Sugarcane as feedstock for Biofuel, a business case of Natal Midlands, South Africa

By

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Declaration

I, **Simphiwe Khuluse**, hereby declare that this business venture project report titled "*Sugarcane as feedstock for Biofuel, a business case of Natal Midlands, South Africa*" submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Business Administration, has not been submitted previously for any degree at this or any other university or tertiary institution. It is my own work, and all reference material contained therein has been duly acknowledged.

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“For I know the plans I have for you,” declares the LORD, “plans to prosper you and not to harm you, plans to give you hope and a future.” (Jeremiah 29:11, NIV)

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Table of Contents

Chapter 1 8
1.1 Overview 8
1.2 Statement of purpose 9
1.3 Business Venture Background 9
1.4 Business Opportunity/Value Proposition 10
1.5 Goals of the Business Venture 11
1.6 Scope of the Business Venture 11
Chapter 2: Literature review 12
2.1 Introduction 12
2.2 Feasibility Assessment (in the form of literature Review) 12
2.2.1 Biofuels globally 12
2.2.2 Sugarcane bioenergy and other products 13
2.2.3 Bioethanol globally 13
2.2.4 Bioethanol Southern Africa 13
2.2.5 Just Energy Transition (JET) 14
2.3 Identification of Business Opportunity Gaps 15
2.4 Theoretical framework 15
2.5 Review of Business Models 16
2.6 Rationale for Selected Business Model 17
2.7 Summary of the literature 17
Chapter 3: Research Methodology 18
3.1 Introduction 18
3.2 Research Design 18
3.3 Data collection methods 18
3.4 Data analysis strategies and interpretation. 19
3.5 Limitation 19
3.6 Quality assurance 20
3.7 Ethical consideration 20
Chapter 4: Results Analysis and Interpretation 21
4.1 Introduction 21
4.2 Feedstock Availability 21
4.3 Descriptive Statistics Feedstock Analysis 23
4.3.1 Hypothesis testing of Zululand and Midlands 23

4.4. Quality assurance........24
4.4.1 Reliability (dependability)........24
4.5 Testing sugar production efficiency........24
4.6 Bioethanol quantity and price estimation........24
4.7 Feedstock for bio-electricity estimation........25
4.7.1 Energy potential of sugarcane biomass........25
4.8 Conclusion........26
4.9 Recommendations and Future Research........26
Chapter 5: Final Business Venture Plan........28
5.1 Executive summary........28
5.2 Basic business information........30
5.3 Current business situation........30
5.4 Strategic analysis........30
5.4.1 PESTEL analysis........30
5.4.2 Key differentiators and unique selling points........32
5.4.3 Value chain analysis........32
5.4.4 Human Resources........33
5.4.5 Competitor analysis........33
5.5 Strategic plan........34
5.5.1 Vision, mission and objective........34
5.5.2 Sources of sustainable competitive advantage.........34
5.5.3 Competitive position........35
5.5.4 Market positioning........35
5.5.5 Brand strategy........35
5.6 Marketing plan........36
5.6.1 Market segments, size, and growth........36
5.6.2 Description of customers, needs and value proposition........36
5.6.3 Pricing and discounting........36
5.6.4 Market forecasts........37
5.7 Operations /production........37
5.7.1 Physical location........37
5.7.2 The production process........37
5.8 Research and development........39
5.9 Management and organisation........40
5.9.1 Top Management........41
5.9.2 Staffing requirements........41

5.10 Forecasts and Financial data 42
5.10.1 Summary of performance ratios 42
5.10.1 Sales forecast 43
5.10.2 Assumptions underpinning financial forecasts 43
5.10.3 Profit and loss account (income statement) 44
5.10.4 Balance sheet 45
5.10.5 Cash flow statement 46
5.10.6 Discounted cash flow and internal rate of return 47
5.10.7 Payback Period 47
5.11 Financing 48
5.11.1 Summary of operations prior to financing 48
5.11.2 Current shareholder loans outstanding 48
5.11.3 Use of proceeds 49
5.11.4 Funds required and timing (funding projections) 50
5.11.5 The deal on offer 51
5.11.6 Anticipated gearing and interest cover 51
5.11.7 Exit routes for investors. 51
5.12 Risk analysis 51
5.12.1 Risk overview and Specific risks 51
5.12.2 Limiting factors and risk-reduction strategies 52
5.12.3 Critical success factors 52
5.12.6 Business controls Information technology 52
5.12.7 Operations Other controls 52
6 References 53
7 Appendices 58

Table of Figures

Figure 1. The business model canvas – adapted from Braun et al. (2021) 16
Figure 2. Proportion of sugarcane crushed per rainfed growing region 22
Figure 3. Total annual sugarcane crushed for period 2012 – 2024 22
Figure 4. BCM Location (adjacent to Eston Mill) 37
Figure 5. Process flow chart of the integrated sugarcane processing plant 38
Figure 6. BCM organisation chart 40
Figure 7: South African Annual Electricity Production 63

Table of Tables

Table 1: Summary Descriptive Statistics and Pearson correlation coefficient....................................23
Table 2: Quanty and Price estimate of bioethanol production 25
Table 3: Estimated feedstock cost for bio-electricity 25
Table 4: Employment and related costs 41
Table 5: Summary Financials and performance ratios 42
Table 6: Revenue forecast 43
Table 7: Income statement 44
Table 8: Balance sheet..45
Table 9: Cash flow statement 46
Table 10: Discounted Cash Flow 47
Table 11: Break-Even Analysis 48
Table 12: Use of proceeds from fundraising 49
Table 13: Funding Projections 50

Table of Appendix

Appendix 1: t-Test: Paired Two Samples for Means was computed...58
Appendix 2: Anova & Cronbach Alpha 58
Appendix 3: Sugar production efficiency 59
Appendix 4: Ethanol production Quantities...60
Appendix 5: Feedstock for bio-electricity estimation 60
Appendix 6: Human Resources and Costing 61
Appendix 7: Bioethanol Quality considerations 64

Chapter 1

1.1 Overview

The nexus of sugarcane and renewable energy. Energy is crucial for economic advancement, as the global economy relies heavily on fossil fuels for energy production (Aluwani, 2023; Dimitriadis et al., 2021). The South African economy, is said to be the most industrialised, sophisticated, advanced and productive on the African continent (Nkosi et al., 2021). The economy is mainly based on extracting resources and powered by fossil fuels, leading to higher greenhouse gas (GHG) emissions compared to countries of similar Gross domestic product (GDP) (Nkosi et al., 2021; van Ryneveld & Islar, 2023). According to Sasu (2023), in 2021, South Africa, whose main source of energy is coal, had the largest production-based carbon dioxide (CO_2) emissions in Africa. Furthermore, van Ryneveld and Islar (2023) stated that the coal-intensive energy system dates back to the British colonial era, with all but two coal-fired power plants built during apartheid era. These power plants are gradually unable to sustain the South African economy, mainly due to a lack of maintenance, mismanagement, corruption and end of life, that has resulted in severe electricity blackouts (Andreoni et al., 2022; Sasu, 2023). The power plants are unsustainable from energy security, social and environmental perspectives, contributing significantly to pollution that is detrimental to human health (CIF, 2021) and climate change (Andreoni et al., 2022; Millar et al., 2022; The Daily Telegraph, 2022; van Ryneveld & Islar, 2023; Wernecke et al., 2022).

Globally, sugarcane is used for renewable energy (Ajala et al., 2021; Kabeyi & Olanrewaju, 2023). There is a need for the South African economy to gradually shift from fossil fuel-based energy to a low-carbon energy mix, led by renewables, in order for the country to be energy secure, reduce pollution, reverse the effects of climate change, and remain competitive in the global economy (CIF, 2021; Gilani et al., 2020; IRENA, 2019; Parascanu et al., 2021; The Daily Telegraph, 2022; Wernecke et al., 2022).

1.2 Statement of purpose

The main purpose of the business venture project is to develop the business venture plan and business model that will convert sugarcane into renewable baseload bioenergy and various other products. The study aims to explore the most efficient process flow for manufacturing these products and seeks to understand optimal production.

1.3 Business Venture Background

The South African sugar industry, located in rural KwaZulu-Natal and southern Mpumalanga provinces, is among the top 15 out of approximately 120 sugar-producing countries in the world (SASA, 2020, 2022). The industry is highly cost-competitive and is valued at 20 billion South African rand (SASA, 2022). In South Africa, sugarcane plant juice has been a main source of refined sugar (sweetener), raw sugar for export, and fermented into alcohol to a lesser extent (de Matos et al., 2020; IRENA, 2019; SASA, 2020).

SASA (2020) stated that, globally, the sugar industry is stagnating due to oversupply. In South Africa, the industry faces a predicament that threatens its existence. Over the past 20 years, it has seen a decline of approximately 25% in annual sugar production. 60% of sugarcane farmers have left the industry, and 45% of jobs have been lost (SASA, 2020, 2022). Therefore, there is a "surplus" of sugarcane which can be converted into energy (Amanful et al., 2024; SASA, 2020).

The major contributors to the decline of the South African sugar industry are distorted global sugar prices that are below South African production cost due to extensive government subsidies, and an increase in imports of low-priced, tariff-free sugar from neighbouring Eswatini (SASA, 2020). Furthermore, South African sugar demand has been reduced because of the Health Promotions Levy (HPL), implemented on the 1st of April 2018. This tax on sugar-containing beverages is aimed at ultimately reducing sugar consumption, thereby promoting a healthy lifestyle (Amanful et al., 2024; SASA, 2020).

1.4 Business Opportunity/Value Proposition

According to Lönngren and van Poeck, (2021), while the idea of wicked problems is commonly referenced in sustainability literature, there is a lack of agreement on its theoretical foundations. In this study, wicked problems refer to the intricate, systemic, interrelated, pressing socio-economic, and environmental challenges that lack a clear and accepted framework for resolution (Andreoni et al., 2022; Lönngren & van Poeck, 2021). The headwinds facing both the South African energy sector and the sugar industry present "wicked problems" that could, if not addressed, negatively affect the socio-economic well-being of citizens. However, these wicked problems present opportunities for both the energy sector and the sugar industry.

The Sugarcane Value Chain Master Plan for 2030 sets a long-term vision that aims to diversify the sugarcane value chain away from refined sugar production into products such as biofuels, bioplastics , co-generated electricity, etc (SASA, 2020).

Other countries, such as Brazil, have a long and demonstrable successful experience in substituting fossil fuels (petroleum products) with bioethanol made from sugarcane (Rossi et al., 2021). Bioethanol is a sustainable fuel source that burns effectively, decreases air pollution, and mitigates climate change by emitting lower levels of GHG emissions (Bressanin et al., 2021; Mat Aron et al., 2020; Parascanu et al., 2021). Therefore, sugarcane can play an important role in addressing the triple challenge of energy insecurity, climate change, and poverty in rural areas in South Africa (Mvelase & Ferrer, 2024b; Vandenberghe et al., 2022).

In South Africa, it is crucial to have sustainable baseload electricity (bioenergy) production to achieve socioeconomic development goals, satisfy the increasing need for renewable energy, and reduce environmental effects. This business venture study seeks to propose a viable business plan option for sugarcane-based biomass electricity generation integrated into a sugarcane bioethanol distillery that will support both the energy sector and sugar industry in Natal Midlands, South Africa.

1.5 Goals of the Business Venture

The overall goal is to develop the business venture plan and business model to diversify sugarcane holistically into multiple products, underpinned by renewable baseload bioenergy, such as bioelectricity, bioethanol, and biogas.

The objective of this project is to:

- Map out a high-level process flow for the bioenergy facility.
- Investigate the potential optimal amount of bioenergy production per available ton of sugarcane.
- Develop a business plan to generate bioenergy from sugarcane.

To address the research objectives, the study will seek to answer the following questions: How much sugarcane is crushed in rainfed regions? Which region(s) are expected to have sustained sugarcane production? What is the amount of electricity measured in kilowatt hour (kWh) per annum that can be produced from the tonnages of discarded sugarcane residues? The study will estimate the price of bioethanol per liter, as well as the price of electricity per kilowatt-hour. The simulated financial statements (Income Statement, Balance sheet, Cash flow statement, Revenue forecast) will be generated.

1.6 Scope of the Business Venture

The scope of the business venture proposal is to establish and grow a sustainable, multi-product renewable energy facility that uses sugarcane as a primary energy source in Natal Midlands, South Africa. The aim is to provide a solution for the decline in demand for sugarcane, create job opportunities within the sugarcane industry, and generate renewable baseload energy. Strategic alliances and partnerships will be established with current sugarcane growers and sugar manufacturers.

Chapter 2: Literature review

2.1 Introduction

Given the high levels of unemployment, rural poverty, energy insecurity, and climate change in South Africa, it is important to consider the debate around decarbonization and Just Energy Transitions in South Africa (Shilomboleni, 2020; van Ryneveld & Islar, 2023). According to Andreoni et al. (2022), this debate frequently takes place within a divided, polarized ideological perspective, with supporters of fossil fuels (the current status quo) facing off against advocates for sustainable renewable energy. This ideological discussion holds significance because it offers a fundamental comprehension of the various perspectives, incentives, and motivations of each faction (Andreoni et al., 2022; Ngcuka, 2024; Yellen, 2023).

This chapter seeks to utilise relevant literature to give an overview of sugarcane as one of the important sources of baseload renewable energy sources, globally, continentally, and potentially in South Africa. Lessons are drawn from international studies and other countries that have effectively diversified sugarcane into a multiproduct crop. A summary is given on the country's bioethanol, cogeneration of electricity potential, and a high-level overview of the technology.

2.2 Feasibility Assessment (in the form of literature Review).

2.2.1 Biofuels globally

Biofuels are renewable energy sources produced from biological processes (Grandis et al., 2024). The two main biofuels are biodiesel, produced from vegetable oils and/or animal fats, and bioethanol produced from plant sugars (Sajid et al., 2021). The United States of America is a leader in producing biodiesel, while Brazil leads the world in bioethanol production from sugarcane (Grandis et al., 2024; Hughes et al., 2020; Sajid et al., 2021).

2.2.2 Sugarcane bioenergy and other products

As stated in Hughes et al. (2020), sugarcane produces sugar juice and at least three bioenergy products, including bioethanol, bioelectricity, and biogas. Moreover, bioethanol can be converted into heavier fuels like Sustainable Aviation Fuel (SAF) and the production of green hydrogen (Grandis et al., 2024; Mvelase & Ferrer, 2024a; Mvelase et al., 2023). As ethanol is a chemical platform molecule, it can be transformed into various essential industrial chemicals and products such as bioplastics, rubber monomer 1,3-butadiene, butanol, propylene, and acetic acid, among others. This implies that an ethanol chemistry industry could be established from sugarcane-based ethanol (Grandis et al., 2024; Mvelase et al., 2023; Rossi et al., 2021).

2.2.3 Bioethanol globally

Compared to biodiesel, bioethanol is the most developed renewable fuel (Sajid et al., 2021). Sugarcane is among the highest-yielding crops for producing bioethanol, with estimated yields of 38 tonnes per hectare (Jain & Kumar, 2024; Sajid et al., 2021). One-third is sugarcane juice, which can be fermented into bioethanol through the first-generation (1G) method, and two-thirds consist of cellulose from bagasse and sugarcane leaves that can be converted into bioethanol through the second-generation (2G) method (Tapia Carpio & Simone de Souza, 2019). In Brazil, sugarcane is a crop of choice in bioethanol production, is at the intersection of agriculture, land use, and energy, and plays a significant role in employment (Gilani et al., 2020; Grandis et al., 2024; Hughes et al., 2020; IRENA, 2019). It is estimated that one hectare (ha) of sugarcane can produce over 8000 liters (L) of bioethanol and 6.5 megawatt-hours (MWh) of electricity per year using the 1G method. In Brazil, bioethanol is cost-competitive and reduces GHG by up to 80% compared to fossil fuel-based gasoline (Grandis et al., 2024; IRENA, 2019).

2.2.4 Bioethanol Southern Africa

Human development in Southern Africa is limited by, among other things, a lack of electricity (Souza et al., 2016). Meanwhile, in this region, sugarcane yields are said to be much higher; therefore, the bioenergy potential is higher (IRENA, 2019). Souza et al. (2016) estimated that bioethanol could replace between 30% and 70% of cooking fossil fuels and increase bioelectricity generation by between 10% and 70% in Malawi, Mozambique, Zambia, Angola, and Eswatini. According to Molobe et al. (2024), the agricultural sector in South Africa is facing a high unemployment rate; however, it is recognized for creating job opportunities. Just like in Brazil, a diversified sugarcane sector can increase demand and boost employment (Hughes et al., 2020; Molobe et al., 2024). In rural KwaZulu-Natal, South Africa, sugarcane has been shown to be a vital source of employment and has provided income more than any other crops (Molobe et al., 2024; Thibane et al., 2023).

Multiple research studies have demonstrated the advantageous social, economic, and environmental outcomes linked to bioethanol manufacturing in South Africa. Researchers discovered that a multi-product biorefinery connected to a standard sugarcane factory was financially appealing (Amanful et al., 2024; Mvelase & Ferrer, 2024a).

2.2.5 Just Energy Transition (JET)

Hanto et al. (2022) argued that moving to low-carbon energy poses social, economic, political, and technical challenges, given that South African energy sector heavily relies on coal. JET proves to be a 'wicked' problem because it is urgent, complex, systemic, and interconnected (Andreoni et al., 2022; Hanto et al., 2022; Lönngren & van Poeck, 2021). There are opportunities accessible through a more decentralized electricity system (Hanto et al., 2022). All stakeholders agree in principle that JET presents new opportunities for South Africa, and no one will be left behind through a worker-centered perspective (Amman, 2023; Hanto et al., 2022). However, the Eskom JET project at Komati has divided stakeholders. The members of the Presidential Climate Commission (PCC) stated that there were mistakes that were made in decommissioning the power station, members of the neighboring community were not being consulted, and several jobs were lost in the process (Amman, 2023). Meanwhile, other stakeholders, such as senior government officials, international partners, and leaders, sang praises for the Komati JET project (Amman, 2023; Andreoni et al., 2022; Ngcuka, 2024; Yellen, 2023).

The Komati JET project highlights the need for serious consideration of justice principles of recognition, distribution, and process in the transition to a low-carbon economy by government, private sector, and civil society (Amman, 2023; Ngcuka, 2024). Governments, private sector, and international partners should balance their concern about the abatement of GHG emissions and opportunities for climate change mitigation with prioritizing local communities directly affected by the renewable energy project (Hanto et al., 2022; Ngcuka, 2024). A JET project should represent the universal value of the 2030 Agenda for Sustainable Development, "Leave No One Behind, " a commitment of all UN Member States "to end poverty and hunger, in all their forms and dimensions, and to ensure that all human beings can fulfill their potential in dignity and equality and in a healthy environment" (Siciliano et al., 2021; United Nations, 2015).

2.3 Identification of Business Opportunity Gaps

In South Africa, there is a business opportunity for further beneficiating a sugarcane crop into bioenergy (bioethanol, electricity, and biogas). This would start with the electricity being sold into the grid. The biorefinery and power station should be located adjacent to the existing sugar mill to take advantage of established feedstock logistics. Moreover, currently, sugarcane trash is burnt in the fields, causing pollution and emitting GHG, this feedstock (trash) should be brought to the plant for energy production.

2.4 Theoretical framework

The theoretical framework that underpins the venture is sustainable entrepreneurship, which is the nexus between the economic, social, and environmental motives of entrepreneurs (Farny & Binder, 2021). The main vision for the venture is to pursue a triple bottom line - profit, people, and the planet, through the production of baseload renewable energy (Farny & Binder, 2021; Rosário et al., 2022).

2.5 Review of Business Models

<table>
<tr><th colspan="6">The Business Model Canvas</th></tr>
<tr>
<td rowspan="2">Key Partners
- Sugar mills.
- Crane growers.
- CSIR (R&D).
- Logistic companies.
- Regulators.
- Eskom transmission.
- Finance institutions.
- Venture capitalists.</td>
<td>Key Activities
- Receiving & pre-treating raw material.
- – processing raw material into bioethanol, biogas and electricity.
- Selling</td>
<td rowspan="2" colspan="2">Value proposition
- Biofuel promotes economic activities in rural areas (sugarcane growing areas).
- Biofuel provides baseload renewable energy.
- Contribute to meaningful to South Africa's JET agenda.</td>
<td>Customer Relationship
- Adding value to customers, by providing baseload renewable energy.
- contribute to customer's sustainability agenda.</td>
<td rowspan="2">Customer Segments
- Private sector companies,
- Municipalities & their utilities,
- Eskom (state owned utility)</td>
</tr>
<tr>
<td>Key resources
- Human capital,
- Capital resources (PPE)
- Raw material, i.e. sugar juice, bagasse, sugarcane trash/scraw, biomass.</td>
<td>Channels
- Electricity through the grid,
- Bioethanol through virtual pipeline.</td>
</tr>
<tr>
<td colspan="3">Cost Structure
- OPEX, plant operational cost.
- Raw material cost
- Human capital remuneration,</td>
<td colspan="3">Revenue Steams
- Selling of electricity (main product).
- Selling of bioethanol
- Carbon credit</td>
</tr>
</table>

Figure 1. The business model canvas – adapted from Braun et al. (2021)

2.6 Rationale for Selected Business Model

The simplicity of the Business Model Canvas (Figure 1) is the basis for choosing it. It is visual, easy to understand and communicate, very focused, and flexible, which makes it easier to change the model and add or remove ideas (Braun et al., 2021; Jin et al., 2022). The customer is king; the canvas helps to focus on the value delivered to the customer. It is one page, that shows how different parts are interconnected (Jin et al., 2022).

2.7 Summary of the literature

The three sugarcane bioenergy products that are discussed in the literature review are bioethanol, bioelectricity, and to a lesser extent, biogas. Bioethanol is the most advanced crop-based renewable energy globally but is not well - developed in South Africa (Mvelase & Ferrer, 2024b; Mvelase et al., 2023; Sajid et al., 2021). Bioelectricity, where it is produced, is mostly limited to internal electricity consumption for sugar mills as the current production processes are generally not efficient (Vandenberghe et al., 2022). The production of bioenergy from sugarcane will boost sugarcane demand and increase employment in sugarcane growing regions, value chain and where biorefineries are located (Ali et al., 2024; Mvelase & Ferrer, 2024a, 2024b; Mvelase et al., 2023). Apart from the positive socioeconomic development, there is also a positive environmental spinoff (Vandenberghe et al., 2022). Therefore, bioenergy has all the characteristics of a Just Energy Transition since it "Leaves No One Behind" in the value chain and surrounding communities (United Nations, 2015).

Chapter 3: Research Methodology

3.1 Introduction

The research methodology is outlined in this chapter to address research questions. Each research question has specific objectives that guide both research design and methods to be employed. This chapter will include the following sections: research design, data collection methods, instruments used, data analysis, results, limitations, and ethical considerations. A quantitative research method will be used. The secondary data from regions in KwaZulu-Natal where sugarcane is cultivated will be analysed using descriptive statistics, hypothesis testing, and simulated financial statements utilising Microsoft Excel software.

3.2 Research Design

The blueprint will guide and achieve the research objectives of this business venture. It is a plan for data collection, measurements, and data analysis to answer the research question. The study will use a quantitative method (Schindler, 2019). The study follows a consecutive approach; it defines the problem, articulates the research objectives, and the methods for data collection, processing, analysis, and discussion (Bougie & Sekaran, 2020; Schindler, 2019).

3.3 Data collection methods

Publicly available secondary quantitative data will be collected from public and private organisations as stated below. A deductive reasoning or "waterfall" approach will be utilised and the data will be subjected to both descriptive and inferential analysis (Bougie & Sekaran, 2020; Schindler, 2019). The data for the period 2006 to 2024 will be collected, based on the assumption that the commercial electricity Power Purchase Agreements (PPA) are 20 years and that the sugarcane-based bioethanol project has a minimum design life of 17 years (Christophers, 2022; Mvelase & Ferrer, 2024a).

The study will use secondary data from South African Sugar Association (SASA) and Department of Mineral Resources and Energy (DMRE). The data to be collected is as follows:

DMRE – the estimated costs, such as capital expenditures (CAPEX) and operational expenditures (OPEX) of bioethanol plants in Southern Africa, as well as insights on regulations for the bioethanol industry. SASA – tonnage of sugarcane crushed, sugarcane crushed by mills and regions, sugarcane prices and sugar sales in South Africa.

3.4 Data analysis strategies and interpretation.

The data will be analysed using the Microsoft Excel package. Feedstock availability will be assessed as a percentage of sugarcane crushed per sugarcane-growing region. The annual sugarcane-crushed data will be used to evaluate the growth of sugarcane in each region. Descriptive statistics will be used to analyse the feedstock quantities. The inferential statistics will be used to test the hypotheses (Bougie & Sekaran, 2020; Schindler, 2019).

The conversion rate for sugarcane to bioethanol will be sourced from literature to determine the bioethanol production and to calculate what would have been the annual quantities of bioethanol production from sugarcane for the period 2012 to 2024. The OPEX will be estimated as the sum of general and administration cost, research and development cost. The calculated selling price for bioethanol will be computed as the sum of fixed costs and variable costs, multiplied by profit margin. The benchmark selling price of bioethanol will be estimated in accordance with the proposal by the biofuel industrial strategy at 95% of the basic fuel price. (Amanful et al., 2024; Mvelase & Ferrer, 2024a; Mvelase et al., 2023).

3.5 Limitation

The study identified the following limitations: there are few South African biofuels studies, particularly regarding bioethanol production for energy purposes. The industry for bioenergy production is still in its infancy in South Africa. Although this is a renewable form of energy in a heavily fossil fuel-based country with decarbonisation imperatives, the researcher acknowledges that this is a broad topic that cannot adequately be addressed within the limitations of an MBA Business Venture Project. Therefore, future studies should look at other geographical areas that produce sugarcane, as well as other products that can be produced from sugarcane.

3.6 Quality assurance

Secondary data from reputable industry organizations will be utilised; therefore, both external and internal validity are assumed to be both valid and reliable. The data will be evaluated for dependability and reliability, which will document the consistency of data collection. This means that other researchers and observers employing the same systematic approach and process in this study will achieve similar results.

3.7 Ethical consideration

The researcher attended a training course in Research Ethics for Non-Medical Human Research and holds a certificate of competence in Research Ethics. The researcher has applied to the University of Witwatersrand's Ethics Committee for permission to conduct this study and has received approval. Data collection commenced after the ethics clearance certificate was issued. The data providers were treated with the utmost respect, honesty, fairness, and care, and their details were kept confidential.

All appropriate guidelines and regulations were taken into account and followed during the execution of this research project. This is essential and will guarantee the safeguarding, welfare, and rights of the involved individuals and institutions, uphold research integrity, and enhance the overall reliability and credibility of the research results.

The subsequent factors were considered:

- **Authorization to use data:** Even though the data is accessible on the institution's websites and in published materials, consent was obtained from the data owners.
- **Informed consent:** Data owners or generators received an email detailing the study's purpose along with any possible risks or benefits. They were informed of their right to ask questions and revoke their consent or authorization for data use at any moment.
- **Confidentiality:** The researcher will maintain the confidentiality of all data received and will securely store it on a Google Cloud that is protected by a password.
- **Prevention of coercion or improper influence:** Data owners were not subjected to pressure or coercion in providing data for the study; involvement was voluntary, and participants had the option to refuse or withdraw their participation at any moment.

Chapter 4: Results Analysis and Interpretation

4.1 Introduction

The selection of a location for commercial bioenergy production is critical, as the location and the actual feedstock need to align with the qualification criteria stated in the Biofuels Feedstock Protocol (BFP) (DMRE, 2020). Commercial-scale bioenergy projects require adequate feedstock and viable logistics for raw material (feedstock) delivery to the facility and product evacuation from the facility (DMRE, 2020). These are the foundation for a bankable, sustainable business case that creates jobs without negatively impacting food security and the environment (air quality, water, and biodiversity). DMRE (2020), the BFP states that biofuels feedstock production that does not require irrigation should be prioritized. There are four prominent rainfed sugarcane-growing regions (Zululand, North Coast, Midlands, and South Coast) in South Africa, all located in the province of KwaZulu-Natal (DMRE, 2020; SASA, 2025).

4.2 Feedstock Availability

Sugarcane crushed is used to indicate feedstock availability. The results presented in Figure 2 show that Zululand has the highest percentage of sugarcane crushed, followed by the Midlands. Meanwhile, the South Coast region has the lowest percentage of sugarcane crushed, followed by the North Coast region.

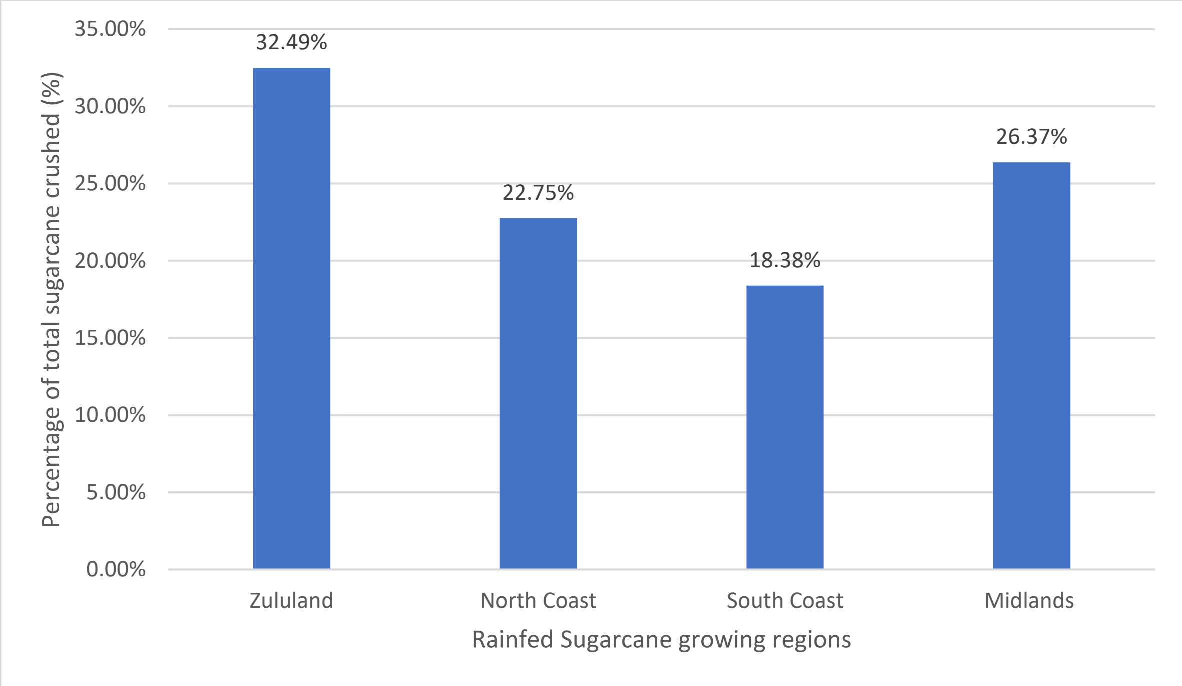

Figure 2. Proportion of sugarcane crushed per rainfed growing region

Figure 3 indicates that Zululand and Midlands regions have an upward-sloping linear trendline, which suggests that sugarcane crushed in these two regions is increasing at a steady rate. Furthermore, South Coast and North Coast have a downward-sloping linear trendline, which suggests that sugarcane crushed is decreasing at a steady rate.

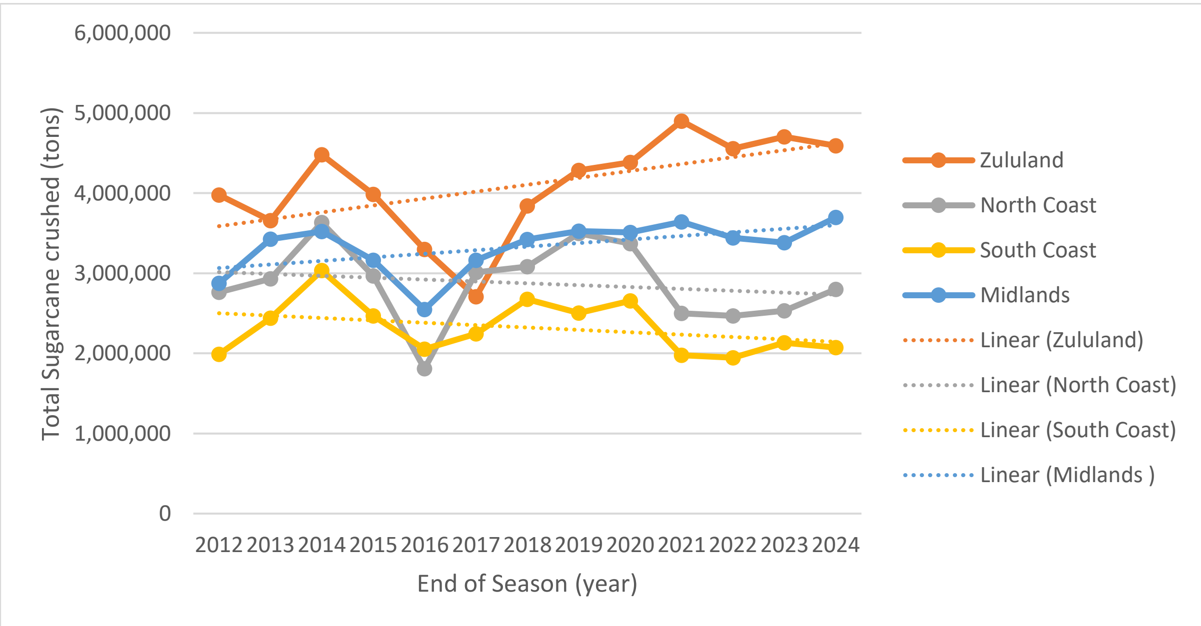

Figure 3. Total annual sugarcane crushed for period 2012 – 2024

4.3 Descriptive Statistics Feedstock Analysis

The descriptive statistics results presented in Table 1 confirm that the Zululand region has the highest average sugarcane crushed at 4.1 million tons, followed by Midlands with an average of 3.3 million tons. The Zululand region has the highest standard error, suggesting that the calculated sample mean might be broadly spread around the actual population mean, while Midlands has the lowest standard error among all regions, indicating that the calculated mean for Midlands is the most reliable and reflects the actual population more accurately. Therefore, a further detailed analysis of Midlands is presented. The skewness of Midlands is excellent at -1, indicating that the distribution is negatively skewed with larger values. The kurtosis of Midlands is 2, suggesting a more peaked distribution. The minimum sugarcane crushed was 2.5 million tons, while the maximum was about 3.7 million tons. In the Midlands, a calculated Pearson correlation coefficient of 0.5 indicates a moderate positive correlation between the tonnages of sugarcane crushed and the price of sugarcane.

Table 1: Summary Descriptive Statistics and Pearson correlation coefficient

	Number (years)	Minimum	Maximum	Mean	Median	Standard Deviation	Standard Error	Kurtosis	Skewness	Pearson correlation coefficient
Zululand	13	2 706 018	4 899 344	4 104 461	4 284 095	617 867	171 365	1	-1	0,4
North Coast	13	1 808 169	3 632 170	2 874 331	2 930 615	488 326	135 437	1	0	-0,3
Midlands	13	2 546 256	3 695 794	3 331 959	3 425 143	322 622	89 479	2	-1	0,5
South Coast	13	1 946 235	3 032 796	2 322 594	2 243 912	336 237	93 255	0	1	-0,4

4.3.1 Hypothesis testing of Zululand and Midlands

H0: There is no significant difference in the means of each sample.

H1: There is a significant difference in the means of each sample.

The t-Test: Paired Two Samples for Means was computed, results presented in Appendix *1*. The P(T <= t) two-tail (0.000083) is the probability that the value of the t-Statistic (5.811055) is larger than the Critical t value (2.179). The p-value is less than the selected alpha of 0.05; therefore, we reject the null hypothesis.

4.4. Quality assurance

4.4.1 Reliability (dependability)

The computed Cronbach's alpha is 0,7 regarded as a measure of internal consistency, suggesting that tonnage of sugarcane crushed are closely related as a group, calculation is in Appendix *2*.

4.5 Testing sugar production efficiency

Sugar production efficiency was calculated as a proportion of total saleable sugar produced and total sugarcane crushed from 2006 to 2024; the calculation is in Appendix *3*. The average efficiency percentage computed was 11%. This aligns with the efficiency findings of a study in India, where bioethanol is produced in distilleries integrated with sugar mills (Shelar et al., 2023).

4.6 Bioethanol quantity and price estimation

To satisfy the feedstock requirements of the bioethanol plant in Midlands, 68% of the sugarcane crushed will be used for producing sugar and molasses, with all the molasses allocated for ethanol production. The remaining 32% of the sugarcane crushed will be designated solely for ethanol production; the calculation is in Appendix *4*, and results presented in Table *2*. Shelar et al., (2023) found that one ton of sugarcane crushed in an Indian sugar factory yields about 76 liters of ethanol if sugar production is sacrificed. If sugar is produced, all the remaining molasses is converted to bioethanol, yielding about 10 liters of bioethanol (Shelar et al., 2023). The results from the Indian sugar factory were used to estimate bioethanol yields in Midlands (Shelar et al., 2023). The unit price of bioethanol is calculated at a 15% markup on the total cost of bioethanol production per liter. The price is increased by 6% year on year, starting from the second year.

Table 2: Quanty and Price estimate of bioethanol production

	Year 1	Year 2	Year 3	Year 4	Year 5
Est. number of Units (l)	109 261 449	113 259 466	107 166 637	105 196 336	115 013 109
Price (at 15% mark up of TC)	4,97				
Price per (l)	4,97	5,27	5,58	5,92	6,27

4.7 Feedstock for bio-electricity estimation

Sugarcane biomass, which includes bagasse and sugarcane straw (trash) currently burned during the harvesting of sugarcane, is designated as feedstock for bioelectricity generation. Sugarcane yields about 23% bagasse (Shelar et al., 2023) and 12% sugarcane straw (Aguiar et al., 2021). These proportions were used to estimate the total biomass for bioelectricity generation, the calculation is in Appendix *5*, the results Table *3* shows that the biomass feedstock is on surplus, by at least 13% over period of five years. The main assumption is that the practice of burning sugarcane during harvesting will be eliminated.

Table 3: Estimated feedstock cost for bio-electricity

		Year 1	Year 2	Year 3	Year 4	Year 5
Plant Capacity (MW)		60	60	60	60	60
Available Total biomass (tons/day)		3 367	3 490	3 302	3 241	3 544
Required Total biomass (tons/day)		3000	3000	3000	3000	3000
Biomass surplus/deficit (%)		12%	16%	10%	8%	18%
Maximum unit produced (kWh/day)	24	1 440 000,00	1440000	1440000	1440000	1440000
Unit (biomass needed (tons/kWh)		0,0021	0,0021	0,0021	0,0021	0,0021
Total cost (bagasse & straw) (rand/tons)		R 9,29	R 10,73	R 11,28	R 11,33	R 15,67
Total cost of biomass (rand/kWh)		R 0,02	R 0,02	R 0,02	R 0,02	R 0,03
Torrefaction Costs per Unit	190%	R 0,04	R 0,04	R 0,04	R 0,04	R 0,06

4.7.1 Energy potential of sugarcane biomass

The bagasse, on a dry matter basis, when used as a solid biofuel, has a calorific value ranging from 16 to 18 MJ/kg, while the calorific value of sugarcane straw is 16.42 MJ/kg, which is within the range of bagasse's energy potential. This means that both feedstocks can be utilized in the same energy generation equipment. Since bagasse and sugarcane straw have high moisture content when exiting the milling process or harvesting, respectively, the biomass will need to be treated through torrefaction, a thermo-chemical process that decrease the moisture content of the feedstock and increase calorific value (Azis et al., 2021; Kalifa et al., 2024).

4.8 Conclusion

Feedstock availability and quantities for both bioethanol and bioelectricity were assessed in the rainfed sugarcane-growing regions. There is, on average, 3.3 million tonnes of sugarcane in the Midlands. This average is expected to at least remain flat, or at best increase moderately, since there is a positive correlation between sugarcane price and sugarcane crushed, giving an incentive for sugarcane farmers to continue farming sugarcane. The bioethanol yield is expected to average 110 million liters over five years. The total available biomass for bioelectricity was calculated to be 3,388 tons per day, which is sufficient to fuel a biomass-to-energy plant with a capacity of 60 MW. The feedstock will need to be pretreated to improve efficiency of the power plant.

4.9 Recommendations and Future Research

The researcher acknowledges that addressing such an important wide-ranging topic within the MBA project timeline might pose a considerable limitation. Consequently, the study suggests a comprehensive future multidisciplinary investigation, allowing sufficient time to include all sugarcane cultivation regions in South Africa to improve the results of the research. Future research should include comprehensive pre-feasibility and feasibility assessments in every sugarcane cultivation area. Some of the objectives that future research could aim to attain include scoping, pre-feasibility and feasibility.

Scoping and Pre-feasibility:

- Site location and assessment,
- Feedstock availability and analysis,
- Revenue options and revenue stream assessment,
- Partner options,
- Project budget,

Feasibility:

- Financial viability – the studies could examine plant design and costing, assess, and confirm financial viability.
- Risk Management – the environmental impact assessment of the selected site location, feedstock supply agreements, storage, and alternatives. Identification and appointment of independent advisors, licensing, and permitting.
- Execution – legal contracting, preparation, and negotiation of off-take agreements, engineering and construction, operations, and maintenance.

Chapter 5: Final Business Venture Plan

5.1 Executive summary

Vision

To be an enabler of individuals and businesses to conduct their activities in a manner that is harmonious with Mother Earth, where together with our customers are changing our world for the better.

Mission

As an integrated renewable energy and biochemical company, we strive to provide baseload renewable energy to provide our customers and biodegradable products.

Business objectives

Bioenergy Campus Midlands (Pty) Ltd (BCM) primary purpose is to produce and supply bioenergy and biochemical products that assist in decarbonizing the South African economy using sugarcane as feedstock.

Current state of the business

BCM is a startup that is currently undergoing prefeasibility activities.

Products and services

Fuel-grade bioethanol for blending with petrol and bio-electricity, as well as biochemical products made from sugarcane.

Strategy and sources of sustainable competitive advantage

Our capabilities and people are the main sources of our competitive advantage. Our low-carbon products are valuable, rare, and not easily imitated on a large scale because of the high capital outlay and limited acceptable feedstock.

Customer acceptance

Consumers are becoming aware of the need to reduce their carbon footprint and are increasingly demanding products that achieve this, as well as directly utilizing renewable energy sources.

Summary financial forecasts

The financial forecast predicts revenue growth from R977 million in year one to R1.4 billion in year five. Only the first year shows negative profitability, while all other four years display positive profitability. Cash flow remains positive throughout the five-year forecast period.

Money required, timing and deal on offer.

BCM requires a total of R12 billion over five years to establish a technologically advanced bioenergy facility in Midlands, KwaZulu-Natal, South Africa. The deal on offer for investors presents a unique opportunity to lead the market in addressing the clean energy insecurity that consumers face, fight climate change, and contribute to the development of a new low-carbon industry in South Africa, which will aid economic growth, create much-needed jobs, and ensure the sustainability of the sugarcane industry.

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5.2 Basic business information

Name of business:	Bioenergy Campus Midlands (Pty) Ltd (BCM)
Contact information	Telephone: +27 83 620 6459
Document control	BVP_V1of 2025
Industry	Electricity generation and “Petrochemical”
Age of the business	0 years (a startup)
Proposed number of employees	128 (during operation)
Market	South African petroleum, electricity utilities and manufactures
Professional advisers	
Capital structure	40% debt and 60% equity
Legal structure	Private Company (Pty) Ltd

5.3 Current business situation

BCM was founded with the vision of addressing the baseload renewable energy gap in the South African market by capitalizing on the decline in sugar production. We are on a mission to construct South Africa's first large-scale Bioenergy Campus, where bioethanol and bioelectricity will be produced using sugarcane as feedstock. The electricity generation plant will have a capacity of 60 MW, while the bioethanol plant will have an annual production capacity of 95 million liters. The business is a startup with no historical financial results and is currently undergoing technical feasibility studies and fundraising. BCM aims to serve the South African market primarily. The team brings 50 years of experience in electricity generation. Our core competencies will be developed around innovation, through research and development, a strong company culture, and the production of high-quality products.

5.4 Strategic analysis

5.4.1 PESTEL analysis

This framework is used to assess external macro-environmental factors, that BCM will be operating under.

Political Factors

South Africa is a stable, democratic country with a functional coalition government of national unity. The government is showing positive signs of fighting corruption, rebuilding institutions, and implementing the Judicial Commission of Inquiry into Allegations of State Capture (Judge Zondo Commission). There is a clear bioethanol-to-fuel policy and framework that protects the industry, as it is still in its infancy.

Economic Factors

South African economic growth has been sluggish over the past 10 years due to factors such as high prices of international petroleum products, lower prices of minerals (gold and platinum), electricity shortages (load shedding), bulk transportation (rail and port) constraints, corruption, and the COVID pandemic. This has resulted in a decrease in disposable income, high levels of unemployment, and the weakening of the rand. However, the inflation rate is well managed by an independent central bank. Our business is positioned to increase employment through the sugarcane value chain, as well as contribute in supplying baseload renewable energy.

Social Factors:

South Africa is a diverse and multicultural society (rainbow nation), with the majority black Africans at 81.4%, coloured at 8.2%, Caucasians at 7.3%, and Indians /Asians at 2.7%. KwaZulu-Natal, the province where the business venture is based, has the second-highest population, estimated at 12.3 million. The median age of South Africa is 28.7 years (SA, 2024).

Technological Factors:

South Africa has a history of innovation in the petrochemical sector, with SASOL being a prime example. Government research institutions and public universities undertake world-class research and development (R&D) activities. The environment is supportive for our organization to develop more products from sugarcane.

Environmental Factors:

South Africa has a comprehensive environmental legal framework, showing that environmental factors are taken seriously. Ecological and environmental aspects such as air emissions (pollution), GHG, effluent discharge into natural water bodies, waste, and the use of natural resources are highly regulated. South Africa aims to prevent pollution whenever possible or reduce it. Our organization contributes positively to the reduction of pollution and carbon footprint through the production of bioenergy and biochemicals, which are biodegradable.

Legal Factors:

South Africa is a constitutional democracy, with numerous specific laws, such as tax laws, labour laws, consumer protection laws, health and safety laws, electricity laws, and environmental legislation, to name a few. Our organization will analyse our processes and ensure that all laws triggered by our activities are complied with and stay abreast of any changes in legislation.

5.4.2 Key differentiators and unique selling points

BCM key differentiator is that our business is a diversified baseload bioenergy producer that also produces other biochemicals, using mainly surplus sugarcane as feedstock.

5.4.3 Value chain analysis

Cultivation of the Feedstock

The bioenergy production process begins in the fields where sugarcane is planted and harvested. This initial stage of the value chain is well-developed due to the sugar industry. The sugarcane to be utilized is sourced from the rainfed growing region of the Midlands.

Transformation into Bioenergy

After harvest, sugarcane is transported to the sugar mill and BCM plant. All sugarcane that goes to the sugar mill is used to produce sugar. The remaining molasses and bagasse are sent to BCM. All sugarcane transported to BCM is converted into bioenergy; specifically, sugar juice and molasses, along with molasses from the sugar mill, are converted to bioethanol through advanced fermentation and distillation processes.

Distribution and Blending

After bioethanol production, bioethanol is transported from the BCM to South African Petroleum Refineries (SAPREF) through virtual pipelines (trucks and rail), where it is distributed to petroleum refineries and blending stations via pipeline. Bioethanol is blended with conventional petrol, improving the combustion properties of conventional petrol and reducing GHG emissions and other pollutants.

Value Creation Through Byproducts

Sugarcane harvesting, crushing, and bioethanol production processes result in valuable byproducts, such as sugarcane straws, bagasse, and CO_2 from the fermentation process. The bagasse and sugarcane straw are treated and utilized as feedstock for bioelectricity generation, while CO_2 captured during the fermentation process is sold for use in carbonation processes, such as the production of carbonated beverages.

5.4.4 Human Resources

BCM will need 128 employees during operations. The breakdown of these employees and costs is provided in Appendix 6.

5.4.5 Competitor analysis

Although South Africa began investigating the possibility of producing biofuels in the early 2000s, there is currently no company that produces bioenergy at a commercial scale. The only company that aims to produce only fuel-grade bioethanol is Mabele Fuels, a start-up planning to convert sorghum into bioethanol located in the Free State Province. BCM has a competitive advantage in producing bioelectricity, industrial-grade CO_2, and bioplastics, using sugarcane as feedstock, while leveraging the established sugarcane value chain.

5.5 Strategic plan

5.5.1 Vision, mission and objective

Vision,

To be an enabler of individuals and businesses to conduct their activities in a manner that is harmonious with Mother Earth, where together with our customers are changing our world for the better.

Mission

As an integrated renewable energy and biochemical company, we strive to provide baseload renewable energy to provide our customers and biodegradable products.

Business objectives

BCM's main purpose is to produce and supply bioenergy and biochemical products that assist in decarbonizing the South African economy using sugarcane as feedstock.

5.5.2 Sources of sustainable competitive advantage.

Our capabilities are the main source of our competitive advantage. Our people are uniquely trained, with streamlined processes and technology that produce bioenergy and biochemical products that enable economic growth. Using the VIRO framework, Value - bioenergy provides a competitive advantage as it produces fewer greenhouse gases while offering high levels of job opportunities in the value chain. Rarity - in South Africa, fuel-grade bioethanol is not produced at a commercial scale, and barriers to entry (such as high start-up costs, government regulations, and licensing) are significant. Imitability - the cost of replicating our business is very high for potential rivals. We are appropriately organized to leverage our capabilities; therefore, we have a sustainable competitive advantage.

5.5.3 Competitive position

BCM is aiming to be first to market with baseload renewable bioenergy. Our product and services not only enable individuals and business to conduct their activities in a manner that reduce climate change and pollution, but also create sustainable livelihood through the value chain.

5.5.4 Market positioning

BCM is positioning itself as a producer of high-quality products at an affordable cost to the consumer.

5.5.5 Brand strategy

The brand strategy of BCM is underpinned by the 4Cs of brand strategy: company, category, consumer, and culture. BCM, as a company, produces baseload bioenergy from sugarcane. The South African economy is stagnant, resulting in high levels of unemployment; energy insecurity is one reason behind this economic phenomenon. BCM will produce energy to power the economy while creating direct jobs and jobs through its value chain. Consumers are becoming more environmentally conscious, thus needing energy from renewable sources. Our culture is based on continuous innovation to develop more efficient, high-quality products.

5.6 Marketing plan

5.6.1 Market segments, size, and growth

Our business's target market is other businesses. The bioelectricity business targets Eskom, other Municipal Electricity Utilities, and large private companies (industries). There are more than 15 municipal electricity utilities in South Africa, with many listed and unlisted companies requiring over 15 megawatts. The bioethanol business will target the top five petroleum companies in South Africa: Sasol Oil, Astron Energy, Engen Petroleum, BP Southern Africa, Shell South Africa, TotalEnergies South Africa, Puma Energy South Africa, and PetroSA. South Africa currently consumes more than 2 billion liters of petrol per annum. The volume of petrol consumption has been fairly stable since 2021 (FIASA, 2024).

5.6.2 Description of customers, needs and value proposition

South African energy consumers need cost effective energy that meets the imperatives of improving ambient air quality and reducing GHG emissions from both electricity and transportation. We aim to satisfy customer needs by providing low-carbon fuels and bioelectricity, thus contributing to a secure and sustainable energy future that aligns with South Africa's net-zero objective by 2050.

5.6.3 Pricing and discounting

The pricing of electricity will be governed by the Power Purchasing Agreement, and bioethanol pricing is regulated by the Department of Mineral Resources and Energy, similar to petroleum products.

5.6.4 Market forecasts

More than 80% of the energy used in South Africa comes from fossil fuels, with electricity being a prime example, as shown in Figure *7*. We forecast growth in renewable energy as fossil fuels decrease in pursuit of the net-zero objective by 2050.

5.7 Operations /production

5.7.1 Physical location

BCM will be located in the Midlands, KwaZulu-Natal, adjacent to the Illovo Sugar Limited Eston Mill, Eston. The location (Figure 4) is about 60 km from SAPREF, which was South Africa's largest oil refinery and still has a petroleum pipeline to Gauteng that will be leveraged to transport bioethanol for blending at either National Petroleum Refiners of South Africa (NATREF) or SASOL Secunda refineries or any inland blending petroleum depot. The site has Eskom's Illovo Substation, which will be upgraded to evacuate electricity from our business.

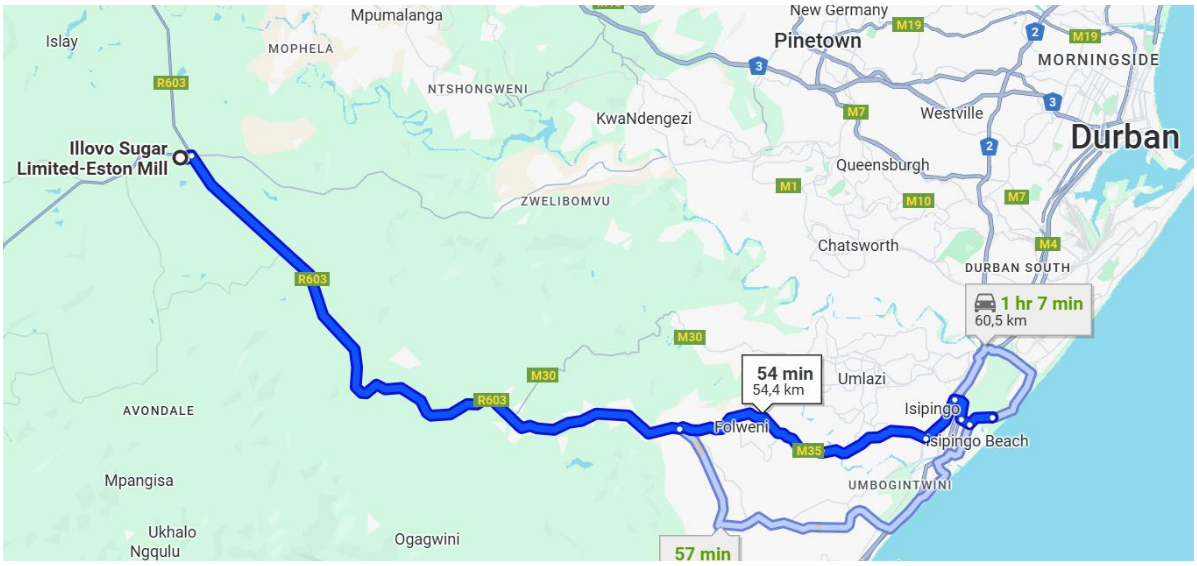

Figure 4. BCM Location (adjacent to Eston Mill)

Source: google maps

5.7.2 The production process

The high-level production process and facilities are indicated in Figure 5.

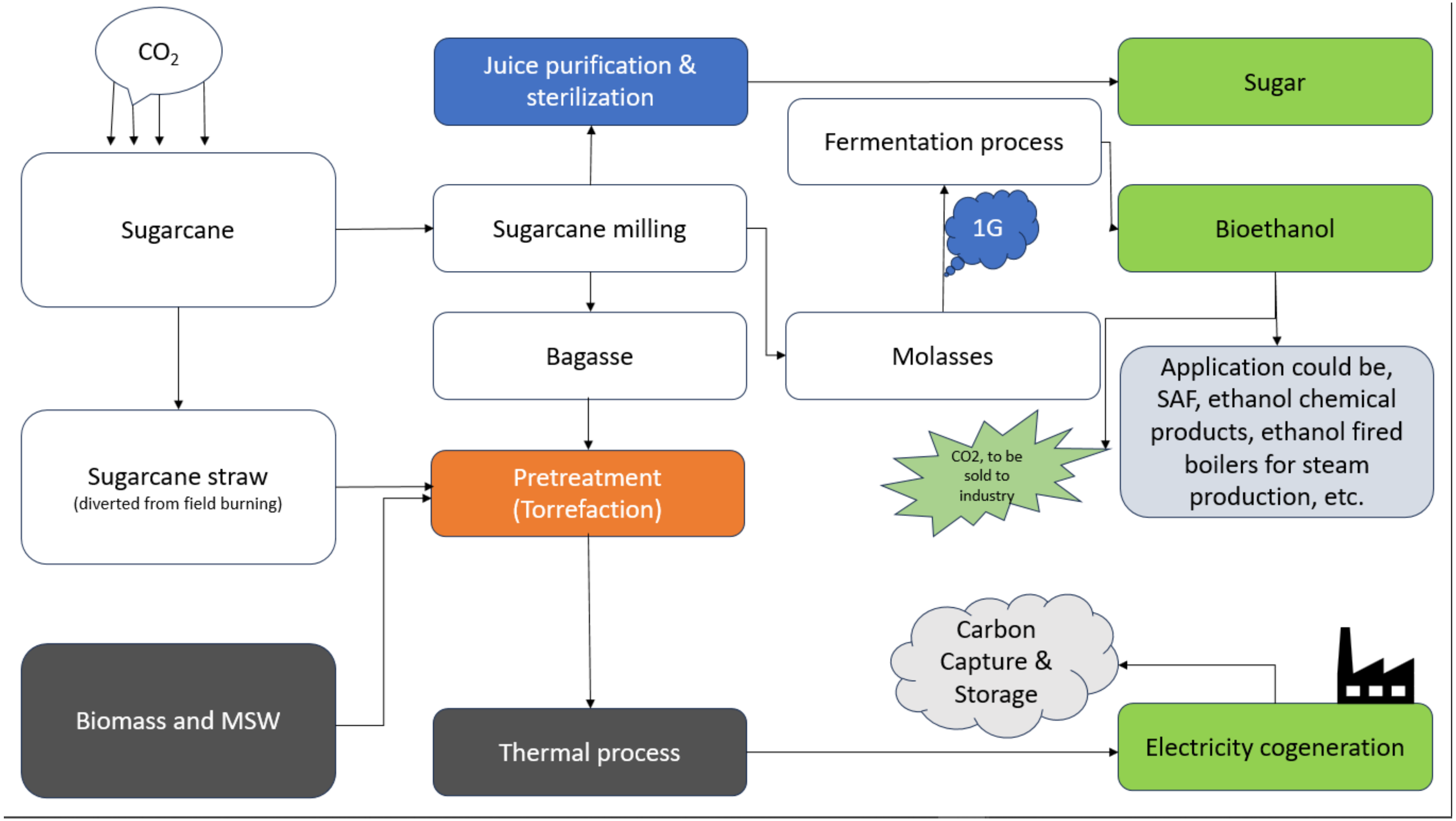

Figure 5. Process flow chart of the integrated sugarcane processing plant.

The author, adopted the process flow diagram (Figure 5) from (Carminati et al., 2019; Kalifa et al., 2024; Karp et al., 2021; Tapia Carpio & Simone de Souza, 2019)

The operations are scalable, depending on feedstock, licensing, and product evacuation channels. The engineering and design support will be provided by the original equipment manufacturer, such as Dabonn (Dabonn, 2024).

The quality management system (QMS) based on ISO 9001 will be implemented to ensure that our products meet the specified, regulated quality.

5.8 Research and development

BCM applies forward-thinking research with the aim of developing high-quality and improving current biologically based products. The BCM Research and Development team is made up of highly skilled scientists and engineers who collaborate with a network of research partners at universities, government research institutes, such as the Council for Scientific and Industrial Research, and companies from all over the world. We believe that collaboration with specialists affords us a powerful resource for development, new knowledge, and increased efficiency in our processes.

5.9 Management and organisation

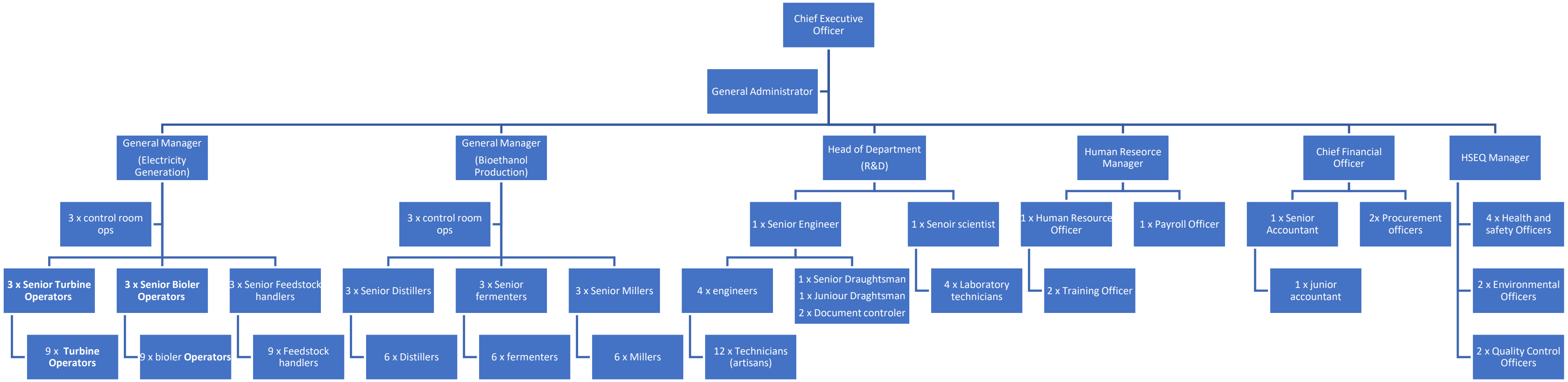

Figure 6. BCM organisation chart

5.9.1 Top Management

BCM shareholders have ultimate control of the company; they will select and vote for the Board of Directors. The main role of the Board of Directors is to provide overall leadership, oversight, and the appointment of professional managers (CEO and CFO) chosen by the Board. Shareholders elect the Board of Directors and vote on corporate and shareholder proposals. BCM's top management team includes the CEO, CFO, General Managers, Head of Research and Development, and Human Resources Manager. Staffing recruitment will be conducted by department heads in collaboration with the Human Resources Manager, who will also ensure that employees receive the required training. The office space will be located within the production facility of BCM.

5.9.2 Staffing requirements

It is estimated that BCM will require a total of 128 employees during operations, as detailed with costs in Table *4*.

Table 4: Employment and related costs

BioEnergy Campus Midlands (Pty) Ltd						
Employment and related costs						
Years 1 to 5						
Rands (ZAR)						
	Number	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Electricity Generation	40	11 507 660	12 198 120	13 154 877	14 301 712	15 159 815
Ethanol Plant	40	11 507 660	12 198 120	13 154 877	14 301 712	15 159 815
Research and Development	27	12 751 075	13 516 139	14 576 275	15 847 027	16 797 848
General & Administration	21	13 089 234	13 874 588	14 707 063	15 589 487	16 524 856
Total	128	48 855 629	51 786 967	55 593 091	60 039 938	63 642 334

5.10 Forecasts and Financial data

5.10.1 Summary of performance ratios

Table 5 provides a summary of the financials and performance ratios forecasted over five years.

Table 5: Summary Financials and performance ratios

BioEnergy Campus Midlands (Pty) Ltd					
Summary of performance ratios					
Years 1 to 5					
Rands (ZAR)					
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Summary Financials					
Revenue	977 875 407	1 089 315 544	1 209 509 273	1 339 056 611	1 412 472 830
Gross Profit	369 617 309	432 592 038	530 358 748	625 246 121	615 984 992
EBIT	434 077 034	503 767 558	590 013 241	677 916 210	676 004 759
EBITDA	548 424 465	624 890 292	718 175 201	813 328 873	820 022 381
Net Earnings	-30 922 966	124 249 518	266 459 666	418 228 833	421 220 774
Net Cash from Operating Activities	45 991 394	246 727 192	391 753 558	549 470 072	562 874 393
Capital Expenditures	17 000 000	4 250 000	2 700 000	3 250 000	3 350 000
Interest Income/(Expense)	-465 000 000	-345 000 000	-225 000 000	-105 000 000	-98 990 000
Dividends	0	0	0	0	0
Cash	2 113 925 349	1 356 402 541	745 456 099	291 676 171	801 200 565
Total Equity	9 019 077 034	9 143 326 552	9 409 786 218	9 828 015 052	10 249 235 826
Total Long term Debt	3 500 000 000	2 500 000 000	1 500 000 000	500 000 000	450 000 000
Growth					
Revenue Growth Rate - CAGR:		11%	11%	11%	5%
Ratios					
Current Ratio	2,7	1,9	1,2	0,7	1,3
Debt to Capital (LT Debt + Equity)	0,3	0,2	0,1	0,0	0,0
Profitability					
Gross Profit %	37,8%	39,7%	43,8%	46,7%	43,6%
Operating Expenses %	5,0%	4,9%	4,8%	4,7%	4,7%
Net Earnings %	-3,2%	11,4%	22,0%	31,2%	29,8%
Returns					
Return on Assets	-0,2%	1,0%	2,3%	3,7%	3,6%

5.10.1 Sales forecast

Table 6 provides revenue projections and sales forecasts (number of units) for the electricity and bioethanol businesses over a five-year period.

Table 6: Revenue forecast

BioEnergy Campus Midlands (Pty) Ltd					
Revenue Projections					
Years 1 to 5					
Rands (ZAR)					
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Electricity (kWh)					
Number of Units (kWh)	378 432 000	425 736 000	473 040 000	520 344 000	520 344 000
Price per unit	1,2	1,2	1,3	1,3	1,4
Total (ZAR)	435 196 800	514 076 220	599 755 590	692 717 706	727 353 592
Ethanol (l)					
Potential Number of Units (l)	109 261 449	113 259 466	107 166 637	105 196 336	115 013 109
Operating Capacity (l)	109 250 000	109 250 000	109 250 000	109 250 000	109 250 000
Price per unit	5	5	6	6	6
Total	542 678 607	575 239 324	609 753 683	646 338 904	685 119 238
Carbon dioxide (l)					
Number of Units	0	0	0	0	0
Price per unit		0	0	0	0
Total	0	0	0	0	0
Net Revenue	R 977 875 407	R 1 089 315 544	R 1 209 509 273	R 1 339 056 611	R 1 412 472 830
	Revenues by Months & Quarters				
Months	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Month 1	0	54 465 777	60 475 464	66 952 831	70 623 642
Month 2	0	54 465 777	60 475 464	66 952 831	70 623 642
Month 3	0	76 252 088	84 665 649	93 733 963	98 873 098
Total 1st Quarter	0	185 183 642	205 616 576	227 639 624	240 120 381
Month 4	48 893 770	65 358 933	72 570 556	80 343 397	84 748 370
Month 5	78 230 033	76 252 088	84 665 649	93 733 963	98 873 098
Month 6	97 787 541	76 252 088	84 665 649	93 733 963	98 873 098
Total 2nd Quarter	224 911 344	217 863 109	241 901 855	267 811 322	282 494 566
Month 7	97 787 541	87 145 244	96 760 742	107 124 529	112 997 826
Month 8	117 345 049	108 931 554	120 950 927	133 905 661	141 247 283
Month 9	146 681 311	108 931 554	120 950 927	133 905 661	141 247 283
Total 3rd Quarter	361 813 901	305 008 352	338 662 597	374 935 851	395 492 392
Month 10	117 345 049	119 824 710	133 046 020	147 296 227	155 372 011
Month 11	127 123 803	130 717 865	145 141 113	160 686 793	169 496 740
Month 12	146 681 311	130 717 865	145 141 113	160 686 793	169 496 740
Total 4th Quarter	391 150 163	381 260 440	423 328 246	468 669 814	494 365 491
Total for year	977 875 407	1 089 315 544	1 209 509 273	1 339 056 611	1 412 472 830
Average Revenue					
by Month	81 489 617	90 776 295	100 792 439	111 588 051	117 706 069
by Quarter	244 468 852	272 328 886	302 377 318	334 764 153	353 118 208

5.10.2 Assumptions underpinning financial forecasts

The financial forecast for the bioethanol business is underpinned by mandatory blending regulations for biofuels with petrol and diesel; these create a captive market, regulated prices, and government incentives. This means that the bioethanol produced will be absorbed by the market. Similarly, the financial forecast for bio-electricity is supported by a long-term (20 years) PPA and the imperative that the South African economy must transition from fossil fuel-based electricity to electricity from renewable sources.

5.10.3 Profit and loss account (income statement)

Table *7* provides the profit and loss account over a five-year period, showing a loss in the first year and profitability from the second year.

Table 7: Income statement

BioEnergy Campus Midlands (Pty) Ltd					
Income Statement					
Years 1 to 5					
Rands (ZAR)					
	Year 1	Year 2	Year 3	Year 4	Year 5
NET REVENUES	977 875 407	1089 315 544	1209 509 273	1339 056 611	1412 472 830
COST OF REVENUE	608 258 098	656 723 506	679 150 526	713 810 490	796 487 838
% of Revenues	62,2%	60,3%	56,2%	53,3%	56,4%
GROSS PROFIT	369 617 309	432 592 038	530 358 748	625 246 121	615 984 992
% of Revenues	37,8%	39,7%	43,8%	46,7%	43,6%
OPERATING EXPENSES					
Research & Development	23 029 829	24 934 295	27 222 617	29 816 405	31 530 330
General and Administration	25 698 040	27 975 598	30 506 190	32 729 475	34 464 324
Total Operating Expenses	48 727 868	52 909 893	57 728 807	62 545 881	65 994 653
% of Revenues	5%	5%	5%	5%	5%
EARNINGS FROM OPERATIONS	320 889 441	379 682 145	472 629 940	562 700 240	549 990 339
Other INCOME / (EXPENSE)	113 187 594	124 085 413	117 383 301	115 215 970	126 014 420
EARNINGS BEFORE INTEREST & T	434 077 034	503 767 558	590 013 241	677 916 210	676 004 759
INTEREST INCOME / (EXPENSE)	-465 000 000	-345 000 000	-225 000 000	-105 000 000	-98 990 000
NET EARNINGS BEFORE TAXES	-30 922 966	158 767 558	365 013 241	572 916 210	577 014 759
TAXES	0	-34 518 040	-98 553 575	-154 687 377	-155 793 985
NET EARNINGS	-30 922 966	124 249 518	266 459 666	418 228 833	421 220 774
% of Revenues	-3,2%	11,4%	22,0%	31,2%	29,8%

5.10.4 Balance sheet

Table 8: Balance sheet

BioEnergy Campus Midlands (Pty) Ltd						
Balance Sheet						
Years 1 to 5						
Rands (ZAR)						
	Begin	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
ASSETS						
CURRENT ASSETS						
Cash	790 933 955	2 113 925 349	1 356 402 541	745 456 099	291 676 171	801 200 565
Accounts Receivable		172 106 072	156 861 438	169 331 298	187 467 925	197 746 196
Inventories		172 106 072	156 861 438	169 331 298	187 467 925	197 746 196
Other Current Assets		17 601 757	15 686 144	16 933 130	18 746 793	19 774 620
Total Current Assets	790 933 955	2 475 739 250	1 685 811 561	1 101 051 825	685 358 815	1 216 467 577
PROPERTY & EQUIPMENT	10 965 066 045	10 867 718 614	10 750 845 881	10 625 383 921	10 493 221 257	10 352 553 636
TOTAL ASSETS	11 756 000 000	13 343 457 864	12 436 657 442	11 726 435 746	11 178 580 072	11 569 021 213
LIABILITIES & SHAREHOLDERS' EQUITY						
CURRENT LIABILITIES						
Short Term Debt	0	500 000 000	500 000 000	500 000 000	500 000 000	500 000 000
Accounts Payable & Accrued Expen		152 274 758	136 469 451	147 318 229	163 097 095	172 039 191
Other Current Liab		172 106 072	156 861 438	169 331 298	187 467 925	197 746 196
Current portion of long term debt	100 000 000	100 000 000	100 000 000	100 000 000	100 000 000	100 000 000
Total Current Liabilities	100 000 000	924 380 830	893 330 890	916 649 528	950 565 021	969 785 387
LONG TERM DEBT (less current portion)	4 400 000 000	3 400 000 000	2 400 000 000	1 400 000 000	400 000 000	350 000 000
SHAREHOLDERS' EQUITY						
Ordinary shares	6 000 000	0	0	0	0	0
Preferred shares	7 250 000 000	9 050 000 000	9 050 000 000	9 050 000 000	9 050 000 000	9 050 000 000
Retained Earnings		-30 922 966	93 326 552	359 786 218	778 015 052	1 199 235 826
Total Equity	7 256 000 000	9 019 077 034	9 143 326 552	9 409 786 218	9 828 015 052	10 249 235 826
TOTAL LIABILITIES & EQUITY	11 756 000 000	13 343 457 864	12 436 657 442	11 726 435 746	11 178 580 072	11 569 021 213

5.10.5 Cash flow statement

Table *9* shows that BCM is forecasting a positive cash flow; this will enable it to meet its commitments.

Table 9: Cash flow statement

BioEnergy Campus Midlands (Pty) Ltd						
Cash Flow Statememt						
Years 1 to 5						
Rands (ZAR)						
		Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
OPERATING ACTIVITIES						
Net Earnings		-30 922 966	124 249 518	266 459 666	418 228 833	421 220 774
Depreciation		114 347 430	121 122 734	128 161 960	135 412 663	144 017 621
Working Capital Changes						
(Increase)/Decrease Accounts Receivable		-172 106 072	15 244 633	-12 469 860	-18 136 627	-10 278 271
(Increase)/Decrease Inventories		-172 106 072	15 244 633	-12 469 860	-18 136 627	-10 278 271
(Increase)/Decrease Other Current Assets		-17 601 757	1 915 614	-1 246 986	-1 813 663	-1 027 827
Increase/(Decrease) Accts Pay & Accrd Expenses		152 274 758	-15 805 307	10 848 778	15 778 866	8 942 096
Increase/(Decrease) Other Current Liab		172 106 072	-15 244 633	12 469 860	18 136 627	10 278 271
Net Cash Provided/(Used) by Operating Activities		45 991 394	246 727 192	391 753 558	549 470 072	562 874 393
INVESTING ACTIVITIES						
Property & Equipment		-17 000 000	-4 250 000	-2 700 000	-3 250 000	-3 350 000
Other						
Net Cash Used in Investing Activities		-17 000 000	-4 250 000	-2 700 000	-3 250 000	-3 350 000
FINANCING ACTIVITIES						
Increase/(Decrease) Short Term Debt		500 000 000	0	0	0	0
Increase/(Decrease) Curr. Portion LTD		0	0	0	0	0
Increase/(Decrease) Long Term Debt		-1000 000 000	-1000 000 000	-1000 000 000	-1000 000 000	-50 000 000
Increase/(Decrease) Common Stock		-6 000 000	0	0	0	0
Increase/(Decrease) Preferred Stock		1800 000 000	0	0	0	0
Dividends Declared		0	0	0	0	0
Net Cash Provided / (Used) by Financing		1294 000 000	-1000 000 000	-1000 000 000	-1000 000 000	-50 000 000
INCREASE/(DECREASE) IN CASH		1322 991 394	-757 522 808	-610 946 442	-453 779 928	509 524 393
CASH AT BEGINNING OF YEAR		790 933 955	2 113 925 349	1356 402 541	745 456 099	291 676 171
CASH AT END OF YEAR	790 933 955	2 113 925 349	1356 402 541	745 456 099	291 676 171	801 200 565

5.10.6 Discounted cash flow and internal rate of return

Table *10*, present discounted cash flow, with an internal rate of return (IRR) of 230%, indicates that the cost of capital exceeds the return on investment.

Table 10: Discounted Cash Flow

BioEnergy Campus Midlands (Pty) Ltd						
Discounted Cash Flow						
Years 1 to 5						
Rands (ZAR)						
Rate of Return	10%					
Years	0	1	2	3	4	5
Cash Outflow	-790933955,1					
Cash Inflow		2 113 925 349	1 356 402 541	745 456 099	291 676 171	801 200 565
Net Cash Flow	-790933955,1	2113925349	1356402541	745456098,8	291676171,3	801200564,7
Discounted Cash Flow	-790933955,1	1921750317	1120993835	560072200,5	199218749,6	497482514,7
NPV	3 508 583 662					
NPV (calculated)	3 508 583 662					
Internal rate of return	230%					

5.10.7 Payback Period

Table *11* shows the forecasted break-even revenues and indicates that the average payback period is 16 years over a span of five years.

Table 11: Break-Even Analysis

BioEnergy Campus Midlands (Pty) Ltd						
Break-Even Analysis						
Years 1 to 5						
Rands (ZAR)						
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	
Revenue	977 875 407	1 089 315 544	1 209 509 273	1 339 056 611	1 412 472 830	
Cost of Revenue						
Variable	319 423 787	352 071 016	356 910 481	371 906 835	432 819 709	
Fixed	288 834 311	304 652 489	322 240 045	341 903 655	363 668 129	
Total	608 258 098	656 723 506	679 150 526	713 810 490	796 487 838	
Operating Expenses						
Variable	19 557 508	21 786 311	24 190 185	26 781 132	28 249 457	
Fixed	29 170 360	31 123 582	33 538 622	35 764 749	37 745 197	
Total	48 727 868	52 909 893	57 728 807	62 545 881	65 994 653	
Total Costs & Expenses						
Variable	338 981 295	373 857 327	381 100 667	398 687 967	461 069 166	
Fixed	318 004 672	335 776 071	355 778 666	377 668 403	401 413 325	
Total	656 985 967	709 633 398	736 879 333	776 356 371	862 482 491	
Variable Costs/Revenue Ratio	0,35	0,34	0,32	0,30	0,33	
Break-Even Point Revenues	486 730 026	511 233 340	519 450 900	537 788 425	595 946 218	
Payback Period	15	6	9	15	34	**Years**
Average payback period over 5 years	16	Years				

Sensitivity analysis is not applicable because the price of bioethanol is regulated and price of electricity is governed by PPA.

5.11 Financing

5.11.1 Summary of operations prior to financing

BCM is undertaking pre-operation activities such as technical feasibility studies, environmental authorization studies, licensing with various government agencies, fundraising, establishing partnerships, sourcing land for construction, marketing, advertising, and hiring key personnel, as well as legal and technical advisers.

5.11.2 Current shareholder loans outstanding

BCM has no outstanding shareholder loans.

5.11.3 Use of proceeds

The proceeds will be used to fund pre-construction, the construction phase, and the commissioning phase. The specific details, funding, actual activities, and costs are provided in Table *12*.

Table 12: Use of proceeds from fundraising

BioEnergy Campus Midlands (Pty) Ltd								
Use of Proceeds from fundraising								
Years 1 to 5								
Rands (ZAR)								
		Pre-construction	Pre -operation (construction) phase				Commissioning & commercial operation	
	rate		**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Funds available								
Common stock		1 000 000						
Prefeasibility funding		5 000 000						
Equity funding			3 501 000 000	2 011 000 000	1 561 000 000	61 000 000	61 000 000	61 000 000
Debt funding			0	3 900 000 000	1 450 000 000	250 000 000	100 000 000	0
Total funding		**6 000 000**	**3 501 000 000**	**5 911 000 000**	**3 011 000 000**	**311 000 000**	**161 000 000**	**61 000 000**
Available cash (TF + S/d)		**6 000 000**	**3 501 200 000**	**7 214 149 000**	**6 416 614 463**	**3 069 242 015**	**2 196 920 771**	**1 276 930 145**
Activities								
Technical feasibility studies		3 000 000	3 000 000	3 000 000				
Environmental Authorisation		1 000 000	2 000 000	2 000 000				
Legal Advisors		500 000	10 000 000					
Fundraiser commission (0,1%)	0,10%	0	3 501 000	2 011 000	1 561 000	61 000	61 000	61 000
Licensing			1 500 000			1 500 000		
Land for construction (99 year lea	5%		1 000 000	1 050 000	1 102 500	1 157 625	1 215 506	1 276 282
EPC contractor			2 000 000 000	3 500 000 000	3 500 000 000	1 000 000 000		
Sales & marketing			1 000 000	1 000 000	1 000 000			
Management		1 000 000	1 000 000	3 923 537	4 158 949	15 052 619	15 955 776	17 207 264
Operations		0	0	0	0	0	955 708 343	999 656 547
Reserve account (5% of funding)	5%	300 000	175 050 000	295 550 000	150 550 000	15 550 000	8 050 000	3 050 000
Total Expenditure		**5 800 000**	**2 198 051 000**	**3 808 534 537**	**3 658 372 449**	**1 033 321 244**	**980 990 626**	**1 021 251 092**
Surplus/deficit		**200 000**	**1 303 149 000**	**3 405 614 463**	**2 758 242 015**	**2 035 920 771**	**1 215 930 145**	**255 679 053**

5.11.4 Funds required and timing (funding projections)

Table *13* The funding projections forecast that all shareholders are investing for the long term.

Table 13: Funding Projections

BioEnergy Campus Midlands (Pty) Ltd						
Funding Projections						
Years 1 to 5						
Rands (ZAR)						
	Begin	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Beginning Cash	790 933 955					
Equity						
Ordinary Shares	6 000 000					
Increase / (Decrease) Previous Period		-6 000 000	0	0	0	0
Preferred Shares						
Shareholder 1	550 000 000	550 000 000	550 000 000	550 000 000	550 000 000	550 000 000
Shareholder 2	1 200 000 000	1 200 000 000	1 200 000 000	1 200 000 000	1 200 000 000	1 200 000 000
Shareholder 3	1 500 000 000	1 500 000 000	1 500 000 000	1 500 000 000	1 500 000 000	1 500 000 000
Shareholder 4	2 000 000 000	2 000 000 000	2 000 000 000	2 000 000 000	2 000 000 000	2 000 000 000
Shareholder 5	2 000 000 000	2 000 000 000	2 000 000 000	2 000 000 000	2 000 000 000	2 000 000 000
Shareholder 6	0	1 800 000 000	1 800 000 000	1 800 000 000	1 800 000 000	1 800 000 000
Total Preferred	7 250 000 000	9 050 000 000	9 050 000 000	9 050 000 000	9 050 000 000	9 050 000 000
Increase / (Decrease) Previous Period		1 800 000 000	0	0	0	0
Total Equity	7 256 000 000	9 050 000 000	9 050 000 000	9 050 000 000	9 050 000 000	9 050 000 000
Debt						
Short Term Debt		500 000 000	500 000 000	500 000 000	500 000 000	500 000 000
Increase / (Decrease) Previous Period		500 000 000	0	0	0	0
Long Term Debt						
Current Portion	100 000 000	100 000 000	100 000 000	100 000 000	100 000 000	100 000 000
Long Term Portion	4 400 000 000	3 400 000 000	2 400 000 000	1 400 000 000	400 000 000	350 000 000
Total Long Term Debt	4 500 000 000	3 500 000 000	2 500 000 000	1 500 000 000	500 000 000	450 000 000
Increase / (Decrease) Previous Period						
Current Portion		0	0	0	0	0
Long Term Protion		-1 000 000 000	-1 000 000 000	-1 000 000 000	-1 000 000 000	-50 000 000
Total Long Term Debt		-1 000 000 000	-1 000 000 000	-1 000 000 000	-1 000 000 000	-50 000 000

Total Long Term Debt -1 000 000 000 -1 000 000 000 -1 000 000 000 -1 000 000 000 -50 000 000

Total Equity & Debt	11 756 000 000	13 050 000 000	12 050 000 000	11 050 000 000	10 050 000 000	10 000 000 000
Interest						
Interest Rate						
Short Term Debt		9,0%	9,0%	9,0%	9,0%	9,0%
Long Term Debt		12,0%	12,0%	12,0%	12,0%	12,0%
Interest Expense						
Short Term Debt		45 000 000	45 000 000	45 000 000	45 000 000	45 000 000
Long Term Debt		420 000 000	300 000 000	180 000 000	60 000 000	54 000 000
Total Interest		465 000 000	345 000 000	225 000 000	105 000 000	99 000 000
Interest Income						
Interest Rate		4,0%	4,0%	4,0%	4,0%	4,0%
Interest Income		0	0	0	0	10 000
Retained Earnings						
Net Income		-30 922 966	124 249 518	266 459 666	418 228 833	421 220 774
Dividends						
Increase / (Decrease) Retained Earnings		-30 922 966	124 249 518	266 459 666	418 228 833	421 220 774
Beginning Retained Earnings		0	-30 922 966	93 326 552	359 786 218	778 015 052
Ending Retained Earnings		-30 922 966	93 326 552	359 786 218	778 015 052	1 199 235 826

5.11.5 The deal on offer

The deal on offer for investors is to lead the market in addressing the clean energy insecurity that consumers face. The solution involves the production of baseload renewable energy and biochemical products. This approach is supported by a team of highly qualified, dedicated professionals who, through innovation, are providing solutions to climate change through Just Energy Transition.

5.11.6 Anticipated gearing and interest cover

BCM anticipates having a low gearing ratio, with debt limited to 40% and equity at 60%, and interest rates on short-term and long-term debt at 9% and 12%, respectively.

5.11.7 Exit routes for investors.

The exit strategy for shareholders includes mergers and acquisitions, initial public offerings (IPOs), as well as filing for liquidation or bankruptcy should BCM fail to operate sustainably.

5.12 Risk analysis

5.12.1 Risk overview and Specific risks

BCM faces five main categories of risk, namely environmental, regulatory compliance, operational, reputational, and safety and security risks.

- Environmental - due to climate change, the risk of drought may result in crop failure and a decrease in feedstock.
- Regulatory compliance - changes in legislation might introduce unforeseen significant costs to BCM.
- Operational - efficiency in operations may reduce over time.
- Reputational risk - this could stem from unethical conduct by managers and leaders.
- Safety and security - high unemployment in South Africa contributes to elevated levels of violent crime.

5.12.2 Limiting factors and risk-reduction strategies

- The environmental risk stated above is mitigated by a government regulatory framework that permits the importation of biofuel feedstocks in the event of crop failure arising from natural disasters (DMRE, 2020). Furthermore, the electricity generation plant will be designed to utilize MSW as feedstock.
- Regulatory compliance will be ensured through an updated legal register, as well as a PPA that protects BCM if there is a change in law that results in a cost increase of more than R200,000. Bioethanol pricing will be set by a government department.
- Operational efficiency risk will be mitigated through preventative maintenance and upskilling of staff.
- Reputational risk will be mitigated by having sound policies that discourage and punish unethical behavior.
- Safety and security risks will be mitigated through a number of strategies that involve employing technology, physical engineering solutions, and personnel.

5.12.3 Critical success factors

The success factors are a highly skilled team, innovation through R&D, high-quality products produced efficiently, positive cash flow, and effective sales and marketing.

5.12.6 Business controls Information technology

BCM will employ a state-of-the-art IT system that will provide internal control of all processes, ensuring the integrity and confidentiality of data and ease of management.

5.12.7 Operations Other controls

BCM is a high-tech business, and comprehensive procedures will be used to manage and control its operations. To ensure high-quality production, ISO 9001 will be employed as a standard.

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7 Appendices

Appendix 1: t-Test: Paired Two Samples for Means was computed

	Zululand	Midlands
	Variable 1	*Variable 2*
Mean	4 104 461	3 331 959
Variance	3,81760E+11	1,04085E+11
Observations	13	13
Pearson Correlation	0,6424	
Hypothesized Mean Difference	0	
df	12	
t Stat	5,811055	
P(T<=t) one-tail	0,000042	
t Critical one-tail	1,782288	
P(T<=t) two-tail	0,000083	
t Critical two-tail	2,178813	

Appendix 2: Anova & Cronbach Alpha

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	4,93E+12	12	4,11109E+11	2,893416451	0,006768	2,032703
Columns	2,22E+13	3	7,38583E+12	51,98201111	3,65E-13	2,866266
Error	5,12E+12	36	1,42084E+11			
Total	3,22E+13	51				
	Cronbach Alpha		0,7			

Appendix 3: Sugar production efficiency

BioEnergy Campus Midlands (Pty) Ltd						
	Saleable sugar produced					
			Saleable sugar produced			
Year	Total Cane crushed (tons)	RV Cane price (Rands/ton)	National Market (tons)	International Market (tons)	Total (tons)	Sugar conversion Efficiency %
2006	21 052 266	173,59	1 261 808	1 238 696	2 500 504	12%
2007	20 278 603	198,78	1 340 524	886 329	2 226 853	11%
2008	19 723 916	208,82	1 399 657	873 842	2 273 499	12%
2009	19 255 404	251,00	1 438 587	821 657	2 260 244	12%
2010	18 655 089	284,15	1 412 273	766 177	2 178 450	12%
2011	16 015 649	331,55	1 583 457	377 879	1 961 336	12%
2012	16 800 277	352,38	1 685 312	137 176	1 822 488	11%
2013	17 278 020	389,08	1 701 731	249 785	1 951 516	11%
2014	20 032 969	394,63	1 543 264	800 386	2 343 650	12%
2015	17 755 537	443,50	1 649 056	458 617	2 107 673	12%
2016	14 861 401	475,89	1 573 504	46 826	1 620 330	11%
2017	15 074 610	564,39	1 534 741	4 998	1 539 739	10%
2018	17 388 177	522,46	1 190 281	795 434	1 985 715	11%
2019	19 031 688	451,58	1 140 990	1 042 831	2 183 821	11%
2020	19 241 812	531,00	1 249 476	967 579	2 217 055	12%
2021	18 220 466	613,28	1 476 011	542 213	2 018 224	11%
2022	17 199 179	644,63	1 453 382	389 282	1 842 664	11%
2023	17 911 409	647,16	1 249 676	676 798	1 926 474	11%
2024	17 943 532	895,29	1 510 902	494 306	2 005 208	11%
					Average	11%
			Average efficiency is in line with *Shelar at al., 2023*			
	Data from: South African Sugar Association					
	Reference:		https://sasa.org.za/facts-and-figures/			

Appendix 4: Ethanol production Quantities

BioEnergy Campus Midlands (Pty) Ltd

Year	Zululand Cane crushed (tons)	North Coast Cane crushed (tons)	South Coast Cane crushed (tons)	Midlands Cane crushed (tons)	Midlands Sugar produced (tons)	Total Sugar produced (tons)
	Total sugarcane crashed by mills (Tons) in rainfed regions					
2006					0	
2007					0	
2008					0	
2009					0	
2010					0	
2011					0	
2012	3 978 265	2 764 357	1 989 673	2 874 162	311 788	11 606 457
2013	3 658 691	2 930 615	2 441 507	3 425 143	386 863	12 455 956
2014	4 478 848	3 632 170	3 032 796	3 522 817	412 133	14 666 631
2015	3 985 468	2 968 429	2 467 112	3 162 959	375 459	12 583 968
2016	3 299 075	1 808 169	2 054 759	2 546 256	277 617	9 708 259
2017	2 706 018	3 012 204	2 243 912	3 163 754	323 150	11 125 888
2018	3 838 963	3 081 015	2 676 133	3 423 151	390 921	13 019 262
2019	4 284 095	3 499 616	2 503 504	3 527 014	404 713	13 814 229
2020	4 382 176	3 369 897	2 655 952	3 510 972	404 537	13 918 997
2021	4 899 344	2 501 079	1 977 200	3 639 443	403 130	13 017 066
2022	4 553 923	2 466 700	1 946 235	3 443 658	368 942	12 410 516
2023	4 703 009	2 532 135	2 132 354	3 380 345	363 575	12 747 843
2024	4 590 122	2 799 916	2 072 584	3 695 794	413 009	13 158 416

Year	Midlands Estimated Ethanol produced Allocation of sugarcane crushed Production: Sugar & Molasses (tons)	Production of Ethanol only (tons)	Ethanol production from: Molasses (l)	Sugarcane crushed (l)	Ethanol plant "Operating Capacity" (l)
	68%	32%	10	76	
2006	-	-	-	-	
2007	-	-	-	-	
2008	-	-	-	-	
2009	-	-	-	-	
2010	-	-	-	-	
2011	-	-	-	-	
2012	1 954 430	919 732	19 544 302	69 899 620	89 443 921
2013	2 329 097	1 096 046	23 290 972	83 299 478	106 590 450
2014	2 395 516	1 127 301	23 955 156	85 674 909	109 630 065
2015	2 150 812	1 012 147	21 508 121	76 923 163	98 431 284
2016	1 731 454	814 802	17 314 541	61 924 946	79 239 487
2017	2 151 353	1 012 401	21 513 527	76 942 497	98 456 024
2018	2 327 743	1 095 408	23 277 427	83 251 032	106 528 459
2019	2 398 370	1 128 644	23 983 695	85 776 980	109 760 676
2020	2 387 461	1 123 511	23 874 610	85 386 839	109 261 449
2021	2 474 821	1 164 622	24 748 212	88 511 254	113 259 466
2022	2 341 687	1 101 971	23 416 874	83 749 763	107 166 637
2023	2 298 635	1 081 710	22 986 346	82 209 990	105 196 336
2024	2 513 140	1 182 654	25 131 399	89 881 710	115 013 109
	2 265 732				103 690 566

Appendix 5: Feedstock for bio-electricity estimation

BioEnergy Campus Midlands (Pty) Ltd

Year	bagasse (tons)	Bagasse (tons/day)	Sugarcane straw (trash) (ton	(tons/day)	Total biomass (tons/day)	RV Cane price (Rands/ton)	Est. bagass (Rands/ton)	Est straw (Rands/ton)	Total (Rands/ton)	Est. Total cost (bagasse & (rand/tons)
	Feedstock for bio-electricity					Estimated feedstock cost for bio-electricity				
	23%	365	12%	365						5%
2006						R 173,59	R 39,93	R 20,83	R 60,76	
2007						R 198,78	R 45,72	R 23,85	R 69,57	
2008						R 208,82	R 48,03	R 25,06	R 73,09	
2009						R 251,00	R 57,73	R 30,12	R 87,85	
2010						R 284,15	R 65,35	R 34,10	R 99,45	
2011						R 331,55	R 76,26	R 39,79	R 116,04	
2012	661 057	1 811	344 899	945	2 756	R 352,38	R 81,05	R 42,29	R 123,33	R 6,17
2013	787 783	2 158	411 017	1 126	3 284	R 389,08	R 89,49	R 46,69	R 136,18	R 6,81
2014	810 248	2 220	422 738	1 158	3 378	R 394,63	R 90,76	R 47,36	R 138,12	R 6,91
2015	727 481	1 993	379 555	1 040	3 033	R 443,50	R 102,01	R 53,22	R 155,23	R 7,76
2016	585 639	1 604	305 551	837	2 442	R 475,89	R 109,45	R 57,11	R 166,56	R 8,33
2017	727 663	1 994	379 650	1 040	3 034	R 564,39	R 129,81	R 67,73	R 197,54	R 9,88
2018	787 325	2 157	410 778	1 125	3 282	R 522,46	R 120,17	R 62,70	R 182,86	R 9,14
2019	811 213	2 223	423 242	1 160	3 382	R 451,58	R 103,86	R 54,19	R 158,05	R 7,90
2020	807 524	2 212	421 317	1 154	3 367	R 531,00	R 122,13	R 63,72	R 185,85	R 9,29
2021	837 072	2 293	436 733	1 197	3 490	R 613,28	R 141,05	R 73,59	R 214,65	R 10,73
2022	792 041	2 170	413 239	1 132	3 302	R 644,63	R 148,26	R 77,36	R 225,62	R 11,28
2023	777 479	2 130	405 641	1 111	3 241	R 647,16	R 148,85	R 77,66	R 226,51	R 11,33
2024	850 033	2 329	443 495	1 215	3 544	R 895,29	R 205,92	R 107,43	R 313,35	R 15,67

Appendix 6: Human Resources and Costing

BioEnergy Campus Midlands (Pty) Ltd							
Human Resources							
Years 1 to 5							
Rands (ZAR)							
	Number	rate (PM	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Inflation adjestment				6%	6%	6%	6%
Net Revenues			977 875 407	1 089 315 544	1 209 509 273	1 339 056 611	1 412 472 830
Cost of Revenue							
Electricity Generation							
Production Manager	1	80 095	961 142	1 018 811	1 079 939	1 144 736	1 213 420
Shift Supervisors (Turbine)	3	22 500	810 000	858 600	910 116	964 723	1 022 606
Shift Turbine Operator	9	17 800	1 922 400	2 037 744	2 160 009	2 289 609	2 426 986
Shift Supervisors (Boilers)	3	22 500	810 000	858 600	910 116	964 723	1 022 606
Shift Boiler Operator	9	17 800	1 922 400	2 037 744	2 160 009	2 289 609	2 426 986
Shift Supervisors (Feedstock)	3	22 500	810 000	858 600	910 116	964 723	1 022 606
Shift Feedstock handlers	9	15 683	1 693 719	1 795 342	1 903 063	2 017 246	2 138 281
Control Room Operators	3	29 917	1 077 000	1 141 620	1 210 117	1 282 724	1 359 688
(other...)							
(other...)							
Total Salary	40	228 794	10 006 661	10 607 061	11 243 484	11 918 093	12 633 179
Benefits							
Percent (%)			15%	15%	17%	20%	20%
Total benefit costs			1 500 999	1 591 059	1 911 392	2 383 619	2 526 636
Total S & M Compensation			11 507 660	12 198 120	13 154 877	14 301 712	15 159 815
% of Revenue			1,2%	1,1%	1,1%	1,1%	1,1%
Ethanol Plant							
Production Manager	1	80 095	961 142	1 018 811	1 079 939	1 144 736	1 213 420
Shift Supervisors (Distiller)	3	22 500	810 000	858 600	910 116	964 723	1 022 606
Shift Distiller Operator	9	17 800	1 922 400	2 037 744	2 160 009	2 289 609	2 426 986
Shift Supervisors (Fermentation)	3	22 500	810 000	858 600	910 116	964 723	1 022 606
Shift Fermenter Operator	9	17 800	1 922 400	2 037 744	2 160 009	2 289 609	2 426 986
Shift Supervisors (Miller)	3	22 500	810 000	858 600	910 116	964 723	1 022 606
Shift Millers	9	15 683	1 693 719	1 795 342	1 903 063	2 017 246	2 138 281
Control Room Operators	3	29 917	1 077 000	1 141 620	1 210 117	1 282 724	1 359 688
(other...)							
(other...)							
(other...)							
Total Salary	40	228 794	10 006 661	10 607 061	11 243 484	11 918 093	12 633 179
Benefits							
Percent (%)			15%	15%	17%	20%	20%
Total benefit costs			1 500 999	1 591 059	1 911 392	2 383 619	2 526 636
Total S & M Compensation			11 507 660	12 198 120	13 154 877	14 301 712	15 159 815
% of Revenue			1,2%	1,1%	1,1%	1,1%	1,1%
Research and Development							
R & D Manager	1	98070,6	1 176 847	1 247 458	1 322 305	1 401 644	1 485 742
Senior Engineers	1	67315,7	807 788	856 255	907 631	962 088	1 019 814
Engineers	4	45867,9	2 201 660	2 333 760	2 473 785	2 622 212	2 779 545
Technicians (Artisans)	12	29182,8	4 202 316	4 454 455	4 721 722	5 005 026	5 305 327
Senior draughtsman	1	23920,9	287 051	304 274	322 531	341 882	362 395
Junior draughtsman	1	15000	180 000	190 800	202 248	214 383	227 246
Document controller	2	11712,8	281 108	297 974	315 853	334 804	354 892
Senoir scientist	1	52885,1	634 621	672 698	713 060	755 844	801 194
Laboratory Technicians	4	27427,1	1 316 500	1 395 490	1 479 219	1 567 973	1 662 051
(other...)			0	0	0	0	0
(other...)							

Senoir scientist	1	52885,1	634 621	672 698	713 060	755 844	801 194
Laboratory Technicians	4	27427,1	1 316 500	1 395 490	1 479 219	1 567 973	1 662 051
(other...)			0	0	0	0	0
(other...)							
Total Salary	27	371 383	11 087 891	11 753 164	12 458 354	13 205 856	13 998 207
Benefits							
Percent (%)			15%	15%	17%	20%	20%
Total benefit costs			1 663 184	1 762 975	2 117 920	2 641 171	2 799 641
Total R & D Compensation			12 751 075	13 516 139	14 576 275	15 847 027	16 797 848
% of Revenue			1,3%	1,2%	1,2%	1,2%	1,2%
General & Administration							
Chief Executive Officer	1	179166	2 149 994	2 278 994	2 415 733	2 560 677	2 714 318
Chief Financial Officer	1	120426	1 445 111	1 531 817	1 623 726	1 721 150	1 824 419
Human Resource Manager	1	92102,2	1 105 226	1 171 540	1 241 832	1 316 342	1 395 323
HSEQ Manager	1	96194,7	1 154 336	1 223 596	1 297 012	1 374 833	1 457 323
Human Resource Officer	1	33102,4	397 229	421 063	446 327	473 106	501 492
Payroll Administrator	1	30992,2	371 906	394 220	417 874	442 946	469 523
Senior Accountant	1	68750	825 000	874 500	926 970	982 588	1 041 543
Procument officers	2	25000	600 000	636 000	674 160	714 610	757 486
Junior Accountant	1	37666,7	452 000	479 120	507 867	538 339	570 640
Training Officer	2	27500	660 000	699 600	741 576	786 071	833 235
Health & Safety Officers	4	25000	1 200 000	1 272 000	1 348 320	1 429 219	1 514 972
Environmental Officers	2	75000	1 800 000	1 908 000	2 022 480	2 143 829	2 272 459
Quality Control Officers	2	25000	600 000	636 000	674 160	714 610	757 486
General Administrator	1	27369,3	328 432	348 138	369 026	391 168	414 638
(other...)							
Total Salary	21	863 269	13 089 234	13 874 588	14 707 063	15 589 487	16 524 856
Benefits							
Percent (%)			15%	15%	17%	20%	20%
Total benefit costs			1 963 385	2 081 188	2 500 201	3 117 897	3 304 971

General & Administration							
Chief Executive Officer	1	179166	2 149 994	2 278 994	2 415 733	2 560 677	2 714 318
Chief Financial Officer	1	120426	1 445 111	1 531 817	1 623 726	1 721 150	1 824 419
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(other...)							
Total Salary	21	863 269	13 089 234	13 874 588	14 707 063	15 589 487	16 524 856
Benefits							
Percent (%)			15%	15%	17%	20%	20%
Total benefit costs			1 963 385	2 081 188	2 500 201	3 117 897	3 304 971
Total G & A Compensation			15 052 619	15 955 776	17 207 264	18 707 384	19 829 827
% of Revenue			1,5%	1,5%	1,4%	1,4%	1,4%
Total Salary & Wages			44 190 447	46 841 874	49 652 386	52 631 529	55 789 421
Total Benefits			6 628 567	7 026 281	8 440 906	10 526 306	11 157 884
Total Compensation			50 819 014	53 868 155	58 093 292	63 157 835	66 947 305
% of Revenue			5,2%	4,9%	4,8%	4,7%	4,7%

Details of market research

Figure *7*, shows that in South Africa, electricity is generated predominantly from fossil fuels (Don Fitzgerald; Monique Le Roux, 2024) ; the market for renewable energy is massive. Furthermore, the fuel-grade bioethanol industry is in its infancy.

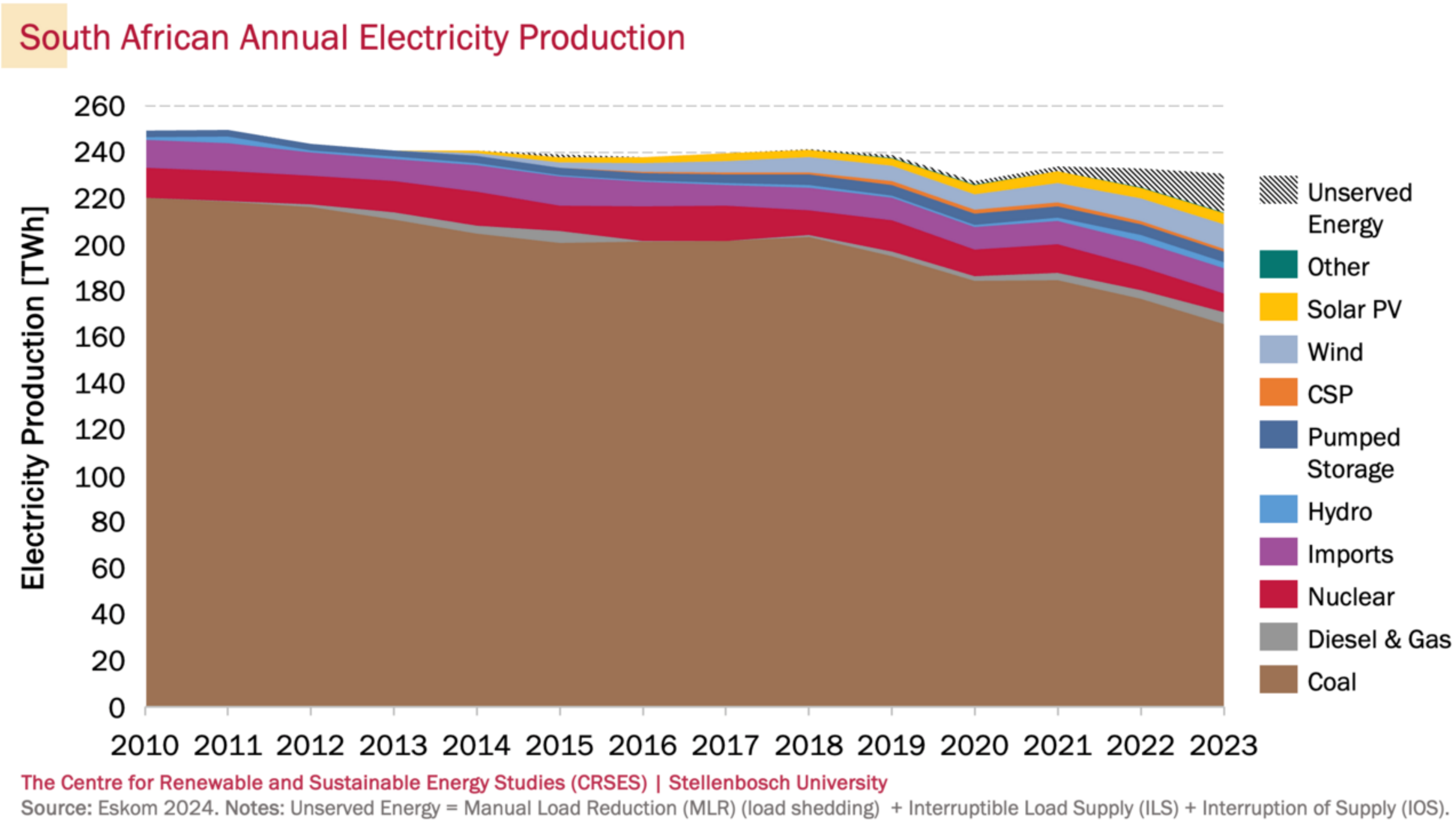

Figure 7: South African Annual Electricity Production

Product specification

Appendix *7*: Bioethanol Quality considerations Appendix *7* highlights some of bioethanol important quality considerations (Unkown, 2015).

Appendix 7: Bioethanol Quality considerations

2. BASE FUEL AND FUEL ETHANOL QUALITY CONSIDERATIONS

2.1. Quality of base fuel

The South African National Standard for petrol (SANS 1598) allow for the blending of fuel ethanol up to 5% for standard grade petrol and 5 up to 10% for E10 petrol. This specification is applicable at the retail site fuel dispenser nozzle and includes the properties to which the final product shall adhere when fuel ethanol is blended into petrol. The blending of fuel ethanol into petrol has a marked influence over the properties of the petrol, therefore a petrol product that is suitably adjusted, commonly termed Blend Stock for Oxygenate Blending (BOB) must be provided. The impacted product properties are driven by the percentage of fuel ethanol to be added, but typically are:

- Distillation characteristics including the Temperature for 50 % (volume fraction) evaporated, Evaporated to 70 °C (E70) and Evaporated to 100 °C (E100)
- Oxygen Content
- Reid Vapour Pressure (RVP)
- Octane number – Research Octane Number (RON) and Motor Octane Number (MON)

There are also seasonal considerations relating to the volatility characteristics such as Reid Vapour Pressure (RVP) and Vapour Lock Index that must be accounted for when providing a BOB suitable for blending of final product from the Refinery or the terminal Tank to Truck Loading Rack (TTLR).

The use of other oxygenates shall be limited to ensure the fungibility of BOB products when this product is conveyed via Multi Product Pipelines or co-mingled with other BOB in terminal and downstream infrastructure. The use of these oxygenates is controlled by the oxygen content of the final fuel blend and must be considered in totality as percentage of the final blend.

For BOB conveyed through the Transnet Pipelines conveyance system, it is required that the base fuel comply with the requirements of SANS 1590, which specifies the product requirements at pipeline injection and pipeline receipt for the addition of fuel ethanol. Terminal operators are advised to take note that Transnet Pipelines may blend pipeline interface material into the BOB up to the limits allowed in SANS 1590. Additional quality assurance measures such as testing of critical properties of the base fuel at a suitable frequency are recommended.

SANS 1590 may also be utilised as guidance for base fuel formulation for product import and refinery blending of fuel ethanol for road and rail dispatch, depending on the fuel ethanol responses of the specific refinery fuel formulation. It is recommended that these formulations are tested to demonstrate compliance with the requirements of SANS 1598 after the blending of the required fuel ethanol content, taking into account supply chain considerations.

2.2. Fuel ethanol quality assurance

2.2.1. Fuel ethanol quality

The fuel ethanol shall comply with the South African National Standard for fuel alcohol (SANS 465). It is recommended that the manufacturing of fuel ethanol be aligned with quality management principles such as the ISO quality management system, and SANS 1462, which provides guidance specific to fuel ethanol manufacturing. It is recommended that a certificate of analysis (COA) for each final product tank batch of fuel ethanol accompany each road tanker or rail tank car (RTC) of fuel ethanol received.

It is recommended that fuel ethanol is denatured with a denaturant, meeting the requirements of the revenue authority and non-harmful to vehicle and petroleum distribution systems. SANS 465 provides guidance on suitable denaturants and recommended quantities thereof. Where denaturant is utilised, it is recommended that the type and concentration of denaturant utilised to be indicated on bill of loading (BOL) or certificate of quality per road tanker/rail tank car.

It is recommended that suitable corrosion inhibitors are added to either the fuel ethanol or to the blended fuel to provide protection to vehicle and petroleum distribution systems. Where corrosion inhibitors are added to the fuel ethanol, it is recommended that the type and concentration of additives utilised be indicated on bill of loading (BOL) or certificate of quality

The South African National Standard that are relevant are:

- SANS 465. (2018). Automotive fuels - Requirements and specifications for fuel ethanol as a blending component with petrol. Edition 2.
- SANS 1598. (2019). Automotive fuels - Requirements and test methods for petrol. Edition 3.1.
- SANS 1590. (2017). Supply chain specifications for white petroleum products – Pipeline specification. Edition 1.

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