Development of a Mining Model

and a

Financial Analysis for the Entuba Coalfields – Zimbabwe.

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Master of Science in Engineering by advanced coursework and research: A research report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Engineering

Johannesburg, 2016

DECLARATION

I declare that this research report is my own, unaided work. It is being submitted for the degree of Master of Science in Engineering to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

Signed:

Quentin Botha

This .... day of............................. year……...........

ABSTRACT

The mining sector plays a significant role in the economy of Zimbabwe. The mining sector is the second largest contributor to the country's GDP at over 20%. Zimbabwe as a country is endowed with abundant mineral resources. The top three commodities in terms of estimated resources are iron ore, coal and platinum with resources of 30 billion tonnes, 26 billion tonnes and 2.8 billion tonnes respectively. Zimbabwe's vast mineral resources and reserves are of strategic importance to the Zimbabwe economy. Coal mining is one of the major economic contributors to the mining industry in Zimbabwe.

The purpose of the study is to determine the optimal operational model for Makomo Resources from a mining and processing point of view. The study is based on a coal-mining project in the Zimbabwean mining industry. Makomo Resources is the largest privately owned coal mining company in the country, which has a mining licence to perform coal-mining activities in the north-west part of the Bulawayo Mining District of Zimbabwe. Makomo Resources applies a conventional strip mining method by means of truck and shovel to extract the coal reserves. Makomo Resources is supplying over 200,000 tonnes of coal per month to the local and export market.

The mine has invested in USD20 million capital to commission a wash plant. The study investigates how to optimise the plant throughput by comparing two mining options:

Mining Option 1 - crush and screen 2m power coal, crush & screen and wash a full 7m low ash coal seam and wash 2m of coking coal.

Mining Option 2 – crush and screen 2m power coal, crush & screen a 3m low sulphur coal seam and wash low ash coal and coking coal of 4m and 2m respectively.

The study investigated all the marketing, geology, mining and financial parameters in the Zimbabwean coal mining context. The study determines the appropriate mining methodology and explore to optimise the coal processing. Two financial models were developed to evaluate and compare the two proposed mining options, determine their feasibility and conclude the optimal mining model. Financial techniques were used to analyse and evaluate the two mining options.

The financial models were used to analyse and evaluate the following:

- The cashflow over the 10-year period.
- The Net Present Value (NPV) and Internal Rate of Return (IRR) of each mining option.
- The payback period of the washing plant.
- Profitability Index per mining option.

The NPV of a project determines the economic value of the mining project. The decision on a mining investment is mostly related to the NPV and IRR of the project.

Discounted Cash flow (DCF) models were developed for both mining options that shows project cash in and out flows and calculates economic indicators, such as IRR and NPV. The NPV and IRR were the main methods for the evaluation of the two mining options. The resulting DCF models were developed in an Excel spreadsheet format designed for a 10-year Life of Mine (LOM) period. Mining Option 1 has a higher NPV of USD38.2 million in comparison to USD9.7 million for Mining Option 2. The IRR for Mining Option 1 was calculated at 48%, which is bigger than the IRR for Mining Option 2 of 26%. Mining Option 1 has a simple payback period and discounted payback period of 2.7 years and 4.9 years respectively. Mining Option 2 has a simple payback period and discounted payback period of 3.9 years and 11.9 years respectively. Mining Option 1 has a shorter payback period than Mining Option 2. Both mining options have a Profitability Index (PI bigger than one with

Mining Option 1 and Mining Option 2 recording values of 1.87 and 1.18 respectively. Mining Option 1 has the better PI value and is therefore more profitable.

Based on the economic evaluation, Mining Options 1 is by far more attractive than Mining Option 2, which results in a better return on the investment and profitability, therefore the preferred option.

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NOMENCLATURE

Acronyms	Description
bcm	bank cubic metre
BH	Bore Hole
CV	Calorific Value
CAPM	Capital Asset Pricing Model
m^3	Cubic Metre
DCF	Discounted Cash Flow
EAA	Equivalent Annual Annuity
EAC	Equivalent Annual Cost
FC	Fixed Carbon
FSI	Free Swelling Index
FEL	Front End Loader
GWh	Giga Watt per hour
GDP	Gross Domestic Product
GTIS	Gross Tonnes In Situ
Ha	Hectares
HCCL	Hwange Coal Company Limited
HCCL	Hwange Colliery Coal Company Ltd
HPS	Hwange Power Station
IRR	Internal Rate of Return
kg	Kilogram
km	Kilometre
LOM	Life of Mine
Mj	Mega Joule
MW	Mega Watt
Mt	Million tonnes
MMCZ	Minerals Marketing Corporation of Zimbabwe
mm	Millimetre
Mbcm	Million bank cubic metres
MEPD	Ministry of Energy and Power Development
MTIS	Minable Tonnes In Situ
NEP	National Energy Policy
NOCZIM	National Oil Company of Zimbabwe
NPV	Nett Present Value
PI	Profitability Index
ROR	Rate of Return

ROI	Return on Investment
ROM	Run Of Mine
ROMt	Run OF Mine Tonnages
The SAMREC Code	South African Code for Reporting of Explorations Results, Mineral Resources and Mineral Reserves
SANS	South African National Standards
SG	Special Grant
SG	Specific Gravity
Km^2	Square Kilometre
t	Tonnes
tpa	Tonnes per annum
TTIS	Total tonnes In Situ
USD	United States Dollar
VM	Volatile Matter
yrs.	Years
ZEEP	Zimbabwe Energy Efficiency Project
ZESA	Zimbabwe Electricity Supply Authority
ZETDC	Zimbabwe Electricity Transmission and Distribution
ZIMRA	Zimbabwe Revenue Authority

APPENDICES

1 INTRODUCTION

1.1 Chapter overview

This chapter gives an overview of the purpose, background and justification of the research report. The problem statement and the objectives of the research report are also discussed.

1.2 Purpose of the Study

The research is conducted to complete a Master of Science in Engineering (MSc) degree at the University of the Witwatersrand. The author is a mining engineer by profession and he is conducting this research on behalf of Makomo Resources (Pvt.) Limited. The purpose of the study is to determine the optimal operational model for Makomo Resources from a mining and processing perspective. The study will investigate all the marketing, geology, mining and financial parameters. The purpose of the study is to investigate the best mining methodology to adhere to in terms of the optimal coal seam selection. The study will also investigate how to optimise the processing of coal by means of dry screening and washing. The objective of the study is to utilise financial techniques to analyse and evaluate two mining options. An optimal mining model will be developed from a mineral economic perspective to maximise shareholders value.

1.3 Research Background

Makomo Resources is a coal mining company in the Bulawayo mining district of Zimbabwe, with its mineral resource at Entuba Colliery, which is situated approximately 17 km from the Hwange town and approximately 100 km from the town, Victory Falls.in the Matabeleland North province of the country.

The company is the largest privately owned coal producer in Zimbabwe and started coal mining in June 2010. At Makomo Resources, it is believed that energy will be the backbone for the future development of the economy of Zimbabwe. By investing in coal, Makomo Resources is building a sustainable future for the people of Zimbabwe by providing an energy source that will enable the revival and creation of various industries. Makomo Resources produce various types of coal products, namely: thermal coal, peas, rounds, duff, nuts and cobbles which supply Zimbabwe's power stations and the industrial and agricultural sectors.

Makomo Resources is geared to increase production and efficiency levels, whilst capitalising on the current increasing demand from domestic and export markets. Makomo Resources operates an opencast mine and supplies coal to Hwange Power Station (HPS) by road. The mine's close proximity to the Entuba siding enables full use of rail transportation into Munyati, Bulawayo and Harare Power Stations. Makomo Resources started exporting coal in June 2015 to the international market with sales of dry and washed coal to Zambia.

Makomo Resources is firmly committed to producing quality coal products; while prioritising community development and environmental management; through various innovative and sustainable strategies. The mine's coal resources forms part of the Entuba Coalfields and it is one of four mining operations in this area. Figure1.1 shows the general location of the mine (Makomo Resources, 2013).

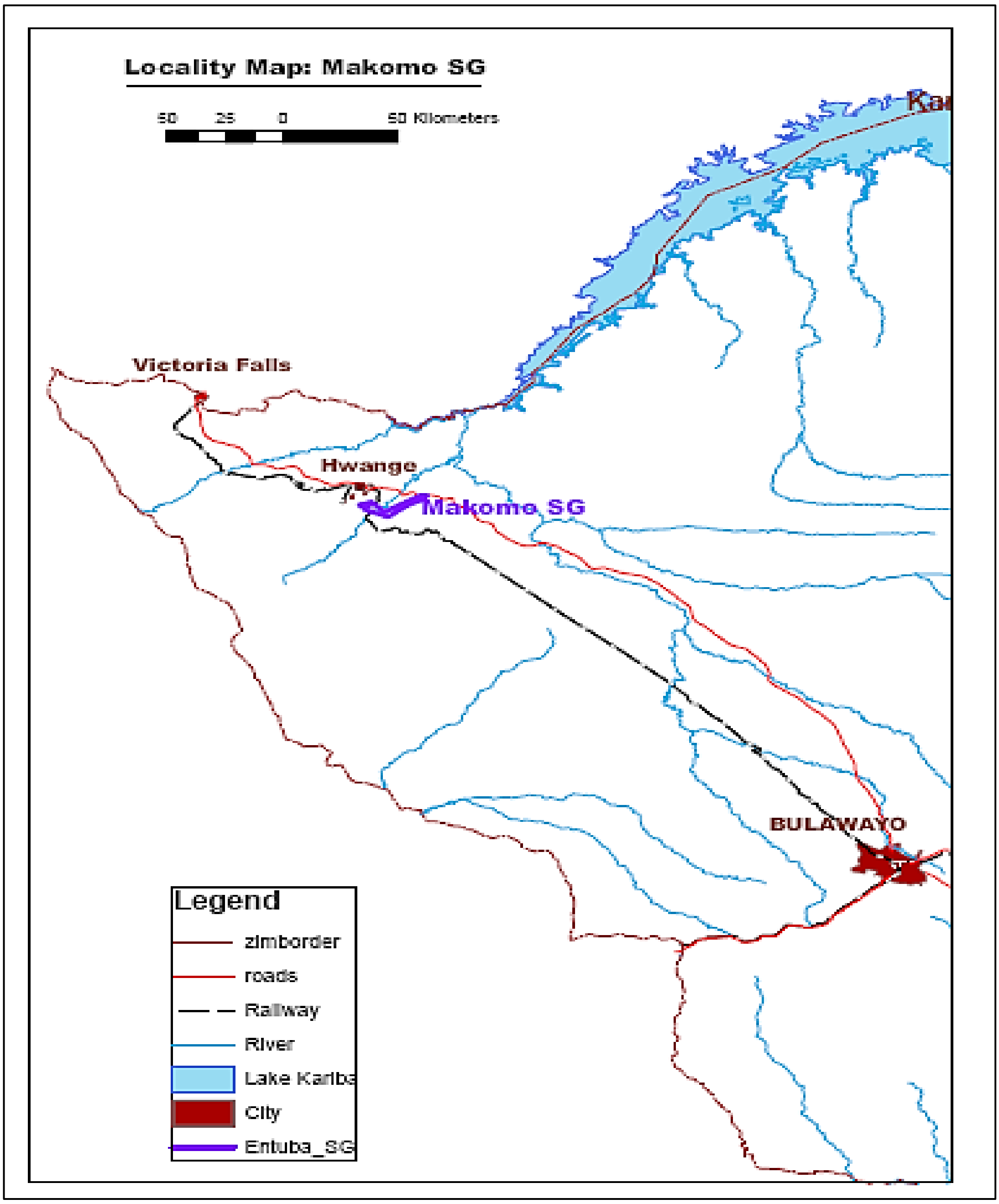


Figure 1.1 Mine Location

Source: Adapted from (Makomo Resources, 2013)

The mine has over 100 million tonnes of coal resources and is currently producing thermal coal and coking coal. Thermal coal is supplied to the local power stations, which is only processed through crush and screening activities. Washed coking coal is supplied to the local coke market. In the Entuba Coalfields, the Wankie main coal seam is about 20.31m thick with the overall ash content averaging about 19%. The operation is currently mining a coal seam of about 11m. The coking coal, both straight and blend, occurs in the basal part, and the thermal coal in the upper two-thirds of the seam. In the opencast portion of the coalfield, the thickness of the thermal coal and coking coal is about on average approximately 9m and 2m respectively. The coal designated as coking coal requires washing before it can be sold to the market (Makomo Resources, 2013).

The mine has invested in USD20 million capital to commission a wash plant to process the coking coal, which only accounts for 18% of the coal resource. The study will investigate how to optimise the plant throughput by comparing two mining options:

Mining Option 1 - crush and screen 2m power coal, crush and screen and wash a full 7m low ash coal seam and wash 2m of coking coal.
Mining Option 2 - crush and screen 2m power coal, crush and screen a 3m low sulphur coal seam and wash low ash coal and coking coal of 4m and 2m respectively.

Fgure1.2 and Figure 1.3 below illustrate the two proposed mining options, which will be analysed and evaluated. The figures shows the coal seam with their ash values, sulphur values (S) and phosphorus values (Phos), including the process, products and markets.

Coal Seam	Process	Coal Products	Market
2m Power Coal 28% Ash, 1.2% S, 0.07% Phos	Crush & Screen	Nuts, Peas & Duff	Power Station
7m Low Ash Coal Ash 15%, 1.8% S, 0.02% Phos	Crush & Screen Washing	Rounds, Cobbles,Nuts, Peas Washed Peas, Washed Duff Washed Fines	Power Station Manufacturing Agriculture Export
2m Straight Coking Coal 8% Ash, 2.5% S, 0.008% Phos	Washing	Washed Peas, Washed Duff Washed Fines	Coke batteries Export
Lower Wankie Sandstone (Floor)			Not mined

Figure 1.2 Model for Mining Option 1

Coal Seam	Process	Coal Products	Market
2m Power Coal 28% Ash, 1.2% S, 0.07% Phos	Crush & Screen	Nuts, Peas & Duff	Power Station
4m Low Ash Coal Ash 17%, 1.8% S, 0.03% Phos	Washing	Washed Peas, Washed Duff Washed Fines	Power Station Manufacturing Agriculture Export
3m Low Sulphur Coal 13,5% Ash, 1.9% S, 0.014% Phos	Crush & Screen	Rounds, Cobbles,Nuts, Peas	Manufacturing Agriculture Export
2m Straight Coking Coal 8% Ash, 2.5% S, 0.008% Phos	Washing	Washed Peas, Washed Duff Washed Fines	Coke batteries Export
Lower Wankie Sandstone (Floor)			Not mined

Figure 1.3 Model for Mining Option 2

The optimal mining model for the mining operation that needs to be adhered to has not yet been determined and there is a need to develop the mining model. The operation does not have a clear understanding which coal seam to select for mining and volumes to process through the wash plant towards meeting the market demand. Firstly, the study will identify and confirm the possible coal seam selection from the pit. This will support the volume of coal to be fed into the wash plant to reach its full capacity in order to meet washed coal product demand. Secondly, the study will determine the optimal balance between crush and screening of coal and the washing of coal. Finally the study will aim to develop a financial model to analyse the two proposed mining options and to determine the feasibility of the optimal mining model.

Two financial models will be developed including all the financial parameters and assumptions to be used to evaluate the two mining options. The financial evaluation will be based on the relevant mining and financial parameters from a Zimbabwean perspective. The optimal mining model will improve the utilisation of the wash plant. The increase in the wash saleable product will create value for the mine and shareholders by improving the financial position for the company.

1.4 Problem Statement

Makomo Resources has been operating for over four years and have processed coal by means of crushing and screening only. The operation has commissioned a new wash plant in October 2014 to produce saleable coal. The wash plant is only processing the coking coal which equates to 18% of the total coal resources. The problem is the under utilisation of the wash and the fact that there is no clear mining model to indicate which part of the 11m coal seam is suitable for washing and which part can be crushed and screened to optimise value for the operation.

1.5 Research Objectives

The aim of the study is to develop an optimal mining model, which will result in a profitable operation. The mining model will evaluate the operation over a 10-year mining period. A Discounted Cash Flow (DCF) model will be developed for the two proposed mining options. The DCF model will be used to conduct a financial evaluation and compare the two mining options. The result from the financial evaluation will identify the optimal mining approach and determine the feasibility of this mining model.

The study is based on a coal-mining project which will be used to develop a techno economic model with all the required mining and financial input parameters to evaluate the feasibility of the project. Finally, the cash flow model provides a means of assessing the project sensitivities to outside cost and production factors, and a means to conduct a post audit of an existing operation.

The study will analyse and investigate the following:

- The cashflow over the 10-year period.
- The Net Present Value (NPV) and Internal Rate of Return (IRR) per mining option.
- The payback period of the washing plant.
- Profitability Index per mining option.

Creation of value from the mineral asset is important and necessary to satisfy various stakeholders' needs. The concern is that this project is a fairly recent project, which has only operated over four years now. There is a lack of detailed mining and geological information. The access to information is also limited to the Entuba coalfields as well as information related to the coal mining industry in Zimbabwe. Another challenge will be to evaluate the level of accuracy of the limited mining information available. The information used will be based on historical data, which is back looking while a DCF is forward looking. There is also a level of risk in the assumptions because of the fluctuation and volatility of the coal market.

1.6 Summary of Chapter 1 and structure of the report

Makomo Resources is a private coal mining company in Zimbabwe, which has a mining licence to perform coal-mining activities in the north-west part of the Bulawayo Mining District. Makomo Resources has sufficient coal resources, which are mined by means of opencast mining techniques. Makomo Resources has the potential to optimise and improve their current mining strategy by determining the optimal mining model. A DCF is a tool to use in the analysis to identify the most feasible mining model, which will increase shareholders wealth. Makomo Resources vast mineral resources and reserves are of strategic importance to the Zimbabwean economy. Coal mining is one of the major economic contributors to the mining industry in Zimbabwe.

This chapter has provided justification for the research work and defined the problem statement. Chapter 1 also provides the background and the objectives of the report. The remainder of the report is structured as shown in Figure 1.4.

Chapter 2 explains the concept of economic evaluation, including which techniques and tools can be applied to measure and analyse the financial performance of a project. The development and application of a cash flow analysis, including the importance of discount rates are also discussed. The chapter provides an overview of the different types of operational cost related to mining projects. Coal handling and preparation of coal are also discussed.

Chapter 3 gives an overview of the mining sector in Zimbabwe. It highlights the different commodities that are mined in Zimbabwe, the role of mining in the Zimbabwe economy and the challenges facing the Zimbabwean mining industry are discussed. The chapter also discusses the mining economy and mining policies of Zimbabwe.

Chapter 4 outlines the coal mining fundamentals in the Zimbabwean mining context highlighting the significance of coal in the country and the factors driving the coal mining industry.

Chapter 5 gives an overview of the company, it provides a better understanding of the geology in the Entuba coalfield's area and the mining methodology applied over the last four years. The management accounts in terms of mine production, sales and operational cost are discussed. The detail project geology, mining methodology and the two proposed mining options are also explained in this chapter.

Chapter 6 evaluates and analyses the feasibility of the two mining options by making use of a discounted cash flow model.

Chapter 7 is summarising the conclusions and Chapter 8 provides the recommendations of the report.

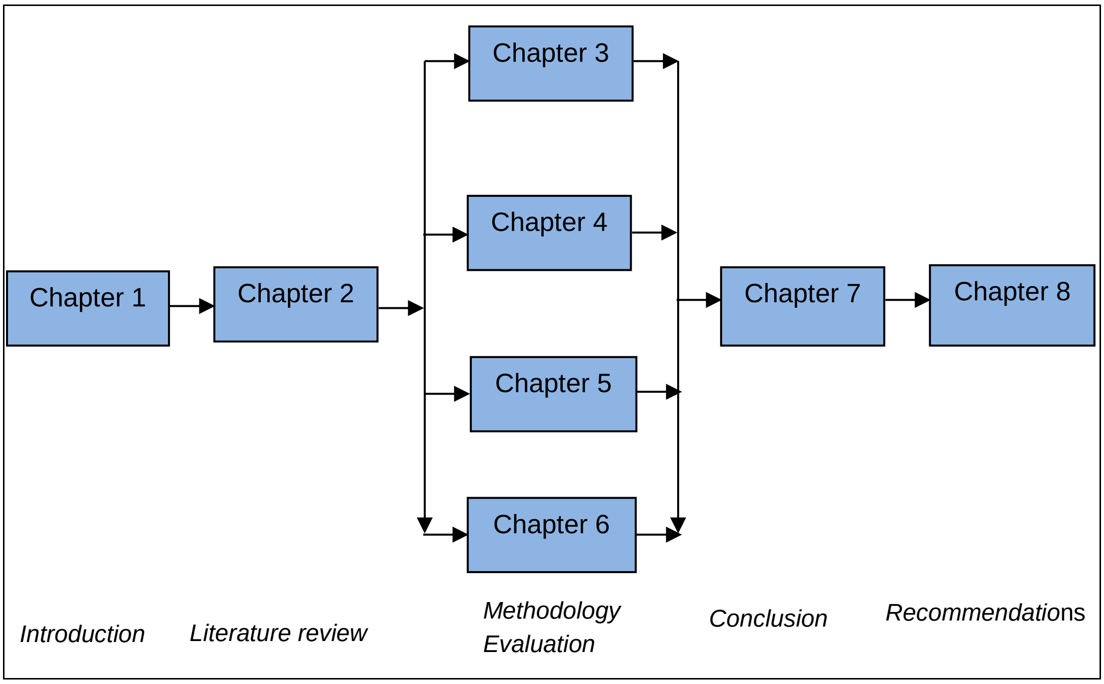


Figure 1.4 Structure of the research report

2 LITERATURE REVIEW

2.1 Chapter Overview

The literature review provides an overview of the concept and objective of economic evaluation. The development and application of a cash flow analysis as well as the different evaluation techniques and tools are discussed in this chapter. The processing of coal by means of a washing plant is also discussed.

2.2 Economic Evaluation

2.2.1 Introduction

“The word *evaluation* in a mining project context implies the broader meaning of determining the numerical values of all possible factors or variables that are important in establishing the worth of a mining project.” In other words, mine evaluation represents the assessment of the relative economic viability of the mining project or the investment opportunity.” (Gentry, 1992,pp.387).

Chilvers (2009) defines economic evaluation as a way of systematically analysing all the costs and benefits associated with a proposal and assessing its overall benefits. She further continues to explain the analysis can incorporate monetary, quantitative and qualitative factors, which can assist in better quantification of the benefits and a more balanced assessment of the relative merit of options. The use of economic evaluation is encouraged in all relevant areas of public sector activity including policy proposals, program evaluation and regulatory review.

Mine evaluation is based on estimates of project ore reserves, mine production rates, revenues, costs, expected returns and associated risks for each project or investment opportunity available to the organization. An investment opportunity defines committing funds with the expectation of earning a return over a certain period. Typical capital investment decisions in mining include the following:

- Equipment replacement
- Expansions projects
- Exploration projects
- New product development
- Leasing or buying of equipment

In order for mining companies to make a constructive decision on any of the above investment options, it is important to validate the economic viability of the project. Engineers typically make this determination through economic evaluation using a tool called cash flow analysis. In its simplest form, a cash flow analysis determine the cash inflows and cash out flows costs, taxes, royalties, capital expenditures or any out of- pocket expenditure arising from the project. The net cash flows are then evaluated using various techniques to indicate the project viability.

Kuestermeyer (2001) stated that a cash flow represents a ‘model’ of the current state of technical and economic knowledge available for a project. Kuestermeyer (2001) also indicated the most important function of the cash flow is to formally display the expected revenues costs and benefits. The cash flow provides a framework for the assumptions and data required. The cash flow also provides a way to evaluate the value of the project to an organization or to evaluate and rank a number of different investment options. Finally, the cash flow model provides a means of assessing the project sensitivities to outside cost and production factors, and a means to conduct a post audit of an existing operation. According to Kuestermeyer (2001) there are four major elements of a cash flow.

1) Geologic Elements: The geology and resource estimation procedures form the basis of all other work in the cash-flow statement, although not much of the geologic information will directly appear in a cashflow

statement. Rarely does a project fail due to operational issues; projects often fail due to problems with the resource estimate.

2) Mining Elements: More information from the mining section of the feasibility study is contained in the cash flow model; however, there is still some data that does not appear directly, but must be available for audits. Since the entire project is dependent on the reserves being present as reported, this area must be scrutinized.
3) Processing Elements: All support data for the processing section of a feasibility study should include metallurgical test work, mineralogy, and a detailed description of the flowsheet.
4) Environmental Elements: Sometimes the environmental aspects may include intangibles. These typically occur in the socio-economic and environmental areas. For example, if the project is in a politically or environmentally sensitive area, it is highly probable that there will be extensive legal costs and delays. The environmental costs must be included in the cash flow model.

A mine project as explained by Allen (2012) is the scheme of facilities needed to mine and extract minerals from defined orebodies: it normally requires a special investment or allocation of resources such as capital and completion within a specified time period. Mine projects are different from 'exploration' projects, which usually have the definition of mineralisation or mineral deposits as their objective.

According to Allen (2012) the evaluation should:

- Provide a base on which economic decisions are made.
- Identify and quantify risk.
- Establish project priority.

Allen (2012) mentioned that at least four aspects of the environment in which the project is evaluated may be identified — technical, financial, social and political, to a certain extent they overlap. Together they form the economic base for an evaluation:

1) Technical aspects. These include the geological setting of the deposit and technology that determines the production system.
2) Financial aspects. The amount, type and cost of capital available for a mining project will depend partly upon the financial environment at the time the investment is undertaken.
3) Social aspects. These involve the social costs and benefits derived from a mining project. The development of infrastructure, the utilisation of local labour and material resources can provide positive contributions to society. On the other hand mines produce tailings and effluents that may have a negative impact on the natural environment.
4) Political aspects. By political aspects are meant the mineral, fiscal, foreign exchange and employment policies of the local and national governments where the deposit is situated. They are particularly important to governments participating in mineral projects.

Financial models must be constructed to estimate the value of a mining project. The economic value of a mining project can be determined by evaluating a cash flow. The aim of evaluation of the cash flow is to investigate the profitability of the project with related uncertainties.

2.2.2 Cash Flow Analysis

As indicated, cash flow analysis relates the expenditures associated with investment to the subsequent revenues or benefits generated from such investment. Cash flows are routinely calculated on an annual basis for evaluation purposes and are determined by subtracting the annual cash outflows from the annual cash inflows that result from the investment. Consequently, a cash flow analysis may be performed for any investment with which income and expenditure are associated. Also the annual cash flows resulting from an investment may be either positive or negative. Typically, the net annual cash flows for a new mining project will be negative during the preproduction years due to large capital expenditures. After production commences, the cash flows will usually be positive and an inflow of cash results from investment in the project will be positive (Gentry, 1988).

Table 2.1 illustrates the components and basic calculation procedure for determining annual cash flows for a mining project.

Table 2.1 Components and basic calculation procedure for developing Cash Flows

Source: (Gentry and O'Neil, 1984).

Calculation	Component
	Revenue
Less	Royalties
Equal	**Gross Income from Mining**
Less	Total Operational Cost
Equal	**Net Operating Profit**
Less	Depreciation and Amortization
Equal	Net Income after Depreciation and Amortization
Less	Depletion Allowance
Equal	**Net Taxable Income**
Less	State Income Tax
Equal	Net Federal Taxable Income
Less	Federal Income Tax
Equal	**Net Profit After Tax**
Add	Depreciation and Amortization
Add	Depletion Allowance
Equal	**Operating Cash Flow**
Less	Working Capital
Equal	**Net Annual Cash Flow**

Gross Income from the mining takes into account annual tonnes produced, ore grade, mine recovery, and process recovery all multiplied by commodity price per tons produced to generate revenue and deducting royalties on revenue earned by government. Total operational cost consist of the costs from mining, beneficiation or process costs, product transportation cost , administrative costs and marketing costs as shown in Table 2.2.

Table 2.2 Classification of total cost of production

Source: (Gentry, 1988).

Operating cost	General expenses
Direct cost	Marketing expenses
Indirect cost	Administrative expenses
Contingencies	
Distribution cost	

Operating costs are all costs considered on the mine, whereas general expenses are costs off the mine expenditures. Direct costs relates to items such as labour, materials and consumables used during the production process. Indirect costs are expenditures which are independent of the production process. General expenses may be directly related to the mine or they may be indirect items incurred by head offices. Depreciation is an allowance for capital investment over the useful life of an asset. Non-cash items, which may consist of depreciation, depletion and or amortization, are applied to reduce taxable income. Taxation typically includes national, provincial and local taxes. Once taxes are removed from the income stream, the mining company is left with operating cash flow. Operating cash flow is further reduced by capital costs, changes in working capital, acquisition costs and required land payments. The resulting calculation yields the project's net annual cash flow (Gentry, 1992).

Table 2.3 lists some of the more important parameters relating to preproduction, production, and postproduction of a mining project. The below mentioned mining factors require consideration in the preparation of cash flow analyses. The appropriate use and manipulation of these input variables are an extremely important aspect of the cash flow analysis.

Table 2.3 Parameters for consideration in Cash Flow analysis of a mining property

Source: (Laing, 1977).

Parameters for Cash Flow	
Pre-Production Period	
Exploration Expenses	Land and Mineral Rights
Water rights	Environmental cost
Mine and Plant Capital	Development cost
Sunk cost	Financial structure
working Capital	Administration
Production Period	
Price	Capital Investment-replacement of expansions
Processing cost	Royalty
Recovery	Mining Cost
Post concentrate cost	Development cost
Revenues and percent removable	Exploration cost
Grade	General and Administration
Investment tax credit	Insurance
State Taxes	Production rates in tons per year
Federal Taxes	Financial year production begins
Depletion rates	Percent production not send to the processing plant
Depreciation	Operating day per year
Post Production	
Salvage Value	Contractual and reclamation expenditures

2.2.3 Economic Evaluation Techniques

The definition of economic evaluation is the process of systematic identification, measurement and valuation of the inputs and outcomes of two alternative activities, and the subsequent comparative analysis of these activities. The purpose of economic evaluation is to identify the best course of action, based on the data available. The DCF technique evaluates the whole project by adjusting and discounting the cash flow of the proposed project against the effects of risk and time (Gentry, 1992).

Objective

The objective of an economic evaluation is putting the data into an analytical framework to help determine whether the considered investment should be supported or rejected. The goal is to determine whether or not the project will provide cash benefits sufficiently in excess of the cash costs of establishing and operating the project in order to justify:

1) The cost of funds employed
2) The risk involved.

Project evaluation tools are very useful for decision-making purposes, however the analyst must always remember that there is no substitute for accurate input data. Nearly every unsuccessful mining project can trace its difficulties back to poor input data estimations and not to the use of improper project evaluation methods (Gentry, 1992).

Investment Criteria

When a company is confronted with several investment opportunities as referred to by Gentry (1992), it becomes necessary to evaluate the attractiveness of each proposal. Gentry (1992) pointed out that any evaluation criterion utilized should provide company management with a means of distinguishing between acceptable projects in a consistent manner. In other words, the criterion should help answer the question: “Is project A and or project B good enough to justify capital investment by the company?”. Gentry (1992) further explains to provide this necessary information for an investment decision making, the satisfactory evaluation criterion must respect two basic principles:

1) Bigger benefits are preferable to smaller benefits.
2) Early benefits are preferable to later benefits.

The following project evaluation criteria section are not intended to represent an exhaustive list available to the analyst. Rather, those discussed represent the major evaluation criteria utilized for evaluation investment proposals within the minerals industry. Spencer (1987) mentioned a number of values and indices that can be used in financial evaluation of a mining project. These include:

- Payback period,
- Net Present Value (NPV) at a predetermined discount rate and,
- Internal Rate of Return (IRR).
- Benefit Cost Ratio.

Payback (Pay-out) Period

Payback period is one of the most common evaluation criteria used by mining companies. The payback period is simply the number of years required for the cash income from a project to return the initial cash investment in the project. The investment decision criterion for this technique recommends that, if the calculated payback period for an investment proposal is less than the maximum value acceptable to a mining company, the proposal is accepted; if not, it is rejected.

Net Present Value (NPV)

The NPV is known as an output from a Discounted Cash Flow (DCF) technique, which it is a standard technique that is widely used to undertake investment appraisals. Lilford (2010) explained that the DCF involves the modelling of critical input data and determining a resultant free cash flow. The method is based upon the principle that for any initial investment in a mining project, the investor will look to the future cash flows to provide a minimum return over their hurdle rate on that investment. The hurdle rate represents the minimum return of a project below which the decision to invest or develop a new project will be negative, and above which the project may be developed with a certain probability of achieving minimum returns. Lilford (2010) further describes that the critical input data referred has to generally be incorporated in a detailed life of mine (LOM) plan, such as that accompanying a pre-feasibility or a bankable feasibility study, and will include at least:

- reserve and resource statements governing the proposed operation;

- the forecast mining exploitation profile in tonnes on a monthly or annual basis;
- the grade distribution and recoveries expected (yield);
- forecast working costs, preferably on a unit basis;
- the anticipated start-up and ongoing capital expenditure profile over the life of the operation; and
- rehabilitation, retrenchment, plant metal lock-up and other specific aspects and / or liabilities specific to the operation.

The DCF methods according to Gentry (1992) require the following:

1) Determination of periodic project cash flows over some uniform planning period.
2) Consideration of the time value of money through the use of an appropriate interest rate.

In the more general case of investment proposal evaluation, one is interested in determining the difference between cash outflows and cash inflows associated with the proposal on a present-value basis. This calculation procedure is referred to as the net present value (NPV) method and is simply the difference between the sum of the present value of all cash inflows and the sum of the present value of all cash outflows. NPV can be expressed as follows:

Net present value = ∑present value of cash benefits — ∑present value of cash costs.

The NPV of the project, derived from the DCF technique is:

$$NPV = (\Sigma\ C_f / (1 + rr)\ t - I_c)$$

where:

C_f = anticipated free cash flow at time t in real or nominal terms;

t = time / period in which the cash flow occurs;

rr = real / nominal discount rate adjusted to reflect risk;

I_c = present value of the capital outlay to bring the project to account.

NPV measures all economic consequences, including the economic consequences of time, by converting the cash flow amounts of all future periods in current value to equivalent amounts at a single point in time to the present value and summing the discounted cash flow values to determine net loss or gain. If the NPV of the project is a positive value (NPV> 0), it means the project is sound and it will increase shareholder's' wealth and then the project should be accepted. A zero NPV (NPV=0) means the project neither increases nor decreases the company's wealth. A project yielding a negative NPV value (NPV< 0) at the required discount rate destroys shareholders value and should be rejected.

Internal Rate of Return

When evaluators in the minerals industry evaluate rate of return on an investment proposed, they are almost always referring to the so-called discounted cash flow return on investment (DCF-ROI) or the discounted cash flow rate of return (DCF-ROR) (Gentry, 1992). These terms are special versions of the more generic term, internal rate of return (IRR), or marginal efficiency of capital. This criterion is employed more in the minerals industry for investment proposal evaluation than perhaps any other technique.

The internal rate of return is defined by Gentry (1992), as the interest rate that equates the sum of the present value of cash inflows with the sum of the present value of cash outflows for a project. This is the same as defining the IRR as the rate that satisfies each of the following expressions:

$$\sum \text{PV cash inflows} - \sum \text{PV cash outflows} = 0$$

$$\text{NPV} = 0$$

$$\text{Profitability Index (PI)} = 1.0$$

$$\sum \text{PV cash inflows} = \sum \text{PV cash outflows}$$

The norm is to compare the IRR to the company's cost of capital (hurdle rate). If the IRR.> hurdle rate, then the project should be accepted because it offers a higher return than the cost of financing the project. When evaluating mutually exclusive project, the project with the highest IRR is selected.

Benefit/Cost Ratio

Gentry (1992) stated the benefit/cost ratio (B/C ratio), sometimes referred to as the profitability index (PI), is generally defined as the ratio of the sum of present value of future benefits to the sum of the present value of present and future investment outlays and other costs. Profitability index is a financial tool which tells the investor whether an investment should be accepted or rejected. It uses the time value concept of money and expressed as follows:

$$Benefit, Cost\ Ratio(PI) = \frac{\sum Present\ Value\ of\ net\ cash\ inflows}{\sum Present\ Value\ of\ net\ cash\ outflows}$$

In order to perform this calculation an interest rate must be specified prior to present value determination. If the calculation results in a PI greater than 1.0, the investment proposal should be accepted; if PI is less than 1, it should be rejected.

Discount Rate

As indicated in the previous section of this chapter, future project receipts and expenditures must be discounted to permit valid comparisons with current cash flows. Although the concept of discounting is widely accepted, selection of an appropriate discount rate has been the source of considerable debate and much disagreement.

The corporate cost of capital is used by evaluators to discount future flows of income from an entity in order to derive a present-day, forward-looking value of that entity. This cost of capital represents the total cost to the entity or company that will be incurred in order to raise and/or secure funding in order for it to acquire, develop and maintain its future sources of income (Lilford and Minnitt, 2002).

According to Lilford and Minnitt (2002) the cost of capital is therefore determined as the weighted cost of the various sources of funding, being typically equity, debt and preference instruments. This weighted funding cost is known in economic and finance theory according to Van Horne (1977), as the weighted average cost of capital (WACC).

Van Horne (1977) and Hull (1989) explains the WACC represents the minimum rate at which future cash flows should be discounted so that the capital raised by the company generates a return at least equivalent to the cost associated with securing those funds. As expected all companies desire investment returns in excess of their WACC, in order for sustainability of existing projects and not to compromise the development of future projects. This cost of capital, is the direct linkage between investment policy and the firm's objective. Further, the cost of capital also relates the financing decision to the investment decision. Indeed, the cost of capital is the only link between these two decisions.

The relationship between the financing decision and the investment decision in corporate finance using the cost of capital criterion is illustrated in Figure 2.1. The logical conclusion from this observation is that this cost of capital represents the "hurdle rate" or the appropriate discount rate to be used in conjunction with discounted cash flow analyses of investment opportunities.

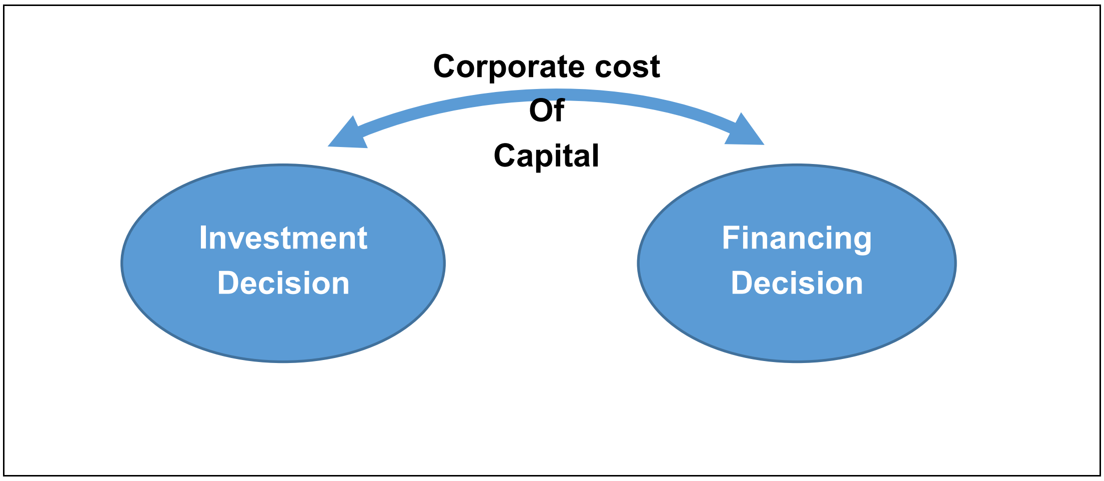


Figure 2.1 Relationship between investment decision and financing

On an all-equity basis, only the cost of equity needs to be considered, which gives rise to the application of the capital asset pricing model (CAPM) method for determining the cost of equity capital. This assumes that the return on any one listed stock can be related to the attained return of the entire market. The capital asset pricing model is used to determine the cost of capital.

The formula of CAPM is:

Rj=Rf + b (Rm- Rf)

where:

Rj = cost of capital

Rf = risk-free rate

b = beta

Rm = the market's expected rate of return

The beta coefficient used in the capital asset pricing model calculation reflects the ratio volatility of a company's listed shares, being its equity, relative to the market as a whole (Van Horne, 1977). The beta can be estimated as the change in share price adjusted for dividends divided by the change in the Market Accumulation Index for the same time period. Company betas are quoted on various market web pages, such as the major banks' share trading websites Therefore, a company that reflects a non-diversifiable risk that is higher than the market average will have a beta coefficient of more than 1 while, conversely, a company that reflects a lower than- average non-diversifiable risk will have a beta coefficient of less than 1 (Van Horne, 1977).

2.3 Operating Costs

The accuracy of estimation of operating costs depends on the quality of the technical assessment and knowledge of expected mining and mineral processing conditions. Operating cost is money that is spent in the production process to produce the final product (Musingwini, 2011). These costs include wages, consumable materials such as chemicals and explosives, transportation and power many of which are susceptible to inflationary and supply demand pressures. Rudenno (2009) described factors that affect operating costs and noted that they vary depending on geographical location, mining and metallurgical factors such that two mines producing identical quantities of a same resource product can have quite different operating costs; however, the order of magnitude of operating costs will often be related to size of the operation.

Operating costs are categorised according to their behavior as the underlying level of activity changes, activity level being defined as production volume. In mining, costs are usually classified as fixed, variable or semi-variable costs (OneMine, 2012). The behavior and difference between the three cost categories are explained below:

2.3.1 Fixed costs

Fixed costs are costs that do not change with production volume, whether a mine produces or not, these costs are still incurred to sustain production capability. These costs are fixed only in relation to a given time period and within a given range of activity, which is not related to the amount of sales. Examples of fixed costs include wages and salaries, rent, interest expense, electricity, depreciation, business license, insurance and permit fees.

2.3.2 Variable costs

Variable costs are costs that change in direct proportion to production volume; the more the production, the higher the costs. The variable cost components in a production environment are usually factored linearly based on such criteria as tonnage mined or processed. Variable cost is the ideal cost to have in a production system. Examples of variable costs include materials, consumables, diesel and supplies used in the mining, processing and transportation of coal.

2.3.3 Semi variable costs

These costs vary according to production volume, but not in direct proportion and are also referred to as step costs or mixed costs. For example, if volume increases by 10% the total amount of semi-variable costs may increase by more or less than 10%. Examples of semi-variable costs include maintenance costs. Total costs are the sum of the fixed and variable cost.

2.4 Coal Wash Plant

A coal handling and preparation plant (CHPP) is also known as a wash plant, which is a facility that crushes the coal, washes coal and screen the coal into different product sizes. Albrecht (1979) explained that coal preparation is both a science and an art. The washing of raw coalproduces a salable product that meets market requirements by removing the impurities. According to Horsfall (1980) coal-preparation techniques have been used in South Africa over the past ten years, (the term "preparation" being taken to refer to processes involving beneficiation techniques). Coal washing was first introduced in South Africa in 1905. The success of the preparation methods adopted can be determined from the coal quality and market requirements

According to Albrecht (1979) concentration is the separation of coal into products characterized by some physical difference such as specific gravity. Concentration is the heart of coal preparation. It is normally accomplished in jigs, dense medium vessels, on tables in dense medium cyclones, water cyclones or flotation cells. Albrecht (1979) further states the selection of a process flow sheet is the single most important step in the plant design process. The following important questions must be asking determining the purpose of the wash plant:

- What characteristics of coal make it necessary?
- What size of raw coal must be cleaned?
- To what degree must the percentage of ash and sulphur be reduced to ensure a saleable product?
- What limit must be placed on preparation cost per clean tonne?

2.5 Conclusion

The objective of every mining business is to derive and maximise shareholders' wealth. Shareholders' wealth is created when a business generates profits, therefore every mining operation must strive to be profitable. Given the importance of coal mining to Makomo Resources profitability, it is important to analyse and compare the two proposed mining projects.

An economic evaluation is required to determine the value and feasibility of a project including analysing all the costs and benefits associated with a proposed project. The purpose of a cash flow analysis is to evaluate a projects feasibility and to rank the different investment opportunities. A good financial model should be created to evaluate the coal reserves. Each uncertainty related to mining should be assessed carefully. A financial model construction needs accurate estimations of income and costs. Estimation of the revenue and costs includes many uncertainties.

The success of the financial modelling simulation depends on the estimation of the uncertainties accuracy. There are several evaluation techniques, which can be applied to assist the decision-making process on the best course of action and in terms of what project to invest. The NPV of a project determines the economic value of the mining project. The decision on a mining investment is mostly related to the NPV and IRR of the project. The discount rate is equally important as the mining and financial parameters of the DCF. On an all-equity basis, the CAPM method determines the cost of capital. Operating costs are categorised as fixed cost, variable cost and semi variable costs. Coal handling and preparation is both a science and an art. It deals with taking raw coal and producing a saleable product that meets market requirements by removing the impurities. The most important aspect of the plant is the salable product produced. Saleable products are produced from Run Of Mine (ROM) coal and need to meet the market specifications.

3 MINING SECTOR OVERVIEW IN ZIMBABWE

3.1 Introduction

The following facts of Zimbabwe were stated by Baruya and Kessels (2013).

- Population: **12.6 million**
- Capital: **Harare**
- Currency: **US$, SA rand, Botswana pula, £ sterling**
- Total coal production (2011 estimate**): 2.58Mt**
- Total coal demand (2010 estimate): **2.73Mt**
- Imports (2010 estimate): **0.046Mt**

Zimbabwe has a land area of 391,000 km^2 and is land locked. The country has land borders with Mozambique, Botswana, Zambia and South Africa. Formerly known as Rhodesia, when the Zimbabwe Liberation War ended in 1980, the country became independent from the United Kingdom and was renamed Zimbabwe.

Zimbabwe is made up of eight provinces and two cities, which are Harare and Bulawayo that have provincial status. The other provinces are Manicaland, Mashonaland Central, Mashonaland East, Mashonaland West, Masvingo, Matabeleland North, Matabeleland South and Midlands (Baruya and Kessels, 2013). The geography of the country comprises a high central plateau known as the high veld. This forms a watershed between the Zambezi and Limpopo river systems. The Zambezi River forms a natural boundary with Zambia and in full flood the Victoria Falls on the river forms the world's largest waterfall when considering width and height. The Limpopo and the lower Zambezi valleys are broad and with relative flat plains. The eastern end of the watershed terminates in a north south mountain spine, called the Eastern Highlands. The Kalahari Desert is on the southwest edge of the country. Figure 3.1 shows the map of Zimbabwe.

Figure 3.1 Map of Zimbabwe

Source: Adapted from (Baruya and Kessels, 2013)

According to Zimbabwe Investment Authority (2015), the Zimbabwe mining industry contributes about 20% towards the country's Gross Domestic Product (GDP). Mining provides employment to 4.5% of the country's population and contributes to about a third of the total foreign exchange earnings. About 60% of the country's land surface comprise of rocks well known worldwide for hosting rich varieties of mineral resources including gold, coal, base metals, industrial minerals and Platinum Group Minerals (PGM's).

Zimbabwe has a significant and diverse mineral resource base. Zimbabwe is endowed with a variety of minerals most of which are being mined economically. The country is an important producer of gold, chrome, asbestos, platinum, emerald, black granite, nickel, copper, pegmatite minerals (lithium, tantalite, tin). Other minerals such as ornamental, diamonds and dimension stones also exist. The country also has vast resources of coal of various ranks (Zimbabwe Investment Authority, 2015).

Zimbabwe has the second largest platinum deposit in the world. The country also has kimberlite deposits in the eastern parts, which produce diamonds. Other important geological environments include the famous Great Dyke, which is hosting platinum and chrome resources. The Mashonaland Dolerite Dykes are marketed as black granite is ranked as the best dimension stone resource in the world. There are also several sequences of sedimentary rocks, which contain significant amounts of coal for power generation, metallurgical markets, and the potential for coalbed methane operations (Chamber of Mines of Zimbabwe, 2015).

Table 3.1 shows the list of the main mineral resource currently being extracted in Zimbabwe.

Table 3.1 Mineral Resources in Zimbabwe

Source: (Reserve Bank of Zimbabwe, 2009).

Mineral	Estimated Resources (Mt)	Current Annual Extraction Rate	Areas of Location
Gold	13 Mt	20t	Bindura district, Kadoma, Mudzi district, Mvuma, Kwekwe district
Platinum	2.8 x10^3Mt	2.4Mt	Great Dyke, Hartley geological complex, Selukwe complex, Wedza complex, Ngezi platinum complex, Msengezi complex
Chromite	930Mt	700,000t	Great Dyke, Shurugwi, Mutorashanga, Mashava
Nickel	4.5Mt	9,000t	Great Dyke, Shangani, Hunters road
Coal	26 x 10^3Mt	4.8Mt	Hwange, Sengwa
Diamonds	16.5Mt	Infancy	Chiadzwa., Murowa, River Ranch
Iron Ore	30 x10^3Mt	300,000t	Buchwa, Ripple Creek, Chiredzi, Nyuni
Copper	5.2Mt		Lomagundi basin, Mhangura, Shamrocke, Umkondo basin
Coal-bed Methane	The largest known reserves in Sub - Sahara Africa		Hwange, Lupane, Tsholotsho, Mzola, Lower Save, Runde, Bubie

Opportunities exist throughout the complete mining value chain from exploration, mining, processing, marketing and downstream industries. There are also opportunities for joint ventures partnerships on existing low capacity running project as well as new ventures (Chamber of Mines of Zimbabwe, 2015). Zimbabwe's mining industry focusses on a diverse range of small to medium mining operations. The most important minerals produced by Zimbabwe include gold, asbestos, chromite, coal and base metals.

ReportLinker (2013) mentioned that due to the general small-scale nature of mining activities in Zimbabwe, there are an estimated 100 – 300,000 informal mining activities throughout Zimbabwe. The lower commodity prices have had a negative effect on these small operations and as a result, several operations have closed down. Thirty-five different metals and minerals are produced, with the formal mining industry employing some 57,000 people. There have been significant job losses because of low commodity prices.

In September 2004, the Zimbabwean Chamber of Mines reported that the overvalued exchange rate in the country continues to be the major cause for concern for the mining sector. Despite the impressive prices for mineral commodities ruling on the international markets, the hard currency earned when converted to Zimbabwe dollar did not provide sufficient cover over operational costs to instill confidence going forward. Mineral producers are battling to contain operational costs given the continued increase in prices of inputs. Though inflation has been on a downward trend, a positive economic attribute, it is still very high and prices of inputs are still rising affecting negatively on the cost base.

The Chamber of Mines of Zimbabwe stated that coal (5.17%), cobalt (80.16%), gold (61.43%), graphite (38%), iron pyrite (3.98%), lithium (110%), nickel (53.27%), palladium (5.4%) and platinum (5.21%) had recorded increase in volumes produced (ReportLinker, 2013). Table 3.2 shows Zimbabwe's contribution to the global mining industry by commodity up to the end of 2015. Table 3.2 shows the production year on year per commodity type.

Table 3.2 Commodity production output for 2011 to 2015

Source: (Chamber of Mines of Zimbabwe, 2015).

Commodity	Unit	2011	2012	2013	2014	2015 Forecast
Gold	kg	13,000	14,724	18,000	21,000	25,000
Nickel	t	7,675	7,899	10,611	12,733	15,279
Coal	mt	2.8	1.8	3.7	4.9	7,1
Asbestos	t	2	2	2	2	2
Chrome	kt	610	408	510	700	700
Platinum	kg	12,000	10,524	15,751	19,721	19,666
Palladium	kg	9,600	8,136	12,601	15,776	15,732
Blackgranite	t	168,000	170,811	173,748	176,602	179,511
Diamonds	kcarat	8,165	12,014	14,837	18,443	21,463

3.2 The Role of mining in the Zimbabwe economy

“The mining sector will be the centerpiece of our economic recovery and growth. It should generate growth spurts across sectors; reignite that economic miracle which must now happen…we need to explore new deposits, developing new greenfield projects in the mining sector. Above all, we need to move purposefully towards beneficiation of our raw minerals”. (Mugabe, 2013).

Mining could become the lead growth sector in a post-crisis economy for Zimbabwe, though this will depend on global commodity market conditions as well as on the macro economic conditions, micro economic conditions and industry governance strategies pursued by the authorities. Hawkins (2009), stated that by global standards, Zimbabwe is not a mineral-rich economy, but it does possess resources sufficient to generate export earnings in the region of USD2 billion annually over the medium term and upwards of USD5.0 billion a year within 15 years, thereby ensuring that mining comfortably remains the country’s largest exporter.

High and increasing levels of capital intensity, especially for major projects, mean that mining will not make a significant direct contribution to employment growth (Hawkins, 2009).

For a quarter of a century, until the commodity price boom of 2002 to 2008, mining operations around the world destroyed, rather than created, value with the rate of return in base metal mining falling slightly below the yield on US government bonds. In other words, with the industry failing to cover the opportunity cost of capital, mining globally was not sustainable. Between 2002 and 2008 two developments changed the face of the industry: firstly the commodity price boom and secondly the demand for state participation in the ownership and development of mining properties. Yet ironically, Zimbabwe's mining industry experienced the worst of all worlds in the sense that, with production volumes falling steeply, it failed to exploit the commodities boom. Simultaneously, however; the government embraced resource nationalism, demanding majority 'indigenous' ownership of all mining ventures, including a 25 percent 'free carry' stake for the state. The combination of a deteriorating macroeconomic situation, the exodus of skills, infrastructural bottlenecks and policy unpredictability and uncertainty, ensured that investment in exploration and development has been minimal (Hawkins, 2009).

The mining sector has grown at an annual rate of more than 30% since 2009. Average contribution of the mining sector to the GDP has grown from an average 10.2 % in the 1990s to an average of 15.0 % from 2009-2012. Mineral exports rose by about 23% over the 2009 -2012 period. Figure 3.2 shows the mining contribution since 1995 to 2012 and the forecast up to 2015 projecting 17.8%.

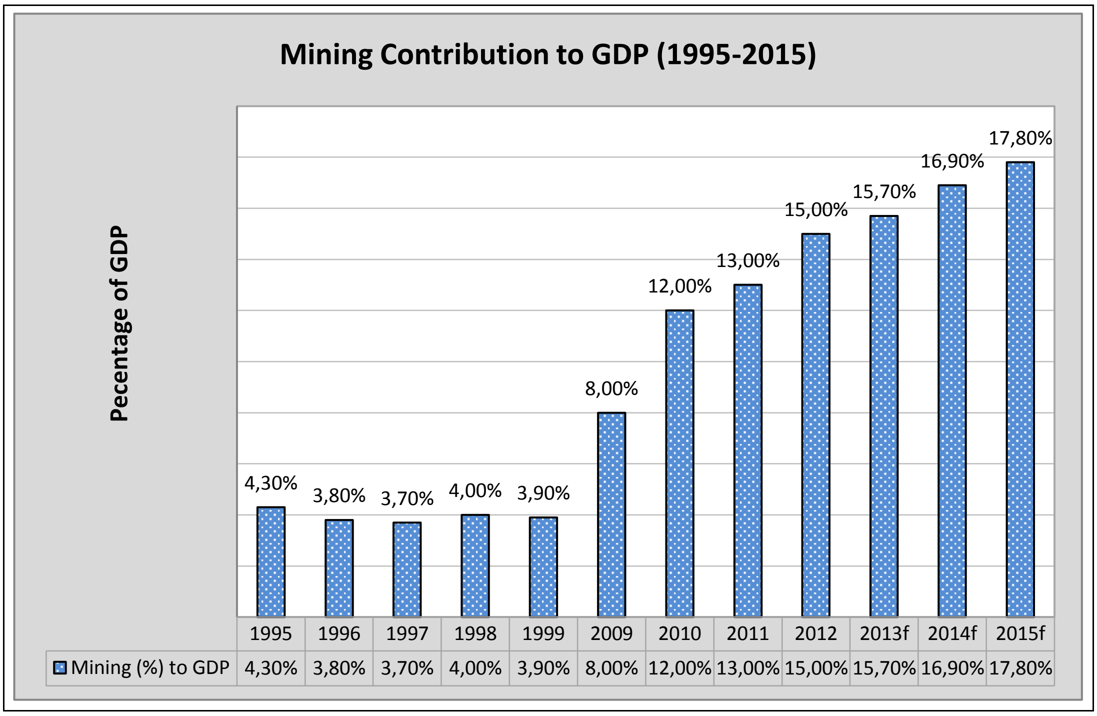


Figure 3.2 Mining contribution to the Zimbabwe GDP

Source: Adapted from (Chamber of Mines of Zimbabwe, 2015)

The tax paid by the mining sector directly to the Zimbabwe government is shown if Figure 3.3. The tax value being paid to Zimbabwe government has increase year on year since 2009 up to 2012 because of the increase in mining activities and new projects in the country. The mining sector has contributed a total of USD1.06 billion between 2009 and 2012.

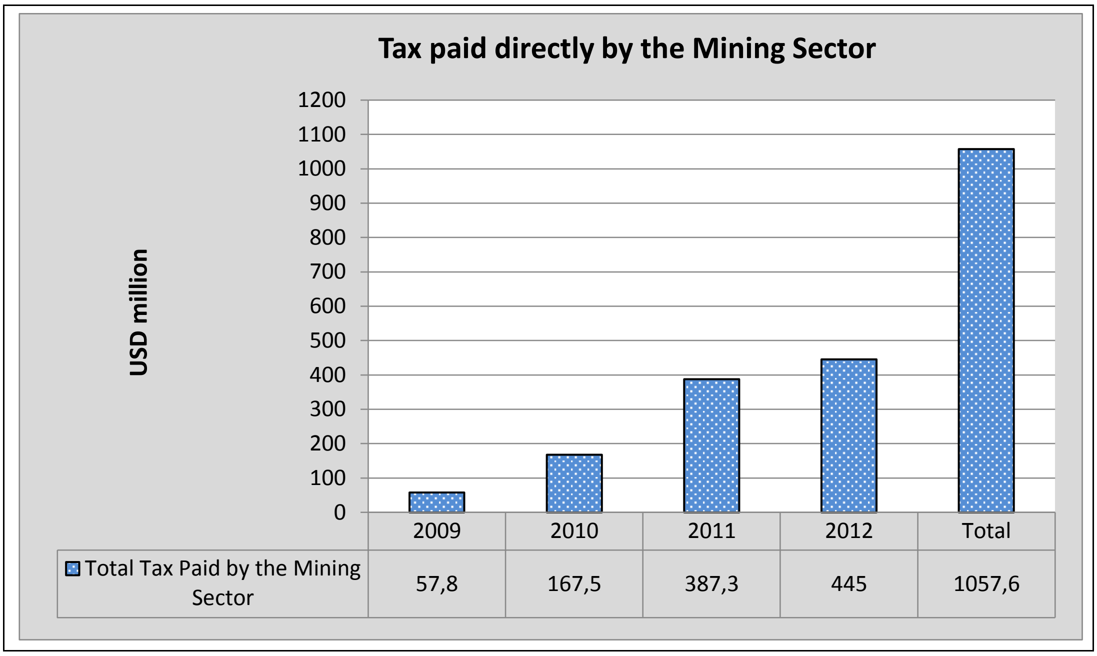


Figure 3.3 Tax paid by the Mining sector

Source: Adapted from (Chamber of Mines of Zimbabwe, 2015)

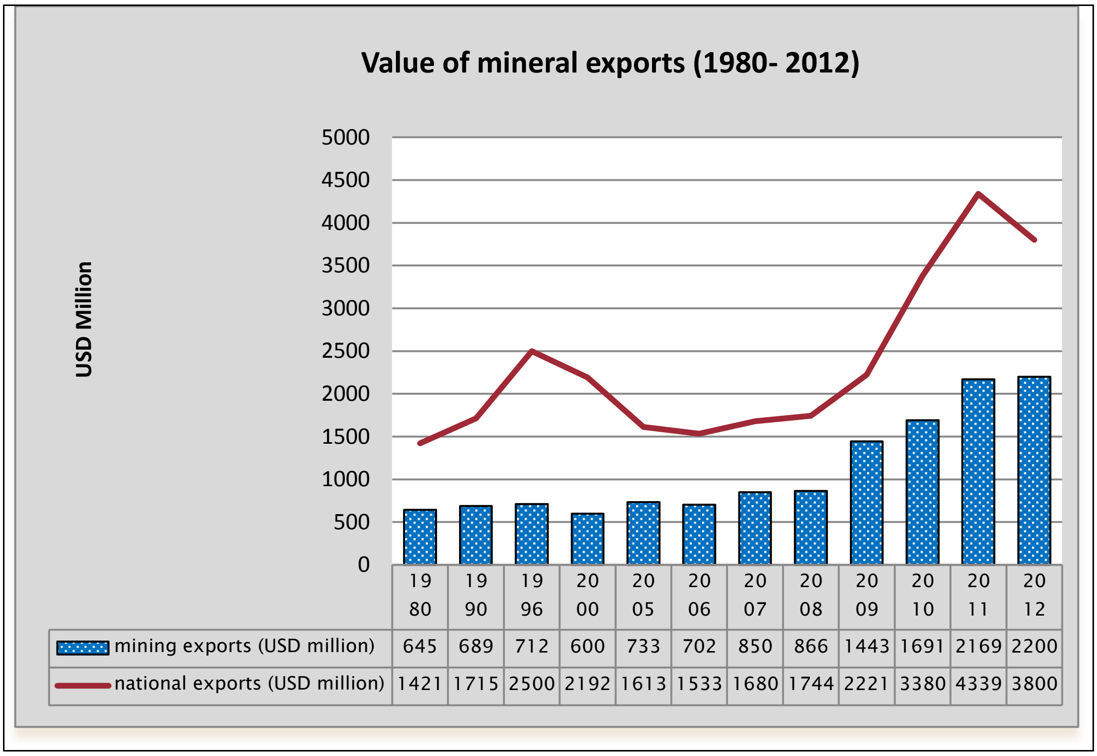
The mining sector has to date been the most dynamic sector of the Zimbabwean economy, leading the 2009-2011 rebound with average annualised growth of 35%. Table 3.3 indicates the average annual growth rates per sector. Mining and quarrying by far had the superior growth rate over the last 5 years followed by agriculture, services, manufacturing and construction, with gas, electricity and water showing the slowest growth.

Table 3.3. The average annual growth per sector in Zimbabwe

Source: (Adapted from Chamber of Mines of Zimbabwe, 2015).

	Average Annual Growth Rate			
Sector	**1988 – 1998**	**1999 – 2008**	**2009 – 2011**	**2012 – 2015**
Mining and Quarrying	2.2%	-9.5%	34.8%	19.2%
Construction	0.3%	-16.0%	2.4%	2.7%
Gas, electricity and Water	-0.8%	-0.4%	1.5%	2.7%
Services	3.7%	-5.0%	2.0%	5.9%
Agriculture	3.9%	-11.6%	12.9%	1.4%
Manufacturing	1.9%	-8.7%	2.3%	4.3%

Figure 3.4 shows the value of mineral exports in comparison to the national exports from 1980 to 2012 and the positive correlation between national export growth and mineral export growth. The top five mineral exports – gold, asbestos, platinum group metals (PGMs), nickel and ferrochrome – accounts for 37 percent of total exports.



	1980	1990	1996	2000	2005	2006	2007	2008	2009	2010	2011	2012
mining exports (USD million)	645	689	712	600	733	702	850	866	1443	1691	2169	2200
national exports (USD million)	1421	1715	2500	2192	1613	1533	1680	1744	2221	3380	4339	3800

Figure 3.4 Value of Mineral Exports in Zimbabwe

Source: Adapted from (Chamber of Mines of Zimbabwe, 2015)

Mining's leading contribution to the economy, especially in recent years, has been its capacity to generate foreign exchange, even with falling output. Since independence in 1980, mining has accounted for almost 40 percent of total exports, dominated by gold, with the other important contributors being ferrochrome, nickel and latterly platinum, which will shortly become the country's major export. Table 3.3 shows the export contribution for Zimbabwe per commodity based on their total mineral exports. PGM's are the leading contributor to the mineral exports at 27.2% since 2004 followed by gold and diamonds at 26.9% and 26.1% respectively.

Table 3.4 Commodity contribution to the total Mineral Exports of Zimbabwe

Source: (Chamber of Mines of Zimbabwe, 2015).

Commodity	1993-2003 (%)	2004-2011 (%)	2012 (%)
Gold	56.0	24.2	26.9
Ferrochrome	20.0	10.7	8.6
Nickel	15.0	11.0	0.7
PGM’s	2.3	46.1	27.2
Diamonds	0.8	6.7	26.1
Others	6.8	1.3	10.5

The mining sector is also responsible for a lot of employment in Zimbabwe and employed over 45,000 people in 2012. Figure 3.5 shows the people employed in the Zimbabwe mining sector over the last 11 years.

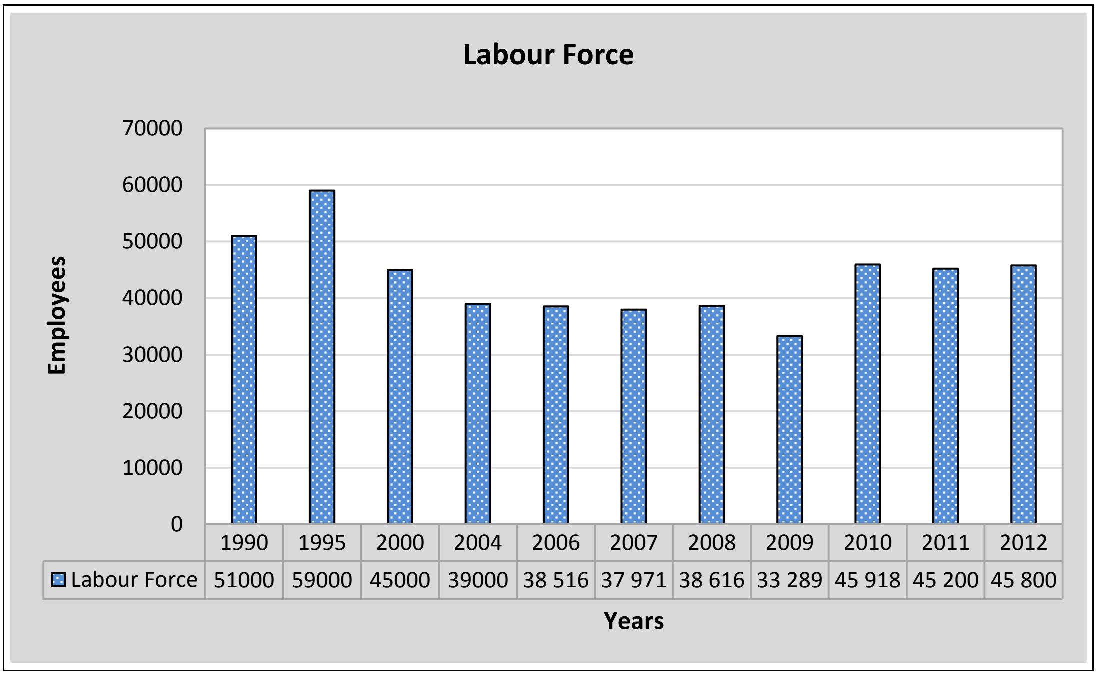


Figure 3.5 Employment in the Zimbabwe mining sector

Source: Adapted from (Chamber of Mines of Zimbabwe, 2015)

3.3 Economy and policy

Historically, Zimbabwe was known as the bread basket of Africa with a vibrant economy. Robert Mugabe was elected the country’s first prime minister in 1980 and has been the president since 1987. The introduction of a land distribution campaign resulted in an exodus of white farmers and the collapse of the economy due to rapid inflation and widespread shortages of basic commodities.

Baruya and Kessels (2013) state that Zimbabwe's current economy is driven by agriculture and mining. In 2008, agriculture accounted for 18% of gross domestic product and mining for 22%. They also continue to say that the government is trying to encourage foreign investment in manufacturing, mining and infrastructure development. Foreign investors could take up to 100% ownership. However, in 2007 the government introduced an Indigenisation Bill that mandates that 51% indigenous ownership of business and this has proved unpopular with overseas investors.

The country's population and businesses faced some of the worst economic conditions, and the country is still recovering. Since 2000, the controversial land reform policy to seize land formerly owned by ethnic white Zimbabweans, and the violence that often accompanied the drive, caused continuing economic decline (Baruya and Kessels, 2013).

3.3.1 Energy policy

Broader energy policy is overseen by the Ministry of Energy and Power Development (MEPD) (Zimbabwe Government Website). The mandate of the Ministry includes policy formulation, performance monitoring and regulation of the energy sector. The MEPD also mandates research and promotion of new and renewable sources of energy and energy conservation (Baruya and Kessels, 2013). The Ministry supervises and oversees the performance of the parastatal energy companies' part owned by government like Zimbabwe Energy Supply Authority (ZESA) Holdings and The National Oil Company of Zimbabwe Private Limited (NOCZIM) (REEEP, 2012). In 2012, the government launched its National Energy Policy (NEP) with strategies and measures to extend and increase electricity transmission and generating capacity. Zimbabwe has set a target of 10,000 MW of installed capacity by

2040. To achieve this goal, the NEP called for a capacity expansion of 800 MW at the Batoka Gorge hydro-electric power station by 2020, 300 MW at the Kariba South hydro-electric power station by 2016, as well as other smaller hydro-electric power plants (Mining Weekly, 2012c). The energy structure in Zimbabwe is shown in Figure 3.6.

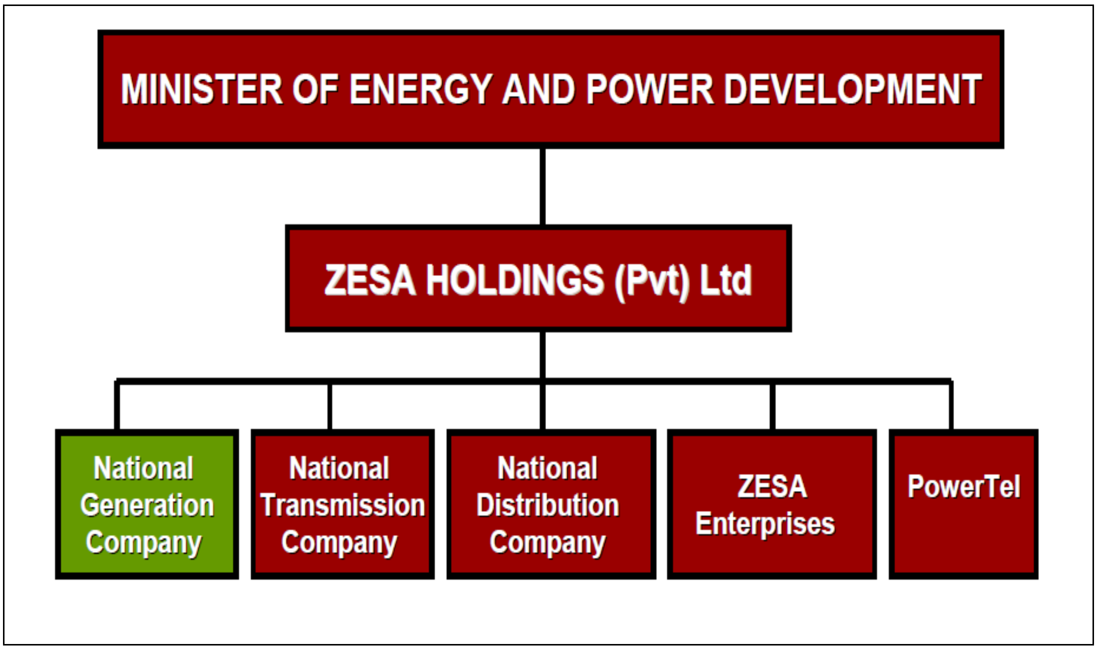


Figure 3.6 Zimbabwe Energy structure
Source: Adapted from (Baruya and Kessels, 2013)

3.3.2 Electricity Market Policy

ZESA is separate from the Ministry of Energy and Power Development. ZESA is an important organisation that provides the majority of electricity based on subsidiary companies, which handle the core services of generation, transmission and distribution. ZESA is a statutory corporation established by the Electricity Act of 1985. A Board of Directors was appointed by the Minister to be in charge of energy and be responsible for the management of ZESA. The electricity market is currently operating with two key companies that generate, supply and import electricity: Zimbabwe Power Company (ZPC), responsible for all generating stations and for the supply of power to the transmission grid, the Zimbabwe Electricity Transmission and Distribution Company (ZETDC). In 2002, the new Electricity Act was implemented, which restructured the power sector from a vertically integrated utility into three separate companies under ZESA Holdings. The separate companies were ZPC and the ZETCO the former transmission company and ZEDC the former distribution company, the latter two being merged in 2010 to form the ZETDC.

Based on (Baruya and Kessels, 2013), ZESA oversees the trade in electricity with other countries, chiefly imports as the country exports little power. Zimbabwe often needs to import electricity, leading to trade imbalances, with ZESA in debt to power suppliers from power-exporting countries. This partly contributed to ZESA's relatively poor financial performance, suffering annual net losses of USD270–418 million in the years 2003 to 2005. By 2008, ZESA owed USD417 million to the Mozambican supplier Hidroeléctrica de Cahora Bassa alone. These losses occurred early during the newly restructured power market – which will require further reforms. The financial losses are due to a variety of problems. Theft of equipment such as transformers and cable and a shortage of spares continue and was estimated to cost USD400,000 per month during 2009. One of the major restrictions on raising cash flow to ZESA is the controlled pricing of domestic electricity by capping. This limits the cost recovery and, when combined with poor billing/collection efficiency estimated at 60% cost recovery in 2009, cash flow is excessively low compared to the cost of operating the system. Tariff caps also reduce confidence amongst financial agencies to loan funds to the company. ZESA also operates the Hwange power plant, which provides the bulk of the country's thermal power generation, and is fueled using coal from the Hwange Colliery. Coal from the colliery is subsidised, but the power plant itself is unable to raise enough funds to pay its subsidised fuel. This in turn weakens the cash flow of Hwange Colliery, which relies heavily on the supply contract with the power station to remain in business (Baruya and Kessels, 2013).

3.3.3 Energy Efficiency

The government's International Energy Initiative runs programmes to promote energy efficiency, notably through the Zimbabwe Energy Efficiency Project

(ZEEP). Under ZEEP, industrial efficiency has improved and government standards for efficient appliances and equipment, for example, lighting, water heaters and refrigerators are being applied (Baruya and Kessels, 2013). Transmission and distribution losses in the country are considerably lower than in many African nations, standing at approximately 12%. Demand-side efficiency could be further encouraged in the country, as electricity tariffs remain amongst the lowest in Africa, at roughly 0.06 USD/kWh, due to heavy subsidies. The low non-technical losses in the transmission and distribution system have been attributed to the exceptionally low power tariffs.

3.4 Energy Demand

Zimbabwe's economy consumed around 9,000 gigawatt hours (GWh) of energy in 2010 and the latest statistics report, indicates a consumption of 7,920GWh (Baruya and Kessels, 2013). The majority of the energy which is consumed in the residential sector, is completely dominated by biomass. This is a common picture seen across this whole region and unlikely to change for some years. Figure 3.7 shows the end user energy consumption per sector

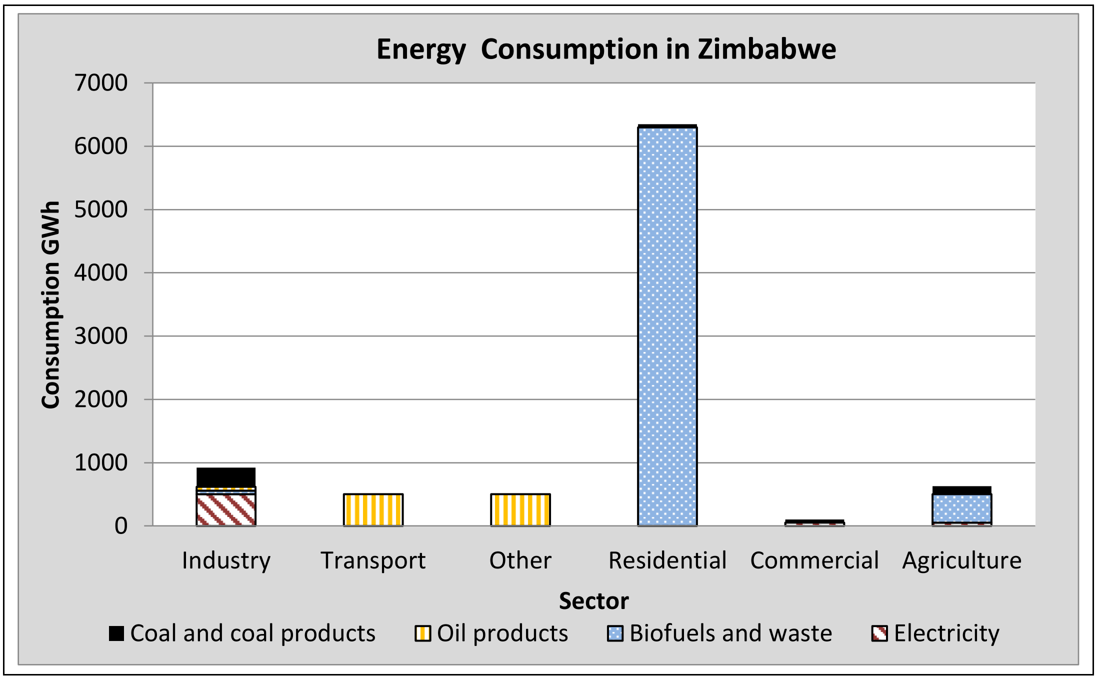


Figure 3.7 End user energy consumption per sector

Source: Adapted from (Baruya and Kessels, 2013)

Figure 3.8 shows the primary energy supply by fuel type in 2010.

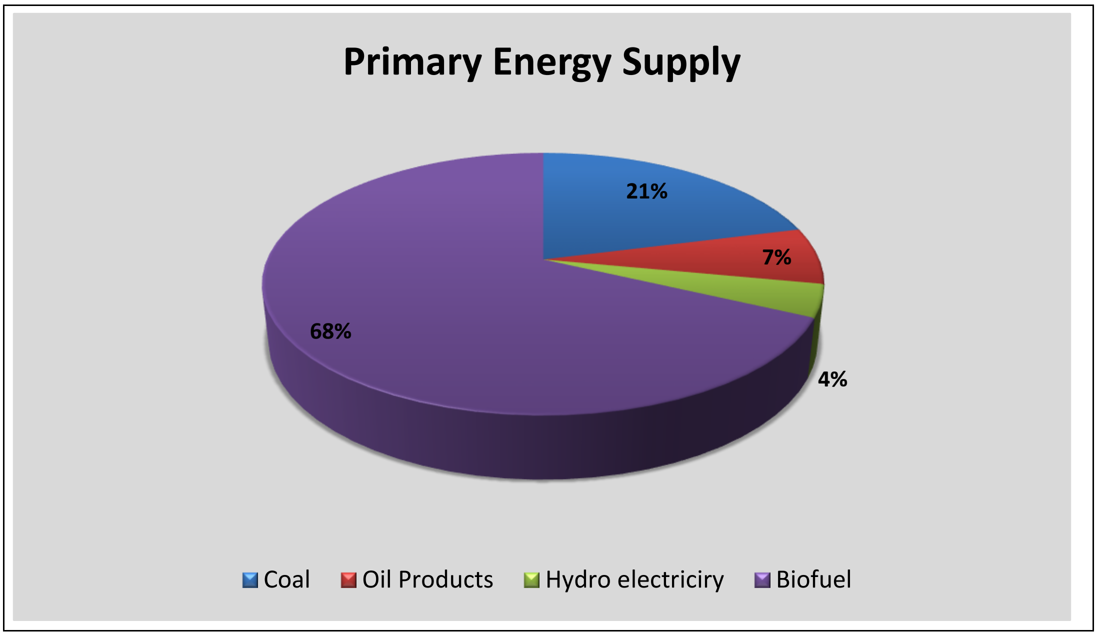


Figure 3.8 Total primary energy supply by fuel type in 2010

Source: Adapted from (Baruya and Kessels, 2013)

Biofuel accounts for about 66% of the energy used. Fuelwood is the most important domestic fuel in the country. It is the major source of energy for cooking, lighting and heating for over 80% of the population mainly in the rural areas. Coal contributes 21% towards the energy used, followed by oil products at 7%. Oil product imports in 2009 were estimated at 13,140 bbl per day. Fuel import spending in 2009 stood at USD454 million, or 15.7% of total import expenditure. Hydro-electricity accounts for 4% of the energy use. Zimbabwe has a hydropower potential of 18,500GWh a year, of which 17,500GWh is technically feasible. To date only 19% of the technically feasible potential has already been exploited.

Energy consumption per capita in 2009 stood at 883-kilowatt hours (kWh), which is higher than the African average of 779kWh per person. The current energy consumption per capita is standing on 560kWh per person. The residential sector accounts for roughly 70% of the total energy consumption in the country. In the residential sector biomass supplies >90% of this energy.
Access to electricity for the country is estimated at nearly 40%, with urban access standing at nearly 80%. Access to electricity in the rural areas of the

country is much lower, at about 19%, due to the prohibitive costs of extending national electricity grids. In rural Zimbabwe, 80–90% of people are heavily dependent on wood fuel and diesel-powered systems for their day to day tasks. The major concern in the energy sector is capacity, no new power plant developments have occurred since 1988. Furthermore, all power stations in Zimbabwe are in need of major upgrades, leading to frequent and long lasting blackouts in the country. As a result, power outages continue to affect the economic performance of industries and services.

3.5 Power Generation

The country's power supplies come primarily from two forms of generation, hydro-electricity and coal power plants, with some net imports necessary to supplement these sources. The Zimbabwean grid is connected to the South African Power Pool. In 2000, power generation supply was around 12,000GWh, with a large proportion coming from imports, and just 7,000GWh coming from the small number of coal and hydro power stations. Figure 3.9 shows the power generation supply in Zimbabwe by source from 2000 to 2009.

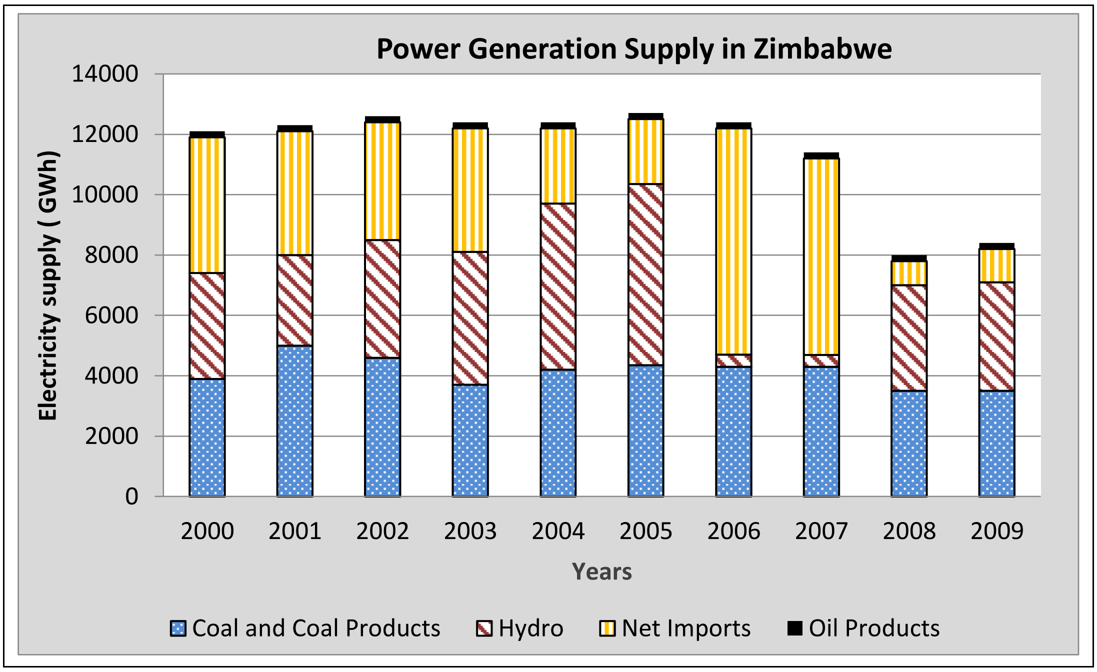


Figure 3.9 Power generation supply in Zimbabwe

Source: Adapted from (Baruya and Kessels, 2013)

By 2005, the output from these power stations increased to more than 10,000GWh, but by 2008, it dropped back to 7,000GWh levels. Net imports also plummeted from 5,000GWh in the early 2000s to below 1,200GWh by 2009. Fulfilling electricity demand with more generation is key to supporting the growing Zimbabwe economy. However, the economy is currently supplied by a few old power stations. Figure 3.10 shows the power generating capacity in Zimbabwe by source up until 2015.

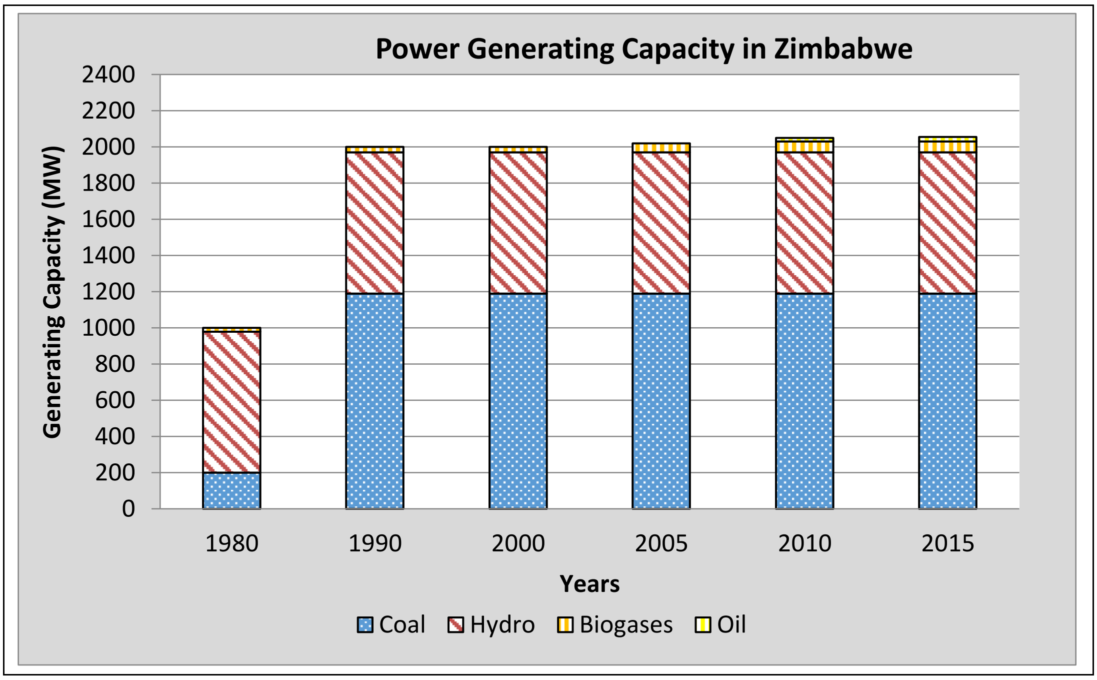


Figure 3.10 Power generating capacity in Zimbabwe

Source: Adapted from (Baruya and Kessels, 2013)

Coal and hydro are the major contributor towards power generation in the country and accounts for more than 1,600MW capacity over the last 5 years, followed by biogases and oil with 40MW and 20MW capacity respectively.

Power generation is controlled by the ZPC, a wholly owned subsidiary of Zimbabwe Electricity Supply Authority Holding group of companies. ZPC was incorporated in 1996 and became operational in 1999 as the power generating investment arm authorised to build, own, operate and maintain power generation stations. ZPC itself operates four coal-fired power stations, they are: Hwange, Bulawayo, Munyati and Harare. In addition, there are two hydro power station, Kariba South Power Station and Gairezi Power Station (Chamber of Mines of Zimbabwe, 2015). Figure 3.11 shows the location of the six major power station in Zimbabwe.

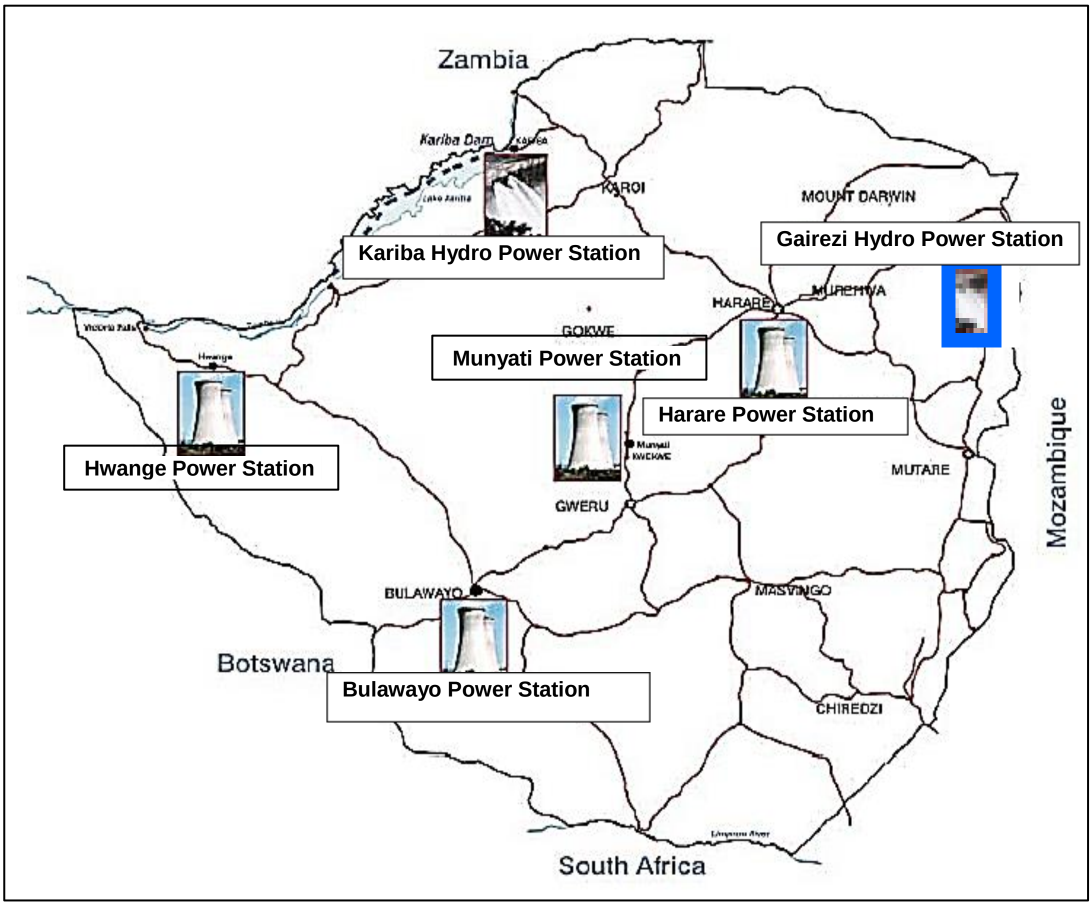


Figure 3.11 Location of Power stations in Zimbabwe

Source: Adapted from (Baruya and Kessels, 2013)

These six stations amount to a total of 1,970MW as installed capacity. Each power station holds a generation license from the Zimbabwe Electricity Regulatory Authority (ZERA). ZPC supplies about 1,200MW of electricity to the network, against a demand of 2,200MW (Baruya and Kessels, 2013).

Transmission losses in the network system are around 11–12% and the infrastructure requires investment. Table 3.5 indicates the capacities and output for the different power stations in Zimbabwe.

Table 3.5 Power Stations Capacity and Output in Zimbabwe

Source: (Chamber of Mines of Zimbabwe, 2015).

Power Station	Type of Power Station	Installed Capacity	Dependable Capacity	Proposed expansion
Hwange Power Station	Thermal	920MW	780MW	600MW
Kariba Power Station	Hydro	750MW	750MW	300MW
Harare Power Station	Thermal	90MW	60MW	40MW
Munyati Power Station	Thermal	90MW	60MW	0
Bulawayo Power Station	Thermal	90MW	50MW	10MW
Galrezi Power Station	Hydro	30MW	30MW	0
Total		**1,970MW**	**1,790MW**	**950MW**

The above table shows the installed capacity and the intended expansion and refurbishment on the current power stations in Zimbabwe. The table shows that there is still deficit in the power supply matrix.

The overall electricity industry infrastructure is outdated and in poor condition due to the lack of maintenance. The stations are in need of refurbishment and upgrading to improve efficiency. Frequent power shortages lead to a significant under-utilisation of production capacity in manufacturing, mining and agriculture. In 2009, the country experienced 15 days of non-consecutive outages. The Kariba hydro station is more reliable with available capacity of 750MW while the Hwange coal plant has frequent outages, which can limit the output to 100MW. The available capacity changes from year to year. According to the Baruya and Kessels (2013) only 1,000MW out of 1,970MW of installed generation capacity is currently available, although the ZPC would claim that this figure is closer to 1,200MW. In May 2010, the country's generation was just 940MW, although the actual dependable capacity at the time was reported to be 1,700MW.

The SAPP plays an important role in helping to fill any shortfalls in generation within the country. Without imports, there would be a greater failure in the country's electricity system. Like Zimbabwe, more neighbouring countries are looking to build coal-fired capacity to ease these shortages. Zimbabwe has a significant amount of potential hydro-electric power resources. Most of these locations are on the Zambezi River and require international agreement with Zambia. The average wind speeds in Zimbabwe are in the range of 2–4 meters a second (m/s) insufficient for large turbines, but suitable for small-scale turbines.

Biomass provides 50% of energy used with coal providing around 13%. Fuelwood is the most important domestic fuel in the country supplying 80% of the population for cooking, heating and lighting. However, biomass is not used in the power market. (Baruya and Kessels, 2013).

3.6 Zimbabwe Royalties

Mineral royalty forms part of the Zimbabwe tax regime and is one of the fiscal instruments. Mining royalties are charged in terms of the Mines and Minerals Act (Chapter 21:05). The royalties are collectable from all the minerals or mineral bearing products obtained from any mining location and disposed by a miner or on his behalf. The royalties are chargeable whether the disposal is made within or outside Zimbabwe.

The objectives of royalty are to:

- Compensate for the loss of non-renewable resources.
- Encourages value addition to mine production.
- Ensures economic and social growth and community development...
- Protect competition.
- Encourage investment in the country.
- Promotes research and development.

Table 3.6 indicates the following persons, as agents for and on behalf of the Commissioner General of the Zimbabwe Revenue Authority (ZIMRA), are required to deduct royalties on the following minerals at source.

Table 3.6 Collection of Mining Royalties

Source: (Chamber of Mines of Zimbabwe, 2015).

Mineral	Agent
Precious stones, precious metals (other than gold), base metals, industrial metals, coalbed, methane and coal	• Minerals Marketing Corporation of Zimbabwe (MMCZ). • Any person authorised by the Minerals Marketing Corporation of Zimbabwe to export such minerals in its own right.
Gold	• Minerals Marketing Corporation of Zimbabwe. • Any person authorised by the Minerals Marketing Corporation of Zimbabwe to export gold in its own right. • Reserve Bank of Zimbabwe or its subsidiaries such as Fidelity Printers and Refiners Pvt. Ltd. • The Chamber of Mines.

Mining royalties are charged based on the face value of the invoice and the rates are as indicated in Table 3.7.

Table 3.7 Rates of Mining Royalties

Source: Minerals Marketing Corporation of Zimbabwe (MMCZ).

Minerals	Rates of royalties with effect from the 1st of January 2012
Diamonds	15%
Other precious stones	10%
Gold	7%
Platinum	10%
Other precious metals	4%
Base metals	2%
Industrial metals	2%
Coal bed methane	2%
Coal	1%

Any royalties deducted should be remitted to ZIMRA on or before the 10th day of the following month in which such deductions are made. A royalty payable rate of 1% was used in the financial models as stated by Mines and Minerals Act (Chapter 21:05).

3.7 Challenges facing the Zimbabwe Mining Industry

Dhliwayo (2013) mentioned the following challenges facing the mining industry in Zimbabwe:

- Potential comparative as opposed to competitive advantage;
- Zimbabwe's mining laws;
  - Poor laws and polices.
  - Importance of laws and policies in unlocking value from mineral resources.
  - Old, archaic and colonial piece of legislation.
  - Obscure legal regime codified in the Mines and Minerals Act.
- Limited transparency and accountability;
- No access to information;
- Role of other stakeholders in the mining sector;
- Lack of participation in the policy and decision making institutions;
- No competitive licensing process with no mechanisms for public accountability;
- Corruption;
- Politicization of the mining sector i.e. Community Share Ownership Schemes; and
- Zimbabwe Mining Revenue Transparency Initiative.

The sector continues to face systematic challenges that include:

- Depressed mineral prices;
- Inadequate funding;

- Frequent power outages;
- Escalating operating costs, such power, labour and consumables; and
- High regulatory taxes, fees, levies and royalties.

This has negatively influenced the output of mining volumes.

3.8 Conclusion

Zimbabwe has a population of 12.6 million people living on a land area of 391,000km^2. It is made up of eight provinces with Harare as the capital city. The mining sector plays a significant role in the economy of Zimbabwe. The mining sector is the second largest contributor to the country's GDP at over 20%. The mining and quarry sector have showed the biggest growth improvement of 32% between 2012 and 2015 compared to the other sectors. The country is endowed with abundant mineral resources.

The top three commodities in terms of estimated resources are, iron ore, coal and platinum with resources of 30 billion tonnes, 26 billion tonnes and 2.8 billion tonnes respectively. The production growth rates per commodity have increased year after year since 2009. The mining sector is very diverse with more than 40 different minerals and over 800 operating mines ranging from small scale mines to world class mines. With the new thrust of mining as the cornerstone of economic growth, it is imperative to: resuscitate existing mining operations, develop new mines, beneficiate mineral output and establish linkages between the mining sector and other sectors of the economy, particularly manufacturing. Mining has accounted for almost 40 percent of total national exports, dominated by gold, platinum and diamonds. (Temba, 2012)

Zimbabwe Energy Supply Authority (ZESA) Holdings is a government parastatal, which is responsible for all the energy and electricity requirements in Zimbabwe. Zimbabwe's economy consumed around 9,000GWh of energy. Biofuel accounts for about 66% of the energy used and coal only contributes 21% towards the energy used. In 2000, power generation supply was around

12,000GWh, with a large proportion coming from imports, and just 7,000GWh coming from the small number of coal and hydro power stations. Zimbabwe's energy requirements are met through a combination of biomass, domestic coal-fired and hydroelectric power plants and imports. The country is serviced by six power stations with a combined total installed capacity of 1,970MW, with hydro accounting for 37% and coal accounting for 61%. More than 35% of electricity required is imported from neighbouring countries (Dhliwayo, 2013).

Each power station holds a generation license from the Zimbabwe Electricity Regulatory Authority. ZPC currently supplies only about 1,200MW of electricity to the network, against a demand of 2,200MW. Inadequate power generation, unreliability of sources and financial constraints to importing has led to frequent power shortages resulting in significant under-utilisation of capacity in manufacturing, mining and agriculture sectors. More than half of the total energy supply is still from biomass products. (Baruya and Kessels, 2013).

Mineral royalty forms part of the Zimbabwe tax regime and is one of the fiscal instruments. The mining industry in Zimbabwe are continuously facing several challenges, which negatively impact on the country's economy.

4 COAL MINING FUNDAMENTALS IN THE ZIMBABWE CONTEXT

4.1 Introduction

Baruya and Kessels (2013) stated that Zimbabwe is a relative small player in the global mining world. Although the country holds large coal reserves, coal production amounted to only 3.6 million tonnes in 2013. Hwange Colliery Company Ltd (HCCL) is the largest coal mining company in Zimbabwe and is planning to increase its production to 500,000 tonnes per month after commissioning their new equipment and capacity additions. As a result, their coal production will reach 6.7million tonnes by 2020. Even though 94% of the coal produced in the country is being supplied to the domestic market, the countries mining industry remains crippled by poor infrastructure and transportation facilities. The country's shortage of electricity is also a big concern and government has approved the construction of additional power stations. Currently five power station projects with a combined output of 7,600MW are scheduled to commence in 2018 China has shown interest to invest USD2.1 billion to develop coal mines and to build a 2,100MW power station to assist with the electricity shortfall (Baruya and Kessels, 2013).

4.2 Significance of Coal to the Zimbabwe Economy

Coal is a mineral with very high linkages with various sectors of the Zimbabwean economy. According to Matyanga (2011) these linkages include:

- Agriculture, electricity, manufacturing, roads, railways, iron and steel, mineral processing and public health;
- Coal is an important raw material in many productive processes, which would otherwise be imported;
- The coal resources are located far from major towns and cities;
- Developing mines at these locations provides opportunities for rural development;
- Generates export revenue from DRC, Zambia, Tanzania, Botswana and India;
- Alternative source of energy to firewood for some urban communities;

- Benefits associated with conservation of indigenous trees;
- Preservation of the carbon sink;
- The coal projects have the potential to add substantially to Foreign Direct Investment;
- With the attendant benefits associated with investment projects;
- Coal is therefore an important industrial mineral with wide applications;
- For Zimbabwe, this resource is critical in economic development at this stage in their history.

4.3 Coal Resources and Quality

Zimbabwe is endowed with world-class coal resources. The coal resource occurs in two major sedimentary basins located on either side of the Zimbabwean Craton, the Mid-Zambezi basin to the north and the Save-Limpopo basin to the south. According to the World Energy Council (2010) at the end of 2008 there were 502 million tonnes of proved recoverable reserves. The country's coal deposits are being explored and surveyed and according to Temba (2012), the coal reserves are in the range 12 – 26 billion tonnes in twenty-one deposits in both proved and probable categories, of which 2 billion tonnes are mineable using opencast methods, but there is little indication of the quantity of proved recoverable reserves from underground seams as yet. Hollaway (2012) believed the country's coal resource to be around 10.2 billion tonnes, but the amount of reserves was not specified. Figure 4.1 shows the coal resource, which occurs in two basins, located on either side of the Zimbabwean Craton. This figure was established by some 5000 drill hole surveys. Subsequently, the greater part of the resource is thermal coal, with subordinate coking coal. Coking coal was best developed in the Hwange deposit.

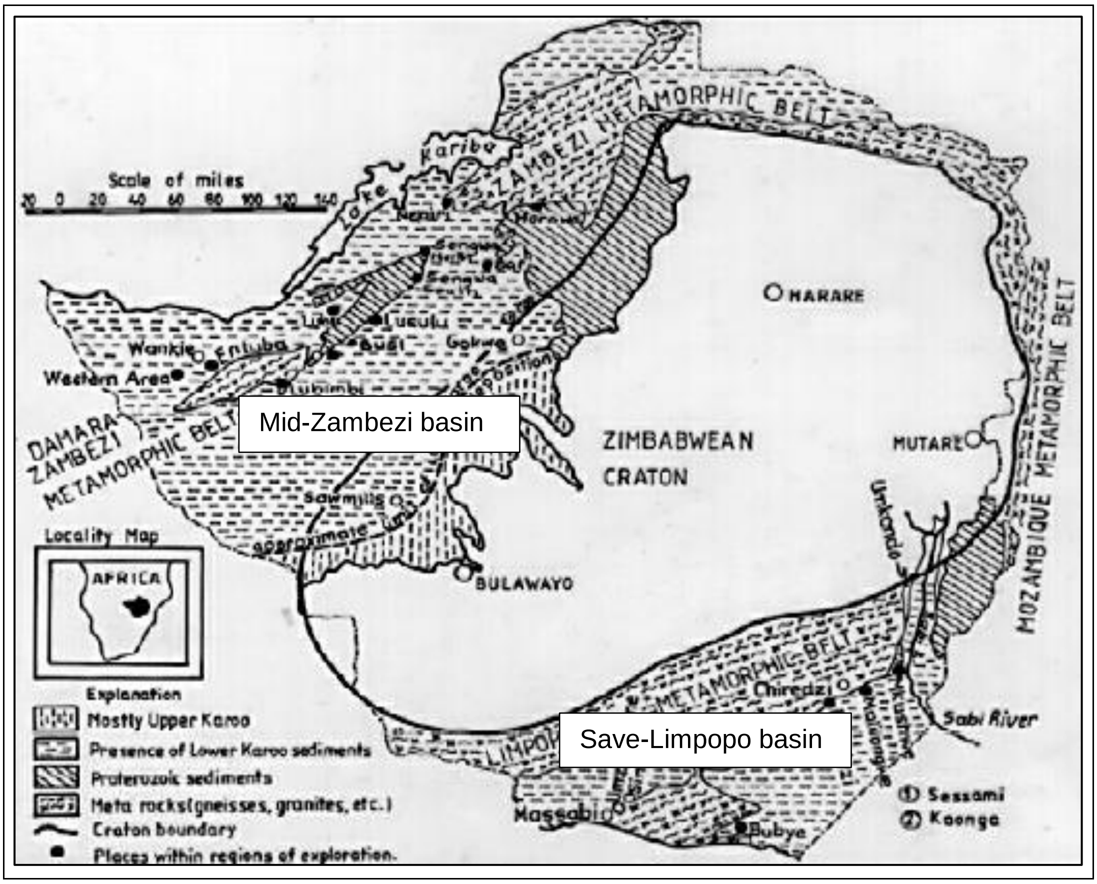


Figure 4.1 Karroo Basin of Zimbabwe
Source: (Matyanga, 2011)

Coal resources are found all over the country, with large reserves in the mid-Zambezi region in the northwest of the country where the current production is concentrated, although large deposits are also found in the southern region of the country in the Save-Limpopo basin (Temba, 2012). The Zambezi area contains the richest resources, with 2.1 billion tonnes in the Hwange area, over 3.0 billion tonnes in the Lubimbi area and a further 4.5 billion tonnes in 'other' Zambezi regions. Figure 4.3 shows a detailed map of the coalfields in Zimbabwe.

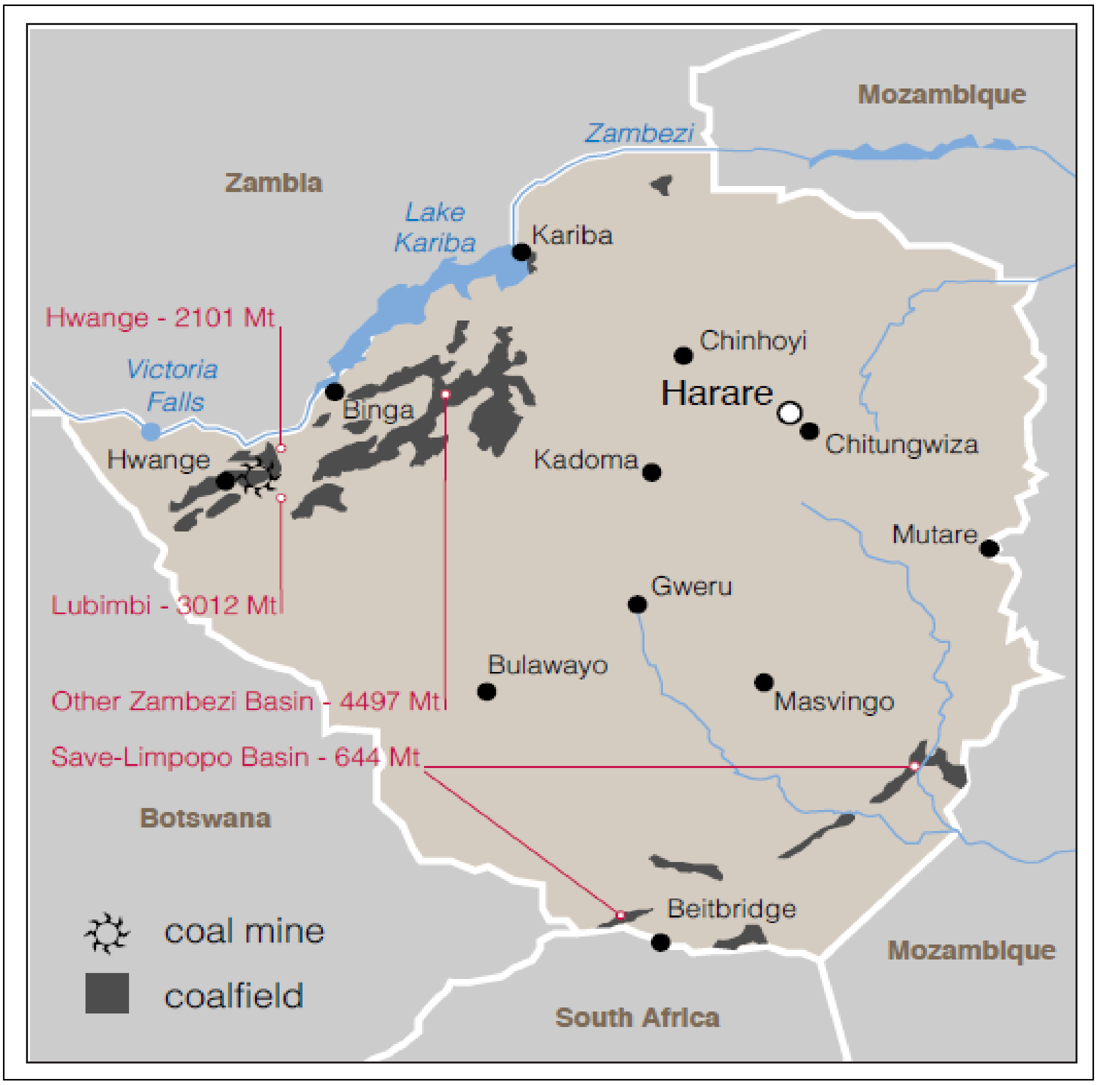


Figure 4.2 Map of Zimbabwe coal resources

Source: Adapted from (Baruya and Kessels, 2013)

The Hwange coal deposit has large reserves of both coking and thermal coal (Temba, 2012). Hwange currently mines one seam at depths ranging from outcrops to 360 meters below ground with seam thicknesses of 10–12 meters. Coal resources outside Hwange, especially those in the Lubimbi, Lusulu and Sengwa regions, are potentially the most abundant, each having 1500–1900 million tonnes. These coal deposits are generally easier to mine, as the geology is more favorable than around Hwange. There is less intrusion by igneous features, the seams are thicker and the coal is lower in ash (Matyanga, 2012). Moving away from the Zambezi region, the southern coal deposits of the Save-Limpopo basin demonstrate more faulting and igneous intrusions with coal of high ash contents and numerous dirt bands. As such, the coal is less suited to the world export market, but could have considerable potential serving local needs. Zimbabwe coal resource is under explored however; the interest in Zimbabwe coal resources has in recent times increased. Currently four mining Special Grants exists:

- Hwange Colliery Company Ltd 220,000 tonnes per month;
- Makomo Resources 150,000 tonnes per month;
- Steel Makers Zimbabwe 30,000 tonnes per month; and
- KW (Chibondo) 20,000 tonnes per month.

Table 4.1 shows the summary of coal deposits in Zimbabwe, including the estimated resources and coal type.

Table 4.1. Coal Deposits in Zimbabwe

Source: Adapted from (Baruya and Kessels, 2013).

Coal Deposit	Resources (Mt)	Number of Drill Holes	Coal type
Zambezi Hwange area			
Hwange	418	3,900	Main seam 8m thick. Coking and thermal, possible gasification and Liquefaction
Chaba	103	150	Main seam 8m thick. Coking and thermal, possible gasification and Liquefaction
Western Area	952	26	Thermal, coking, possible liquefaction
Entuba	532	34	Coking, blend coking, gasification and thermal
Sinamatella	96	6	Ash content 17-23%, main seam 5-6m thick. Gasification and thermal.
Sub total	2,101	4,116	
Zambezi Lubimbi area			
Lumbimbi	1,742	124	Possible coking, gasification, liquefaction, pyrolysis; Fischer assay oil yield 6.4-8.7%
Hankano	571	12	Gasification
Dahlia	699	6	Gasification, thermal
Sub total	3,012	142	
Other Zambezi Basin			
Lusulu	1,900	185	High ash sub-bituminous to medium volatiles Thermal, gasification, possible Liquefaction and pyrolysis
Sengwa	1,500	450	Sub-bituminous to bituminous coal with low ash. Thermal, gasification
Lubu-sebungu	83	5	High-ash and medium volatile bituminous coal, coking; thermal, gasification
Marowa	14	3	High-ash coal
Sessani-Kaonga	1,000	12	High ash and volatiles, low carbon coal. Gasification.
Sub total	4,497		
Save -Limpopo Basin			
Bubye	60	13	Semi-anthracite, low volatiles 13-19.3%, low ash 12%, high Coking, gasification.
Save area	569	12	Limited data, but possibly small underground reserves
Tuli	15	5	Limited data, but possibly small underground reserves
Sub total	644	30	

The coal quality being mined by the Hwange coalfield area ranges from steam coal quality to coking coal quality (Temba, 2012). At the base of the seam, the lower ash and lower volatile coal is produced for coking markets. The coking coal quality ash content is no more than 15% and the volatile content is above 23.5%. The rest of the seam is marketed as steam coal, with ash contents reaching 24% and a calorific value of 24–26 MJ/kg. The representative coal qualities are shown in Table 4.2.

Table 4.2. Representative coal qualities for Zimbabwe

Source: Adapted from (Baruya and Kessels, 2013).

Coal Properties Air-dried basis	Unit	Metallurgical coal	Steam coal
Calorific Value	MJ/kg	29.8	24 - 26
Inherent Moister	%	0.8	0.8
Ash	%	9.8	15 - 30
Volatile Matter	%	23.4	21
Fixed Carbon	%	64	64
Sulphur	%	1.3	1
Free Swelling Index	%	2	0.5

4.4 Coal demand

The current coal market is limited with few mine power stations able to use the low grade coals produced by coal preparation plants. According to Baruya. and Kessels (2013), both steam coal and coking coal are supplied to various customers in Zimbabwe. Apart from the Hwange power station, the heavy industry sector makes use of coal. Other markets include the small overland export market of coal fines to Zambia. The agriculture sector also provides a valuable market for coal, such as tobacco industries, which require heat for curing from coal-fired industrial boilers (Matyanga, 2012). Coke products are used mainly by the Zisco steel company. Coke is used in foundries and by other steel customers in Zimbabwe, Zambia and the DRC. Coal demand is anticipated to rise with the anticipated economic development of the country. The agricultural sector is critical to the growth in demand. The development of export markets provide an opportunity for increase output. The development of the iron and steel industry will result in increased output.

4.5 Coal production

The history of coal in Zimbabwe dates back to 1895 when the first coal claims were pegged around Hwange. Actual mining commenced in 1903 when the first shaft was commissioned by Wankie Coal, Railway and Exploration Company at No.1 Colliery. Figure 4.3 shows, production peaked in the 1990s at around 6Mt per year, comprising of predominantly steam coal (Baruya and Kessels, 2013).

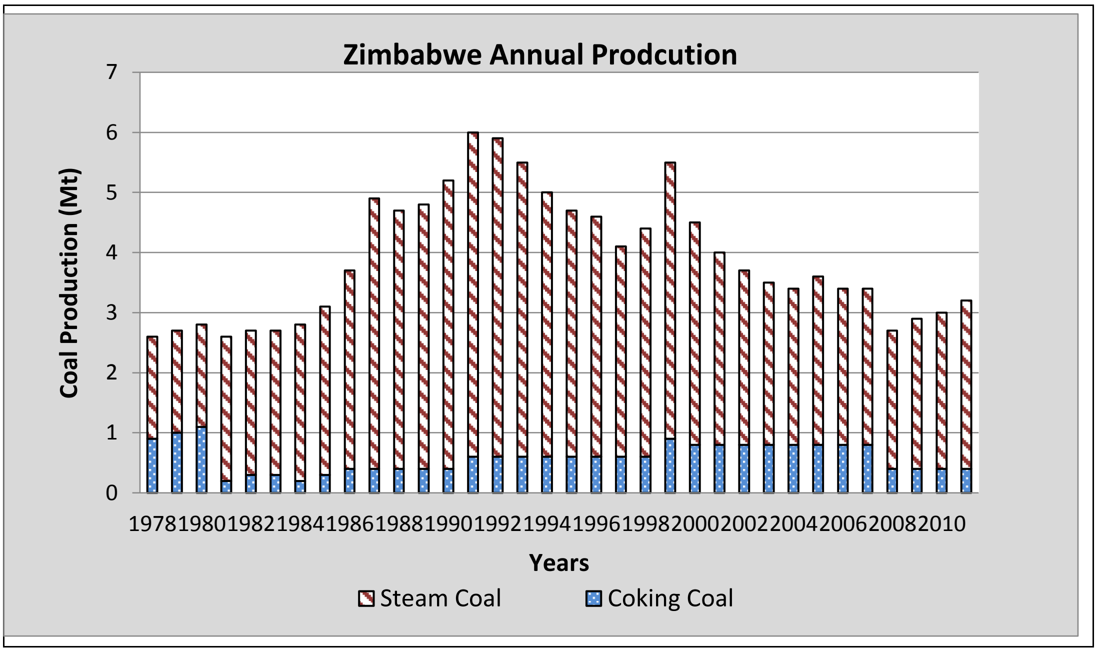


Figure 4.3 Zimbabwe Coal Production since 1978

Source: Adapted from (Baruya and Kessels, 2013)

Production in recent years has been closer to 3Mt per year, with steam coal still accounting for most of the production. Baruya and Kessels (2013) stated that the partially state-owned Hwange Colliery operates at 60% of its nominal capacity. A lack of capital, poor logistics and low prices prevent any major expansion or drive to increase productivity. Mining prior to independence in 1980 was mainly underground by board and pillar mining; opencast mining was limited. Soon after independence, the commissioning of a 905MW Hwange power station created enough demand to stimulate more production at the associated coal operation. This brought about the need for an opencast mine using a dragline strip mining method.

In the underground operations, the No. 3 colliery was upgraded in the late 1990s using a continuous miner, three shuttle cars and mechanical roof bolters. With sales set at 2.5Mt in 2011, Hwange Colliery Company Ltd accounted for at least 76% of the country's production, not including any coal that is produced for stockpiles or lost in transformations such as coke making. The remainder of the country's production, some of which is coking coal, comes from other smaller operations. RioZim operates the Sengwe coal company with a small production of around 25,000 tonnes per month from an opencast operation. In the past, coal-mining licenses were issued to few companies, but deregulation has opened more opportunity to apply for coal blocks. Figure 4.4 shows, average global coal price, since 2003 up to 2012.

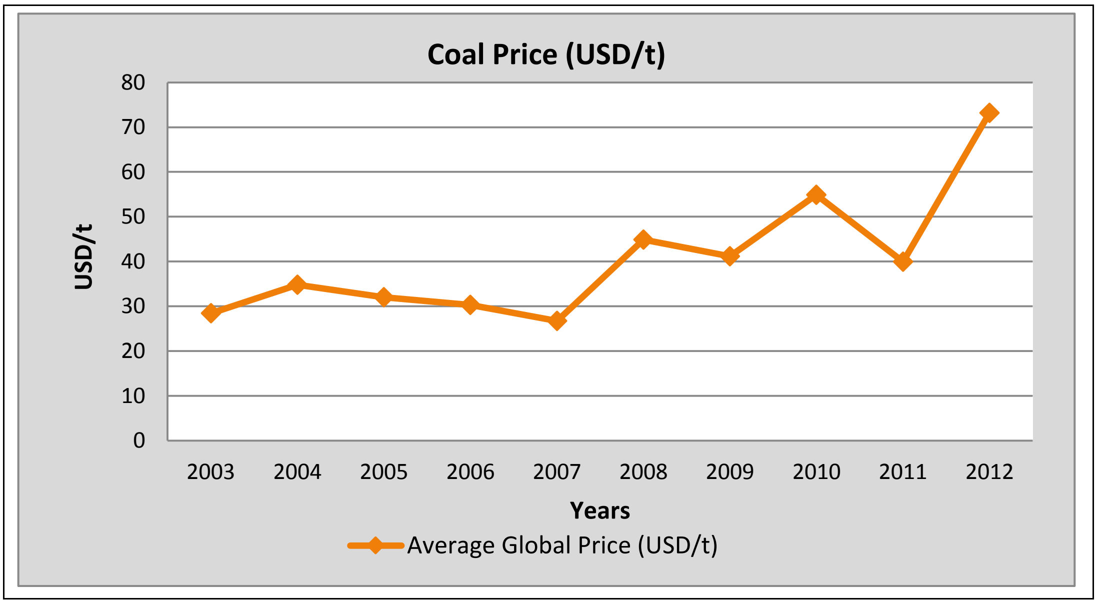


Figure 4.4 Average coal prices
Source: Adapted from (Chamber of Mines of Zimbabwe, 2015)

The coal price has steadily increased over the past ten years from USD28/t in to 2003 to over USD70/t at 2012. The required demand of coal out stripped the coal supply. The current coal price is sitting at about USD50/t

4.6 Coal exports

Existing rail networks can be used to transport coal from western Zimbabwe where the coalfields are being developed to the ports of Beira and Maputo in

Mozambique and Richards Bay and Durban in South Africa. The latter could provide direct routes or coal could be transported through the Botswana's rail network that also goes close to the Botswana coalfields. A number of coal export opportunities is being considered aside from coal production, such as power generation, coke production, coal-to-liquids (CTL), coalbed mine methane (CBM) operations and gasification (Baruya and Kessels, 2013).

Previous exports by rail to Zambia may well continue, but growth could be squeezed until Zambia develops the current railway network. To rehabilitate the 2583 km railway network would cost around USD1.1 billion and a further USD870 million to replace or upgrade rolling stock. One of the key challenges is that the coal deposits that are being mined are in the west of the country, while the market is in the east of the country, hence railway transportation is key to connecting these two development regions. Exports are currently only delivered through the ports located on the Indian Ocean, these ports are in Mozambique and South Africa. Table 4.3 shows the rail line distances from the Zimbabwe coal regions to the export ports.

Table 4.3. Rail distance from Zimbabwe Regions to the export ports

Source: Adapted from (Baruya and Kessels, 2013).

Coal Region	Beira Port	Maputo Port	Durban Port	Richards Bay Coal Terminal (RBCT)
Gweru	869km	967km	1,764km	1,684km
Bulawayo	1,051km	1,083km	1,880km	1,800km
Hwange	1,389km	1,421km	2,218km	2,138km
Muatre	290km	1,546km	2,641km	2,561km
Beitbridge	1,333km	745km	1,598km	1,518km
Chicualacuala	1,300km	536km	1,879km	1,799km

Distance is a major obstacle. The Hwange coal region is close to the Zambian border, which itself is landlocked. The Mozambique and South African coast offers a number of export ports. However, the Hwange coal region is a distance of 1,389–2,218km from the east coast ports, a similar distance to the transport of Russian coals to the Baltic ports, where the cost of inland transportation is half the export cost of coal. Access to suitable ports needs serious attention and should be taken into account by the Zimbabwean coal developers. Namibia is a possible route but less practical as the rail links are still undeveloped, and the key market for Zimbabwean coal lies in Asia. It is likely that coal exports will only go to neighbouring countries. The market is likely to remain domestically for the next couple of years (Baruya and Kessels, 2013).

The Africa Development Bank reported that Hwange Colliery is securing an export supply contract to India and Europe as part of the company's strategy to diversify its portfolio of customers. While it is recognised that the majority of customers will be in the domestic industry and power sector, 40kt of coal was transported via Mozambique from an unspecified port. Coal exports have traditionally been with neighbouring countries such as DRC, Zambia and South Africa, but with an international price of USD100/t, seaborne shipments are increasingly attractive (Baruya and Kessels, 2013).

The US-based company Steelmakers Zimbabwe operates the Chiredzi mine and announced the possibility of exporting coal to India after a USD6 million investment at the Chiredzi Ores Anthracites Lignite's Zimbabwe Coal Colliery (Baruya and Kessels, 2013). Coal is crushed and screened in a preparation plant capable of screening 200 tonnes per hour. December 2012 saw production reach 60,000 tonnes, supplying local customers in construction and the agriculture sector. Steelmakers Zimbabwe applied for a Mining Special Grant in 2004 to mine coal as Hwange Colliery was unable to fulfil supply commitments, which had a negative impact on the Steelmaker Masvingo sponge iron plant.

Hwange avoided the process of obtaining foreign currency in order to make coal purchases from the world market, although initial investments required importing capital equipment for mining. The coal-mining venture was intended to help drive the expansion plans for the group's steel interests in Zimbabwe, and produce low-sulphur low-phosphorous coal from a 2500ha area, which could contain 500Mt of coal.

4.7 Coal-fired power generation

Out of the small number of power stations in the country, only the Hwange Power Station is of significance in terms of overall output to the public grid. The 920MW Hwange Power Station operates as a base load station and meets approximately 40% of the country's electricity supply. (Baruya and Kessels, 2013). According to the Baruya and Kessels (2013) the plant availability averages 80% and has a load factor of 65%, but as observed before, reliability is an issue. The station design largely represents technologies of the late 1960s and some of the equipment such as the boiler controls has had to be replaced with modern digital process controls. The power plant consists of four units of 120MW each and two units of 220MW each. Stage 1 units were commissioned from 1983 to 1986 and the Stage 2 units in 1986-87. Stage 2 is however of more modern design.

Coal is transported to the station by a 3.5km conveyor from the Wankie Colliery opencast mine and via road from the Makomo mining operation. Coke oven gas is used as an alternative to imported diesel fuel on Stage 1 units. The coke oven gas, which used to be flared to the atmosphere, is a by-product of the coking process at the nearby Wankie Colliery coke ovens (Baruya and Kessels, 2013).

The Harare Power Station is located in the capital city of Zimbabwe and consists of three units with coal supplied by rail from the Hwange coal fields. The Munyati power plant was built between 1946 and 1957 and is situated in the Midlands province. The station originally had a capacity of 120MW, comprising of multiple 20MW units, but the station is currently generating 30MW. The station uses stoker boilers, burning bituminous coal under subcritical conditions. The operators of Munyati aim to use lower sulphur products to limit Sulfur Dioxide (SO_2) emissions, but particulate and Nitrogen oxides (NOx) control are not installed, in common with all of the smaller thermal plants (Baruya and Kessels, 2013).

The Bulawayo Power Station is situated in the city of Bulawayo, which is Zimbabwe's second largest city. The plant was commissioned between 1947 and 1957 as an undertaking for the Municipality of Bulawayo. It joined ZESA in 1987 after the amalgamation of all the Local Authority Electricity Undertakings. Unbundling of business units has resulted in the power plant joining Zimbabwe Power Company. It has an installed capacity of 90MW but is capable of generating 60MW due to the deactivation of 2 x 15MW units. The Hwange, Munyati and Bulawayo Power Station are ISO 9001:2008 certified (Zimbabwe Investment Authority, 2015).

4.8 Conclusion

Zimbabwe has more than 10 billion tonnes of coal reserves in twenty-one deposits in both proven and probable categories, of which 2 billion tonnes are mineable using opencast mining methods. The coal resource occurs in two major sedimentary basins located, the Mid-Zambezi basin and the Save-Limpopo basin. Currently only four mining Special Grants are existing in the Mid Zambezi Basin where mining operations are taking place. The coal demand is mainly driven by the local power stations and the agriculture sector. Production in recent years has been closer to 3Mt per year, with steam coal still accounting for most of the production. Coal exports are mainly into Zambian.

5 PROJECT BACKGROUND

5.1 Location

A Special Grant was granted to Makomo Resources for coal exploration and mining in March 2010. The Special Grant which is located in the Bulawayo mining district, about 17km to the south of the town Hwange occupies the greater part of the Entuba Coalfield opencast coal resources. The Special Grant is indicated by the blue boundary line as shown in Figure 5.1.

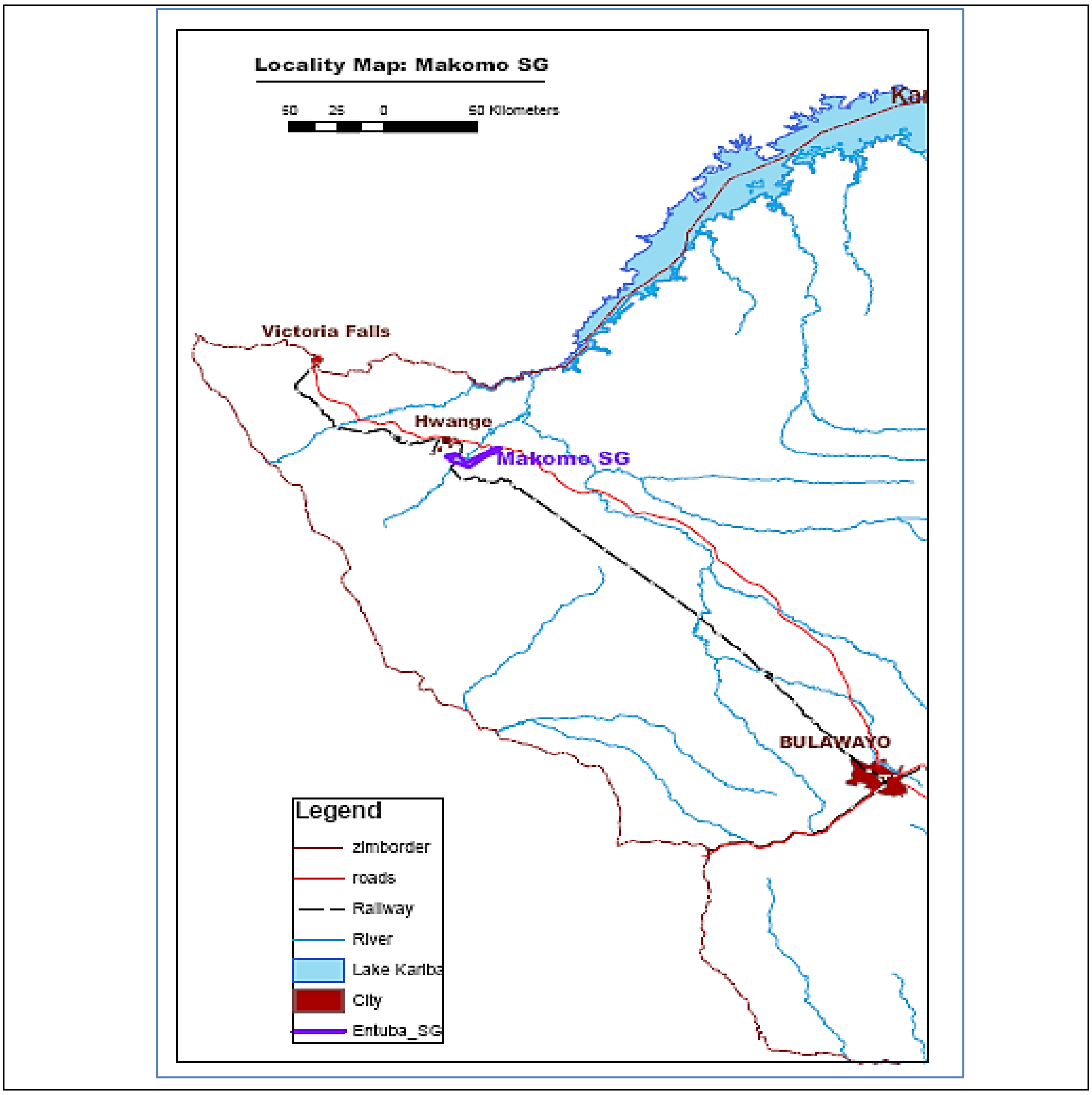


Figure 5.1 Locality Map of Makomo

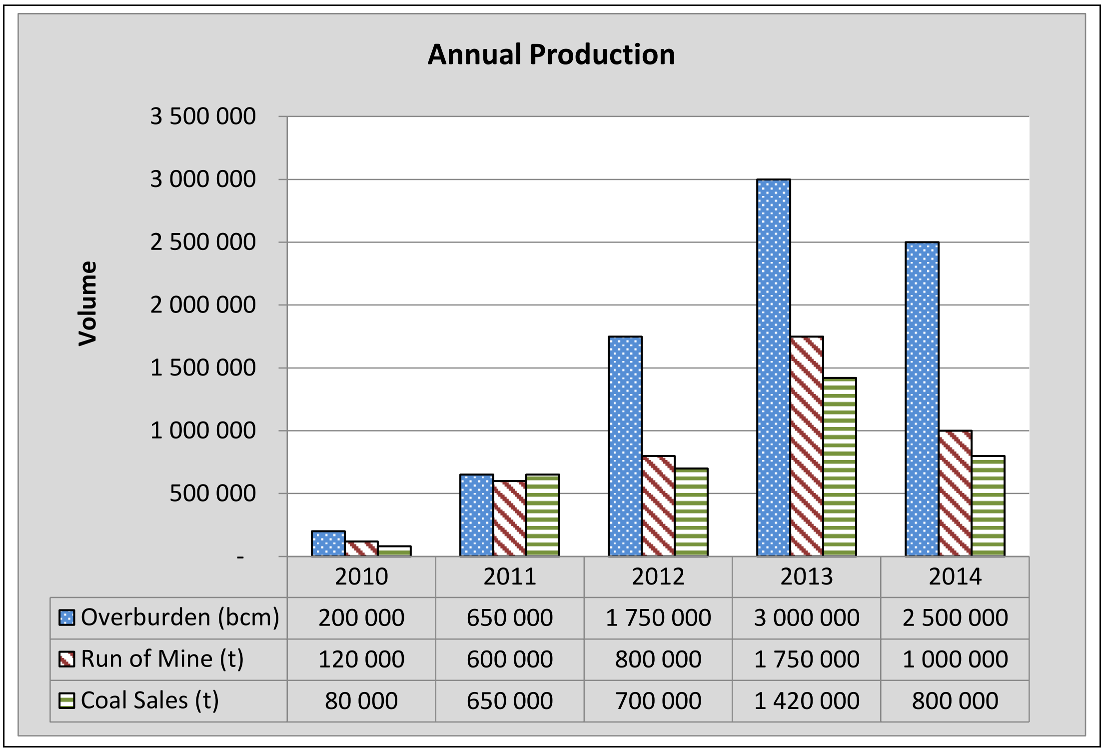
Source: Adapted from (Makomo Resources , 2013)

5.2 Operation Overview.

Makomo Resources obtained its Entuba Special Grant (SG) mining license on the 22nd of March 2010. The SG is located in the Bulawayo mining district about 17km to the south-east of the Hwange town. The SG occupies the greater part of the Entuba Coalfield's open-cast resources. An Environmental Impact Assessment of the mining and exploration venture was carried out before the project commenced operations in June 2010 (Makomo Resources , 2013).

The company has managed to establish the largest privately owned coal mine in the country within its short time of existence. Makomo Resources is the first company in the country to open a coal mine within less than a year of being granted the SG. The mine is currently employing more than 500 people directly. Mining commenced as a pilot project with produced coal trial-run at Hwange Power Station, Munyati and Bulawayo Power Stations for power generation. After several trial runs, product specifications were determined and a contract agreement was entered with the power company. This encouraged further mine development and increased production.

A crushing and screening plant plus a mobile screen to process thermal coal and peas respectively were set-up during the first six months. The mine has managed to maintain constant supply of thermal coal to HPS and has increased its deliveries of coal peas to the smaller powers stations in Zimbabwe thereby stabilizing the country's coal demands. The operation has mined a total of 7.5 million Run Of Mine (ROM) tonnes of coal to-date. Most of the coal was supplied to HPS while a significant tonnage was delivered to smaller power stations, Bulawayo, Munyati and Harare. Figure.5.2 shows the annual production and sales from when the mining commenced in June 2010 until 2014.



	2010	2011	2012	2013	2014
Overburden (bcm)	200 000	650 000	1 750 000	3 000 000	2 500 000
Run of Mine (t)	120 000	600 000	800 000	1 750 000	1 000 000
Coal Sales (t)	80 000	650 000	700 000	1 420 000	800 000

Figure 5.2 Annual Production 2010-2014

Source: Adapted from (Makomo Resources, 2015)

The mine's production plan is 180,000t/month. Hence most investment over the period was towards improving the mining capacity through acquisition of equipment to meet the anticipated targets. The crushing and screening were also capacitated through the coming in of a third crushing plant with a capacity to process 60,000t/month bringing the total capacity to 180,000t/m. Furthermore, in order to beneficiate coal products, Makomo has commissioned a washing plant in October 2014 which is not yet running at full capacity.

The products are washed peas and nuts for the small thermal Power Stations and coking coal for metallurgical requirements. Two exploration projects were performed during the last reporting period, a geological mapping exercise accompanied by percussion drilling over an area of about 15 hectares (ha), and a ground penetrating radar geophysical survey estimation within the license area. The entire Entuba Coalfield covers an area of 32,500ha including the area where Hwange Colliery Coal Company Ltd (HCCL) conducted detailed drilling and mapping work. The Makomo license area covers 19,300ha, and the defined coal resource covers approximately 409.6ha.

The monthly ROM production for 2015 is shown in Figure 5.3. The mining operation has produced 1.73 Million tonnes (Mt) of ROM coal year to date for 2015. Makomo Resources had to re-structure mining operation in the month of March 2015 due to the decrease in market demand and to manage costs and their large coal stockpiles. Since April 2015 a positive increase in the ROM is shown due to the improvement in the demand of the local and export markets. Makomo entered the export market to Zambia in June 2015 and delivered over 60,000 tonnes of coal up to November 2015. The month of September 2015 reported the best performance month to date, with a rise in production also expected into 2016. The ROM production has improved significantly month by month since March 2015 (Makomo Resources, 2013).

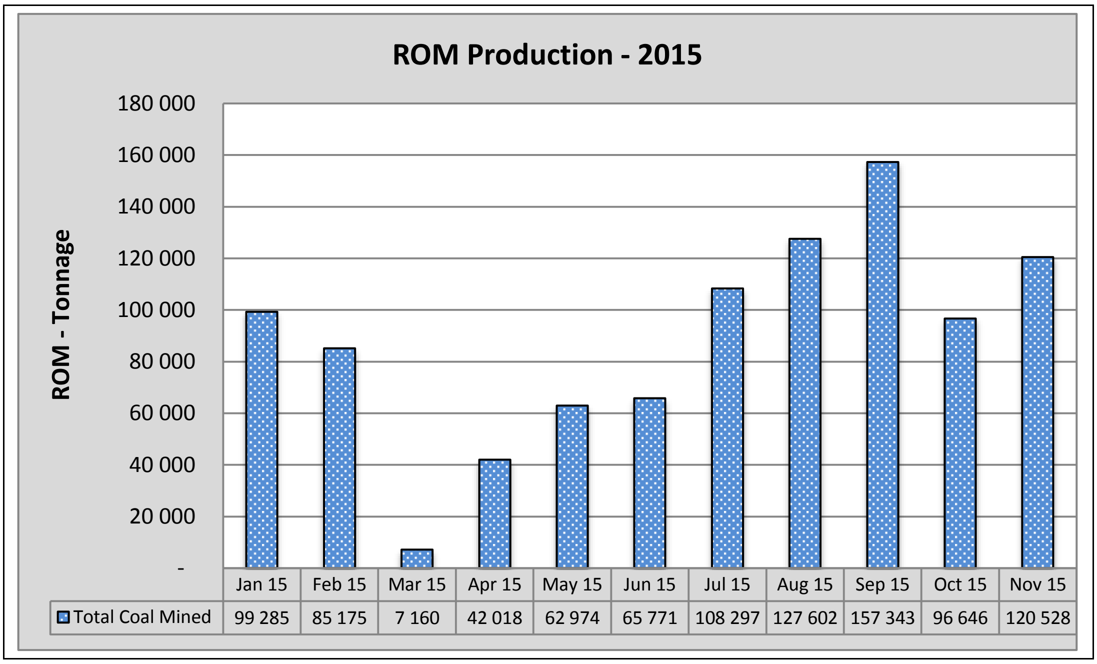


Figure 5.3 ROM production for 2015

Source: Adapted from (Makomo Resources, 2015)

Figure 5.4 indicates the processing performance for 2015. The mining operation has processed 1.06Mt of dry coal products through a crush and screen facility and send 200,000 tonnes of coal through the wash plant. The processing volumes decrease from January 2015 to April 2015 due to the drop in the local and export market demand. From May 2015 the tonnage started to improve again, resulting in the best performance in the month of September 2015. No washed coal was produced from the second month of the year up to April 2015 for the reason that the wash plant was down with an electrical transformer breakdown (Makomo Resources, 2015).

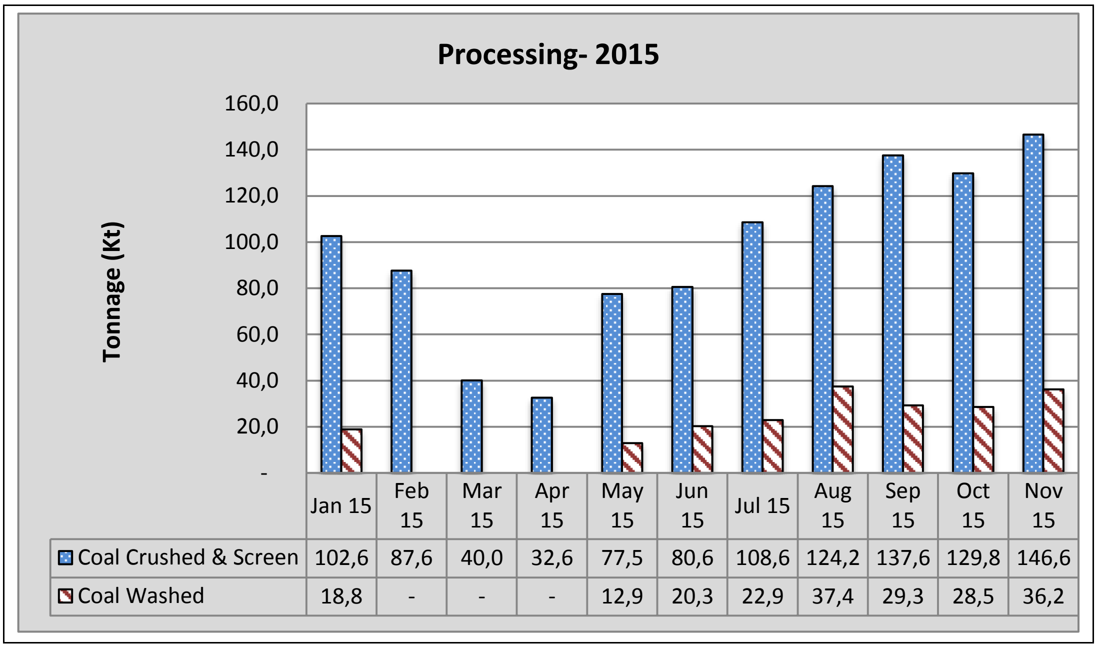
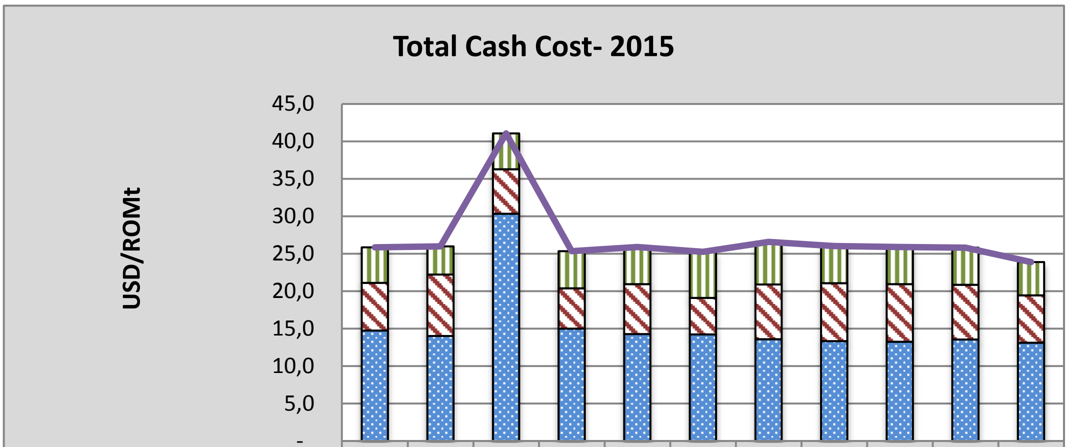


Figure 5.4 Plant production for 2015

Source: Adapted from (Makomo Resources, 2015)

Figure 5.5 indicates the operating cost over the past eleven months of 2015. The average mining cost of USD15.2/ROMt was reported. An average processing and distribution cost of USD6.6/ROMt and USD4.8/ROMt were recorded year to date for 2015. The total operational cost over the previous eleven months of 2015 was quite consistent and in line with opencast mining operating in Zimbabwe with an average total cost of USD27.2/ROMt (Makomo Resources, 2015).



	Jan 15	Feb 15	Mar 15	Apr 15	May 15	Jun 15	Jul 15	Aug 15	Sep 15	Oct 15	Nov 15
Cost of Transport/ROMt	4,7	3,7	4,8	5,0	5,0	6,2	5,7	5,0	5,0	5,0	4,4
Cost of Processing/ROMt	6,4	8,2	5,9	5,4	6,7	4,9	7,3	7,7	7,7	7,3	6,3
Cost of Mining/ ROMt	14,8	14,0	30,3	15,0	14,3	14,2	13,6	13,3	13,3	13,5	13,1
Total Cost of Mining/ROMt	25,9	26,0	41,1	25,4	25,9	25,3	26,6	26,0	25,9	25,8	23,9

Figure 5.5 Operating cost for 2015

Source: Adapted from (Makomo Resources, 2015)

Makomo Resources produces various types of coal products. The split of the coal type's year in terms of tonnages for 2015 are shown in Figure 5.6. Thermal coal is the major contributor towards the coal sale profile at 73% followed by peas and Nuts Peas and duff (NPD) at 17% and 5% respectively. The rest of the sales profile is made up of coking coal, rounds cobles and nuts.

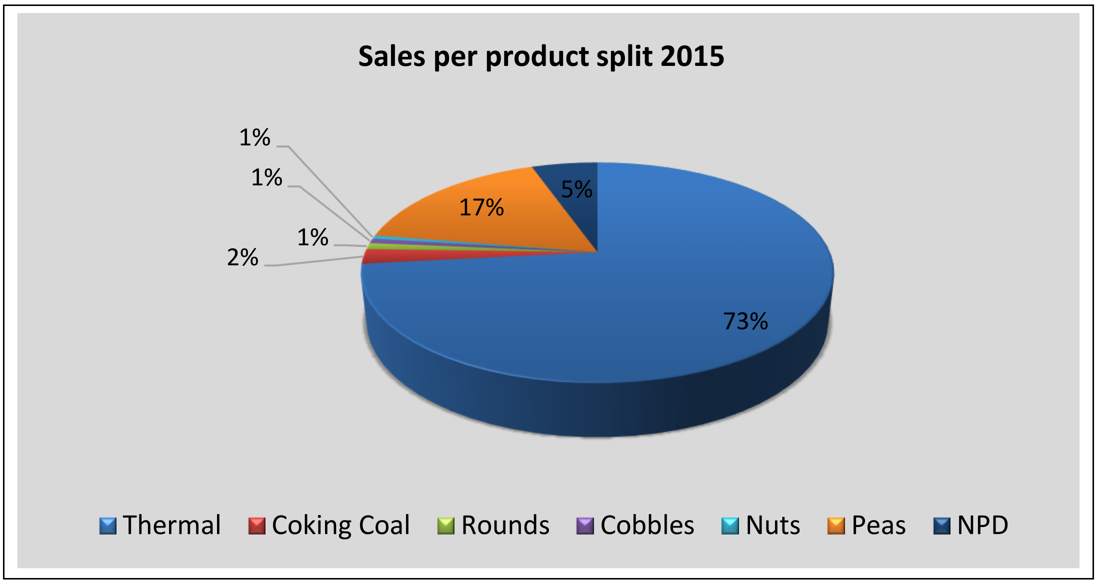


Figure 5.6 Coal Sales product split for 2015

Source: Adapted from (Makomo Resources, 2015)

5.3 Site Description

Generally, the mining site occupies a gently undulating to flattish terrain surrounded by hills. The topography is largely controlled by geology and drainage. The lower ground is occupied by Lower Karoo Sediments and higher ground by Upper Karoo, which rests upon Madumabisa Mudstone. The Lower Karoo sediments have gentle dips, whereas the Upper Karoo sediments form flat topped-plateaus rising to about 900m above sea level. Hills of Lower Wankie Sandstone also exist. The area is traversed by few streams, which flow mainly to the seasonal Lukosi River about 5km to the south east (Venmyn, 2010).

5.4 Geology

5.4.1 Geology Description

The Entuba Special Grant (SG) largely occupies the greater part of the open-cast resource of the Entuba Coalfield which is located in the Mid-Zambezi Basin. The western part of the SG contains Lower Karoo rocks comprising of Lower Wankie sandstone, Black Shale Group, Upper Wankie sandstone and Madumabisa mudstone. The Black Shale Group hosts the main seam, which is equivalent to the Wankie main seam. The eastern part of the SG is largely covered by Upper Karoo rocks comprising Escarpment Grit, red marly sandstone and pebbly arkose. However, Madumabisa mudstone also exists on low grounds on the eastern part of the SG. The resource area is bound by three NE-trending lineaments; Entuba Fault marking the north-western boundary, Lukosi Fault being the south-eastern limit and John's Fault truncating the area near the center (Makomo Resources, 2013). Figure 5.7 shows the geological map indicating the Entuba Fault, John' Fault and Lukosi Fault. The latter, which marks the open-cast coal limit, has a down throw of more than 300m.

The main coal seam is about 11m thick lying below shales, which are overlain by the Upper Wankie sandstone, which is in turn overlain by the Madumabisa mudstone. The lower 3m of the seam has coking properties with the basal

1.5m having straight coking properties and the overlying 1.5m zone having blend coking properties. However, both zones are not being mined for their coking properties. The main coal seam is separated from the overlying 1.5m thick No. 1 seam by 2.5m grey shale inter-burden. The No. 1 seam has coking properties with a Free swelling index (FSI) of 3.5 and an average ash of 19%. The main coal seam has been split based on ash content into; a bottom ~3m thick coal seam of low ash of 8% “Coking coal”, a 6m thick lower sub-seam of low ash 15% “Low Ash/Low Sulphur coal” and an upper 2m power coal seam with a target ash of less than 28%.

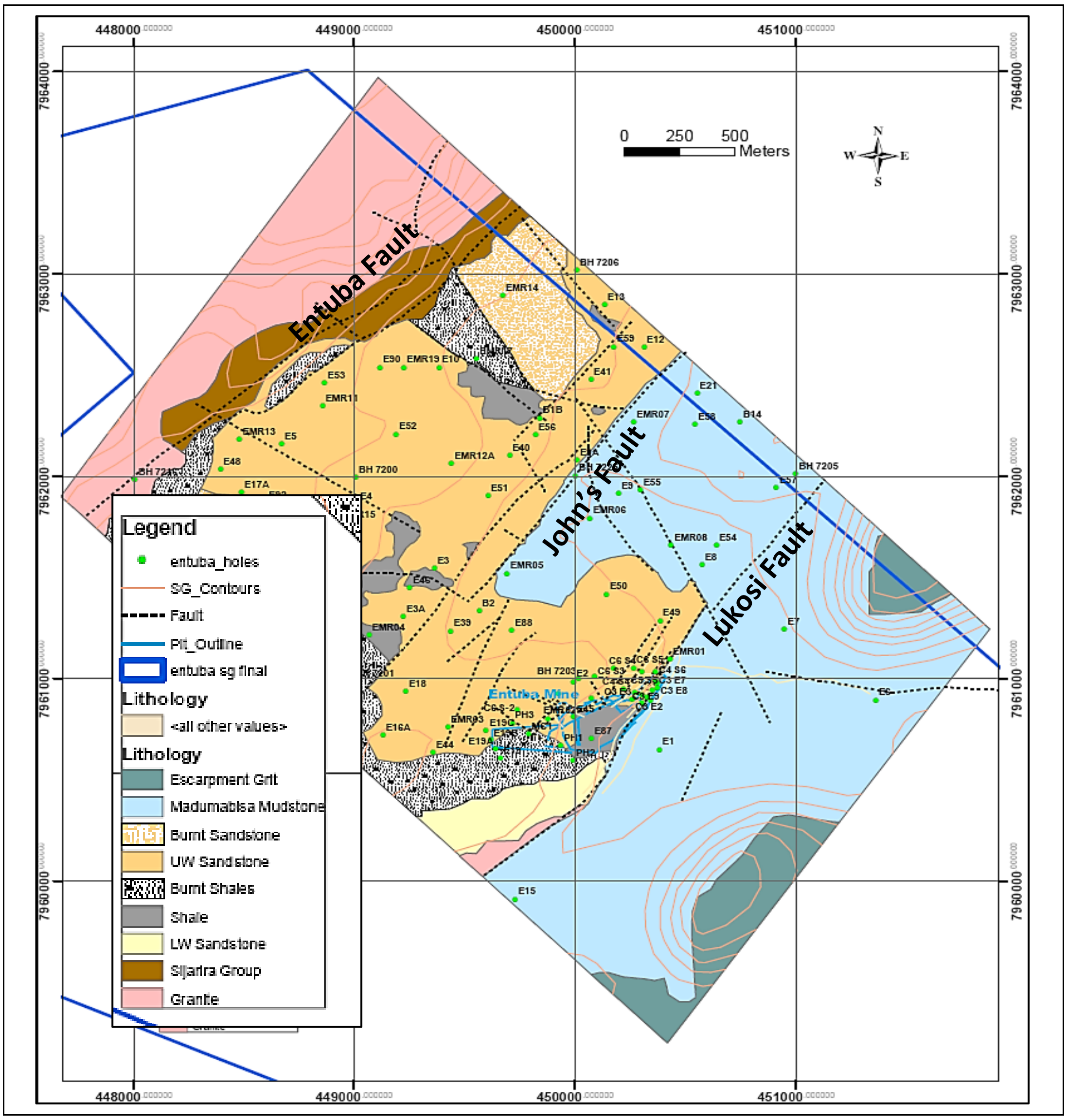


Figure 5.7 Geology map of Makomo Resources

Source: Adapted from (Makomo Resources, 2013)

Figure 5.8 shows a general stratigraphic column for the Entuba Coalfields, which is representative of the Makomo Resources SG area.

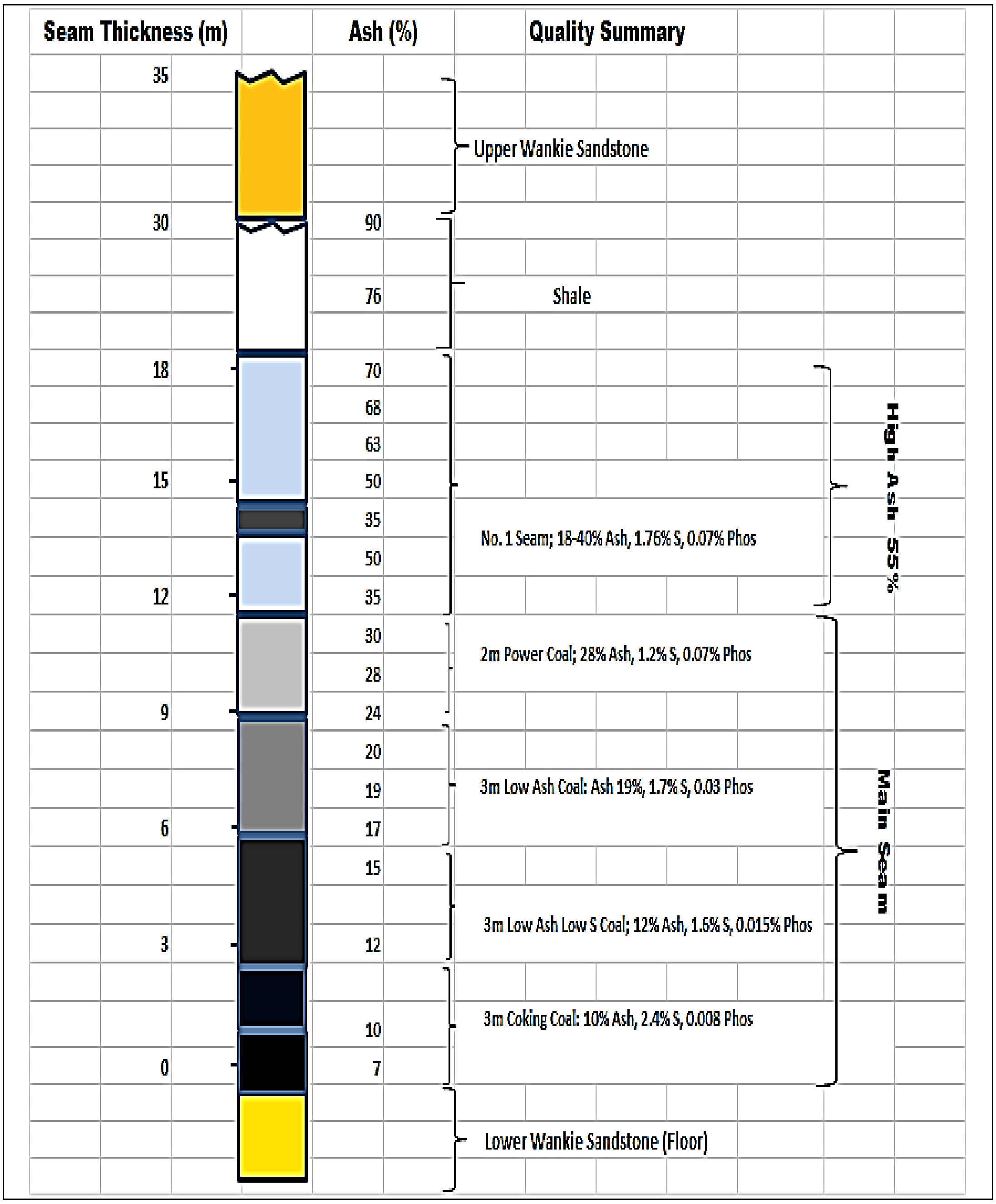


Figure 5.8 Stratigraphic Column

A ROM coal reserve of 65Mt are declared based on a stripping ratio of 2.5 bank cubic meters (bcm)/t of in-situ coal and is suitable for open pit mining methods. Additional coal resources with a stripping ratio greater than 2.5bcm/t is only economic extractable using underground mining methods and hence they were excluded in the current mining plan and in the declared coal reserves.

The borehole quality information was used to calculate the drilling density in the area of the deposit that is mineable and within the boundaries of the special grant as the final deposit outline. Table 5.1 below shows the drilling density based on total holes drilled and the quality data criteria. The number of boreholes per 100ha is as per SANS 10320:2004 (Edition 1) specifications.

Table 5.1 Drilling density with defined limits

Source: (Venmyn, 2010).

Entuba Coalfield Area (ha)	Global bore hole density (per 100 ha)	Borehole Density (per 100 ha) with Raw quality data	Borehole Density (per 100 ha) with Washed quality data
1154.05	8.4	4.58	3.38

Figure 5.9 shows the geological map of the mine area and the location of the different drilling campaigns

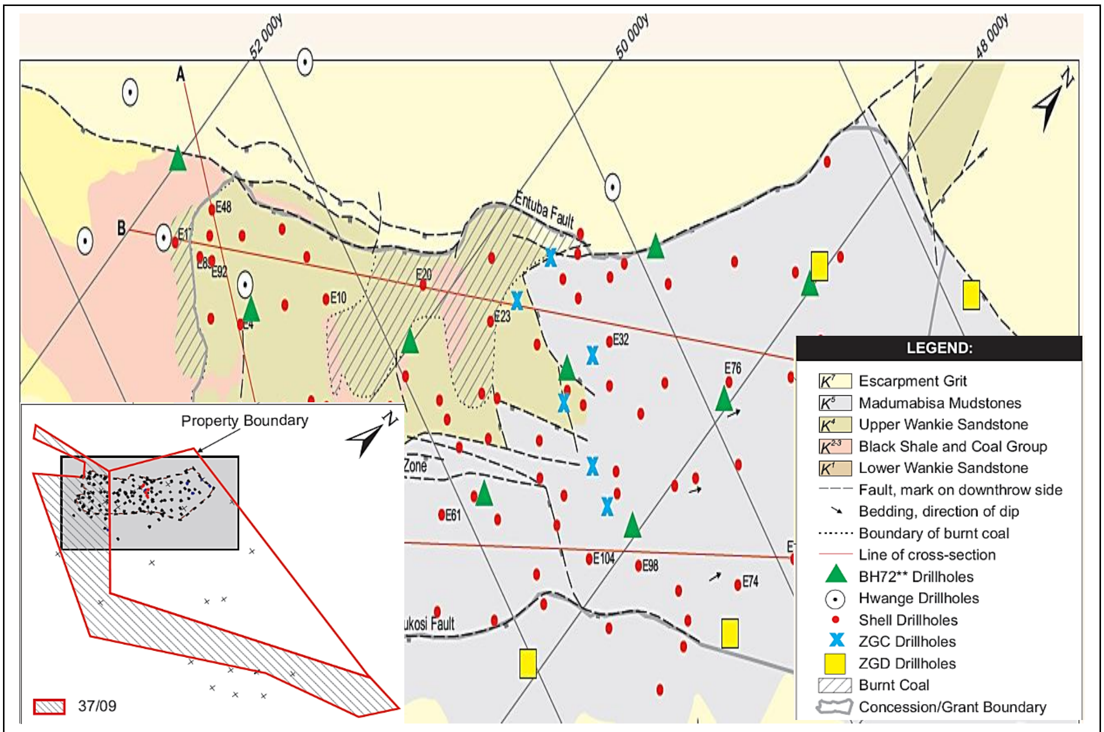


Figure 5.9 Geological Map of the borehole drilling campaigns

Source: Adapted from (Venmyn Deloitte, 2013)

5.4.2 Coal Resource Classification

All coal resources must be classified according to the SAMREC Code (2009). The code refers the competent person to the classification scheme stipulated in the SANS (South African guide to the systematic evaluation of coal resources and coal reserves, SANS10320:2004. This Standard specifies the classification scheme for coal resources based upon the amount of information available on a particular deposit. The SANS 10320 standard divides coal deposits into two types namely; thick interbedded deposits and multiple seam deposits. The coal resource classification is summarised in Table 5.2.

Table 5.2 SANS Classification of Coal Resources

Source: (Venmyn, 2010).

	For Thick Interbedded Seam Deposit (<65%Ash)		For Multiple Seam Deposit (<50%Ash)	
Category	**Max Distance between Bore Hole (m)**	**No. Bore Hole per Ha**	**Max Distance between Bore Hole (m)**	**No. Bore Hole per Ha**
Measured Resources	350	8BH per 100Ha	350	8BH per100Ha
Indicated Resources	1000	1BH per 100Ha	500	4BH per 100Ha
Inferred Resources	3000	1BH per 1,000Ha	1000	1BH per 100Ha
Reconnaissance	4000	1BH per1,600Ha	2000	1BH per 400Ha

The Makomo Resources mining area was classified as the former, a thick interbedded seam deposit. Venmyn has modelled and classified each of the coal seams in the mining area. The volume of each coal seam was calculated from the modelled average coal thickness. As specified in SANS for the reporting of gross tonnes in-situ coal, all coal with a thickness of less than 0.5m were excluded from the calculations.

5.4.3 Reporting of Coal Resources and Coal Reserves

The coal resource estimation and classification were undertaken using best practice and follows the principles and guidelines of the SAMREC Code (2009) and the SANS 10320:2004 (Edition 1). Makomo Resources (2013) was mindful of the bold definitions in the (SAMREC Code, 2009) and has reviewed the historical and current exploration results which form the basis of this coal resource estimation. Makomo Resources followed the SAMREC Code, (2009) to classify their coal resources and coal reserves. Figure 5.10 shows the relationship between a coal resource and a coal reserve.

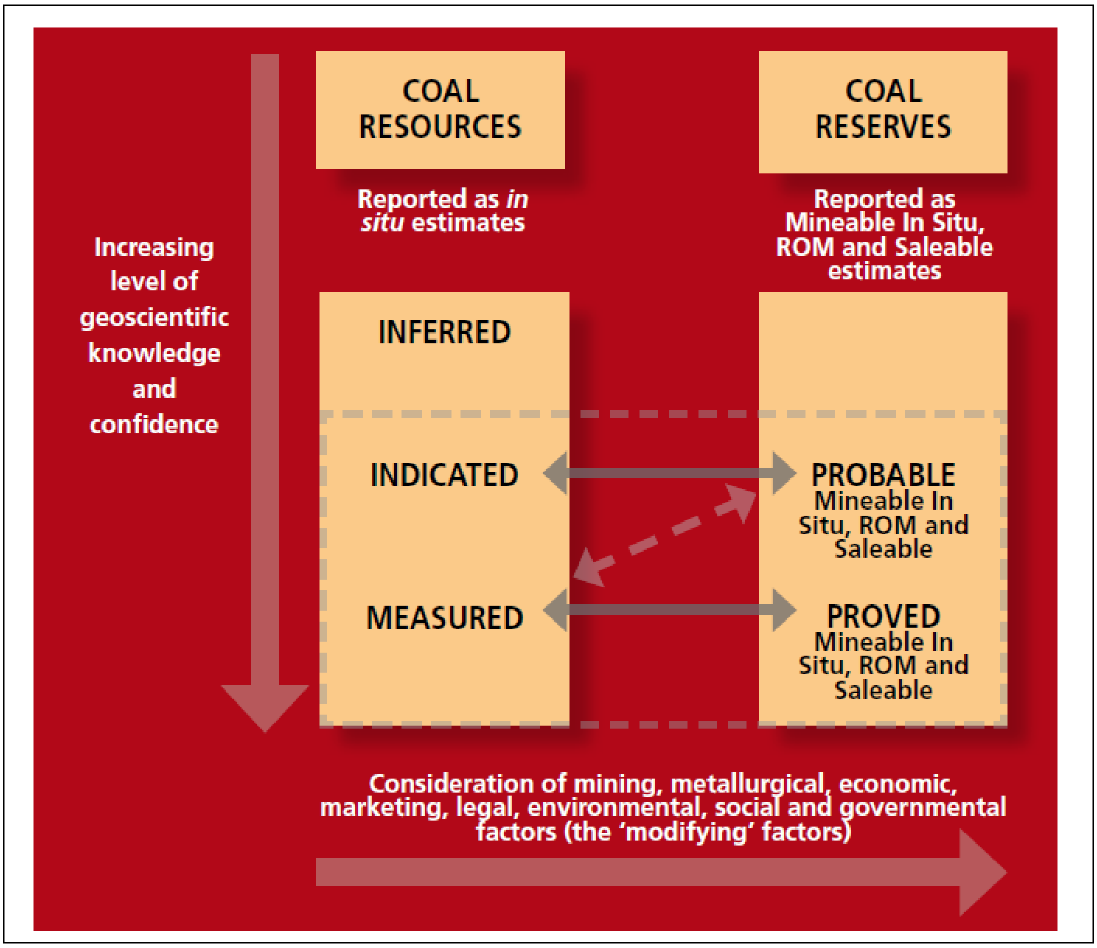


Figure 5.10 Relationship between coal Resources and Coal Reserves

Source: Adapted from (SAMREC Code, 2009)

5.4.4 Coal Resource Statement

In the Entuba Coalfield the Wankie main seam is up to 20.31m thick with the overall ash content averaging approximately 19%. The main seam contains both coking and thermal coal. The coking coal, both straight and blend, occurs in the basal part, and the thermal coal in the upper two-thirds of the seam. In the open-cast portion of the coalfield, the coking coal is on average 2.5m thick. It should be noted that all the coal designated as coking coal requires washing before it can be sold to the market.

An estimated Gross Tonnes In-Situ (GTIS) coal resource was modelled and amounted to 107Mt for the modelled mining area. After the application of discounts of 15% for geological losses, thickness variation, brecciated coal, burnt coal and faulting, a Total Tonnes In-Situ (TTIS) coal resource of 91.7Mt was declared. This tonnage has been classified as shown in Table 5.3 below, and are according to the SAMREC Code (2009) and SANS guidelines based on prerequisite coal quality data and borehole density stipulations.

Table 5.3 Makomo Coal Resources Statement as at 31July 2010

Source: (Venmyn, 2010).

Resource Blocks	Resource Category	Area (km^2)	Seam thickness (m)	Volume (m3)	SG	GTIS (Mt)	TTIS (Mt)
Block A	Measured	2,361	11.72	27,6688,25	1.5	41.5	35.4
	Indicated	1,528	10.96	16,750,188	1.5	25.1	21.4
	Inferred	89	10.47	940,912	1.5	1.4	1.2
	sub total	3,980	11.15	45,359,925	1.5	68.3	57.8
Block B	Measured	2,047	10.86	22,2370,51	1.5	33.5	28.4
	Indicated	421	10.20	4,298,105	1,5	6.4	5.5
	sub total	2,468	10.75	26,535,156	1,5	39.8	3.4
Grand Total		**6,449**	**11.15**	**71,895,081**	**1.5**	**107**	**91.7**

An estimated coal tonnage was estimated using the property boundary and the Lukosi and Entuba faults as the limits of the coal deposit. The breccia zone and geological losses were discounted for in the coal resource estimation. Figure 5.11 shows the mining boundary and location of mining Block A and Block B

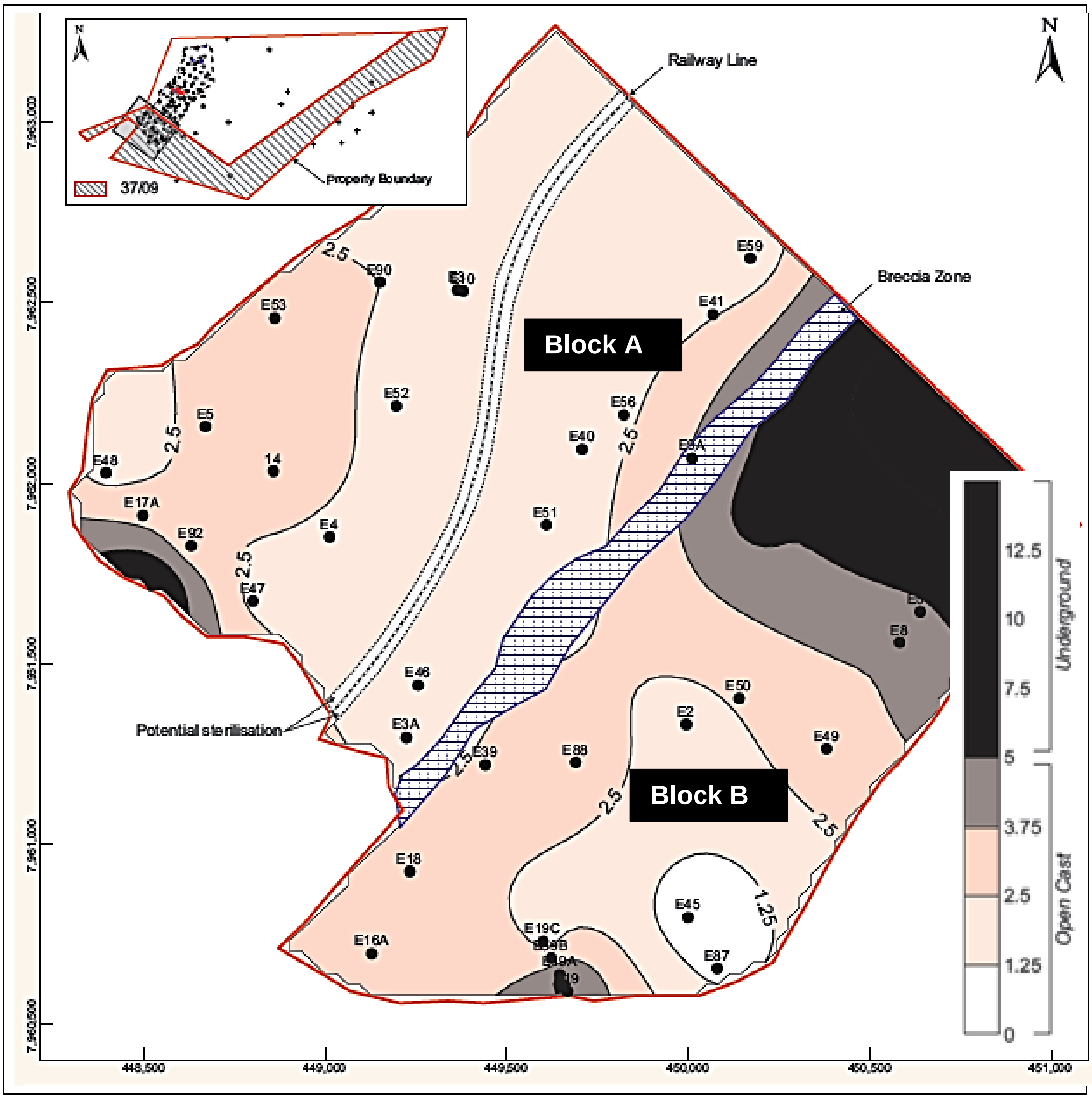


Figure 5.11 Map of the Coal Resources

Source: Adapted from (Makomo Resources , 2013)

5.4.5 Coal Reserve Statement

The opencast portions both on Block A in the north and B in the south have fairly consistent stripping ratios and the seam thickness is on average about 11 meters. The effects of pinching of the coal resource due to imbricate faults should be expected especially close to the breccia zone. The overall effects of the railway line thickness variation, brecciated and burnt coal and faulting were discounted in the coal reserve statement. The discount due to the fact of a railway line passing through the coal resources has a potential to sterilise 5.7Mt of ROM coal in Block A and has also affected the orientation of the mining strips as detailed in this report. In the mining layout a minimum of 50m on either side of the railway line has been allowed.

The Coal Reserve was declared as 65Mt of ROM coal at a stripping ratio of 2.5bcm/t of in-situ coal and is amenable to open pit mining methods. Additional coal resources with a stripping ratio greater than 2.5bcm/t were considered only extractable using underground mining methods and hence they were excluded in the current mining plan and in the declared coal reserves (MineQuest, 2010). Table 5.4 below summarises the Probable Coal Reserve tonnages and the average coal qualities within the mining areas.

Table 5.4 Coal Reserve Statement as 31 July 2010

Source: Adapted from (MineQuest, 2010)**.**

Reserve Block	Reserve Category	Area (km^2)	Seam thickness (m)	SG	MTIS (Mt)	Ash %	VM (%)	CV (MJ/kg)	ROM (Mt)
Block A	Probable	3,280	11.51	1.5	56.7	17.7	19.8	26.55	48.2
Block B		1,345	9.90	1.5	19.9	17.5	20.8	27.59	16.9
Grand Total		**4,625**	**11.04**	**1.5**	**76.6**				**65.1**

5.4.6 Seam selection

The main seam is about on average 11m thick. Intended for Mining Option 1, three primary economic seams have been identified as the power coal seam, low-ash coal seam and coking coal seam, with average thicknesses of 2.0m, 7.0m and 2.0m respectively. For Mining Option 2, four primary economic seams have been identified as the power coal seam, low-ash coal seam, low sulphur coal seam and coking coal seam, with average thicknesses of 2.0m, 4.0m, 3.0m and 2.0m respectively. Figure 5.12 shows the seam selection for Mining Option 1

Coal Seam	Process
2m Power Coal 28% Ash, 1.2% S, 0.07% Phos	Crush & Screen
7m Low Ash Coal Ash 15%, 1.8% S, 0.02% Phos	Crush & Screen / Washing
2m Straight Coking Coal 8% Ash, 2.5% S, 0.008% Phos	Washing
Lower Wankie Sandstone (Floor)	

Figure 5.12 Seam selection for Mining Option 1

The seam selection for Mining Option 2 is shown in Figure 5.13

Coal Seam	Process
2m Power Coal 28% Ash, 1.2% S, 0.07% Phos	Crush & Screen
4m Low Ash Coal Ash 17%, 1.8% S, 0.03% Phos	Washing
3m Low Sulphur Coal 13,5% Ash, 1.9% S, 0.014% Phos	Crush & Screen
2m Straight Coking Coal 8% Ash, 2.5% S, 0.008% Phos	Washing
Lower Wankie Sandstone (Floor)	

Figure 5.13 Seam selection for Mining Option 2

5.4.7 Mining Method

Under the current techno-economic indications, the majority of the coal resource in the mining area will be exploited using opencast mining methods. Most coal deposits generally occur layered or stratified and in most instances parallel strip mining methods are applied in opencast operations. The ratio of 3.5 of waste bank volumes to the tonnage of coal exposed will imply open cast mining methods. In the case of Makomo Resources, Venmyn Deloitte (2010) took the stripping ratio cut-off at 3.5/t for an opencast mining operation. The overburden thickness dictates the appropriate equipment sizes capable of efficiently exposing the coal seam for extraction.

Mining consultant, Venmyn (2010) calculated first pass annual production rates and life of mine parameters for the opencast portion of the reserve at the break-even strip ratio of 3.5bcm/t. Taylors rule is used as a benchmark to find an estimate of optimal production and the lifespan of the mine. The results of this exercise show that a LOM of about 20 years for Block A and 10 years for Block B were suggested. Table 5.5 below shows the results of the exercise.

Table 5.5: The LOM at the estimated annual production rates

Source: Adapted from (Venmyn, 2010).

Project area	Estimated Annual Production (tpa)	LOM (years)
Block A	2,437,000	20
Block B	1,740,000	10

The opencast portions both on Block A (North) and B (South) have fairly consistent stripping ratios that gradually increases in the north-east general direction and seam thickness averaging greater than 11m. The effects of pinching of the coal resource due to imbricate faults should be expected especially close to the breccia zone. The overall effects of the railway line thickness variation, brecciated and burnt coal and faulting were discounted and excluded in the coal reserve statement. The discount because of a railway line passing through the coal resources, has a potential to sterilise 5.7Mt of

ROM coal in Block A and has also affected the orientation of the mining strips. In the mining layout a minimum of 50m on either side of the railway line has been allowed.

The mining method applied for extracting the mineable coal reserve is a conventional strip mining method by means of truck and shovel. Contractors will be employed to perform the mining activities. Mining operations will commence in the box-cut and advance in to steady state mining. The detailed description of the mining method for each mining activity is as follows:

Topsoil Removal

Topsoil in all areas will be stripped to an average depth of 0.4. The topsoil will be stockpiled at designated areas and will be replaced during the rehabilitation stage.

Overburden Removal

Overburden removal is the most important activity of the mining system. Once the overburden has been exposed, drilling and blasting will commence. Overburden drill machines are used to drill holes into the strata, which are filled with explosives and blasted. The blasted overburden is then loaded and hauled to designated stockpiles by means of truck and shovel mining equipment.

Coaling operations

Once the coal seam has been exposed following overburden removal, coal drilling and blasting will commence. Coal drilling machines are utilised to perform the task of drilling holes, which are charged with explosives and blasted. The blasted coal is loaded and hauled by means of a Cat 992 Front End Loader (FEL) machine and a truck fleet into the crushing and washing plants. Figure 5.14 shows the truck and shovel mining method in process.

Figure 5.14 Truck and Shovel mining method

5.4.8 Mine Planning

The original strip layout for the mining area was designed in GEMS. GEMS is a mining software package supplied by the company, Dassault Systèmes GEOVIA. GEMS is one of the leading geology and mine planning solutions. GEMS provides the right capabilities for open pit and underground mining professionals in exploration, modelling, mine design, long-term planning and production scheduling. The mine design was based at a block size of 50m x 100m on either sides of the brecciated area of the fault zone identified. Coal within this fault line area was not included in the strip layout. An accumulation of blocks in a defined mining direction constitute a mining strip. Practically all mining blocks in the first strip are mined before the next adjacent strip is mined. The first strip is mined as a box cut to create waste dumping space for subsequent adjacent strips. Access ramps to the exposed coal strip are usually located perpendicular to the strips. The orientation of the strips is influenced by various factors which include among others:-

- strike of the of the ore body;
- structural features including faults;

- stripping ratio distribution across the deposit area; and
- floor contours

5.4.9 Mine Strip Layout Design

Life of Mine (LOM) scheduling was conducted in XPAC, a popular scheduling software designed primarily for coal deposits. XPAC is a mine scheduling software solution built exclusively for strip coal mines operated by truck and shovel, which is product supplied by the company Runge Pincock Minarco. Each of the mining blocks qualities and physical parameters were exported into the XPAC scheduling software to facilitate the scheduling and the resultant output. Modifying factors were applied on the in-situ resource to derive the estimate mineable reserve catered for:

- Geological loss : 5%;
- Mining layout losses: as per designed strip layout;
- Seam height losses: 4%; and
- Mining extraction losses: 6%.

Coal qualities including overburden thickness and coal seam thickness were estimated for each block and further calculations of coal tonnage, waste volumes and stripping ratio was conducted. The south bottom portion of the deposit has the shallowest resource as depicted in the Figure 5.13, which is the current main pit location. However the coal seam thickness in the area is also lower than the rest of the deposit. The eastern portion highlighted in purple, host the deepest section of the deposit with overburden thickness greater than 70m. The scheduled reserve area with a strip ratio of 2.5bcm/t is shown in Figure 5.15 and hosts approximately 65Mt of ROM coal.

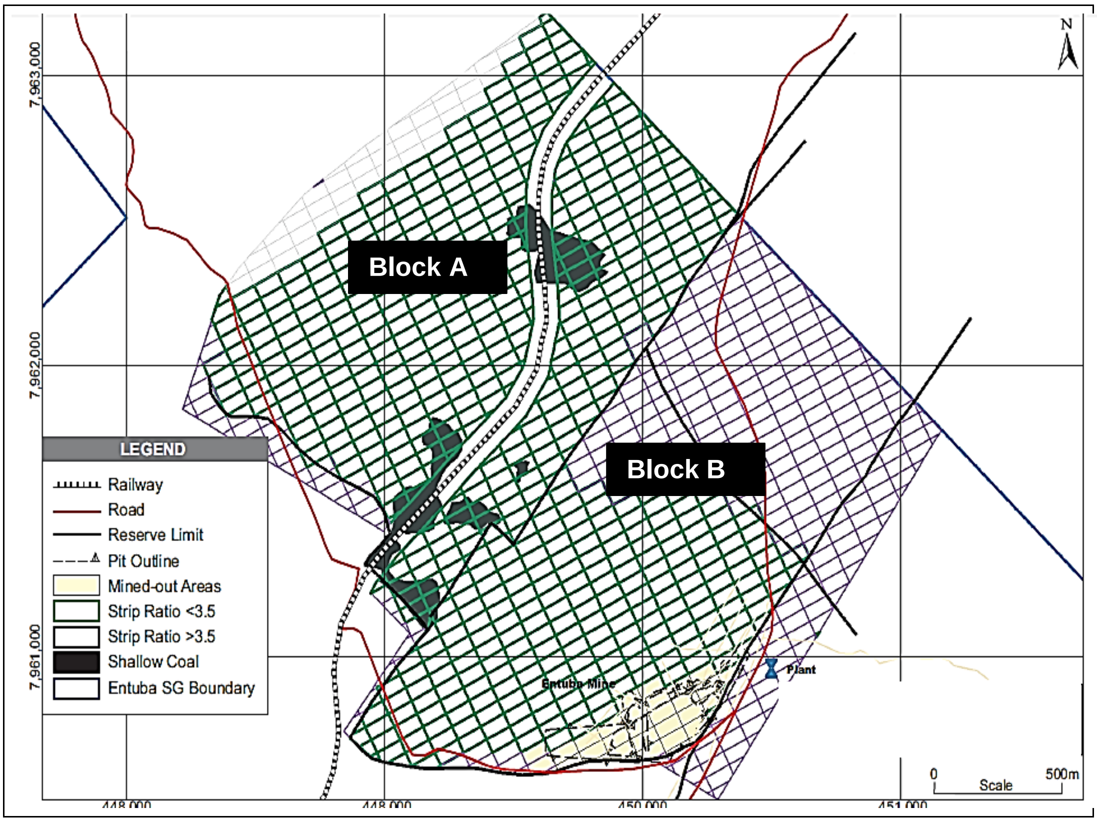


Figure 5.15 Mining layout for a coal reserves at strip ration 2.5

Source: Adapted from (Venmyn Deloitte, 2013)

A rate of 2.2 Mtpa ROM coal steady state production, results in a 25 year LOM combined for Block A and Block B.

5.4.10 Mining Equipment Selection and Requirements

The primary equipment includes drills, loaders and trucks. Drill selection is equally important, as well as all the other secondary or ancillary equipment, which includes dozers, graders, water bowsers, service trucks, lubrication truck, fuel bowsers, and skid steers among others.

There is a number of opencast coal mines using large truck and shovel for efficient movement of high volumes of both waste and coal. These ranges from the RH400 manufactured and serviced by Terex and off highway trucks including CAT 793. The selection of size of shovels and trucks mainly depends on the annual waste volume to be moved as well the maximum bench height that the loading equipment can operate efficiently. The higher the overburden depth, the bigger the mining equipment required to strip the waste. There is number of manufactures for large off high way trucks, front end loaders and shovels that include P&H, Caterpillar, Komatsu and many others. Table 5.6 shows examples of different equipment and their respective capacities.

Table 5.6: Mining Equipment

Source: Adapted from (MineQuest, 2010).

Loaders/Shovels		Trucks		
Model	**Bucket size (m^3)**	**Model**	**Payload tonnes (t)**	**Payload (m^3)**
CAT 994	19m^3	CAT 775	62t	41.2m^3
CAT 5230	17m^3	CAT 777	100t	60.2m^3
Terex RH200	24m^3	CAT 785	140t	78m^3
Terex RH340	24m^3	CAT 789	177t	105m^3
Terex RH400	50m^3	CAT 793	218t	129m^3

The current primary loading and hauling mining equipment selected to mine 2.2Mt of ROM coal is shown in Table 5.7.

Table 5.7 Current Primary Mining Equipment

Mining Activity	Overburden Operation		Coaling Operation	
	Make & Model	**Capacity**	**Make & Model**	**Capacity**
Loading	1 x CAT994	19m^3	2 x CAT990 FEL	9m^3
	2 x CAT992	9m^3	1 x (Ex 870)	2.5m^3
Hauling	9 x CAT 777	100t	6 x EH 1100	50t
			2 x Terex 60	50t

Figure 5.16 shows the loading and hauling operations with the Cat 992 FEL and Cat777 haul trucks

Figure 5.16 Cat 992 FEL and Cat 777 haul truck

5.4.11 Mine Scheduling

The production schedule was developed for a LOM of ten years. The schedule indicates the waste and ROM volumes to be removed at a strip ratio of 2.5bcm/t. Figure 5.17 shows the LOM schedule over the life of the project for Mining Option 1. The detail production schedules per mining option are explained in the Appendix section 10.1 and 10.2

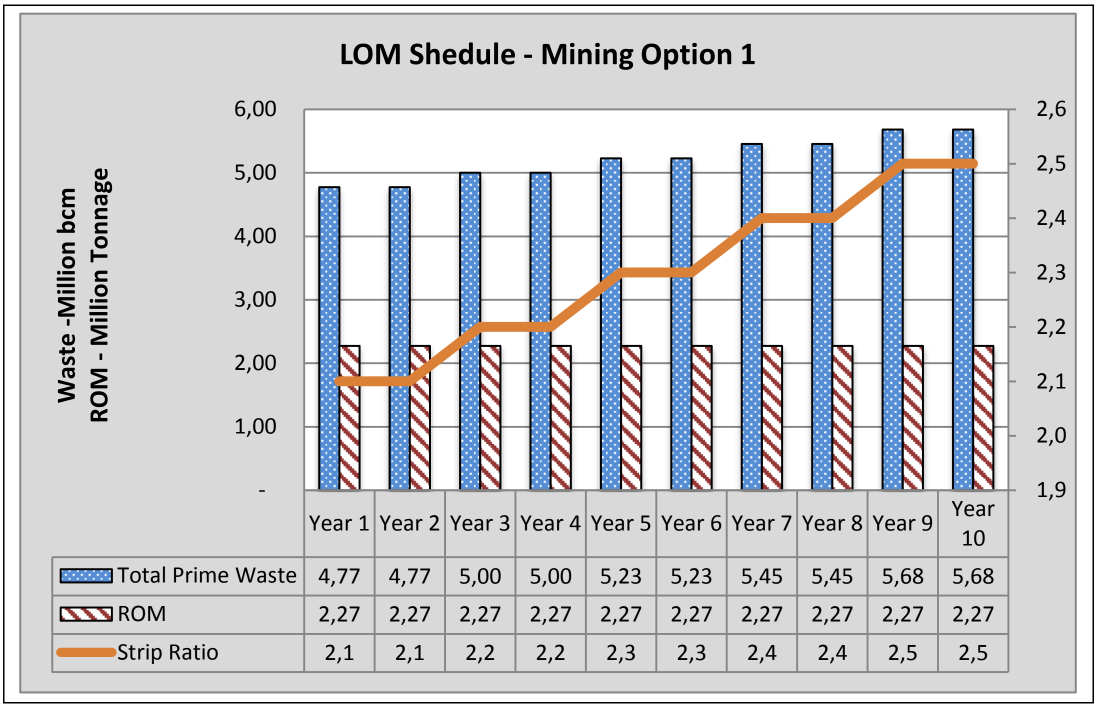


Figure 5.17 LOM Schedule: for Mining Option 1.

The total prime waste ramps up from 4.77 Million bank cubic meters (Mbcm) to 5.68Mbcm with a constant ROM production of 2.27Mt over the project life for Option1. Figure 5.18 shows the LOM schedule over the life of the project for Mining Option 2

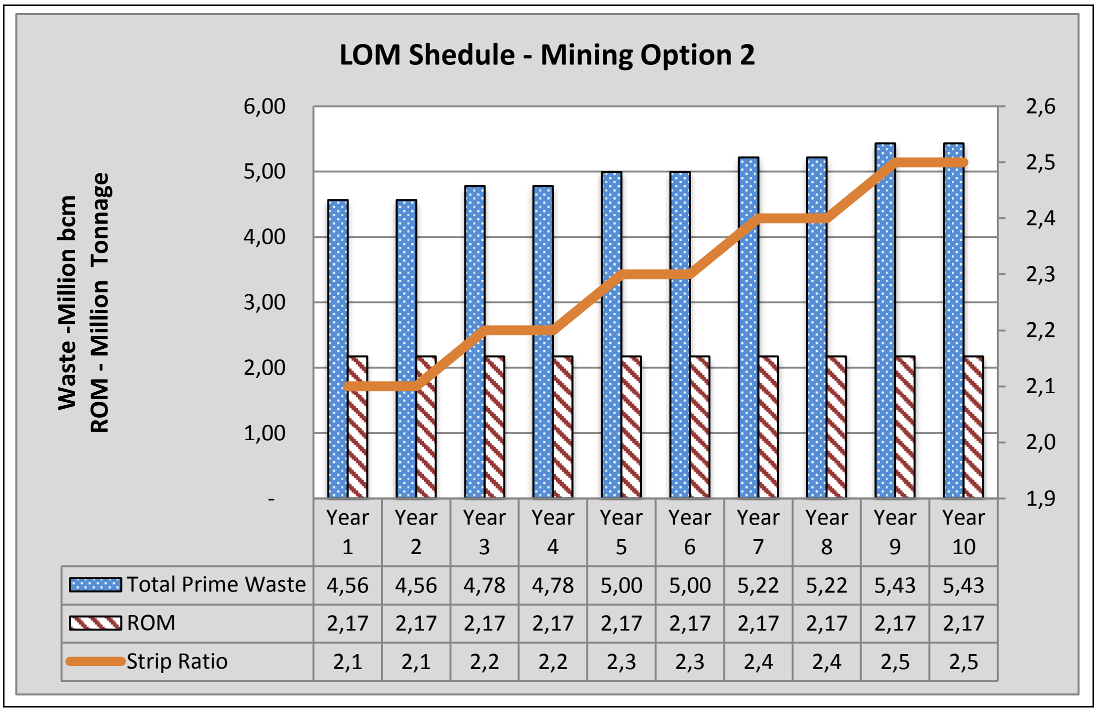


Figure 5.18 LOM Schedule: Mining Option 2.

The total prime waste ramps up from 4.56Mbcm to 5.43Mbcm with a constant ROM production of 2.17Mt over the project life for Option 2.

5.5 Processing

The processing operation consists out of three crush and screen plants together with a washing plant. Plant 1 was the first plant to be commissioned in 2010, followed by Plant 2 in 2011 and Plant 3 in 2012. The Washing plant was commissioned in October 2014.

Crush and Screen Plants

The processing capacities in terms of monthly through put and hourly rates are shown in Table 5.8. Plant 1 is planned on a rate of 116t/hr. with a monthly through put of 55,440 tonnes per month. Plant 2 and Plant 3 are identical plants planned with a capacity of 127t/hr. and monthly through put of 60,480 tonnes. All plants are planned to have an availability of 85% and have 18 hours operational running time.

Table 5.8: Current Processing Capacity for Plants.

Plant	Monthly Throughput tonnages (t)	Rate (t/hr)
Plant 1	55,440	116
Plant 2	60,480	127
Plant 3	60,480	127
Total	**176,400**	**370**

Wash Plant

The washing plant is also known as a coal handling and preparation plant. It is a facility that washes coal, soil and rock and separate the coal product from the waste product. The ROM coal is delivered into Plant 2, crushed and then fed into the Washing plant.

The washing capacity is planned on 18 hours running time per day. The processing specifications of the Wash Plant are shown in Table 5.9.

Table 5.9: Current Processing Capacity for the Washing Plant.

Description	Unit	Specification
Monthly Throughput	tonnage	76,320
Plant Rate	t/hr	160
Raw coal feed size	mm	50
Raw coal bulk density	t/m^3	0.01
Raw coal particle density	t/m^3	1.35-1.68

5.5.1 Coal Products

The following types of coal are available from Makomo Resources:

Thermal

Thermal coal product mainly is used by the power stations for the generation of electricity. Ash values are generally between 20 and 28%. Sizing is +0.5mm and -32mm.The +0.5mm to 6.7mm fraction is generally less than 10% of the consignment.

Peas

Peas is a product mainly used to fire coal based boilers for agriculture, electricity generation, as well as refineries. Ash values are less than 15%, with volatiles averaging 23%. Sizing is between 12mm and 32mm.

Cobbles

Cobbles are used by tobacco farmers for curing produce, as well as refractories. Ash values between 18 and 22% are acceptable. Sizing is between 50mm and 100mm.

Rounds

Rounds are also used by tobacco farmers and some refractories. Ash values are also between 18 and 22%, while sizing is generally 100mm to 150mm.

After having gone through the diverse coal products Figure 5.19 below shows the diagrammatic configuration of products being produced by Makomo Resources.

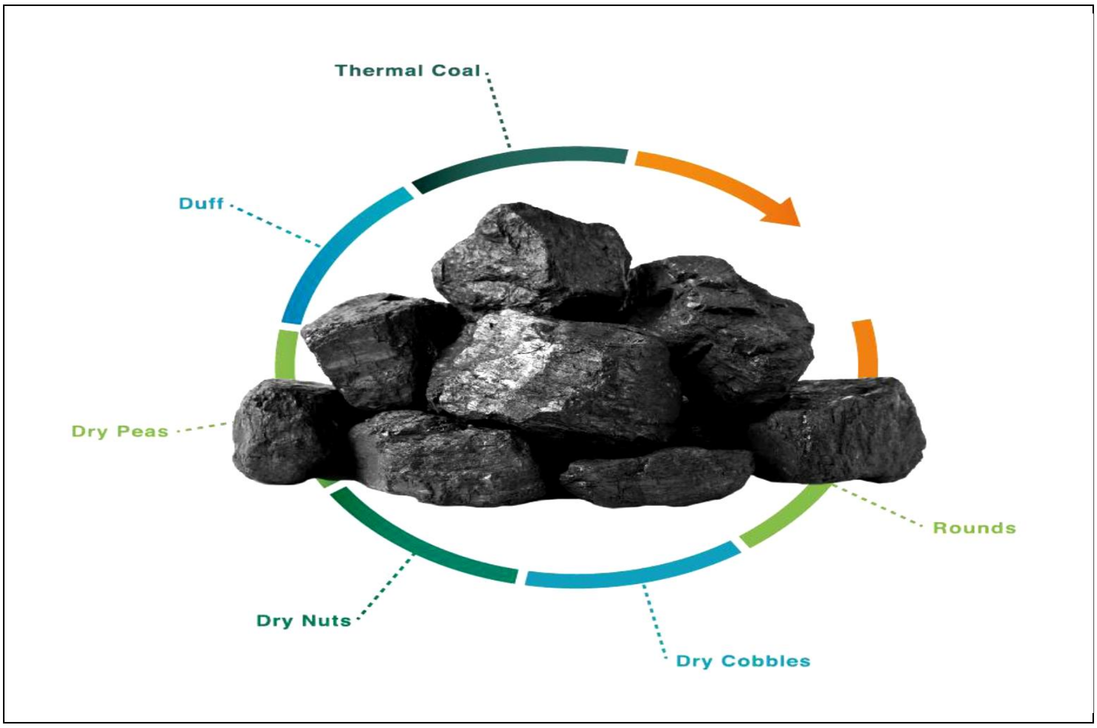


Figure 5.19 Makomo Resources Current Product Portfolio
Source: (Makomo Resources, 2015)

Table 5.10 shows a summary of the product types and product sizing.

Table 5.10: Coal product types and sizing.

Products type	Size Range (mm)
Rounds	+100mm -150mm
Cobbles	+50mm -100mm
Nuts	+32mm - 50mm
Thermal (NPD)	+.0.5mm - 32mm
Peas	+12mm - 32mm
Duff	+3mm - 12mm
Fines	-3mm

5.5.2 Washability Data

The coal samples were send to Noko Lab and Advanced Coal Technology Lab in South Africa for washability tests in preparation for the washing plant. The results are of 1m interval samples from the bottom 7m of the main seam and one sample of the whole bottom 8m of the seam. The lower 3m show a recovery of more than 90% coal with an ash of less than 10%. Furthermore, the lower 0-5m has a recovery of about 90% with ash less than 10% and the lower 0-8m show a recovery of above 75% with less than 10% ash.

The lower 5m has a cumulative yield of 95% of coal with less than 10% ash after washing at SG 1.4 to 1.8. The 0-7m has a 75% recovery of coal of <10% ash after washing at SG 1.45. The 5-10m interval show a 21% yield of coal with <10% ash at SG 1.45. The 10-15m which comprises part of the power coal, interburden shale and No. 1 Seam has a yield of 14% of coal with an ash <10% at SG 1.45.

5.5.3 Product Yields

The product yields for the plants were collected from the processing database over the last four years and the different yields are shown in Table 5.11. Plant 1 and Plant 3 crush and screen products whereby Plant 2 is used to crush and feed the DMS plant. The yields for the plants are the same for both mining options.

Table 5.11: Product yields for plants

Product	Plant 1 Yield	Plant 2 Yield	Plant 3 Yield
Power Coal	-	-	100%
Low Ash Peas	37%	-	42%
Low Ash Cobbles	8%	-	0%
Low Ash Rounds	5%	-	0%
Low Ash Duff	50%	-	50%
Feeding DMS Plant	-	100%	-

The product yields for the wash plant were collected from the washability tables and the different product yields are shown in Table 5.12 and Table 5.13.

Table 5.12: Wash Plant product yields for Mining Option 1

Wash Plant – Mining option 1	
Washed Low Ash 7m	**Yield**
Discard	33%
Low Ash Peas	41%
Low Ash Duff	22%
Low Ash Fines	4%
Total Washed Yield	**67%**
Coking Coal	**Yield**
Discard	18%
Peas	50%
Duff	27%
Fines	5%

A low ash coal seam of 7m will be washed for Mining Option 1. The 7m coal seam will yield peas, duff and fines of 41%, 22% and 4% respectively. Mining the full 7m coal seam results in a higher coal quality with a discard yield of 33%.

Table 5.13: Wash Plant product yields for Mining Option 2

Wash Plant – Mining Option 2	
Washed Low Ash 4m	**Yield**
Discard	54%
Low Ash Peas	28%
Low Ash Duff	15%
Low Ash Fines	3%
Total Washed Yield	**46%**
Coking Coal	**Yield**
Discard	18%
Peas	50%
Duff	27%
Fines	5%

A low ash coal seam of 4m will be processed through the washed for Mining Option 2. The 4m coal seam will yield peas, duff and fines of 28%, 15% and 3% respectively. The 4m coal seam is the top part of the 7m coal, which provide lower coal qualities and higher value of discards with a yield of 54%. For both mining options the discard material generated by the wash plant will be load and hauled back into the pit.

5.5.4 Processing Methodology

The processing methodology for Option 1 and Option 2 are shown in Figure 5.20 and Figure 5.21 respectively.

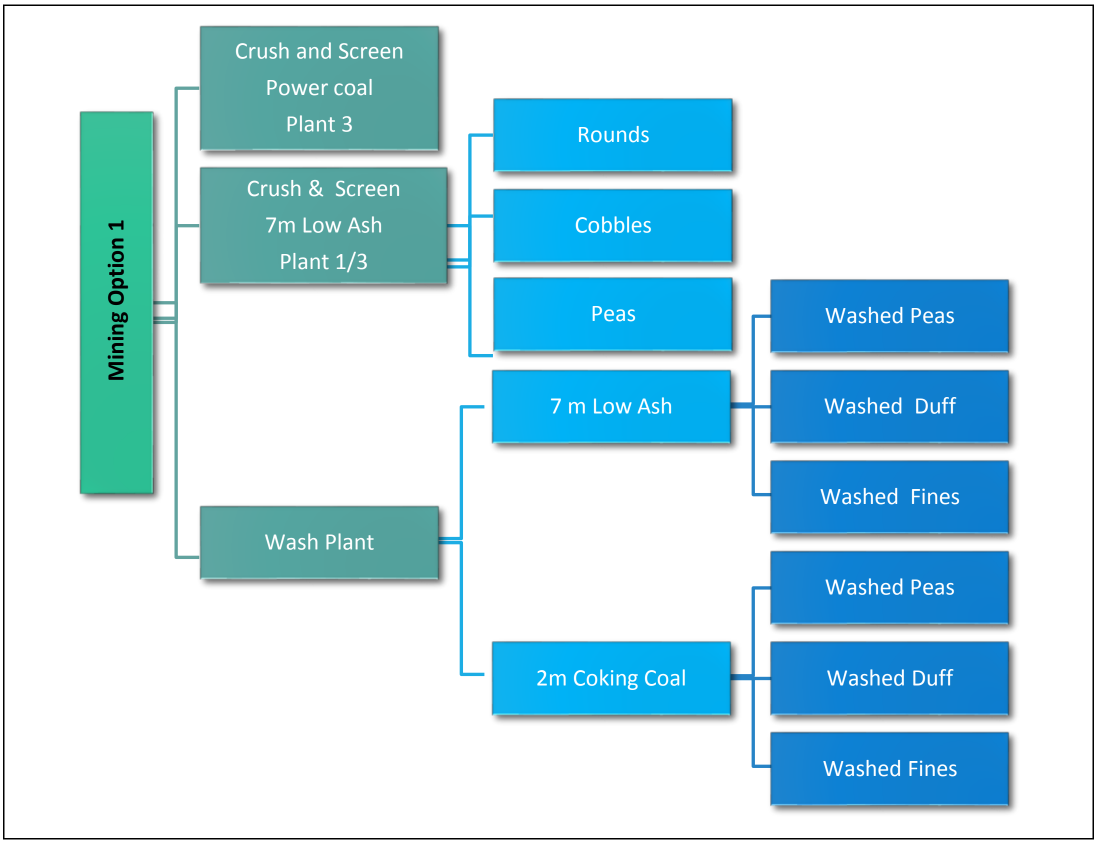


Figure 5.20 Mining model for Mining Option 1

Mining Option 1 will produce power coal on plant 3 and produce rounds, cobbles, nuts and peas from the 7m low-ash coal seam in Plant 1 and Plant 3. The 7m low-ash coal seam and the coking coal seam will be processed through the Wash plant to produce washed peas, washed duff and washed fines.

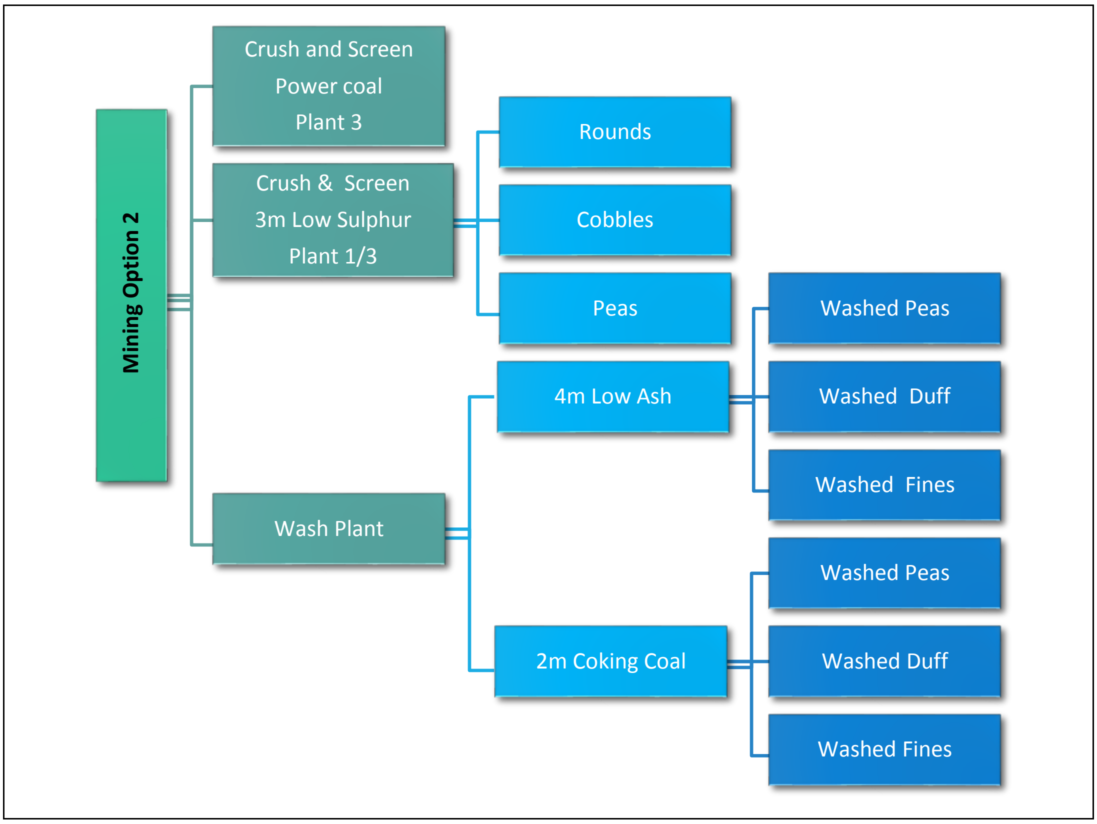


Figure 5.21 Mining model for Mining Option 2

Mining Option 2 will produce power coal on plant 3 and produce rounds, cobbles, nuts and peas from the 3m low-sulphur coal seam in Plant 1 and Plant 3. The 4m low-ash coal seam and the coking coal seam will be processed through the Wash plant to produce washed peas, washed duff and washed fines.

5.6 Coal Markets

Makomo Resources are supplying coal to the local and export markets
The internal and export markets for coal products are as follow:

5.6.1 Domestic market

Makomo Resources supplies the domestic coal market a total of 179,000 tonnes per month, which includes clients like Hwange, Bulawayo, Munyati and Harare power station, Moveline, Fruitstone, Kadoma Magnesite, Beta Bricks, McDonalds, Saiwit, Delta Breweries and Triangle.

5.6.2 Export Market

Makomo Resources supplies the domestic coal market a total of 22,500 tonnes per month, which includes clients like SAB Miller in Zambia and Glencore in South Africa.

Table 5.14 below provides the total tonnes of coal supplied on a monthly basis per client base. The monthly coal volumes were based on the actual coal supplied to the clients in 2015 (Makomo Resources, 2015).

Table 5.14: Coal Markets.

Product	Clients	Application	Monthly Requirements	Market
NDP Power Coal	Hwange Power Station Coal	Power Generation	120,000t	Local
Peas	Bulawayo & Munyati Power Stations	Power Generation (Small Thermals)	30,000t	Local
Cobbles	Moveline Fruitstone	Manufacturing & Agriculture	3,500t	Local
Rounds	Kadoma Magnesite Beta Bricks McDonalds	Manufacturing & Agriculture	3,000t	Local
Washed Peas	Triangle/SAB Miller Saiwit	Manufacturing & Agriculture	8,000t	Local/ Export
Washed Duff	Triangle/SAB Miller Saiwit Delta	Manufacturing & Agriculture	12,000t	Local/ Export
Washed Fines	Triangle/SAB Miller Saiwit	Manufacturing & Agriculture	1,000t	Local/ Export
Coking Coal	Glencore HCGC South Mining	Manufacturing & Mining	24,000t	Local/ Export

The market potential is in excess of 200,000 tonnes of coal. It depends on how much market share Makomo Resources is able to claim from its contractors. The market share will depend on the pricing structure, timing and quality of product that is offered to the customers.

5.6.3 Coal Qualities

The historical exploration programmes on the Entuba coal resource were principally investigated for its coking potential. This is evidently based on an inconsistent sampling and analysis procedures that were followed in the analysis of certain sections of the coal seam, as noted from the density of cut selections examined. As is the case in the neighboring Hwange Colliery, the quality of the main seam at Entuba is variable, decreasing in quality from the base towards the top. At the base seam the coal is of higher quality possessing a lower ash and a higher volatile matter content. The basal 1.5m of the seam produces a straight coking coal whilst the overlying 1.5m is of a blend coking coal quality. The bulk of the upper portion of the seam consists of high grade thermal coal (Venmyn, 2010). The dry product qualities ae summarised in Table 5.15. The figures in the table are based on 2015.

Table 5.15 Coal quality for dry products

Source Adopted from (Makomo Resources, 2015).

Dry Products				
Product	**Rounds**	**Cobbles**	**Dry Peas**	**Thermal Coal**
Pricing	US$50	US$41	US$58	US$26,50
Parameter	Average	Average	Average	Average
Free Moisture (%)	1.1	1.4	1.7	2.9
Inherent Moisture	0.6	0.6	0.8	0.6
Ash (%)	12.6	13.3	15.0	23.4
Volatile Matter (%)	23.1	23.3	22.7	21.2
Fixed Carbon (%)	63.3	62.7	62.7	54.7
Phosphorous %			0.010	
Sulphur %			1.80	1.20
Calorific Value (MJ/kg)	30.41	30.07	29.39	25.43
Calorific Value (kCal/kg)	7,267	7,187	7,050	6,077

The washed product qualities ae summarised in Table 5.16. The figures in the table are based on 2015.

Table 5.16 Coal quality for washed products

Source Adopted from (Makomo Resources, 2015).

Washed Products				
Coal type	**Peas**	**Duff**	**Fines**	**Coking Coal**
Pricing	US$65	US$45	US$25	US$85
Parameter	Average	Average	Average	Average
Free Moisture (%)	2.0	3.5	3.5	3.5
Inherent Moisture	1.0	1.0	0.8	1.0
Ash (%)	12.0	12.0	13.5	8.6
Volatile Matter (%)	23.0	23.0	23.0	24.5
Fixed Carbon (%)	64.0	64.0	62.7	67.4
Phosphorous %	0.0	0.0	0.0	0.012
Sulphur %	1.0	1.0	1.0	1.62
Calorific Value (MJ/kg)	32.2	32.2	29.0	32.16
Calorific Value (kCal/kg)	7,686	7,686	7,686	7,686
FSI	0.5	0.5	0.5	2.0

5.6.4 Mining Models

The detail mining models for Mining Option 1 and Mining Option 2 are summarised in Figure 5.22 and Figure 5.23 respectively. The figures indicate the coal type, process method, coal products which will be generated, ash qualities, product yield and the plants.

Coal Type	Process	Coal Products	Ash Qualities	Yield	Plant
2m Power Coal	Crush & Screen	Nuts, Peas & Duff	26%	100%	Plant 3
7m Low Ash Coal	Crush & Screen Washing	Rounds, Cobbles,Nuts, Peas Washed Peas, Washed Duff, Washed Fines	15%	37% 41%	Plant 1/Plant 3
2m Straight Coking Coal	Washing	Washed Peas, Washed Duff, Washed Fines	8%	50%	Wash Plant
Lower Wankie Sandstone (Floor)					

Figure 5.22 Mining model for Mining Option 1

Coal Seam	Process	Coal Products	Ash Qualities	Yield	Plant
2m Power Coal	Crush & Screen	Nuts, Peas & Duff	26%	100%	Plant 3
4m Low Ash Coal	Washing	Washed Peas, Washed Duff, Washed Fines	15%	28%	Wash Plant
3m Low Sulphur Coal	Crush & Screen	Rounds, Cobbles,Nuts, Peas	12%	37%	Plant 1/Plant 3
2m Straight Coking Coal	Washing	Washed Peas, Washed Duff, Washed Fines	8%	50%	Wash Plant
Lower Wankie Sandstone (Floor)					

Figure 5.23 Mining model for Mining Option 2

5.7 Conclusion

A Special Grant was granted to Makomo Resources for coal exploration and mining in March 2010. Makomo Resources has been operating and opencast mine in the Bulawayo mining district since June 2010. The company is the largest privately owned coalmine in the country. The operation has mined 7.5 million ROM tonnes of coal to-date. Majority of the coal is supplied to the local power stations in Zimbabwe as thermal coal. The coal product range and client base for Makomo Resources are very diverse. Makomo has commissioned a washing plant in October 2014 to expand their current capacity in order to enter and explore the coking coal and export markets. Makomo Resources have large coal resources and coal reserves. At an annual mining production rate of 2.5 million ROM tonnes of coal and at an average strip ratio of 2.5bcm/t provides the operation with a life of mine of over 20 years. The mine planning, mine scheduling and equipment requirements lacks detail as a result there is stillroom for improvement in order to get the mine technical services up to the required standard. Makomo Resources has reported 2015 the best year in terms of ROM production tonnage, coal processed and coal sales to the market, despite the struggling economic climate and drop in the coal demand. The mine managed the operation well over the past 5.5 years showing improvements on productivity and effective cost management.

The Special Grant area is located in the Bulawayo mining district, which forms part of the Entuba Coalfield located in the Mid-Zambezi Basin. Makomo Resources has large coal resource of over 90 million tonnes available for underground and opencast mining. In their current open pit, they declared a total coal reserve of 65Mt ROM tonnes based on a stripping ratio of 2.5bcm/t (Makomo Resources , 2013).

The main coal seam is quite thick with about an average thickness of 11m intended for Mining Option 1, three primary economic seams have been identified as the power coal seam, low-ash coal seam and coking coal seam, with average thicknesses of 2.0m, 7.0m and 2.0m respectively. For Mining

Option 2, four primary economic seams have been identified as the power coal seam, low-ash coal seam, low sulphur coal seam and coking coal seam, with average thicknesses of 2.0m, 4.0m, 3.0m and 2.0m respectively. The mining seam selection for Mining Option 1 gives a better coal quality product with a yield of 67% compared to 46% for mining Option 2. Therefore Mining Option 1 will produce more saleable product than Mining Option 2.

Makomo Resources currently applies a conventional strip mining method by means of truck and shovel to extract the coal reserves. Contractors will be employed to perform the mining activities. The production schedules were developed for both mining options for a LOM of ten years. The schedule indicates the waste and ROM volumes to be removed at a strip ratio of 2.5bcm/t.

The processing operation consists of three crush and screen plants together with a washing plant, with a combined capacity of over 250,000 tonnes. Makomo Resources produces four dry coal products consisting of rounds, cobbles, peas and NPD for the domestic market. Makomo Resources also produces four washed product like washed peas, washed duff, washed fines and coking coal peas for the local and export market. Makomo Resources has the capacity to produce over 250,000 tonnes of saleable coal, however only supplying 201,000 tonnes to the local and export market.

6 FINANCIAL/ECONOMIC EVALUATION

6.1 Introduction

Two DCF models were developed for each mining option. The DCF models project cash flows and calculates economic indicators, such as IRR and NPV for the production phase. The models were based on the following parameters and aspects:

- Opencast LOM production schedules.
- Plant recoveries and throughput.
- Saleable products.
- Product sales price.
- Estimated mining and processing operating expenditures.
- Coal logistic cost.
- Overhead cost.
- Royalties and Corporate Tax.
- Capital expenditures (CAPEX) schedule.
- Discount Rate.

The resulting DCF models were developed in an Excel spreadsheet format designed for a 10 year period. The models were prepared on an all equity basis and in real money terms to permit the robustness of the project to be readily seen. The financial models are in dollar (USD) currency. This project economic evaluation is important and it has a bearing on government and local communities. It is also important to the company and the shareholders because it has a bearing on their profits and return on investment, which ultimately affects the foreign investment into the country.

The DCF will analyse and investigate the following:

- The cashflow over the 10-year period.
- The Net Present Value (NPV) and Internal Rate of Return (IRR) of both mining options.
- The payback period of the washing plant.

- Profitability index per mining option.

6.2 Life of Mine Scheduling

The optimum production profile for Mining Option 1 is shown in Table 6.1. This profile was used to assess the project.

Table 6.1 Life of Mine schedule for Mining Option 1.

Mining Option 1							
LOM	**Strip Ratio**	**Waste**	**ROM**	**Plant 1**	**Plant 2**	**Wash Plant**	**Plant 3**
	Waste:ROM	**Mbcm**	**Mt**	**Mt**	**Mt**	**Mt**	**Mt**
Year 1	2.1	4.77	2.272	0.665	0.881	0.617	0.726
Year 2	2.1	4.77	2.272	0.665	0.881	0.617	0.726
Year 3	2.2	4.99	2.272	0.665	0.881	0.617	0.726
Year 4	2.2	4.99	2.272	0.665	0.881	0.617	0.726
Year 5	2.3	5.22	2.272	0.665	0.881	0.617	0.726
Year 6	2.3	5.22	2.272	0.665	0.881	0.617	0.726
Year 7	2.4	5.45	2.272	0.665	0.881	0.617	0.726
Year 8	2.4	5.45	2.272	0.665	0.881	0.617	0.726
Year 9	2.5	5.68	2.272	0.665	0.881	0.617	0.726
Year 10	2.5	5.68	2.272	0.665	0.881	0.617	0.726
Total	**2.3**	**52.26**	**22.72**	**6.65**	**8.81**	**6.17**	**7.26**

The schedule for Mining Option 1 will produce 52.26Mbcm of overburden at an average strip ratio of 2.3, resulting in 22.72Mt of ROM coal. Plant 1, plant 2 and plant 3 will crush & screen a total volume of 6.65Mt, 8.81Mt and 7.26Mt of coal respectively. A total of 6.17Mt of coal will be processed through the wash plant. The detailed production schedule for Mining Options 1 is shown in the Appendix under section 10.1 and section 10.5

The optimum production profile for Mining Option 2 is indicated in Table 6.1. This profile was used to assess the project.

Table 6.2 Life of Mine schedule for Mining Option 2

Mining Option 2							
LOM	Strip Ratio	Waste	ROM	Plant 1	Plant 2	Wash Plant	Plant 3
	Waste:ROM	Mbcm	Mt	Mt	Mt	Mt	Mt
Year 1	2.1	4.56	2.17	0.665	0.782	0.548	0.726
Year 2	2.1	4.56	2.17	0.665	0.782	0.548	0.726
Year 3	2.2	4.78	2.17	0.665	0.782	0.548	0.726
Year 4	2.2	4.78	2.17	0.665	0.782	0.548	0.726
Year 5	2.3	4.99	2.17	0.665	0.782	0.548	0.726
Year 6	2.3	4.99	2.17	0.665	0.782	0.548	0.726
Year 7	2.4	5.21	2.17	0.665	0.782	0.548	0.726
Year 8	2.4	5.21	2.17	0.665	0.782	0.548	0.726
Year 9	2.5	5.43	2.17	0.665	0.782	0.548	0.726
Year 10	2.5	5.43	2.17	0.665	0.782	0.548	0.726
TOTAL	**2.3**	**49.98**	**21.73**	**6.65**	**7.82**	**5.47**	**7.26**

The schedule for Mining Option 2 will produce 49.98Mbcm of overburden at an average strip ration of 2.3 resulting in 2173Mt of ROM coal. Plant 1, plant 2 and plant 3 will crush & screen a total volume of 6.65Mt, 7.82Mt and 7.26Mt of coal respectively. A total of 5.47Mt of coal will be processed through the wash plant. The detailed production schedule for Mining Options 2 is shown in the Appendix under section 10.2 and section 10.6.

6.3 Sales Volumes

Four dry sale products are produced for Mining Option 1 comprising of power coal, dry peas, dry cobbles and dry rounds as indicated by Table 6.3. A total power coal, dry peas, dry cobbles and dry rounds of 11.1Mt, 3.47Mt, 0.53Mt and 0.33Mt, respectively, will be produced over the LOM for Mining Option 1.

Table 6.3 Crush and screen sales products for Mining Option 1.

Mining Option 1 : Crush and Screen Products				
Coal Products	Power coal	Dry Peas	Dry Cobbles	Dry Rounds
	Mt	Mt	Mt	Mt
Year 1	1.11	0.347	0.053	0.033
Year 2	1.11	0.347	0.053	0.033
Year 3	1.11	0.347	0.053	0.033
Year 4	1.11	0.347	0.053	0.033
Year 5	1.11	0.347	0.053	0.033
Year 6	1.11	0.347	0.053	0.033
Year 7	1.11	0.347	0.053	0.033
Year 8	1.11	0.347	0.053	0.033
Year 9	1.11	0.347	0.053	0.033
Year 10	1.11	0.347	0.053	0.033
Total	**11.11**	**3.47**	**0.53**	**0.33**

Table 6.4 shows the four washed sales products over the LOM for Mining Option 1. Total washed peas, washed duff, washed fines and coking coal of 1.04Mt, 1.52Mt, 0.108Mt, and 2.96Mt will be produced respectively.

Table 6.4 Washed sales products for Mining Option 1.

Mining Option 1: Washed Product				
Coal Products	Washed Peas	Washed Duff	Washed Fines	Coking Coal
	Mt	Mt	Mt	Mt
Year 1	0.104	0.152	0.011	0.296
Year 2	0.104	0.152	0.011	0.296
Year 3	0.104	0.152	0.011	0.296
Year 4	0.104	0.152	0.011	0.296
Year 5	0.104	0.152	0.011	0.296
Year 6	0.104	0.152	0.011	0.296
Year 7	0.104	0.152	0.011	0.296
Year 8	0.104	0.152	0.011	0.296
Year 9	0.104	0.152	0.011	0.296
Year 10	0.104	0.152	0.011	0.296
Total	**1.04**	**1.52**	**0.108**	**2.96**

Four dry sale products are produced for Mining Option 2 consisting of power coal, dry peas, dry cobbles and dry rounds as indicated by Table 6.5. Total power coal, dry peas, dry cobbles and dry rounds of 12Mt, 3.47Mt, 0.53Mt and 0.33Mt respectively will be produced over the LOM for Mining Option 2.

Table 6.5 Crush and screen sales products for Mining Option 2.

Mining Option 2: Crush and Screen Products				
Coal Products	**Power coal**	**Dry Peas**	**Dry Cobbles**	**Dry Rounds**
	Mt	**Mt**	**Mt**	**Mt**
Year 1	1.20	0.347	0.053	0.033
Year 2	1.20	0.347	0.053	0.033
Year 3	1.20	0.347	0.053	0.033
Year 4	1.20	0.347	0.053	0.033
Year 5	1.20	0.347	0.053	0.033
Year 6	1.20	0.347	0.053	0033
Year 7	1.20	0.347	0.053	0.033
Year 8	1.20	0.347	0.053	0.033
Year 9	1.20	0347	0.053	0.033
Year 10	1.20	0.347	0.053	0.033
Total	**12.00**	**3.47**	**0.530**	**0.333**

Table 6.6 shows the four washed sales products over the LOM for Mining Option 2. Total washed peas, washed duff, washed fines and coking coal of 0.93Mt, 1.02Mt, 0.10Mt, and 1.77Mt will be produced respectively.

Table 6.6 Washed sales products for Mining Option 2.

Mining Option 2: Washed Product				
Coal Products	**Washed Peas**	**Washed Duff**	**Washed Fines**	**Coking Coal**
	Mt	**Mt**	**Mt**	**Mt**
Year 1	0.093	0.050	0.010	0.177
Year 2	0.093	0.107	0.010	0.177
Year 3	0.093	0.107	0.010	0.177
Year 4	0.093	0.107	0.010	0.177
Year 5	0.093	0.107	0.010	0.177
Year 6	0.093	0.107	0.010	0.177
Year 7	0.093	0.107	0.010	0.177
Year 8	0.093	0.107	0.010	0.177
Year 9	0.093	0.107	0.010	0.177
Year 10	0.093	0.107	0.010	0.177
Total	**0.93**	**1.02**	**0.10**	**1.77**

6.4 Coal Price

The coal prices are controlled and determined by the government body called Mineral Marketing Cooperation of Zimbabwe (MMCZ). MMCZ is a wholly owned government parastatal with the exclusive mandate of selling and marketing all minerals produced in Zimbabwe. On a quarterly basis MMCZ meets and consults with the various coal producers to set the minimum coal price per coal type and product. The coal price is also based on the quality of the coal. NPD power coal is sold at USD26.5/t, which is the lowest quality product, and coking coal, which is the highest quality product, is sold at USD85.0/t. Table 6.7 illustrates the coal sales prices based on the fourth quarter of 2015, which were used in both financial models.

Table 6.7 Coal sales price per product

Product	Unit	Price
NDP Power Coal	USD/t	$26.5
Peas	USD/t	$58.0
Cobbles	USD/t	$50.0
Rounds	USD/t	$55.0
Washed Peas	USD/t	$65.0
Washed Duff	USD/t	$45.0
Washed Fines	USD/t	$25.0
Coking Coal	USD/t	$85.0

6.5 Operating Costs

The operating cost includes the monthly mining cost, the coal crush and screen cost, the wash plant cost, the blending cost, the overhead cost, as well as the logistic cost. Table 6.8 indicates the average operating cost assumptions for Mining Option1 and Mining Option 2 used in the financial model. Mining Option 1 and Mining Option 2 have a total operating cost of $26.97/t and $27.15/t respectively. The detail operational cost breakdown for Mining Option 1 and Mining Option 2 are shown in the Appendix under section 10.3 and section 10.4, respectively.

Table 6.8 Operating cost per Mining Option

		Mining Option 1.	Mining Option 2.
Cost Driver	**Unit**	**Cost**	**Cost**
Mining Costs	USD / ROMt	$15.67	$15.70
Coal Crush and Screen Costs	USD / ROMt	$2.51	$2.51
Washing Costs	USD / ROMt	$1.56	$1.45
Loading Cost	USD / ROMt	$1.00	$1.00
Overhead Cost	USD / ROMt	$3.79	$3.79
Logistic Cost	USD / Salest	$3.79	$3.79
Total Operational Costs	**USD / ROMt**	**$26.97**	**$27,15**

The mining cost is the cost of production. The detailed mining cost is made up of the individual mining activities, which include drill and blast of sandstone, load and haul sandstone, drill and blast shale, load and haul shale, drill and blast coal and load and haul of coal. The mining cost contributes 58% towards the total operational cost.

The processing costs are split into the crush and screen cost and washing cost which contributes 15%. The loading of coal products into the trucks creates the loading cost at 4% of the total operational cost. Overhead cost is all the expenses incurred by the company, which are not directly related to mining. The logistic cost include the cost for transportation of coal via road to the HPS and to the Lukosi railway siding. Overhead cost and logistic cost contribute 14% and 12% respectively.

6.6 Royalties

Mineral royalty forms part of the Zimbabwe tax regime and is one of the fiscal instruments. Table 6.9 indicates the following persons, as agents for and on behalf of the Commissioner General of the Zimbabwe Revenue Authority (ZIMRA), are required to deduct royalty on the following minerals at source.

Table 6.9 Collection of Mining Royalties

Source: Minerals Marketing Corporation of Zimbabwe (MMCZ).

Mineral	Agent
Precious stones, precious metals (other than gold), base metals, industrial metals, coalbed, methane and coal	• Minerals Marketing Corporation of Zimbabwe (MMCZ). • Any person authorised by the Minerals Marketing Corporation of Zimbabwe to export such minerals in its own right.

Mining royalty for coal is charged based on the face value of the invoice and the rate is indicated in Table 6.10.

Table 6.10 Rates of Mining Royalties

Source: Minerals Marketing Corporation of Zimbabwe (MMCZ).

Minerals	Rates of royalties with effect from the 1st of January 2012
Coal bed methane	2%
Coal	1%

A royalty payable rate of 1% was used in the financial models as stated by Mines and Minerals Act (Chapter 21:05).

The contribution of royalties for each mining option can be clearly seen in Figure 6.1. The mining royalty to be paid per annum for Mining Option 1 and Mining Option 2 is USD0.92million and USD0.82 million respectively.

Figure 6.1 Royalties per Mining Option

6.7 Capital Costs

The capital and operating costs of open pit mines are influenced by the number and sizes of equipment for drilling, blasting, loading, and haulage of open pit ore and waste, including the processing of coal.

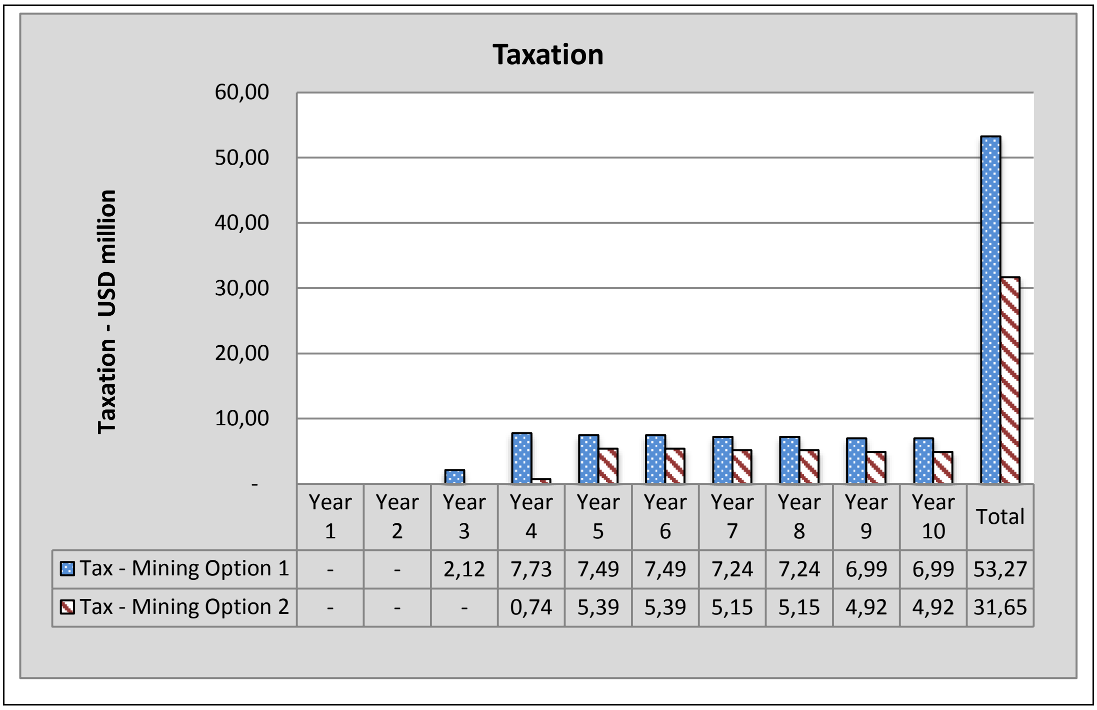
The estimated total capital in real terms is USD95.8 million for each mining option in order to complete the project. The Capital costs assumed are shown in Table 6.11. Capital cost for both options are the same. The sustaining capital expenditure is USD10.8 million and the expansionary capital expenditure is USD85.0 million over the life of both mining options. The sustaining capital includes the replacement cost for mining equipment and plant equipment from the second year to the end of the project. The expansionary capital includes the upfront capital require for mining equipment and plant equipment to commence with operation. These expenditures were estimated on 2015 figures.

Table 6.11 Capital cost per Mining Option

Item	Mining Option 1 USD million	Mining Option 2 USD million
Grand Total	**95.8**	**95.8**
Sustaining Capex	**10.8**	**10.8**
Expansionary Capex	**85.0**	**85.0**
DMS Plant	20.0	20.0
Mining Equipment/Crusher Equipment	65.0	65.0

6.8 Taxation

The Zimbabwe Revenue Authority (ZIMRA) was established on 19 January 2001 as a successor organisation to the then Department of Taxes and the Department of Customs and Excise following the promulgation of the Revenue Authority Act on February 11, 2000. The normal tax rate of 25.75% for companies in Zimbabwe was used in the financial models. Figure 6.2 indicates the corporate tax paid over the LOM of each mining option. The first two years no tax is payed because no profits were recorded during this period. Mining Option 1 records a profit from year 3, whereby a profit is reported in fourth year for Mining Option 2. The total corporate tax paid for Mining Option 1 is USD53.7 million with an average of USD5.3 million over 10 years. Mining Option 2 contributes a total of USD31.6 million towards corporate taxation with an average of USD3.1 million. More taxation is paid over the LOM for Mining Option 1.



	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Tax - Mining Option 1	-	-	2,12	7,73	7,49	7,49	7,24	7,24	6,99	6,99	53,27
Tax - Mining Option 2	-	-	-	0,74	5,39	5,39	5,15	5,15	4,92	4,92	31,65

Figure 6.2 Tax Contribution per Mining Option

6.9 Discount Rate

The success of the discounted cash flow technique depends on how well the analysts choose the discount rate. If a selected discount rate is too high, projects that add value to the firm will be unnecessarily rejected. On the other hand, if the discount rate is too low, projects that do not add value to the firm will be accepted. Therefore, choosing the appropriate discount rate is an important as the estimation of appropriate future cash flows. The net cash flow for each year-end has been discounted at a rate of 20.9%, composed of 14.7% for risk free rate and 18% for the expected market rate of return at a beta of 1.9. This rate can be changed, since the choice of risk factor will be affected by the cost of capital in the future and the perceived risks attached to the project by the investor.

6.9.1 Cost of Equity

Guru Focus uses Capital Asset Pricing Model (CAPM) to calculate the required rate of return.

The formula of CAPM is:

$$Rj = Rrf + b\ (Rm-Rrf)$$

where:

Rj = Cost of Capital (Discount rate)

Rrf = the rate of return for a risk-free security

Rm = the market's expected rate of return

b = beta, which is the sensitivity of the expected excess asset returns to the expected excess market returns.

Step 1: Calculation of Rrf

The calculation of the risk free rate is explained in Table 6.12.

Table 6.12 Risk Free Rate

Description	**Percentage (%)**	**Source**
US 10 year bonds as at 30 September 2015 (US Department of Treasury)	2.06%	(US,Treasury, 2015) US treasury bonds are assumed to be risk-free because the likelihood of US governments defaulting is perceived to be extremely low
Inflation differential (Average Consumer Price change - IMF estimations 2015)	0.2%	(Taborda, 2015) Zimbabwe rates not used as it is in deflationary mode: The risk free rate as per USA Treasury bills must be adjusted in regards to the difference in inflation rate between the USA and Zimbabwe
Country Equity Risk Premium	12.50%	(Damodaran, 2015) Percentage not available for Zimbabwe, therefore used the average rate for Zambia
Risk Free Rate(r_{rf})	14.76%	

Step 2: Calculation of Rm

18% as stated in www.allafrica.com (2015) by Reserve bank of Zimbabwe in Mid-Term Monetary Policy Review Statement for 2015 was used.

Step 3: Calculation of *b*

Not available for Makomo because they are an unlisted company.

Hwange Colliery Co Ltd.'s beta is 1.90.as per www.gurufocus.com (2015) on 27 October 2015. Hwange Colliery Co Ltd is the neighbour colliery of Makomo Resources and therefore the assumptions was to adopt their beta value in the calculation.

Step 4: Calculation of Rj

Rj = Rrf + b (Rm-Rrf)

Rj = 14.76% + 1.9(18% - 14.76%)

Rj = 20.9%

A discount rate of 20.9% was calculated and used in the DCF model for Mining Option 1 and Mining Option 2

6.10 Evaluation Techniques

Evaluation techniques were used to compare the performance and profitability of the two mining options. The object of these techniques were to determine which mining option would provide better return on the investment and increase shareholders wealth. Two Discounted Cash Flow (DCF) models were created to conduct the evaluation of the two mining options. The detail cash flow analysis for each mining option is shown in the Appendix under section 10.5 "Financial model for Mining Option 1" and section 10.6 "Financial model for Mining Option 2". The results from the financial models are summarised in terms of:

- Payback period.
- Net Present Value (NPV)
- Internal Rate of Return (IRR)
- Profitability Index (PI)
- Equivalent Annual Cost (EAC)
- Equivalent Annual Annuity (EAA)

The payback period for each mining options is shown in Figure 6.3.

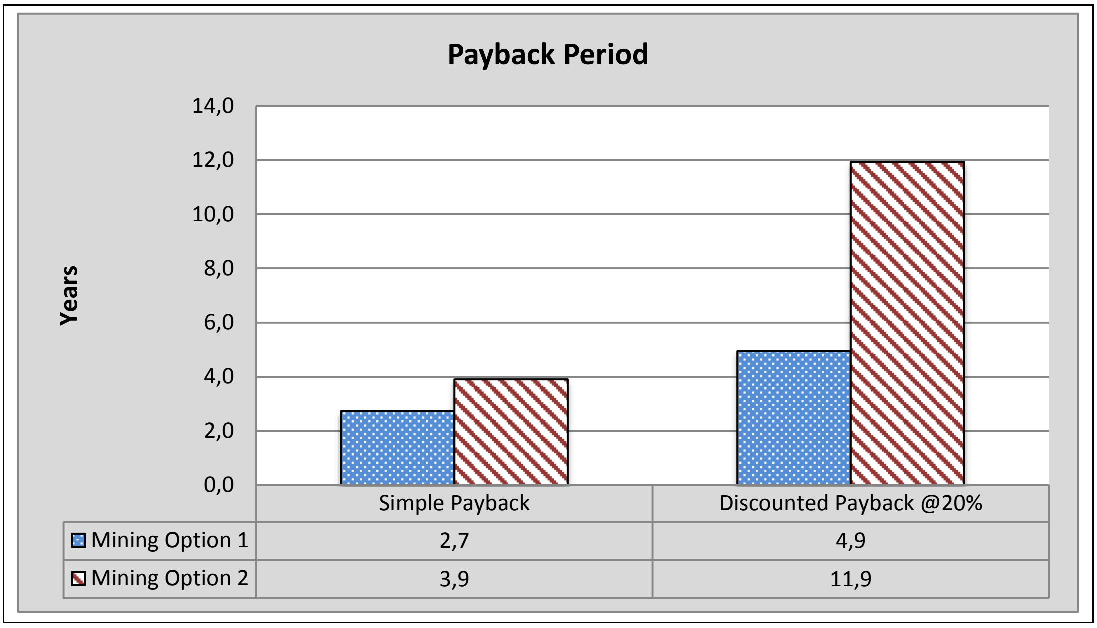


Figure 6.3 Payback period per Mining Option

Mining Option 1 has a simple payback period and discounted payback period of 2.7 years and 4.9 years, respectively. Mining Option 2 has a simple payback period and discounted payback period of 3.9 years and 11.9 years, respectively. Mining Option 1 has a shorter payback period, which is the favorable option.

NPV and IRR are popular investment performance measures of profitability used in corporate and capital budgeting to assess and compare the potential return on investment of given project's. Figure 6.4 and figure 6.5 indicate the NPV and the IRR for both mining options over the LOM. Both mining options have a positive NPV.

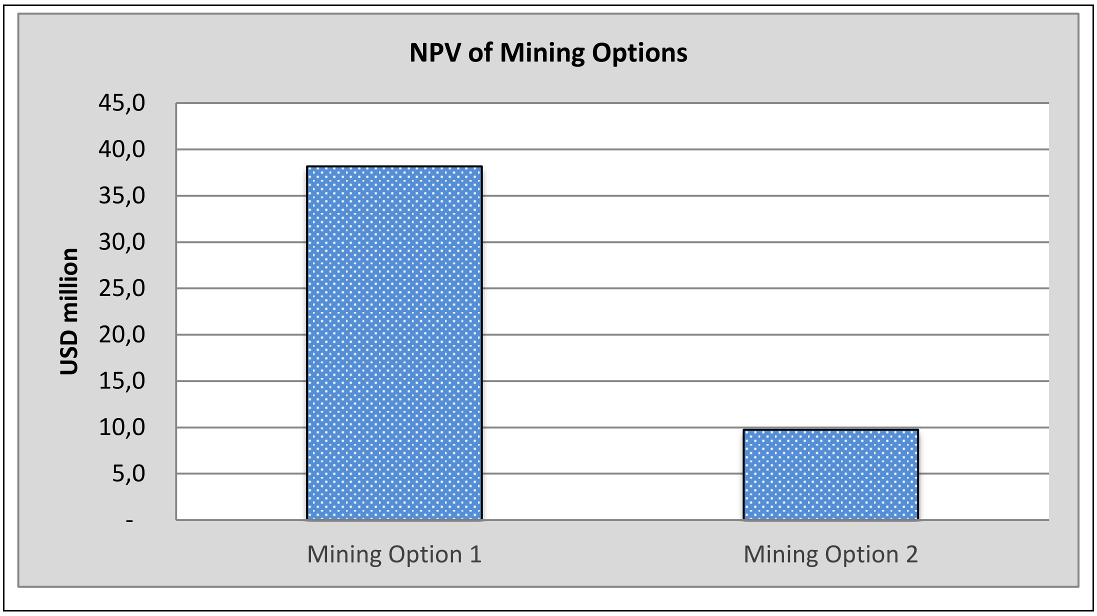


Figure 6.4 NPV of each Mining Option

Mining Option 1 has a higher NPV of USD 38.2 million in comparison to USD 9.7 million for Mining Option 2.

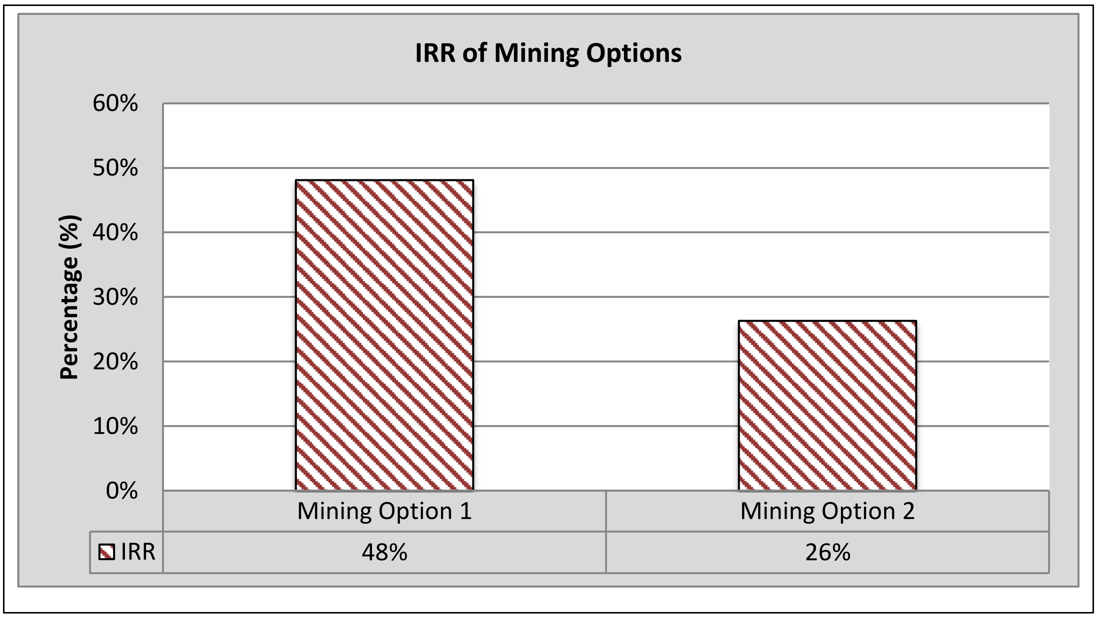


Figure 6.5 IRR of each Mining Option

The IRR for Mining Option 1 was calculated at 48%, which is bigger than the IRR for Mining Option 2 of 26%. Mining Option 1 is therefore the more attractive option.

Profitability index (PI) helps in ranking investments and deciding the best investment that should be selected. PI greater than one indicates that present value of future cash inflows from the investment is more than the initial investment, thereby indicating that it will earn profits. PI of less than one indicates loss from the investment. PI equal to one means that there are no profits. Thus, profitability index helps investors in making decisions about whether or not to make a particular investment. Figure 6.6 indicates the profitability for both mining options over their LOM.

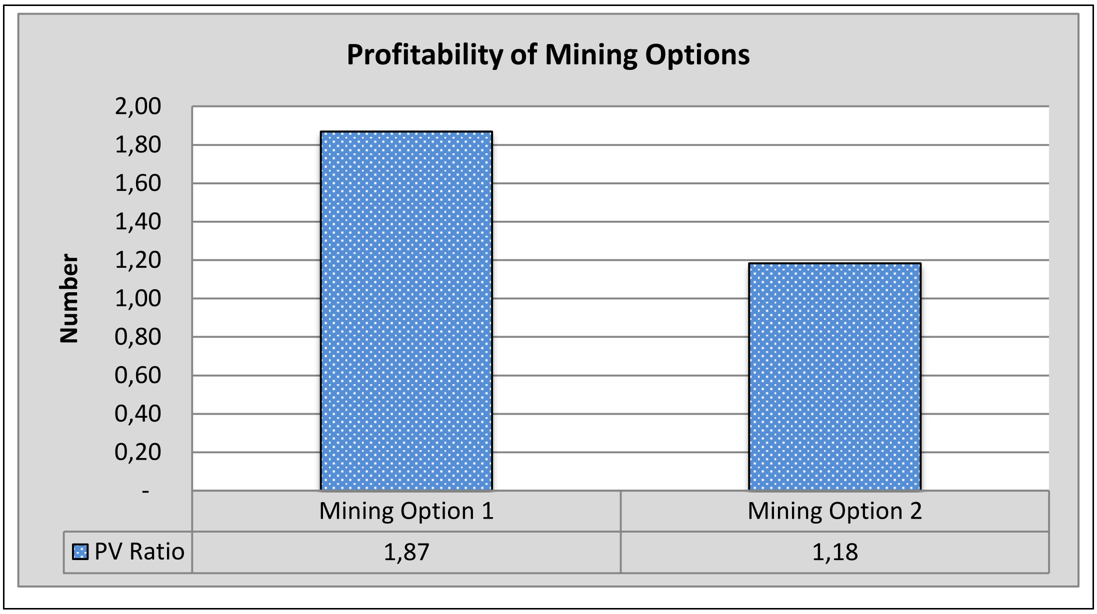


Figure 6.6 Profitability of each Mining Option

Both mining options have a PI greater than one with Mining Option 1 and Mining Option 2 recording values of 1.87 and 1.18 respectively. Mining Option 1 has the better PI value and is therefore more profitable.

Equivalent Annual Cost (EAC) is the annual cost of owning an asset over its project life'. Equivalent annual cost is often used by companies for capital budgeting decisions (Investopedia, 2015). Equivalent Annual Cost is calculated by the following formulae.

$$EAC = \frac{PV of funding}{PV annuity\ factor}$$

EAC allows a company to compare the cost effectiveness of various assets. It is best used in instances where investment projects have different lifespans. EAC allows companies to compare NPVs of differing projects over different periods to accurately determine the best option (Investopedia, 2015). Select the lowest EAC, because it is the lower cost on an annual basis. Equivalent Annual Annuity (EAA) is used in capital budgeting to compare mutually exclusive projects with unequal lives. The EAA approach calculates the constant annual cash flow generated by a project over its life if it was an annuity (Investopedia, 2015). Equivalent Annual Annuity is calculated by the following formula.

$$EAA = \frac{NPV\ of\ the\ Project}{PVannuity\ factor}$$

When used to compare projects with unequal lives, the one with the higher EAA should be selected. Choose the highest value, because it would add the most value on an annual basis. Figure 6.6 shows the value of both Mining Options the Weighted Average Cost of Capital (WACC) of 20% was calculated as in Section 6.9 and used to compare Mining Option 1 and Mining Option 2.

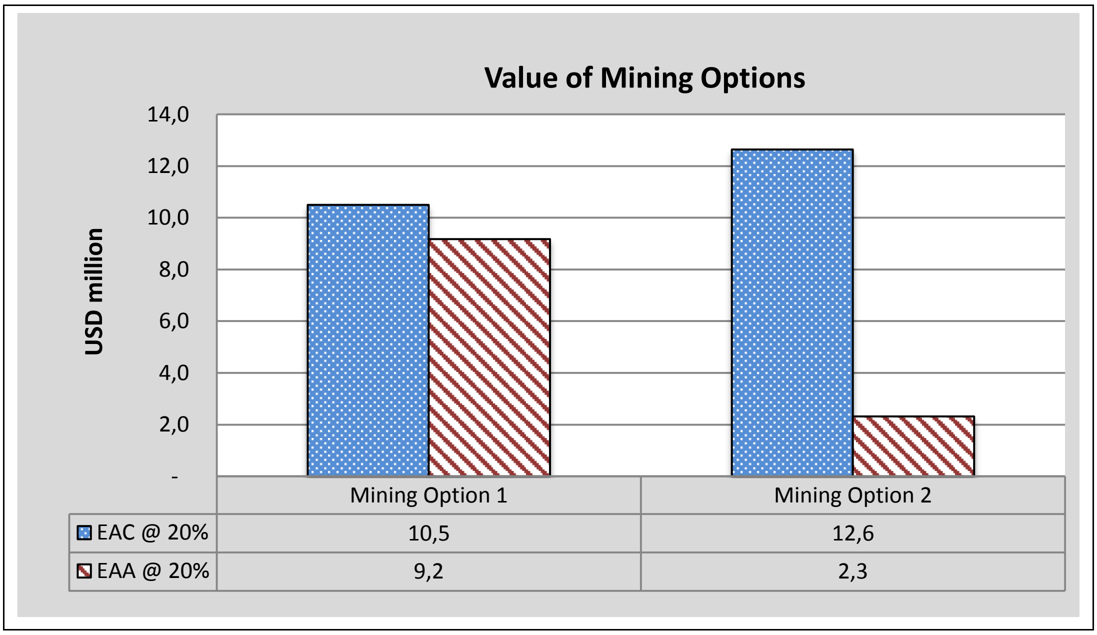


Figure 6.7 Value of each Mining Option

Mining Option 1 has an EAC of USD10.5 million and Mining Option 2 has an EAC of USD12.6 million. Under the EAC approach, Mining Option 1 should be selected because it has a lower annual cost. Mining Option 1 has an EAA of USD9.2 million compared to Mining Option 2 with an EAA of USD2.3 million. Under the EAA approach, Mining Option 1 is more favorable and should be selected since it has the higher annual annuity value.

6.11 Financial Model

Two financial models were created to conduct a Discounted Cash Flow (DCF) valuation of the two mining options. The two financial models were used to compare and determine the viability of each mining option. The models were constructed in real terms. The detail cash flow analysis for each mining option is shown in the Appendix under section 10.5 “Financial model for Mining Option 1” and section 10.6 “Financial model for Mining Option 2”. The results from the financial models can be summarised as follow in Table 6.13.

Table 6.13 Summary comparison of financial models

Parameter	Units	Mining Option 1	Mining Options 2
Basis of Comparison			
*** Pricing Basis**		**2015**	**2015**
*** Discount Rate**		**20%**	**20%**
*** LOM**		**10 Years**	**10 Years**
Production figures			
Total ROM	Mt	22.7	21.7
Total Saleable Tonnes	Mt	21.1	20.1
Yield	%	92,8%	92,7%
Total Saleable Tonnes - Power Coal	Mt	11.1	12.0
Total Saleable Tonnes - Thermal	Mt	4.3	4.3
Total Saleable Tonnes - Washed	Mt	2.7	2.0
Total Saleable Tonnes - Washed Coking Coal	Mt	3.0	1.8
Equivalent Saleable Product	Mt	21.1	20.1
Non-discounted cash flows			
Total Operational Cost	Million USD	612.7	590.0
Royalty Tax	Million USD	9.2	8.2
Total Cash Cost	Million USD	622.0	598.2
Total CapEx	Million USD	95.8	95.8
Average CapEx	**USD/t**	**4.22**	**4.41**
Total Cash Cost	**USD/Saleable t**	**29.51**	**29.69**
Mine EBITDA	Million USD	302.7	218.7
Capex	Million USD	95.8	95.8
Tax	Million USD	53.3	31,7
Nett Cashflow after tax	Million USD	153.6	91.3
Resulting NPV	**Million USD**	**38.2**	**9,7**
Internal Rate of Return	**%**	**48%**	**26%**
Simple Payback	**years**	**2.7**	**3.9**
Discounted Payback @20%	**years**	**4,9**	**11.9**
PV Ratio		**1.87**	**1.18**
PI	**%**	**87%**	**18%**
EAC @ 20%	**Million USD**	**10.5**	**12.6**
EAA 20%	**Million USD**	**9.2**	**2.3**

All prices and cost were based on 2015 figures. A discount rate of 20% was used for the DCF models over a LOM of 10 years. The table indicates the production figures for both mining option. Mining Option 1 has a ROM production of 22.7Mt of coal versus a 21.7Mt ROM coal for Mining Option 2. An overall yield of 92.8% was determined for Mining Option 1 compared to 92.7% for Mining Option 2, resulting in 21.1Mt of saleable coal product for Mining Option 1 and 20.1Mt of salable coal for Mining Option 2. Mining Option 1 has a lower operating cost than Mining Option 2, with a total cash cost of USD29.5/t in comparison to USD29.7/t. The NPV for Mining Option is higher at USD38.2 million than for Mining Option 2 at USD9.7 million, resulting in an better IRR of 48% for Mining Option 1 than 26% for Mining Option 2

6.12 Conclusion

DCF models were developed for both mining options that shows project cash in and out flows and calculates economic indicators, such as IRR and NPV. The NPV and IRR were the main methods for the evaluation of the two mining options. The resulting DCF models were developed in an Excel spreadsheet format over a 10 year LOM period. The models were prepared on an all equity basis and in real money terms in USD currency. Mining Option 1 will produce a total ROM coal production of 22.7 million tonnes at operational yield of 92.8% resulting in a total saleable product of 21.1 million tonnes. Mining Options 2 will produce slightly less than Mining Option 1 with total ROM coal production of 21.7 million tonnes at operational yield of 92.7% resulting in a total saleable product of 20.1 million tonnes. Mining Option 1 will produce 1 million saleable tonnes more than Mining Option 2 because of a better washed yield at 67% compared to 46%

Mining Option 1 and Mining Option 2 have a market related total operating cost of USD29.5/t and USD29.2/t respectively. Mine royalty for coal mines in Zimbabwe is stated at 1% of the revenue, hence a royalty payable rate of 1% was used in the financial models. The total capital outlay for each mining options was estimated at USD95.8 million. The sustaining capital expenditure is USD10.8 million and the expansionary capital expenditure is USD85.0 million over the life of both mining options. The normal tax rate of 25.75% for companies in Zimbabwe was used in the financial models.

Mining Option 1 has a simple payback period and discounted payback period of 2.7 years and 4.9 years, respectively. Mining Option 2 has a simple payback period and discounted payback period of 3.9 years and 11.9 years, respectively. Mining Option 1 has a shorter payback period than Mining Option 2. Mining Option 1 has a higher NPV of USD38.2 million in comparison to USD9.7 million for Mining Option 2. The IRR for Mining Option 1 was calculated at 48%, which is greater than the IRR for Mining Option 2 of 26%. Both mining options have a PI greater than one with Mining Option 1 and Mining Option 2 recording values of 1.87 and 1.18 respectively. Mining Option 1 has the better PI value and is therefore more profitable. Based on the economic evaluation, Mining Options 1 is by far more attractive than Mining Option 2, which results in a better return on the investment and is therefore the preferred option.

7 CONCLUSION

7.1 Introduction

Makomo Resources is a relatively new coal mining company in Zimbabwe. The company is the largest privately owned coal mine in the country, which have a mining licence to perform coal-mining activities in the north-west part of the Bulawayo Mining District of Zimbabwe. Makomo Resources started mining in June 2010. Makomo Resources has 91.7Mt of coal resources and coal reserves of 65.1Mt, which is mined by means of open cast mining techniques. The operation has mined 7.5 million ROM tons of coal to-date. Majority of the coal is supplied to the local power stations in Zimbabwe as thermal coal. Makomo Resources has a very diverse coal product range and client base. The operation has a life of mine of 20 years at an annual production rate of 2.5milion ROM tons of coal at an average strip ratio of 2.5t/bcm.

Makomo has commissioned their washing plant in October 2014 to expand their current capacity in order to enter and explore the coking coal and export markets. The mine has invested in USD20 million capital to commission a wash plant to wash the coking coal, which is only about 18% of the coal resource. The study investigated how to optimise the plant throughput by comparing two mining options:

Mining Option 1 - crush and screen 2m power coal, crush and screen and wash a full 7m low ash coal seam and wash 2m of coking coal.

Mining Option 2 – crush and screen 2m power coal, crush & screen a 3m low sulphur coal seam and wash low ash coal and coking coal of 4m and 2m respectively. Given the importance of coalmining to the Makomo Resources profitability, it was important to analyse and compare the two proposed mining options.

The study determined the optimal operational model for Makomo Resources from a mining, processing and mineral economic point of view. The study investigated all the marketing, geology, mining and financial parameters. Financial techniques were used in the study to analyse and evaluate the two mining options. An economic evaluation was required to determine the value and feasibility of each mining option, including analysing all the costs and benefits associated with these mining options. Two financial models were created to evaluate the coal reserves. The financial models were constructed from estimations of income and costs. The optimal mining model was developed to maximise shareholders value. The objective of every mining business is to derive and maximise shareholders wealth. Shareholders wealth is created when a business generates profits, therefore every mining operation must strive to be profitable. . There are several evaluation techniques, which can be applied to assist the decision-making process on the best course of action and in which project to invest. The NPV of a project determines the economic value of the mining project. The decision on a mining investment is mostly related to the NPV and IRR of the project. The discount rate is equally important comparing to mining and financial parameters of the DCF. The CAPM method was used to determine the cost of capital for the two mining options.

7.2 Zimbabwe Mining Sector

The mining sector plays a significant role in the economy of Zimbabwe. The mining sector is the second largest contributor to the country's GDP at over 20%. The mining and quarry sector have showed the biggest growth improvement of 32% between 2012 and 2015 compared to the other sectors. The country are endowed with abundant mineral resources. The top three commodities in terms of estimated resources are iron ore, coal and platinum with resources of 30billion tonnes, 26 billion tonnes and 2.8 billion tonnes respectively. The production growth rates per commodity have increased year after year since 2009. The mining sector is very diverse with more than 40 different minerals and over 800 operating mines ranging from small scale mines to world class mines. With the new thrust of mining as the cornerstone of economic growth, it is imperative to: resuscitate existing mining operations, develop new mines, beneficiate mineral output and establish linkages between the mining sector and other sectors of the economy, particularly manufacturing. Mining has accounted for almost 40 percent of total national exports dominated by gold, platinum and diamonds. The mining industry in Zimbabwe is continuously facing several challenges, which negatively impact on the country's economy. Zimbabwe's vast mineral resources and reserves are of strategic importance to the Zimbabwe economy. Coal mining is one of the major economic contributors to the mining industry in Zimbabwe.

Zimbabwe has a population of 12.6 million people living on a land area of 391,000km^2. Zimbabwe is divided into eight provinces with the Harare as the capital city. Zimbabwe has more than 10 billion tonnes of coal reserves in twenty-one deposits in both proven and probable categories, of which 2 billion tonnes are mineable using opencast mining methods. The coal resource occurs in two major sedimentary basins located, the Mid-Zambezi basin and the Save-Limpopo basin. Currently only four mining Special Grants are existing in the Mid Zambezi Basin where mining operations are taking place.

Zimbabwe Energy Supply Authority (ZESA) Holdings is a government parastatal, which is responsible for all the energy and electricity requirements in Zimbabwe Mining provides a significant contribution to the country's economy and accounts for more than 20% of the gross domestic product. Zimbabwe's economy consumed around 9,000GWh of energy. Biofuel accounts for about 66% of the energy used and coal only contributes 21% towards the energy used. In 2000, power generation supply was around 12,000GWh, with a large proportion coming from imports, and just 7,000GWh coming from the small number of coal and hydro power stations. Zimbabwe's energy requirements are met through a combination of biomass, domestic coal-fired and hydroelectric power plants and imports. The county is serviced by six power stations with a combined total installed capacity of 1,970MW, with hydro accounting for 37% and coal accounting for 61%. More than 35% of electricity required is imported from neighbouring countries. Each power station holds a generation license from the Zimbabwe Electricity Regulatory Authority. ZPC supplies about 1,200MW of electricity to the network, against a demand of 2,200MW. Inadequate power generation, unreliability of sources and financial constraints to importing has led to frequent power shortages resulting in significant under-utilisation of capacity in manufacturing, mining and agriculture sectors. More than half of the total energy supply is still from biomass products

7.3 Makomo Mining Model

Makomo Resources has a large coal resource of over 90 million tonnes available for underground and opencast mining. In their current open pit there is a declared total coal reserve of 65Mt ROM based on a stripping ratio of 2.5bcm/t. The main coal seam is on average 11m tick. The following mining seam selection have been identified for the mining options:

Mining Option 1: three primary economic seams comprising of power coal seam, low-ash coal seam and coking coal seam, with average thicknesses of 2.0m, 7.0m and 2.0m respectively.

Mining Option 2: four primary economic seams comprising of power coal seam, low-ash coal seam, low sulphur coal seam and coking coal seam, with average thicknesses of 2.0m, 4.0m, 3.0m and 2.0m respectively.

Makomo Resources currently applies a conventional strip mining method by means of truck and shovel to extract the coal reserves. The production schedules for both mining options were developed for a LOM of ten years. The processing operation consists out of three crush and screen plants together with a washing plant, with a combined capacity of over 250,000 tonnes.

Makomo Resources produces four dry coal products comprising of rounds, cobbles, peas and NPD for the domestic market. Makomo Resources also produces four-washed product like washed peas, washed duff, washed fines and coking coal peas for the local and expert market. Makomo Resources has the capacity to produce over 250,000 tonnes of saleable coal; however, only supplying 201,000 tonnes to the local and export market.

7.4 Economic Evaluations

The evaluation of potential mining systems requires the calculation of a number of technical inputs, such as mineable reserves, production rates, recoveries, costs and revenues. The financial evaluation of mining projects is based on values of variables that are estimated from changeable data. The risk associated with a mining project comes from the uncertainties involved in the industry. A DCF is a great tool to aid in the analysis to identify the most feasible mining model, which will increase shareholders wealth.

DCF models were developed for both mining options that show project cash in and out flows and calculates economic indicators, such as IRR and NPV. The NPV and IRR were the main methods for the evaluation of the two mining options. The resulting DCF models were developed in an Excel spreadsheet format over a 10-year LOM period. The models were prepared on an all equity basis and in real money terms in USD currency. Mining Option 1 will produce a total ROM coal production of 22.7 million tonnes at operational yield of 92.8% resulting in a total saleable product of 21.1 million tonnes. Mining Options 2 will produce slightly less than Mining Option 1 with total ROM coal production of 21.7 million tonnes at operational yield of 92.7% resulting in a total saleable product of 20.1 million tonnes. Mining Option 1 will produce 1 million saleable tonnes more than Mining Option 2 because of a superior-washed yield at 67% compared to 46%

Mining Option 1 and Mining Option 2 have a market related total operating cost of $29.5/t and $29.2/t respectively. Mine royalty for coal mines in Zimbabwe is stated at 1% of the revenue, hence a royalty payable rate of 1% was used in the financial models. The total capital outlay for each mining option was estimated at USD95.8 million. The sustaining capital expenditure is USD10.8 million and the expansionary capital expenditure is USD85.0 million over the life of both mining options. The normal tax rate of 25.75% for companies in Zimbabwe was used in the financial models.

Mining Option 1 has a simple payback period and discounted payback period of 2.7 years and 4.9 years, respectively. Mining Option 2 has a simple payback period and discounted payback period of 3.9 years and 11.9 years, respectively. Mining Option 1 has a shorter payback period than Mining Option 2. Mining Option 1 has a higher NPV of USD38.2 million in comparison to USD9.7 million for Mining Option 2. The IRR for Mining Option 1 was calculated at 48%, which is greater than the IRR for Mining Option 2 of 26%. Both mining options have a PI greater than one with Mining Option 1 and Mining Option 2 recording values of 1.87 and 1.18 respectively. Mining Option 1 has the better PI value and is therefore more profitable. Based on the economic evaluation, Mining Options 1 is by far more attractive than Mining Option 2, which results in a better return on the investment and is therefore the preferred option. Mining Option 1 is the optimal mining model, which gives a higher NPV, better return on the investment and creates more shareholder wealth.

8 RECOMMENDATIONS

The operation must apply the coal seam selection of Mining Option 1, which indicates power coal seam, low-ash coal seam and coking coal seam, with average thicknesses of 2.0m, 7.0m and 2.0m, respectively. The operation must apply the coal processing methodology, which includes processing power coal on plant 3, produce rounds, cobbles, nuts and peas from the 7m Low-Ash coal seam in Plant 1 and Plant 3 and process the 7m Low-Ash coal seam and the Coking coal seam through the Wash plant to produce washed peas, washed duff and washed fines.

The economic evaluation clearly showed mining Option 1 to be the most feasible option, with and higher NPV and IRR. Mining Option 1 had a shorter payback period than Mining Option2. The profitability index for Mining Option1 was better than Mining Option 2. Mining Option 1 is therefore the optimal mining model to be followed by Makomo Resources. Option 1 gave a better return on investment and created more shareholders wealth.

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10 APPENDICES

10.1 Total waste production Mining Option 1

MAKOMO RESOURCES LOM PLAN - DATA INPUT SHEET: Waste Mining Option 1															
PERIOD			1	11	Mine Life Years	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Item			Units		Sum / Ave										
3.	TOTAL WASTE														
	Total Sandstone - Drill and Blast		bcm		16 724 275	1 526 999	1 526 999	1 599 713	1 599 713	1 672 428	1 672 428	1 745 142	1 745 142	1 817 856	1 817 856
	Total Sandstone -Load and Haul		bcm		16 724 275	1 526 999	1 526 999	1 599 713	1 599 713	1 672 428	1 672 428	1 745 142	1 745 142	1 817 856	1 817 856
	Total Shale Bench 1 - Drill and Blast		bcm		23 518 512	2 147 342	2 147 342	2 249 597	2 249 597	2 351 851	2 351 851	2 454 106	2 454 106	2 556 360	2 556 360
	Total Shale Bench 1 - Load and Haul		bcm		23 518 512	2 147 342	2 147 342	2 249 597	2 249 597	2 351 851	2 351 851	2 454 106	2 454 106	2 556 360	2 556 360
	Total Shale Bench 2 - Drill and Blast		bcm		12 020 573	1 097 531	1 097 531	1 149 794	1 149 794	1 202 057	1 202 057	1 254 321	1 254 321	1 306 584	1 306 584
	Total Shale Bench 2 - Load and Haul		bcm		12 020 573	1 097 531	1 097 531	1 149 794	1 149 794	1 202 057	1 202 057	1 254 321	1 254 321	1 306 584	1 306 584
	Total- Drill and Blast		bcm		52 263 360	4 771 872	4 771 872	4 999 104	4 999 104	5 226 336	5 226 336	5 453 568	5 453 568	5 680 800	5 680 800
	Total Truck & Shovel - Load And Haul		bcm		52 263 360	4 771 872	4 771 872	4 999 104	4 999 104	5 226 336	5 226 336	5 453 568	5 453 568	5 680 800	5 680 800

10.2 Total waste production Mining Option 2

MAKOMO RESOURCES LOM PLAN - DATA INPUT SHEET: Waste Mining Option 2															
PERIOD			1	11	Mine Life Years	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Item			Units		Sum / Ave										
3.	TOTAL WASTE														
	Total Sandstone - Drill and Blast		bcm		15 996 317	1 460 533	1 460 533	1 530 082	1 530 082	1 599 632	1 599 632	1 669 181	1 669 181	1 738 730	1 738 730
	Total Sandstone -Load and Haul		bcm		15 996 317	1 460 533	1 460 533	1 530 082	1 530 082	1 599 632	1 599 632	1 669 181	1 669 181	1 738 730	1 738 730
	Total Shale Bench 1 - Drill and Blast		bcm		22 494 820	2 053 875	2 053 875	2 151 678	2 151 678	2 249 482	2 249 482	2 347 286	2 347 286	2 445 089	2 445 089
	Total Shale Bench 1 - Load and Haul		bcm		22 494 820	2 053 875	2 053 875	2 151 678	2 151 678	2 249 482	2 249 482	2 347 286	2 347 286	2 445 089	2 445 089
	Total Shale Bench 2 - Drill and Blast		bcm		11 497 353	1 049 758	1 049 758	1 099 747	1 099 747	1 149 735	1 149 735	1 199 724	1 199 724	1 249 712	1 249 712
	Total Shale Bench 2 - Load and Haul		bcm		11 497 353	1 049 758	1 049 758	1 099 747	1 099 747	1 149 735	1 149 735	1 199 724	1 199 724	1 249 712	1 249 712
	Total- Drill and Blast		bcm		49 988 489	4 564 166	4 564 166	4 781 508	4 781 508	4 998 849	4 998 849	5 216 190	5 216 190	5 433 531	5 433 531
	Total Truck & Shovel - Load And Haul		bcm		49 988 489	4 564 166	4 564 166	4 781 508	4 781 508	4 998 849	4 998 849	5 216 190	5 216 190	5 433 531	5 433 531

10.3 Detail Operational cost for Mining Option 1

MAKOMO RESOURCES LOM PLAN - DATA INPUT SHEET: Costs Mining option 1														
	PERIOD	**1**	**11**	**Mine Life Years**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**
Item		**Units**		**Sum / Ave**										
1.	**SUMMARY**													
	TOTAL OPERATIONAL COSTS													
	Mining Cost	USD		356 103 263	33 684 652	33 684 652	34 647 489	34 647 489	35 610 326	35 610 326	36 573 164	36 573 164	37 536 001	37 536 001
	Crush and Screen	USD		57 059 586	5 705 959	5 705 959	5 705 959	5 705 959	5 705 959	5 705 959	5 705 959	5 705 959	5 705 959	5 705 959
	Washing	USD		35 440 555	3 544 056	3 544 056	3 544 056	3 544 056	3 544 056	3 544 056	3 544 056	3 544 056	3 544 056	3 544 056
	Loading Cost	USD		22 798 536	2 279 854	2 279 854	2 279 854	2 279 854	2 279 854	2 279 854	2 279 854	2 279 854	2 279 854	2 279 854
	Overhead Cash Costs	USD		86 120 928	8 612 093	8 612 093	8 612 093	8 612 093	8 612 093	8 612 093	8 612 093	8 612 093	8 612 093	8 612 093
	Logistic Cost	USD		55 214 560	5 521 456	5 521 456	5 521 456	5 521 456	5 521 456	5 521 456	5 521 456	5 521 456	5 521 456	5 521 456
	TOTAL	**ZAR**		612 737 429	**59 348 068**	**59 348 068**	**60 310 906**	**60 310 906**	**61 273 743**	**61 273 743**	**62 236 580**	**62 236 580**	**63 199 418**	**63 199 418**
	TOTAL COST PER ROMt													
	Total Direct Mining Costs	USD / ROMt		15,67	14,82	14,82	15,25	15,25	15,67	15,67	16,10	16,10	16,52	16,52
	Total Coal Crush and Screen Costs	USD / ROMt		2,51	2,51	2,51	2,51	2,51	2,51	2,51	2,51	2,51	2,51	2,51
	Total Washing Costs	USD / ROMt		1,56	1,56	1,56	1,56	1,56	1,56	1,56	1,56	1,56	1,56	1,56
	Total Loading Cost	USD / ROMt		1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
	Total Overhead Cost (Excluding Non Cash Costs)	USD / ROMt		3,79	3,79	3,79	3,79	3,79	3,79	3,79	3,79	3,79	3,79	3,79
	Total Logistic cost	USD / ROMt		2,43	2,43	2,43	2,43	2,43	2,43	2,43	2,43	2,43	2,43	2,43
	Total Operational Costs	**USD / ROMt**		**26,97**	**26,12**	**26,12**	**26,54**	**26,54**	**26,97**	**26,97**	**27,39**	**27,39**	**27,81**	**27,81**

10.4 Detail Operational cost for Mining Option 2

MAKOMO RESOURCES LOM PLAN - DATA INPUT SHEET: Costs Mining Option 2													
	PERIOD	1	11	Mine Life Years	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Item		Units		Sum / Ave										
1.	SUMMARY													
	TOTAL OPERATIONAL COSTS													
	Mining Cost	USD		341 255 156	32 283 660	32 283 660	33 204 588	33 204 588	34 125 516	34 125 516	35 046 443	35 046 443	35 967 371	35 967 371
	Crush and Screen	USD		54 575 950	5 457 595	5 457 595	5 457 595	5 457 595	5 457 595	5 457 595	5 457 595	5 457 595	5 457 595	5 457 595
	Washing	USD		31 518 786	3 151 879	3 151 879	3 151 879	3 151 879	3 151 879	3 151 879	3 151 879	3 151 879	3 151 879	3 151 879
	Loading Cost	USD		21 806 183	2 180 618	2 180 618	2 180 618	2 180 618	2 180 618	2 180 618	2 180 618	2 180 618	2 180 618	2 180 618
	Overhead Cash Costs	USD		82 372 336	8 237 234	8 237 234	8 237 234	8 237 234	8 237 234	8 237 234	8 237 234	8 237 234	8 237 234	8 237 234
	Logistic Cost	USD		58 514 312	5 851 431	5 851 431	5 851 431	5 851 431	5 851 431	5 851 431	5 851 431	5 851 431	5 851 431	5 851 431
	TOTAL	**ZAR**		590 042 722	**57 162 416**	**57 162 416**	**58 083 344**	**58 083 344**	**59 004 272**	**59 004 272**	**59 925 200**	**59 925 200**	**60 846 128**	**60 846 128**
	TOTAL COST PER ROMt													
	Total Direct Mining Costs	USD / ROMt		15,70	14,85	14,85	15,28	15,28	15,70	15,70	16,13	16,13	16,55	16,55
	Total Coal Crush and Screen Costs	USD / ROMt		2,51	2,51	2,51	2,51	2,51	2,51	2,51	2,51	2,51	2,51	2,51
	Total Washing Costs	USD / ROMt		1,45	1,45	1,45	1,45	1,45	1,45	1,45	1,45	1,45	1,45	1,45
	Total Loading Cost	USD / ROMt		1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
	Total Overhead Cost (Excluding Non Cash Costs)	USD / ROMt		3,79	3,79	3,79	3,79	3,79	3,79	3,79	3,79	3,79	3,79	3,79
	Total Logistic cost	USD / ROMt		2,69	2,69	2,69	2,69	2,69	2,69	2,69	2,69	2,69	2,69	2,69
	Total Operational Costs	**USD / ROMt**		**27,15**	**26,30**	**26,30**	**26,72**	**26,72**	**27,15**	**27,15**	**27,57**	**27,57**	**28,00**	**28,00**

10.5 Financial Model for Mining Option 1

10.5.1 Mining production and sales for Mining option 1

Makomo Resource 2015 LOMP Financial Mode: Mining Option 1l			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
PRODUCTION (100% BASIS)		**Average / Total**										
MINING												
Waste (Prime) - Opencast	**bcm**	**52 263 360**	4 771 872	4 771 872	4 999 104	4 999 104	5 226 336	5 226 336	5 453 568	5 453 568	5 680 800	5 680 800
Coal Mined - Opencast	**t**	**22 723 200**	2 272 320	2 272 320	2 272 320	2 272 320	2 272 320	2 272 320	2 272 320	2 272 320	2 272 320	2 272 320
ROM	**t**	**22 723 200**	**2 272 320**	**2 272 320**	**2 272 320**	**2 272 320**	**2 272 320**	**2 272 320**	**2 272 320**	**2 272 320**	**2 272 320**	**2 272 320**
ROM Strip Ratio - Opencut		**2,30**	2,10	2,10	2,20	2,20	2,30	2,30	2,40	2,40	2,50	2,50
Operations Yield	**%**	**92,76%**	92,8%	92,8%	92,8%	92,8%	92,8%	92,8%	92,8%	92,8%	92,8%	92,8%
EQUIVALENT SALEABLE TONNES BY PRODUCT												
Power coal	**t**	**11 114 194**	1 111 419	1 111 419	1 111 419	1 111 419	1 111 419	1 111 419	1 111 419	1 111 419	1 111 419	1 111 419
Dry Peas	**t**	**3 467 439**	346 744	346 744	346 744	346 744	346 744	346 744	346 744	346 744	346 744	346 744
Dry Cobbles	**t**	**532 224**	53 222	53 222	53 222	53 222	53 222	53 222	53 222	53 222	53 222	53 222
Dry Rounds	**t**	**332 640**	33 264	33 264	33 264	33 264	33 264	33 264	33 264	33 264	33 264	33 264
Washed Peas	**t**	**1 042 685**	104 268	104 268	104 268	104 268	104 268	104 268	104 268	104 268	104 268	104 268
Washed Duff	**t**	**1 520 046**	152 005	152 005	152 005	152 005	152 005	152 005	152 005	152 005	152 005	152 005
Washed Fines	**t**	**108 465**	10 846	10 846	10 846	10 846	10 846	10 846	10 846	10 846	10 846	10 846
Coking Coal	**t**	**1 808 739**	180 874	180 874	180 874	180 874	180 874	180 874	180 874	180 874	180 874	180 874
Coking Coal Duff	**t**	**964 208**	96 421	96 421	96 421	96 421	96 421	96 421	96 421	96 421	96 421	96 421
Coking Coal Fines	**t**	**188 153**	18 815	18 815	18 815	18 815	18 815	18 815	18 815	18 815	18 815	18 815
Total	**t**	**21 078 794**	**2 107 879**	**2 107 879**	**2 107 879**	**2 107 879**	**2 107 879**	**2 107 879**	**2 107 879**	**2 107 879**	**2 107 879**	**2 107 879**

10.5.2 Product coal prices for Mining option 1

Makomo Resource 2015 LOMP Financial Model: Mining Option 1			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
COAL PRICES		**Average / Total**										
Power coal	**USD / t**	**26,50**	26,50	26,50	26,50	26,50	26,50	26,50	26,50	26,50	26,50	26,50
Dry Peas	**USD / t**	**58,00**	58,00	58,00	58,00	58,00	58,00	58,00	58,00	58,00	58,00	58,00
Dry Cobbles	**USD / t**	**41,00**	41,00	41,00	41,00	41,00	41,00	41,00	41,00	41,00	41,00	41,00
Dry Rounds	**USD / t**	**50,00**	50,00	50,00	50,00	50,00	50,00	50,00	50,00	50,00	50,00	50,00
Washed Peas	**USD / t**	**65,00**	65,00	65,00	65,00	65,00	65,00	65,00	65,00	65,00	65,00	65,00
Washed Duff	**USD / t**	**45,00**	45,00	45,00	45,00	45,00	45,00	45,00	45,00	45,00	45,00	45,00
Washed Fines	**USD / t**	**25,00**	25,00	25,00	25,00	25,00	25,00	25,00	25,00	25,00	25,00	25,00
Coking Coal Peas	**USD / t**	**85,00**	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00
Coking Coal Duff	**USD / t**	**85,00**	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00
Coking Coal Fines	**USD / t**	**85,00**	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00

10.5.3 Discounted Cash Flow for Mining Option 1

Makomo Resource 2015 LOMP Financial Model: Mining Option 1			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
CASHFLOWS		**Average / Total**										
Sales Revenue	**USD**	**924 672 603**	**92 467 260**	**92 467 260**	**92 467 260**	**92 467 260**	**92 467 260**	**92 467 260**	**92 467 260**	**92 467 260**	**92 467 260**	**92 467 260**
Average Realisation ZAR (Ex-Mine)	**USD / t**	**43,87**	**43,87**	**43,87**	**43,87**	**43,87**	**43,87**	**43,87**	**43,87**	**43,87**	**43,87**	**43,87**
Operational Cost												
Direct Mining Cost	**USD**	**356 103 263**	33 684 651	33 684 651	34 647 488	34 647 488	35 610 326	35 610 326	36 573 164	36 573 164	37 536 001	37 536 001
Crush and Screen Cost	**USD**	**57 059 586**	5 705 958	5 705 958	5 705 958	5 705 958	5 705 959	5 705 959	5 705 959	5 705 959	5 705 959	5 705 959
Washing Cost	**USD**	**35 440 555**	3 544 055	3 544 055	3 544 055	3 544 055	3 544 056	3 544 056	3 544 056	3 544 056	3 544 056	3 544 056
Loading Cost	**USD**	**22 798 536**	2 279 853	2 279 853	2 279 853	2 279 853	2 279 854	2 279 854	2 279 854	2 279 854	2 279 854	2 279 854
Overhead Costs (Excl. Cash costs)	**USD**	**86 120 928**	8 612 092	8 612 092	8 612 092	8 612 092	8 612 093	8 612 093	8 612 093	8 612 093	8 612 093	8 612 093
Logistic Cost	**USD**	**55 214 560**	5 521 456	5 521 456	5 521 456	5 521 456	5 521 456	5 521 456	5 521 456	5 521 456	5 521 456	5 521 456
Total Operational Cost	**USD**	**612 737 429**	**59 348 068**	**59 348 068**	**60 310 906**	**60 310 906**	**61 273 743**	**61 273 743**	**62 236 580**	**62 236 580**	**63 199 418**	**63 199 418**
Unit Cost	**USD / St**	**29,1**	**28,16**	**28,16**	**28,61**	**28,61**	**29,07**	**29,07**	**29,53**	**29,53**	**29,98**	**29,98**
Operating Profit		**311 935 174**	**33 119 192**	**33 119 192**	**32 156 355**	**32 156 355**	**31 193 517**	**31 193 517**	**30 230 680**	**30 230 680**	**29 267 843**	**29 267 843**
Distribution & Royalty Costs												
Royalty Tax	**USD**	**9 246 726**	924 673	924 673	924 673	924 673	924 673	924 673	924 673	924 673	924 673	924 673
Total Cost	**USD**	**621 984 155**	**60 272 741**	**60 272 741**	**61 235 578**	**61 235 578**	**62 198 416**	**62 198 416**	**63 161 253**	**63 161 253**	**64 124 090**	**64 124 090**
Unit Cost	**USD / St**	**29,5**	**28,59**	**28,59**	**29,05**	**29,05**	**29,51**	**29,51**	**29,96**	**29,96**	**30,42**	**30,42**
Cash Margin (Ex-Mine)	**USD / St**	**14,36**	15,27	15,27	14,82	14,82	14,36	14,36	13,90	13,90	13,45	13,45
Mine EBITDA - Cash Margin (ZAR)	**USD**	**302 688 448**	32 194 519	32 194 519	31 231 682	31 231 682	30 268 845	30 268 845	29 306 007	29 306 007	28 343 170	28 343 170

Makomo Resource 2015 LOMP Financial Model: Mining Option 1				Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
CASHFLOWS			**Average / Total**										
Mine EBITDA - Cash Margin (ZAR)	**USD**		**302 688 448**	**32 194 519**	**32 194 519**	**31 231 682**	**31 231 682**	**30 268 845**	**30 268 845**	**29 306 007**	**29 306 007**	**28 343 170**	**28 343 170**
Capital Expenditure			**95 800 000**	**85 000 000**	**1 200 000**	**1 200 000**	**1 200 000**	**1 200 000**	**1 200 000**	**1 200 000**	**1 200 000**	**1 200 000**	**1 200 000**
Sustaining Capital	**USD**		**10 800 000**	-	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000
Expansion Capital	**USD**		**85 000 000**	85 000 000	-	-	-	-	-	-	-	-	-
Tax													
Income Tax			**53 273 775**	-	-	2 116 836	7 733 158	7 485 228	7 485 228	7 237 297	7 237 297	6 989 366	6 989 366
Net Cash Flow After Tax	**USD**		**153 614 672**	**-52 805 481**	**30 994 519**	**27 914 846**	**22 298 524**	**21 583 617**	**21 583 617**	**20 868 710**	**20 868 710**	**20 153 804**	**20 153 804**
Net Cash Flow After Tax Cumulative	**USD**			-52 805 481	-21 810 961	6 103 885	28 402 409	49 986 027	71 569 644	92 438 354	113 307 065	133 460 869	153 614 672
NPV CALCULATION													
NPV	**USD**	**20%**	**38 168 006**	**-52 805 481**	**30 994 519**	**27 914 846**	**22 298 524**	**21 583 617**	**21 583 617**	**20 868 710**	**20 868 710**	**20 153 804**	**20 153 804**
IRR			**48%**										
TAXATION													
EBIT				-52 805 481	30 994 519	30 031 682	30 031 682	29 068 845	29 068 845	28 106 007	28 106 007	27 143 170	27 143 170
Carried forward				-52 805 481	-21 810 961	-	-	-	-	-	-	-	-
Taxable income				-	-	8 220 721	30 031 682	29 068 845	29 068 845	28 106 007	28 106 007	27 143 170	27 143 170
Tax paid			**25,75%**	-	-	2 116 836	7 733 158	7 485 228	7 485 228	7 237 297	7 237 297	6 989 366	6 989 366

10.6 Financial Model for Mining Option 2

10.6.1 Mining production and sales for Mining option 2

Makomo Resource 2015 LOMP Financial Model: Mining Option 2			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
PRODUCTION (100% BASIS)		**Average / Total**										
MINING												
Waste (Prime) - Opencast	**bcm**	**52 263 360**	4 564 166	4 564 166	4 781 508	4 781 508	4 998 849	4 998 849	5 216 190	5 216 190	5 433 531	5 433 531
Coal Mined - Opencast	**t**	**22 723 200**	2 173 413	2 173 413	2 173 413	2 173 413	2 173 413	2 173 413	2 173 413	2 173 413	2 173 413	2 173 413
ROM	**t**	**22 723 200**	**2 173 413**	**2 173 413**	**2 173 413**	**2 173 413**	**2 173 413**	**2 173 413**	**2 173 413**	**2 173 413**	**2 173 413**	**2 173 413**
ROM Strip Ratio - Opencut		**2,30**	2,10	2,10	2,20	2,20	2,30	2,30	2,40	2,40	2,50	2,50
Operations Yield	**%**	**92,76%**	90,3%	93,0%	93,0%	93,0%	93,0%	93,0%	93,0%	93,0%	93,0%	93,0%
EQUIVALENT SALEABLE TONNES BY PRODUCT												
Power coal	**t**	**11 114 194**	1 200 122	1 200 122	1 200 122	1 200 122	1 200 122	1 200 122	1 200 122	1 200 122	1 200 122	1 200 122
Dry Peas	**t**	**3 467 439**	346 744	346 744	346 744	346 744	346 744	346 744	346 744	346 744	346 744	346 744
Dry Cobbles	**t**	**532 224**	53 222	53 222	53 222	53 222	53 222	53 222	53 222	53 222	53 222	53 222
Dry Rounds	**t**	**332 640**	33 264	33 264	33 264	33 264	33 264	33 264	33 264	33 264	33 264	33 264
Washed Peas	**t**	**1 042 685**	92 948	92 948	92 948	92 948	92 948	92 948	92 948	92 948	92 948	92 948
Washed Duff	**t**	**1 520 046**	49 549	107 325	107 325	107 325	107 325	107 325	107 325	107 325	107 325	107 325
Washed Fines	**t**	**108 465**	9 669	9 669	9 669	9 669	9 669	9 669	9 669	9 669	9 669	9 669
Coking Coal	**t**	**1 808 739**	108 381	108 381	108 381	108 381	108 381	108 381	108 381	108 381	108 381	108 381
Coking Coal Duff	**t**	**964 208**	57 776	57 776	57 776	57 776	57 776	57 776	57 776	57 776	57 776	57 776
Coking Coal Fines	**t**	**188 153**	11 274	11 274	11 274	11 274	11 274	11 274	11 274	11 274	11 274	11 274
Total	**t**	**21 078 794**	**1 962 950**	**2 020 726**	**2 020 726**	**2 020 726**	**2 020 726**	**2 020 726**	**2 020 726**	**2 020 726**	**2 020 726**	**2 020 726**

10.6.2 Product coal prices for Mining Option 2

Makomo Resource 2015 LOMP Financial Model: Mining Option 2			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
COAL PRICES		**Average / Total**										
Power coal	**USD / t**	**26,50**	26,50	26,50	26,50	26,50	26,50	26,50	26,50	26,50	26,50	26,50
Dry Peas	**USD / t**	**58,00**	58,00	58,00	58,00	58,00	58,00	58,00	58,00	58,00	58,00	58,00
Dry Cobbles	**USD / t**	**41,00**	41,00	41,00	41,00	41,00	41,00	41,00	41,00	41,00	41,00	41,00
Dry Rounds	**USD / t**	**50,00**	50,00	50,00	50,00	50,00	50,00	50,00	50,00	50,00	50,00	50,00
Washed Peas	**USD / t**	**65,00**	65,00	65,00	65,00	65,00	65,00	65,00	65,00	65,00	65,00	65,00
Washed Duff	**USD / t**	**45,00**	45,00	45,00	45,00	45,00	45,00	45,00	45,00	45,00	45,00	45,00
Washed Fines	**USD / t**	**25,00**	25,00	25,00	25,00	25,00	25,00	25,00	25,00	25,00	25,00	25,00
Coking Coal Peas	**USD / t**	**85,00**	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00
Coking Coal Duff	**USD / t**	**85,00**	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00
Coking Coal Fines	**USD / t**	**85,00**	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00	85,00

10.6.3 Discounted Cash Flow for Mining Option 2

Makomo Resource 2015 LOMP Financial Model: Mining Option 2			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
CASHFLOWS		**Average / Total**										
Sales Revenue	**USD**	**816 943 161**	**79 354 389**	**81 954 308**	**81 954 308**	**81 954 308**	**81 954 308**	**81 954 308**	**81 954 308**	**81 954 308**	**81 954 308**	**81 954 308**
Average Realisation ZAR (Ex-Mine)	**USD / t**	**40,54**	**40,43**	**40,56**	**40,56**	**40,56**	**40,56**	**40,56**	**40,56**	**40,56**	**40,56**	**40,56**
Operational Cost												
Direct Mining Cost	**USD**	**341 255 156**	32 283 660	32 283 660	33 204 588	33 204 588	34 125 516	34 125 516	35 046 443	35 046 443	35 967 371	35 967 371
Crush and Screen Cost	**USD**	**54 575 950**	5 457 595	5 457 595	5 457 595	5 457 595	5 457 595	5 457 595	5 457 595	5 457 595	5 457 595	5 457 595
Washing Cost	**USD**	**31 518 786**	3 151 879	3 151 879	3 151 879	3 151 879	3 151 879	3 151 879	3 151 879	3 151 879	3 151 879	3 151 879
Loading Cost	**USD**	**21 806 183**	2 180 618	2 180 618	2 180 618	2 180 618	2 180 618	2 180 618	2 180 618	2 180 618	2 180 618	2 180 618
Overhead Costs (Excl. Cash costs)	**USD**	**82 372 336**	8 237 234	8 237 234	8 237 234	8 237 234	8 237 234	8 237 234	8 237 234	8 237 234	8 237 234	8 237 234
Logistic Cost	**USD**	**58 514 312**	5 851 431	5 851 431	5 851 431	5 851 431	5 851 431	5 851 431	5 851 431	5 851 431	5 851 431	5 851 431
Total Operational Cost	**USD**	**590 042 722**	**57 162 416**	**57 162 416**	**58 083 344**	**58 083 344**	**59 004 272**	**59 004 272**	**59 925 200**	**59 925 200**	**60 846 128**	**60 846 128**
Unit Cost	**USD / St**	**29,3**	**29,12**	**28,29**	**28,74**	**28,74**	**29,20**	**29,20**	**29,66**	**29,66**	**30,11**	**30,11**
			22 191 972	**24 791 891**	**23 870 964**	**23 870 964**	**22 950 036**	**22 950 036**	**22 029 108**	**22 029 108**	**21 108 180**	**21 108 180**
Operating Profit		**226 900 438**	32 283 660	32 283 660	33 204 588	33 204 588	34 125 516	34 125 516	35 046 443	35 046 443	35 967 371	35 967 371
Distribution & Royalty Costs												
Royalty Tax	**USD**	8 169 432	793 544	819 543	819 543	819 543	819 543	819 543	819 543	819 543	819 543	819 543
Total Cost	**USD**	598 212 154	**57 955 960**	**57 981 960**	**58 902 887**	**58 902 887**	**59 823 815**	**59 823 815**	**60 744 743**	**60 744 743**	**61 665 671**	**61 665 671**
Unit Cost	**USD / St**	29,7	**29,52**	**28,69**	**29,15**	**29,15**	**29,61**	**29,61**	**30,06**	**30,06**	**30,52**	**30,52**
Cash Margin (Ex-Mine)	**USD / St**	**10,86**	10,90	11,86	11,41	11,41	10,95	10,95	10,50	10,50	10,04	10,04
Mine EBITDA - Cash Margin (ZAR)	**USD**	**218 731 007**	21 398 428	23 972 348	23 051 421	23 051 421	22 130 493	22 130 493	21 209 565	21 209 565	20 288 637	20 288 637

Makomo Resource 2015 LOMP Financial Model: Mining Option 2				Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
CASHFLOWS			**Average / Total**										
Mine EBITDA - Cash Margin (ZAR)	**USD**		**218 731 007**	**21 398 428**	**23 972 348**	**23 051 421**	**23 051 421**	**22 130 493**	**22 130 493**	**21 209 565**	**21 209 565**	**20 288 637**	**20 288 637**
Capital Expenditure			**95 800 000**	**85 000 000**	**1 200 000**	**1 200 000**	**1 200 000**	**1 200 000**	**1 200 000**	**1 200 000**	**1 200 000**	**1 200 000**	**1 200 000**
Sustaining Capital	**USD**		**10 800 000**	-	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000	1 200 000
Expansion Capital	**USD**		**85 000 000**	85 000 000	-	-	-	-	-	-	-	-	-
Tax													
Income Tax			**31 654 734**	-	-	-	739 957	5 389 602	5 389 602	5 152 463	5 152 463	4 915 324	4 915 324
Net Cash Flow After Tax	**USD**		**91 276 272**	**-63 601 572**	**22 772 348**	**21 851 421**	**21 111 464**	**15 540 891**	**15 540 891**	**14 857 102**	**14 857 102**	**14 173 313**	**14 173 313**
Net Cash Flow After Tax Cumulative	**USD**		**218 731 007**	-63 601 572	-40 829 223	-18 977 803	2 133 661	17 674 552	33 215 443	48 072 545	62 929 647	77 102 960	91 276 272
NPV CALCULATION													
NPV	**USD**	**20%**	**9 727 120**	**-63 601 572**	**22 772 348**	**21 851 421**	**21 111 464**	**15 540 891**	**15 540 891**	**14 857 102**	**14 857 102**	**14 173 313**	**14 173 313**
IRR			**26%**										
TAXATION													
EBIT				-63 601 572	22 772 348	21 851 421	21 851 421	20 930 493	20 930 493	20 009 565	20 009 565	19 088 637	19 088 637
Carried forward				-63 601 572	-40 829 223	-18 977 803	-	-	-	-	-	-	-
Taxable income				-	-	-	2 873 618	20 930 493	20 930 493	20 009 565	20 009 565	19 088 637	19 088 637
Tax paid			**25,75%**	-	-	-	739 957	5 389 602	5 389 602	5 152 463	5 152 463	4 915 324	4 915 324