Growing the Sugar Industry in South Africa

Document 5: Investigation and Evaluation of Alternative Uses and Products from Sugarcane: A Cost Benefit and Macro-Economic Impact Analysis

February 2013

The reporting on the outcome of the study consists of a number of technical reports and a Management Report as listed below. This Report corresponds to the report **Document 5** below:

- Management Report: Lessons, Justifications and Challenges – Guidelines for Decision Making.
- Document 1: Overview of the Sugar Industry: Contribution to Social and Economic Development and Contentious Issues.
- Document 2: Comparative Advantage Analysis of the Sugar Industry.
- Document 3: Legislative Environment of the Sugar Industry.
- Document 4: Evaluation of the Viability of the Sugar Industry: A Cost Benefit Analysis and Macroeconomic Impact analysis.
- ***Document 5: Investigation and Evaluation of Alternative Uses and Products from Sugar Cane: A Cost Benefit and Macroeconomic Impact Analysis.***

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EXECUTIVE SUMMARY

The purpose of this task of the study: *Investigation of Alternative Uses of Sugar* is to ascertain the opportunity with regard to the further beneficiation of sugar cane and to increase the range of alternative uses of sugar cane.

The need for alternative sources of crude oil and fuel has been a pressing issue worldwide and South Africa is no exception. There is, therefore, a need to consider other viable options of producing substitutes to oil based fuel. Sugar cane is one of the agriculture crops that can be used to produce ethanol. The use of sugar cane to produce ethanol will serve as an important substitute to crude oil, thereby helping to meet the country's crude oil needs. However, the financial and economic viability of such a venture will need to be considered from time to time as it appears not to be financially viable under present prices. Globally, support provided by government is a key variable in determining the viability of ethanol production and would in any event be a prerequisite via a mandated market.

Firstly the study investigates the production of ethanol fuel by additional sugar cane production for new greenfields ethanol only mill. This will contribute to import substitution of crude oil and open up an alternative outlet for sugar cane production.

This study also investigates the opportunity for increasing generation of electricity and to add to the alleviation of the present deficit in electricity supply in South Africa. Generation of electricity from sugar bagasse for own use by the sugar mill has already been implemented and the evaluation confirms this, especially in the context of much higher electricity prices going forward. Electricity generation from high efficiency generation, improved mill steam efficiency and conventional high efficiency condensing generation based on conventional bagasse and additional sugarcane leaves can increase electricity generation by up to 5 times compared to the current generation. The use of sugar cane bagasse for the production of electricity does not substitute the end product of sugar cane namely sugar but provides a supplementary product.

Access to ethanol and electricity will not only improve the value created of the sugarcane value chain but also offer opportunities for improved optimization and reduced cost. Access to ethanol and electricity are thus the key to the long-term global competitiveness of the sugarcane industry. This has not been investigated and is beyond the scope of this study.

To estimate the financial and economic feasibility of the production of ethanol and the generation of electricity, two instruments were used namely, cost benefit analysis (CBA) which calculates the immediate effects of the projects and macro-economic impact analysis (MEIA). The MEIA takes into account the ripple effects of the projects through the total economy in terms of the forward and backward linkages of the projects.

Ethanol

According to the Engineering News of August 2009 it is estimated that up to 4% of South Africa's liquid fuel pool, about 500-million litres, could potentially be supplied from ethanol manufactured from sugar currently exported to world markets.

However, currently the Bio fuels Industrial Strategy for South Africa excludes established sugar cane areas from the production of ethanol as the aim is not to reduce the sector's sugar-as-food production capacity in favour of sugar as fuel, but rather to grow the sector as a whole. The most expedient and cost effective opportunity of converting export sugar to ethanol and supporting the recovery of sugarcane supply to the full capacity of the existing and re-optimised sugar industry was not considered but has been raised with Department of Energy and is currently under review.

For instance the proposed Makathini ethanol-from-sugar processing facility will be using sugar cane from new and additional planting areas. The plant is calculated to cost R1.7 billion (2009 prices) and will be able to produce about 100 million litres of ethanol per year.

According to the Engineering News, sucrose extracted from sugarcane accounts for little more than 30% of the chemical energy stored in the mature plant, while 35% resides in the leaves and stem tips, which are left in the fields during harvest, and 35% in the fibrous material, called bagasse, which is used to generate steam and electricity for own use. All sugar mills in South Africa are energy self-sufficient.

The Major Assumptions in the Analysis of the Viability of Ethanol Production

The financial viability of producing ethanol from sugarcane is largely determined by the world crude oil price and the world sugar price. Ethanol is part of the fuel basket of South Africa of which the price of fuel is determined by free market principles, which are ultimately driven by the world price of crude oil. Due to the fact that surplus sugar can either be exported or domestically used as a raw material for the production of ethanol, the world sugar price is a determinant for the price of sugar that is used in the ethanol production process.

Globally it is acknowledged that the costs of the impact of carbon emissions and the mitigation thereof are not included in fuels produced and electricity generated from fossil fuels. As these cost are external to the fossil fuel based energy product, low carbon energies are currently not able to compete with fossil fuels. All countries with ethanol in the fuel mix provide support in the form of tax exemptions, incentives and subsidies. Brazil also claims that the cost of support for ethanol is less than the cost of supporting people who migrate from rural agriculture to urban low or non-income areas.

This study determines the viability of the ethanol industry in the base case scenario and no subsidies or any kind of government assistance forms part of the income stream of ethanol production. However, this is not to say that eventually the government cannot subsidise the industry if it feels there is merit for other priority objectives such as job creation and meeting South Africa's carbon emission reduction commitments. The South African fuel ethanol strategy has always been based on supporting ethanol production through additional measures such as tax rebates which can be as high as 100%. The level of support required is dependent on the combination of world sugar and oil prices.

As no new sugar mills are viable at supplying only to the world export market the greenfields ethanol mill will also not be viable at export market conditions without support.

The World Sugar Price

It should be noted that the world sugar price which are quoted in US dollars, fluctuate regularly. However, the Rand/US dollar exchange price has been deteriorating constantly over the years. This implies that, even should the world price of sugar decline significantly in the near future, the export price of sugar in rand terms will not decline at the same rate. Thus, the future S.A. export price of sugar will be cushioned by the decline in the exchange rate.

The analysis was performed at an assumed constant world sugar price of 19.35 US cents per pound (10 July 2012). The base case evaluation of the future sugar scenarios assumed the international raw sugar price to rise to 31.5 /c per lb in 2030 in real terms with an average real sugar price of 26.4 c/lb over the period. [See section 4 paragraph 6.1.1.1] The world sugar price was historically much lower than the 22.5 US cents and it could be argued that the assumption is too high. However, agriculture economists also argued that a structural change in the sugar market has taken place due to the fact that Brazil, the biggest producer of world sugar (23%) and exporter of sugar (50%), also uses sugar on a large scale to produce ethanol. Due to the fact that they have the ability to switch from the export of sugar to the production of ethanol, they have the ability to stabilise the world price of sugar but at a higher price level than the historic levels.

The World Crude Oil Price

Similar to the world price of sugar, is the world price of crude oil also quoted in US dollars and will be similarly be affected by the long term rand/US dollar exchange rate. As ethanol is a substitute energy source for oil, the future local price thereof will similarly be positively influenced should the exchange rate deteriorate over time, even if the world crude price declines over time.

An international crude oil price of 105$ per barrel is used in this analysis in the base case scenario. This price is much higher than the historic price of a few years ago. However, on the other hand the price has also reached a high of $132 per barrel in July 2008. The oil price is currently very unstable and the consultant is of the view that for purposes of this analysis a price of the order of $105 per barrel, in constant terms, is a reasonable assumption.

The principles underlying the Cost Benefit Analysis (CBA)

The principles underlying the Cost Benefit Analysis (CBA) of the alternative uses for sugar are applied to evaluate the financial and economic viability of a project to produce ethanol.

Financial and Economic CBA Results Ethanol (Base Case)

The results are as follows:

Evaluation Criteria	Financial CBA Results	Economic CBA Results
Net Present Value (NPV) (R'millions)	R-435	R-569
Internal Rate of Return (IRR)	8,34%	4,1%
Benefit Cost Ratio (BCR)	0.94	0.90

- The financial NPV above that includes inflation, indicates that the net benefit accrued is not positive as there is a net deficit of approximately R435 million expected from this project. The economic NPV which is performed at constant prices also indicates a negative value of R569 million.
- The financial BCR of 0.94 above indicate that for each Rand invested in the project there is an expected return of R0.94. The economic BCR shows a value of 0.90.
- The financial IRR is 8.34% and the economic is 4.1%, which are both lower than the discount rates of 11% and 8% respectively.
- The sugarcane price linked to export sugar is around 67% of the future scenario of the sugar base case which is below the operating cost of growers as used in section 4. This ethanol base case scenario is the same as the "Scenario 1: Domestic Prices equal Export Prices" of section 4 which is not viable for either grower or miller (at depreciated capital cost). A new greenfields mill will thus not be viable enough to establish the sugarcane grower and sugarcane supply at this price of sugarcane.
- On the other hand, the analysis also shows that the production of ethanol from sugar can become viable at a world crude oil price of around $120 per barrel, assuming a fixed world sugar price of 22.5 US cents per pound (current price, 10 July 2012). Currently the world crude oil price is just above $112 per barrel (19 September 2012), which is below the breakeven price level of $120 per barrel. This is to say that at a world sugar price of 22.5 US cents per pound and the world crude oil price of $120, the production of ethanol from sugar could become a profitable venture. Similarly, the sustainability of the higher world crude oil price is not certain, considering that the average world crude oil price in 2010 was $71.21 in nominal prices.

Macro-economic Impact Analysis Ethanol

The macro-economic impact analysis is conducted at a national and provincial level. However the main focus of the analysis is the RSA national economy. The impact analysis is based on the contribution that the project is expected to make towards the national and provincial economies in terms of the following macro-economic aggregates:

- Gross Domestic Product (Economic Growth),
- Employment Creation,
- Capital Utilisation (Investment), and

- Household Income (Poverty Alleviation in terms of Low Income Households).

The macro-economic impact analysis was structured to reflect the average annual production output over the project period of 20 years. Furthermore these macro-economic impacts also reflect the ultimate or total outcome, i.e. through the direct, indirect and induced linkages of the project.

According to the macro-economic impact analysis, the ethanol plant will increase the RSA GDP by about R1.2 billion per annum and create about 8 884 job opportunities in the RSA national economy, of which 7 655 will be in the KwaZulu Natal economy. It's important to note that over 4 000 jobs of the total number of jobs is created in the growing of the sugarcane. If it's only a diversion of sugar cane from the production of sugar to ethanol then this 4 000 jobs can't be seen as additional jobs since it exists already.

With regard to the efficient use of scarce capital, the production of ethanol from sugarcane is slightly less efficient than the average for the total economy, as far as GDP and labour is concerned, but much higher in terms of household income. The GDP/Capital ratio of the ethanol plant is 0.31 compared to 0.45 of the total for RSA. The Labour/Capital ratio for the ethanol plant is 2.21 and that of the national economy 2.94. For low income households it provides 18.6% of total household income in the production of ethanol from sugar cane compared to 16.2% for the entire South African economy.

Generation of Electricity from Sugarcane Bagasse

The Major Assumptions in Analysing the Viability of Generation of Electricity from Sugar Bagasse

- **The Price of Bagasse**

The front-end of the sugar mill separates the sugar from the fibre (bagasse). All of the bagasse is used as the fuel to generate steam and electricity in a power station. All sugar mills in South Africa are energy self-sufficient. Conventional sugarcane bagasse can be separated into pith and refined fibre. Around 6 to 7% of the sugar industry bagasse is used in the production of animal feed, paper and furfural products; 2% as pith in the production of animal feed, 4 to 5% as refined fibre by two South African paper mills while the net use of bagasse for furfural production is negligible.

Currently bagasse is effectively used in the production process of sugar and, although the cane producers receive no direct income from the bagasse; the savings in electricity costs are an indirect benefit to them.

For purposes of this study, bagasse is seen as having an alternative use in the current production process at sugar mills and as such has a cost if it is used in the generation of electricity. A bagasse price scenario could linked to the current price of electricity that the mills would be paying. The current price that mills pay for electricity is in the region of 0.85 and 1.01 R/kWh in real terms going forward.

It is not very clear what the present opportunity cost of bagasse is and therefore for purposes of this study the price was set to 0.30 R/kWh. The *Comprehensive Design of the South African Renewable Energy Sectoral Business Case, 2009 set the price at 23 cents per kWh.*

- **The Electricity price per kWh**

The price at which the electricity produced from bagasse can be sold can greatly influence the viability of the project. If the price is too high, then Eskom might be deterred from buying electricity produced from generation and rather generate electricity through the use of coal fired power stations which are currently the cheapest way to produce electricity in South Africa. It seems that this cost is currently between R0.65 and R0.75 per kWh. The evaluation is based on 1.01 R/kWh in real terms. This is at the lower end of IRP 2010-2030 forecasted range and lower than the latest multi-year price determination (MYPD3) by ESKOM.

Economists are, however, of the opinion that this price does not take into account the total production costs, since it does not take into account the negative externalities that coal fired power stations have on the environment. The IPCC and McKinsey have estimated the cost of carbon mitigation and adaptation around 40 to 50 USD/ton or 50 Euro/ton carbon dioxide respectively. This translates to about 0.30 to 0.50 R/kWh. The carbon tax proposed by treasury is phased in starting with 0.12 and rising to 0.72 R/kWh.

However, it could also be argued that for environmental purposes, the government is prepared to stimulate renewable energy sources by paying a higher price for electricity through generation. The current price paid for generation by ESKOM lies between R0.90 and R1.25 which has led to very few projects in the paper and forestry industry and none in sugarcane industry or biomass in general.

- **Generation**

In the South African context, generation refers to the production of electricity and useful heat from a fuel/energy source which is biomass, industrial waste and Combined Heat and Power [Ministerial determination 19 December 2012]. It differs from conventional generation in that it is coupled to an industrial process of the host plant. Sugarcane bagasse is the residue remaining after extraction of the sucrose from the sugarcane. The bagasse is currently burned for electricity generation, allowing the plant to be self-sufficient in energy and to generate additional electricity for own use and very limited quantities into the local power grid.

For the generation of electricity from sugarcane bagasse, it was estimated that about 93% of sugarcane production can be used for the generation of electricity. Currently (2010) about 18.6 million tons of sugarcane is crushed annually. The total fibrous material available for the production of electricity is, therefore, 18.6 million tons of cane multiplied by 84%, multiplied by the 35% re-bagasse of sugarcane. This is equal to 5,4 million tons of bagasse for the production of electricity.

Technologies Considered for Generation of Electricity from Sugarcane Bagasse

The following technologies have been considered under the three types of eligible generation projects under the Generation Feed-In Tariff (Cofit):

- TYPE I Technologies: Waste Heat
- TYPE II Technologies: Coal
- TYPE III Technologies: Sugarcane Bagasse

Evaluation Criteria	Financial CBA Results	Economic CBA Results
Net Present Value (NPV) (R'millions)	R 1 765	R 536
Internal Rate of Return (IRR)	15.2%	9.6%
Benefit Cost Ratio (BCR)	1.31	1.10

Financial and Economic CBA Results of Generation

- The financial NPV which includes inflation, indicates that the net benefit accrued is positive as there is a net surplus of approximately R 1 765 million expected from this project at a discount rate of 11%. The economic NPV which is performed at constant prices indicates a positive value of R536 million at an 8% discount rate.
- The financial BCR of 1.31 above indicates that for each Rand invested in the project there is an expected return of R1.31. The economic BCR shows a value of 1.10.
- The financial IRR indicates a value of 15.2% and the economical IRR indicates a value of 9.6%.
- Based on the evaluation criteria it is evident that the production of electricity from sugarcane bagasse is viable and confirms the previous investment by sugar mills into the generation of electricity for own use.

Macro-economic Impact Analysis of Generation

The plant for generation of electricity from sugarcane bagasse will increase the RSA GDP by about R1 366 million per annum and create about 3 643 job opportunities in the RSA national economy, of which about 2 483will be in the KwaZulu Natal economy.

From the analysis, a unit of investment in the generation of electricity from sugarcane bagasse is less efficiently utilized than the average for the total economy, as far as GDP and labour is concerned, but much higher in terms of household income. However, it's not appropriate that the general economy be used as benchmark. It compares much better with the electricity sector, which should rather be used as benchmark. The GDP/Capital ratio of generation of electricity from sugarcane bagasse is 0.42 and the Labour/Capital ratio is 1.12 in comparison with the GDP/Capital ratio of 0.24 and the Labour/Capital ratio of 1.13 of the electricity sector respectively. For low-income households it provides a percentage of % for the generation of electricity compared to 16.7% for the electricity sector.

Conclusion

From the above analysis, specifically the Cost Benefit Analysis, it appears that the co – generation of electricity is economically and financially viable and that it benefits the mill owners, cane suppliers and rural population in general. The results of the analysis actually indicate that the production of electricity from sugar bagasse is very lucrative and should be encouraged.

However it appears that the production of ethanol without support is not financially viable.

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ACRONYMS

BCR	Benefit Cost Ratio
CBA	Cost Benefit Analysis
DBSA	Development Bank of Southern Africa
DPLG	Department of Provincial and Local Government
EU	European Union
IRR	Internal Rate of Return
KZN	KwaZulu-Natal
NPV	Net Present Value
RV	Recoverable Value
SACU	South African Customs Union
SAM	Social Accounting Matrix
SARB	South African Reserve Bank
SASA	South African Sugar Association
StatsSA	Statistics South Africa

1 INTRODUCTION

1.1 Background

The purpose of this task of the study: *Investigation of Alternative Uses of Sugar* is to ascertain the opportunity with regard to the further beneficiation of sugarcane and to increase the range of alternative uses of sugarcane.

The need for alternative sources of crude oil and fuel has been a pressing issue worldwide and South Africa is no exception. There is, therefore, a need to consider other viable options of producing substitutes to oil based fuel. Sugarcane is one of the agriculture crops that can be used to produce ethanol. The use of sugarcane to produce ethanol will serve as an important substitute to crude oil, thereby helping to meet the country's crude oil needs. However, the financial and economic viability of such a venture will need to be considered from time to time as it appears not to be financially viable under present prices. Globally, support provided by government is a key variable in determining the viability of ethanol production and would in any event be a prerequisite via a mandated market.

Firstly the study investigates the production of ethanol fuel by additional sugarcane production for new greenfields ethanol only mill. This will contribute to import substitution of crude oil and open up an alternative outlet for sugarcane production.

This study also investigates the opportunity for increasing generation of electricity and to add to the alleviation of the present deficit in electricity supply in South Africa. The generation of electricity from sugarcane bagasse for own use by the sugar mill has been already been implemented and the evaluation confirms this, especially in the context of much higher electricity prices in future. Electricity generation from high efficiency generation, improved mill steam efficiency and conventional high efficiency condensing generation based on conventional bagasse and additional sugarcane leaves can increase electricity generation by up to 5 times compared to the current generation. The use of sugarcane bagasse for the production of electricity does not substitute the end product of sugarcane namely sugar, but provides a supplementary product.

Access to ethanol and electricity will not only improve the value created of the sugarcane value chain but also offer opportunities for improved optimization and reduced cost. Access to ethanol and electricity are thus the key to the long-term global competitiveness of the sugarcane industry. This has not been investigated and is beyond the scope of this study.

To estimate the financial and economic feasibility of the production of ethanol and the generation of electricity two instruments were used namely, cost benefit analysis (CBA) which calculates the immediate effects of the projects and macro - economic impact analysis (MEIA) which also takes into account the ripple effect of the projects through the total economy in terms of the forward and backward linkages of the projects.

2 ETHANOL FUEL

2.1 Background

According to the Engineering News of August 2009[1] it is estimated that up to 4% of South Africa's liquid fuel pool, about 500-million litres, could potentially be supplied from ethanol manufactured from sugar currently exported to world markets.

However, currently the Bio fuels Industrial Strategy for South Africa excludes established sugar cane areas from the production of ethanol as the aim is not to reduce the sector's sugar-as-food production capacity in favour of sugar as fuel, but rather to grow the sector as a whole. The most expedient and cost effective opportunity of converting export sugar to ethanol and supporting the recovery of sugarcane supply to the full capacity of the existing and re-optimised sugar industry was not considered but has been raised with the Department of Energy and is currently under review.

For instance the proposed Makathini ethanol-from-sugar processing facility will be using sugar cane from new and additional planting areas. The plant is calculated to cost R1.7-billion (2009 prices) and will be able to produce about 100 million litres of ethanol per year.

Please refer to Paragraph 3.2 below, for the status of current ***Strategic and Policy Level Considerations,*** with regard to biofuels production, as well as generation of electricity from sugarcane.

According to the Engineering News, sucrose extracted from sugarcane accounts for little more than 30% of the chemical energy stored in the mature plant, while 35% is contained in the leaves and stem tips, referred to as *tops and trash*, which are left in the fields during harvest, and 35% in the fibrous material, called bagasse, which is utilised to generate steam and electricity for own use.

The main aim of the milling process is to extract the largest possible amount of sucrose from the cane and a secondary, but important, aim is the production of bagasse with low moisture content as boiler fuel. The steam is let down in a turbine to generate electricity, allowing the plant to be self-sufficient in energy and to generate electricity for the local power grid. All sugar mills in South Africa are energy self-sufficient.

The cane juice is filtered, treated by chemicals and pasteurised. Before evaporation, the juice is filtered once again, producing vinasse, a fluid rich in organic compounds.

The syrup resulting from evaporation is then precipitated by crystallization, producing a mixture of clear crystals surrounded by molasses. A centrifuge is used to separate the sugar from molasses, and the crystals are washed by steam and then dried by airflow. When cool, sugar crystallizes out of the syrup, from which point the sugar refining process continues to produce different types of sugar.

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[1] Generating Energy from Sugar: What does it mean for South Africa?; Engineering News; Aug 2009

The remaining molasses is sterilized for fermentation, during which process sugar is transformed into ethanol by adding yeast.

2.2 Cost Benefit Analysis of the Production of Ethanol

2.2.1 Objective of the Cost Benefit Analysis

The principles underlying the Cost Benefit Analysis (CBA) of the alternative uses for sugar are applied to evaluate the financial and economic viability of a project to produce ethanol. The CBA approach provides a logical framework by means of which development projects can be objectively evaluated and, as such, serves as an aid in the decision-making process

2.2.2 Cost Benefit Analysis Methodology

A CBA comprises two distinct portions, a financial CBA component and an economic CBA component. The financial CBA component is based on market and nominal prices, whilst the economic CBA component is based on shadow/economic and constant prices. The use of shadow/economic prices is necessary in order to reflect more realistic values of scarce economic resources. Market prices often do not give a true representation of the scarcity values of resources owing to interference in market price setting such as government tax regulation and artificial adjustments to, for example, fossil fuels prices, electricity tariffs and minimum wage levels.

Within the CBA framework, various impacts have been calculated for each year of the project period. The impacts for each year of the project are discounted to present values, using an appropriate discount rate. The financial CBA is conducted in current prices (with the assumption that the SA inflation rate over the longer period will be less than 6%) and a real yield on capital of 5% giving a discount rate of 11% per annum, reflecting the cost of capital. The economic CBA is done in constant prices and discounted by a social discount rate of 8% per annum.

The CBA methodology has been chosen to indicate whether the project in question is feasible or not. Within the framework, the estimated cost of the project is compared by means of a ratio (Benefit Cost Ratio) to the estimated benefits of the project. In order for a project to be considered financially and economically viable, this ratio must have a value greater than 1 in order to indicate that benefits outweigh costs.
Additional viability indicators provided are Net Present Value (NPV) and Internal Rate of Return (IRR). A more detailed discussion on the interpretation of each indicator is included in the results section of each of the two CBA components.

2.2.3 General Overview

The CBA clearly distinguishes between cost and benefit aspects of the project. The study was benchmarked on the reported Makathini ethanol-from-sugar processing facility as well as a similar project in Guyana, appraised by the United Nations.

Costs: Within the CBA framework, the costs related to the project can be separated into two distinct components:

- Capital Expenditure,
- Operational Expenditure

This breakdown mirrors that of the more widely-defined macro-economic impact, a discussion of which follows later herein.

Capital Expenditure includes:

- Civil works
- Equipment
- Vehicles
- Pre-operational Costs

Operational expenditure includes:

- Sugarcane processing
- Energy (Steam and Electricity)
- Chemicals
- Wages
- Maintenance
- Other Fixed Costs

It is important to note that the value of the sugarcane has been taken as its alternative usage for the production of sugar.

The benefits of the project are in the form of revenue generated from the sale of the ethanol.

2.2.4 Key Assumptions – Ethanol Fuel

In the analysis of the viability of the production of ethanol, the world crude oil price and the world sugar price are of cardinal importance. A discussion and the assumptions thereof are given below.

The financial viability of producing ethanol from sugarcane is largely determined by the world crude oil price and the world sugar price. Ethanol is part of the fuel basket of South Africa where the price of fuel is determined by landed import parity pricing of final fuel products, which is ultimately driven by the world price of crude oil, refining margins and logistic costs. Due to the fact that surplus sugar can either be exported or domestically used as a raw material for the production of ethanol, the world sugar price is a determinant for the price of sugar that is used in the ethanol production process.

Globally it is acknowledged that the costs of the impact of carbon emissions and the mitigation thereof are not included in fuels produced and electricity generated from fossil fuels. As these costs are external to the fossil fuel based energy product, low carbon energies are at present not able to compete with fossil fuels. All countries with ethanol in the fuel mix provide support in the form of tax exemptions, incentives and subsidies. Brazil also claims that the cost of support for ethanol is less than the cost of supporting people who migrate from rural agriculture to urban low or non-income areas.

This study determines the viability of the ethanol industry in the base case scenario. No subsidies or any kind of government assistance are included in the analysis in the income stream of ethanol production. However, this does not exclude the possibility that the government cannot decide eventually to subsidise the industry should it feels there is merit for this due to other priority objectives such as job creation and meeting South Africa's carbon emission reduction commitments. The South African fuel ethanol strategy has always been based on supporting ethanol production through additional measures such as up to 100% tax rebates. The level of support required is dependent on the combination of world sugar and oil prices.

As no new sugar mills is viable at supplying only to the world export market the greenfields ethanol mill will also not be viable at export market conditions without support.

The World Sugar Price

It should be noted that the world sugar price which are quoted in US dollars, fluctuate regularly. However, the Rand/US dollar exchange price has been deteriorating constantly over the years. This implies that, even should the world price of sugar decline significantly in future, the export price of sugar in rand terms will not decline at the same rate. Thus, the future S.A. export price of sugar will be cushioned by the exchange rate**.**

The World Crude Oil Price

It should be noted that the world sugar price which are quoted in US dollars, fluctuate regularly. However, the Rand/US dollar exchange price has been deteriorating constantly over the years. This implies that, even should the world price of sugar decline significantly in the near future, the export price of sugar in rand terms will not decline at the same rate. Thus, the future S.A. export price of sugar will be cushioned by the decline in the exchange rate.

An international crude oil price of $105 per barrel is used in this analysis in the base case scenario. This price is much higher than the historic price of a few years ago. However, on the other hand the price has also reached a high of $132 per barrel in July 2008. The oil price is currently very unstable and the consultant is of the view that for purposes of this analysis a price of the order of $105 per barrel, in constant terms, is a reasonable assumption.

The detailed assumptions for modelling the cost benefit analysis of ethanol production are as follows:

Ethanol Production Capacity ('000 Litres)	(1)	100 000
Analysis Period		20 Years
Construction Period		2 Years
Litres Ethanol Produced from 1 Ton Sugarcane (Litres)	(2)	85
Cost of Ethanol Processing Facility (R'000)		R 2 122 446
(2011 Prices) **Value of 1 Ton Sugarcane**	(3)	R272.90
World Sugar Price per ton	(4)	$0.225
Basic Fuel Price - Dec 2010 (RSA R/Litre Ethanol)	(5)	R 7.77
Production Costs/Litre Ethanol	(6)	R 4.78
Net Farm Gate Price - Cane/Litre Ethanol	(3)/(2)	R 3.21
Other Production Costs per Litre Ethanol		R 1.57
Rand/US Dollar exchange rate		R 8.25
Annual Ethanol Sales (R'000)	(1) X (5)	R 621 205
Actual Ethanol/Petrol Blend		80%
Annual Production Costs	(1) X (6)	R 478 123

Table 1: Assumptions on the Key Determinants of Ethanol Production

2.2.5 Results – Ethanol Fuel:

The results of the financial and economic CBA are depicted in the tables below.

Discount Rate	11.0%
Net Present Value (NPV) (R' millions)	R -485
Internal Rate of Return (IRR)	8.34%
Benefit Cost Ratio (BCR)	0.94

Table 2: Financial CBA Results Ethanol Base Case (R millions, Nominal Prices)

Discount Rate	8.0%
Net Present Value (NPV) (R'millions)	R -569
Internal Rate of Return (IRR)	4,1%
Benefit Cost Ratio (BCR)	0.90

Table 3: Economic CBA Results Ethanol Base Case (R millions, Economic Prices)

- The Net Present Value (NPV) of an investment compares the present value of the benefits from an investment with the present value of all costs. In order for a project to be considered viable, a positive NPV is required as this indicates that the overall benefits outweigh the overall costs of the project over time. The financial

NPV which includes inflation, indicates that the net benefit accrued is negative as there is a net loss of approximately R0.485 million in nominal prices expected from this project. The economic NPV which is performed at constant prices also indicates a negative value of R569 million in economic prices.

- The Benefit Cost Ratio (BCR) is a ratio of the present value of benefits relative to the present value of costs. A project should only be considered viable if the BCR is greater than 1. The financial BCR of 0.94 above indicates that for each Rand invested in the project there is an expected return of R0.94. The economic BCR shows a value of 0.90.
- The Internal Rate of Return (IRR) is the discount rate at which present values of both benefits and costs are equal. Projects should have an IRR greater than the discount rate to be considered viable. The IRR in nominal prices is 8,34% which is lower than the discount rate of 11%. The economic IRR is 4,1% is also lower than the social discount rate of 8%.

2.2.6 Sensitivity Analysis

A sensitivity analysis was done to determine the profitability of ethanol production with regard to changing world sugar prices and world crude oil prices. The sensitivity analysis was done by fixing one variable (world sugar price) and changing the price of the other variable (world crude oil price) and vice versa.

The analysis was done at an assumed world crude oil price of $105 per barrel and an assumed world sugar price of 22.5US cents per pound (10 July 2012), which for this analysis translates into $33.08 (R272.90) per ton of sugarcane. At a fixed world crude oil price of $105 per barrel, the results showed that the world sugar price should be in the region of 22US$ cents per pound before the production of ethanol from sugarcane can become a viable proposition. This means that the price of a ton of sugarcane should be around $33 (R266) for production of ethanol from sugarcane to break even. Currently the world sugar price is in the order of 19.44 US cents per pound (19 September2012), which is well below the 22US$ cents above.

The sugarcane price linked to the export sugar is around 67% of the sugar base case future scenario which is below the operating cost of growers as used in section 4. The growers share is based on the RV value, which includes both export and domestic sales. This ethanol base case scenario is the same as the “Scenario 1: Domestic Prices equal Export Prices” of section 4 which is not viable for either grower or miller (at depreciated capital cost). A new greenfields mill will thus not be viable enough to establish sugarcane growers and sugarcane supply should the price of sugarcane stabilise at such a price.

The results of changes to NPV due to changes in the world sugar price are given in the figure below.

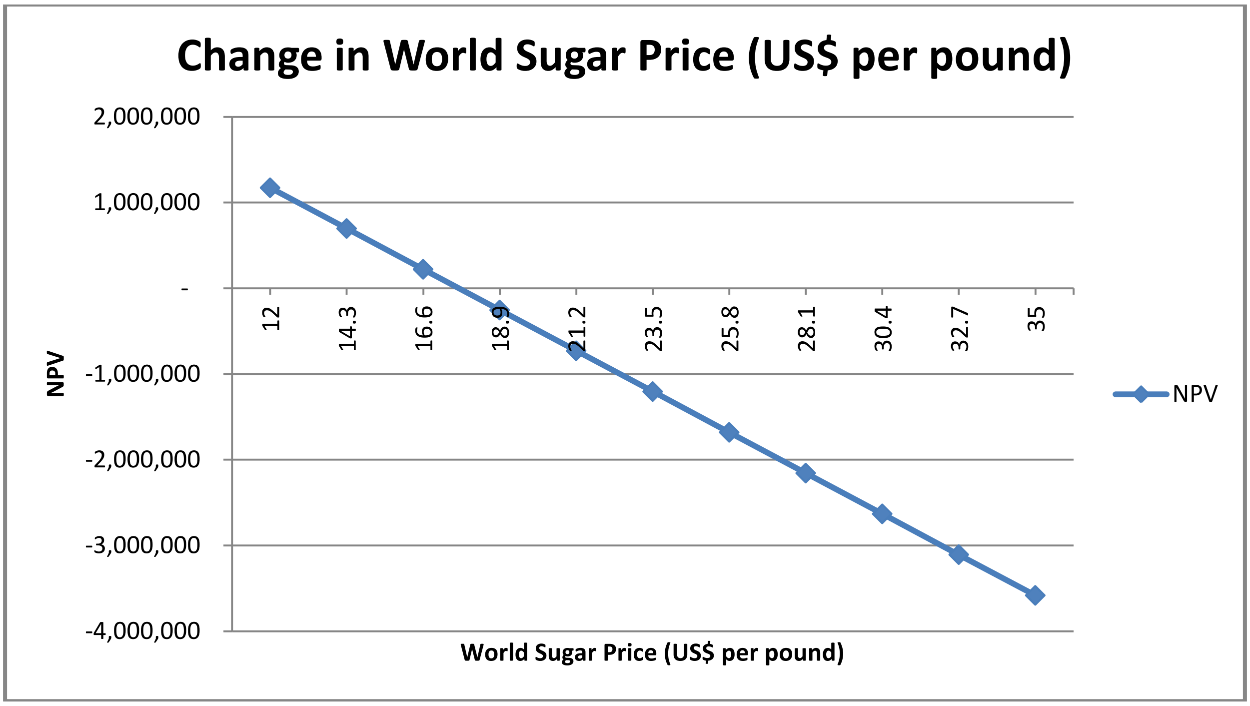

Figure 1: Sensitivity of NPV (Financial CBA) to Changes in World Sugar Price (US$ per pound) at an oil price of 105 $/bbl

On the other hand, the analysis shows that the production of ethanol from sugar can become viable at a world crude oil price of around $120 per barrel, assuming a fixed world sugar price of 22.5US$ cents per pound (current price, 10 July 2012). Currently the world crude oil is just above $112 per barrel (19 September 2012), which is below the breakeven price level of $120 per barrel. This is to say that at world sugar price of 22.5US$ cents per pound and the world crude oil of $120, the production of ethanol from sugar could become a profitable venture. Similarly, the sustainability of the higher world crude oil price is not certain, considering that the average world crude oil price in 2010 was $71.21 in nominal prices. The results in the figure below show changes in NPV values as world crude oil price changes.

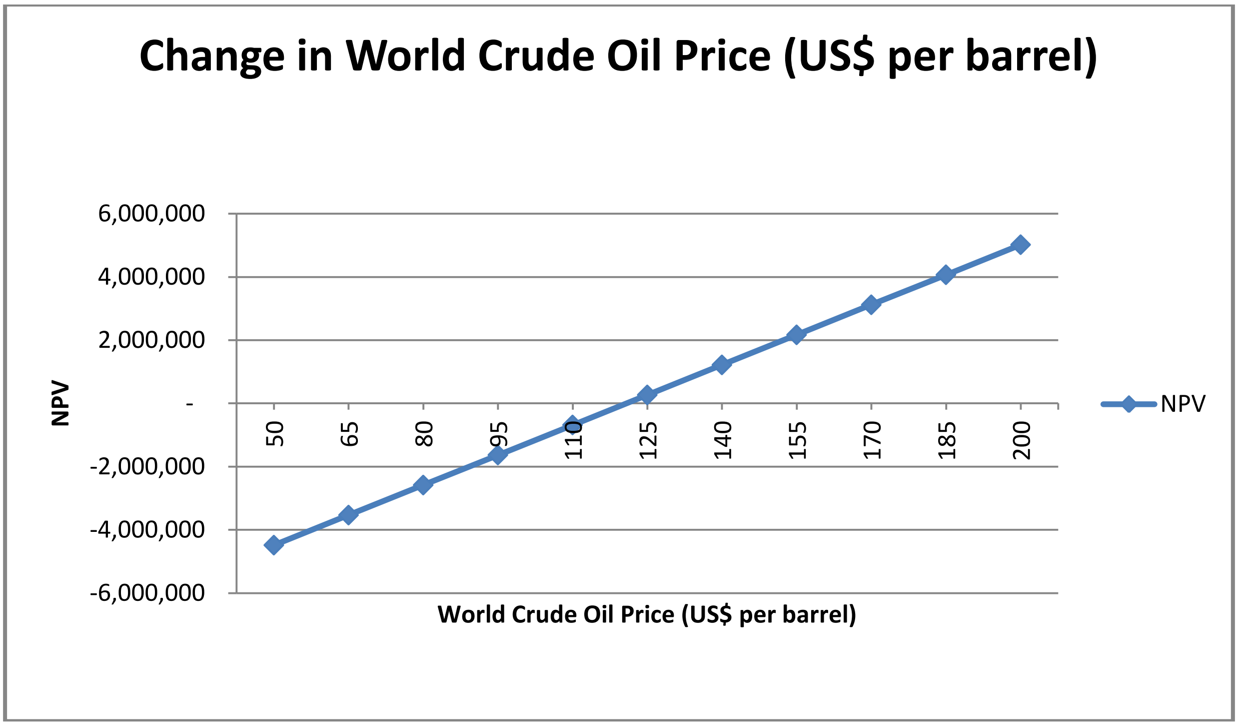

Figure 2: Sensitivity of NPV (Financial CBA) to Changes in World Crude Oil Price (US$ per barrel) at an sugar price of 22.5 c/lb

2.3 Macro-Economic Impact of the Production of Ethanol

2.3.1 Objective

The objective of this section is to present the combined macro and socio-economic impacts that emanates from the capital investment in producing Ethanol from Sugar Cane. The Cost Benefit Analysis (CBA) preceded the macro-economic impact analysis and the information requirements for the CBA will serve as a major data source needed (See Section 2.2.4) to initiate the macroeconomic modeling system that quantifies the impacts.

As is the case with the Cost Benefit Analysis, the proposed Makathini ethanol-from-sugar processing facility was used for the macro-economic modeling, where use will be made of the sugar cane from new and additional planting areas. The plant is calculated to cost R1.7 billion (2009 prices) and will be able to produce about 100 million litres of ethanol per year.

The macro-economic impact analysis is conducted at a national and provincial level. However the main focus of the analysis is the RSA national economy. The impact analysis is based on the contribution that the project is expected to make towards the national and provincial economies in terms of the following macro-economic aggregates:

- Gross Domestic Product (Economic Growth),
- Employment Creation,
- Capital Utilisation (Investment), and
- Household Income (Poverty Alleviation in terms of Low Income Households).

The macro-economic impact analysis was so structured to reflect the average annual production output over the project period of 20 years. Furthermore these macro-economic impacts also reflect the ultimate or total outcome, i.e. through the direct, indirect and induced linkages of the project.

2.3.2 Methodology

2.3.2.1 Overview of the Macro-Economic Impact Analysis

As indicated previously in the report, the main purpose of this section of the study is to estimate the impact of producing ethanol from sugar cane, which is seen as a possible alternative use for sugar cane, on the South African economy as well as the KwaZulu-Natal provincial economy.

For purposes of the impact analysis Conningarth Economists has compiled and updated Social Accounting Matrixes (SAMs) for the South African and KwaZulu-Natal economies which formed the basis of the impact model – *viz* – a general equilibrium model. This model will quantify the direct, indirect and induced impacts over time.

The compilation of the updated South African and KwaZulu-Natal SAMs were part of a major initiative by the Development Bank of Southern Africa (DBSA), Department of Provincial and Local Government (DPLG), StatsSA and the South African Reserve Bank (SARB) to compile nine comparable provincial SAMs that have all been updated to 2006 prices and have been benchmarked with the new South African SAM of 2006. The KwaZulu-Natal SAM was finalized in October 2009, and was overseen by an expert group of people from the KwaZulu-Natal Province, chaired by the KwaZulu-Natal Economic Development Department.

The benchmarking exercise was necessary to ensure that all control totals add up to the National Account figures as reflected in the SARB Quarterly Bulletin – June 2008 and the relevant figures reflected in the StatsSA publications, especially P0144 that reflects the 2006 Supply and Use Matrix.

The provincial SAMs compiled by Conningarth Economists were converted into user-friendly macro-economic impact models which can be used by each province to calculate the economic impact of "interventions" by way of programmes and projects on the economy of a relevant province.

The model makes use of Excel spreadsheets and is driven by a set of "Macros" which are used to eliminate the need to repeat the steps in a simple task over and over. For a specific project or say a policy intervention, the model provides the size of the macro-economic impacts, the values of which are then used to calculate key economic performance or efficiency indicators at national and provincial government level. Such key macro-economic performance indicators can be produced for both the construction and operational phases of a specific project.

It is also important to highlight the fact that the macro-economic impact model is robust enough to cater for varying degrees of input data qualities and availability. For instance, if the impacts are required at local government level, the model lends itself well to adjusting relevant provincial coefficients to realistically portray the situation at lower levels.

2.3.2.2 The Social Accounting Matrix

In layman's terms a Social Accounting Matrix (SAM) also represents a mathematical matrix depicting the linkages that exist in financial terms between all the major role players in the economy, i.e. business sectors, households and government. It is very similar to the input/output table in the sense that it also reflects the inter-sectoral linkages that are present in an economy. The development of the SAM also provides a logical framework within the context of the National Accounts in which the activities of especially households are accentuated and distinguished prominently. The households are indeed the basic economic unit where significant decisions are taken affecting economic variables, such as consumption expenditure and personal saving. By combining households into homogenic groups in the SAM, makes it possible to study how the economic welfare of these groups is affected by changes in the economy.

To sum up the SAM serves a dual purpose. Firstly, it is a reflection of the magnitude of financial linkages that exist between the major stakeholders in an economy, and secondly, it becomes a powerful econometric tool that can be used to conduct various economic analyses such as calculating the impact of investment projects on the economy. A more detailed technical description of the SAM and its analytical attributes are provided in Appendix A.

By applying the general tenets of the general equilibrium economic model to the SAM structure, the so-called direct, indirect and induced effects emanating from the various levels of value adding at all levels i.e. primary (including mining), manufacturing, commercial services etc. are quantified.

The direct impact that occurs, for example, in the manufacturing industry is measured through changes in production/turnover, payment of remuneration to employees and profit generation. The indirect impacts refer to impacts on industries that provide inputs to the manufacturing industry and other backward linkages. The induced effect or income effect refers to a further round of economic activity that takes place in the economy because of additional consumer spending as a result of the additional salaries and wages that occur throughout the economy. The impact analysis will be based on the standard economic aggregates. A brief overview of the definitions of each of these aggregates is given in Appendix B.

2.3.3 Data Sources and Assumptions

Modelling the total macro-economic impact of the construction and operational phases of a development project requires certain detailed information regarding the two phases of the project.

When evaluating the construction and operational phases the model required information on the production of ethanol from sugarcane such as costs of buildings, machinery and equipment, etc. This type of data as well as the planned outputs of the production of ethanol from sugarcane, etc. is discussed in detail in section 2.2.4. Examples of the type of inputs the model requires are given in Appendix C.

2.3.4 Macro-economic Impact Results

2.3.4.1 Summary of Results on the South African and KwaZulu-Natal Economy

The macro-economic impact assessments contained in this study covered the average annual totals for the period 2010 to 2021.

RSA National Economy	Direct Impact	Indirect Impact	Induced Impact	Total Impact
Impact on GDP (R millions)	56	675	497	1,228
Impact on Capital Formation (R millions)	2,167	936	919	4,022
Impact on Employment [numbers]:	869	5,479	2,536	8,884
Impact on Households:				818
Low Income Households (R millions)				152
Medium Income Households (R millions)				176
High Income Households (R millions)				491

Table 4: Macro-Economic Impact of the Production of Ethanol from Sugar Cane on the South African Economy (2010 prices).

KwaZulu-Natal Economy	Direct Impact	Indirect Impact	Induced Impact	Total Impact
Impact on GDP (R millions)	51	574	182	808
Impact on Capital Formation (R millions)	2,160	787	412	3,359
Impact on Employment [numbers]:	850	5,425	1,379	7,655
Impact on Households:				440
Low Income Households (R millions)				88
Medium Income Households (R millions)				113
High Income Households (R millions)				240

Table 5: Macro-Economic Impact of the Production of Ethanol from Sugar Cane on the KwaZulu-Natal Economy (2010 prices).

2.3.4.2 Impact on GDP

GDP is a good indicator of economic growth and welfare as it represents, among other criteria, remuneration of employees and gross operating surplus (profits) as components of value added at all the levels of the economy.

According to the above tables, the total impact on RSA's GDP, is estimated to amount to approximately R1 228 million (in constant, 2010 prices), of which the direct impact is estimated at R56 million. The total GDP production of ethanol from sugarcane comprises 0.06% of the national GDP. The total impact on KwaZulu-Natal's GDP is estimated at R808 million (in constant, 2010 prices), of which the direct impact is estimated at R51 million.

One can already assume from these figures that the ultimate benefit of the bulk of salaries and wages paid out, directly and indirectly, in the course of constructing and operating the project will not only accrue within KwaZulu-Natal, but will filter through to the other provinces in SA.

2.3.4.3 Impact on Capital Formation

Productive capital assets are required to support or generate any given amount of economic activity (i.e. GDP). These capital assets, together with labour and entrepreneurship, form the core productive factors needed for production. Obviously the effectiveness and efficiency with which these factors are combined will determine the overall level of productivity and profitability of such assets. The former will in turn depend on a whole array of factors, of which the appropriate technology and skills content of the labour force are important. The above tables indicate the following:

The overall capital stock that need to be employed (utilised) nationally to sustain this project, amounts to R4 022 million, of which, R2 167 million is attributed directly from the production of ethanol from sugar cane. The provincial capital stock that is required to be employed in order to sustain this project provincially amounts to R3 359 million.

2.3.4.4 Impact on Employment Creation

Labour input is a key element of the production process. It is one of the main production factors in any economy and employment levels are indicators of the extent that labour is effectively absorbed in the economy. This study will determine the number of new employment opportunities that will be created through the impact of the construction and operation of the production of ethanol from sugar cane on an average annual basis.

The total impact on employment creation amounts to 8 884 employment opportunities which will be sustained nationally and 7 655 employment opportunities created and sustained provincially.

2.3.4.5 Impact on Households

One of the crucial aspects of any macro-economic assessment is determining the personal income distribution characteristics thereof, especially with regard to how low income households will be impacted. In this section the extent to which low-income households will be positively affected by the spin offs created by the production of ethanol from sugarcane.

The impact on low-income households is presented in the above tables. From this table it is evident that the total impact nationally on low-income households will be R152 million per annum which translates to 18.6% of total household income.

2.3.4.6 Macro-Economic Impact in terms of the two (2) main elements

The table below identifies the macro-economic impact in terms of GDP and employment of main elements Ethanol & Sugarcane independently over the national and provincial economies.

Area of Jurisdiction	Economic Aggregate	Ethanol Element	Sugar Cane Element	Total
RSA National Economy	Impact on Gross Domestic Product (GDP) [R millions]	664	564	1,228
	Impact on employment [Numbers]	4,367	4,517	8,884
KwaZulu Natal Provincial Economy	Impact on Gross Domestic Product (GDP) [R millions]	359	448	808
	Impact on employment [Numbers]	3,586	4,069	7,655

Table 6: Macro-Economic Impact in terms of GDP and Employment Linked to Area of Jurisdiction and Element Specific (2010 prices).

It is evident from the table above that the major contributor to GDP and employment is the sugarcane element. Sugarcane is expected to contribute on a national level, R564 million towards GDP as well as create and sustain 4 517 employment opportunities. This makes sense as sugarcane is the primary raw material used as input into the production of ethanol and sugar cane farming is also particularly labour intensive.

2.3.4.7 Impact Comparisons between Provinces (Provincial Impacts)

As already explained the project in total during construction and operation make use of various inputs directly and indirectly such as water, electricity, machinery and equipment, electrical machinery, etc. Even products and services consumed by employees involved in these processes in one way or another can be regarded as inputs. Some of these inputs will be sourced from within the KwaZulu-Natal Province; however several of these inputs will have to be sourced from outside of the KwaZulu-Natal Province. The last mentioned will prompt economic activity in various other provinces of South Africa.

The table below contains estimates of the impacts that the production of ethanol from sugar cane will have on the various provinces through their backward linkages.

	Impact on Gross Domestic Product [R millions, 2010 Prices]	% of GDP	Impact on Labour [Numbers]	% of Labour
Eastern Cape	R 49.5	4.0%	174	2.0%
Free State	R 46.9	3.8%	164	1.8%
Gauteng	R 220.4	17.9%	556	6.3%
KwaZulu-Natal	-	0.0%	-	0.0%
Limpopo	R 24.3	2.0%	74	0.8%
Mpumalanga	R 35.5	2.9%	118	1.3%
Northern Cape	R 19.3	1.6%	66	0.7%
North West	R 11.4	0.9%	40	0.4%
Western Cape	R 13.1	1.1%	37	0.4%
Total excl. KwaZulu-Natal Province	R 420.3		1,229	
KwaZulu-Natal Province Impact	R 807.8	65.8%	7,655	86.2%
National Impact	R 1,228		8,884	
% Impact on KwaZulu-Natal Province	65.8%		86.2%	

Table 7: Provincial Impacts from the Production of Ethanol from Sugar Cane (2010 prices).

The above table indicates that with regard to the total economic impact on the rest of South Africa, KwaZulu-Natal will draw the largest portion, followed by Gauteng. The provincial impacts were obtained by making use of a so-called gravity model using a commodity basis with regard to the intermediate demand for products and services. A gravity model is based on two variables, namely size of a project as well as the distance between the origin of the product demand, and the nearest possible supplier of the product.

2.3.4.8 Efficiency Levels of the Production of Ethanol from Sugarcane

In order to provide some indication of the efficiency with which the production of ethanol from sugar cane employs scarce productive sources, the table below provides a number of criteria that can be used to compare the efficiency of its investment with the same amount of money in other economic sectors. The particular efficiency ratios used are:

- A GDP/Capital ratio, which measures the additional GDP that could be, generated from the investment of R1 million in capital in the various sectors.
- A Labour/Capital ratio, which measures the number of additional employment opportunities that can be created from the investment of R1 million in capital in the various sectors.
- A Low Income Households/Total Household ratio, which measures the proportion of total income flowing to all households that will accrue to low income households.

The data in the following table indicates that a unit of investment in the production of ethanol from sugar cane is slightly less efficiently utilized than the average for the total economy, as far as GDP and labour is concerned, but much higher in terms of household income. For low income households it provides a percentage of 18.6 for the production of ethanol from sugar cane compared to 16.2% for the entire South African economy. When compared to manufacturing in general, it also compares favourably.

	GDP/Capital Ratio	Labour/Capital Ratio	Low Income Households/Total Household Ratio
Total Production of Ethanol Impact on South Africa	0.31	2.21	18.6%
Impact in the event that a similar amount, as invested in the production of ethanol, is invested in the main sectors			
Agriculture, Hunting, Forestry and Fishing	0.43	4.54	17.4%
Mining and Quarrying	0.45	2.18	18.7%
Manufacturing	0.47	2.88	16.7%
Electricity, Gas and Water	0.24	1.13	16.7%
Construction	0.59	5.99	17.5%
Wholesale and Retail Trade	0.57	4.52	16.7%
Transport, Storage and Communication	0.35	1.95	16.6%
Financial, Insurance, Real Estate and Business Services	0.44	2.24	15.2%
Community, Social and Personal Services	0.78	4.45	14.9%
Total RSA Economy	0.45	2.94	16.2%

Table 8: Efficiency of the Impact of the Production of Ethanol from Sugar Cane on the National Economy in terms of Capital Utilization and Poverty Alleviation

2.4 Conclusion

Measured in terms of the above evaluation criteria, it is evident that production of ethanol from sugarcane is not currently financially and economically viable without support. However, it seems that the production of ethanol from sugar could be viable at relatively high world crude oil prices.

With regard to the macroeconomic impact, the ethanol plant could increase the RSA GDP by over R1.2 billion per annum and create about 8 884 job opportunities in the RSA national economy, of which 7 655 will be in the KwaZulu Natal economy. It is important to note that over 4 000 jobs of the total number of jobs are created in the growing of the sugarcane. If it is only a diversion of sugarcane from the production of sugar to ethanol then this 4 000 jobs cannot be seen as additional jobs since they already exist, provided the sugar industry is at full capacity. This is, however, not the case.

3 GENERATION OF ELECTRICITY FROM SUGARCANE BAGASSE

3.1 Introduction

The NERSA Consultation Paper on Generation Regulatory Rules and Feed-In Tariffs of 19 January 2011[2] mentions that Generation is the simultaneous generation of electricity and

[2] Cogeneration Regulatory Rules and Feed-In Tariffs; NERSA; Jan 2011

useful thermal energy from a common fuel/energy source. In the South African context, generation also refers to the production of electricity and useful heat from a fuel/energy source which is biomass, industrial waste and Combined Heat and Power [Ministerial determination 19 December 2012]. It differs from conventional generation in that it is coupled to an industrial process of the host plant. The following technologies have been considered under the three types of eligible generation projects under Generation Feed-In Tariff (Cofit):

- TYPE I Technologies: Waste Heat
- TYPE II Technologies: Coal
- TYPE III Technologies: Renewable (Sugar Cane Bagasse and Paper and Forestry)

This report did not consider electricity generation from bagasse which is a fibrous residue left after the juice-fibre separation stage in the sugar milling process that can be used to generate steam from a high efficiency, high pressure boiler. The steam is expanded either in a back pressure or condensing extraction turbo generator to generate power and steam from proven technologies. Some of the steam is used for processes within the milling plant (drying and crystallization). The calorific value is inversely proportional to the moisture content and the bagasse is utilised during the period when the harvesting and milling of the sugar cane is done, typically a seven to eight month period in South Africa. Bagasse can be stored up to one year if its moisture content is less than 30 per cent and thus generation during the intercrop period (between harvests) can continue. The use of coal is limited to start-up periods when the harvesting and milling resumes.

However, as the NERSA paper is only of a consulting nature at present, the values as reflected in the paper were not used in this report. This report sets the bagasse fuel value at 0.30 R/kWh.

Electrical energy can be generated from this bagasse in a typical conventional boiler and turbine alternator configuration as used in the South African sugar industry in the sugar mills were electricity is mostly generated for own use. Thus, the sugar industry is not yet engaged in generation in any significant way for selling it to Eskom. The current generation facilities installed efficiency is based on matching the fuel supply with the demand for energy at the lowest capital cost. By improving efficiency of both the power station and the sugar mill as much as four to five times more electricity can be generated from the same bagasse.

In a current conventional sugar factory roughly 15MW of electricity is generated using bagasse and burning it at 230 tons/hour exhaust steam, the boilers operate at 32 bar. Industry models indicate that by raising the pressure in the boilers to 105 bar the electricity generated can be increased to 50MW. Allowing for the 15 MW for internal use it leaves a residue of 35 MW that can be contributed to the national grid. The efficiency issue in this case is that the exhaust steam remains at 230 tons/hour. The cost element is the capital needed to improve or replace the boilers that they can operate at the higher pressure levels. Without discussing the technical issues it appears to be possible to bring the exhaust steam levels down to 115 tons/hour and increase the output to the grid to 65 MW.

At present, the average electrical power generated in the South African sugar industry is approximately 30 kWh/ton of cane. For example, a cane crop of 21 million tons, results in a total electrical energy of 630 GWh with present capacity and efficiency levels. Most of this energy is used within the industry itself and very little is exported to the grid.

Sugar industries around the world are in the process of increasing their electricity generating capacity in excess of their own requirements for the purpose of generation. The conventional steam power plant is, however, incapable of increasing electricity-generating rates much beyond 120 kWh/ton of cane; therefore, new technologies are being explored.

The most promising of these new technologies is the Biomass Integrated Gasification/Combined Cycle (BIG/CC). This technology is based on the gasification of bagasse to form a combustible gas that can be used in a gas cycle on top of the steam cycle currently employed. The projected yield of this combined cycle is in excess of 200 kWh/ton of cane. When the "trash" and the "tops" of the sugarcane (which are currently being removed on the farm and not delivered to the mills) are included, the yield could even be as high as 460 kWh/ton of cane.

The need for additional fuel (mostly coal) for generation varies from factory to factory and from time to time. It depends mainly on factory and process design, the steadiness of operation and the fibre content of the cane. Most sugar factories are designed to burn all of the bagasse so as to avoid the need for a costly bagasse disposal system. Others are fitted with a back-end refinery (5 mills) or are exporting bagasse (5 mills) and burning significant amounts of coal. At present only three mills are doing a little generation.

3.2 Strategy and Policy Level Considerations

In April 2011 SASA responded to the Department of Energy on its Integrated Resource Plan for 2010-2030 (IRP), and requested an urgent meeting with the Minister, Ms E. Peters, to determine the way forward to enable the implementation of renewable generation of electricity from sugarcane fibre at a fair cost both to the industry and the consumer. The salient aspects to discuss with the Minister included the following:

- The sugar industry urgently needs consideration and support of the Minister with regard to the negative consequences of the IRP 2010-2030.
- Concern that the submission by SASA for 1000MW of generation of electricity from 2010-2030 has been excluded.
- Generation's significant contribution to the limitation of carbon emissions.
- The generation feed in tariff (COFIT) being more cost effective than *inter alia* concentrated solar power (CSP).
- Consideration in the IRP of only the capital portion of the cost of energy generation technologies and not the opportunities that exist to reduce the cost of fuel in the tariff through improved efficiencies.
- Sugarcane bagasse based generation of electricity has the highest job intensity of all the various options available for renewable energy generation, which is a key imperative in all Government's strategic socio-economic directives.

Further outcome of these initiatives are still awaited from the Minister and are aimed at getting Government to include the sugar industry into biofuels production and generation of electricity from sugarcane.

3.3 Cost Benefit Analysis

3.3.1 General Overview

The sugarcane fibre, bagasse, is derived from sugarcane. The duration of the sugarcane harvest season is typically 8 months and stretches from April to December. Electricity supply is limited to the harvest period.

The sugarcane fibre content varies over the season. The day to day supply is impacted by weather and can for example be interrupted by rains. The year on year sugar cane supply also is variable due to seasonal weather patterns and risks related to agricultural production.

As is the case with other renewable energies the buyer needs to be obliged to purchase electricity when it is generated.
The energy (kWh) sold over a year will vary from season to season due sugarcane supply variability.

The CBA clearly distinguishes between the cost and benefit aspects of the project.
Within the CBA framework, the costs related to the project can be separated into three distinct components:

- Capital Expenditure and
- Operational Expenditure

This breakdown mirrors that of the more widely-defined macro-economic impact, a discussion, which follows later herein.

According to the Engineering News, sucrose extracted from sugar cane accounts for little more than 30% of the chemical energy stored in the mature plant, while 35% resides in the leaves and stem tips, which are left in the fields during harvest, and 35% in the fibrous material, called bagasse, which is left over from pressing. For purposes of the CBA of this study it was assumed that only the 35% in the fibrous material will be used for producing electricity.

To obtain an estimate of the magnitude of electricity that can be generated from sugarcane bagasse it was assumed that about 83% bagasse of sugarcane production can be used for the generation of electricity. The reason for deciding on 83% is because a percentage of bagasse is used for animal feed, alcohol and paper production. Currently about 18.6 million tons of sugarcane are crushed annually. The total fibrous material available for the production of electricity is therefore the 18.6 million tons of cane multiplied by 83%, multiplied by the 35% residue/bagasse. This is equal to 5,4 million tons of bagasse for the production of electricity.

In this analysis it was also assumed that Clean Development Mechanism (CDM) criteria will be applicable to this sugar bagasse energy source.

Capital Expenditure includes:

- Civil Construction
- Mechanical Machinery
- Electrical Machinery

In the following table the estimated capital costs are presented as used in the CBA, it is an estimation of the total need for the industry.

Activity	Amount Rand million
Civil Construction	R580
Mechanical Machinery	R3 645
Electrical Machinery	R133
Total	R4 358

Table 9: Estimated Capital Expenditure (2012 prices)

Operational Expenditure includes:

- Consumable Inputs
- Staff (Salaries)
- Maintenance Costs

In the following table the estimated operational expenditure are presented as used in the CBA, it is an estimation of the total need for the industry.

Activity	Amount Rand million
Consumable Inputs	R27
Staff (Salaries)	R5
Maintenance Cost	R84
Total	R116

Table 10: Estimated Annual Operational Expenditure (2012 prices)

3.3.2 Key Assumptions – Sugarcane Bagasse

The viability of generating electricity from sugarcane bagasse is determined by among other things, the price of bagasse which is the basic raw material for generation and the price (Feed-In-Tariff -FET) that the government is willing to pay for the electricity generated through sugar bagasse. The assumptions made in regard to each are explained below.

Price of Bagasse

Bagasse is a waste product of crushing cane. If there is no use for bagasse, then it has no cost to the system if it is used as an input in the co-generation of electricity, cane producers receive no direct income from bagasse, indirectly they benefit because of the savings in electricity costs. However, if bagasse is effectively used in the production process of sugar or other product, it has a value.

For purposes of this study, a percentage of, bagasse is seen as having an alternative use in the current production process at sugar mills and as such has a cost if it is used in the co-generation of electricity. It is important to note that this price should probably not be higher than the current price of electricity that the mills are paying. This is due to the fact that most of the bagasse is currently used by the mills for heating purposes and it will not be cost effective if the mill uses bagasse at a higher cost than buying electricity from outside. The current price that mills pay for electricity is in the region of R0.85 kWh. It is not clear what the opportunity cost of bagasse is at present and therefore for purposes of this study a price of R0.30 is used, which is almost equivalent to the cost of coal if the mills use coal instead of bagasse to produce electricity. This price is also in line with the price of R0.23 (adjusted to current prices) that was calculated in an earlier study: *Comprehensive Design of the South African Renewable Energy Sectoral Business Case, 2009.* Furthermore, apart from the opportunity cost of the bagasse, there are other costs involved in the co-generation process using bagasse.

Electricity price per kWh

The price at which the electricity produced from bagasse can be sold can greatly influence the viability of the project. If the price is too high, then Eskom might be deterred from buying electricity produced from co-generation and rather generate electricity through the use of coal fired power stations which are currently the cheapest way to produce electricity in South Africa. It seems that this cost is currently between R0.65 and R0.75 per kWh. The evaluation is based on 1.01 R/kWh in real terms. This is at the lower end of IRP 2010-2030 forecasted range and lower than the latest multi-year price determination (MYPD3) by ESKOM.

Economists are, however, of the opinion that this price does not take into account the total production costs, since it does not take into account the negative externalities that coal fired power stations have on the environment. The IPCC and McKinsey have estimated the cost of carbon mitigation and adaptation in order of 40 to 50 USD/ton or 50 Euro/ton carbon dioxide respectively. This translates to a 0.30 to 0.50 R/kWh. The carbon tax proposed by treasury is phased in starting with 0.12 and rising to 0.72 R/kWh. and forestry industry and none in sugarcane industry or biomass in general.

However, it could also be argued that for environmental purposes, the government is prepared to stimulate renewable energy sources by paying a higher price for electricity through generation. The current price paid for generation by ESKOM is between R0.90 and R1.25 which has led very few projects in the paper and forestry industry and none in the sugarcane industry or biomass in general.

The detailed assumptions for modelling the cost benefit analysis of generation from sugarcane bagasse are as follows:

Analysis Period		**20 Years**
Construction Period		2 Years
Average Cane Available for Generation (2010)		18.6 million tons
Average Bagasse vs. Cane	(1)	29%
Ton Bagasse /MWh	(2)	4.5
Cane/Bagasse	(3) = (20/(1)	15.52 tons
Power Generation	(4)	64.44/ton cane
Power Generation – 15.52 tons cane	(5) = (3) x (4)	1 000 kWh
Total Power Generated	(6) =18.6/(3)	1 198 666 667 kWh
Percentage exported	(7)	51%
Power Available for Export to Grid	(8) = (6) x (7)	610 367 067 kWh
Energy price per kWh	(9	R 1.01
CDM Credit for Renewable Energy / Ton Carbon	(10)	R 138.00

Table 11: Detailed assumptions for modelling the Cost-Benefit Analysis of Generation from Sugarcane Bagasse

3.3.3 Results – Sugarcane Bagasse Electricity Generation:

The financial and economic results of generation are presented in the tables below.

Discount Rate	11.0%
Net Present Value (NPV) (R'millions)	R1765
Internal Rate of Return (IRR)	15.2%
Benefit Cost Ratio (BCR)	1.31

Table 12: Financial CBA Results (R millions, Nominal Prices):

Discount Rate	8.0%
Net Present Value (NPV) (R'millions)	R536
Internal Rate of Return (IRR)	9.6%
Benefit Cost Ratio (BCR)	1.10

Table 13: Economic CBA Results (R millions, Economic Prices)

- The financial NPV above which includes inflation, indicates that the net benefit accrued is positive as there is a net surplus of approximately R 1 765 million in nominal prices expected from this project at a discount rate of 11%. The economic NPV which is performed at constant prices indicates a positive value of R536 million in economic prices at an 8% discount rate.
- The financial BCR of 1.31 above indicates that for each Rand invested in the project there is an expected return of R1.31. The economic BCR shows a value of 1.10.
- The financial IRR indicates a value of 15.2% and the economical IRR indicates a value of 9.6%.
- The NPV, BCR and IRR all confirm the financial and economic viability of generation of electricity from sugarcane bagasse and confirms the previous investment by sugar mills into the generation of electricity for own use.

3.4 Macro-Economic Impact of the Generation of Electricity from Sugarcane Bagasse

3.4.1 Objective

The objective of this section is to present the combined macro and socio-economic impacts that emanates from the capital investment in the Generation of Electricity from Sugarcane Bagasse. The Cost Benefit Analysis (CBA) preceded the macro-economic impact analysis and the information requirements for the CBA will serve as a major data source needed (See Section 3.2.2) to initiate the macroeconomic modelling system that quantifies the impacts.

The macro-economic impact analysis is conducted at a national and provincial level. However the main focus of the analysis is the RSA national economy. The impact analysis is based on the contribution that the project is expected to make towards the national and provincial economies in terms of the following macro-economic aggregates:

- Gross Domestic Product (Economic Growth),
- Employment Creation,
- Capital Utilisation (Investment), and
- Household Income (Poverty Alleviation in terms of Low Income Households).

The macro-economic impact analysis was so structured to reflect the average annual production output over the project period of 20 years. Furthermore these macro-economic impacts also reflect the ultimate or total outcome, i.e. through the direct, indirect and induced linkages of the project.

3.4.2 Methodology

3.4.2.1 Overview of the Macro-Economic Impact Analysis

As indicated previously in the report, the main purpose of this section of the study is to estimate the impact of the generation of electricity from sugarcane bagasse, which is seen as a possible alternative use for sugarcane bagasse, on the South African economy as well as the KwaZulu-Natal provincial economy.

For purposes of the impact analysis Conningarth Economists has compiled and updated Social Accounting Matrixes (SAMs) for the South African and KwaZulu-Natal economies which formed the basis of the impact model – *viz* – a general equilibrium model. This model will quantify the direct, indirect and induced impacts over time.

The compilation of the updated South African and KwaZulu-Natal SAMs were part of a major initiative by the Development Bank of Southern Africa (DBSA), Department of Provincial and Local Government (DPLG), StatsSA and the South African Reserve Bank (SARB) to compile nine comparable provincial SAMs that have all been updated to 2006 prices and have been benchmarked with the new South African SAM of 2006. The KwaZulu-Natal SAM was finalized in October 2009, and was overseen by an expert group of people from the KwaZulu-Natal Province, chaired by the KwaZulu-Natal Economic Development Department.

The benchmarking exercise was necessary to ensure that all control totals add up to the National Account figures as reflected in the SARB Quarterly Bulletin – June 2008 and the relevant figures reflected in the StatsSA publications, especially P0144 that reflects the 2006 Supply and Use Matrix.

The provincial SAMs compiled by Conningarth Economists were converted into user-friendly macro-economic impact models which can be used by each province to calculate the economic impact of “interventions” by way of programmes and projects on the economy of a relevant province.

The model makes use of Excel spreadsheets and is driven by a set of “Macros” which are used to eliminate the need to repeat the steps in a simple task over and over. For a specific project or say a policy intervention, the model provides the size of the macro-economic impacts, the values of which are then also used to calculate key economic performance or efficiency indicators at national and provincial government level. Such key macro-economic performance indicators can be produced for both the construction and operational phases of a specific project.

It is also important to highlight the fact that the macro-economic impact model is robust enough to cater for varying degrees of input data qualities and availability. For instance, if the impacts are required at local government level, the model lends itself well to adjusting relevant provincial coefficients to realistically portray the situation at lower levels.

3.4.2.2 The Social Accounting Matrix

In layman's terms a Social Accounting Matrix (SAM) also represents a mathematical matrix depicting the linkages that exist in financial terms between all the major role players in the economy, i.e. business sectors, households and government. It is very similar to the input/output table in the sense that it also reflects the inter-sectoral linkages that are present in an economy. The development of the SAM also provides a logical framework within the context of the National Accounts in which the activities of especially households are accentuated and distinguished prominently. The households are indeed the basic economic unit where significant decisions are taken affecting economic variables, such as consumption expenditure and personal saving. By combining households into homogenic groups in the SAM, makes it possible to study how the economic welfare of these groups is affected by changes in the economy.

To sum up the SAM serves a dual purpose. Firstly, it is a reflection of the magnitude of financial linkages that exist between the major stakeholders in an economy, and secondly, it becomes a powerful econometric tool that can be used to conduct various economic analyses such as calculating the impact of investment projects on the economy. A more detailed technical description of the SAM and its analytical attributes are provided in Appendix A.

By applying the general tenets of the general equilibrium economic model to the SAM structure, the so-called direct, indirect and induced effects emanating from the various levels of value adding at all levels i.e. primary (including mining), manufacturing, commercial services etc. are quantified.

The direct impact that occurs, for example, in the electricity industry is measured through changes in production/turnover, payment of remuneration to employees and profit generation. The indirect impacts refer to impacts on industries that provide inputs to the electricity industry and other backward linkages. The induced effect or income effect refers to a further round of economic activity that takes place in the economy because of additional consumer spending as a result of the additional salaries and wages that occur throughout the economy. The impact analysis will be based on the standard economic aggregates. A brief overview of the definitions of each of these aggregates is given in Appendix B.

3.4.3 Data Sources and Assumptions

Modelling the total macro-economic impact of the construction and operational phases of a development project requires certain detailed information regarding the two phases of the project.

When evaluating the construction and operational phases the model required information on the generation of electricity from sugarcane bagasse such as costs of buildings, machinery and equipment, etc. This type of data as well as the planned outputs of the generation of electricity from sugarcane bagasse, etc. is discussed in detail in section 3.2.2. Examples of the type of inputs the model requires are given in Appendix C.

3.4.4 Macro-economic Impact Results

3.4.4.1 Summary of Results on the South African and KwaZulu-Natal Economies

The macro-economic impact assessments contained in this study covered the average annual totals for the period 2010 to 2021.

RSA National Economy	Direct Impact	Indirect Impact	Induced Impact	Total Impact
Impact on GDP (R millions)	836	75	454	1,366
Impact on Capital Formation (R millions)	2,264	152	842	3,258
Impact on Employment [numbers]:	931	396	2,316	3,643
Impact on Households:				747
Low Income Households (R millions)				135
Medium Income Households (R millions)				152
High Income Households (R millions)				460

Table 14: Macro-Economic Impact of the Generation of Electricity from Sugar Bagasse on the South African Economy (2010 prices).

KwaZulu-Natal Economy	Direct Impact	Indirect Impact	Induced Impact	Total Impact
Impact on GDP (R millions)	836	51	158	1,045
Impact on Capital Formation (R millions)	2,263	123	362	2,749
Impact on Employment [numbers]:	931	369	1,184	2,483
Impact on Households:				390
Low Income Households (R millions)				49
Medium Income Households (R millions)				90
High Income Households (R millions)				252

Table 15: Macro-Economic Impact of the Generation of Electricity from Sugar Bagasse on the KwaZulu-Natal Economy (2010 prices).

3.4.4.2 Impact on GDP

GDP is a good indicator of economic growth and welfare as it represents, among other criteria, remuneration of employees and gross operating surplus (profits) as components of value added at all the levels of the economy.

According to the above tables, the total impact on RSA's GDP, is estimated to amount to approximately R1 366 million (in constant, 2010 prices), of which the direct impact is estimated at R836 million. The total GDP of the generation of electricity from sugar bagasse comprises 0.045% of the national GDP. The total impact on KwaZulu-Natal's GDP is estimated at R1 045 million (in constant, 2010 prices), of which the direct impact is estimated at R836 million.

One can already assume from these figures that the ultimate benefit of the bulk of salaries and wages paid out, directly and indirectly, in the course of constructing and operating the project will not only accrue within KwaZulu-Natal, but will filter through to the other provinces in SA.

3.4.4.3 Impact on Capital Formation

Productive capital assets are required to support or generate any given amount of economic activity (i.e. GDP). These capital assets, together with labour and entrepreneurship, form the core productive factors needed for production. Obviously the effectiveness and efficiency with which these factors are combined will determine the overall level of productivity and profitability of such assets. The former will in turn depend on a whole array of factors, of which the appropriate technology and skills content of the labour force are important. The above tables indicate the following:

The overall capital stock that need to be employed (utilised) nationally to sustain this project, amounts to R3 258 million, of which, R2 264 million is attributed directly from the generation of electricity from sugarcane bagasse. The capital stock that is required to be employed in order to sustain this project provincially amounts to R2 749 million.

3.4.4.4 Impact on Employment Creation

Labour input is a key element of the production process. It is one of the main production factors in any economy and employment levels are indicators of the extent that labour is effectively absorbed in the economy. This study will determine the number of new employment opportunities that will be created through the impact of the construction and operation of the generation of electricity from sugar bagasse on an average annual basis.

The total impact on employment creation amounts to 3 643 employment opportunities which will be sustained nationally and 2 483 employment opportunities created and sustained provincially.

3.4.4.5 Impact on Households

One of the crucial aspects of any macro-economic assessment is determining the personal income distribution characteristics thereof, especially with regard to how low income households will be impacted. In this section the extent to which low-income households will be positively affected by the spin offs created by the generation of electricity from sugar bagasse.

The impact on low-income households is presented in the above tables. From these tables it is evident that the total impact nationally on low-income households will be R135 million per annum which translates to 21% of total household income.

3.4.4.6 Impact Comparisons between Provinces (Provincial Impacts)

As already explained the project in total during construction and operation make use of various inputs directly and indirectly such as water, electricity, machinery and equipment, electrical machinery, etc. Even products and services consumed by employees involved in these processes in one way or another can be regarded as inputs. Some of these inputs will be sourced from within the KwaZulu-Natal Province; however several of these inputs will have to be sourced from outside of the KwaZulu-Natal Province. The last mentioned will prompt economic activity in various other provinces of South Africa.

The table below contains estimates of the impacts that the generation of electricity from sugar bagasse will have on the various provinces through their backward linkages.

	Impact on Gross Domestic Product [R millions, 2010 Prices]	% of GDP	Impact on Labour [Numbers]	% of Labour
Eastern Cape	R 37.6	2.8%	146	4.0%
Free State	R 36.8	2.7%	157	4.3%
Gauteng	R 167.7	12.3%	544	14.9%
KwaZulu-Natal	-	-	-	-
Limpopo	R 17.0	1.2%	62	1.7%
Mpumalanga	R 29.4	2.2%	121	3.3%
Northern Cape	R 13.9	1.0%	56	1.5%
North West	R 8.2	0.6%	36	1.0%
Western Cape	R 10.3	0.8%	38	1.0%
Total excl. KwaZulu-Natal Province	R 321.0		1,160	
KwaZulu-Natal Province Impact	R 1,044.7	76.5%	2,483	68.2%
National Impact	R 1,365.6		3,643	
% Impact on KwaZulu-Natal Province	76.5%		68.2%	

Table 16: Provincial Impacts from the Generation of Electricity from Sugar Bagasse (2010 prices).

The above table indicates that with regard to the total economic impact on the rest of South Africa, KwaZulu-Natal will draw the largest portion, followed by Gauteng. The provincial impacts were obtained by making use of a so-called gravity model using a commodity basis with regard to the intermediate demand for products and services. A gravity model is based on two variables, namely size of a project as well as the distance between the origin of the product demand, and the nearest possible supplier of the product.

3.4.4.7 Efficiency Levels of the Generation of Electricity from Sugar Bagasse

In order to provide some indication of the efficiency with which the generation of electricity from sugar bagasse employs scarce productive sources, the table below provides a number of criteria that can be used to compare the efficiency of its investment with the same amount of money in other economic sectors. The particular efficiency ratios used are:

- A GDP/Capital ratio, which measures the additional GDP that could be, generated from the investment of R1 million in capital in the various sectors.
- A Labour/Capital ratio, which measures the number of additional employment opportunities that can be created from the investment of R1 million in capital in the various sectors.
- A Low Income Households/Total Household ratio, which measures the proportion of total income flowing to all households that will accrue to low income households.

The data in the following table indicates that a unit of investment in the generation of electricity from sugar bagasse is less efficiently utilized than the average for the total economy, as far as GDP and labour is concerned, but much higher in terms of household income. For low income households it provides a percentage of 18.1 for the generation of electricity compared to 16.2% for the entire South African economy. When compared to electricity in general, it compares positively for GDP and low income households.

			Low Income
	GDP/Capital	Labour/ Capital	Households/ Total
	Ratio	Ratio	Household Ratio
Total Generation of Electricity Impact on South Africa	**0.42**	**1.12**	**18.1%**
Impact in the event that a similar amount, as invested in the production of ethanol, is invested in the main sectors			
Agriculture, Hunting, Forestry and Fishing	0.43	4.54	17.4%
Mining and Quarrying	0.45	2.18	18.7%
Manufacturing	0.47	2.88	16.7%
Electricity, Gas and Water	0.24	1.13	16.7%
Construction	0.59	5.99	17.5%
Wholesale and Retail Trade	0.57	4.52	16.7%
Transport, Storage and Communication	0.35	1.95	16.6%
Financial, Insurance, Real Estate and Business Services	0.44	2.24	15.2%
Community, Social and Personal Services	0.78	4.45	14.9%
Total RSA Economy	0.45	2.94	16.2%

Table 17: Efficiency of the Impact of the Generation of Electricity from Sugar Bagasse on the National Economy in terms of Capital Utilization and Poverty Alleviation

3.5 Conclusion

For purposes of this report, a CBA was applied in order to consider the viability of sugar bagasse as a source for power generation. The results of the analysis indicate that the production of electricity from sugarcane bagasse is viable and should be encouraged.

The macroeconomic impact analysis results show that the plant for generation of electricity from sugarcane bagasse could contribute to the economic growth of South Africa, KZN and the Lowveld. Through the direct and secondary impacts, generation of electricity could increase the RSA GDP by about R1.3 million per annum and create about 3 643 job opportunities in the RSA national economy, of which about 2 483 will be in the KwaZulu Natal economy.

4 APPENDICES

4.1 Appendix A: The Social Accounting Matrix (SAM)

A Social Accounting Matrix (SAM) is a comprehensive, economy-wide database, which contains information on the flow of resources that take place between the different economic agents that exist within an economy (i.e. business enterprises, households, government, etc) during a given period of time – usually one calendar year.

When economic agents in an economy are involved in transactions, financial resources change hands. The SAM provides a complete database of all transactions that take place between these agents in a given period, thereby presenting a "snapshot" of the structure of the economy for that time period. As a system for organising information, a SAM presents a powerful tool in terms of which the economy can be described in a complete and consistent way:

Complete in the sense that it provides a comprehensive accounting of all economic transactions for the entity being represented (i.e. country, region/province, city, etc.), and Consistent in that all incomes and expenditures are matched.

Consequently, a SAM can provide a unifying structure within which the statistical authorities can compile and present the national accounts.

Like the traditional Input-Output Table, the SAM reflects the inter-sectoral linkages in terms of sales and purchases of goods and services, as well as the remuneration of production factors that forms the essence of any economy's functioning. What is also of importance is that a SAM reflects the economic related activities of households in some detail. Households are responsible for decisions that have a direct and indirect effect on important economic variables such as private consumption expenditures and savings. These economic aggregates are important drivers of the economic growth processes and ultimately the creation of employment opportunities and wealth. Private consumption expenditure, for example, comprises approximately 60% of total gross final domestic spending in the economy. By combining households into meaningful categories, such as a range of income levels, the impact on these households' welfare of a changing economic environment is made possible by the SAM.

It is clear from the above that because of the intrinsic characteristics of the SAM, once compiled, it renders itself as a useful tool for analytical purposes. Especially, based on the mathematical traits of the matrix notations that describe its structure, a SAM can be transformed into a powerful econometric tool/model. For example, the model can be used to quantify the probable impact on the economy of a new infrastructural project such as a new power station – both the construction phase and the operational phase will be modelled.

Thus apart from serving as an extension to a country's National Accounts, the SAM in its model form opens up many opportunities for the economic analyst to conduct rigorous policy and other impact analyses for the purpose of ensuring optimal benefit to the stakeholders concerned.

4.1.1 Application(s) of the SAM

The development of the SAM is very significant as it provides a framework within the context of the International System of National Accounts (SNA) in which the activities of all economic agents are accentuated and prominently distinguished. By combining these agents into meaningful groups, the SAM makes it possible to clearly distinguish between groups, to research the effects of interaction between groups, and to measure the economic welfare of each group. There are two key reasons for compiling a SAM:

Firstly, a SAM provides a framework for organising information about the economic and social structure of a particular geographical entity (i.e. a country, region or province) for a particular time period (usually one calendar year), and

Secondly, to provide a database that can be used by any one of a number of different macro-economic modelling tools for evaluating the impact of different economic decisions and/or economic development programmes.

Because the SAM is a comprehensive, disaggregated, consistent, and complete data system of economic entities that captures the interdependence that exists within a socio-economic system, it can be used as a conceptual framework for exploring the impact of exogenous changes in such variables as exports, certain categories of government expenditure, and investment on the entire interdependent socio-economic system. The SAM, due to its finer disaggregation of private household expenditure into relatively homogenous socio-economic categories that are recognisable for policy purposes, has been used to explore issues related to income distribution.

The SAM's main contribution in the field of economic policy planning and impact analysis is divided into two categories:

4.1.2 As a Primary Source of Economic Information

As a detailed and integrated national and regional accounting framework consistent with officially published socio-economic data, a SAM instantly projects a picture of the nature of a country or region's economy. It lends itself to both descriptive and structural analysis.

4.1.3 As a Planning Tool

Due to its mathematical/statistical underpinnings it can be transformed into a macro-econometric model that can be used to:

- Conduct economic forecasting exercises/scenario building.
- Conduct economic impact analysis both for policy adjustments at a national and provincial level and for large project evaluation.
- Conduct self-sufficiency analysis i.e. gap analysis to determine, with the help of the inter industry and commodity flows contained in the provincial SAM, where possible investment opportunities exist, and

- Calculate the inflationary impacts on provincial level of price changes instigated at national level (i.e. administered prices, VAT, etc.).

To summarise, the SAM mechanism provides a universally acceptable framework within which the economic impact of development projects and policy adjustments can be reviewed and assessed at both national and provincial/regional levels. It serves as an extension to the official National Accounts of a country's economy and, therefore, provides a wealth of additional information, especially when disaggregated to more detailed levels.

4.2 Appendix B: Magnitude of Linkages

Formally, economists distinguish between direct, indirect and induced economic effects. Indirect and induced effects are sometimes collectively called secondary effects. The total economic impact is the sum of direct, indirect and induced effects within a region. Any of these impacts may be measured in terms of gross output or sales, income, employment or value added. The sectors utilised in this appendix are only for the purposes of providing examples.

4.2.1 Direct Impacts

The direct impacts refer to the effect of the activities that take place in the manufacturing and electricity industries. It refers to the income and expenditure that is associated with the everyday operation of each of the components of the relevant industry. For instance if the manufacturing and electricity component is taken as an example the direct impacts refer to the total production/turnover of the factory; the intermediate goods bought by the factory; the salaries and wages paid by the factory; the profits generated by the factory.

4.2.2 Indirect Impacts

The indirect impacts refer to economic activities that arise in the sectors that provide inputs to the mining and electricity industries' components and other backward linked industries. For example, if the electricity sector uses steel, the indirect impacts refer to the activity (paying of salaries and wages; and profit generation) that occurs in the steel sector as well as the sectors that provide materials to the steel sector.

4.2.3 Induced Impacts

Induced impacts refer, inter alia, to the economic impacts that result from the payment of salaries and wages to people who are (directly) employed at the various consecutive stages of beneficiation of the manufacturing and electricity industries. In additional the induced impact also includes the salaries and wages paid by businesses operating in the sectors indirectly linked to these industries through the supply of inputs. These additional salaries and wages lead to an increased demand for various consumable goods that need to be supplied by other sectors of the economy that then have to raise their productions in tandem with the demand for their products and services.

These induced impacts can then be expressed in terms of their contributions to GDP, employment creation and investment or other useful macro-economic variables. Added together, the direct, indirect and induced impacts provide the total impact that these industries will have on the South African and KwaZulu-Natal economies.

4.2.4 Definitions of Macro-Economic Aggregates

Impact analysis will be based on a number of standard economic parameters and the results will be presented under the following headings:

- Impact on Gross Domestic Product (GDP).
- Impact on Capital Utilisation.
- Impact on Employment Creation.
- Skilled labourers.
- Semi-skilled labourers.
- Unskilled labourers.
- Impact on Households Income (Income distribution).
- Impact on Balance of Payments, as a result of Imports and Exports.

The following is a brief overview of the definition of each of these economic parameters.

4.2.5 Impact on Gross Domestic Product (GDP)

The impact on GDP reflects the magnitude of the values added to the manufacturing and electricity industries from activities within the industry. Value added is made up of three elements, namely:

- Remuneration of employees,
- Gross operating surplus (which includes profit and depreciation), and
- Net indirect taxes

4.2.6 Impact on Capital Utilisation

For an economy to operate at a specific level of activity, investment in capital assets (i.e. buildings, machinery, equipment, etc.) is needed. Capital, together with labour and entrepreneurship, are the basic factors needed for production in an economy.

The effectiveness and efficiency with which these factors are combined influence the overall level of productivity/profitability processes, bearing in mind that productivity is affected by an array of factors of which appropriate technology and skill level of the labour force are two important elements.

4.2.7 Impact on Employment Creation

Labour is a key element of the production process. The study will determine the number of new employment opportunities that will be created by investment in the manufacturing and electricity industries. These employment opportunities will be broken down into those created directly by a particular project and those indirectly created and induced throughout the broader economy. Furthermore, a distinction can be made between skilled, semi-skilled and unskilled labourers.

4.2.8 Impact on Household Income

One of the elements of the additional value added (i.e. GDP) which will result from the proposed expansion is remuneration of employees, which, in turn, affects households income.

The SAM measures the magnitude of changes that will occur to both household income and spending/savings pattern. As such, the study will highlight the impact of the manufacturing and electricity industries on the low-income households as this can be used as an indicator of the extent to which the manufacturing and electricity industries contributed to poverty alleviation throughout the economy.

4.2.9 Impact on the Current Account of the Balance of Payments

The manufacturing and electricity industries will have direct, indirect and induced impacts on the exports and imports of goods and services that will take place across all of the various economic sectors that are affected by the manufacturing and electricity industries. Imports consist of direct and indirect material imports, as well as goods consumed by households that are imported as a result of the induced impact.

4.3 Appendix C: Input Data Required to Conduct the Macro-Economic Impact Analysis

Modelling the macro-economic impact of the construction and operational phases of the total development project requires detailed information regarding these two phases of the project. The relevant "building blocks: containing the required data and information are given and discussed below.

4.3.1 Construction Phase

The information required to model the macro-economic impact of the construction phase of a project relate to the nature and costs of the capital assets that are actually created. The following standard breakdown of the asset types is used:

- Civil engineering costs:
- Earth works (site clearance, foundations, etc.).
- Structures (bridges, dams and other structures built mainly from concrete).
- Roads (freeways, other arterials and streets).
- Building and construction costs:
- Residential buildings (houses, etc.).
- Non-residential buildings (factories, offices, shopping centres, etc.).
- Machinery and other equipment costs:
- Mechanical equipment.
- Electrical and electronic equipment.
- Research, design, architecture and development costs.
- Furniture.
- Rubber products.
- Structural metal products.
- Other fabricated metal products.
- Manufacturing of transport equipment.

- Other manufacturing and recycling.
- Water related construction costs:
- Bulk water (dams).
- Reservoirs.
- Pump stations (water and sewerage).
- Bulk pipelines (water and sewerage).
- Treatment works (water and sewerage).
- Reticulation (water and sewerage).
- Storm water.
- Parks and recreation.

4.3.2 Operational Phase

In order to quantify the macro-economic impact of the operational component of a project, the following information is required by the model:

- Production/turnover, divided between:
- Sales/turnover destined for domestic consumption; and
- Export sales

Production/Operating costs, broken down into:

- Intermediate input costs, i.e. all materials and services necessary for the production process broken down by industries from which inputs are sources (classified according to the Standard Industrial Classification (SIC) code system),
- Remuneration of staff, broken down by skill levels (i.e. skilled, semi-skilled and unskilled workers), and
- Gross operating surplus (i.e. remuneration of capital)

The table below provides an example of the exogenous vector for Water – Water Supply. These figures are used as the inputs for the operational phase of the model, but are only used as an example to give the reader more clarity on the input requirements for such a model.

4.3.3 An Example of the Inputs Required by the Modelling System

		Values	*Percentages*
1.	**Production/Turnover per annum (Rand millions; 2008 prices)**	**495.62**	
2.	**Number of Labourers (Numbers, 2008)**		
	Skilled Labourers	272	
	Semi-skilled Labourers	2 361	
	Unskilled Labourers	6 989	
3.	**Apportionment of Production**		
	Total Production in terms of:		
	Domestic Sales	29.84	60%
	Exports	19.85	40%
	Total	49.69	100%
4.	**Split of Production between Economic Entities**		
	Intermediate Demand	191.27	39%
	Labour Remuneration	176.65	36%
	Gross Operating Surplus	124.79	25%
	Total	**492.71**	**100%**
5.	**Split of Intermediate Demand between Commodities**		
	Agriculture	12.56	7%
	Mining	0.49	0%
	Meat, Fish, Fruit, Vegetables, Oils & Fat Products	0.68	0%
	Dairy Products	0.12	0%
	Grain Mill, Bakery & Animal Feed Products	0.08	0%
	Other Food Products	0.04	0%
	Beverages & Tobacco Products	0.00	0%
	Textiles, Clothing, Leather Products & Footwear	0.39	0%
	Wood & Wood Products	0.40	0%
	Furniture	0.00	0%
	Paper & Paper Products	3.30	2%
	Publishing & Printing	0.21	0%
	Chemicals & Chemical Products (incl. Plastic Products)	86.99	45%
	Rubber Products	0.41	0%
	Non-Metallic Mineral Products	2.24	1%
	Basic Metal Products	0.22	0%
	Structural Metal Products	0.83	0%
	Other Fabricated Metal Products	0.48	0%
	Machinery & Equipment	40.20	21%
	Electrical Machinery & Apparatus	0.00	0%
	Communication, Medical & Other Electronic Equipment	0.00	0%
	Manufacturing of Transport Equipment	1.95	1%
	Other Manufacturing & Recycling	2.09	1%
	Electricity	10.71	6%
	Water	12.03	6%
	Buildings and Other Construction	2.02	1%

	Trade	1.37	1%
	Accommodation	0.00	0%
	Transport Services	2.01	1%
	Communications	0.11	0%
	Insurance	8.59	4%
	Real Estate	0.00	0%
	Business Activities	0.19	0%
	Community, Social and Personal Services	0.54	0%
	Total	**191.27**	**100%**
6.	**Split of Labour Remuneration between Labourers**		
	Africans - Skilled	3.57	2%
	Africans - Semi-Skilled	28.64	16%
	Africans - Unskilled	17.60	10%
	Coloureds - Skilled	7.38	4%
	Coloureds - Semi-Skilled	32.93	19%
	Coloureds - Unskilled	31.82	18%
	Asians/Indians - Skilled	0.42	0%
	Asians/Indians - Semi-Skilled	0.52	0%
	Asians/Indians - Unskilled	0.02	0%
	Whites - Skilled	21.46	12%
	Whites - Semi-Skilled	29.56	17%
	Whites - Unskilled	2.72	2%
	Total	**176.65**	**100%**

Table 18: Exogenous Vector for Water – Water Supply