months ILLOVO gets into its “off- production season” hence no molasses flowing in to the ethanol producing companies forcing them to follow suit. This has been argued to be one factor that contributes to production below

[3] If 12.9m = 20% then 80% =51.6m
[4] 108m – 51.6m = 57.2m
[5] 20% of 57.2 = 11.4m
[6] 57.2m – 11.4m = 45.76m
[7] 12.9m + 11.4 = 24.3m

capacity. To counter this challenge initiatives are being put in place for the producing companies to start producing ethanol straight from sugarcane. The initial plan is to use the sugarcane that will be grown for production of ethanol in the"off-season". (Ethcol, 2016)

Because the existing production capacity is under-utilized, it is believed that there is room for expansion of sugarcane fields at Dwangwa, Nchalo and Kasinthula to produce more sugar that will result in more molasses for more ethanol. While there is an option for importation of molasses to supplement the locally produced molasses, the sustainability of this option is questionable because biofuel development is spreading across the continent and beyond. This leaves Ethanol producing companies with the only option of encouraging cane growing to supplement what is being sourced from ILLOVO, hence producing ethanol straight from sugarcane.

2.6 The Sugarcane Industry in Malawi

The sugar industry in Malawi is dominated by ILLOVO – a monopoly in sugar producing, previously with government shareholding. The listed company on the Malawi Stock Exchange (MSE) is involved in commercial cane growing to be used in sugar production. About 70% of total cane used for sugar production by ILLOVO is sourced from within, the rest is supplied by the out grower farmers. Whereas smallholder cane growers in Malawi (which operate in various associations) hold land ranging from 0.4 hectares (at lowest) to 25 hectares (at most), total cultivated area for ILLOVO is in excess of 20,000 hectares. Because cane growing is water intensive, the commercial sugar growing company has in place irrigation scheme which enable them to produce throughout the year. The out grower farmers on the other hand mostly rely on rain fed cane growing.

Table 2: The Sugar Industry

Year	**2011**	**2012**	**2013**	**2014**	**2015**
Total area harvested (hectare)	19,521	19,698	20,179	19,567	18,961
Yield (Tons cane per hectare)	109	105	104	101	103
Cane Produced (Million Tons)	2,127,789	2,068,290	2,098,616	1,976,267	1,952,983
Molasses Produced[8] (Tons)	85,111.56	82,731.6	83,944.64	79,050.68	78,119.32
sugar produced (tons)	282,445	283,487	299,494	289,013	282,962

Source: Illovo's 2015 financial report, own computation using ILLOVO data

Linking the information from Table 2 above to that in Table 1 above, it can be argued that either the available molasses were underutilized or efficiency in terms of use of molasses by ethanol producing companies has been increasing evidenced by the negative relationship between volume of ethanol produced and that of molasses.

To estimate the molasses volume required to meet the E100 mandate, since 240 metric tonnes of molasses produce 60,000 litres, impliedly 72,000 metric tonnes were used to produce 18m litres of ethanol in 2015. To produce 108m litres (2015 petrol demand) which implies all petrol vehicles running on E100, 432,000 tonnes of molasses would be required translating to about 105,000 hectares of land for irrigated cane growing.

2.7 Potential Impact to the Economy

As one of the least developed country in Africa with an agro-based economy, Malawi is very economically unstable. Looking at the volatility of the economy, and a realization that the escalation of fuel prices on the global market exerts some pressure on this state of the economy, it has been argued that the use of ethanol as an alternative fuel to petrol is beneficial to the country in the following ways;

[8] About 4% of cane produced come out as molasses (data source – Illovo)

2.7.1 Impact on Foreign Exchange

Fuel accounts for a great percentage to the country's import bill. The commodity has been ranked the third largest foreign expense in the country preceded by fertilizer and medical drugs. From 2015 to May 2016, the monthly import bill for fuel ranged from USD 5 million to USD 10 million translating into an annual import bill of USD 60 million at best and USD 120 million at worst. This worst case scenario translates to about 18% of the country's foreign exchange reserve position.

Figures from MERA and PIL presents an almost one-to-one relationship between fuel import bill and total volume consumed. To put it differently, on average, landing cost for one litre of petrol was one USD in 2015. On this basis, it can be argued that about USD 18 million was saved in 2015 due to the use of ethanol. In general, how much foreign exchange currency is saved due to use of ethanol as an alternative fuel will among other factors be positively related with depreciation of USD and negatively affected with its appreciation.

2.7.2 Impact on Price Volatility

The fuel pricing regime in the country was changed from the Targeted Approach to an Automatic Pricing Mechanism (APM) in 2000. Under the APM, fuel pump prices are adjusted to reflect fuel price movements on the international market so as to allow for cost recovery. Movements of the local unit to the USD and changes in the value of the In Bond Landed Costs (IBLC) directly influence pump price adjustments.

The reintroduction of APM in 2012 (after its suspension in 2004) brought about fuel price volatilities. To take the edge off the frequent fuel price adjustments, the APM operates within a plus or minus 5 percent threshold which is basically the trigger limit to fuel price changes. A Price Stabilization Fund (PSF) was introduced with the aim of cushioning the price when the variation is less than plus or minus 5% in order to ensure continued importation of fuel. The PSF comes in handy especially during episodes of under recoveries which, if not dealt with may pose threats to the supply chain.

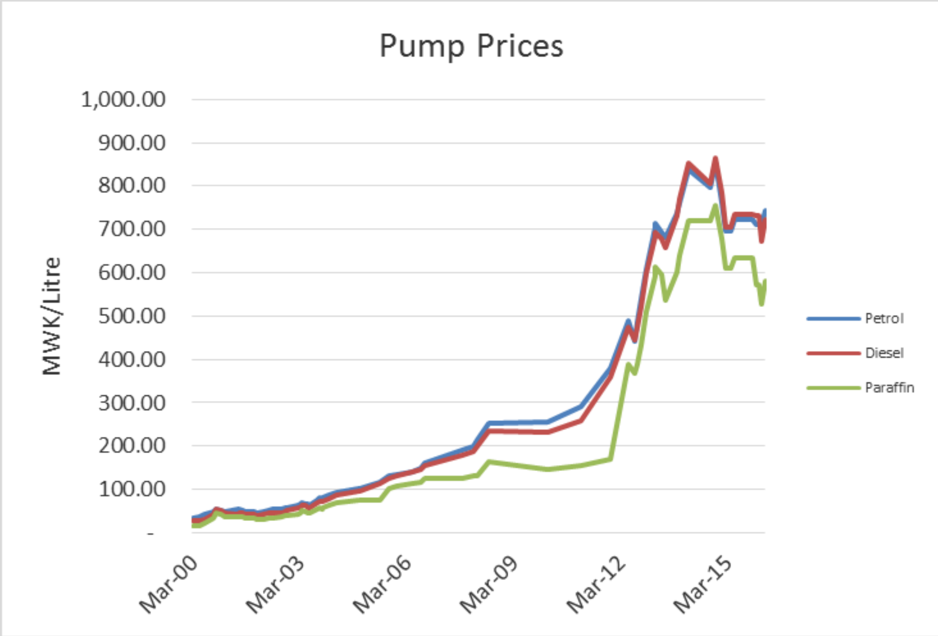

Figure 3: Movements of fuel prices

As it can be seen from figure 3 above, fuel prices have been fluctuating, generally taking the upward trajectory. A huge jump was reported in 2012 mainly due to the 49% currency devaluation which resulted into an increase in petrol prices from Mk 380.00 to MK490.00 and diesel from MK360.00 to MK 475.00. The reintroduction of the APM the same year compounded the negative impact of the devaluation to fuel prices.

In terms of ethanol, pricing has over the years been a function of gasoline prices as opposed to its cost of production. In view of this, ethanol has not been spared from price volatilities. In as long as ethanol pricing depends on petrol prices, the coming in of ethanol to replace gasoline will not take away fuel price volatilities. So far, the producing companies submitted a pricing model to the Ministry of Finance but the contents of this model have not yet been disclosed. However, the producers expect the price of ethanol to be 86% that of petrol price.

2.7.3 Impact on Farmers

The use of ethanol as an alternative fuel will demand an increase in sugarcane production. This increased demand will make farmers to realize that cane is being valued more than before, resulting in high pricing for the commodity. The demand will also attract farmers to join the cane growers associations and of course will attract new entrants into growing sugarcane. Expansion of sugarcane fields will offer more employment opportunities to local Malawians; the high commercial value of sugar and ethanol will bring considerable socioeconomic benefits to both smallholder farmers and estate workers in Malawi; Malawians will also get additional employment opportunities in sugar company as well as ethanol production and marketing, thus from the factory to the vehicle through pump stations (Mkoka, 2006).

2.8 Critical Issues in Ethanol Production

2.8.1 Cost Effectiveness

Biofuel production has been argued to be associated with high cost of production. The promotion of biofuel presents competition to conventional fossil fuels, therefore an analysis of the cost effectiveness of biofuel production with reference to fossil fuels gives a hint on the possible success of the biofuel industry more especially because in most cases pricing of a product is to a large extent a function of its cost of production. However, in order to stand the competition and to render the industry profitable and successful, the giants of biofuel production have been subjecting the product to subsidies and preferential tax treatment. This is fuelled by the fact that biofuel particularly ethanol, contains about 30% less energy than gasoline putting the commodity at a price disadvantage as compared to gasoline. Zenebe et al, 2014 analyzed the profitability of biofuel production in Africa taking Ethiopia as the case study. Their findings reveal that if the world oil price is expected to vary between USD42 and USD200 per barrel, biodiesel firms in Ethiopia must be able to produce at less than USD1 per litre. To enhance the competitive edge of biofuel production, their study suggests a consideration of viable alternatives of coproduction through value addition from by-product seedcake and intercropping options. They also recommended for research and development efforts and knowledge support to the biofuels industry, including a search for better adaptive and better yielding varieties and good oil quality biofuels crops, including better regulatory frameworks.

2.8.2 Technological and Environmental factors

Biofuel development has been considered a renewable fuel presenting an opportunity to reduce greenhouse gas emissions. However, there is some recent evidence indicating that biofuels may emit more greenhouse gases than it saves (Bamikole et al, 2010). Other evidence however reveals that its lifecycle impact has been shown to be far from carbon neutral when factoring in land usage (Chao K, 2008). In Africa, where populations are already water stressed, new demands for water for irrigation and refining would have unanticipated consequences, especially because biofuels production is very land and water intensive (Michael & Tsegay, undated). There are also talks about negative externalities through chemical pollution on communities and an interference with ecosystem functioning. In Kenya, for example, biofuels sugar cane development project was blocked by a court due to environmental concerns. In Ethiopia, conflicts have risen between biofuels farming and environmentalists. Controversies have arisen in Uganda because of plans to clear the Mabira Forest Reserve to grow sugar cane for biofuels production (Michael & Tsegay, undated). These examples illustrate the seriousness of probable consequences of biofuel production and therefore validate the need for government intervention.

2.8.3 Barriers to Adoption of use of ethanol

The use of ethanol as an alternative to fossil fuels is prone to barriers. The major barrier is believed to be the competition from fossil fuels. Table 3 below compiles major barriers as per a survey done in the EU (third largest biofuel producer) and probable solutions to the barriers.

Table 3: Barriers to adoption of use of ethanol

Category	Barrier	Probable Solution
Vehicle	Limited availability of biofuel vehicles.	Promote importation of FFVs
Fuel	Fossil fuel standards limit the use of biofuel blends	Installation of conversion kits
	High biofuel price at the pump compared to fossil fuels	Government intervention either through high tax on fossil fuels or tax credits/ subsidies on ethanol
Infrastructure	High costs to construct a refuelling infrastructure, or convert existing infrastructure.	Subsidize fuel suppliers
	Fossil fuel industries oppose the introduction of biofuels into the fuel distribution network	Government intervention through policy
	Insufficient biofuel production capacity	Allocation of more land for production of biofuel feedstock
Feedstock	Limited availability of locally produced feedstock	Sensitization to farmers, allocation of more land and modern farming technology
	Lack of an alternative fuels strategy on national level	Government policy
	Slow market and infrastructure development	Government initiative
Policy and Market	Lack of an alternative fuels strategy on regional or local level	Government initiative
	Lack of experience on the market	Training

Category	Barrier	Probable Solution
	Lack of customer awareness and market acceptance	Civic education
	Lack of a proactive approach within many local authorities/major business to biofuel use in general	Civic education
	Lack of harmonisation throughout concerning fuel taxes, biofuel tax reductions and obligation systems	Government intervention
	Lack of readily available independent information	Research
	Lack of harmonisation concerning biofuel targets, applied biofuel blends and fuel standards	Government intervention
	Consumer passivity	Civic education from government

Source : Senter Novem, 2008

Adoption of biofuel crops also presents a critical issue in the development of the biofuel industry. Adoption of growing of biofuels crops is believed to be related to membership to an association, gender, education qualification, and knowledge on biofuels. Civic education on biofuel crops can positively entice farmers to adopt.(Michael & Tsegay, undated)

2.9 Learning from Experience

2.9.1 The case of Brazil

Sugarcane ethanol production in Brazil started in 1975 by the federal government; currently the industry is concentrated with the private sector. The initiative was put in place with the objective of reducing importation of gasoline. Production has over the years increased from 100,000 litres per annum in the 1970’s to 25 billion barrels in 2015. Vehicles in Brazil either run on E-100 – 100 percent ethanol or at a minimum of E-27.5 – a mandatory blend of 27.5 percent ethanol and 72.5 percent gasoline. It is believed that the success of the biofuel industry in Brazil rests on government policies and technological advancements that have been put in place.

To begin with, the Brazilian ethanol industry was initially boosted with an E5 mandate which drastically increased the number of producers from 1 to 54. Ever since, the mandatory blend has gradually increased to rest at E-27.5 (2016), and there is a policy through which vehicles can run on E-100 based on consumer preferences. Ethanol demand in Brazil is usually affected by seasonal variations (bad harvests) and performance of the local currency. These two factors have a bearing on the price of the product at the pump. Generally, motor vehicle users switch to ethanol when petrol prices are 30% higher than ethanol prices since it is believed that ethanol from sugar yields 30% less energy per litre than gasoline.
To promote development of ethanol the government of Brazil made the following initiatives;

- Increasing mandatory blend of ethanol in petrol from 5% to 27.55%.
- Reinstating the levy on fossil fuel
- Terminating subsidies on petrol.
- Impose an import tariff on gasoline
- Ban diesel-powered personal vehicles to boost the demand for ethanol-powered vehicles.
- Instructing all government entities to purchase 100-percent hydrated alcohol-fuelled vehicles
- Production quotas on sugar

These initiatives are believed to have been behind the success of the industry and have resulted into Brazil to be the second largest producer and consumer of biofuels.

2.9.2 The Case of USA

In USA, the government started looking at the biofuel industry more seriously in 1990. Currently 297 producers are in operation. The initiative to develop the use of biofuel was in order to reduce the dependence of imported fuel. Biofuel in the USA is produced mainly from corn and accounts for about 10% of transport fuel supply. The industry supports over 852,000 jobs, $56 billion in wages and generates about $14.5 billion in tax revenue per annum (National Cane Growers Association, 2014).

Over the years, the USA has been well known for corn ethanol production. However recently, attention is diverting to cellulosic ethanol. To reduce corn biofuel production which is believed to be a threat to food supply, the advanced biofuel payment programme subsidizes producers of biofuel refined from sources other than corn and government provides a production tax credit of $1.01 per gallon of cellulosic biofuels so as to achieve viability.

Having realized the impact of biofuel to the USA economy, government has in place policies to support the industry, and sets aside a budget allocation year on year to support the industry. For example currently government is running a campaign to support the development of bio refineries aimed at producing advanced biofuels. Loan guarantees have been set aside for this project.

2.9.3 A Sad Story for Africa

Despite its revolution in the 1970's, the development of biofuel production in Africa has not been very impressive. About 30 biofuel projects are reported to have been abandoned in 15 African countries (the Guardian Newspaper- www.theguardian.com accessed on 12 June 2016). In Tanzania for example a British biofuels company commenced operations in 2008 to specialize in exports, only to break down on account of insolvency. The company had acquired huge landholdings from villagers in Kisarawe district in return for financial compensations and jobs and a promise for corporate social responsibility in form of water wells, improved schools, road networks and health facilities. The collapse of the company had a huge social impact to the community as it left the villagers landless (because the land is now owned by government) and jobless.

In Ghana on the other hand a Norwegian biofuel company destroyed a local forest to establish a large jatropha plantation which later on collapsed. In Kenya the efforts to develop biofuel production by Bedford Biofuel Company in Tana River were proved futile in 2011. Factors relating to bureaucratic obstacles, civil society campaign against the project and funding problems due to lost investor confidence are believed to have contributed to the collapse of the project. According to the Kenyan government nowhere in the world was Jatropha project a success to complement diesel hence giving up so much land for biofuel development in the food deficient country was not a wise decision (Qatar Foundation, 2013)

In Zimbabwe, the state owned biodiesel project has been facing administrative, funding and feedstock availability challenges and its impact to the Zimbabwean economy is believed not to have been felt since its opening in 2007, forcing the legislative arm of government to recommend for its closure. A huge ethanol plant in Mozambique called ProCana was cancelled by the government due to failure by the investors to finance the investment agreement. The project was allocated 30,000 hectares of land to support production of ethanol, sugar, fertilizer and power generation. However despite such support from the Mozambican government, the company was non-committal to its offer to immediately start the cane plantation, build the ethanol in 2010, and start production in 2012. The investors reported to have abandoned the project because they felt it would be difficult to raise the necessary financing due to what they deemed the global economic climate and reduced interest in non-carbon related fuel products.

2.10 Conclusion

The development of the biofuel industry will require government to seriously consider the liquid fuel and gas sub sector independent of the energy sector as a whole. The policy inconsistencies that have been identified need to be addressed and pricing will be very crucial as it is capable to determine the success of the project.

For the promotion of biofuel to be a success, there is need for conceited effort from government, the producers, civil society organisations, fuel suppliers and of course the final user of the product.

CHAPTER THREE

LITERATURE REVIEW

This chapter provides context and background for this research. The chapter further reviews empirical evidence on biofuel production across the world.

3.1 The Concept

Biofuels are produced from biomass materials and can be solid, liquid, or gaseous fuels (Worldwatch, 2007). The two common liquid biofuel produced across the world are ethanol and biodiesel. These are used to blend with fossil gasoline and diesel respectively. Ethanol is produced from a variety of feedstock particularly from sugar and starch crops, while biodiesel is produced from vegetable oils or animal fats.

Ethanol Production requires high starch or sugar content crops like sugarcane, corn, wheat, and sugar beets (Lora, et al. 2010). These crops are essential as they produce energy through the fermentation of carbohydrates. Traditionally, ethanol has been used for alcohol production, but in recent years the commodity has been increasingly used in transportation fuels.

After fermentation and distillation, ethanol can be mixed with petrol in different proportion. Low concentration ethanol blends like E20 (which means 20 percent ethanol and 80 percent gasoline) can be used in conventional vehicles just as it is with Malawi currently. Blends higher than E30 can only be used in specially motorized vehicles, such as Flexible Fuel Vehicles (FFVs) or requires installation of conversion kits in the normal engine.

3.2 Theoretical Background

Various theories have been developed to explain investment decisions. For the purposes of this study, three investment theories will be discussed namely the Profits Theory, the Accelerator Theory and the Tobins Q Theory.

3.2.1 The Profits Theory of Investment

The profits theory regards undistributed profits as a source of internal funds for refinancing investment. The theory states that investment depends on profits and in turn the profits depend on income. High income and high profits translate into high earnings, and earnings retained are relevant where imperfect capital markets exists (Eklund, 2013). The theory postulates a negative relationship between profits (and earnings) and cost of capital. This gives a justification for preference of firms to reinvest their extra profits in their investment as opposed to investing in financial instruments or to declare dividends to shareholders. This is the liquidity version of the profits theory (Nicholson, 2000)

3.2.2 The Accelerator Theory

The accelerator theory as suggested by Clark (1917) presents a different approach to profit maximization. The approach is being argued to be a special case of the neo classical theory of investment. According to the theory, a certain amount of capital is necessary to support a given level of output. This relationship is described as follows;

$K_t = vY_t$..i

Where, Kt is the stock of capital

Yt for the level of output or income, and

v for capital-output ratio (K/Y) and is assumed to be constant.

This is the accelerator principle in which the desired stock of capital is proportional to output implying that any investment at any period will depend on the output growth.

Under the assumption of constant capital-output ratio, changes in output are a function of changes in the capital stock. This means that any change in the stock of capital at any particular period will yield a corresponding output. This corresponding output will be v times higher than the previous period output. In this regard, the capital-output ratio represents the magnitude of the accelerator.

3.2.3 Tobins Q Theory

The Q theory of investment was proposed by James Tobin, a nobel Laureate economist (1918). The theory links investment decisions by firms to performance of the stock market. The theory argues that when a company lists on the stock market in a bid to raise capital, its share price is influenced by the investment decisions undertaken by the firm. Therefore, when the stock market is bullish, firms are willing to sell equity to finance investment than when the stock market is bearish. James Tobin explained the relationship between the stock market and investment by defining q as the market value of the firm. According to Tobin, net investment depends on the value of q. If q> 1, the market value of the firm's shares in the stock market is more than the replacement cost of its real capital. In this case the firm would prefer buying more capital by issuing additional shares on the stock market to raise funds. In so doing more profits will be earned to finance new investments.

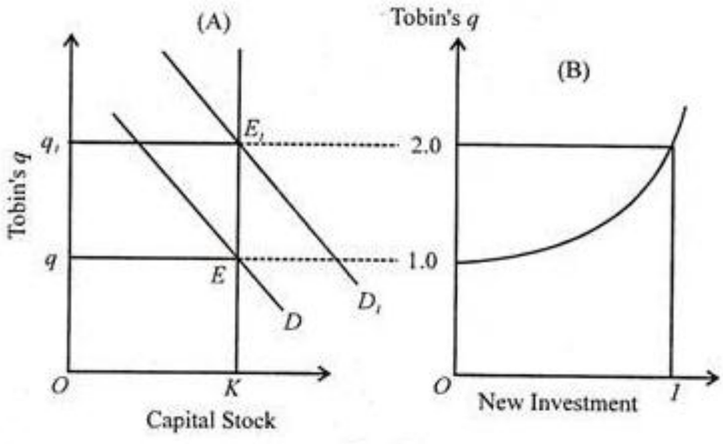

Figure 4: Illustration of Tobin's Q Theory

Figure 4 above presents an illustration of the Tobin Q theory. From the figure, if demand for desired capital increases the demand curve of capital shifts to the right from D to D1. This pushes the price of capital up from MK 1 to MK 2. At this point, the actual capital stock is K. Therefore, in the short run there exists a gap between the Actual Capital stock (K) and the desired Investment. In the long run however, this gap will be filled such that the desired capital stock equals the actual capital stock. The Model shows that various investment behaviors can be depicted based on the values of the economic variables in different time periods.

3.3 Empirical Evidence on Biofuel feasibility studies

This section outlines previous studies on general biofuel production from across the world. The section further analyzes feasibility studies on production of biofuels and the methodology used.

A study by Gallagher et al, (2005) assessed the relationship between plant size and capital cost in the ethanol industry. From their estimation, capital costs increase less than proportionately to plant size/capacity in the dry mill ethanol industry. Their study also established that capital costs increase more rapidly for ethanol than for a typical processing enterprise. In other circumstances (other than the average 0.6 factor), estimates suggest a phase of decreasing unit costs followed by a phase of increasing costs. Their study also suggests variability in the average capital cost for plant of a given size at a particular location. This, according to them is due to costs associated with factors like water availability, utility access and environmental related factors.

In Peru, social and techno-economical aspects of biodiesel production were analyzed by Quintero et al. (2012). In their study, different scenarios were assessed to find the costs of biodiesel production from oil palm and jatropha. Their study estimated total production costs for oil palm biodiesel production to range from 0.23USD/L and 0.31USD/L, while jatropha biodiesel production costs were almost 3 fold higher. Their results recommended involvement of smallholder farmers in the supply chain suggesting that this can be competitive with liquid biofuel production systems that are purely large scale.

In India, Barnwal and Sharma (2005) assessed prospects of biodiesel production from vegetable oils. Their findings revealed that the biodiesel produced from non-edible oils is cheaper than that from edible oils. James and Swinton (2009) found that the break-even biomass prices and yields provide benchmarks for evaluating the profitability potential of biofuel production.

In Africa, a strand of literature on viability of ethanol production suggests positive results. Zenebe et al (2014) investigated the profitability of biofuels production in Africa, taking Ethiopia as a case point. Specifically, the study analyzed the viability of bioethanol from molasses and biodiesel from other feedstock. Findings revealed that while bioethanol production (from molasses) in Ethiopia is viable, the viability and competitiveness of biodiesel production largely depends on the cost and price of feedstock.

In Tanzania, Frohberg, (2007) explored the potential of producing biofuels and the prospective influence of biofuels production on poverty alleviation among small-scale farmers. The results show that a comparison of the ethanol production cost figures and the threshold production cost shows that ethanol can be produced profitably in the country by using sugarcane, maize and/or cassava as feedstocks. Also the results show that ethanol can be produced competitively by using sugarcane even if world oil prices would fall to as low as US$ 40 a barrel. Felix et al. (2010) identified the scenarios that best match biofuel production in Tanzanian. Their study made a comparison of ethanol production from sugar-cane juice, with feedstock being supplied from a combination of out-growers (smallholder farmers) and commercial estates; ethanol from molasses; ethanol production from cassava, with feedstock supplied from small-scale cassava producers; and biodiesel from jatropha, with feedstock supplied by out-growers (small-scale farmers). Their results showed that production of biodiesel from palm oil is not economically viable and places too much risk on oil palm use for food and hence is not recommended for Tanzania.

Using a profit maximizing linear programming model, English, Short, and Heady (1981) analyzed the feasibility of using crop residues for direct combustion in Iowa's electrical generating power plants. Study results shows that the use of energy increased slightly with the removal of residues. However, these results did not apply for coal as energy source

Ribera et al. (2007a) analyzed the feasibility of integrating an ethanol production facility into an existing sugarcane mill in the United States using Monte Carlo simulation. The economic benefits of operating a sugar/ethanol mill that makes sugar from sugarcane and ethanol from sugarcane juice and molasses were analyzed. Another study in the United States by Outlaw et al. (2007) also used the Monte Carlo financial statement model to analyze the economic feasibility of integrating ethanol production from sugarcane juice into existing sugar mills. The results indicated positive net cash income each year on the back of government subsidies on ethanol.

The study further depicted a 100% chance of positive net present value over a ten year period for a 40 MMGY plant. The NPV over 10 years ranged between \$4.7 and \$90.4 million when sugarcane producers received \$17 per ton of sugarcane and the average ethanol price was \$2.00 per gallon.

Humbird et al (2011) used discounted cashflow analysis to explore the feasibility of ethanol production from lignocellulosic biomas by disregarding regulatory factors. Gonzalez et al (2012) computed the NPV, IRR and payback period to establish the viability of biofuel production. Their results revealed effectiveness in thermal chemical conversion because of its capability to several feedstock

Hanson, (1985) conducted a financial feasibility study of producing corn ethanol in Alabama. The study used NPV to assess the financial viability. Study results established that ethanol cogeneration was financially feasible on a net present value basis although losses were incurred in the first three years. The study further found that ethanol production without cogeneration was not feasible. High cost of feedstock was established to be the cause of delayed payback period.

3.4 Conclusion

As revealed by the literature, various methodologies have been used to undertake feasibility studies of ethanol production. The three most common and widely used are the financial model, the Monte Carol simulation and the linear programming model. This study however has used the financial model to explore the feasibility of ethanol scale up due to its simplicity in computation and interpretation of results.

CHAPTER FOUR

METHODOLOGY

In this chapter, the methodology employed in the study is presented. The chapter begins by reviewing the conceptual framework drawn in this study and then demonstrates the financial analysis. The feedstock that is currently used for production of ethanol in Malawi is Molasses and the two producing companies are Ethanol Company Limited (ETHCOL) and PRESSCANE.

4.1 Conceptual Framework

As stated in the background, the general objective of the study is to explore the feasibility of scaling up ethanol production in Malawi. As per the definition, a feasibility study is an analysis of the viability of an idea. Thus, the attempt to determine the viability of producing ethanol will provide a clear picture of whether scaling up ethanol production is achievable or not. In order to facilitate the assessment, various methods of investment appraisal have been developed over the years which among others include; the Accounting Rate of Return (ARR), the Pay Back Period (PBP), the Internal Rate of Return (IRR), the Profitability Index (PI) and the Net Present Value (NPV). The NPV and IRR are the most commonly used approaches to project appraisal and have therefore been chosen for this study.

4.1.1 Net Present Value (NPV) Method

Net Present Value method (NPV) is the present value of the expected cash flows of an investment less the cost of acquiring that investment.

$$NPV = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0 \quad \text{...ii}$$

The NPV method is the most widely and preferred investment appraisal approach. Its dominance is on account of its flexibility particularly as it considers the time value of money and its ability to accommodate non-normal cash flows. The investment appraisal method also scores highly as a profitability indicator as compared to all the other methods and leads to a single “accept” decision.

4.1.2 Internal Rate of Return (IRR) Method

Internal rate of return measures the expected rate of return of an investment. In other words, the IRR is the discount rate which when applied to net revenues of a project sets them equal to the initial investment. Mathematically, the IRR is calculated by setting the NPV equation equal to zero.

$$0 = \sum_{t=0}^{N} \frac{CF_t}{(1+IRR)^t} \quad \text{..........iii}$$

Although this method ranks lowly when it comes to appraising projects with two or more economic life and when you ought to grade competing projects, the method is mostly preferred because it reveals to the investor their return on investment (Röhrich 2007, Götze et al. 2008).

4.1.3 Sensitivity Analysis

The sensitivity analysis considers uncertainty as an important factor that influences investment decisions. By changing targeted assumptions, the sensitivity analysis establishes how such changes affect the output of the project. In doing so, it is possible to identify those parameters and assumptions to which the outcome of the analysis is more responsive and therefore put measures in place to yield the best possible results.

The sensitivity analysis helps to answer an important for the risk management question – “what can go wrong?” It identifies what variables are most sensitive, allowing the user to see the importance of each separate input variable and decide what areas of an investment project should be closely monitored and controlled (Röhrich 2007).

4.2 Financial Analysis

The study has built two financial models for ethanol production in Malawi, taking PRESSCANE as the case study considering two scenarios;

4.2.1 Ethanol Production through molasses

Historically, PRESSCANE has been producing ethanol from molasses sourced from the only sugar producing company in Malawi – ILLOVO. It is believed that how much PRESSCANE produces is to a larger extent a function of the availability of molasses. The financial model that has been built in this study has taken into consideration production of ethanol through molasses sourced from ILLOVO, which is the case currently.

4.2.2 Ethanol production straight from Sugarcane

Due to the challenges of availability of molasses, PRESSCANE has in place an initiative through which ethanol will be produced straight from sugarcane. This will require an installation of a cane crushing machine for production of ethanol. Through this model, PRESSCANE will be required to source sugarcane which will be grown by out-grower farmers. The major challenge however is availability of land through which the cane can be grown in the lower shire. Unlike production through molasses, sugarcane ethanol production is heavy on costs as it adds sugarcane processing cost to the cost of production. The two appraisal methods; NPV and IRR will then be used to see whether ethanol produced straight from sugarcane is viable or not.

4.2.3 Differences in Production

The research established that there is no much difference in the production process encountered by using the two somewhat similar feedstocks – molasses and sugarcane. The only difference comes at the onset through cane processing encountered by the use of sugarcane. Because sugarcane ethanol production is new in Malawi, the study adopted a cane processing cost of USD 5.1 at MK700.00 from a feasibility report by Shapouri et al, (2006)

4.3 General Set Up of the Models

4.3.1 Production

There are two main products that come out of the production process of ethanol; Anhydrous Alcohol (AA) and Rectified Spirits (RS). AA comes out as 99% pure ethanol and is the one that is blended with petrol as E20 whereas RS comes as 95% to 96% pure ethanol and is used as a standalone fuel or can be blended in any ratio on flexi vehicles or if a conversion kit is installed on normal petrol vehicles.

4.3.2 Product Price

Production of RS is mostly based on demand and is usually used for exports. This gives the producing companies a price negotiating advantage. As it can be evidenced therefore, the price for RS has been higher than that of AA. From the production process, RS comes out first and a further step is conducted for the molecular sieves to trap water from the RS in order to produce AA. This therefore demonstrates that if the pricing is based on the cost of production, RS ought to be cheaper than AA. For local consumption therefore, the study assumed uniform pricing for both RS and AA hence base year price of AA was used for estimation.

4.3.3 Inflation

Inflation of 18.4% has been used in the study being the average inflation from 2010 to 2015 obtained from National Statistical Office. This rate is being used to estimate the respective prices.

4.3.4 Rate of Exit of AA

Currently, petrol is blended with AA but the implementation of the EDVP will entail more production of RS to either be used as a standalone fuel or be blended with petrol in any ratio. AA on the other hand will either be blended with petrol in the 20-80 ratio or will not be blended at all based on the market demand for RS. This implies that implementation of use of ethanol in Malawi will entail more production of RS and less of AA. The study therefore assumed a 20% declining rate of production of AA per annum in favour of RS. This declining trend is assumed to start in 2017.

4.3.5 Production Period

The study assumed 30 days of production per month since production is done inclusive of the night. A total of 10 producing months per annum is also assumed on the background that ILLOVO goes offseason in January and February hence no molasses flowing in for ethanol production.

4.3.6 Production of RS per AA

Using the 2015 figures, the study computed how much RS was produced per unit AA. This rate was used to estimate 2016 volume for RS.

4.3.7 Capacity

To scale up production using the available molasses, PRESSCANE has undergone a plant upgrade. Through this initiative production per day will increase by 30,000 to firm at 90,000 litres per day (current production capacity is at 60,000 litres per day). An estimated 27 million litres per annum is expected to be produced through this project. On this basis, the study assumed a 30,000 plant upgrade every 8 years.

In 2016, it is assumed that in the first 7 months, 60,000 litres per day will be produced and the last 3 months will make use of the plant upgrade to produce 90,000 litres per day.

4.3.8 Plant Life

The estimated plant life is 20 years. PRESSCANE started production in 2004. This means a new plant will be installed in 2024. An assumption of 120,000 litres per day capacity has been made on this plant and a further plant upgrade in 2029 which adds in 30,000 litres to production per day.

4.3.9 Capacity Utilization Rate

The capacity utilization rate for the plant at PRESSCANE has been gradually increasing from 56 percent in 2010 to over 95 percent in 2015 with a dip in 2013. A big jump was recorded between 2014 and 2015 from 69 percent to 95 percent capacity utilization rate respectively. Table below shows the movements;

Table 4: Capacity Utilization

Year	Production per annum (in Million Litres)	Capacity Utilization Rate (%)
2010	10.2	56.67
2011	10.8	60
2012	10.9	60.56
2013	10.5	58.33
2014	12.5	69.44
2015	17.2	95.56
Average	12.01	66.76

Although a 66.76% average capacity utilization rate was recorded, the study assumes a 90% rate for the molasses model because major movements have been observed in recent years and also because biofuel development has become of serious consideration in Malawi thus producing companies will make use of all available opportunities to utilize the capacity at the highest possible rate. On the other hand a capacity utilization rate of 56.67% being the lowest utilization rate achieved from 2010 has been assumed on the sugarcane model to give room for learning from experience.

4.3.10 Capital treatment

An initial capital of MK2.4 billion was made in 2004. Since the study takes 2015 as the base year, this amount has been compounded at 20% to estimate the 2015 value. The cost of acquisition of a new plant in 2024 has also been estimated using the initial capital. The 2016 plant upgrade of MK 1.9 billion is also treated likewise for all plant upgrades in respective years. Looking at the cash flows, an assumption is made that the company will use its own resources to finance any plants acquisition and plant upgrade.

4.4 Production straight from sugarcane

PRESSCANE is engaging out grower farmers to produce sugarcane all year round to be used in ethanol production. This initiative will enable PRESSCANE to enter into a contract with the farmers to grow and supply the canes to them. Approximately 2000 hectares of land is targeted and is expected to bring in about 200,000 tonnes of sugarcane. Since rain fed cane growing is not reliable, there will be need for irrigation scheme to be planted to ensure sugarcane growing throughout the year. In terms of production, a cane crushing machine will have to be purchased.

4.4.1 Land Issues

The Land Act of 1971 categorizes land into public, private or customary land, whose proportions are 22%, 13% and 65% respectively. PRESSCANE is in the process of engaging out grower farmers to grow sugarcane so as to start producing ethanol straight from sugarcane. The process is estimated to cost MK33,600 million and is targeting about 2000 hectares of land which is expected to produce 18m litres of ethanol per annum.

4.5 Variables and Data

A detailed questionnaire was designed to collect the relevant data from PRESSCANE. The instrument covered questions related to inputs used to produce ethanol and their associated prices per litre produced of plant capacity. Data relating to gross profit and revenues for the period covering 2010 to 2015 was also collected and has been used for estimation.

Other sources of data were MERA, PIL and ILLOVO. Through MERA data relating to fuel consumption and ethanol production was uncovered and also prices for petrol, diesel and ethanol. Data relating to fuel imports in USD was obtained from PIL. ILLOVO provided data for molasses output and respective prices.

The key variables used in the study are presented in the table 5.

Table 5: Key variables in the study

Category	**Variable**
Dependent	NPV IRR
Independent	Cash Flow Discount Rate
Intermediate	Inputs – Molasses and transport Chemicals Sales and Distribution Tax and Levies Coal and transport
	Outputs–Sales Revenue Net Cash flow
	Prices – Input Prices Output prices
Other	Land, cane crushing machine

CHAPTER FIVE

RESULTS AND DISCUSSION

This chapter presents the findings from the study observed from the two models; the molasses and the sugarcane model.

5.1 The Molasses Model

5.1.1 Net Cash flow

Figure 5 below shows the net cash flow for the molasses model for a period of 30 years. The net cash flow is presented in million kwacha (M).

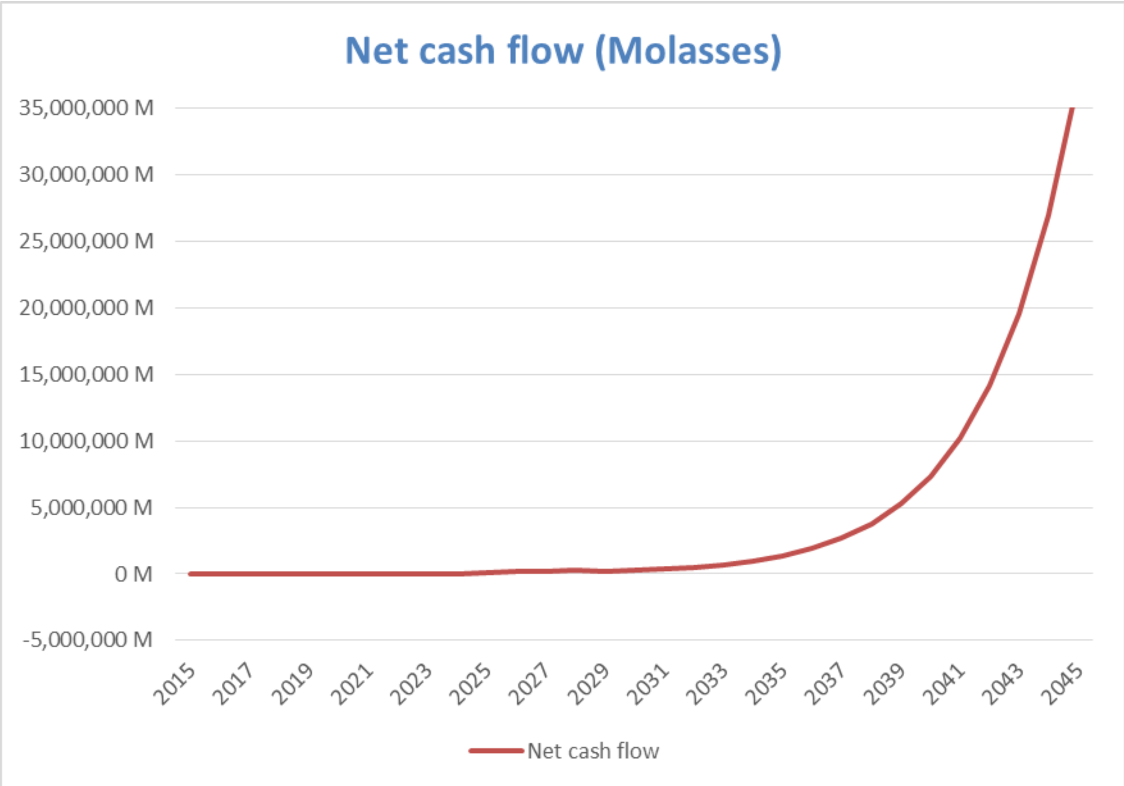

Figure 5: Net Cash Flow (Molasses)

For the whole thirty year period it was observed that total revenue exceeds total costs implying that the project is able to sustain its operations profitably. This implies that assuming the pricing of the commodity is not changed, and costs follow the historical trend, the project is capable of meeting its expenses as depicted by its cash flow movements in figure 5 above.

5.1.2 Unit Cost Analysis

Figure 6 below represents a unit cost analysis in comparison with the price of rectified spirits. Theoretically, a unit cost refers to the total expenditure incurred to produce one unit of a certain product.

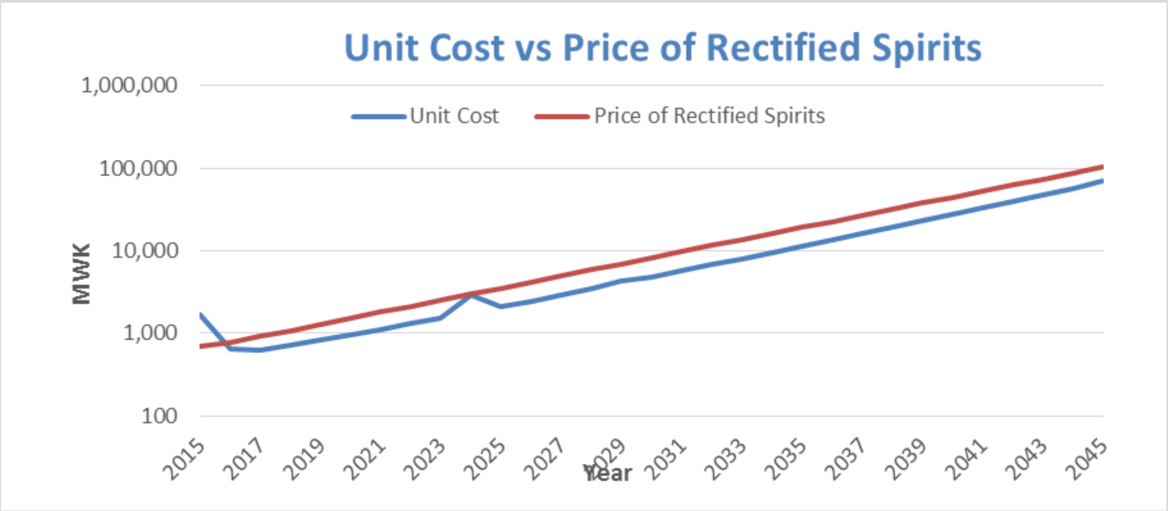

Figure 6: Unit Cost vs Price

An analysis of the unit cost demonstrates a picture similar to that of the cash flow. It is observed that ethanol price is capable of meeting the cost per unit produced. In 2017 for example, the price at which ethanol production breaks even is forecasted at MK 623.20. Any price below this threshold results in loss making position and a price higher than that leads to abnormal profits.

5.1.3 Key Results

Study results confirm viability from molasses ethanol scale up. It is observed that this viability increases over time as stipulated by the IRR. The molasses project has proved to be very viable even at 27% discount rate. Model results demonstrate an encouraging IRR of 44% implying that the project would not be feasible at a discount rate higher than 44%. In other words these results show that if the cost of capital was higher than 44% then the project would be rendered unviable.

Table 6: Key Results Molasses Model

Discount Rate	NPV (MK)	IRR
0%	133,783,575,516,844	44%
15%	1,102,417,359,002	
27%	192,555,768,196	

5.1.4 Sensitivity Analysis

Results show that production of ethanol using molasses is highly sensitive to the cost of feedstock. This is mainly because the cost of molasses accounts for about 50% of total costs. The sensitivity analysis reveals that if the cost of molasses were to increase by 10 percent, the project will be highly unviable even at zero percent discount rate

Table 7: Sensitivity Analysis 1; Change in cost of feedstock

Discount Rate (in %)	**Change (in %)**	**NPV (in MK)**	
		Before Change	**After Change**
0	30	133,783,575,516,844	-206,697,755,878,114,000
	20		-20,605,713,972,650,600
	10		-1,511,856,059,737,430
	-10		251,186,212,675,378
	-20		258,197,980,011,892
	-30		258,599,814,189,134
15	30	1,102,417,359,002	-241,197,182,786,035
	20		-40,003,876,908,504
	10		-4,547,591,244,155
	-10		1,961,409,452,015
	-20		2,098,060,551,876
	-30		2,125,891,521,036
27	30	192,555,768,196	-27,495,048,831
	20		-4,840,534,266,227
	10		-576,854,819,902
	-10		337,276,316,262
	-20		370,133,312,852
	-30		380,449,290,684

In this study, inflation was used to project future price changes for ethanol. In that regard, the impact of inflation was observed in sales revenue. That being the case, an increase in inflation is good news for the project as it translates to an increase in sales revenue. As observed from the table above, as inflation increases, holding growth in cost of production constant, ethanol scaling up becomes more and more viable. The sensitivity analysis also reveals that ethanol production is sensitive to inflation.

Table 8: Sensitivity Analysis 2; Change in inflation

Discount Rate	Change	NPV	
		Before Change	After Change
0%	30%	133,783,575,516,844	636,589,754,814,320,000
	20%		63,769,754,062,395,200
	10%		5,163,020,787,939,090
	-10%		-222,316,326,382,010
	-20%		-243,241,898,860,359
	-30%		-244,388,975,145,774
15%	30%	1,102,417,359,002	690,571,137,348,443
	20%		117,373,855,630,387
	10%		17,020,091,657,329
	-10%		-1,260,173,621,661
	-20%		-1,622,802,771,411
	-30%		-1,692,848,338,574
27%	30%	192,555,768,196	78,311,127,482,623
	20%		14,244,553,729,101
	10%		2,307,970,646,440
	-10%		-192,885,327,114
	-20%		-276,407,859,098
	-30%		

5.2 The Sugarcane Model

It was observed that despite being the only African country that has used ethanol for over 30 years, production of ethanol straight from sugarcane has never been experienced in Malawi. Due to this, the option of using sugarcane for production of ethanol seems to be quite a tall order particularly because the option is heavy on capital requirements. In addition to the high initial cost of capital, sugarcane ethanol production differs from molasses in that it adds processing costs to the production process. Despite such realizations, production of ethanol straight from sugarcane has proved to be feasible.

5.2.1 Net Cash Flow

Figure 7 below represents the net cash flow analysis for the sugarcane model

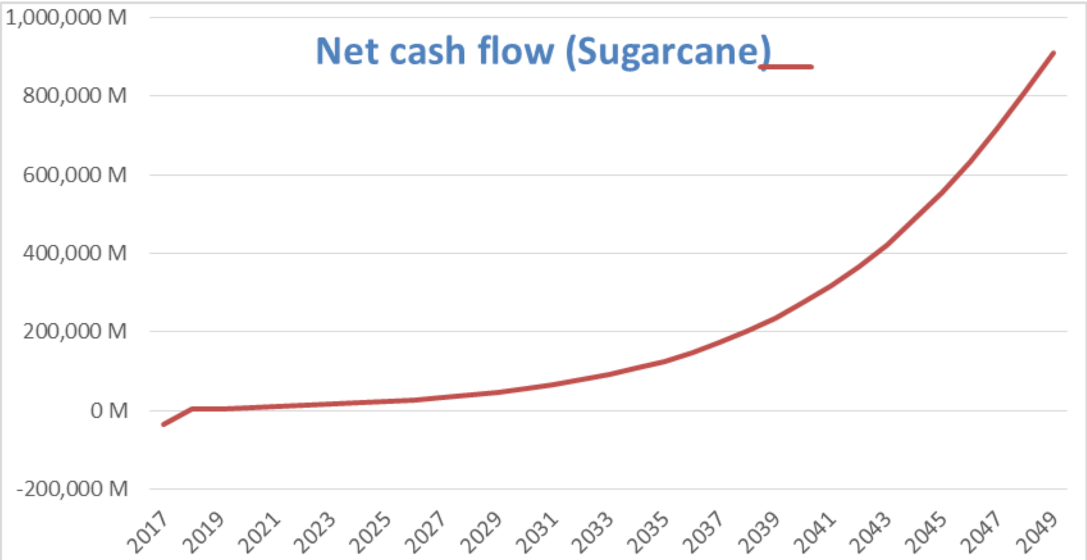

Figure 7: Net Cash Flow (Sugarcane)

Net cash flows for the sugarcane model were observed to be stable during the first years of production owing to the high initial cost of acquiring the machine only to show signs of resilience from 2037 going onwards. Due to its nature, ethanol production ensures a guaranteed market for the commodity firming the sustainability of positive net cash flows. However, pricing remains crucial to guarantee such sustainability.

5.2.2 Unit Cost Analysis

Figure 8 below demonstrates a unit cost analysis to reveal break even points for the sugarcane model.

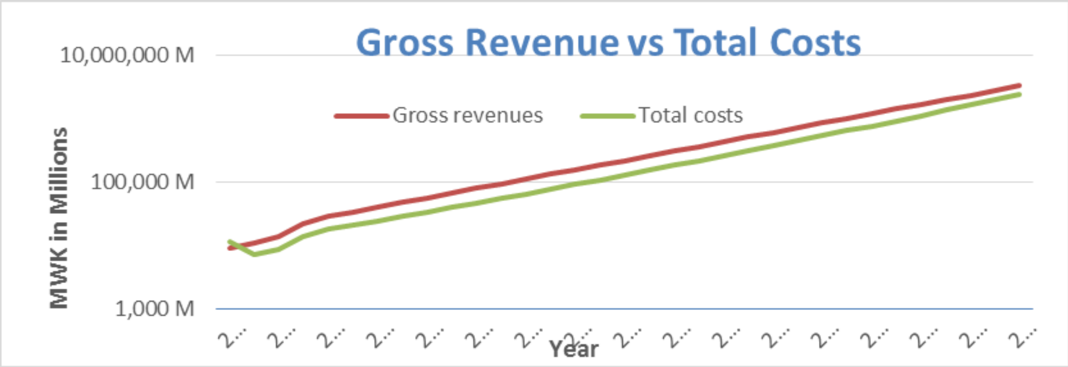

Figure 8: Revenue vs Costs

As observed from figure 8 above, unit cost analysis reveals a breakeven price of MK 1,151.50 in 2017 beyond which the firm will make abnormal profits. This implies that any price below the breakeven point will result into making losses and any price above will mean abnormal profits

5.2.3 Key Results

Study results for the sugarcane model confirm that production of ethanol straight form sugarcane is also viable despite being heavy on cost of the initial capital and despite being disadvantaged from the molasses model due to its requirement on processing of cane into a form suitable for ethanol production. Due to this the molasses model can be deemed as superior compared to the sugarcane model in terms of viability.

Table 9: Key Results Sugarcane Model

Discount Rate	NPV	IRR
0%	5,256,786,141,821	35%
15%	201,861,979,201	
27%	60,760,330,607	

Table 8 above shows positive NPV for all the discount rates assumed by the study. This strengthens the viability of the project having realized that even at 27% discount rate the sugarcane model proves to be viable. An IRR of 35% implies that the project would be rendered unviable if the return on capital exceeds 35%.

5.2.5 Sensitivity Analysis

Just as in the molasses model, sugarcane ethanol production is very sensitive to the cost of sugarcane and inflation. An increase in the cost of sugarcane is capable of creating unviability even at zero percent discount rate.

Table 10: Sensitivity Analysis 1; Change in cost of feedstock

Discount Rate	Change	NPV	
		Before Change	After Change
0%	30%	5,256,786,141,821	-5,603,694,298,351,770
	20%		-595194561368865
	10%		-47138585708570
	-10%		9,774,702,093,786
	-20%		10,177,157,999,891
	-30%		10,229,753,777,055
15%	30%	201,861,979,201	-21,813,562,378,035
	20%		-3,953,759,706,690
	10%		-461,825,455,277
	-10%		336,040,206,891
	-20%		369,621,993,785
	-30%		381,251,506,735
27%	30%	60,760,330,607	- 2,866,500,859,012
	20%		-570,717,909,494
	10%		-59,990,873,580
	-10%		94,831,960,413 107,367,322,099
	-20%		113,271,325,222
	-30%		

Since inflation has been used to project future product prices, the sensitivity analysis as depicted in the table below shows that an increase in inflation increases viability and a decrease in inflation decreases viability. The study established that a 10 percent decline in inflation can create unviability to the project.

Table 11: Sensitivity Analysis 2; Change in inflation

Discount Rate	Change	NPV	
		Before Change	After Change
0%	30%	133,783,575,516,844	188,907,575,317,814
	20%		15,077,689,058,655
	10%		6,578,189,285,046
	-10%		-9,589,859,711,602
	-20%		-9,668,728,595,105
	-30%		-9,695,974,112,465
15%	30%	1,102,417,359,002	2,400,749,146,690
	20%		424,619,480,820
	10%		67,308,340,312
	-10%		-253,395,299,078
	-20%		-274,641,044,970
	-30%		-285,974,112,465
27%	30%	192,555,768,196	460,784,803,554
	20%		115,902,342,610
	10%		4,174,341,432
	-10%		-59,883,825,430
	-20%		-71,325,510,691
	-30%		-78,409,692,557

CHAPTER SIX

CONCLUSION AND POLICY RECOMMENDATIONS

Having conducted this research on financial viability of scaling up ethanol production, this chapter aims at drawing a conclusion from the study and also on the recommendations for further research. The chapter goes on to outline policy recommendations.

6.1 Conclusion and further Research

Although study results suggest viability in ethanol production, the practicality of using molasses to scale up production of ethanol is questionable. This is on account of limited availability of the feedstock, more so because the sugar industry runs as a monopoly currently. The option of sourcing the molasses from neighbouring countries presents a reasonable opportunity however sustainability will be crucial since efforts to promote biofuels have been deployed across the continent**.**

In terms of land, the study established a minimum of 105,000 hectares as a requirement to satisfy an E100 mandate. This is on the condition that cane growing on this land will use irrigation schemes. ILLOVO currently cultivates cane on land in excess of 20,000 hectares. This therefore looks like a tall order and may of course be at the expense of food security. To enhance the viability, this will require government dedication, new entrants to the sugar industry and a creation of new offshore sugar markets.

The sugarcane ethanol production despite being better off on land usage requires huge financing which is compounded by the high cost of capital in the country. To make it sustainable there is need for government to harness the macroeconomic environment which will boost the business confidence and enable more players in the sugar and ethanol market to work in association (especially on irrigation infrastructure) so as to benefit from the economies of scale.

The study observed that the cost of the feedstock in ethanol production accounts for more than 50% of total unit cost of production. The sensitivity analysis therefore confirms a high sensitivity in output variable to changes in the cost of production.

Because fossil fuels are non-renewable, promotion of biofuel production is believed to be the sustainable way to energy. Being a developing country with few export activities, foreign exchange has always been an important variable in macroeconomic development. At best, the use of ethanol to totally substitute petrol takes out petrol as a foreign expenditure thereby resulting into the country to save on the hard earned foreign exchange. Not to mention that vinasse – the by product from ethanol - is used in manufacturing fertilizer (Fertilizer is the largest import in Malawi). This therefore means that promotion of ethanol production has the multiplier effect and can transform the economy for the better. This argument provide for the increasing need for research in the area of biofuel development. Further research can take the direction of effective land use, exploration of the potential for ethanol production using other feedstock, biofuel and poverty alleviation and of course a detailed social impact analysis of biofuel production in Malawi.

6.2 Policy Implications

The study used the current market price to forecast future ethanol prices. As indicated in previous chapters, the current regulation requires that ethanol be charged as a percentage of petrol i.e MK5.00 less. Using these figures it can be rightly argued that the difference in prices of petrol and ethanol is not that significant. Not to mention that consumers will have to install a kit in order to consume high ethanol blends. This background shows that in as much as the employment of ethanol as an alternative to gasoline is beneficial to government, the benefits for the consumer is not that significant. In view of this it is essential for government to foster increased publicity of the use of ethanol in place of petrol in order to ensure consumer acceptance of the technology in the country. Bearing in mind that ethanol contains less energy than petrol, there is a huge need to foster price advantage of ethanol over petrol. Government can use initiatives like tax waivers on ethanol infrastructure, increase levies on petrol and impose import tariff on petrol.

As it has been revealed in this study, the current ethanol production is not able to meet the demand at E-20, it is imperative that production be scaled up. Because the alternative of ethanol use to petrol is not a market led initiative but rather a government one, it is important for government to seriously work with the current producers to look into measures that can effectively increase production. These may include allocation of land for sugarcane growing and promoting commercial farmers to venture into the sugarcane industry. When this is done there will be need for more producers to enter the market so as to ensure sustainability and competition. This requires creation of a conducive environment to attract investors into the market.

Being a new innovation, there will be need for ethanol refilling points to be mounted by fuel distributors. Government will need to enforce measures that enable fuel distributors to mount these refilling points in all the filling stations across the nation. Trained personnel to install the conversion kit should therefore be placed in all those filling stations to enhance increased uptake of the technology.

6.3 Limitations of the Study

Throughout the course of this study, there have been certain limitations that were observed. This implies that the results should be treated with a caution.

The major limitation was on ethanol pricing. The study used the current market price to project future prices. The current price is derived from petrol prices as required by the regulator. Large scale ethanol use and/or production will likely come with a new pricing mechanism.

Another limitation is on data availability particularly when making projections on costs. The study used the Consumer Price Index as opposed to the Producer Price Index which was not available during the course of this study. Another major data limitation was observed on processing costs for the sugarcane model, which, due to the realization that ethanol development is in its infancy in Africa, the processing costs were adopted from an empirical study in USA.

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APPENDICES

Appendix 1: Presscane

Sales	2010	2011	2012	2013	2014	2015
Fuel Ethanol	5,328,527	11,471,735	10,883,193	9,034,894	10,148,000	
Portable Alcohol						
Rectified Alcohol	2,972,286	783,833	738,915	563,203	684,987	
Total sales	8,300,813	12,255,568	11,622,108	9,598,097	10,832,987	17,360,000.00
Total export	1,704,853	354,281	327,414	140,475	-	
Plant Capacity per yr	18,000,000	18,000,000	18,000,000	18,000,000	18,000,000	
Total production				9,806,757	11,781,045	14,671,520

Appendix 2: Ethanol Company

Sales	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Fuel Ethanol	2,002,664	1,724,968	2,983,842	3,094,605	2,836,828	3,417,417.00
Portable Alcohol	5,086,424	7,251,128	5,167,175	5,776,111	5,711,432	6,317,439.00
Rectified Alcohol	877,714	400,980	56,400	6,690	336,018	136,320.00
Total sales	7,966,802	9,377,076	8,207,417	8,877,406	8,884,278	9,873,191.00
Total export	2,999,632	4,121,218	2,020,005	270,267	39,953	
Plant Capacity per yr	18,000,000	18,000,000	18,000,000	18,000,000	18,000,000	18,000,000.00
Total production				3,133,948	2,858,814	3,499,381

Appendix 3: Fuel Consumption (in million litres)

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	**Totals**
2008	Petrol	9	8	7	8	10	9	8	11	8	11	9	5	103
	Diesel	15	15	14	15	15	17	19	18	20	20	18	13	199
														302
2009	Petrol	10	7	9	10	10	8	10	8	7	10	7	10	106
	Diesel	15	14	18	13	16	14	19	21	20	17	12	19	198
														305
2010	Petrol	10	7	10	7	11	11	10	11	7	8	12	7	110
	Diesel	16	15	15	15	18	17	20	19	16	22	17	17	207
														317
2011	Petrol	9	8	7	11	8	7	5	3	6	6	5	5	81
	Diesel	17	13	16	17	16	13	8	4	0	1	9	7	120
														201
2012	Petrol	4	1	0	1	1	6	1	5	5	6	5	7	43
	Diesel	9	2	4	2	5	14	8	6	10	11	7	10	89
														132
2013	Petrol	11	8	7	8	8	10	11	11	9	10	7	8	109
	Diesel	25	12	15	11	15	11	18	16	18	16	15	17	189
2014	Petrol	10	8	8	9	12	8	9	10	9	9	7	10	109
	Diesel	13	12	9	11	11	11	14	13	11	14	14	11	145
														254
2015	Petrol	9	11	9	11	9	11	13	12	12	14	9	13	133
	Diesel	14	12	12	11	12	16	12	15	15	16	17	15	166

Appendix 4: Ethanol consumption

	AA SALES (LTRS)	AA AVERAGE PRICE	RS SALES LOCAL (LTRS)	RS MK AVERAGE PRICE	RS SALES EXPORT (LTRS)	RS US$ AVERAGE PRICE
2009	4,884,207	MK165.78	506,534	MK123.70	3,819,775.00	$0.611
2010	5,117,734	MK210.53	391,826	MK180.55	2,503,915.00	$0.69
2011	10,977,758	MK260.03	419,516	MK212.00	661,938.00	1.03
2012	11,289,943	MK434.70	682,115	MK342.82	360,914.00	$1.03
2013	9,040,894	MK629.75	573,203	MK547.83	140,475.00	$1.03
2014	10,039,478	MK724.64	684,987	MK639.84	-	$0.00
2015	15,763,132	MK651.84	1,415,021	MK687.80	-	$0.00

Appendix 5: Questionnaire on ethanol production in Malawi – Press Cane

1. What are the inputs used in the production of ethanol and their associated costs (Including labor costs)?

i. Fixed Costs

Salaries and Wages of employees
Depreciation of the existing plant
Security costs, Safety Health and Environment costs
Insurance Costs
Production and wholesale licences
General Administration Costs
Total fixed costs MK95/litre

ii. Variable costs

Molasses costs and related transport costs MK298/litre
Coal and related transport costs MK5.43/litre
Cost of Chemicals for treating water and production MK6.28/litre
Selling and Distribution costs MK7.2/litre to Blantyre
Levies payable to Malawi Energy Regulatory Authority MK 26.57/litre
Excise Tax MK 36.99

Total VC = 380.47
Total Costs = 475.47
Molasses cost = 62% of TC
Levies and excise tax costs = 13.36% of TC

2. What is the initial capital investment of PRESSCANE

   The investment done in 2004 was MK2,158 million approximately USD 20 million

3. What will be the cost of the conversion kit

   About USD100 a kit

4. What is the minimum blend that will require installation of the kit (Since now we are using E20 but it fits on the original engines. What blend will require an installation of the kit?)

   The current blending does not require conversion kit. The conversion kit will enable a car run with any ratios of Petrol and Ethanol from say nil ethanol to 100 % ethanol.

5. Are there any byproducts? If yes list them and their associated prices
   Vinasse/Effluent
   Fuse Oil in small quantities

6. What are the outputs and their prices

   None, However the company has to spend to manage the effluent, by digging ad maintaining the ponds to ensure that they do produce bad smell to the community

7. How much are you producing now?

   We are producing 12 to 16 million litres depending on availability of raw materials- Molasses

8. What is the maximum you can produce?

18 million litres annually

9. What initiatives are in place to boost production and how will this affect production

   Currently undergoing plant upgrade from 18 million litres to 27 million litres annually. Also investing in cane juice/syrup mill for production of ethanol straight from sugarcane. The cane will be grown by out-grower farmers