

https://dspace.org/

The Witbank junior coal miners: a blue print for success in the South African coal industry

Oduah, Richard Chukwudumebi

2018

https://hdl.handle.net/10539/25737

Oduah, Richard Chukwudumebi, (2018) The Witsbank junior coal miners: a blue print for success in the South African coal industry, University of the Witwatersrand, Johannesburg, https://hdl.handle.net/10539/25737.

Downloaded from a DSpace repository. https://dspace.org/



THE WITBANK JUNIOR COAL MINERS: A BLUE PRINT FOR SUCCESS IN THE SOUTH AFRICAN COAL INDUSTRY

Oduah Richard Chukwudumebi

A dissertation submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, in fulfilment of the requirements for the degree of Master of Science in Engineering.

Johannesburg, 2018

DECLARATION

I declare that this research report is my own unaided work. It is being submitted to the University of the Witwatersrand and has not being submitted before for any degree or examination. I fully acknowledge the rules of the University with regards to plagiarism.

……This day of……. year……

Signature……..

ABSTRACT

In 1998, the HDSA Act was promulgated with a view to economically empower black owned business entities including junior coal mining companies. However, many Witbank junior coal miners continue to struggle to establish themselves and to compete sustainably with their larger and more established counterparts in the South African coal mining industry. It is therefore still unclear as to what level of success has been achieved in light of this Act.

Numerous challenges continue to face every junior coal mining operation, including knowledge and skills gaps, limited access to funding, barriers to entry, poor access to reliable coal geological data and knowledgeable service providers, difficult compliance to mining legislation and unpredictable coal market volatility. A further challenge is the threat of reduction in coal usage as a source of power generation, this as a result of strong global and national initiatives to use alternative energy sources in the form of renewables.

However, as long as coal remains a key commodity for industry, power generation and export, which is considered to be well into the next 2 to three decades if not longer, the Witbank junior coal miners have the potential to achieve considerably higher levels of success in their operations, marketing and earning capacity than is currently the case. Investigations undertaken in this study have found that, by taking certain steps, even the smallest mining entity would be enabled to compete more effectively in the coal industry. It is proposed that an in-depth knowledge of the coal industry coupled with industry-specific technological innovations and skills, business management models and the consolidation of the junior coal sector through cooperatives could see junior coal miner assets sustainably upgraded into more profitable business ventures.

In order to address the many issues facing initiation, start-up and early operation of an emerging or junior coal mine, a protocol was developed during the course of this study in which a number of key aspects are addressed. These have been laid out in a manner easily understood and achievable by even the smallest coal mining operator. These aspects include the technical and business side of small scale coal mining, including the benefits of single owner-operated versus cooperative operations. Matters such as safety health and environmental legislations which are essential to all mining operations are applied to the smaller scale operators.

DEDICATION

To Nonhlanhla and Ikenna Oratile Oduah

ACKNOWLEDGEMENT

- To God almighty, for his everlasting grace, love and blessings.
- Prof Gladys Oduah, University of Jos. She has been my pillar of strength, love and motivation.
- Prof Rosemary Falcon, University of the Witwatersrand. For her immense support, mentorship and guidance over my education and career in South Africa.
- Mr Mashat Malo, University of the Witwatersrand. For his support and being my best friend.
- Nonhlanhla Ngwenya, University of the Witwatersrand. For her enduring love and encouragement.

CONTENTS **PAGE**

TITLE PAGE 1

DECLARATION 2

ABSTRACT 3

DEDICATION 4

ACKNOWLEDGEMENT 5

TABLE OF CONTENTS 7

LIST OF FIGURES 10

LIST OF TABLES 11

LIST OF ABREVIATIONS 14

LIST OF SYMBOLS 15

TABLE OF CONTENTS

1. INTRODUCTION

1.1 RESEARCH BACKGROUND…….,,,,……...16
1.2 PROBLEM STATEMENT...……17
1.3 AIMS AND OBJECTIVES OF RESEARCH……..……....17
1.4 ASSUMPTIONS…….……....18
1.5 RESEARCH LIMITATIONS.....18
1.6 RESEARCH OUTLINE…….……..……...19

2. CHAPTER 2: LITERATURE REVIEW OF THE SOUTH AFRICAN COAL MINING INDUSTRY

2.1 INTRODUCTION…….20
2.2 GEOLOGICAL OVERVIEW.……...20
2.2.1 Origin and formation of the Southern African Coalfields…….....21
2.2.2 Lithostratigraphy of the Karoo Supergroup…….....21
2.3 RUN-OF- MINE AND BENEFICIATED COAL PRODUCTS……...…….…...23
2.3.1 Coal products and specifications for local merchants…….…….....24
2.4 COAL MARKETS…….…….....27
2.5 COAL TRANSPORTATION..…….....28
2.6 LEGAL FRAMEWORK……..……...29
2.6.1 Pre- 1994 Legislation……...……..29
2.6.2 Post-1994 Legislation…….....…….29
2.6.3 Regulatory policies on Carbon Emissions……...……. 31
2.7 HISTORICAL PRODUCTION AND SALES OF SOUTH AFRICAN COALS…. 34
2.8 SUMMARY..…….… 34

3. CHAPTER 3: METHODOLOGY

3.1 SELECTION OF JUNIOR COAL MINING ENTITIES……...……..36
3.2 RESEARCH DESIGN…….……39
3.3 DATA COLLECTION...…….....39
3.4 DATA ANALYSIS.…….....40

4. CHAPTER 4: THE JUNIOR COAL MINING SUBSECTOR VALUE CHAIN

4.1 INTRODUCTION.…….....41
4.2 THE JUNIOR COAL MINING VALUE CHAIN……...41
4.2.1 Geology of the Witbank Coal Field……...…….....41

4.3 COAL MINING METHODS……..43
4.3.1 Surface and Underground methods of mining……..43
4.3.2 Opencast Mining……....43
4.3.3 Strip Mining……...43
4.3.4 Longwall Mining……43
4.3.5 Shortwall Mining……...44
4.3.6 Bord and Pillar Mining……..44
4.4 Coal washing or processing……..44
4.5 DOMESTIC COAL MARKETS……46
4.5.1 Eskom……46
4.5.2 Eskom coal products and specifications……47
4.6 LOCAL MERCHANTS……..50
4.7 EXPORT COAL MARKET……51
4.8CLEAN COAL TECHNOLOGIES…….55
4.9 LEGISLATIVE FRAMEWORK……62
4.10 SUMMARY……...65

5. CHAPTER 5: RESULTS AND DISCUSSIONS

5.1 INTRODUCTION……67
5.2 JUNIOR COAL COMPANIES, PROJECTS AND OPERATIONS……....67
5.3 CHALLENGES IDENTIFIED BY WITBANK JUNIOR COAL MINERS…...84
5.4 OPPORTUNITIES IDENTIFIED BY WITBANK JUNIOR COAL MINERS..94
5.4.1 The potential for cooperative development between junior coal miners……..94
5.4.2 Benefits of operating cooperative joint ventures……..95
5.5 OTHER COAL OPPORTUNITIES FOR THE JUNIOR COAL MINERS…...100
5.6 SUMMARY……...105

6. CHAPTER 6: A PROPOSED PROTOCOL REQUIRED TO UPGRADE AN EMERGING OR OPERATING JUNIOR COAL MINING COMPANY

6.1 INTRODUCTION.……...109
6.2.1 Coal resources industry cycle……..……109
6.2.2 Reserves and Resources and reserves: Commodity Availability……..110
6.2.3 Coal project value chain……..…….....110
6.2.4 Financial statement……..…….....111
6.2.5 The coal mining project pathway..……..…….....111
6.2.6 The Business Investment Model…...……..…….....112
6.3 THE JUNIOR COAL COMPANY ASSETS…..…….113
6.3.1 Exploration……...…….....113
6.3.2 Pre-feasibility and feasibility studies……...…….....115
6.3.3 Coal production and project closure...…….…….....116

6.4 BUSINESS STRATEGIES…….…….....116
6.4.1 Review of the coal industry and business environment……..…….....116
6.4.2 Technological innovations……..…….....118
6.4.3 PEST analysis……...…….....119
6.4.4 SWOT analysis……...……..…….....121
6.4.5 Key success factors…….....122
6.5 RISK MANAGEMENT.…….....123
6.5.1 Applying the risk management principle to all stages of mine life…….....124
6.5.2 Applying risk management processes to the materials value chain…….....125
6.5.3 Risk identification……..…….....126
6.5.4 Risk analysis and evaluation…….…….…….....126
6.5.5 Risk control……...…….…….....126
6.6 SPECIFIC RISKS FACING THE JUNIOR MINERS IN THE WITBANK COALFIELD…….....128
6.7 FINANCIAL MANAGEMENT.……..…….....135
6.8 OPERATIONAL MANAGEMENT……..137
6.9 TEAM MANAGEMENT……...…….....138
6.10 SUMMARY……140

7. CHAPTER 7: CONCLUSION AND RECOMMENDATIONS FOR FUTURE RESEARCH……...142

REFERENCES…….……...147

APPENDICES...…….....152

LIST OF FIGURES

2.1 South African mining and environmental legislation……...30

4.1 A map of South African coalfields showing the position of the Witbank coalfield…….42

4.2 An ESKOM power station layout…….……..……..49

4.3 Export and domestic coal markets by sector……....55

5.1 Coal price volatility over a 10-year period……...…85

5.2 A map of the Witbank area showing ESKOM's coal haul road network……..…….91

5.3 Coal scheduling between coal mines, power stations, sidings, and coal wash plants.....91

5.4 Coal exportation challenges for junior coal companies…….....93

6.1 South Africa's main coal users by industry……118

6.2 Summary of coal exports by region (2015) ……...…118

LIST OF TABLES

2.1 Lithostratigraphy of the Karoo Supergroup in the main Karoo basin……...22

2.2 Specification requirements for pulverized coal boilers…….…….....25

2.3 Coal quality for pulverized coal…….…….……..26

2.4 Coal specification requirements for industrial stokers……...…….....26

2.5 Requirements for the issuing of prospecting or mining rights and permits…….....33

2.6 Sectors exposed to carbon tax in South Africa based on electricity consumption and heavy reliance on coal for electricity generation…….…….33

3.1 Comparisons between large scale, small scale and junior mining…….....…..…...37

3.2 Proposed parameters used to define junior mining entities…….38

4.1 ESKOM commissioned power stations…….……..……....47

4.2 ESKOM coal specification and rejection limits…….……..48

4.3 Breakdown of coal tonnages consumed in South Africa's domestic coal market……...51

4.4 South Africa coal exports by country (2014) …….……...…….52

4.5 Export specification for South Africa thermal coal…….…….....54

4.6 Characteristics of different gasifier types……....58

4.7 Legislative requirements for coal activities……..64

5.1 Summary of Shanduka coal projects and operations…….....68

5.2 Summary of Kangra coal projects and operations…….....69

5.3 Summary of Keaton Energy coal projects and operations…….....70

5.4 Summary of Wescoal Holdings coal projects and operations…….....72

5.5 Summary of Coal of Africa coal projects and operations…….…….....73

5.6 Summary of Eyethu/Iyanga coal projects and operations……..…….....74

5.7 Summary of Continental coal projects and operation…….....……75

5.8 Summary of Umcebo Mining coal projects and operations……77

5.9 Summary of HoskenConsolidated Investments Limited coal projects and operations…78

5.10 Summary of Muhanga Mines coal projects and operations……..……...…..79

5.11 Summary of the 10 analyzed junior coal companies……..…....82

6.1 Risks facing junior coal miners in the Witbank coalfield……133

6.2 Top 10 business risks...……....134

LIST OF ABREVIATIONS

AEL-Atmospheric Emissions Licenses
BEE-Black Economic Empowerment
CAPEX-Capital Expenditure
CBM-Coal Bed Methane
CCS-Carbon Capture and Storage
CCT-Clean Coal Technology
CITT-Coal Industry Task Team
CMM-Coal Mine Methane
CPVC-Coal Project Value Chain
CSMI-Centre for Sustainability in Mining and Industry
CV-Calorific Value
DME-Department of Minerals and Energy
DMR-Department of Mineral Resources
EBITDA-Earnings before Interest Tax Depreciation Amortization
EIA-Environmental Impact Assessment
EMP-Environmental Management Plan
ESP-Electrostatic Precipitators
FBC-Fluidized Bed Combustion
FGD-Flue Gas Desulphurization
GHG-Green House Gases
ICGC-Integrated Combine Gas Cycle
IPP-Independent Power Producers
IRR-Internal Rates of Return
JMC-Junior Mining Company
JV-Joint Venture
KPI-Key Performance Indicators
MHA-Mine Health and Safety
MPRDA-Mineral and Petroleum Development Act
MQA-Mining Qualifications Authority
NEMA-National Environmental Management Act
NEMAQA-National Environmental Management Air Quality Act
NEMBA-National Environmental Management Biodiversity Act

NEMWA-National Environmental Management Water Act

NPV-Net Present Value

OHS-Occupational Health and Safety

OHSAS-Occupational Health and Safety Management Systems

OPEX-Operational Expenditure

PEST-Political Economic Social and Technological

ROM-Run-of-Mine

RBCT-Richard's Bay Coal Terminal

RBTG-Richard Bay Terminal Grindrod

SAMI-South African Mineral Industry

SAMREC-South African Code for Reporting of Exploration Results, Mineral Resources and Mineral Reserves

SAMVAL-South African Code for the Reporting of Mineral Asset Valuations

SWOT-Strengths Weaknesses Opportunities and Threats

TFR-Transnet Freight Rail

UCG-Underground Coal Gasification

LIST OF SYMBOLS

AC-Alternating Current

AI-Abrasive Index

CO_2-Carbon Dioxide

CV-Calorific Value

DC-Direct Current

H_2O-Water

KCAL/KG-Kilo Calorie per Kilogram

M_e-Metal Oxide

MW-Mega Watt

MJ/Kg-Mega Joules per Kilogram

MM-Millimeters

MT-Million Tons

MTPA-Million Tons per Annum

N-Nitrogen

SO_{2-} Sulphur dioxide

TCO_{2e}-Total Carbon Dioxide Emissions

TPH-Tons Per Hour

USD($)-US Dollar

ZAR(R)-South African Rand

^{0}C-Degree Celsius or Centigrade

%-Percentage

> Greater than

< Less than

CHAPTER ONE: INTRODUCTION

1.1 RESEARCH BACKGROUND

The junior coal mining subsector in South Africa only started to thrive after the newly elected democratic government in 1994. Even though small scale mining had been in existence prior to that time it was mainly carried out by historically disadvantaged South Africans (HDSA). The junior coal subsector had also been lagging behind and could not compete with counterparts in other developed countries of the world as well as with the big mining houses such as Anglo America, BHP Billiton, Glencore and Exxaro Resources (Seeger, 2007). The newly elected government in 1994 then implemented Black Economic Empowerment (BEE) programme aimed at empowering HDSA's to participate in economic activities of the country by way of owning and controlling business investments. With respect to the coal mining industry the empowerment was aimed at transferring some degree of ownership or equity of existing coal assets to the HDSA's, including employment equity, skills and expertise for that industry.

The first few years saw the process of empowerment developing slowly as the government enacted the BEE Act which has been amended to better suit and speed up the objectives of the BEE scheme. The HDSA's could apply for mining and prospecting rights with a minimum of 26% black ownership of assets in the bigger mining companies, (South Africa Mining Charter, 2002). Many opportunities continue to exist for the junior coal mining companies with South Africa being one of the largest exporters of coal in the world and coal being the largest energy mineral consumed in South Africa. The junior coal companies could adequately supply these huge export and domestic markets. However, a number of challenges face the junior coal mining companies. These include: complying with the existing legislative framework on mining and the environment, skills or knowledge gaps, access to finance, and constraints in transport logistics and infrastructure. Most recently is the dynamic nature of the global market place where the prices and demand for coal products, like most mineral commodities, are continually irregular and generally significantly reduced in demand and value. These factors are further compounded by a large number of economic, technical and human risks. These include insufficient capital, equipment failure, inadequate mining and beneficiation methods, change in tax regime (carbon tax), health, safety and environmental issues, corruption and political instability.

A number of studies have been undertaken on artisanal and small-scale mining of strategic minerals in South Africa, the core being sustainable development concerning profitable investments, best mining practises, environmental, health and safety issues (Coaltech, 2002). However, little has been published on the junior coal miners in the Witbank area. It is in this sector that the current research intends to study, namely, to add to the current knowledge base by laying emphasis on coal as a strategic mineral, highlighting its value and its potential in terms of upgrading (exploration, mining, beneficiation and marketing) and proposing considerations for the development of those small scale mines into larger mines and successful business entities. It also aims at studying the consolidation of junior coal companies, a topic that has become of renewed interest in recent times.

1.2 PROBLEM STATEMENT

Junior coal businesses in South Africa are faced by a large number of industry specific challenges along the coal value chain, that is, exploration, mining, beneficiation, legislation, finance, marketing and the coal business. There is a general lack of success in all these areas hence, this research aims to address this by studying specific Witbank coal operations within the junior coal mining sub-sector.

1.3 AIMS AND OBJECTIVES OF THE RESEARCH

The primary aim of this study is to assess the status quo in the junior coal-mining sub-sector and to explore the opportunities (technical and financial) to enhance the development of that sector: To achieve this, the following objectives will be undertaken:

- **To set the scene in geological terms for the development of coal exploitation** in the Witbank Coalfield
- **To examine the market opportunities** which exist for junior coal miners in the Witbank area.
- **To examine the challenges facing the junior coal mining subsector,** including aspects such as the following:
    - **current mining legislations** as they impact upon the activities of the junior coal miners.
    - The **impact of climate change** and the need for **clean coal technology** as an advancing technology for energy from coal.

- The **skills required** in the junior coal mining industry and, if required, proffer solutions to bridge the gap.
- The junior coal miners' **access to finance** for greenfield and/or brownfield coal projects.
- The **risks and challenges** with regards to exploration, mining, beneficiation, transportation, marketing and ultimately the sale of their coal products that junior coal miners face in the Witbank Coalfield.

- **To create a protocol including strategies and tactics that individual emerging or junior coal miners can adopt** to upgrade their mines from small or medium to large scale mines.
- **To consider the impacts of broader corporate collaboration or mergers** amongst number of junior coal companies, and how that may impact upon the growth of the junior coal mining sector.

1.4 ASSUMPTIONS

For the purpose of this research, the following assumptions are made:

- South Africa relies on coal as its primary source of energy supply with the junior coal miners required to play a vital role in the redistribution of this energy resource.
- The majority of South Africa's easy to mine and most accessible coal reserves and coal mining activities still lie in the Witbank coalfields.
- The operations of junior coal miners are small to medium scale.
- The junior coal miners are faced with a high number of business risks and challenges which are not adequately managed in comparison to their well-established large scale coal mining counterparts.

1.5 RESEARCH LIMITATIONS

- It was observed that there are a large number of junior coal miners in the Witbank coalfield with complex and interrelated coal operations. As such, only a limited number of coal companies were used in this study.

- The business management concepts used in this study where generalised due to the unique nature of each junior coal company.
- The ever evolving nature of the coal industry might have resulted in changes to a number of technical, socio-economic, financial and political considerations initially recorded in this study.

1.6 RESEARCH OUTLINE

Chapter 1 is a general overview of the study comprising of the research background, problem statement, aims and objectives, assumptions and limitations.

The literature review in chapter 2 covers the origin, formation, distribution and exploitation of the South African coalfields with an overview of the markets for coal and current legislation pertaining in the country at present.

Chapter 3 proposes definitions for junior coal mining entities and outlines the research design stating the type and sources of data that were used in the study.

In chapter 4, the junior coal-mining sub-sector was described with emphasis on the junior coal mining value chain; Geology, mining methods, processing, coal markets, technologies and legislative provisions.

Chapter 5 provides the results and discussions of junior coal mining companies in the Witbank coalfield with key opportunities in the form of cooperative development available to them and the challenges they face in carrying out their coal activities.

Chapter 6 discusses the means of upgrading a junior or developing an emerging coal company operation into more successful and larger scale operations, and conclusions drawn from these findings and recommendations for future work are reported in chapter 7.

CHAPTER TWO: LITERATURE REVIEW OF THE SOUTH AFRICAN COAL MINING INDUSTRY

2.1 INTRODUCTION

In South Africa coal still remains the most significant source of energy. About 290 - 300 million tonnes are mined annually from an estimated reserve of 33.8 billion tonnes (Prevost, 2012). South Africa is currently the seventh largest coal producing country and the seventh largest exporter of coal in the world, where coal accounts for about 95 % of the country's domestic electricity and 25% is exported. (Chamber of Mines, 2012), Prevost personal communication, 2016).

Most of the coal (about 80%) is mined in the Highveld, Witbank, and Ermelo coal fields in Mpumalanga though recent studies have suggested great potentials in terms of reserves in the Waterberg coal fields. Fifty one percent is extracted by underground mining methods and the remaining by open cast methods (Snyman, 1998). As such there are hundreds of coal mines and collieries actively mining coal with a substantial number of junior coal mining companies in the industry.

2.2 GEOLOGICAL OVERVIEW

2.2.1 Origin and Formation of the Southern African Coalfields

The Southern African coals were formed in the ancient Gondwana subcontinent rich in minerals and highly variable in rank or maturity and organic matter (Falcon, 2012). These can be attributed to the geologic conditions prevalent at the time the peat swamps were being formed. The coal forming materials were deposited in cold temperate conditions under stable conditions in glacial valleys and on margins of continental lakes and the Karoo sea. The degradation of the coal- forming plant matter was as a result of varied topography and sedimentary environments. Those plants that were washed into the lakes, deltas and shallow seas were accompanied by mineral matter.

The Gondwana subcontinent was populated by vegetation of cold-cool deciduous forests and in time, warm savannah woodlands. These formed mineral-rich peat forming swamps which were never deeply buried resulting in shallow thick mineral-rich coal seams. When

Gondwana broke up, these seams were intruded by volcanic intrusions such as sills and dykes resulting in varying degrees of maturity and devolatilisation in the coal seams.

2.2.2 Lithostratigraphy of the Karoo Supergroup

The South African coal deposits are found in the Karoo Supergroup of the Late Carboniferous to Middle Jurassic era (320-180 Ma), formed in the Gondwana basins of South Africa (Synman, 1998). Within these basins coal seams occur in the Vryheid Formation of the Ecca Group, the Normandien Formation of the Beaufort Group and also in the Molteno Formation.

The Dykwa Group which was deposited in Late Carboniferous to Early Permain era occupies the base of the Karoo Supergroup and is made up of various glacial sediments, sandstones and mudrocks (Falcon, 2012).

The Ecca Group in the north eastern portion of the main Karoo Basin consists of facies of fluviodeltaic sandstones making up the Vryheid formation as well as siltstone and mudstone facies that make up the Pietermaritzburg and Volkrust Formations. The southerly flowing rivers and northward retreating glaciers scoured part of the pre-Karoo basement and were partially filled with fluvioglacial sediments which gradually turned into lakes and transformed into swamps. These resulted in the lower coal seams of the Witbank, Highveld, Free State and the Soutspansberg coal fields (Snyman, 1998). In general, the topography of the pre-Karoo floor played an important role in the distribution of the coal seams, and in their mineral and maceral (organic matter) composition. The table below summarizes the lithostratigraphy of the Karoo Supergroup.

Table 2.1 **Lithostratigraphy of the Karoo supergroup in the main Karoo basin.** (After Johnson et al. 1996)

Formation (F) or Group (G)	Southwestern Facies	NortheasternFacies	Age
Drakensberg G	Flood Basalt		Middle to Early Jurassic ~ 180Ma
Clarens F	Aeolian sandstone		Early Jurassic
Elliot F	Red mudstone and sandstone		Late Triassic
Molteno F	Sandstone, mudstone, minor coal	Sandstone, mudstone	Late Triassic ~210 Ma
Beaufort G	Greenish, bluish and reddish mudstone, grey sandstone	Mud stone and shale: Dreikoppen Formation. Conglomerate, coarse to medium grained sandstone: Verkykerskop Formation.Sandstone, mudstone, coal: Normandien Formation	Early Triassic
Ecca G	Grey to black shale and mudstone, grey sandstone	Shale and mudstone: Volksrust Formation. Feldspathic sandstone, shale, mudstone, coal: Vryheid Formation. Shale, mudstone: Pietermaritzburg Formation.	Late to Early Permian ~260Ma
Dwyka G	Tillite, minor sandstone and shale	Tillite, fluvioglacial conglomerate, varved shale and drop stones	Early Permian to Late Carboniferous ~320 Ma

2.3 RUN-OF-MINE AND BENEFICIATED COAL PRODUCTS

In the Witbank area coal that is mined may be analysed, screened and beneficiated to remove unwanted contaminants and inherent impurities. These are done to meet the requirements of the various markets being served. According to Snyman (1998), the following are the specification parameters and elements used in coal analysis:

1. **Proximate Analyses**: This is the analysis of ash content, volatile matter, inherent moisture and fixed carbon reported as percentages. These may be reported on the following bases, each subject to inclusion of varying levels of moisture content.

- Air dried basis: When the analysis has been performed on an air dried basis.
- As received basis: When the analytical data includes moisture content.
- Dry basis: When the analytical data as received has zero moisture.

2. **Ultimate Analyses**: This is the analysis of coal expressed as a percentage of carbon, hydrogen, nitrogen, oxygen and sulphur. The analysis gives account of the carbonaceous material only, and may be reported on air dry, dry ash free or mineral matter free bases.

3. **Forms of sulphur**: The element sulphur occurs in organic and inorganic forms, which when combined, is also reported as Total Sulphur content. The organic sulphur is part of the carbonaceous material of the coal while the inorganic sulphur is part of the mineral component- pyrite or related mineral forms occurring as sulphates or sulphides formed during deposition or emplacement of the coal.

4. **Calorific value**: This is the energy coefficient or the heat value of the coal measured in Kcal/kg for export markets or MJ/kg for domestic markets.

5. **Abrasiveness index** *(Eskom method)*: This indicates the abrasiveness of coal. The Abrasiveness Index gives an indication of the hardness of the coal and the influence the coal will have on the wear-and-tear of the plant.

6. **Hardgrove Grindability index**: The characterisation of the relative grindability of coal. The Hardgrove Grindability index is used empirically to estimate the capacity and power consumption required to break up or grind the coal to specified product fineness.

7. **Dilatation** (Ruhr dilatometer)*:* This is the determination of the volume change of coal produced by heating. The temperature range in which the coal starts contracting, expanding and the percentage contraction/expansion (maximum dilatation) are important factors in blending of coals from different sources for coke production.

8. **Free swelling index**: This is the simplest indicator of the potential of a coal for coking purposes.

9. **Roga index***:* This is the simplest indicator for the potential of a coal for caking purposes in terms of the mechanical strength of the coke obtained by carbonisation.

10. **Ash fusion temperature***:* This is a measure of the four critical temperatures at which the minerals (transforming into ash) in coal change in structure, passing in stages from softening to fluid flow (initial deformation, softening, hemispherical and fluid temperature) when heated at a specified rate in either reducing or oxidizing atmosphere.

    Examples of coal analyses from various collieries in the Witbank coalfield showing properties that are used in domestic and export markets can be found in appendix A. It is of interest to note the variations in quality when different sized or washed products are produced from the same mine.

    Other analyses on Ash, phosphorus and reducing fusion temperatures of selected Witbank coal products can be found in appendix A.

2.3.1 Coal products and specifications for local merchants

On the domestic or inland market, coal is sold mainly for large scale power generation purposes, for manufacturing synfuels and chemicals, and for a range of smaller scale industrial purposes including such users as in cement industries. Pulverised coal firing as is used in the large Eskom boilers and some smaller boilers is simply the combustion of powdered coal in a combustion furnace by passing heated air through it. The coal is finely divided such that depending on its rank, between 60% and 90% can pass through a 75 microns' mesh size screen from the mill to the burners in the furnace (Steyn, 2009). This size classification also determines the burn out rate of the coal in the furnace. The primary air that is passed through is heated to between 250 and 350-degree Celsius depending on the moisture content of the coal and is reduced as it carries the coal from the mill to the burners, not

exceeding 85 degrees Celsius. A secondary air is injected to speed up ignition of the coal near the tip of the burner. Similar to the power station set up, coarse dry ash or molten slag is removed at the base of the furnace while finer fly ash passing out of the top of the furnace is captured by means of an electrostatic precipitator. The burners used in pulverised coal firing are of three types: Conical burners, tangential or corner burners and down –firing burners. The aim of these burners is to make sure that the coal and combustion air mixes rapidly and efficiently to utilize the entire volume of the furnace during combustion. Travelling grate stokers are examples of other smaller scale industrial boilers which involves feeding sized coal onto a moving grate with mechanisms for discharging ash. These are classified into underfeed, overfeed and spreader stokers. Ignition takes place on the grate or in the over fire area, and water-filled tubular walls and super heaters capture the heat thereby providing the steam for power generation. Examples of coal specifications for pulverised and sized coal for the boilers described above are listed below.

Table 2.2 Specification requirements for pulverised coal boilers

Parameter	**Units**	**A Grade**	**B Grade**	**C Grade**	**D Grade**
Calorific Value	MJ/Kg ad	>27.5	>26.5	>25.5	>24.5
Total Moisture	Maximum % (ar)	12.0	12.0	8.0	8.0
Ash	Maximum % (ar)	15.0	16.0	18.0	21.0
Volatile Matter	Maximum % (ar)	24.0	23.0	23.0	23.0
Sulphur	Maximum % (ar)	1.0	1.0	1.0	1.5

Source: Steyn (2009).

Table 2.3 Coal quality for pulverised coal

Parameter	**Limits**	**Comments**
Total moisture	Max. 15% (ar)	Reduces net calorific value. If moisture content is too high, it could create coal handling problems. Total moisture limits are usually higher for low rank coals such as lignite.
Ash	Max. 20% (ad)	Reduces calorific value
Calorific value	As high as possible	With tech-advanced equipment coal or fuels with any calorific value can be used or utilised.

Chlorine	Max. 0.2 to 0.3% (ad)	Causes ash fouling problem in boilers
Hardgrove grindability index	Min. 45 to 50mm	Lower HGI values require larger grinding capacity and more energy.
Maximum size	Max. 40 to 50mm	Dependent on capacity of grinding equipment.
Fines content	Max. 25 to 30%	High fines content can increase moisture content and create handling problems.
Ash fusion temperature	Various	Dry bottom boilers– IDT greater than 1200ºC. Wet bottom boiler– flow temperature less than 13000C

Source: Steyn (2009)

Table 2.4. Coal specification requirements for industrial stokers.

Parameter	**Limits**	**Comments**
Total moisture	8 to 15% (ar)	If too low, fines can be blown away from the bed without burning
Ash	7 to 30% (ad) 3 to 35% (ad)	For overfeed stoker. Spreader stoker requires minimum ash content to protect grate from reflected heat.
Volatile matter	25 to 49% (daf)	
Maximum size	30mm	
Ash fusion temperature	IDT min. 1200^0C	As melts and clinkers if too low
Crucible swelling number	Max. 3	High swelling coals give uneven combustion.

Source: Steyn (2009)

2.4 COAL MARKETS

More coal is produced in the Witbank, Highveld and Ermelo Coalfields. Coal production and sales in domestic and export markets are dependent on a number of economic parameters such as demand and supply, quality, pricing and transportation costs (Prevost, 2009). However, domestic consumption and export patterns for South African coals have changed considerably over the past 5 years. Prior to the year 2007 80% of the thermal coal exports went to the Atlantic Basin (Europe, USA and South America). Currently, however, more than

half of the export products are sold into the Pacific Basin (Asia), that is, about 54% in 2015 with India topping the list. This surge in importation from the East has also resulted in global coal prices being solely determined by the Asian market which has had a direct impact on global exporters such as South Africa. For example, China only imports coal when the global coal price is lower than the domestic coal price and vice versa (Sylvie, 2013). This shift in coal exportation by South Africa from the West (Atlantic Basin) to the east (Pacific Basin) has also caused a change in terms of coal grade as export quality products prior to 2007 were defined according to fixed ranges of specifications in order to meet the various export markets they served. Such grades controlled the prices of each product. Currently however, export grades are now varying to meet the less stringent and lower qualities required by customers in the East. In addition, export coal is currently being hampered by the introduction of impending carbon taxes and emissions regulations by thermal coal importing countries (Falcon, 2015). This situation is once again fast changing global export patterns, which in turn is resulting in gluts of unsold coal in many coal producing countries and lower prices for coal products. This is causing many mining companies and investors worldwide to struggle financially. In South Africa, these patterns will further change if certain bottlenecks in transportation at the Richard's Bay Coal Terminal (RBCT) are not addressed. With an expansion of the rail network capacity, there could be a further increase in exportation to about 91 million tonnes per annum in due course.

Domestic coal consumption in South Africa accounts for more than 75% of the total quantity of coal produced annually with the remaining quantity exported. The major domestic markets for South African coals are Eskom and Sasol while the remaining users are metallurgical plants, cement, brick and tile, paper and pulp and the sugar industries, and a host of other manufacturing and services industries. The junior coal mining companies produced approximately 22 million tonnes of coal in 2012 primarily supplying Eskom power generating plants (Chamber of Mines, 2012).

Eskom South Africa's sole electricity utility company, the largest in Africa and amongst the top seven utilities in the world, generates approximately 95% of the country's electricity with a combined total of 24 power stations 13 of which are coal fired and the remaining either nuclear or hydroelectric power stations. ESKOM has a net generating capacity of 41, 647MW, with annual sales of 224, 785Gwh and annual revenue of R113billion (ESKOM Annual Report, 2012). ESKOM consumes approximately 110 million tonnes of coal

annually. The majority of the collieries (about 55%) that supply ESKOM with thermal coal are located in the Witbank area. This represents a major long term opportunity for the junior coal miners located in the Witbank Coalfields. Supplying other smaller scale industrial users of coal is more problematic for junior miners as the quantities are smaller, qualities are more stringent and contracts generally small term.

2.5 COAL TRANSPORTATION

Export coals are dispatched via the Richard's Bay Coal Terminal (RBCT) which is the largest export facility in Southern Africa with a current capacity to export 91 million tonnes of coal annually. This is being serviced by Transnet rail. Access to the terminal is limited to specific shareholders with annual allocations of coal quantity and grade to be exported, with 4 million tonnes per annum special, allocation given to non- shareholders, particularly 18 Junior mining companies known as the Quattro tonnes (Steyn, 2009). This latter translates to 20% of the allocations at the RBCT.

The Maputo Coal Terminal which is the closest facility to the Witbank Coal field handle an annual export tonnage of about 1.5 million tonnes, while the Durban Coal Terminal handles similar export tonnage for companies who do not have allocations at the Richard's Bay Coal Terminal.

Coals supplied to the inland market are transported by road and rail to specific domestic users, with the infrastructure in the Witbank Coalfield well developed. Plans are in place to expand the rail networks to Eskom power stations, given the enormous quantities of coal required for each station most of which are currently supplied by hundreds of trucks per day.

2.6 LEGAL FRAMEWORK

2.6.1 Pre-1994 legislation

Prior to 1994, there were few laws protecting the environment from mining and beneficiation activities. Some of these include:

- Mines and works Act 27 of 1956 which was later amended, firstly in 1977 on issues relating to the conservation of the environment and secondly in 1980, an obligation to submit a rehabilitation programme to the inspector of mines.

- Minerals Act 50 of 1991- Regulations on the requirement to submit an Environmental Management Plan (EMP) and for the earlier regulations on mines and works to remain in force.

- The Atmospheric Pollution Prevent Act of 1965

- The National Monuments Act of 1969

- The National Parks Act of 1976

- Environmental Conservation Act of 1989

2.6.2 Post 1994 Legislation

After 1994, stricter laws were passed to govern mining activities as they impact upon the environment; water, air quality, protected areas or heritage sites. Therefore, companies applying for prospecting/mining rights or permits needed to do so in accordance with these legislations.

According to the Centre for Sustainability in Mining and Industry (2011), section 24 of the MPRD Act of 1998 (also amended in 2002) was meant to develop the nation's resources in a sustainable manner which is least harmful to the environment whilst ensuring and promoting economic development. Also, the National Environmental Management Act of 1998 was meant to avoid or mitigate waste or loss of vital elements of the environment (such as ecosystems and areas of critical biodiversity) through activities such as mining and construction. These acts govern the following entitlements with respect to prospecting and mining rights:

- Entry onto the land with plant, machinery or equipment.

- Constructing any surface or underground infrastructure which may be required for prospecting or mining.

- Prospecting and mining for own account on or under the land and removing and disposing of any mineral found.

- Subject to the National Water Act, using water from any natural spring, lake, river or stream situated on or flowing through the land.

- Apart from prospecting and mining, carrying out any other activity which does not contravene the provisions of the MPRDA.

Other legislations of note include; the Mines Health and Safety Act of 1996, the Skills Development Act of 1998, and the Basic Conditions for Employment act of 1997. Applicants are generally required to know these legislations before applying for prospecting and/or mining rights.

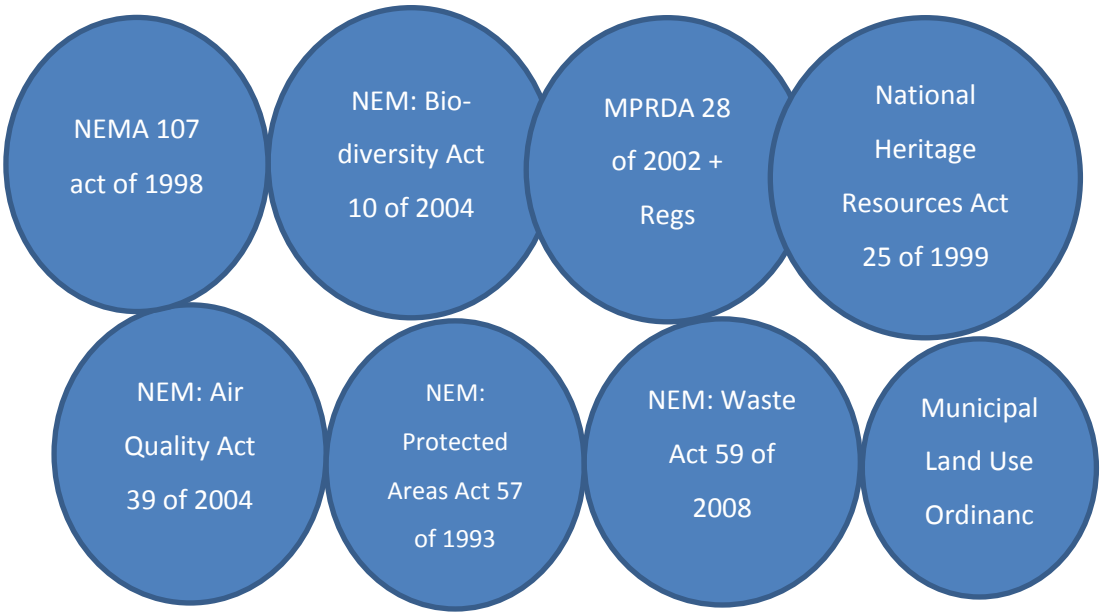


Fig 2.1 South African mining and environmental legislation. **Source:** (Centre for Sustainability in Mining and Industry, 2011)

The Environmental Management Plan (EMP) is also a key aspect of the of the MPRDA in the granting of prospecting and mining rights. An Environmental Impact Assessment (EIA) is also required by NEMA and the assessment is carried out on a number of listed activities some of which are listed below:

- The construction of facilities or infrastructure for electricity generation. where: (i) the electricity output is more than 10MW but less than 20MW; or (ii) the output is 10MW or less but the total extent of the facility covers an area in excess of 1 hectare.

- The construction of facilities or infrastructure for the storage of ore or coal that requires an atmospheric emissions licence in terms of the Air Quality Act of 2004.

- The construction of facilities or infrastructure for the storage and handling of dangerous goods where such containers have a combined capacity of not more than 500 cubic meters.

- The construction of facilities or infrastructure for refining and extraction with an installed capacity not exceeding 50 cubic meters.

The Minister or MEC of the Department of Mineral Resources has the discretion to consult with the organs of state responsible for issuing the respective legislations on any of these activities to coordinate them and in light of any written agreement, can take account of the information submitted or processes carried out that the legislative requirements are sufficient enough for authorization or exemption. The companies carrying out such activities are held liable and failure to comply with these legislations (unless exempted or the activity carried out in response to an emergency) is a criminal offense which may attract a penalty; fine of R5million maximum or a maximum imprisonment of 10 years.

2.6.3 Regulatory Policies on Carbon Emissions

South Africa is ranked among the top 20 countries measured by absolute carbon emissions (DNT, 2010). The majority of carbon emissions in South Africa is contributed by the electricity sector which depends on coal (about 95%) for power or electricity generation and this will further increase if production and demand for low- cost -fossil fuel-sourced power increases, and also in response to increasing economic growth and development. The South African government in a bid to reduce these Green House Gases (GHG) emissions has proposed two main regulatory or economic schemes which will be formalised in due course, namely; Carbon Tax and Emission Trading Schemes (DNT, 2010). These schemes are meant to discourage the use of coal that release huge amounts of greenhouse gases into the atmosphere by putting a “price” on such emissions in the form of taxes or by allowances to trade in fossil fuels not exceeding certain specific emission targets.

The more important of these two regulatory systems is the one introducing carbon taxes, an upstream taxation method which is determined by the fossil fuel consumed by an installation (power stations, mining and mineral processing plants) in a year (DNT, 2010). The taxes are based on the emissions equivalent to the fossil fuels consumed at a rate of 120 ZAR/tCO_{2e} (where ZAR = South African Rand, t = tax, CO_2 = Carbon dioxide, and e =emission). It is estimated that companies exposed to the carbon tax will be required to pay about 17 billion ZAR. However, up to the year 2020 there will be a 60 per cent-free threshold on those taxes and 10 per cent corrected for emission exposure allowances.

As a global response, South Africa pledges to reduce GHG emissions by 34% by the year 2020 and a further 42% in 2025 with adequate financial, technological and any other support deemed necessary. These GHG destroy the ozone layer of the atmosphere resulting in increased global warming which at the current rate is somewhere in the region of 2^0 Celsius per year and with increasing emissions could increase to 5^0 Celsius by the year 2035. Such climate changes are anticipated to have huge impacts on the well-being of humans in terms of the weather, environment, water, and agriculture in the years to come.

However, there are current debates as to what impacts these carbon taxes and emission trading schemes will have on the prices of goods and services, and the entire value chain throughout all industries. Whilst the intention is to change the behaviour of these industries in line with recent global initiatives whose major aim is to minimize activities involved in carbon emissions, the impact such taxes will have on the use of coal, and in turn, the junior coal miners is cause for concern, and will be until methods can be developed to reduce or eliminate the emissions under review.

Table 2.5 Requirements for the issuing of prospecting or mining rights and permits.

Mining Right: Requirements	**Mining Permit: Requirements**
Prospecting complete	Life of project must be less than 2 years
Financial ability	Area must be smaller than 1.5 hectares
Technical ability	Environmental plan
Economic program	
Work program	
Environmental Management Plan	
Social plan	
Labour plan	
CONDITIONS	**CONDITIONS**
Payment of royalties	Payment of loyalties
Comply with charter	Must not be leased or sold but is mortgage- able

Source: (Hoadley, Limpitlaw; 2004)

Table 2.6. Sectors exposed to carbon tax in South Africa based on electricity consumption and heavy reliance on coal for electricity generation.

Sector	**tco_{2e} per $sector_2$**	**Taxable emissions (tCO_{2e})**	**Total exposure ZAR**
Electricity	199, 040, 000	79, 616, 000	9, 553, 920, 000
Petroleum (Coal to Liquid, Gas to liquid)	60, 047, 000	18, 014, 100	2, 161, 692, 000
Petroleum-Oil refinery	13, 288, 900	3, 986, 670	478, 400, 400
Iron and Steel	92, 620 ,000	18, 524, 000	2, 222, 880, 000
Aluminium	2, 000, 000	400, 000	48, 000 ,000
Cement	9, 300, 000	1,860, 000	223, 200, 000
Glass and ceramics	30, 000	6, 000	720, 000
Chemicals	5, 030, 000	1, 006, 000	120, 720, 000
Pulp and paper	7, 490, 000	2, 247, 000	269, 640, 000
Sugar	1, 393, 200	417, 960	50, 155, 200
Agriculture, forestry, and land use	38, 000, 000	-	-

Waste	21, 000, 000	-	-
Fugitive emissions: Coal mining	1, 800, 000	360, 000	43, 200, 000
Other	Unknown	-	-
Total	451,039, 100	126, 437, 730	15, 172, 527, 600

Source: (Department National Treasury 2010).

2.7 HISTORICAL PRODUCTION AND SALES OF SOUTH AFRICAN COALS

Coal production and sales were initially recorded in South Africa 140 years ago (Steyn, 2009). In those early days, coal supplied low cost energy to other sectors of the local mining industry such as the gold, platinum, diamond, cement, and metallurgical industries. In 1890, coal production in the KwaZulu Natal and Gauteng provinces rose from 500 kilo tonnes to about 2 million tonnes in 1900, and by 1945 production had risen to about 20 million tonnes doubling a few decades later to about 40 million tonnes. A hundred million tonnes were reached in 1982 and with a continuous annual growth rate of around 7% production stand at approximately 280 million tonnes per annum (Prevost, *per.comm*, DMR, 2010). As far as sales are concerned 188.1 million tonnes of coal were sold domestically and about 66.3 million tonnes was exported in 2010 at a total value of R73.2 billion (SAMI report, 2010). The major export market is currently India and other countries in the far and Middle East, the remaining coal is consumed domestically for electricity generation, metallurgical coal, petrochemicals and domestic heating.

2.8 SUMMARY

Coal is the most significant source of energy in South Africa with substantial reserves in the Highveld, Witbank and Ermelo Coalfields. These coal deposits are found in the Karoo Super Group and are of a type and grade typical of the Gondwana subcontinent which formed under varying geological conditions and sedimentary environments. The Witbank coalfield represents the northern sector of the Karoo Basin and is divided into the Western, Central and Eastern portions. It is comprised of the Dwyka Group, the Vryheid Formation of the Ecca Group, the Normandien Formation of the Beaufort Group and the Molteno Formation.

Five coal seams are present in the Vryheid Formation, of which the Nos 2 and 4 seams are the thickest and most economic. Significant portions of the coal seams have been

devolatilised by the Ogies dykes as well as by a number of other dolerite dykes and sills in the region, all of which influence coal quality, mine plans, mining methods, roof support and equipment selection requirements. This coalfield is the most exploited coalfield in South Africa but there are areas yet to be developed, generally in smaller and more discreet sectors.

The export markets for South African coals mainly lie in the Pacific basin (Asian countries) and these are influenced by economic parameters such as demand, supply, transportation, pricing and coal quality. Coals are exported mainly via the RBCT and Maputo coal terminal. Domestic coal consumption account for about 79% of the coal produced in South Africa with Eskom and Sasol being the major domestic markets. Eskom generates 95% of the total electricity consumed in South Africa from 13 coal fired power stations mostly located in the Witbank coalfield.

The legislative framework with regards to the Mining Charter in South Africa is mainly made up of the MPRDA Act as well as a number of environmental legislations required to protect the atmosphere from carbon emissions and the environment from mining activities. The framework also includes regulations on evaluations and recording of mineral reserves and resources in South Africa as well as the BEE Act which is required to economically empower Historically Disadvantaged South Africans (HDSA's).

CHAPTER THREE: METHODOLOGY

This chapter presents the definitions and identities of the "Junior Coal Mining entities'' to be assessed in this dissertation. It also outlines the approach to the topic, the research design adopted, the nature of the data collected, how this was collected and how it was handled.

3.1 SELECTION OF JUNIOR COAL MINING ENTITIES

The Junior Coal Mining sub-sector is comprised of a number of levels of different legal, technical, operational and financial entities. This situation has arisen because of the BEE empowerment Act which has led to variations in development, sophistication and success over the intervening period. Some entities merely have applied for and been granted exploration licenses, whilst others have sold their licenses, some have proceeded to apply for mining and water licenses and have initiated mining,. The more successful mines have developed into larger scale operations known as mid-tier mining companies.

Junior mining entities sometimes referred to as mid-tier entities have been defined in a number of instances as follows;

- The Casey's International Speculator Report (2013): A small-cap, high profit company sitting on discoveries that could significantly increase its profits and of course the value of its stock.

- Seeger (2007): A small, entrepreneurial mining company that is focused on the identification of exploration targets, undertakes exploration, develops feasibility studies and in some cases develops mines in-house.

- Mining Qualifications Authority (MQA), Centre for Sustainability in Mining and Industry (CSMI) and the Chamber of Mines (2010): A mining or quarrying operation that has between 50 and 200 employees, gross assets of between R4.5and R18million and a turnover of between R7.5 and R30million.

However, the proposed definitions for junior mining entities used in this study are derived from table 3.1 and summarised in table 3.2 below.

Table 3.1 Comparison between large scale, small scale or artisanal and junior mining (adapted from Mintek report)

Large Scale Corporate Mining	**Junior Mining**	**Small Scale or Artisanal Mining**
Covers bigger sizes or concession areas, up to 5000 hectares. Make up about 85% global production of a particular mineral commodity. 2.5 million Employees worldwide. Revenues higher than R40 billion. Heavy equipment, high-tech and large output operations. Highly diversified investment portfolios.	Much smaller concession areas of about 1000 hectares. Make up above 15% global production of a particular commodity. Employs a few hundreds of people but sometimes in thousands with turnovers in tens to hundreds of millions of Rand. Focus on exploration with little or no revenue from production. High investment risk of exploration which is critical in the initial stages of the coal value chain. Mining operations which are mechanized and sometimes high-tech.	Make up less than 15% global production of a particular commodity. Turnover of less than R7 million. Employs less than 50 people. Manual labour using rudimentary tools and equipment.

Source: MINTEK; Mineral Economics and Strategy Unit, (2014)

In this study, ten junior coal mining entities were selected based on the parameters proposed for junior mines in table 3.2 (categories 'A to C'), as well as the following criteria:

(i). Black Economic Empowerment (BEE).

(ii). Company size and operations: Production capacities, active and inactive collieries.

(iii). Financials: gross earnings or revenues.

(iv). Mine performance.

The companies include:

1. SC (Shanduka Coal, now Izimbiwa Coal), Junior mine category 'A'
2. KC (Kangra Coal), Junior mine category 'B'
3. KE (Keaton Energy), Junior mine category 'A'

4. CA (Coal of Africa), Junior mine category ‘B’
5. CC (Continenal Coal), Junior mine category ‘ B’
6. MM (Muhanga Mines), Junior mine category ‘B’
7. EIC (Eyethu/Iyanga Coal), Junior mine category ‘B’
8. UM (Umcebo Mining, also part of Izimbiwa Coal), Junior mine category ‘B’
9. HCI (Hosken Consolidated Investments), Junior mine category ‘A’
10. WH (Wescoal Holdings). Junior mine category ‘B’

Table 3.2.Proposed parameters used to define junior mining entities.

Type	**LARGE SCALE MINE**	**JUNIOR MINE**			**SMALL SCALE MINE**
		Category ‘A’ (Mid-Tier)	**Category ‘B’ (Junior)**	**Category ‘C’ (Licensee)**	
Key licenses	Exploration, water and mining.	Exploration, water and mining.	Exploration, water and mining.	Exploration	Unregulated or illegal.
Size	>5000 hectares	>1000 <5000 hectares	1000 hectares	<1000 hectares	<100 hectares
Operations	Complex mining operations and technologically advanced equipment. Highly diversified assets and investment portfolio.	Complex mining operations and technologically advanced equipment. Assets and investment portfolio are simple.	Mining operations and equipment are advanced with simple assets and investment portfolio.	Exploration studies.	Unproductive mining using Rudimentary tools, equipment or machinery.
Employees	>10,000	>500	>100	<100	<50
Finance	>R10 bill ZAR	>R100 mill ZAR	>R10 mill ZAR	<R 10 mil ZAR	<R10 mill ZAR. Usually un-documented.

3.2 RESEARCH DESIGN

This study used descriptive qualitative and quantitative research methods. This method will try to investigate the current spate of junior coal mining in the Witbank area using:

(i) *Quantitative data* including tonnages currently under the banner of junior coal miners in different categories (small, medium and large) and

(ii) *Qualitative data* describing the junior coal companies, their advantages, disadvantages, risks and opportunities, with the services and experts available to them in the industry.

3.3 DATA COLLECTION

The information collected included;

(i) *Quantitative data* i.e. tonnages currently under the banner of junior coal miners in different categories (small, medium and large)

(ii) *Qualitative data* i.e. structure, status and success rate of the selected junior coal companies, their advantages, disadvantages, risks and opportunities, with the services and experts available to them in the industry.

(iii) *Additional data* was collected from corporate and parastatal organisation (Mintek and Chamber of Mines Emerging Miners' desks), coal mines, laboratories, academia and consultants.

The method included:

- *specific interviews* with junior coal miners, a number of specialising consultants and others, and
- *reviews from literature* on a wide range of relevant topics, sourced from libraries, annual company reports, World-Wide Web, seminars, conferences, meetings and workshops.

3.4 DATA ANALYSIS

The data analysed during the survey of the Witbank junior coal miners were mostly derived from the following key research questions;

- What coal markets are most beneficial to a junior coal miner? The domestic or export coal market?
- What coal products could effectively serve these markets?
- What particular impacts have these coal markets had on the bottom line of a junior coal business?
- Could these coal markets be regarded as key opportunities for a junior coal miner?
- What other opportunities exist for a junior coal miner?
- What are the major risks and challenges facing a junior coal miner?
- Is it necessary for a junior coal miner to possibly upgrade its operations into that of a mid-tier or major coal company?
- Is it necessary for a junior coal miner to collaborate with other junior coal miners in view of optimizing value along the coal value chain?

It is hoped that this will ultimately shed more light on the activities of the Witbank junior coal miners and to further stamp their credentials in a highly dynamic coal-based energy industry.

CHAPTER FOUR: THE JUNIOR COAL MINING SUBSECTOR

4.1 INTRODUCTION

The junior coal mining sub-sector accounts for approximately 9% of South Africa's total coal production. These juniors are approximately 300 in number and are predominantly small to medium scale in operation, which produce an average of between 1 to 10 million tonnes of coal per annum.

4.2 THE JUNIOR COAL MINING VALUE CHAIN

The junior coal mining value chain encompasses the geology of the Witbank Coalfield, mining methods, markets, technologies and legislative provisions for the junior coal mining subsector, with regards to the Witbank junior coal miners analysed in this study.

4.2.1 Geology of the Witbank Coal Field

The Witbank Coalfield is one of the most developed and exploited coal fields in South Africa hosting a lot of active collieries, railways and infrastructure that were strategically put in place to service the domestic and export coal markets. The Karoo Supergroup in this coalfield is stratigraphically made up of five coal seams with alternating sandstone, siltstone and mudstone (Snyman, 1998). The Nos. 1 and 2 seams are influenced by the Karoo Paleo floor or topography while the Nos. 4 and 5 have been partly eroded away by present day topographical activities. The Nos. 1 seam is on average 2 meters thick while the Nos. 2 seam averages 6 meters in thickness and contains the most mineable coal resource. Visible benches of coal can be seen and are mined separately because they vary in quality and composition. The Nos. 4 seam averages 4 meters in thickness with the second highest mineable coal resource, followed by the Nos. 5 seam which averages 1.5 meters thick. Seam Nos. 3 is very thin (less than 1 meter) and is uneconomically mineable (Snyman, 1998). The Witbank field is also made up of dykes and sills, the most prominent being the Ogies dyke which is about 15 meters thick and cuts across the area over a distance of 100 kilometres resulting in extensive coal devolatilisation. Also common in the Witbank coal field are inseam partings between coal seams which are visible throughout the area (Prevost, 1997).

The most active mining area is in the Witbank coalfield where the most common and widely used methods of mining are strip mining and board and pillar mining. The major

environmental constraint to mining in the Witbank coal field is the presence of the Ogies dyke as well as other dolerite dykes and sills which render Strip and Board and Pillar mining difficult and result in devolatilisation of parts of the coal seams which, in turn, influences the mine plans, reduces the quality of coal causing problems in the washing plant during beneficiation therefore resulting in higher operational costs (Falcon, 2012). The problem of equipment choice or selection also arises due to the varying thickness of coal seams in the area, while the presence of sandstone in-seam partings leads to damage to equipment by wear and tear.



Fig 4.1 A map of South African coal fields showing the position of the Witbank Coal field Source: (Steyn, 2009).

The Witbank area is divided into the west, central and east portions with active and inactive collieries that provide a lot of coal data compiled by major mining companies and coal experts. As such the quality varries considerably from these portions with a general trend increasing from west to east (Council for Geoscience; 2011).

4.3 COAL MINING METHODS

Coal mining in South Africa is undertaken using two main methods; Surface mining (Open cast and Strip mining methods) and Underground mining (longwall, shortwall and bord and pillar mining methods). Bord and Pillar mining methods use Pillar Extraction, and Continuous Miners as equipment for coal extraction. The methods used depend on the thickness and depth of coal seams as well as certain geological factors that guide their distribution. Each of these methods will be discussed as all of them are used in the Witbank area. (Snyman, 1998).

4.3.1 Surface and Underground Methods of Mining

4.3.2 Open Cast Mining

The Open cast method also known as Open pit, is used when coal seams are somewhat close to the surface. The overburden on top of the coal is removed in a series of benches to ensure the stability of the pit using heavy machinery such as the dragline, bucket wheel excavator or the shovel and truck. This is undertaken before the coal is drilled, broken and transported to the required destination.

Open cast method in this case is usually more efficient in extracting larger quantities of coal than underground methods where most of the coal is tied up in pillars or walls.

4.3.3 Strip Mining

In Strip mining the overburden overlying the coal seams is removed in ‘strips’ and deposited in an area outside the mine site. As coal is progressively mined, the next strip of overburden known as the spoil is placed in the empty mined out area and another block is exposed to be mined. The process is repeated continuously until all the coal has been mined. As in Open cast mining, the overburden is removed using heavy machinery such as the dragline, shovel, trucks and excavators. The coal is transported to the stockpile or to the wash plant for further beneficiation. Strip mining is very effective in flat terrains.

4.3.4 Longwall Mining

In Longwall mining, a wide wall of the coal seam is excavated using sophisticated machinery that moves mechanically forward and backward tearing down the coal which falls unto a

conveyor system for transportation away from the mining area. The longwall also has its roof support system which collapses in a safe and controlled manner behind the machinery after the coal has been removed from unwanted rock materials. This is a very effective method of underground mining in which up to 75% of coal is removed.

4.3.5 Shortwall Mining

This is similar to Longwall mining except that each wall is temporary and continues to shift as new faces of the coal seam is mined. The coal is removed from each wall and transported away from the mine site in a safe and controlled manner. Excavation from each shortwall is also determined by the geologic nature of the coal seams.

4.3.6 Bord and Pillar Mining

In this method the underground mine is divided into 5 to 10 meter rooms with supporting pillars of coal. The coal is removed by equipment with large rotating steel drums or excavators in a safe and controlled manner and the coal is transported in a conveyor belt system out of the mine.

4.4 COAL WASHING OR PROCESSING

This is the process by which impurities such as sulphur and waste rock materials are removed from coals to increase the quality; particularly the calorific value (CV) as such impurities imply higher ash content of the coals. This method is also known as coal cleaning, preparation or beneficiation. Run-of-mine (ROM) coal is washed or processed using different techniques to improve the qualities either for domestic or export use. Coal preparation involves the homogenization, size reduction, grinding, screening and handling of ROM coal. The most important stage of the preparation is coal beneficiation or washing in which the final material is greatly determined by the market the product will serve. Most of the coal used in power stations and industrial boilers are either pulverized or crushed to different size fractions before they are feed into the boilers, kilns or stockers. The non-combustible materials in the coal is the main reason for washing as these increase wear and tear in coal handling equipment and boilers, generally reducing overall efficiency. Therefore, coal can be washed to different degrees depending upon the intended utilisation and the degree of washability (liberation) of the coal material.

Coal preparation process starts with the crushing and screening of freshly mined ROM coal, which removes some of the non-combustible materials. Washing is actually the process of separating the non-combustible materials or undesirable materials in coal by using a liquid medium. The liquid medium usually has a relative density of 1.5 and coal is between 1.3 and 1.55. Higher quality coal which are lower in ash content are "lighter" and will float in the liquid medium while the "heavier" fraction with higher ash content would sink. This is the principle used to separate coal into different quality fractions and this is called "coal washing" or beneficiation. If a very high density liquid is used to separate the coal from rock, then it is called destoning. Magnetite added to water forms the density liquid medium and magnetite is selected because it can be magnetically recovered.

Wet or "hydraulic" washing is a process which uses hydrocyclones and froth flotation to recover fine coal particles from unwanted materials particularly sulphur based on their relative densities as well. Dry washing is seldom but involves the process of separating the crushed coals from the feed from unwanted materials using pneumatic air-flow in the separation chamber and is usually done before the actual washing or beneficiation. Having beneficiated the coal in the liquid medium, it has to be dewatered to remove excess moisture which lower the heat content (CV) of the coal as well as increases the weight of the coal. The equipment used in dewatering include; vibrating screens, filters, centrifuges, rotary kilns or dryer units.

However, the ROM coal must undergo a number of tests or analysis to determine if they can be washed or beneficiated. The two most common tests are the "washability and "float and sink" tests. The washability test method is mainly used on coarse and fine fractions of high ranking coals. It determines the type of impurities as well as the ease at which the coals can be separated from the unwanted materials. The float and sink test is also an important and effective test for analysing coal washability. In this method, the freshly mined ROM coal are first crushed into different size fractions and then passed through a screen with mesh sizes from 3 microns up to 100 microns. The different fractions of the coal are separated by washing in organic solutions with different specific densities such as carbon tetrachloride, perchloroethylene, benzene and other inorganic salts. The float and sink tests are then carried out in these solutions with densities from 1.25 to 2.3 depending on the coal rank with the coal fractions separated as well as the ash. By doing so, samples of the coal fractions are categorised in increasing order of specific gravity and ash value. As such, the results are

plotted giving rise to the total float-ash curve, total sink-ash curve and instantaneous ash curve to determine the coal's washability. The most widely used washing equipment is the jig and cyclone. A typical coal processing plant produces both metallurgical coal and steam coal for power generation and is commonly used by a number of junior coal mining companies. Run-off-mine coal (ROM) is crushed to a certain size say -2microns before being fed into a wash plant. The crushed coal then passes through a screen with an appropriate mesh size of say 2" x 10 mesh screened and goes to the primary dense medium cyclone circuit, if there is any coking coal at this point it would be recovered from a refuse below the dense medium cyclone. The middlings with sizes of say -10 x 60 mesh are processed in a Secondary Dense Medium Cyclone Circuit to recover the coal middlings which are usually higher in ash content and may be suitable as steam or thermal coal. Certain coal products can be passed through an intermediate screen if necessary to enhance the coking properties. Much smaller sized coals from this intermediate screen are deslimed and processed in a flotation circuit to produce coking coal. The washed coals are dried in a centrifuge or a belt filter press while coarse coal rejects are crushed and recombined with the fine tailings for disposal to the refuse fill. The quantity of coal processed is a function of the capacity of the wash plant and is measured in tonnes per hour.

4.5 DOMESTIC COAL MARKETS

4.5.1 Eskom

The major domestic coal market for the junior coal sub-sector in South Africa is Eskom were bituminous thermal coal required for electricity generation at various coal-fired power stations are supplied. With an ever-increasing demand to meet the country's energy needs, Eskom has embarked on many long- term contracts with these junior coal companies to supply thermal coal on a regular basis.

Eskom is planning to increase its generation capacity by between 85000MW and 125000MW in the next few decades. In order to achieve this, it has mapped out long and medium term supply requirements from coal mines in South Africa and it is here that, the Witbank junior coal miners could play a vital role in thermal coal supply. The long term supply includes a life extension of all its existing long term contracts and new projects such as the New Largo agreement for the Kusile power station. The estimated saleable coal from these mines is approximately 1.12 billion tonnes which is a significant opportunity for the Witbank junior

coal miners to enter into and supply a fair portion of this. Also, the medium term contract aims at buying approximately 1.05 billion tonnes, an average 11Mtpa from the year 2018 onwards and will be sourced from new coal supply agreements which will also provide an opportunity for these junior coal miners.

Table 4.1 Eskom commissioned power stations

Power Station	**Generating Capacity (MW)**	**Power Station**	**Generating Capacity (MW)**
Komati	1000	Kriel	3000
Grootvlei	1,180	Arnot	2400
Camden	1,520	Duvha	3600
Medupi	4,764	Matla	3600
Kusile	4,800	Tutuka	3500
Lethabo	3708	Majuba	4110
Gourikwa	746	Ingula	1,332

Source: (ESKOM Annual Report, 2012)

4.5.2 Eskom coal products and specifications

Most often, the run-of-mine coal from junior coal mines are not beneficiated before they are supplied to Eskom power stations. However, recent studies have proven that beneficiated coals with improved quality will directly influence a power station's performance with respect to electricity generation. For instance, poor quality coals with low volatile matter and high ash contents cause slagging in plant boilers. Also, coals with low calorific values and high moisture contents are difficult to combust reducing the efficiency of the boiler(s) at the power stations. Therefore, Eskom has a specification for thermal coal at their power stations if they are to achieve maximum generation efficiencies and insist that junior coal miners wash or beneficiate their coals before supply.

Table 4.2 **ESKOM coal specification and rejection limits**

Parameter	**Units**	**ESKOM**	**Rejection**
Calorific values	MJ/Kg (NAR)	21	20
Total Moisture	Maximum % (AR)	10.0	12.0
Ash	Maximum % (AR)	25-33	>35
Volatile Matter	Maximum % (AR)	20	20
Sulphur	Maximum % (AR)	1.0	2.0
Abrasiveness Index	Maximum	500	550

(Source: ESKOM Technical Team; 2009).

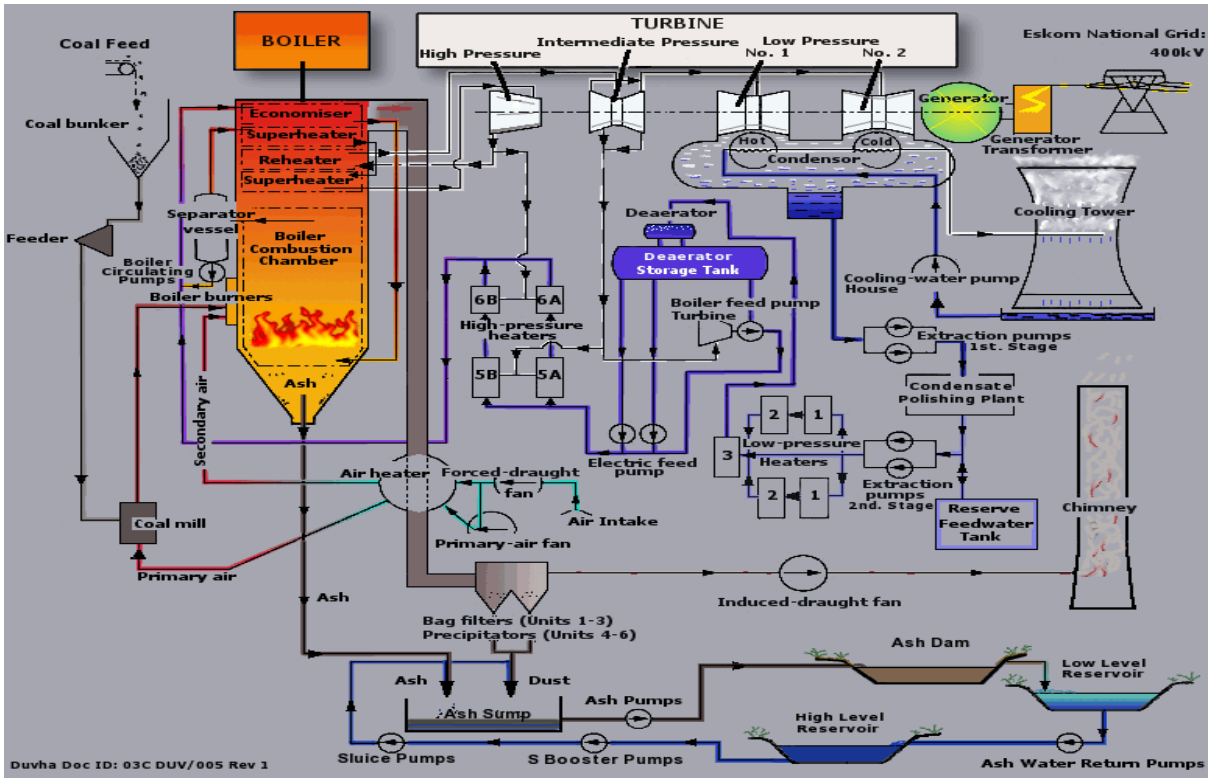


Fig 4.2. An Eskom power station layout. **Source:** (Van Alphen C; 2012)

Figure 4.2 is a layout of a typical Eskom power station. Simplistically, when coal is fed and burnt in the combustion chamber of the boiler plant, it generates steam at very high temperatures and pressures which rotates the turbines that generate electricity. The residual components of the combusted coal which is usually ash and water are filtered and removed via reservoirs at the base of the boilers and excessive heat from the steam generated is condensed and removed via cooling towers. The remaining gaseous components of combustion mainly oxides of carbon, nitrogen and sulphur are released via chimneys or may be captured and stored, for instance, in power stations that use flue-gas desulphurisation technology.

Power stations have an average efficiency of 30% and may go as high as 40% depending on the quality of coal supplied and the age of the power station. It is expressed as follows:

$$\text{Efficiency } (\eta): \quad \frac{\text{Useful heat output of steam}}{\text{Heat input of coal}} \quad \text{or} \quad \eta = 1 - \frac{\text{Boiler Losses}}{\text{Heat input of coal}}$$

Boiler efficiency is a function of the following parameters:

- Moisture content
- Flue Gas Exit Temperature

- Excess Air
- Flue Gas Loss
- Latent Heat Loss
- Heat in Ash
- Un-burnt Carbon

The following coal quality parameters are key to combustion in power stations:

- **Calorific Value (CV):** This is the most important quality parameter that measures the energy contained in the coal.

- **Ash Content:** This is the non-combustible material in coal and is inversely proportional to the calorific value.

- **Volatiles:** These are the gaseous substances in the coal that ignite the coal in the furnace.

- **Abrasive Index (AI):** It is the tendency of the coal to cause wear and erosion to the power plant and handling equipment. This is often cause by quartz and other silicate minerals which are harder than steel.

- **Sulphur**: During coal combustion, sulphur in the coal (organic and inorganic) combines with oxygen forming sulphur dioxide an environmental pollutant. Eskom requires coals with low sulphur because of carbon emission taxes and regulations currently shaping the industry. Any sulphur value above 2% attracts stiff penalties.

- **Moisture content**: This is a measure of the quantity of water in the coal. Excessive water can damage handling equipment. It can also hamper combustion in boilers. There are two types of moisture; Inherent moisture which occurs within the structure of the coal and external moisture acquired during mining or handling of the coal.

4.6 LOCAL MERCHANTS

In South Africa, there are industries which use lesser quantities of coal accounting for just over 10% of the total domestic coal consumption in the country. They include merchants which use coal for domestic and industrial heating as well as the cement, chemical, agricultural and metallurgical industries.

Table 4.3 Breakdown of coal tonnages consumed in South Africa's domestic coal market

User	**Tonnage (Mt)**	**User**	**Tonnage (Mt)**
Electricity	117.3	Cement	1.0
Synfuels	39.6	Brick and tile	0.2
Merchants and domestic	10.1	Agriculture	0.02
Industries	5.2	Transport	0.01
Steel	3.2	Mines	0.01
Chemical	2.2	-------	-------
Metallurgical	1.7	**TOTAL**	**180.08**

Source: (Prevost 2015).

4.7 EXPORT COAL MARKET

The junior coal mining sub-sector could play a vital role in supplying South Africa's export coal market. Even though coal demand and prices in the global export markets are currently low, junior coal miners could still achieve profitable investments in the near future when coal demand and prices make an up-turn on the global commodity cycle. Recent reports from the International Energy Agency suggest that global coal demand by the year 2040 would have risen by 15%, mainly from Southeast Asia, Middle East, India, Brazil and Africa. This is mainly because coal cannot easily be replaced as an energy mineral despite global regulations on carbon or greenhouse gases emissions and the continuous growth of the renewable energy industry.

Table 4.4 South Africa Coal exports by Country, 2014

Country	**Mt**	**Country**	**Mt**
Argentina	0.367	**Malaysia**	**1.606**
Bangladesh	0.079	Mauritius	0.591
Benin	0.0697	**Morocco**	**1.338**
Brazil	0.1336	Mozambique	0.844
Canada	0.1826	**Netherlands**	**9.690**
China	**3.176**	Nigeria	0.135
Croatia	0.135	**Pakistan**	**3.366**
Egypt	0.157	Romania	0.043
Ethiopia	0.0485	Senegal	0.552
France	0.836	**Spain**	**2.937**
Germany	0.304	Switzerland	0.064
Ghana	0.040	**Taiwan**	**1.344**
Guyana	0.075	Tanzania	0.046
Kuwait	0.336	Madagascar	0.532
India	**30.454**	Togo	0.094
Irish Republic	0.127	Tunisia	0.065

Continued…

Country	**Mt**	**Country**	**Mt**
Israel	2.503	**Turkey**	**3.581**
Italy	**1.516**	UAE	2.284
Japan	0.145	Uganda	0.010
Kenya	0.445	**UK**	**1.128**
Republic of Korea	0.305	Ukraine	0.521
USA	0.574	Uruguay	0.033

Source: (Prevost; 2015)

The countries in bold italics are the major importers of coal from South Africa. India is the largest importer even though it is the third largest producer with an estimated reserve of over a 100 billion tonnes. The major problem is that these reserves are low in quality (high ash and sulphur contents) and they are located in the eastern and south-central parts of the country where the necessary infrastructures required to transport those coals to power stations are lacking or not well developed. Also, domestic coal production is not sufficient enough to cater for the country's growing electricity demand evident by power outages in recent years and about 40% of its population do not have access to electricity. With expanding infrastructural development there is continuous need for coal in iron and steel production. In India, thermal coal accounts for about 68% of its electricity generation. It plans on commissioning two additional ultra- mega power station projects in the next 5 years that is, in addition to the 14 power station projects commissioned in 2006. These could generate over 60 Giga Watts of electricity requiring almost a billion tonnes of coal annually. Such power station expansion projects are also evident in countries like Taiwan, Japan, and Pakistan where coal imports are rising remarkably. Coal exports to countries in Asia, Africa and the Middle East will continue to rise as these are developing countries with increasing economy growth, poverty alleviation and infrastructural development. These include growths in the electricity, agriculture, industrial and manufacturing sectors that require coal as a primary

source of energy. The World Coal Association recently released a paper aimed at accelerating coal efficiency in power stations. In terms of electricity generation, countries choosing to use coal should use the most efficient power plant technologies possible which would have a huge impact on reducing carbon emissions. It is for this reason that countries such as China and those in Europe have greatly reduced coal importation affecting what would have been a more flourishing export market opportunity for coal companies in South Africa. The average efficiency of a coal-fired power plant is 33% at present but such improved technologies could increase it to 40% cutting down about 2 Gigatons of carbon emissions globally.

Table 4.5 Export specification for South Africa Thermal Coal

Parameter	**Units**	**RB1 Maximum**	**RB1 Minimum**
Calorific Value	Kcal/Kg (NAR)	6,000	5,850
Total Moisture	%(AR)	12.0	
Ash	%(AR)	15.0	
Volatile Matter	%(AR)		22.0 - 25.0
Sulphur	%(AR)	1.0	
Hardgrove Index		70	45
Ash Fusion Temp	Celsius (^{O}C)		1,250
Calcium oxide in Ash	% (DB)	12	12
Sizing	0 x 50mm	0 x 50mm	0 x 50mm

Source: (Steyn 2009).

Note: Export specifications for South Africa thermal coal are no longer as stringent as in the past years considering declining coal qualities and export coal prices.

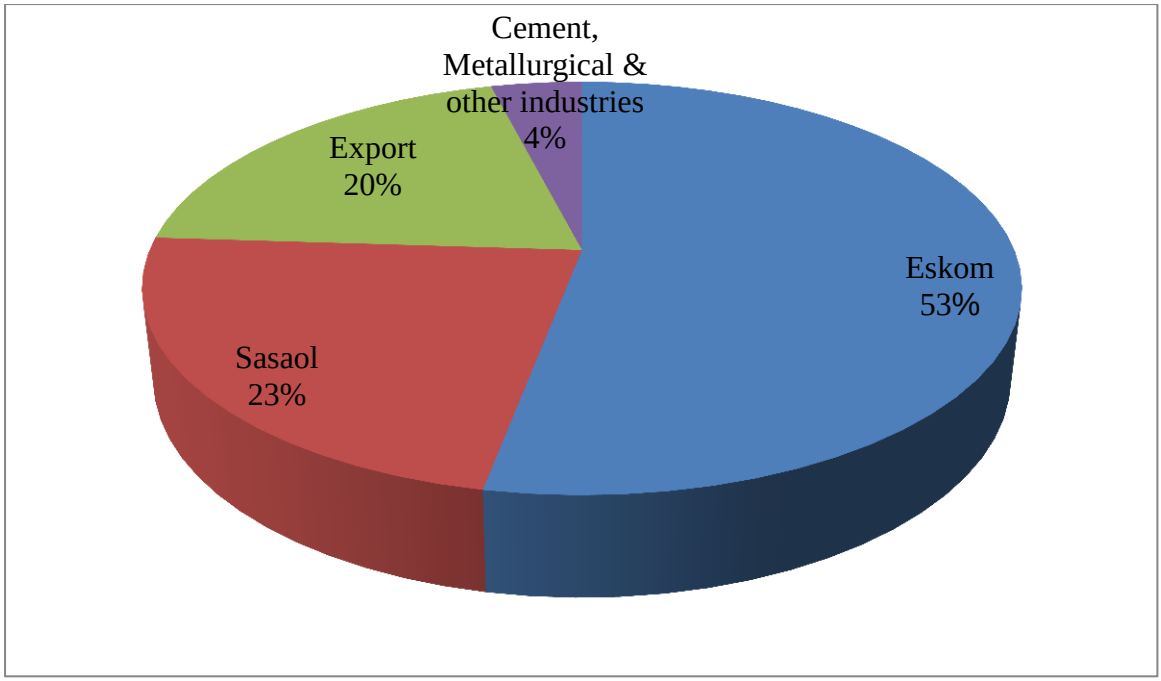


Fig. 4.3 Export and domestic coal markets by sector. **Source:** (Prevost, 2015)

4.8 CLEAN COAL TECHNOLOGIES (CCT)

The most commonly used clean coal technology by Witbank junior coal miners is coal washing or processing of coals for domestic and export coal markets. However, a number of clean coal technologies exist which could be used by junior coal miners to derive cleaner coal products ultimately for utilisation in power plants or stations. For example, they could utilise coal products to generate own electricity which could be used in existing coal projects or even added commercially to the national electricity grid according to Eskom's recently launched Multi-Site Base Load Independent Power Producer's (IPP) Programme. Kuyasa junior coal company in the Middleburg area and its independent power producing subsidiary, KIPower PTY LTD, is developing a mine mouth coal-fired power station with a generation capacity of 2400 megawatts (gross) and a life of 30 years (Kuyasa Mining, 2015). The project describes the use of low calorific value and high ash pulverised coal using circulating fluidised bed and flue gas desulphurization technologies.

The following clean coal technologies could shed more light on coal utilization for power generation hence encouraging other junior coal miners in the Witbank coalfield to adopt the IPP initiative;

1. Flue Gas Desulphurisation (FGD)-The FDG technology typically uses calcium or sodium based alkaline reagent known as a sorbent and the reagent is injected in the flue gas. The SO_2 is absorbed, neutralized and/or oxidized by the alkaline reagent into a solid compound, either calcium or sodium sulphate. The solid is removed from the waste gas stream using downstream equipment. FGD technologies include wet systems, dry systems, semi dry systems and regenerable processes.

(i) Wet Systems

In a wet scrubber system, an aqueous slurry of sorbent is injected into the flue gas. A portion of the water in the slurry is evaporated and the waste gas stream becomes saturated with water vapour. Sulphur dioxide dissolves into the slurry droplets where it reacts with the alkaline particulates and is collected by the absorber. Effluent from the absorber is sent to a reaction tank where it is neutralised in an SO_2 -alkali reaction.

(ii) Regenerable Systems

In regenerable systems, the spent slurry is recycled back to the absorber. The spent slurry is dewatered in this system to be used or disposed. Sorbent material is usually cheap with efficiencies of above 90%, used on site by Electrical companies to prepare the sorbent material. In general, companies which use coal-fired power plants prefer this method due to the low cost of lime or limestone to absorb SO_2 as well as the relatively high efficiency of the sorbent material used in regenerable systems.

(iii) Semi-Dry Systems

Semi-dry systems are similar to wet systems except that the slurry has a higher concentration of the sorbent material. The waste product derived from SO_2 and sorbent reaction in the slurry can also be recycled or disposed, and efficiencies though lower (between 80% and 90%) usually have lesser capital and operating costs compared to wet systems.

(iv) Dry systems

In dry sorbent injection systems, powdered sorbent is injected directly into the furnace or economizer. The dry waste product is removed using particulate control equipment such as an electrostatic precipitator (ESP). The flue gas is generally cooled prior to the entering control device and water can be injected upstream of the absorber to enhance SO_2 removal.

The flue gas injection temperatures are between 950°C to 1000°C in order to decompose the sorbent into porous solids with high surface area. Injection into the economizer requires temperatures of 500°C to 570°C. Duct injection requires the dispersion of a fine sorbent spray into the flue gas downstream of the air preheater. Injection occurs at temperatures between 150°C to 180°C.

Dry sorbent systems mainly use alkaline reagents made up of calcium and sodium, even though other reagents are available. Dry sorbent systems also are useful in smaller scale boilers with the ability to recycle and reuse reagents but SO_2 removal and efficiencies are generally lower than in wet systems. They also require lower costs of capital, operation and maintenance because their designs are less complex in terms of water use and waste disposal. However, costs could be higher if applied on larger scale plants.

2. Integrated Gasification Combined Cycle

The integrated gasification combined cycle (IGCC) produces electricity from a solid or liquid fuel. The fuel is converted to syngas; a mixture of hydrogen and carbon monoxide which is then converted to electricity in a combined cycle power block consisting of a gas turbine process and a steam turbine process which includes a heat recovery steam generator(HRSG). This technology is similar to that used in modern natural gas fired power plants.

A number of gasifiers have been developed mainly to compete with the conventional pulverised coal plants in capturing carbon dioxide and other emissions such as mercury. Table 4.6 below lists these types of gasifiers which is mainly a function of their operating temperatures largely determined by the ash properties of the coal.

Table 4.6 Characteristics of different gasifier types

Gasifier type	**Fixed bed**	**Fluidised bed**	**Entrained flow**
Outlet temperature	Low. (425-600 0C)	Moderate (900-1050 0C)	High. (1250-1600 0C)
Oxidant demand	Low	Moderate	High
Ash conditions	Dry ash or slagging	Dry ash or agglomerating	Slagging
Size of coal feed	6-50mm	6-10mm	< 100 µm
Acceptability of fines	Limited	Good	Unlimited
Other characteristics	Methane, tars, and oil present in syngas	Low carbon conversion	Pure syngas, high carbon conversion

Source: (Maurstad, 2005)

The Sasol-Lurgigasifier used by Sasol's synfuel plants in South Africa is an example of a commercial gasifier. It is a fixed bed and non-slagging type of gasifier.

Electrical efficiencies for IGCC commercial plants without CO_2 are usually between 40 % and 60% while the efficiencies of those with CO_2 capture indicates efficiencies in the range 31-40 %. The factors that influence efficiency include:

- ***Coal type***: Coals of high rank can be gasified more efficiently than coals of low rank because the higher moisture and ash content in the later require a higher degree of oxidation to achieve slagging temperatures.
- ***Gasification technology***: Dry feed gasifiers are more efficient than slurry feed gasifiers because less water must be vaporized.

- ***Degree of integration***: There is increased electrical efficiency if air and gas separation units are integrated.

The reduction in electrical efficiency for a plant with CO_2 capture is explained by the following factors:

- The produced heat from syngas fuel is less efficiently converted to electricity than chemical energy (fuel heating value).
- If the steam/carbon ratio is too low (in some gasifiers), steam must be supplied from the steam cycle and is equivalent to an electricity production loss.

Advantages

- Environmental Performance-There is potential for lower emissions when using the IGCC process compared to FGD and FBC and impurities can be removed more effectively and economically.
- Most gasifier types have relatively lower operational and management costs.

Disadvantages

- Technology Issues- The majority of gasifiers particularly those that capture CO_2 have low efficiencies.
- Requires large sized process equipment to deal with the mass (high ash and moisture content) of low ranked coals.
- Removal of slag is a complex process unless in gasifiers with higher operating temperatures.
- Capital cost of the gasifier is higher when low ranked coals are used.

3. Fluidised Bed Combustion- This is made up of a fluidized furnace usually enclosed but having openings at the base to admit air. High velocity combustion air is forced through a bed of crushed or pulverised coal, ash and pulverised limestone (sorbent for sulphur dioxide) in the furnace. By steadily increasing the velocity of the combustion air, pressure increases and becomes equal to the weight per unit cross-section of the bed known as the minimum

fluidising velocity. From this point onwards, materials on the bed start mixing and with additional air being passed through the bed, temperatures in the furnace continue to rise until there is complete combustion.

The heat is used to drive a steam turbine for electricity generation and by increasing pressures within the bed, a high-pressure gas stream can also be used to drive a gas turbine, generating additional electricity. Fluidised bed combustion (FBC) systems can meet stringent NOx and SO_2 emission regulations and these technologies are also more suited for applications using low quality or mixed fuels, such as biomass and coal. Examples include bubbling and circulating fluidised beds (atmospheric fluidised bed combustion) and pressurised fluidised bed combustion (PFBC).

Advantages

- High thermal efficiency.
- Easier ash and waste removal compared to other combustion technologies.
- Efficient operation at temperatures down to 150° C which is well below the ash fusion temperature.
- Reduced need for coal crushing or pulverisation.
- Reduces air pollution since beds are operated at lower temperatures. This is further achieved by the presence of the lime or limestone sorbents in the furnace which reduce oxides of nitrogen and sulphur.

Disadvantages

- High operational and maintenance costs.
- They are not as common and widespread as the conventional Pulverised Coal Combustion technologies.

4. Chemical Looping Combustion (CLC)

Chemical-looping combustion can be used to capture carbon dioxide from other flue gas components such as N_2 and unused O_2. In the chemical reactions that take place, the gases are

inherently separated from each other without any special equipment. The CLC system is composed of two reactors, an air and a fuel reactor. The fuel is introduced in the fuel reactor, which contains a metal oxide, MexOy. The fuel and the metal oxide react according to:

$$(2n+m)\,MexOy + CnH_{2m} \rightarrow (2n+m)\,MexOy\text{-}1 + mH_2O + nCO_2 \quad (1)$$

The exit gas stream from the fuel reactor contains CO_2 and H_2O and a stream of CO2 is obtained when H2O is condensed. The reduced metal oxide, MexOy-1 is transferred to the air reactor where it is oxidized, reaction (2):

$$MexOy\text{-}1 + \tfrac{1}{2}\,O_2 \rightarrow MexOy \quad (2)$$

The air which oxidizes the metal oxide produces a flue gas containing only N_2 and some unused O_2. Depending on the metal oxide and fuel used, reaction (1) is often endothermic, while reaction (2) is exothermic. The total amount of heat evolved from reaction (1) and (2) is the same as for normal combustion, where the oxygen is in direct contact with the fuel. The advantage of chemical-looping combustion compared to normal combustion is that CO_2 is not diluted with N_2 but obtained in a separate stream without the need of any active separation of gases. And the metal oxides used for the oxygen transfer, are called oxygen carriers. Most research work so far have been directed towards the application where the reactor system is made up by two interconnected fluidized beds, with the oxygen carrier in the form of particles being circulated between the two beds. Clearly, the need to develop suitable oxygen-carrier materials for the process, and comprehensive testing of these under realistic conditions is one of the cornerstones in the development of this technology. Another issue is of course to adapt the comprehensive experience from circulating fluidized bed boilers to this application.

Most experiments on CLC are focused on the application to gaseous fuels, but liquid and solid fuels could be used. The process could also be modified as is the case with chemical-looping reforming to capture CO_2 while producing a hydrogen fuel. This could also be an interesting method of carbon capture and storage.

In order for the fluidized bed systems to be good oxygen-carriers for improved efficiencies, the following are important criteria:

- High reactivity with fuel and oxygen, and ability to convert the fuel fully to CO_2 and H_2O.

- Low fragmentation and attrition, as well as low tendency for agglomeration.

- Low production cost and preferably being environmentally sound.

4.9 LEGISLATIVE FRAMEWORK

The current legislative framework in granting of prospecting and mining rights to junior coal miners is fundamentally aimed at encouraging them to prospect and carry out mining activities in sustainable ways that would maximize the country's coal mineral wealth and ultimately lead to economic growth. This is clearly represented in the Mining Charter of the Minerals and Petroleum Resources Development Act 28 of 2002 which requires that the nation's mineral and petroleum resources be developed in an orderly and ecologically sustainable manner while promoting justifiable social and economic development.

However, where management cannot decide on a particular mining right to apply for the best coal project over the same geological environment, may result in fragmentation of the coal deposit(s) to be mined if eventually several mining rights are applied for and subsequently granted. The impact of this is that there is duplication of capital such as mining equipment, coal preparation and beneficiation plants, transportation infrastructure, logistics and personnel. This could be costly in financial terms and may lead to the sterilisation of potentially mineable coal deposits and value addition on the coal chain may not be optimised under such circumstances. A solution to this could be to consolidate the coal rights of the individual right holders in a specific coal-bearing geographical area. This would ensure that there is a larger consolidated area to exploit the coal resource and value chain optimization could be achieved.

There are a number of stringent legislations on environment, health and safety that guide how a junior coal miner should go about exploiting a coal resource and complying with such legislations, often described as 'responsible and sustainable mining practices,' is a major challenge. In addition, supplying coal to Eskom, a major market for many junior coal miners requires documentation on the following information in which having a dedicated consultant to provide such documentation is often difficult;

1. Environmental and Legal Requirements

- Valid Mining Right/Permit and Off-Take Agreements where applicable.
- Approved Environmental Management Program Report.
- Latest detailed Closure Cost Assessment Report.
- Integrated Water Use License Application/Permits (IWULA).
- National Environmental Management Act 98 (NEMA) authorizations

2. Safety and Health Requirements

- Safety Health and Environmental Policy.
- Letter of Good Standing with the Compensation Commission.
- A copy of legal appointments and related qualifications.
- Baseline Safety Health and Environment (SHE) Risk Assessment

According to section 24 of the South African constitution, Everyone has the right (a) to an environment that is not harmful to their health or well-being; and (b) to have an environment protected, for the benefit of present and future generations; through reasonable legislative and other measures that; (i) prevent pollution and ecological degradation; (ii) promote conservation; and (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development.

This has been further backed by sections 38, 41, 42 and 43 of the MPRDA, section 28 of the National Environmental Management Act (NEMA), section 19 of the National Water Act (NWA), and the National Environmental Managements Acts on Air Quality (NEMAQA), Waste (NEMWA), Biodiversity (NEMBA) and Heritage Resources.

Table 4.7 Legislative requirements for coal activities**.**

Permit to carry out restricted activity in relation to Endangered or Threatened Species	NEMA EIA for Listed Activities	Water Use License
SAMREC and SAMVAL Codes	Prospecting/Mining Right	Change in Land Use/Zoning Authorized by Local Authority.
EMP	Atmospheric Emissions License	Permissions from Heritage Authorities

Source: (Centre for Sustainability in Mining and Industry, 2012)

The challenges facing junior coal miners while complying with environmental, health and safety legislations include the following:

- Preparation of a suitable Environmental Management Plan. It provides baseline information on the environment by identifying and evaluating the socio-economic impacts, protection, mitigation, management and remedial measures including mine closure and alternatives to land use. Therefore, all environmental impacts as a result of such prospecting or mining activities must be in accordance with an approved EMP.

- Consultation with the landowner where the coal resource is located, for new coal entrants this could be a very tedious and lengthy process. In such consultations it is required that details of the prospecting and mining operations is communicated to the land owner so that a reasonable agreement to land use could be reached with regards to environmental pollution and compensations.

- Financial provisions for mine rehabilitation, premature closure, decommissioning and final closure could weigh heavily on the company's finances especially to those who profit marginally. This also includes post-closure management of all environmental impacts after land use.

- The burden of criminal liabilities associated with environmental pollution by mining activities. This often discourages investors and a survey conducted by the CSMI indicated an average of about 10% of such investors. These liabilities are only lifted after a closure certificate has been granted.

- Water resource management where specific measures are required to protect and conserve water resources. A major water pollutant is acid mine drainage. This also carries criminal liabilities.

- Environmental impact assessments for substances that cause air pollution such as smoke, dust, fly ash, gases and fumes. Such assessments could be tedious and require high levels of expertise from environmental specialists. Failure to submit such assessment reports to the designated NEMAQA authority could result in revocation of Atmospheric Emissions Licenses (AEL).

- Waste management; This includes handling, storage, treatment and disposal of general and hazardous wastes such as radioactive waste, coal discards, explosives and wastes from construction. It also includes remediation of contaminated land in the areas covered by the mining right. A continuous assessment of the land is required and must be reported to the designated NEMWA authorities.

- Protection of areas of critical biodiversity in terms of threatened and endangered plant and animal species. This also includes protection of national heritage sites such as structures older than 60 years, graves (outside of formal cemeteries) older than 60 years, archaeological and paleontological sites.

- With regards to health and safety, a thorough understanding of the complex regulations presented in the Mine Health and Safety (MHS) and Occupational Health and Safety (OHS) Acts is required and this could be challenging..

4.10 SUMMARY

The Witbank Coalfield of the Karoo Supergroup is stratigraphically made up of five coal seams with alternating sandstone, siltstone and mudstone. They are numbered from 1 to 5 which vary in thickness and depth. The No. 2 and 4 seams which are 6 and 4 meters thick respectively are the most mineable coal seams in the Witbank coalfield. The coal seams contain inseam partings and the presence of dykes, mainly the ‘Ogies’ and sills influence

mining in the area due to coal devolatilisation. Mining methods of use in the Witbank Coalfield are mostly strip mining and bord and pillar mining after which coals can be processed by washing.

The major domestic coal market for the Witbank coals are Eskom, followed by local merchants who use much lower quantities. The coals are also exported to various countries around the world, mainly to Asia through the RBCT and Maputo coal terminal and conveyed there mainly by road and rail.

In order to carryout coal mining in the Witbank Coalfield, there are a number of stringent legal, environmental, health and safety requirements that must be adhered to. The legislative framework is put in place to ensure responsible and sustainable mining in the junior coal sub-sector, further translating to more successful junior mining operations.

CHAPTER FIVE: RESULTS AND DISCUSSIONS

5.1 INTRODUCTION

Ten junior coal companies with operations in the Witbank coalfield were selected for analysis in this research; some of them are BEE owned and share the common objective of creating some degree of economic equality in the coal industry through the HDSA empowerment Act. Majority are single asset owners possessing, for example, a prospecting license with a stockyard, mining operations in various forms and a crushing plant and in some cases a washing plant and/or conveyors or haulage trucks for daily coal trade.

The status and financial success levels of these 10 junior coal mines range widely but statistics were difficult to obtain in detail mainly due to fast-changing ownership or licences of operational coal assets.

5.2 JUNIOR COAL COMPANIES, PROJECTS AND OPERATIONS

The junior and major coal companies described here started a number of years ago as ordinary permit holders or perhaps as single asset owners but all have turned out to be key players in the South African coal industry as evidenced by the scope of their operations and current size of their coal assets.

1. Shanduka Coal (Izimbiwa)

Izimbiwa Coal is a joint venture between Phembani (Shanduka) Resources 50.01 percent and Glencore International Plc. 49.99 percent shareholding respectively. It owns the Graspan and Townlands Collieries but the Leeuwfontein and Lakeside Collieries in the Witbank coalfields are currently under care and maintenance. Izimbiwa Coal is one of the most stable in terms of its coal assets in the Witbank Coalfield. It is currently carrying out development projects to extend and replace current operations such as the Argent project which is at its feasibility stage of exploration and scheduled to commence operations in the year 2018. Also, an extension project of the Graspan Colliery is in the process of obtaining mining, environmental and water management rights. This project will see an increase in production at the Graspan colliery by up to 2.85 million tonnes per annum and an extension of the life of mine by an additional 4 years. Coal will basically be mined from the No. 4 lower (4L), No. 2 lower (2L) and No. 1 coal seams.

Table 5.1 Summary of Shanduka Coal (Izimbiwa) projects and operations.

<table>
<tr>
<td rowspan="3">Company description

Izimbiwa Coal is a coal producing company with coal operations in the Witbank Coalfield. It is not yet listed on the JSE.

51% black owned (BEE) company.

Key Financials:

EBITDA R600m ZAR</td>
<td rowspan="2">Coal products: Thermal and metallurgical coal.

Number of employees: 250

Major mines/mining assets Graspan, Townlands and Middleburg collieries

Development/expansion project: Springlake project</td>
<td>Resources and reserves Graspan extension: 32.24Mt. L.O.M: 6Years

Coal products and market: Eskom thermal coal.</td>
</tr>
<tr>
<td rowspan="2">Operations

Open cast mining: truck and shovel Underground Extracting coals from seams No. 4(L), 2(L), and No.1</td>
</tr>
<tr>
<td>Exploration/Feasibility Studies: Argent and Springboklaagte projects</td>
</tr>
</table>

Source: Izimbiwa Coal (2017)

2. Kangra Coal (STA Coal)

Kangra coal commenced its operations officially in the early 1990's extracting coal from its Savmore Colliery and transporting it via an overland conveyor to its washing plant in the East of Maquasa in Mpumalanga. It extracts coal using both open cast and underground mining methods producing approximately 5million tonnes per annum of run-off-mine coal. The yield from this coal extracted is 70% while the remaining 30% go as discards. This leaves the company with about 3milliom tonnes of coal of which 2 million tonnes are exported via the Richard's Bay Coal Terminal and the remaining sold to the domestic coal markets; cement, sugar factories and timber mills but mainly a paper mill company known as Mondi. The current life of mine is approximately between 3 and 5 years, but there are proposed extension projects to further increase the life span of those mines. The most notable is the extension of their current mine workings into the Kusipongo Resource, and the expansion of the open pit Maquasa mine workings. The management of the Kusipongo project will have a number of surface and underground infrastructure such as an adit, a ventilation shaft, and a 7 km long

conveyor belt system to transport coal to the wash facilities at the Savmore Colliery. The Maquasa expansion project will see an expansion of the open cast pit into 8 new pits. It will also have a number of surface and underground mine infrastructure and a conveyor system to transport coal to its washing plants in the East. Both projects will inculcate the management of coal discards with additional wash facilities provided at both sites. This will inadvertently increase the total quantity of coal produced by the company and the percentage yield at both mines.

Table 5.2 Summary of Kangra Coal projects and operations.

Company description Established in the 1990's, 30% joint venture with Shanduka . Produces coal for domestic and export markets. Current LOM is between 3 and 5 years. **Number of employees**: Over 100. **Run-Of-Mine** is 5Mt. **Key Financials:** ***Gross Revenue R50 m ZAR***	**Major mines/mining assets:** Savmore colliery and Wash plant. ***Coal products***: Domestic bituminous coal for local merchants. Export bituminous coal. **Development/Expansion project**: Kusipongo project **Exploration/Feasibility project**: Maquasa Project	**Resources and reserves** Kusipongo project: Approx. 240Mt. in-situ resources. **Operations** Open cast and underground mines. Overland conveyor system transporting coals to wash East of Maquasa.

Source: (STA Coal, 2017).

3. Keaton Energy Holdings Ltd

Keaton energy holdings operates the Vanggatfontein open cast colliery which is located 15 km southeast of Delmas on the edge of the central Witbank Coalfield. Coal is extracted from the No 5, 4 and 2 seams and the run-of-mine is sent to two processing plants operating at an average capacity of 500 tonnes per hour. The first plant processes coals from the no 5 seam producing duffs, peas and nuts mainly for the domestic metallurgical industry, while the second plant processes coals from the Nos 4 and 2 seams producing thermal coals mainly for

Eskom. Keaton energy also has a number of development projects in the Witbank area; the Sterkfontein, Moabsvelden and Roodepoort collieries.

Table 5.3 Summary of Keaton Energy coal projects and operations.

<table>
<tr>
<td>Company description</td>
<td>South African junior coal Miner producing thermal and metallurgical coal. Listed on the JSE.

BEE ownership: 26% by Rutendo Mining PTY LTD

Number of employees: Over 1,400.

Key Financials: CapEx. R678.8m. EBITDA. R1.45bn</td>
<td>
<table>
<tr><th>Project (2015)</th><th>Resources (Mt)</th><th>Reserves (Mt)</th></tr>
<tr><td>Vangat-fontein</td><td>119.3</td><td>49.2</td></tr>
<tr><td>Sterk-fontein</td><td>90.9</td><td>23.6</td></tr>
<tr><td>Braak-fontein</td><td>60.1</td><td>---------</td></tr>
<tr><td>Vaalkrantz</td><td>11.5</td><td>2.0</td></tr>
<tr><td>Moabsveld</td><td>54.7</td><td>39.8</td></tr>
<tr><td>Koudelager</td><td>12.3</td><td>---------</td></tr>
<tr><td>Bankfontein</td><td>16.1</td><td>--------</td></tr>
<tr><td>Roodepoort</td><td>25.1</td><td>---------</td></tr>
</table>
Production capacity (FY 2015): 2.85Mt

Operations
</td>
</tr>
<tr>
<td>Coal products and markets:

Vangatfontein:Eskom thermal coal and domestic metallurgical coal.

Sterkfontein: Grade A export metallurgical coal and Eskom thermal coal.

Moabsvelden: RB3 export thermal coal. Middling for domestic power generation.</td>
<td>
<table>
<tr><th>Projects</th><th>L.O.M</th></tr>
<tr><td>Vangatfontein</td><td>17</td></tr>
<tr><td>Sterkfontein</td><td>15</td></tr>
<tr><td>Moabsvelden</td><td>18</td></tr>
</table>
Major mines/mining assets

•Vangatfontein Colliery

•Vaalkrantz colliery,
</td>
</tr>
</table>

Eskom. ***Roodeport*:** Domestic thermal coal. ***Vaalkrantz*:** Domestic Anthracite and export metallurgical coal.	**Development/expansion projects:** Sterkfontein, Bankfontein, Balgray and Moabsvelden collieries **Exploration/Feasibility studies**: Roodeport, Mooiklip, Koudelager and Braakfontein projects	Open cast mining (truck and shovel). Underground mining (board and pillar) 100tph 5-seam coal washing plant producing duff, peas and nuts. 500tph coal washing plant producing domestic thermal coal for Eskom. 110tph two-stage anthracite washing plant producing duff, peas and nuts

Source: (Keaton Energy 2015).

4. Wescoal Holdings Ltd

Wescoal Holdings ltd is made up of 3 main subsidiaries which make up the group of companies namely; Wescoal mining, Wescoal Mineral Recoveries and Wescoal Trading Ltd. The company is listed on the JSE operating the Khanyisa open cast Colliery 10km west of the Ogies and also close to the Kendal power station. Wescoal could potentially increase the life of mine through its Khanyisa colliery by another 2 years which is currently between 12 and 18 months.

In 2013, it started operating the Intibane Colliery also in the Ogies area. There are development plans to commence operations at the Elandspruit Colliery in which a mining right has been obtained. This colliery promises to be the backbone of the company's mining subsidiary with over 40 million Tonnes of coal Gross Insitu. Its life of mine will be somewhere between 12 and 15 years.

Table 5.4 Summary of Wescoal Holdings Coal projects and operations

<table>
<tr>
<td>Company description

Junior coal company with 3 subsidiaries and listed on the JSE.

Number of employees: Over 180.

Key Financials:
Trading revenues: R1.16bn ZAR.
EBITDA: R34.3m ZAR</td>
<td>Coal products and markets: Khanyisa colliery: Eskom thermal coal: Kendal power station. Export Thermal Coal RBCT.
Intibane colliery: Eskom thermal coal;Tutuka power station.

Operations: Intibane open cast mine. Khanyisa open cast and underground mine</td>
<td>
<table>
<tr><th>Project (2015)</th><th>Resources (Mt)</th><th>Reserves (Mt)</th></tr>
<tr><td>Khanyisa</td><td>0.86</td><td>0.63</td></tr>
<tr><td>Intibane</td><td>0.74</td><td>0.7</td></tr>
<tr><td>Elandspruit</td><td>36.15</td><td>34.35</td></tr>
</table>
</td>
</tr>
<tr>
<td>Major mines/mining assets: Khanyisa colliery. L.O.M: 1.5 years</td>
<td>Development/expansion projects: Elandspruit colliery. L.O.M: 12 to 15 years.
Intibane colliery. LOM: 2 years.</td>
<td>Exploration/Feasibility studies:
None</td>
</tr>
</table>

Source: Wescoal Holdings (2015)

5. Coal of Africa

Coal of Africa Ltd is a junior coal mining company in South Africa producing high quality thermal and coking coal. The Mooiplaats Collirery is currently under care and maintenance and the management is looking at a number of joint ventures with other neighbouring collieries to further expand the production capacity to increase the bottom line of the business

Table 5.5 Summary of Coal of Africa coal projects and operations

Company description Junior coal company producing high quality thermal and coking coal. Transition from contracting coal company to full ownership. Listed on the JSE, AIM, and ASX. BEE ownership: 49% by Vuna Coal Holdings. **Number of employees**: Over 250. **Key Financials** ***Net Loss: R66.583m ZAR*** ***Total equity: R274.5m ZAR***	**Major mines/assets:** Mooiplats colliery (In advanced stages of asset sale) **Development/expansion projects.** Vele colliery, Makhado project.	**Exploration/Feasibility studies**. Chapudi, Generaal and Mopane exploration studies on coking and thermal coal in the Soutpansberg Coalfield.

Source: Coal of Africa (2017)

6. Eyethu/Iyanga Coal

Eyethu Coal (Pty) Ltd is a BEE junior coal company whose major business is in supplying Eskom with beneficiated thermal coals. It is also in partnership with Iyanga Mining (Pty) Ltd, and operates a number of active collieries in the Witbank Coalfield as summarised below:

Table 5.6 Summary of Eyethu/Iyanga coal projects and operations

<table>
<tr>
<td>Company description

BBEEE junior coal company. Number of employees: Over 300

R.O.M: 7Mt

Key Financials: Gross Revenue: R150m ZAR.</td>
<td>Active collieries and coal markets: Leeuwpoort Colliery: (No. 2 Seam Mined).Domestic Bituminous Coal sold to coal distributor Mcphail.

Mooifontein Colliery: Domestic Bituminous Coal sold mainly to Eskom.

TNDB Colliery: Export Bituminous Coal

Welgelegen Coal: (Iyanga Coal Mine): Domestic Bituminous Coal.

Products: Eskom and domestic thermal coal</td>
<td>
<table>
<tr><th>Project (2016)</th><th>Measured Resource (Mt)</th><th>Indicated Resource (Mt)</th></tr>
<tr><td>Leeuwpoort</td><td>3.0</td><td>2.0</td></tr>
<tr><td>Mooifontein</td><td>2.0</td><td>1.0</td></tr>
<tr><td>TNDB</td><td>1.0</td><td>-------</td></tr>
<tr><td>Welgelegen</td><td>1.0</td><td>1.0</td></tr>
</table>
</td>
</tr>
<tr>
<td>Development/expansion projects: Kroomdai North Colliery: (No. 2 and 4 seams).</td>
<td>Exploration/feasibility studies: Kroomdrai North Colliery project</td>
<td>Operations: Opencast Box-cut (Seam 4),Underground mining methods (Seam 2),Crushing and screening plants.

Opencast-Truck and shovel (Leeuwpoort Colliery).Crushing plant (Leeuwpoort Colliery).Opencast-Surface (Mooifontein Colliery). Opencast. (TNDB Colliery).Opencast. (Welgelegen Coal).</td>
</tr>
</table>

Source: Eyethu and Iyanga Coal (2016)

7. Continental coal

Continental coal is an Australian listed company with coal operations in the Witbank coalfield**.** Even though continental recently sold its Vlakvarkfontein asset to Ichor coal to recover from financial losses it still has a number of assets such as the Penumbra, Ferrreira, De Witekrans, Vlakplaats and Wolverfontein collieries as well as a coal project in Botswana hosting one of its largest coal reserves. Continental Coal's operations have been summarised in table 5.7.

Table 5.7 Summary of Continental Coal projects and operations

Company description

South African thermal coal producer in the Witbank coalfield. Listed on the JSE, ASX, LONDON AIM.

BEE ownership: 26% by Mashala Resources.

Number of employees: Over 200

Key Financials

Net Loss*: *R34.5m ZAR

Total equity (R7.1m)ZAR

Exploration/feasibility studies: Vlakplaatscoal project, Wolvenfontein

Coal products and markets:*Vlakvarkfontein mine*: Eskom thermal coal.

***Ferreira mine*:** Export thermal coal.

Penumbra mine: Export thermal coal.

Major mines/ mining assets: Vlakvarkfontein Coal Mine, Ferreira Coal Mine.

Project(2015)	**Resources (Mt)**	**Reserves (Mt)**
Vlakvark-fontein	17.4	14.1
Ferreira	1.3	0.8
Penumbra	68.3	13
DeWitekkr-ans	251.1	48.4
Vlakplaats	187.5	-------
Wolvenfo-	36.7	-------

coal project, Ermelo coal project, Botswana coal project	**Operations:** Board and Pillar underground mining. Box cut. Delta processing plant **Development/expansion projects**: Penumbra coal mine, De Wittekrans coal project.	ntein		
		Ermelo	40.0	9.0
		Botswana	2,159.0	-------

Source: Continental Coal (2015)

8. Umcebo Mining

Umcebo Mining is Black Economic Empowerment Company which produces domestic and export thermal coal from active coal mines and a beneficiation plant. Incorporated in 2003, the company is owned by Shanduka Coal and Glencore International plc which owns about 43%. Umcebo coal operations are summarised below:

Table 5.8 Summary of Umcebo Coal projects and operations.

Company description BBEEE junior coal company. **Number of employees**: Over 100. **Key Financials:** ***Gross Revenue: R100m ZAR***	**Major mines/assets** Wonderfontein colliery, Kleinfontein colliery. ***Middlekraal Colliery*: (No 2 seam)**. Bituminous Coal. Eskom thermal coal. ***Strathrae Colliery:* (No 1 and 2 seams).** Domestic, Export Bituminous Coal. Eskom thermal coal. ***Norwesco Colliery:*** Sold ***Wonderfontein-Umsimbithi***: Domestic Bituminous Coal. Merchants.	
Major coal product: Eskom Thermal Coal.		
Active collieries*:* ***Doornrug Colliery*: (No 1 seam).** Domestic and Export Bituminous Coal**.** ***Klippan Colliery*: (No 1 and 2 seams).** Domestic and Export Bituminous Coal. ***Kleinfontein Colliery*: (No 2 and 4 seams).** Domestic and export bituminous coal.	**Operations:** ***Doornrug Colliery***: Opencast and underground operations which include coal preparation; on site crushing and screening, onsite Wash plant (Toll washing)**.** ***Klippan Colliery:*** Opencast; surface coal Preparation-Onsite crushing and screening. Beneficiation at Strathrae. ***Kleinfontein Colliery:*** Opencast. Coal Preparation-Onsite crushing and screening. On site wash plant	

Project	Measured Resource (Mt)	Indicated Resource (Mt)
Doornrug	4.0	-------
Klippan	4.0	1.0
Kleinfontein	12.0	-------
Middlekraal		
Strathrae	1.0	-------
Norwesco	1.0	-------
Wonderfontein-Umsimbithi	100.0	-------
Hendrina	180.0	180.0

Operations continued…

Middlekraal and Strathrae Colliery: Opencast mine ***C***oal Preparation-Onsite crushing and screening, wash plant and Air plant. ***Norwesco Colliery***: Opencast-surface

Wonderfontein-Umsimbithi: Underground method

Development/expansion project:

Rietfontein coal mine

Source: Umcebo Mining (2015)

9. Hosken Consolidated Investments limited

Hosken Consolidated Investments Limited (HCI) is a BEE investment company which is listed on the JSE. The company has a number of investments but it's coal mining division is of key interest in this study. The three major coal assets include; Palesa and Mbali coal mines while the Nokuhle Colliery is still under development.

Table 5.9 Summary of Hosken Consolidated Investments Limited projects and operations

<table>
<tr>
<td>Company description

BBEEE junior coal company located in the Witbank coalfield.

Number of employees: Over 500.

Key Financials: (coal operations).Gross revenue: R556m ZAR

EBITDA: R86m ZAR</td>
<td>Major mines/assets: Palesa and Mbali Coal

Active collieries and coal markets: Palesa Colliery: (No 2 and 4 seams). Bituminous coal. Eskom thermal coal.

Mbali Colliery. Bituminous Coal. Eskom thermal coal.</td>
<td>
<table>
<tr><th>Project (2016)</th><th>Measured resource(Mt)</th><th>Indicated resource(Mt)</th></tr>
<tr><td>Palesa</td><td>50.0</td><td>45.0</td></tr>
<tr><td>Mbali</td><td>10.0</td><td>3.0</td></tr>
<tr><td>Rooipoort</td><td>32.0</td><td>-------</td></tr>
<tr><td>Nokhule</td><td>-------</td><td>-------</td></tr>
</table>
</td>
</tr>
<tr>
<td>Development/expansion projects: Rooipoort Colliery, Mbali colliery wash plant</td>
<td>Products; Domestic (Eskom) and export coal</td>
<td>Run-Off-Mine 1.93Mt</td>
</tr>
<tr>
<td>Exploration/Feasibility studies: Nokuhle coal mine still awaiting mining right approval.</td>
<td></td>
<td>Operations: Palesa Colliery: opencast mining. Coal preparation- crushing, screening and washing. Mbali Colliery: Opencast.</td>
</tr>
</table>

Source: HCI Limited (2016)

10. Muhanga Mines

Muhanga Mines is a BEE junior coal company listed on the JSE, it has a major open cast coal operation in the Witbank coalfield. Muhanga Mines operations and projects are summarised below:

Table 5.10 Summary of Muhanga Mines projects and operations.

Company description

BBEEE Level 7 junior coal company.

Number of employees: Over 150

Key financials (Coal operations):

*Gross revenue**: R300m ZAR***

Development and expansion projects: Welgemeend project**.** **(**Joint venture with Ichor/Mbuyelo Coal company**).**

Exploration/Feasibility studies: None

Major mines/assets: Naauwport Mine**,** Goedenhoop section**.**

Active collieries and coal markets: Naauwpoort Mine: (No 1 and 2 seams). Domestic and export bituminous coal. **Vlaklaagte Mine:** Domestic Bituminous Coal for local merchants. **Langkloof Mine:** Domestic Bituminous Coal for local merchants

Project (2016)	**Measured resource(Mt)**	**Indicated resource(Mt)**
Naaupoort Mine	35.0	20.0
Vlaklaagte	20.0	12.0
Langkloof	10.0	-------
Welgemeend	56	-------

Coal resource: 56Mt.

Products: Eskom and export thermal coal

Operations: ***Naauwpoort Mine:*** Opencast mining, Coal preparation-washing.

Vlaklaagte Mine: Opencast mining.

Langkloof Mine: Opencast mining

Muhanga wash plant to be acquired by Wescoal subject to Water Use License.

Source: Muhanga Mines (2016).

Ten junior coal companies were analysed namely;

1. SC (Shanduka Coal, now Izimbiwa Coal),
2. KC (Kangra Coal),
3. KE (Keaton Energy),
4. CA (Coal of Africa),
5. CC (Continenal Coal),
6. MM (Muhanga Mines),
7. EIC (Eyethu/Iyanga Coal),
8. UM (Umcebo Mining, also part of Izimbiwa Coal),
9. HCI (Hosken Consolidated Investments),
10. WH (Wescoal Holdings).

This analysis was done in terms of the following parameters;

1. ***Black Economic Empowerment (BEE) structure and status***: Of the 10 companies analysed, SC, KC (STA Coal), EIC, UM, HCI and MM are partly BEE owned coal companies (Tables 5.1 to 5.10). CA is partly owned (49%) by Vuna Coal Holdings, while KE and CC are backed by Rutendo Mining PTY (LTD) and Mashala Resources respectively, each with 26% BEE ownership or stakes in both companies. WH has a BEE ownership of 32%.
2. ***Coal company sized status***: The 10 companies fall into the category of 'junior or mid-tier mining company' according to the Chamber of Mines and the Centre for Sustainability in Mining and Industry's definition. This is in terms of the company's total number of employees (each numbering above 50), gross assets and turnovers. All the analysed companies are involved in exploration, development and/or of their expansion coal projects.
3. ***Gross earnings or total revenue generated***: SC and KE top the list, followed by MM, EIC, UM, HI, KC and WH as observed in Table 5.11 below. CA and CC recorded huge

financial losses over the past financial year averaging losses of about R50 million ZAR. Solutions to recover from such losses are currently being sought by the relevant mine owners through strategic market penetration, collaborations and joint ventures, fund raising through equity finance. If unsuccessful, the only option is to sell the underperforming asset to willing investors or other junior miners who are more financially stable. CC recently sold its asset to another junior coal miner who had the required capital injection to turn that asset into an operational and profitable mine.

4. ***Market share performance:*** The 10 junior coal companies all supply various types of coal products with the greatest proportion of their market share sold mainly to Eskom in the form of low grade steam coal. Other coal products include higher grade bituminous coals for local industrial consumption, lower grades to merchants for domestic household use and high grade thermal and metallurgical coal or coking coal for export.

5. ***Overall performance***, the top performers were those junior coal companies with the highest financial earnings or revenue generated (SC and KE) while the poor performers are those companies which recorded annual financial losses (CA and CC). The companies categorised as 'average performers' are those assumed to have tight margins because gross earnings or total revenues do not account for profitability, assets and liabilities, cash flows, share price and other financial variables such as total expenditure, depreciation, tax, and amortisation.

Table 5.11. Summary of 10 analysed junior coal companies

Company	**Coal products and market share (2016)**	**Profitability: Gross Earnings/Total revenue**	**Market Performance**
(SC). Shanduka Coal	Domestic and export bituminous coal, metallurgical coal, anthracite.	R600m ZAR	***Top***
(KC). Kangra (STA) Coal	Domestic and export bituminous coal	R50m ZAR	***Average***
(KE). Keaton Energy	Domestic (middlings) and export thermal coal. Metallurgical coal, anthracite.	R1.45bn ZAR	***Top***
(WH). Wescoal Holdings	Export thermal coal.	R34m ZAR	***Average***
(CA). Coal of Africa	High quality thermal and coking coal. Eskom thermal coal	(R66.583m) ZAR	***Poor***

Company	Coal products and market share	Profitability: Gross Earnings/Total revenue	Market Performance
(CC). Continental Coal	Eskom thermal coal, export thermal coal.	(R34.5m) ZAR Total equity (R7.1m) ZAR	***Poor***
(EIC). Eyethu/Iyanga Coal	Eskom and domestic thermal coal.	R150mill ZAR	***Average***
(UM). Umcebo Mining	Domestic and export bituminous coal. Eskom thermal coal.	R100mill ZAR	***Average***
(HCI). Hosken Consolidated Investments	Eskom thermal coal. Bituminous coal.	R86mill ZAR	***Average***
(MM). Muhanga Mines	Domestic bituminous coal for local merchants. Domestic and export bituminous coal.	R300mill ZAR	***Average***

5.3 CHALLENGES IDENTIFIED BY WITBANK JUNIOR COAL MINERS

As noted in Table 5.11, the majority of the companies analysed where average performers.

The key reasons for poor to average performance recorded by the junior coal companies were said to be due to the following factors:

1. Coal market volatility: Coal market volatility is a major challenge facing junior coal companies and volatility is a function of price, demand and supply. In global terms, coal market volatility is primarily due to shifting demands for coal to alternative sources of cleaner and sustainable energy by a number of coal importing countries such as China, USA and countries of the European Union. This is in line with the just concluded COP21 climate deal held in Paris to curb greenhouse gases emissions from non- renewable fuels that cause global warming and other forms of environmental degradation. Even though a number of countries in the past had adopted certain policies on carbon emissions, the climate deal will make such policies or regulations even more stringent thus affecting the type of coal products exported and their prices. Coal prices have been the lowest the in the year 2015 compared to the past few years. The domestic coal market might seem more stable in terms of volatility and perhaps a better option for the junior coal miners to sell their coal products, but coal prices equally fluctuate and are presently at their lowest. As such, coal prices would have to make a cyclical price upturn in the nearest future if investors are to remain in business or stand the risk of investment liquidations and perhaps mine closures.

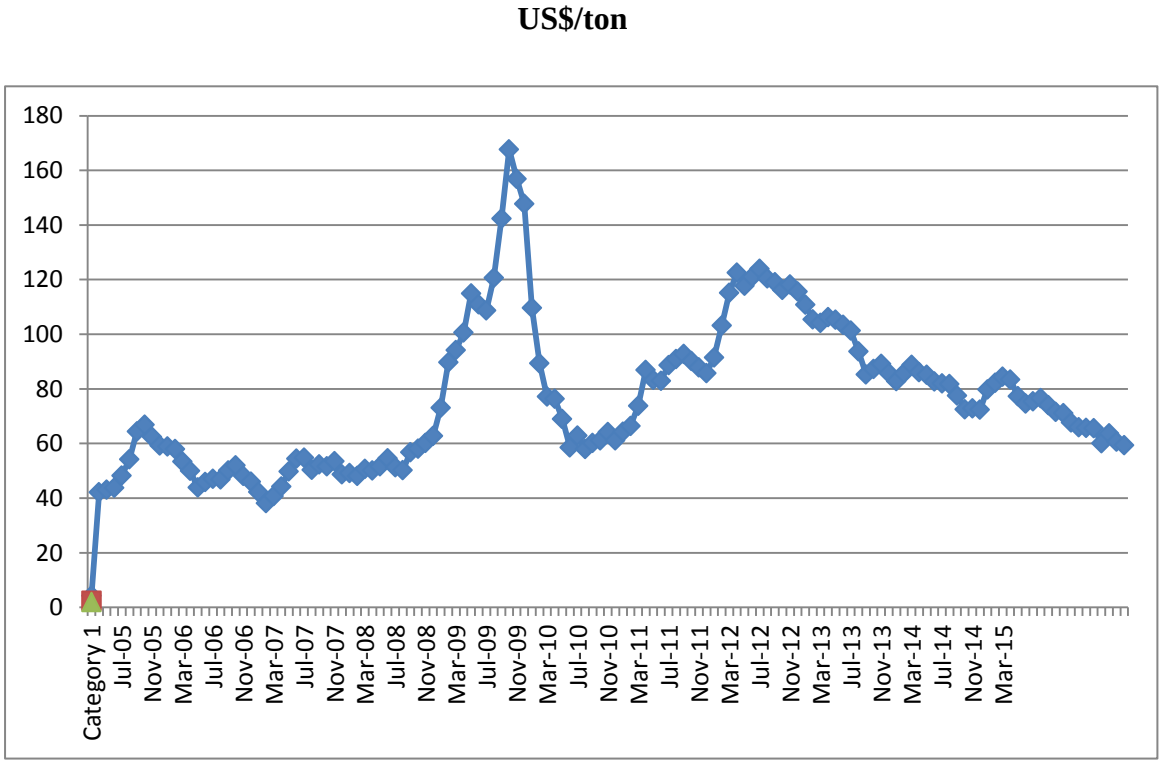


Fig 5.1 Coal price volatility over a 10-year period

2. Financing junior coal companies: The junior coal companies in the Witbank coalfield have restricted access to finance for their coal projects or investments. The coal business is capital intensive and requires substantial funds from conception, development, design, operation and closure of a coal project. Junior coal companies could obtain funds from financiers; having obtained a mining right and a business plan that demonstrates project viability. This is then followed by a track record of the company (often very difficult for new entrants) in the form of financial statements through income statements (total revenue less total costs and expenditures), positive cash flows, that is, cash required for day to day project deliverables and a balance sheet showing total assets and liabilities. Projects are funded by consortium of individuals, financial institutions, government agencies and trust funds. In South Africa, financial institutions such as Investec, Standard Bank, Nedbank and the DBSA are known sponsors of Small and Medium Enterprises (SME's), as well as government agencies such as the Department of Trade and Industry (DTI), Industrial Development Corporation (IDC), Department of Labour, National Treasury, Anglo America Trust Fund and the Department of Mineral Resources (DMR). Funds are also occasionally gotten from foreign based institutions such as the CIFA Mining Fund from Canada and the World Bank.

However, it is always very difficult to obtain funding from these institutions as most of them sponsor mainly 'green projects' on renewable energy as substitutes to fossil fuels or climate saving technologies. The following reasons have been summarised below:

- Environmental issues associated with coal projects and regulations on climate change leaves a certain degree of uncertainty as to the future of the coal industry. This includes regulations on carbon tax and alternative energy substitutes. For coal companies with marginal profits such taxes could greatly affect the overall bottom line of their businesses.

- Competition from junior coal companies in the industry vying for similar funding. Only a few junior coal companies have positive cash-flows that are sufficient enough to justify loans or investments from financiers.

- Business confidence in investing as a number of junior coal companies have been liquidated in the past few years, some before the end of the coal project or the business life of the junior coal company.

- Financiers are becoming more risk averse to the funding of long term coal projects due to the cyclical nature of coal projects and unpredictable market forces in the coal industry that determine future coal prices and demand and supply of coal products. These make project viability and profitability more difficult to estimate.

3. The Witbank coal reserves which have long been known to host top quality and easily mineable coal seams, are fast depleting. i.e. much of the "low hanging fruit" or sweeter coals have been extracted over the years for lucrative high-value export purposes. Seams being mined now are generally lower in quality and often more complex to extract, with shallow seams being exposed to greater levels of oxidation, and deeper seams to heat affects from sills and dykes that abound in certain sectors of the coalfield. Such issues require careful mine planning and control. As a consequence of the fast depleting reserves of good quality coal, many junior coal companies who have relied heavily on supplying coal to Eskom and other industrial consumers are now finding it more challenging to meet the contractual coal quality supply requirements. In such cases, it is essential to maintain good and consistent quality control to meet the customer's boiler operational and efficiency requirements, so mining companies are faced with selectively mining the better quality coal sections of a seam or mining whole seams followed by washing to obtain the grades required by consumers.

Such steps require more complex considerations in mining and production operations than si ply mining and selling run-of-mine coal. Such experience is often lacking in many junior coal mining companies.

Many junior coal projects are nearing end of mine life because they have chosen to develop some of the smaller blocks of coal lying between, or adjacent to, the large blocks mined by the major coal mining companies. Those smaller "parcels" of coal are often not large in quantity or prime in quality and have often been previously discarded by earlier mining companies.

4. Legislative Framework: Further challenges facing the Witbank junior coal miners are centred on the legislative framework with regards to obtaining prospecting and mining rights, complying with safety, health and environmental laws and obligations as well as evaluating and reporting resource and reserve estimates in line with the SAMREC and SAMVAL codes. In many cases, junior mines do not employ specialised staff to handle such specialised legal and technical requirements and are therefore forced to resort to employing consultants. This adds to the financial burden of development and adds time to the inception of operations.

5. Barriers to entry: In addition to legislative requirements on Health, Safety and Environmental issues, Eskom has changed its coal procurement system, which makes it more difficult for junior coal miners to supply coal to power stations. The common practise in the past was simply for a junior coal miner to approach Eskom and sign a supply or off-take agreement as long as their coals meet the required specifications. Now, however, a junior coal miner has to submit a 'request for proposal' to Eskom and wait for approval which could take lengthy periods of time especially if certain supply criteria have not been met. The most challenging is providing a valid B-BBEE verification certificate which requires a BEE ownership of over 50 %. Many junior coal companies only have a total ownership of between 26 % and 30% B-BBEE shareholding. Other challenging supply requirements include;

- Adding value to in-situ coal with qualities that do not meet Eskom specifications. As such, there would be need for proof of beneficiation. This includes washing, crushing, screening, de-stoning or beneficiation of the coal to improve the qualities of the coal supplied to Eskom.

- Beneficiation methods and blending ratios - Projected production for Eskom supply (expected qualities, proposed quantities). Some junior coal companies do not have wash plants in certain collieries and may lack sufficient expertise to carry out such projections.

- Logistics / transport options with indicative pricing- often difficult to evaluate.

- List of directors and shareholding.

- Certificate of compliance with the Employment Equity Act (if employees number more than 50).

- Supplier development and localization- committing to the development of black owned small medium enterprises in the local communities where they operate. This includes auditable skills development and job creation beneficial to identified communities surrounding their coal operations.

6. Lack of skills and knowledge required to manage the operations on a coal mine: Many junior coal miners do not possess the right level of skills to adequately manage their coal operations and as a result risk huge financial losses or reputational damage to their business entities. Such gaps and shortages in skills usually occur when the junior coal company is not able fill all positions with the right number of skilled personnel, or certain positions lack the required skilled personnel to carry out industry-specific job functions. It is also not uncommon that the proportion of semi-skilled and unskilled junior level personnel is quite large compared to that of the mid-level and senior level personnel who are skilled, therefore creating more skills gaps in those companies. Also, management often deploys personnel with qualifications and experience which do not match those that are ideal for a particular job. This may be due to declining number of professionals in coal related disciplines as a result of an ageing work force, changes in career paths, emigration to countries with better remuneration and employment in larger or well established coal companies. Usually, the management's motive for deploying a candidate who holds qualifications and experience not specific to the coal industry is that they can develop the industry-specific skills within an acceptable period. This in itself is often insufficient and should be backed with appropriate training and mentorship programs for such personnel. Some examples of impending skills gap and shortages in junior coal operations include the following;

- Core logging during exploration; JMC's often deploy the services of consultants (outsourcing) with cost implications and sometimes with unreliable data.
- Mining methods and equipment selection.
- Coal handling, preparation and storage, with emphasis on coal analysis, sampling techniques, stockpiling, and washing or beneficiation to derive the required coal products.
- Logistics in coal transportation and supply chain management.
- Coal marketing fundamentals such as demand and supply, pricing, and contract agreements.
- Safety, health and environmental issues.
- Mine closure and rehabilitation.

7. Lack of professional service providers and adequate databases to assist in building and supporting of mining operations: The quality of data available to make informed business decisions is often insufficient, outdated or unreliable which is a major challenge for junior coal companies. For example, the percentage yield in washability tables is normalised to 100,00 per cent without taking cognisance of the percentage fine coal fraction, normally the -0,5mm size fraction and will therefore only represent the yield of the +0,5mm fraction. Also, combining or composting coal samples to establish averages is only approximate and when analysed the values or data obtained could be highly biased or far from accurate. In many cases as well, fixed carbon by difference is dependent on how correctly captured the other coal parameters are which is unreliable. Inaccurate coal data could be costly to investors as coal parameters largely determine coal markets and prices for coal products. The custodians of such database such as the Chamber of Mines, DMR, and Council of Geosciences should ensure that such data are adequately captured and updated regularly by experts, professionals or competent persons in the coal industry and should be close to recognised international reporting standards. There are many investors who have acquired prospecting rights without adequate knowledge of the coal industry and have sought professional assistance from service providers in the industry to explore and further develop their mining assets. The challenge is that many service providers do not deliver the required professional service which apart from being very costly to investors may result in a coal

project being poorly developed, over budgeted and behind schedule to the original project plan.

A suggestion would be to establish a network of professional service providers in the coal industry who can register as a consortium to render professional services in accordance with specific requirements to the junior coal miners. The services provided can also be reviewed or audited by independent consultants to ensure that the best possible output is achieved.

8. Poor logistics and infrastructure to transport coal products to market destinations: The Witbank junior coal miners are faced with a number of challenges with regards to transport infrastructure and logistics for coal supply. The redistribution of coal by junior coal miners has to be well coordinated for coal products to get to their various markets or end users. This is hinged on a number of elements in the coal supply chain and they include the following:

(i) The mine; where the processes of mining, beneficiation, stockpiling and sampling take place. It also includes the load out facility for the coal products.

(ii) The Inland terminal; where the coal products are received either by road, rail or conveyor, stockpiling, blending and the load-out facility usually with a road or rail interface.

(iii) Transportation (road or rail); The roads from the inland terminals should be connected to national roads, road loading facilities and road weighing systems and linked by the nearest rails to the main rail line.

(iv) Port terminal or powers station; These include roads for receiving the coal products, off-loading facility, rail sidings, rail off-loading facility, stockpiling, ship loading and shipping.

The major coal market for junior coal miners is Eskom hence transportation infrastructure and logistics are vital to their business operations. Thermal coal is transported from junior coal mines to ESKOM power stations; approximately 30% or 40Mtof its coal by road which is costly and socially unacceptable. The remaining 60% or 80Mt is transported by conveyor and 10% or 13Mt by rail.

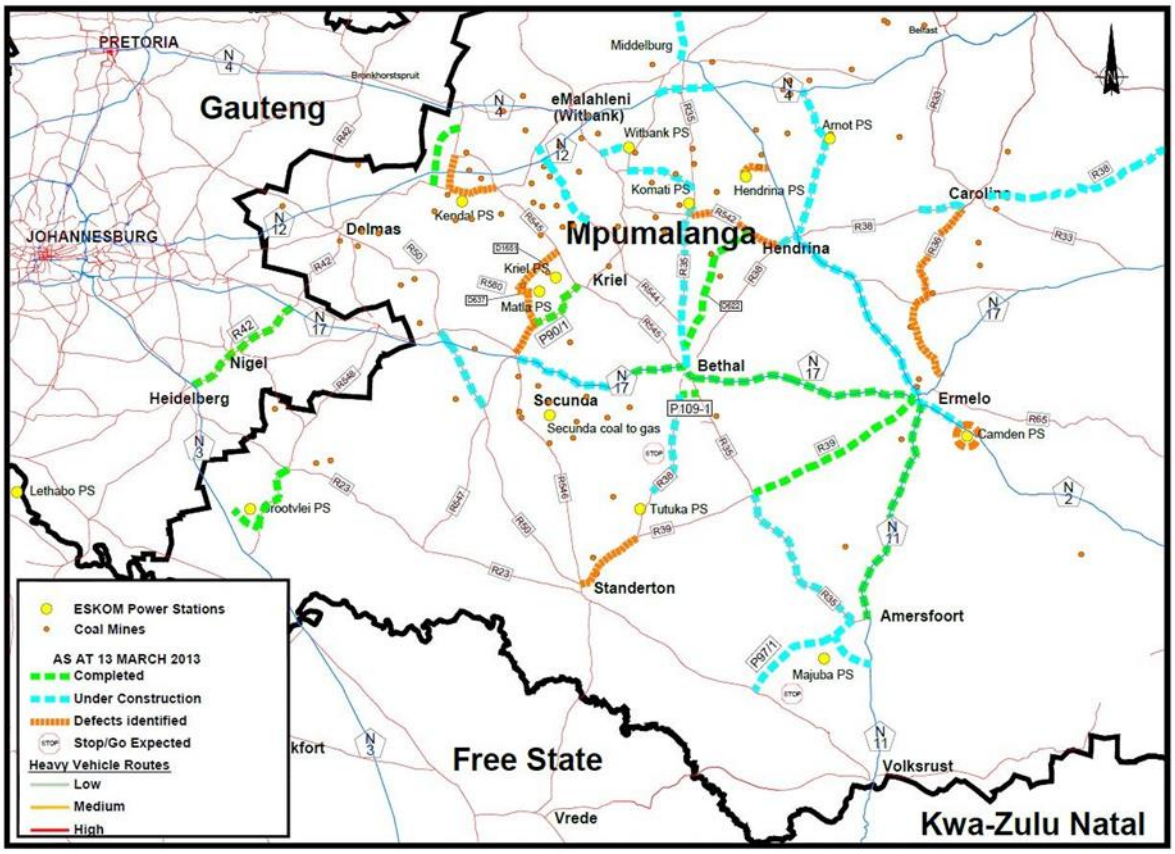


Fig 5.2. A map of the Witbank area showing Eskom's coal haul road network. **Source:** (Eskom task team on transportation infrastructure and logistics, 2015)

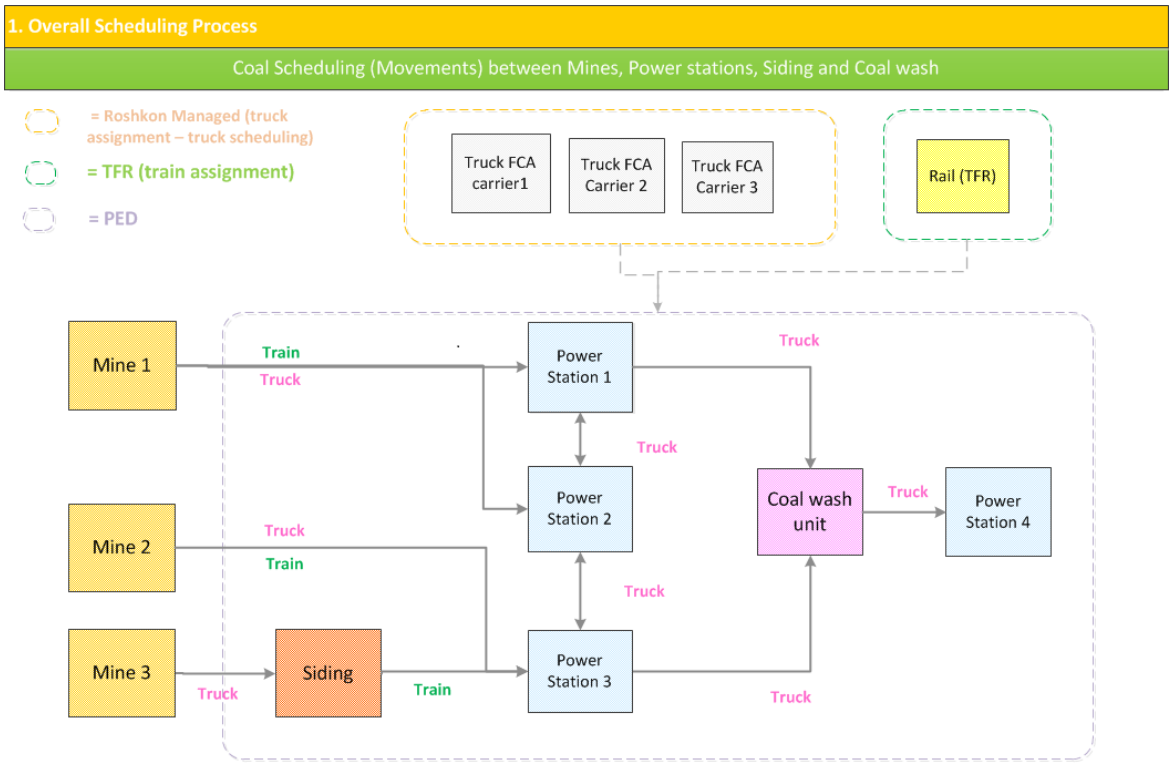


Fig 5.3 Coal Scheduling between coal mines, power stations, sidings and coal wash plants. **Source:** (Eskom task team on transportation infrastructure and logistics, 2015)

The major challenges with regards to transportation infrastructure include;

- Fiscal constraints because the transportation industry requires new sources of investors or financiers who have justifiable reasons to invest in that industry.
- The infrastructure must be accessible by new coal entrants.
- Infrastructure development is highly capital and cost intensive. Once executed, it may result in higher tariffs being imposed on users.
- In times of oversupply of transported coal ahead of actual demand, it may be difficult to ascertain who bears the transportation costs. This puts a huge strain on transportation logistics.
- Investments in transportation infrastructure may not be viable during cycles of low coal prices.
- Investments in transportation infrastructure are faced with financial risks due to timing and coordination of logistics and supply chain management which could result in huge financial losses.
- Investors or financiers have to face the enormous scale of coal projects, particularly Greenfield projects that may have some degree of foreign ownerships, unless the financiers are predominantly foreign based to ensure success of the investment.
- Investors or financiers are also faced with political risks such as changing government policies on coal transportation and use.

The major challenges faced by junior coal miners with respect to coal exportation include the following;

- **Markets and coal quality**-The current export market conditions particularly declining global prices and demand make it continuously more difficult for junior coal miners to export coal. They have small production figures and subsequently export allocation at the

RBCT. In addition, there is a growing market for RB3 quality coal which is a prescriptive specification by the DMR.

- **Logistics**- The take- or- pay agreement with TFR is too onerous on junior coal exporters. There are constraints in production and lack of flexibility. Loading equipment from TFR are too onerous on junior exporters with poor quality and control constraints at point of dispatch. Compliance with legal framework is also a major issue.

- **Funding**- Rail rate and Quattro throughput charges are not adjusting to changing market conditions. Also, due to low coal prices, long-term commitments and uptake is uncertain. It makes it really difficult to plan into the future.

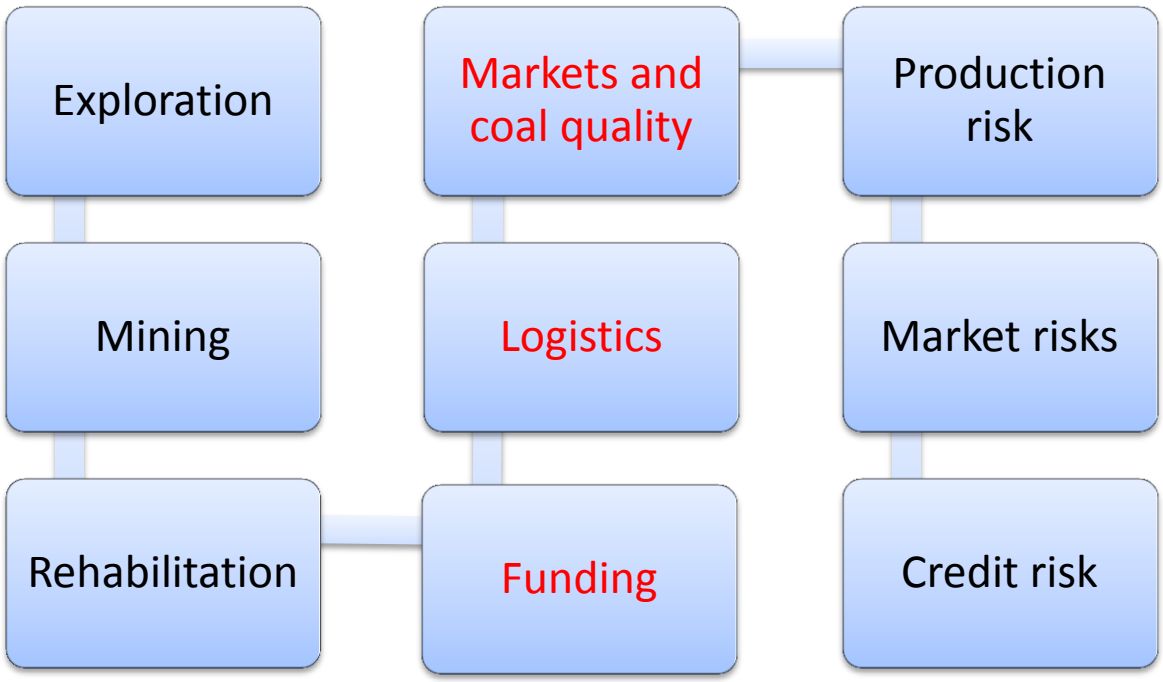


Fig 5.4 Coal exportation challenges for junior coal companies. **Source:** (Liezl Bottman, 2015).

The following key issues need to be addressed as soon as possible in the marketing chain;

- A reduction or subsidy in rail tariffs particularly when the export margins are below sustainable levels.

- The government and state owned companies should stand in for TFR financial guarantees, in a similar way to the Transvaal coal owners association of 1972. They supplied thermal coal to Japanese Steel Mills for over a 10-year period which resulted in the construction of the RBCT.

- There should be flexible train handling times to accommodate logistics and loading infrastructure.

- There should be flexible train scheduling to accommodate production.

- New coal markets should be established on the African continent to grow export coal volumes.

- The principle of "use it or lose it'' amongst junior coal and some major coal companies should be applied to optimise export coal allocations at the RBCT. Coal stockpiles can be consolidated amongst junior coal miners to increase export volumes at the RBCT.

These challenges impact significantly on business investor confidence and on the overall success of the junior coal mining sub-sector per se. As a consequence, many junior coal miners who may have obtained mining rights for coal deposits some based on fairly inaccurate reserve, resource and quality estimations, have had little or no option to develop those deposits into actively producing mines or assets. The most common practise is then to sell those mining rights to another willing junior or to a major coal company who might be able to buy and develop such assets along with others in the vicinity. This precludes the original intentional of owner-development and BEE upliftment.

5.4 OPPORTUNITIES IDENTIFIED BY THE WITBANK JUNIOR COAL MINERS

5.4.1 The Potential for Cooperative Development between Junior Coal Miners

Given the constraints of such single entities, junior coal miners have the opportunity to consider alternative structures for their collective benefit. Collaboration, or the formation of *cooperatives*, in the simplest terms, is the process of working together to realize shared goals and objectives amongst individuals, organisations, and companies or business entities. Collaboration amongst junior coal miners has become a topic of renewed interest in recent years, and most of the relevant stakeholders in the coal industry have urged junior coal

miners to collaborate with one another for the prime purpose of optimising value addition whilst also stamping their collective BEE credentials on the South African coal industry.

Collaboration or *cooperative structures* can occur at various stages of the coal value chain, i.e. from collective exploration, through shared washing facilities to community marketing of coal products and beyond in terms of sustainable development and corporate social responsibility. Some of the key prerequisite factors required for effective collaborations would include;

- Adequate finance due to the capital-intensive nature of coal projects.
- Research and development as well as the necessary expertise required to drive innovative collaboration between junior coal miners.
- Clustering and linkages to enhance the treatment and movement of joint owned coal assets, these to include relevant infrastructure such as mining equipment, wash plants, rail sidings, conveyors, haulage trucks and port allocations.
- Legislative framework to support effective collaboration among junior coal miners.

5.4.2 Benefits of operating cooperative joint ventures

The benefits of cooperative joint ventures would include the following:

1. Witbank coal reserves*:*

As the extraction of coal in such small and widely dispersed locations is becoming increasingly more costly and difficult to extract, collaboration in cooperative ventures would see the junior coal miners forming structures which could jointly develop the combined assets more effectively and feasibly. This could be achieved by designing more innovative and efficient opencast or underground coal mine operations taking into account shared mining methods and equipment, installing centralised washing plants for common use and, most significantly, undertaking communal marketing structures which could undertake market analyses to identify impending coal markets that could be supplied by such collaborating companies in the short, medium and long term. The shared asset development could also see cost effective collaborations with vendors, suppliers and service providers, operating

internally or outsourced, to provide other necessary services and infrastructures as required for the project.

Such some joint cooperative situations could provide common facilities including the following;

- A site layout: surface and underground mine blocks, load out areas and routes for conveyors or rail sidings and site access roads.
- Power supply: transmission lines and connection to the main power supply grid system based on technical, economic, social and environmental considerations.
- Water supply**:** water treatment and storage facilities required to provide potable and utility water requirements to support the facilities. Water supply systems will be designed to meet industrial, provincial and local standards.
- Waste water handling: provisions for adequate wastewater disposal systems to meet the project standards.
- Heavy maintenance workshop: a facility designated for haulage trucks and large support equipment maintenance.
- Mine Warehouse: a common location designated for all mine materials, supplies and equipment or machinery parts.
- Coal Laboratory: a facility equipped with the necessary equipment required to perform daily onsite coal analysis.
- Transportation: facilities for mine access, light vehicle roads, haul roads, personnel transport, and coal transportation to the various inland markets or export terminals.
- Administration Block: for all management and administration.
- Short Term Housing: facilities for on-site officials
- Access control; security control

2. Safety health and the Environment:

Junior companies could further collaborate to remediate the impacts of their coal activities on the health, safety and wellbeing of relevant stakeholders such as employees and members of affected communities. Collaboration in this sense is easily achievable since the partners would share in the agreed corporate governance goals in line with sustainable national development and corporate-social responsibility.

With regards to health and safety, such groupings could develop and enforce a safety culture for all employees and could do so by applying, tracking and reporting health and safety performance measures in line with internationally recognised health and safety Management Systems such as the OHSAS 18001 standard.

With regards to the environment, such groupings could develop corporate and operation-specific Environmental Management Systems throughout mine planning, development and operations, consistent with the ISO 14001 standard. In addition, this could apply the appropriate standards of environmental performance towards sustainable mining. Also, due to the nature of coal mining activities and their impending impacts on the environment, all necessary EIA's, EMP's and adherence to environmental, health and safety legislations could be better and more rapidly achieved.

3. *Corporate competition*.

Very few junior coal mining companies dominate the coal industry in terms of sizeable coal assets, production, sales and market share. Competition is rife between current junior coal companies who vie for rights to the same coal deposits, or for customers, markets, transportation infrastructure and storage facilities at coal ports and terminals. This is largely the case for the junior coal mining companies under review in this study and as they exist at present. On the other hand, collaboration and consolidation could see the consortium of junior coal mining companies upgrade and increase their reserve base through asset expansion in the form of improved reserves, exploration, extraction and product enhancement whilst boosting production tonnages and market penetration.

Even though collaborating parties stand the risk of disclosing the identity of customers there could be government and private stakeholder intervention to ensure that junior coal miners do not overstep their boundaries in terms of the competition law. Fortunately, however, the

Competition Act offers some degree of protection against unethical business practices therefore encouraging collaborations as long as they are strategically poised to explore diverse opportunities and effect the well needed changes in the South African coal industry.

4. Investment for junior coal mines.

Investment in coal mining activities is on the decline in South Africa. As emphasized earlier, this is mainly due to volatile coal markets and the lack of investor confidence in high risk smaller entities. However, innovative planning, creative thinking and consolidation with respect to a cooperative coal asset base, whatever the degree of interaction or amalgamation, could increase the productivity level and profit margins of collaborating junior miners and thereby provide a better financial base with lower risk and increased confidence leading to potential greater investment funding.

By way of example at the lowest level of collaboration, WH does not possess a washing plant at its Colliery which is situated in very close proximity to TR Colliery which does host a washing plant to service its box cut mine. Coal from WH colliery could be transported to TR Colliery washing plant though the box cut and jointly the companies could arrange for transport of the individual products to their respective destinations. This collaboration would assist both companies by sharing operational and maintenance costs for the wash plant and perhaps provide higher value products and thereby access to more buyers.

In similar vein, junior coal miners could exploit other avenues by buying or leasing coal equipment from other juniors during project off-cycles or closures.

5. Infrastructure and logistics

In some quarters, investors do not see a justification to invest in an expanded coal transport infrastructure because it is perceived that coal from the junior coal mining sector is high risk, low in quantity and quality, and generally found in uneconomic coal blocks in widely scattered geographical locations. By collaborating in clusters in closely located areas, junior coal miners would benefit by developing centralised stockyards from which their coal, or a combined shipment of mixed coals, could be transported on via rail to designated locations. This would assist investors in transport projects, and rail in particular, to determine project viability in terms of coal availability, tonnages, overhead costs, transport tariffs and hence long term feasibility.

Currently, junior coal miners with allocations at RBCT for export coals find it difficult to meet the total capacity requirements and, as such, they risk penalties or revocation of slots at that port according to the 'use it or lose it' principle. By collaborating or amalgamating, junior coal miners could resolve such capacity issues by providing higher quantities of coal on a more consistent and regular basis.

6. ***Marketing opportunities for the Witbank Junior Coal Miners***

With the benefit of government support in terms of BEE structures, those HDSA's wishing to establish a business entity to mine and market their coals should be in a position to take optimised advantage of this preferred status. By way of example, Eskom can only acquire coal products from coal mining companies that have 51% BEE status or higher. Similar contractual obligations arise with certain other large scale consumers thereby providing a ready market for such junior coal mining companies.

Eskom is the largest consumer of coal in the country and, due to Eskom's ever increasing demand for thermal coal to supply its 14 coal-fired power stations, this market is the biggest primary target for junior coal miners. Furthermore, Eskom accepts low grade coals per se, indicating that in many cases, the coals being mined may not require expensive washing processes in order to meet Eskom's contractual quality requirements. However, each power station has boilers that require specific stated specifications and, as such, quality requirements must be met.

Junior coal miners are known to have supply contract types with Eskom such as the 'cost-plus' long term contract, 'fixed price' long term contract and 'fixed-price' short to medium term contract. While each has merits and demerits, junior coal miners can profit considerably from these contract types. What is of vital concern, however, is the long-term supply of coal to Eskom for electricity generation which will need to be supplied by the junior coal mining subsector. Joint ventures, mergers and acquisitions among junior and major coal companies will be required to release or acquire more assets, exploit larger reserves and expand coal projects in order to serve this important market.

Apart from Eskom, junior coal miners in the Witbank coalfield have the opportunity to supply many other coal consuming industries in the country. These include the synfuels, chemical, iron and steel, ferroalloy, pulp and paper, brick and tile, agricultural, transport and cement industries amongst others. In all cases, high to medium grade coals are required, some

with further specialised specifications. In almost all cases, washed products, some in specific sizes, are required. With the impending advent of coal-fired Independent Power Producers (IPPs), junior coal miners may be required to supply coal to this new market as well.

With depleting Witbank coal reserves, junior coal miners could also exploit alternative sources of energy to align their operations to evolving global regulations on green-house gases emissions. This would include taking over existing discard stockpiles and upgrading those for use in clean coal technologies such as fluidised bed boilers or exploiting unconventional gas resources such as coalbed methane and underground gasification in specific locations.

In terms of export, opportunities continue to exist for junior coal miners to supply various markets abroad, despite falling coal prices and shifting demands from coal to cleaner sources of energy. Currently markets of choice lie predominantly in the Middle and Far East, with some exports going to Africa and Europe. Export coal specifications markets have coal product specifications that must be met by junior coal miners and this is difficult for some especially in cases of those who do not undertake beneficiation of the coal products. Export coal specifications vary from market to market, with blend coking coal and anthracite products being the most specific. This is difficult for some junior miners in cases where beneficiation of the coal is required, but markets to India and the Far East need medium to low grade thermal coals and these are ideally suited to the junior mining fraternity. Richards Bay Coal Terminal (RBCT) already allocates a considerable proportion of its annual throughout to junior mining companies through a stated share block.

5.5 OTHER COAL OPPORTUNITIES FOR THE JUNIOR COAL MINERS

There are opportunities which exist for the junior coal miners in the Witbank coalfield to explore alternative sources of energy with the purpose of securing the future of coal resources available to them, further strengthening the bottom line of their business ventures. These may include greenfield projects on underground coal gasification, coal bed methane and coal mine methane mainly because top quality coals in the Witbank coalfield are fast depleting and exiting legislations on coal mining are fast changing and becoming more stringent for the junior coal miners. Therefore, with such new and more stringent safety, health and environmental legislations due to be promulgated in the near future, opportunities exist for

junior coal companies to build mines and carryout coal projects utilising new and more modern initiatives such as carbon capture and storage.

1. Underground coal gasification (UCG)

Underground coal gasification (UCG) involves burning coals underground to yield carbon dioxide (CO_2) suitable for power generation, industrial heating, and other liquid or gas fuels. It is a clean source of carbon energy gotten from coals or coal seams that are usually thin (less than 3 meters) very low in quality, deeply buried and hence un-economic to mine. The coal seams are drilled with vertical holes (production and injection wells) and evenly spaced so that upon burning, the gases flow from the injection wells through to the production well and up to the surface. There are different styles to this technique as others only require burning the coals between the vertical holes drilled to form a gasification front linked between the holes by hydro fracturing and brought to the surface. Other techniques use already mined tunnels and the tunnels linked together with drilled holes for the gasified coals to simply flow to the surface.

In many developed countries like the USA, Russia, Uzbekistan, Australia and the United Kingdom UCG has been extensively research, and developed to the extent that they have commercial- sized plants that use this technology, with on-going UCG projects to further harness this source of energy. The junior coal miners could initiate such UCG projects as vast amounts of coal seam are low in quality, deeply buried and uneconomic to mine. In summary, the benefits of UCG technology include the following:

- It utilizes low quality deeply buried coal seams that are economically un-mineable.
- It reduces costs in the actual coal processing plant.
- It has a lower impact on the environment compared to actual coal mining.
- It does not require ash/waste and coal handling at the surface.
- It extracts the CO_2 in such an efficient manner which experts often categorize as “clean coal technology”, in line with global greenhouse emission policies.

The bottlenecks in using UCG in the Witbank area include the following:

- There are difficulties in understanding the dynamics especially of commercial UCG projects in terms of reaction kinetics, heat transfer and gas flow through the production wells or the drilled holes at depths below.

- It may still have impacts on the environment such as on underground aquifers which is not taken lightly in South Africa due to the on-going concerns in reducing accessibility to fresh water.

- There are still uncertainties about commercializing UCG in terms of project duration, profitability, capital expenditure, and so on.

2. Coal Bed Methane (CBM)

Coal Bed Methane is naturally occurring methane gas trapped under pressure within coal seams and surrounding rocks in their cleats, cracks and fractures during coal formation (coalification). Coal Bed Methane increases with the rank and depth of the coal and can be extracted by injecting the coal seams under pressure with a compound mixture of water, foam and sand to hold open the fractures and release the methane gas. The technique is done in such a way that it does not affect the properties of the surrounding coals hence it could be applied simultaneously with actual coal mining.

In developed countries CBM has been well researched and considered to be a very vital energy resource, and countries such as Ukraine, Russia and China have well established CBM projects that extract trillions of cubic feet (TCF) of methane gas every year. The Witbank Coalfield, even though it contains mainly lower rank bituminous coals, still has the potential to bear large volumes of CBM, due to the vastness of the coalfield (containing various ranks of coal) and depth of the coal seams. More feasibility studies and research has to be conducted to determine CBM viability in the Witbank Coalfield in terms of replacing coal and other fuels as a source of energy, breaking into the natural gas market, pricing, capital expenditure for CBM projects and environmental impact assessments. The benefits of CBM include the following:

- It could be extracted without affecting the properties of the coals in the area.

- Its extraction can facilitate actual coal mining since a lot of boreholes are drilled to release the gases. Sure boreholes are used in geological resource evaluations and also expose the coal seams for extraction.

- It has very little impacts on the environment and is a way of getting rid of the dangerous methane gas that coal mining is faced with.

- It could be a vital source of revenue if adequately harnessed.

- It also does not require coal and waste handling at the surface.

- Junior coal mines could use methane gas (as is the case with gas turbines) to generate electricity locally. This electricity could be used on remote mine operations.

However**,** the bottlenecks encountered in the development of CBM in the Witbank coalfield include the following:

- Ownership problems may arise because the MPRDA Act of 1998 has it that companies can have two separate rights, one for extracting the methane gas and the other for mining the coal. Thus, a new or existing company willing to venture into CBM extraction may clash with the company already mining coal in the area.

- Ownership rights for abandoned mines which may still have large volumes of CBM has not yet been established. Unless the ownership right to be applied for can be revoked from the original mine owner which without serious reasons is unconstitutional.

- Complex technical and geological problems may arise pertaining to the extraction of the CBM such as coal permeability, type and quality of the methane gas.

- It may not be able to break into the natural gas market considering that gas prices are generally lower than other energy fuels, coupled with other project costs and capital expenditure.

3. Coal Mine Methane (CMM)

Coal Mine Methane is naturally occurring methane gas that is released from coal seams and surrounding rocks by fracturing during actual coal mining. Methane is a very potent and highly explosive gas that coal mines tend to remove during mining operations otherwise

known as degasification. However, methane gas trapped in coal mines are removed through ventilation. Degasification is achieved by drilling vertical boreholes from the surface of the mine, in goaf areas (areas with collapsed coal strata) and even horizontal boreholes inside the mine to release the methane gas. Most coal mining companies in the Witbank coalfield extract the gases in advance of the actual coal mining to reduce the hazards (explosions and air pollution) caused by CMM. If adequately harnessed, CMM could serve as vital sources of energy. In the USA for example, about 17 CMM pipeline projects were established supplying about 4.2 billion cubic meters of CMM every year (USEPA, 2002), utilizing more than 85% of the captured methane gas. In Australia, the captured CMM was used by BHP Billiton at their Appin colliery to generate 7% of energy. This scenario is similar to those in the United Kingdom, Russia and Ukraine who have major coal basins with huge CMM potentials. China still contributes the highest CMM emissions in the world till date, while countries like Germany are also highly placed on that list. The junior coal miners in the Witbank coalfield could potentially harness this CMM. The benefits of CMM include the following:

- It reduces the hazards associated with coal mining operations such as explosions and air pollution.
- It reduces greenhouse emissions into the atmosphere.
- It can be used as an alternative source of energy in electricity generation, and production of other chemical and industrial fuels and compounds.
- It also does not require coal and waste handling at the surface with little environmental impacts and could serve as a major source of revenue.

The bottlenecks include the following:

- It may be difficult to compete in the natural gas market especially for medium to low quality methane gas.
- There may be ownership problems and conflicts in ownership rights.
- There may be problems associated with storage of the methane gas especially for mines not close to the gas pipelines/network, and if not available, high capital expenditure and costs associated with transportation would be required as huge volumes are expected.

4. Coal extraction by biotechnology

This technique involves desulphurising coals by microbiological activities that react mainly with the inorganic components in low quality coals. In other words, the microbiological activities remove the sulphur in those low quality coals increasing the quality for combustion (thermal coal), and eliminating Sulphur which is hazardous to the environment. Even though it is still being research and developed in most countries, it has the following benefits:

- The junior coal miners could make use of large quantities of low quality coals in the Witbank coalfield considering that high quality coals are fast depleting.
- It could really go a long way in extending coal reserves of the Witbank coalfield.

The bottlenecks include the following:

- It sounds impractical to concentrate microorganisms in coal seams below and at great temperature and pressure depths to carry out such microbiological activities or desulphurization.
- It still involves extracting those low quality coals which entails every single bit of actual coal mining including environmental impacts.
- It may be difficult and capital intensive to carry out on a very large or commercial scale, since a separate laboratory or facility would be required to engineer those microorganisms under certain biological and chemical conditions.

The current status of clean coal technologies and technical responses on greenhouse gases can be found in appendix C.

5.6 SUMMARY

The junior coal industry accounts for approximately 9% of the total coal produced in South Africa with most operations being small to medium scale averaging only between 1 and 10 Mtpa. Most of the junior coal companies in South Africa are BEE owned and only a few are listed on a stock exchange such as the JSE. There are several opportunities which exist for the junior coal miners; they could supply coal to several domestic coal markets in South Africa, with Eskom being the largest customer. This is due to Eskom's ever increasing demand for thermal coal to supply its power stations and increase generation capacity at these stations.

Junior coal miners are known to have supply contract types with Eskom such as the 'cost-plus' long term contract, 'fixed price' long term contract and 'fixed-price' short to medium term contract. Though they each have merits and demerits, the junior coal miners could still profit considerably from these contract types.

Apart from Eskom, junior coal miners in the Witbank coalfield can supply other 'local coal users' in South Africa. Some of these include the synfuels, steel, chemical, metallurgical, agricultural, transport and cement industries.

Opportunities still exist for the junior coal miners to supply various export coal markets despite falling coal prices and shifting demands from coal to cleaner sources of energy.

Considering markets lie in the Middle East, Africa, and parts of Asia and Europe. However, both the domestic and export coal markets each have coal product specifications that must be met by junior coal miners and this is difficult for some.

Furthermore, opportunities still lie for junior coal miners in coal transport infrastructure. There have been a number of initiatives between government (public) and private stakeholders to develop coal transport infrastructure in South Africa. This could see junior coal miners of the Witbank area have access to more domestic and export coal markets through, ports, terminals and rail.

In addition, joint ventures, mergers and acquisitions among junior and major coal companies could be seen in positive light. This could serve as an opportunity to acquire more assets, exploit larger reserves and expand coal projects. With depleting Witbank coal reserves, junior coal miners could exploit alternative sources of energy to align their operations to evolving global regulations on green-house gases emissions.

The major challenges facing the Witbank junior coal miners are often centred on the legislative framework with regards to obtaining prospecting and mining rights, complying with safety, health and environmental laws and obligations as well as evaluating and reporting resource and reserve estimates in line with the SAMREC and SAMVAL codes. This is further compounded by restricted access to financing of junior coal projects, skills and knowledge gaps in the junior coal industry, transportation logistics, infrastructure, barriers to entry, lack of access to adequate data base and service providers and highly volatile coal

markets in which junior coal miners are exposed to. These challenges impact on business investor confidence and the overall success of the junior coal industry.

Collaboration with respect to a group of junior coal miners or companies in the Witbank coalfield may be the answer to greater success in the medium to long term. Collaboration in cooperative ventures is the process of working together to realize shared goals and objectives and could occur at various stages of the coal value chain and beyond in terms of sustainable development and corporate social responsibility. Collaboration requires adequate finance, research and development, clusters and linkages and a supportive legislative framework for it to thrive. It becomes necessary for junior coal companies to collaborate with each other due to depleting Witbank coal reserves where by the remainder of viable coal assets could jointly be explored or developed by junior coal companies in the region. Collaboration is also necessary due to competition, declining number of coal investors and the need to further identify opportunities whilst managing risks and challenges facing the Witbank junior coal miners.

CHAPTER SIX

A PROPOSED PROTOCOL FOR DEVELOPING AN EMERGING COAL MINER OR UPGRADING AN EXISTING JUNIOR COAL MINING COMPANY

Based upon the data sought, accumulated and collated in the earlier chapters, this chapter presents a set of guidelines in the form of a protocol for an emerging mine owner to develop a successful mine, or for an existing junior coal miner to upgrade to a more lucrative and successful operating venture. The protocol is presented in the following manner:

6.1 - Introduction
6.2 - The Foundations of a Junior Coal Mining Company
6.3 - Junior Coal Company Assets
6.4 - Business Strategies
6.5 - Risk Management
6.6 - Financial Management
6.7 - Operational Management
6.8 - Team Management
6.9 – Summary

6.1 INTRODUCTION

A junior or mid-tier coal mining company is potentially a high profit entrepreneurial venture that is required to undertake exploration and subsequently develop a coal deposit into an active mine or sell the newly discovered concession to other investors wholly or partly in the form of a joint venture or shareholding. The latter step is often the preferred option as a junior coal licensee generally has relatively low capital and high expenditure in order to attain and develop its assets and gain employees. Thus, although the scope of operations is structurally less complex in comparison to major coal mining companies, it generally has many uncertainties surrounding its development and ultimately its earnings potential.

Against that generalised background, the purpose of this chapter is to provide a framework with a set of guidelines to assist a junior coal mining company owner to upgrade the company's business credentials and to become a well-established, productive, sustainable and successful coal mining operation. This requires an effective business model centred on

developing its mining assets using key business strategies that inculcate financial, operational, risk and team management concepts.

6.2 THE FOUNDATIONS OF A JUNIOR COAL MINING COMPANY

A number of factors provide the foundation for a mining venture, as outlined by this sub-section.

6.2.1 Coal Industry Cycle

The coal industry in South Africa is at a point in the commodity's cycle where there are many emerging coal miners with rising exploration, development and expansion projects particularly geared to meet increasing domestic coal market demands by Eskom and other local consumers. It is also at a point where there are increasing numbers of mergers and acquisitions amongst existing coal companies to further boost their market shares and financial standings. A junior miner must consider all such opportunities.

The global coal industry is presently at a stage where many coal importing countries are passing laws on carbon emissions arising thorough the burning of fossil fuels and seeking alternative and renewable sources of energy. This is putting a strain on global coal demand and prices are currently low. For example, China which used to be the largest importer of coal globally no longer imports coal from South Africa as it plans to reduce domestic coal use by monitoring coal production and handling from existing coal mines in its country.

However, there are indications that the demand for coal will increase and that prices will start to rise as other export markets such as India are expanding power station capacities that would require more coal. This is vital for the future of South Africa's export market as coal generates the highest foreign exchange earnings of all South African mining commodities (Prevost, 2017, per comm). In addition, many of the large coal mines supplying Eskom will reach their end of life within the next few years, thus the future of coal supply to sustain the country's major power generating utility will fall largely to the junior coal mining fraternity. It is in this context that all steps must be taken to assist this sector to achieve their maximum outputs in the most effective, clean and sustainable way.

6.2.2 Resources and Reserves: Commodity availability

A fundamental step to be taken before moving on to other phases in developing a mine is the coal exploration phase. In this, the quantitative and qualitative measure of the coal available in a potential mine requires to be assessed. Two levels of measurements are considered: A coal *resource* is a concentration of a coal in a deposit that has economic value and that can be realistically extracted at some point in time. It can be classified into indicated, inferred and measured resource on the basis of geological certainty. A coal *reserve* on the other hand is the measured or indicated portion of the resource than can be mined primarily with a defined market in mind and the potential to make a profit. Assessing the resource and reserve requires standardised, experienced and professional services, and once obtained these are reported in the form of a Competent Person's Report (CPR). This is an essential component when drawing up bankable, pre-feasibility and feasibility documents which are required when applying for funding in due course. Coal resources and reserves are vital components of the foundation of junior coal companies. See also section 6.2.1.

6.2.3 Coal Project Value Chain

The **Coal Project Value Chain (CPVC)** encompasses every activity from the exploration phase to mine development, production, beneficiation (processing), marketing and sales of the coal product. Having discovered a coal deposit an advanced exploration is carried out followed by pre-feasibility and bankable feasibility studies. Once these studies have been completed, the mine can be developed for coal production to commence.

The key elements for a junior coal miner to follow in order to obtain a comprehensive and creditable value chain CPVC include the following:

Asset value: The value of the asset (coal) increases from the exploration phase to the bankable feasibility stage after which it flattens and decreases until coal production commences.

Risk: The risk of a coal mining project is greatest during the exploration phase as incorrect data can jeopardize the entire project. However, the risk decreases once the project progresses towards the feasibility, development and production phase.

Capital allocation: Only about 20% of capital is expended up to the bankable feasibility phase as risk is the highest after exploration. After this, the remaining 80% may be expended during the mine development and production phase.

6.2.4 Financial Statement

A critical aspect in the foundation of a junior mine is its financial statement or report. This is a summary of the company's financial activities reported on a year to year basis, otherwise known as the financial year. It is analysed by investors or shareholders of the company to determine the viability of the investment or financial performance of the company in the year under review. The key elements of the financial statement for a coal mine include:

- **Income Statement**: This is the summary of the company's gross and net earnings (total revenue) after accounting for total costs and expenditures to determine whether it has recorded a profit or loss at the end of that financial year.
- **Balance Sheet**: This is a snap shot of the company's total assets and total liabilities.
- **Cash Flows**: This is cash required for the daily activities of the mine.
- **Company Share Price**: This only applies to those junior coal companies listed on a stock exchange which is the current price in which the shares are being traded.
- **Financial Ratios**: These are numerical values based on the relativity of the magnitude of those values and are derived from the company's financial statements to determine the financial standing of the company.

6.2.5 The Coal Mining Project "Pathway"

A further critical aspect in the development of a coal mine entails an understanding of the "pathway" or sequential steps to be taken in order to achieve full success. Of the many junior coal mining projects initiated in recent years, very few exploration projects end up being developed into an operational mine. This is because many of the unsuccessful ones lack the strategies and /or will to focus on the key issues required to sustain mining and which could lead to project profitability. Many embark on exploration projects without addressing the initial phases to the depths that is required, so, by the time the project progresses to the feasibility phase, very few projects can be developed into an operational mine. For all round

success to be achieved, a junior coal miner must strategically plan and execute the coal exploration phase before moving to other phases in the pipeline

6.2.6. The Business Investment Model

The business investment model is a benchmark against which every junior coal mine must be compared. As such, this is fundamental to the development of any mine. This model is made up of the company's mission, team, leadership, cash flow, communication, systems, legal, and product. These may be described as follows:

- **Mission**: A mission statement enables the junior coal company to remain focused in running their business.
- **Team:** A company needs to work as a team with collective inputs from people with different skills and professional backgrounds rather than a single individual making all the decisions.
- **Leadership:** A company needs a good leader that can lead people towards the right direction, a leader who can adequately manage situations in times of business crises.
- **Cash flow:** This is required to keep the project running from exploration through to the start of production where it is able to generate its own income. A business cannot run without adequate cash flow.
- **Communication:** This is required in order to run a business successfully. Internal and external communication has to be effective and efficient amongst staff members, the investors and the outside world.
- **Systems:** Business and operational management systems should operate on the highest levels of efficiency to drive optimum company performance.
- **Legal:** A functional legal team is very important as issues surrounding mining activities may arise at any given time. These may include mining rights and permits, government legislations, royalty claims, and even disputes surrounding corporate- social responsibilities.
- **Product:** The profitability of a company is also a reflection of how well the market receives it products. It also takes into consideration the various stages on the value chain that ultimately lead to the sale of the product.

6.3 THE JUNIOR COAL COMPANY ASSETS

The assets of a junior coal company are those physical products or actionable activities in the coal value chain which include exploration projects, pre-feasibility and feasibility studies and developmental or expansion projects with regard to the development of a fully operational coal mine. The conception and development of these assets are the first steps required in starting up or upgrading a junior coal company.

6.3.1 Exploration

Coal exploration is carried out to determine the nature, location, size and quality of coal that can be economically extracted. Upon raising the required capital for exploration and being granted the prospecting right or permit, the junior coal company would need to analyse all geological information about the area, including surface and subsurface exploration, sample analyses and other infrastructure, logistics, environmental and community-related information that could impact upon successful coal production. The major activities carried out during coal exploration include geological mapping, geophysical surveying, drilling coal for core logs and analysing the core logs for early evaluations of the coal reserve. A junior mine owner should ensure that the resources and reserves of the licensed area held by the company are professionally and correctly assessed. This would entail:

- Employing a SACNASP-accredited geologist with more than 5 years of relevant experience.
- Obtaining a resource and reserve base which must be evaluated according to SAMVAL and SAMREC requirements in order to standardise the methodologies and create a creditable report. Such a report provides information which is transparent, unbiased and not misleading. The reliability of the resource estimate is a function of the quality, quantity and interpretation of available engineering and geological data that should enable an investor to make well informed judgments regarding a coal investment.
- Compliance with health, safety and environmental (HSE) legislations as well as social-corporate governance;

A Competent Person's Report (CPR) compiled from such geological information is an essential component when drawing up pre-feasibility and feasibility documents for funding applications. See also section 6.3.2. Once completed, the junior mining licence holders then

may decide to sell the coal concession to other coal mining investors or to proceed with developing the coal concession into a producing mine

1. Geological maps

Geological mapping comprises the compilation of a base map with an appropriate scale depending on the degree of geological detail required for the exploration program. Mapping is carried out to determine the location of the coal deposit, thickness of the beds and overlying strata and quality variations as well as other geological features that affect the emplacement of coal beds or strata. In the Witbank coalfield it is important to determine the location of dolerite dykes or sills which devolatilise coal beds as well as structural faults that influence mine planning and selection of mining methods or techniques.

Geological mapping is also conducted as part of surface and subsurface investigations on major coal zones using a starting point on the base map which are described as 'markers' such as outcrops of limestone, sandstones and clay beds, zones of diagenesis or unique topographic or palaeontological features.

2. Geophysical surveys

Geophysical surveys are carried out during exploration to further define the sedimentary basin. This includes investigations into the coal-bearing strata and the structural geology of the coalfield. These surveys together with the geological mapping exercise pave ways for advancement into the drilling program, all of which are part of the pre-feasibility and feasibility studies for a potential mine. Geophysical surveys are carried out using various methods such as;

- **Gravity methods;** based on contrasting densities between coals and surrounding rocks in the sedimentary basin under investigation.
- **Magnetic methods;** based on the magnetic properties of coal, basement rocks and other rocks that make up the sedimentary basin under investigation.
- **Electromagnetic methods;** based on contrasting affinities coals and other rock types have to electromagnetic fields generated through a system of electric current. This method is mainly employed in subsurface investigations.
- **Electrical resistivity methods;** based on the electrical resistivity of mineral bearing coals and other rock types under investigation**.** Bituminous and sub-bituminous coals are

known to have very high resistivity compare to surrounding limestone sandstones and shale beds.

- **Seismic reflection methods;** based on reflectance of seismic waves by coals and surrounding rocks in the sedimentary basin under investigation. The pattern of reflectance is used to define rock boundaries as well as structural features such as faults that must be considered in mining operations.

3. Coal drilling, sampling and testing

Coal drilling is required to define the depth and thickness of coal seams and for providing cores (cylindrical rods of coal drilled out of the seams) from which coal qualities can be logged and samples obtained for analysis. Such data provides information on coal lithology and coal quality. The conventional rotary and diamond drilling is used in obtaining samples of core logs. Wide diameter cores are sampled from coal seams for the purpose of obtaining representative washability and carbonization data,. It could also be backed by a float and sink analyses for consistency of laboratory data results and better predictability or projection of coal quality.

6.3.2 Pre-feasibility and feasibility Studies

Pre-feasibility and feasibility studies are undertaken to establish the economic potential of a mining project at increasing levels of confidence. This entails evaluating the size of the coal reserve in order to determine the life of mine, capital and operating costs, mining methods, environmental control to prevent acid mine drainage and/or spontaneous combustion in coal seams and stockpiles, production, beneficiation, coal products, markets, project infrastructure and risk management. Such studies also include economic analysis on cash flows, net present values and internal rates of return, total costs, production taxes and royalties. The junior coal mining entrepreneurs would seek funding from financiers who require this information to evaluate the viability of a coal project. This information is provided in the form of an overall summarising 'bankable' report.

The team to compile such pre-feasibility and feasibility reports would include the geologist who provides the resource/reserve data, a mining engineer who would assess the costs of extracting the coal and a surface plant metallurgical engineer responsible for estimating the cost for upgrading or beneficiating the coal to provide saleable qualities, marketing personnel to estimate the needs in the market place and a manager to coordinate the process.

6.3.3 Coal production and project closure

On conclusion of the mine development phase including environmental assessments and water usage with licencing, the junior coal company enters into full scale production and beneficiation to derive coal products as envisaged during the exploration and feasibility phases with the intention of selling those coal products to various coal markets. Production, beneficiation and sales are carried out strategically to maximize profit or returns on investment. These aspects become routine processes over the life of mine with on-going maintenance, environmental control and mine rehabilitation as land surfaces are disturbed.

Once coal reserves have been depleted to uneconomic concentrations, management would move to close the mine. Thereafter, the company is required to honour various environmental and social obligations in terms of long-term ground rehabilitation, water control and personnel re-training.

6.4 BUSINESS STRATEGIES

In order to be competitive in the industry and in order to ensure sustainability, value addition and business growth, a junior coal mining company needs to adopt, develop and implement *key* ***business strategies***. These would take into consideration the local and global coal industry with respect to coal markets, products, demand and supply, pricing and competition. Also relevant to the coal mining sector are political, economic, social and technological considerations.

Inhouse strategies would need to include analyses of the company, its historic operation and its personnel in terms of strengths, weaknesses, opportunities, threats and key success factors and clear goals should be defined to strive for. These business strategies should be supported by risk management, financial management, operational management and team management.

Examples of key ***business strategies*** are outlined below.

6.4.1 Review of the coal industry and business environment

On the global scene, there have been a number of new developments in the coal industry mainly with regards to climate change and regulations surrounding carbon emissions and carbon tax. These are generally affecting coal demand and prices worldwide with many top coal consumers in the European Union, Asia and the U.S.A resorting to cleaner alternative

forms of fossil fuels and renewable energy. For example, China has reduced coal imports by over 15Mt due to policy changes on carbon emissions despite new technologies for cleaner coal or technologies that could generally increase power plant efficiencies. Exports from Indonesia as well as Australia have declined considerably due to low coal prices with coal companies being forced to recapitalize and diversify their investment portfolios. Electricity production in the U.K from coal-fired power stations has been the lowest in over 5 years while South Africa's thermal coal exports also fell to just above 10% in 2015. These developments have put a strain on the bottom line of many coal businesses not only in South Africa but around the world with coal companies recording huge annual losses, declines in share prices, investor confidence and sale of major coal assets such as Anglo America.

According to the World Coal Association, coal in Europe and the U.S.A is struggling to compete with lower priced natural gas which has always been a non-renewable source of energy or fossil fuel. Projections or forecasts for a cyclical increase in coal demand and prices globally could happen in the next few years and this is an implication for a junior coal company to upgrade its coal mining activities and investment. A second implication is that there are many developing countries in Africa and Asia, particularly India who cannot simply substitute coal as an energy resource due to their huge appetites for coal in electricity generation and infrastructural development in the steel, agricultural and manufacturing industries.

A list of countries importing coal from South Africa can be found in Table 4.16 and an overview by country/continent in figure 5.3 below. The final implication is that the demand for coal in South Africa by local or domestic consumers is still very stable despite low prices, diminishing coal reserves and quality in the Witbank, Highveld and other major coal bearing coalfields (see Figure 6.1 below). The electricity sector in South Africa is under pressure to meet increasing electricity demands and Eskom will continue to procure more coal from junior coal companies. This could remain the most ideal market opportunity for the junior coal company. Therefore, a new or an upgrading coal company should develop its strategies based on the implications of: (i) a forecasted cyclical increase of coal demand and prices, (ii) a continuous dependence by developing countries on coal as a vital source of energy and infrastructural development and (iii) an electricity sector with high growth expectations in South Africa.

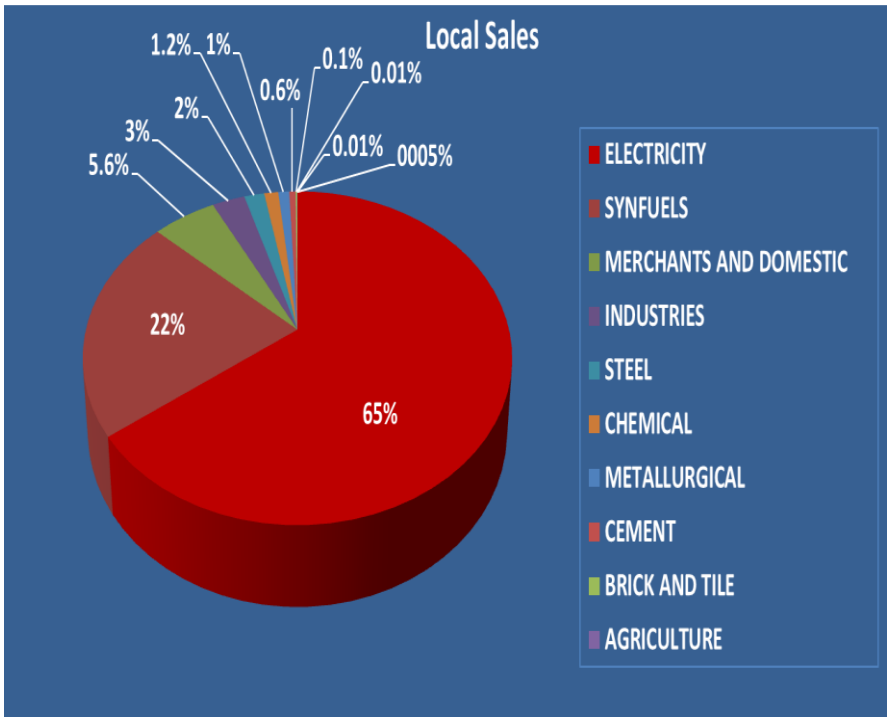


Fig 6.1 South Africa's main coal users by industry. **Source:** (Prevost, 2015)

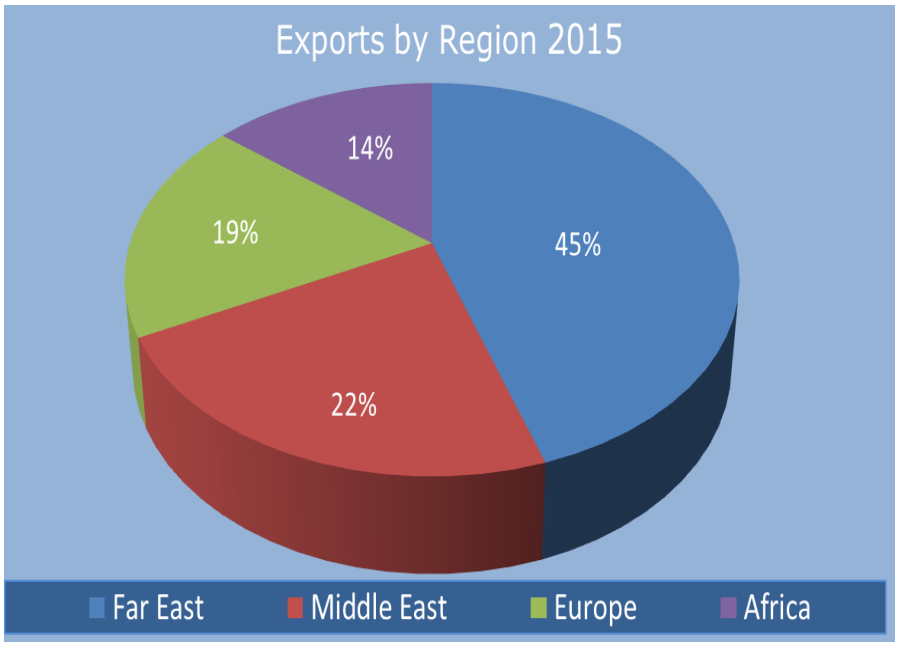


Fig 6.2 Summary of coal exports by region 2015. **Source:** (Prevost, 2015)

6.4.2 Technological innovations

The junior coal company's strategies should also be centred on current technological innovations in the coal industry. The most trending innovations in recent years have been clean coal technologies that can reduce greenhouse gases and particulate matter associated

with coal production and utilisation. The implication for the junior coal company is that some consumers will require coals for cleaner technologies, or for processes that upgrades coals into better qualities, all of which are likely to become components of the country's low carbon blue print.

Clean coal technologies include:

- Increased efficiency in mining with reduced fines
- Coal washing (beneficiation)
- Higher efficiencies when burning coal in advanced combustion technologies (super- and ultra-supercritical pulverised boilers) with CO_2 capture and storage or utilisation
- Flue gas desulphurisation
- Fluidised bed combustion
- Integrated gasification combined cycle (Gasifiers)
- Other innovations that should form part of the company's strategies include potentials for underground coal gasification, coal bed methane, coal mine methane and biotechnological methods of extracting poor quality coals from seams which are uneconomic to mine.

6.4.3 Political, Economic, Social and Technological Factors (PEST)

This includes an analysis of political, economic, social and technological (PEST) factors by the junior coal company in developing company strategies.

Political factors to consider may include;

- Legislations such as the HDSA act on empowering BEE owned junior coal companies, even though the beneficiaries of such empowerments are usually the rich and politically influential. Other legislations include those on carbon emissions, health, safety, environment, employment equity and compensation.
- Government policies with regards to independent power producers (IPP's) and impending impacts on junior coal companies. This may include off take coal supply agreements.

- Government policies on prospecting or mining rights, royalties, taxation and litigation. These impacts on coal businesses locally and when there are joint ventures between coal companies.

- Government's method of engagement with mine unions and interventions when conflicts arise such as lengthy strike actions.

Economic factors to consider may include;

- Diminishing coal reserves and coal quality in South Africa's coalfields make most coal companies profit marginally.

- Fluctuations in exchange rates; the value of the South African rands to the US dollars has been falling over the past few years.

- Volatility in coal demand and prices affect the bottom line of many coal companies particularly those with poorly diversified portfolios.

- Infrastructural development in South Africa and many other developing countries in the world could remain a suitable driver for growth and survival of the coal industry.

- High cost of transportation infrastructure and logistics.
- High costs of running a mine and maintenance.
- Coal supply uncertainties make long term contracts difficult. For example, it may be difficult to determine when a power station may open or close as well as a producing coal mine.

- Decreasing access to finance for junior coal projects and skills shortages.

Social factors to consider may include;

- Shortages in many basic social amenities such a portable water and electricity.
- Increasing rate of unemployment and a need to create employment particularly for HDSA's.

- Corporate social responsibility by engaging stakeholders and alleviating poverty by providing communities with roads, schools, healthcare services and other basic amenities.

- Other social concerns such as diseases, strike actions, xenophobia and racism.

Technological factors to consider may include;

- Technologies to improve exploration, mining and beneficiation methods and equipment.

- Technologies to improve coal extraction and quality such as in using clean coal technologies.

- Technologies to improve mine planning, design, and rehabilitation.

- Technologies to improve occupational or work place health and safety.

The key ***Inhouse strategies*** to be considered are outlined below.

6.4.4. Strength, Weaknesses, Opportunities and Threats (SWOT) Analysis

This includes analysis of the strengths, weaknesses, opportunities and threats (SWOT) in developing company strategies by the junior coal mining company.

The company's strengths may include;

- Adequate knowledge of the coal industry.

- Mining assets be it exploration, development and expansion projects.

- Ability to exploit coal reserves and derive coal products that can serve various markets.

- Access to technological innovations that can transform poor quality coals into saleable products.

- Ability to compete with other coal companies and still maintain profitable margins.

The company's weaknesses may include;

- The capital intensive nature of coal projects and the duration required to execute such projects.

- Ability to cope with business risks.
- Limited ability to remain financially afloat in times of severe economic down turn or recession.

Opportunities that exist may include;

- Access to domestic and export coal markets.
- Expansion of coal projects into other coalfields.
- Joint ventures with junior or major coal companies.
- Purchase of mining assets, skills and expertise from defunct collieries.
- Collaboration with competitors to share mining, beneficiation and transportation infrastructure.

The company threats may include;

- Evolving business conditions, risks and challenges in the South African coal industry
- Competition from other coal companies.
- Uncertainties in actual market share and penetration.

6.4.5 Key success factors

A number of factors determine the success and sustainability of a junior coal mining company and these should form part of the company's strategy development. Successful operating factors include the following;

- **A sound company structure** made up of board of directors (or equivalent), and a core of dedicated management, administrative and technical personnel.
- **Reasonable duration of life-of-mine** to allow for planning and cost projections
- **Reliable resource and reserve quantification** with knowledge of coal qualities, properties and available markets.
- **Availability of mining equipment and relevant infrastructure** such as conveyors, rail sidings, ports, terminals, storage and discard plants.
- **Appropriately designed and efficiently operating** coal beneficiation plant and process.

- **Suitable off-take contracts or agreements** with coal customers, locally and abroad
- **Short-term return on investment** (ROI) from initialization with high/secure income generation,
- **Availability of surplus funds** for mine, plant and project capital (CAPEX) , operating costs (OPEX) and on-going maintenance and possible expansion
- **Availability of experienced and accredited skills and expertise,** both as employed staff members or as outsourced consultants and service providers (e.g. geologists, mining engineers).
- **If not an "own development" mining operation, then successful collaboration** with respect to mining, beneficiation and transportation in a mutually suitable Co-Op arrangement.
- **Compliance with health, safety and environmental (HSE) legislations as well as social-corporate governance;** adequate knowledge of impending environmental constraints (greenhouse gases emissions and others) and the need for ever-increasing clean coal High- Efficiency-Low Emissions operating systems.

6.5 RISK MANAGEMENT

Risk is often described as the chance or probability of an event occurring often with negative consequences attached to it. From a business perspective, risks are those events which impact on a company's overall business goals and objectives and should be avoided where possible, or at least identified, evaluated and controlled. Risks impact upon every stage of the coal value chain and should be identified and managed at the earliest stage of mine planning.

The main elements of ***risk management*** include:

- **Identifying the risks** in each sector of the value chain.
- **Communicating and consulting** with all stakeholders in the risk management process.
- **Establishing the criteria** for risk analysis by determining consequences, likelihood and level of risks.
- **Evaluating risks by comparing risk levels** against the pre-established risk criteria and considering the balance between potential benefits and adverse outcomes. This enables

decisions to be made about the extent and nature of treatments required, and about priorities.

- **Treating the risks** by developing and implementing specific cost-effective strategies and action plans for increasing potential benefits and reducing potential costs.

- **Monitoring and reviewing the effectiveness of all steps** of the risk management process for continuous improvement.

6.5.1 Applying the risk management processes at *all stages of mine life*

Risks in both newly developing and currently operating coal mines must be identified and managed at all stages of a mine life cycle. Examples of such risks in each section of the value chain are given below:

- **In exploration**: poor qualities of coal, inadequate or insufficient coal reserves, difficult geological features which would impact on the mine plan and extraction;

- **In the pre-feasibility, feasibility, project design and CPR studies**: insufficient information, inadequate data, lack of viability, lack of funding

- **In new mine development**: lack of timeous commissioning of mine and mineral processing facilities.

- **In operation and production**: labour unrest, equipment breakdown, bad weather (rain prevents extraction in opencast mines); accidents and fatalities

- **In marketing and sales**: imbalance in demand and supply; price volatility,

- **In closure**: costs and mechanisms of decommissioning and rehabilitation.

- **In post-closure**: long term costs of rehabilitation and monitoring

In addressing risks in the mine and project life cycle, it is essential to understand the following:

- **Which stakeholders could be affected** or are likely to be affected by those risks. For example, employees, clients, service providers, local communities.

- **What legal, corporate or technical instruments are needed** to address a specific risk. For example, employment obligations, impact of the mine on water resources such as acid mine drainage (AMD), land usage, and so forth.

- **What strategies could be employed in minimising those risk**. For example, employ corporate social responsibility practices, undertake regular environmental impact studies (EIAs).

NB: It is essential that risk management is carried out with the participation of affected stakeholders in all stages of a coal project in order to build good and lasting relationships all through the project life cycle. Once trust has been damaged during, for example, an exploration stage, it would be very difficult to re-engage those affected stakeholders and to progress smoothly to the project development and operation or production stage.

Once all risks have been identified, weighed and prioritised, an additional evaluation should be undertaken to establish how these risks might consequently impact upon other aspects of the mine. For example, what impact would such issues have on the risks related to the environmental, economic and business sectors . This additional study is required in order to preserve the company's reputation, legacy and overall business operation.

6.5.2 Applying risk management processes to the *materials value chain*

Risk management in the ***materials value chain*** is also required throughout the life cycle of a coal mine. This is required in order to maximise the value addition of a coal product and to manage any and all risks that result from coal production and utilization. Waste management of hazardous substances and products is part of this risk assessment.

Risk management in the materials value chain includes potentially hazardous elements that could arise from the use of coal products or the disposal of coal discards. This would include the chemical substances used in the coal washing process or the potentially harmful trace elements and compounds that may be present in, or associated with some coal and their by-products. Examples of deleterious trace and major elements are mercury, arsenic, and radioactive substances and certain organic compounds occurring as volatile gases.

It is essential to understand the impact of such hazardous materials on the environment and the wellbeing of stakeholders involved: These include the following:

- The nature and quantity of deleterious elements or compounds occur in stockpiled or transported coals. When rain water passes through such stockpiles, these are released thereby entering the water systems associated with mines (acid mine drainage and so forth).

- Such deleterious elements or compounds also enter the atmosphere when coals are combusted for power generation. Such elements contribute to deleterious emissions, including those associated with greenhouse gases. Clean coal technologies are required to capture or remove them..

Such understanding would be significant for the community, regulators, suppliers, customers, manufacturers, transporters and plant operators and would assist them to manage such material risks effectively.

6.5.3 Risk identification

In risk identification, the factors that contribute to the risks need to be identified in order to describe their impacts on the environment, communities and relevant stakeholders and to arrange for their mitigation, control or elimination. This is usually defined in a cause-and-effect relationship with an understanding of the consequences of those risks in economic, financial, business, environmental, social, and health and safety terms. Specific risks pertaining to coal miners at the present time (2017) have been discussed separately in section 6.6.

6.5.4 Risk analysis and evaluation (Assessment)

Risk analysis is required to evaluate the nature and distribution of risk, and strategies to manage the risk, with data obtained after risk identification. Events with more significant consequences and likelihood of occurrence are identified as ‘higher risk’, and are of higher priority compared to events with lower risks and consequences. Risk analysis uses both quantitative and qualitative methods to identify, analyse and evaluate risks. Qualitative methods identify, describe and record consequences and likelihoods of events and resultant risk while quantitative methods identify likelihoods as frequencies or probabilities in a relative scale or in specific values. A rating scale can then be designed for likelihood, consequence and resultant risks for both qualitative and quantitative methods.

6.5.5 Risk control

Risk control is basically the avoidance of the impacts of risks that the coal company is exposed to by carrying out an effective risk management. Risk control can be preventive (risk

preventive measures), detective (detecting risks as they occur), protective (reducing the immediate impacts of risks) and mitigating (reducing long-term impacts of risks).

The following is the order in which risks can be controlled;

- Eliminate the risk.
- Minimise or replace the risk.
- Control the risk using engineered devices.
- Control the risk by using physical barriers.
- Control the risk with procedures.
- Control the risk with personal protective equipment.
- Control the risk with warnings and raising awareness.

There should be set objectives and performance targets to assess the effectiveness of risk control, followed by execution and assurance that those risks have been controlled efficiently as part of an effective risk management system. An effective risk management should be well understood and carried out by the management or decision makers of junior coal companies in order to succeed further and contribute to a sustainable coal industry.

Risk management should focus on the following key areas:

- **The health and safety of employees** without also compromising the wellbeing of local communities and the general public.
- **Financial performance and profitability** of the business.
- **Corporate-social responsibility** in executing coal projects hence strengthening the company's reputation.

In terms of sustainable development, risk management should endeavour to address the social, economic and environmental risks to all stakeholders affected by the coal project. These could cover certain aspects of the project such as production and beneficiation, coal handling and stockpiling, spontaneous combustion, acid mine drainage, waste management,

water management, mine rehabilitation, biodiversity, indigenous people and heritage sites, community engagement and development, closure and post closure activities. Coal projects are also subject to risks that impact upon the success of the business, in economic terms; that is, the cost of energy, commodity prices and exchange rates and in this case a combined approach between management and the government to develop policies or regulations in mitigating those risks might be essential.

While environmental and economic risks of mining are generally well identified and managed, social risks remain more challenging for the coal industry and manifest in a number of ways. The social, environmental and economic risks have very close boundaries and must be addressed together in order to achieve sustainable development.

6.6 SPECIFIC RISKS FACING THE JUNIOR MINERS IN THE WITBANK COALFIELD

The following risks facing the Witbank junior coal miners have been discussed as follows:

1. Market risk

Market risks are associated with the prices, markets, demand and quality of their coal products. The price given to a coal product after accounting for the total costs of extraction and beneficiation is usually a profit maximization strategy by the junior coal company and the higher the prices the greater the desire to increase coal production. However, coal prices fluctuate in a cyclical manner termed ‘price volatility’ and this volatility is a measure of the frequency and duration of price change over time. From the risk perspective it causes degrees of uncertainties to the junior coal company with respect to revenues generated and to their customers in relation to the costs they would incur in buying coal products. Price volatility is associated with tight demands for coal products and from the supply side; the junior coal company cannot simply cut production as coal projects are long term, capital intensive and are linked to other sectors of the economy.

2. Political risk

Political risks are those risks, which are present due to the involvement of government entities and stakeholders in mining operations. A junior coal project is often saddled with political risks due to its capital-intensive nature where huge sums of money have been sunk

in by investors. In almost any country, there is always a direct influence by the host government on such projects, and where there are elements of corruption for example, there might be unsolicited increases in government taxes, or royalties and sometimes nationalization of the project at the expense of the junior coal company. In South Africa for example, the government BEE empowerment is often saddled with corruption as the beneficiaries are usually the most affluent and politically influential members of the current ruling democratic party or the society in general. Unfortunately, the host government's interest in such projects and desire to change existing contracts usually occurs when the company has started becoming profitable as the company cannot simply abandon the project and forfeit all capital investments made and future earnings. Political risks occur both at the regional and national levels and can only be minimized, for example, if the financiers for the coal project are government agencies such as the Chamber of Mines and Eskom. Challenge to such government decisions may be made in various capacities as they can affect the junior coal company.

3. Infrastructure risk

The infrastructure required in coal transportation either by road, rail or conveyor is a vital component of any coal project as discussed in chapter 5. The type of transportation used has to be logistically efficient meaning that the infrastructure should remain technologically and economically sound over the duration of the project or life of mine. Also, coal terminals and port capacities that handle sizeable tonnages of coal have to be well structured as these could ultimately affect project profitability in terms of pricing, transport taxes and freight charges at these ports or terminals.

4. Project systems risk

The project systems required in the execution of a coal project have to be available and reliable at all stages of the project value chain. This is the risk that certain tangible assets such as equipment used in planning, design, and production and intangible assets such as management decisions do not perform or conform to the desired levels of value addition. Such risks could ultimately impact upon the profitability of the project.

5. Technology risk

With respect to technology risk, the capital needs of a coal project require the right level of technology and innovation to maximize operational performance in terms of increased production and cost reduction. Technology risks often impact upon coal exploration, production, beneficiation, marketing, projects systems as well as health, safety and environment.

6. Geological Risk

Geological risks involve all that should be considered in the assessment of a coal deposit during geological pre-feasibility and feasibility studies. The risks are usually associated with the estimation and evaluation of a coal resource as they would ultimately determine the viability of the coal project.

7. Business risk

The following risks generally affect the coal business and they include community health and safety, environment, production, regulatory, reputation, financial and legacy risks.

- **Community health and safety Risks-**These are risks which affect the health or safety of people and communities at large. Community, health and safety risks must be addressed properly due to the nature of hazards that are associated with the coal industry and which ultimately affects a wide range of stakeholders particularly employees of those coal companies and the surrounding communities.

- **Environmental Risk-**Environmental risks are those risks which impact on the environment resulting in losses to areas of critical biodiversity, heritage sites and indigenous people. The major activities include; exploration, mining or mineral processing activities resulting in disturbance of the surface, subsidence, water and air pollution, acid mine drainage and spontaneous combustion. Environmental risks also impact on health and safety, company reputation and could generally affect the bottom line of junior coal businesses.

8. Regulatory risk

Regulatory risks also impact on the junior coal industry. When changes occur to some aspects of the legislative framework, for example in the emergence of carbon tax regulations it could have some consequences such as difficulties in obtaining mining rights, litigation, project shut down and damage to company reputation. The junior coal company has to be aware of such changes as those regulations seek to protect the health and wellbeing of employees, communities and all stakeholders involved.

9. Production risk

Production risks are economic in nature impacting on the company's production capacity, coal quality and, ultimately, the cost and revenue generated by the business. These risks could be closely linked with non- economic issues when for example, project activities such as mining and beneficiation impact on the environment and vice versa.

Some examples of production risks include pit failure, equipment and infrastructure which could result in shutdown of major production and washing plants.

10. Risk to reputation

Risk to a company's reputation is usually a consequence from other types of risk. As long as risks are managed properly, the junior coal company can maintain its reputation in line with sustainable development, company growth and success.

Poor risk management may impact negatively on reputation of the company resulting in the closedown of a project if affected stakeholders take all necessary actions against that coal company. In addressing reputational risks, the views and wellbeing of affected stakeholders must be strongly communicated and represented.

11. Financial risk

Financial risks which impact on all aspects of the coal project must be evaluated. These are risks which relate to capital expenditure, net cash flows, net present values, internal rates of return, operating costs, production, and revenue generated by the company. These risks ultimate impact either positively or negatively on the profitability of the company.

12. Legacy risk

Legacy risks are associated with the closure and post-closure phase of a coal project. An effective management of such risks would protect the reputation of the junior coal company and give it a good legacy at the end of the project. An example of a closure and post closure activity is rehabilitation which involves bringing the project or mining site to a condition very close to its original form. This should be in line with the original livelihoods of those communities before the project was brought there.

In summary, while the risks identified above are common to all coal mining communities world-wide, they have particular relevance to South Africa and the junior coal miners in the Witbank coalfield. Table 6.1 below summarise the risks under the three headings.

Table 6.1 Summary of the risks facing junior coal miners in the Witbank Coalfield

Economic Risks	**Technical Risks**	**Human Risks**
Mining company forced to use government services even if not competitive	The geology does not materialize according to the studies:	Host government does not honour agreement:
Insufficient capital and underestimation of costs	Environmental risk:	Threat to health and safety of employees:
Underestimation of operating costs	Equipment failure:	Land claims
Decreasing control in project management:	Cost and availability of electricity and water	Lack of project performance from the state:
Incorrect market-forecast:	Wrong selection of mining method:	Important restrictions:
Change in tax regime	Poor yields	Political instability
Cannot obtain finance	Infrastructure failure	Delay in obtaining leases, permits and mining rights.
Delay in production start-up:	Geological data and record losses/unavailability	Unstable, unionised labour force:
Cost and availability of electricity and water	----------	Mining company cannot adapt to cultural diversity:
Decreasing commodity prices	----------	Lack of consensus between joint venture partners

Source: (Seegar. M, 2007)

Table 6.2 Summary of the top 10 Business risks

	Risks	**Description**
1	Resource Nationalism	Many governments around the world going beyond taxation in seeking greater offtake from the sector, uncertainty caused by sudden changes in policy by government of resource-rich nations.
2	Skills shortage	Insufficiency of qualified candidates to fill market-place demands for employment from the mining sector, associated risks include project delays, increasing labour costs and impact on production.
3	Infrastructure access	Lack of sufficient infrastructure being the primary obstacle to the development of mining activities.
4	Cost inflation	Cost being driven up by the high cost of production, labour and compliance and is expected to intensify over the years
5	Capital project execution	As the project pipeline becomes significant over the years, it is also expected at the same time high delivery cost and heightened macroeconomic activity.
6	Maintaining a social license to operate	Refers to the acceptance within local communities of both mining companies and their projects. The consequences include increased expectation from local communities, changing how business is run and other acquisition of challenges
7	Price and currency volatility	Still needs to be defined.

Continued…

	Risks	Description
8	Capital management and access	Risks facing the mining companies in allocating and accessing capitals were proving to be the biggest challenge facing global mining and metals companies.
9	Sharing the benefits	Risks pertaining to the sharing of benefits equitably between shareholders and local communities as well as other relevant shareholders.
10	Fraud and corruption	Mining projects including large and junior scale are operating in countries prone to corruption and hence this environment provides an increased exposure to corruption and fraud risks.

Source: (Landu. L, 2015).

6.7 FINANCIAL MANAGEMENT

Financial management is a critical aspect in the development or operation of a junior coal mine. Processes vary and the financial structure in place is frequently modified based on the financial performance of the junior coal company at the end of each specific financial year. The following parameters are analysed in financial management;

6.7.1 Economic and sensitivity analysis

Economic analysis is involved primarily with cash flows using the most recent FOB price per tonne of saleable coal on an after-tax basis. This analysis also captures direct costs such as labour, equipment, materials, production taxes and royalties and indirect costs such as overhead costs, mineral and property tax, whilst factoring in depreciation of all purchased equipment and facilities for the coal project.

Sensitivity analysis is usually carried out with respect to the internal rate of return (IRR) and the Net present values (NPV) on the coal sales price, inflation, interest rates production rates and revenues whilst evaluating direct mining costs and capital expenditures. It also analyses the anticipated cash flows over the development phases of the project and seeks to find out if those cash flows are positive or negative during these phases. Cash flows are required for daily activities on the mine and play a key role in the success of a coal project.

6.7.2 Capital and operating costs

Capital and operating costs are required to bring a project to full production including coal handling, coal preparation, train, load out facilities or sidings, surface facilities, site access, electricity and mine development. It also includes all surface and underground mining equipment either purchased in full or leased over a period of time during the coal project.

The operating costs are estimated costs for operating the mine and could be based on equipment hours, labour hours and materials and supplies and estimated contract rates as applicable to each mining method.

In general, valuations of a junior coal project are carried out to determine these NPV's, IRR's debts, equity, total costs and expenditure. Financial management takes into consideration funds which are raised for coal projects either from financiers or equity financing through Initial Public Offers (IPO's) or public share sales and listing on a stock exchange. A majority of junior coal companies under study recorded annual losses in the past financial year with major shareholders, resulting in having to sell part or most of their shares as a strategy to increase the company's capital and to remain afloat. In debt financing, they could approach financiers for more funding but is often very difficult unless proven through competent persons' reports that the remaining phases of the project would eventually lead to profitability.

Financial management also takes into consideration project budgeting which have to be precise and as much as possible close to the actual figures. Funds have to be budgeted for project development and operations. This also includes mining equipment use, drilling, blasting, sampling, processing, stockpiling, transportation, maintenance, salaries and so on.

6.8 OPERATIONAL MANAGEMENT

Operational management on a coal mine involves adequate planning and execution of every coal activity to increase performance and output, in this case a junior coal asset. For example, the geological exploration project would entail designing a prospecting plan and an exploration business plan by undertaking the following.

- Determining what geological data is available, the geological setting and previous work, including historical drill holes and perhaps historical mining in the coalfield. It includes field reconnaissance to identify geological structures and infrastructure on the surface as well as land use patterns for social considerations. Depending on the geological complexity of the area and on previous work done, an exploration plan could be designed using non-invasive techniques (Aeromagnetic surveys to locate dolerite dykes and sills, aerial photographs and field mapping) or invasive techniques such as trenching, diamond core drilling, percussion drilling and analytical techniques for coal sampling, geotechnical sampling to determine mine methods and geophysical surveys.

- Costing self-managed or contractor based options, that is, the cost implications of using either the company's personnel or outsourcing experts to carry out the exploration project. It also includes costing all equipment to be used as well as laboratory services.

- Determining possible coal utilisation scenarios for the deposit under investigation and designing a sampling and analytical programme using proximate coal qualities, relative density, calorific value, ultimate analysis, ash composition analysis, petrographic analysis, spontaneous combustion liability and so on.

- Undertaking data management to capture borehole logs, identify, capture and submits samples and analytical results. It also includes proof or rehabilitation as well as all execution of all legal and contractual obligations.

- Devising the geological model.

The key performance indicators (KPI's) with respect to the prospecting and exploration business plan would be;

- Measurements of personnel health and safety during prospecting and exploration.

- Costs of exploration techniques; aeromagnetic surveys, aerial photography, field mapping, trenching, diamond and percussion drilling etc.

- Costs of drilling boreholes, sampling and core logging. This would also include measurements of the required borehole density and spacing either for multiple seam coal deposits or for thick interbedded seam coal deposits. However, these are subject to judgement from a Competent Person.

- Measurement of coal quality for utilisation.

- Measurement of the duration of work put in by the Geologists, Contractors, Engineers, Procurers, and Surveyors. The work has to meet set standards and target dates for completion.

Similar operational management and costing exercise would be necessary for the remaining sectors in the coal value chain, that is, for mining, beneficiation, marketing, sales and so forth.

6.9 TEAM MANAGEMENT

A junior coal company requires a well experienced and qualified team of personnel to manage and execute coal projects. Even for junior coal miners, the ***Senior Management*** team should be made up of a Board of Directors, which includes Executive and Non-Executive Chairmen and Directors. The Chief Executive Officer heads the entire company while the Chief Financial Officer and Mine Manager are in charge of the company's financial management and mining operations respectively. Other personnel should include ***Administration Managers*** including the Human Resources, Business Development, Legal and Marketing personnel for downstream optimisation of the coal value chain. The ***Technical Management team*** encompasses exploration, mining, production, processing, marketing, sales and waste management activities of the entire project.

The following section summarizes the job profiles and functions of the management team; in addition, such personnel must possess high levels of leadership and communication skills in making tactical strategic decisions that could keep the junior coal company in business.

1. Chief Executive Officer (CEO)

- Leadership, communication and decision making in line with the company's mission, vision and set objectives.
- High level management of the company's operations; production, financial, human resources, business plan, legal, health and safety objectives.
- Reporting to the board of directors.

2. Chief Financial Officer (CFO)

- Raising capital for the entire project; equity and debt financing, listing of company on a stock exchange.
- Budgeting.
- Cost control.
- Financial management and systems.
- Aligning with Human Resources to staff the finance department.
- Reporting to the CEO

3. Business Development Officer

- Developing business plan.
- Designing feasibility, exploration, development and expansion programmes.
- Assisting the CFO in raising capital for these projects.
- In charge of project contracting, tenders, and identifying new investment opportunities.
- Aligning with Human Resources to staff business management department.
- Reporting to the CEO and CFO.

4. Mine Manager

- Coal production; mine planning, extraction, processing and operations.
- Engineering; mining methods and optimisation techniques.
- Aligning with mine health and safety requirements.
- Budgeting and allocating funds for mine operations; equipment procurement, mine supplies.

- Liaising with coal customers with regards to R.O.M and yields.
- Aligning with Human Resources for staffing; Mine Engineers and Artisans.
- Reporting.

5. Human Resources

- Staffing,
- Salaries, wages and bonuses.
- training and career development
- Retrenchment.

6. Legal Officer

- Contracts and agreements
- Legal representative; Disputes and litigation.
- Legal Framework; monitoring and compliance.

7. Marketing Officer

- Coal marketing; products, quality, availability and pricing.
- Liaising with clients: negotiations, transportation and delivery.

By appointing a team such as those listed above, a junior mining company or emerging miner would be ensured of an appropriate skills base to take the endeavours forward.

6.10. SUMMARY

Based upon the definition of junior coal mining ventures presented in Chapter 3, this chapter has sought to present the key factors required to (i) initiate a new junior coal mining company or (ii) upgrade an existing company in need of optimisation. This has been done in the form of a set of guidelines which, collectively, form a protocol which could be followed by those in the coal mining industry for defined purposes.

In summary, a junior or mid-tier coal mining company aspires to be a relatively low-capital and high-profit entrepreneurial venture that explores and subsequently develops or sells a coal deposit to other investors wholly or partly in the form of a shareholding, with the latter option being the most common. In this manner, the junior coal miners of South Africa and in the Witbank Basin in particular, are now forming one of the most important sources of coal

for the export market and power generation in the country. Their success is vital to the country's economy and it is hope that this protocol would assist those junior or emerging miners currently encountering problems to develop into highly successful operations in the mining subsector.

CHAPTER SEVEN

CONCLUSION AND RECOMMENDATIONS FOR FUTURE RESEARCH

Based on the investigations undertaken in this study, the following observations, conclusions and recommendations have been drawn:

- **BACKGROUND AND OVERALL SUMMARY:**
  With regard to setting the scene for the development of coal exploitation by junior coal miners in the Witbank Coalfield, the following points are most relevant:

  - Albeit largely exploited, **the Witbank Coalfield of the Karoo Supergroup is the most important, coalfield in South Africa** hosting the majority of the country's remaining coal reserves. Five seams are encountered, occurring in the Vryheid Formation. No. 2 and 4 are the most economically important to mine.
  - **The largest mines, easiest to extract seams and better quality coals are fast being depleted**, leaving smaller pockets of coal in widely dispersed arears, more difficult seams to mine and lower grades of for future exploitation.
  - Following 1994, many struggling junior coal miners were given the opportunity to enter and expand into the coal mining sector under the newly promulgated Black Economic Empowerment legislation. Considerable **numbers of miners took up this challenge and over the years have been granted exploration licences but many were unsuccessful in converting their licences into successful developing mining operations.**
  - **The study investigated the many challenges facing the junior coal miners today.** Apart from legislation, these include limitations in scope and development due to inadequate funding, poor technical resources, limited information and no understanding of the skills required to undertake an operation as complex as a mine.
  - In order for junior coal companies in the Witbank Coalfield to stamp their credentials in the coal industry and become more viable and successful, **this study has shown that this sector would need to become more knowledgeable and innovative** in exploration techniques, mine planning, design, selection of mining methods, equipment and beneficiation techniques. These factors would ultimately determine the type of coal products that could be produced, the amount of market share that could

be expected and ultimately the development of a platform that would lead to a successful coal business.

- **INCENTIVES AND MARKETING OPPORTUNITIES**

  The incentives for junior coal miners to develop in the Witbank area are summarised as follows:

  - Eskom is the major consumer of coal in South Africa and, following the BBBEE legislation, the company has announced that only coals from coal mining companies with BBBEEE shareholding in the majority would be accepted. Some large coal mining ventures are therefore limited in this regard, while other BBEEE large mines are due to be mined out within the next few years. **The future for coal-fired power generation therefore lies in the hands of the junior coal miners in the future.**
  - Currently**, the coal market for junior coal miners lies predominantly in supplying Eskom with thermal coal required for electricity generation** but their capacity to do so in the longer term is in question due to the lack of success of many mines and the multiplicity of the short-term small units currently operating ones. Coal is also supplied in small quantities to other industrial users and for export via Richards Bay.
  - Witbank junior **coal miners will also be required to supply higher grade cleaner** coals if they are to compete in an evolving coal industry which is fast becoming **more sensitive to greenhouse gases emissions and climate change.** The majority of energy investors now prefer funding renewable energy projects or cleaner energy fuels due to concerns surrounding climate change. Therefore, opportunities lie in coal beneficiation technologies that can extract better quality coals from low quality coal seams with minimal environmental and socio-economic impacts.

- **THE CHALLENGES FACING THE JUNIOR COAL MINING FRATERNITY:**

  A number of challenges facing the junior coal miners were investigated. These include the following:

  - **Current mining legislations** as they impact upon the activities of the junior coal miners include a plethora of legislations in terms of water, environment, safety

and health, mine closure and many other formal issues. Different departments require to be approached and the time lag between each is generally considerable.

- **The impact of climate change** and the impending requirement for reduced CO2 and greenhouse gas emissions in coal-fired industries has led to the need for better qualities of coal in the market place. These, in turn, are required to ensure greater efficiency in coal-fired processes thereby lowering CO_2 and greenhouse gas emissions. Junior coal miners would therefore be required to provide products that are better in quality (higher grades) as one of the key **clean coal technologies of the future.** Few possess beneficiation equipment to provide such products.

- The **skills required** in the junior coal mining industry is a wide spread problem, primarily because of the nature of the exploration and mining licensing mechanism to unqualified and inexperienced personnel. Once such licences are attained, such personnel are often unprepared to take the next steps to acquire the necessary information to proceed further down the development chain. Hiring consultants has had varied success, as many are themselves ill equipped to conduct the required investigations. Considerable amounts of funds have been lost in such deals, along with inadequate or incorrect information provided. Strong solutions were found to be necessary to bridge this knowledge and experiential gap.

- **The junior coal miners' access to finance** for greenfield and/or brownfield coal projects. With little in the way of security to bank large scale funding from third parties, funding is often the first and foremost stumbling block

- **The risks and challenges** with regards to exploration, mining, beneficiation, transportation, marketing and ultimately the sale of their coal products that junior coal miners face in the Witbank Coalfield are significant. Not least is the severe knowledge gaps and lack of overall experience, poor service providers to assist them, and difficulties to enter into any large market on the basis of small scale production, often run-of-mine unprepared products with irregular qualities. Other challenges include limited access to reliable funding for coal projects, barriers to entry levels for development and lack of coal data and service providers,

compliance to mining legislation and coal market volatility, all of which make it difficult to forecast and make certain informed business decisions.

- **A PROTOCOL FOR INDIVIDUAL EMERGING OR JUNIOR COAL MINERS.**

  In order to face the lack of knowledge many new or currently unsuccessful owners of coal mining licences face, a set of guidelines or checklist in the form of a protocol has been drawn up. This sought to address the legal, technical and financial information with business strategies and risk management, all of which is required by any coal mine owner.

- **THE IMPACTS OF BROADER CORPORATE COLLABORATION OR MERGERS**

  Given the limitations that many small individual junior coal miners are exposed to, this study has concluded that larger and more sustainable collaborating units with shared facilities such as washing plants are likely to lead to greater efficiency, better productivity and more security of supply with larger profit margins for those junior mines associated with them**.** This could lead to growth and enhanced diversification of coal transport and infrastructure in the relevant mining sectors South Africa and better marketing opportunities.

  The observations therefore concluded that the following steps should be considered sooner rather than later, namely:

  (i) **collaboration and the sharing of communal facilities** such as beneficiation plants between a group of junior coal miners or

  (ii) **the development of mergers and acquisitions** of smaller units to build bigger and more efficient operational units due to benefits arising from economy of scale.

  Such actions would lead to greater productivity, reduced risk, better opportunities for corporate funding and easier logistics when marketing the products produced. In this manner, increased growth of the junior coal mining sector would be ensured in future, and with that, the guarantee of availability of good quality, sustainable coal products for power generation and some for industrial utilisation and export. Without such assurance of production, the country may fall back into a period of constrained power generation, a situation such as that which occurred in the 2008 in South Africa. The country can ill-afford to allow this to happen.

In summary, the Witbank Coalfield junior coal miners are well placed to play a critical role in supplying future clean coal-based energy technologies in this country, but the many challenges faced by the current community require to be overcome in order to do so. It is hoped that the protocol provided in this dissertation would go some way to providing the guidance required for this goal to be achieved.

REFERENCES

Brenda, H F. (2015). Collaborative advocacy to improve supply chain efficiency for global competitiveness. Southern Africa Shippers Transport and Logistics Council. pp6

Casey, I, Christopher S W, and Samanthala, H. (2013). Junior Mining Sector Capital-raisi ngs: The Effect of Information Asymmetry and Uncertainty Issues. Journal of Applied Business and Economics vol. 15 no 3. pp 56-60.

Centre for Sustainability in Mining and Industry., (2012). Mining and the Environment. pp 1-10.

Chamber of Mines South Africa., (2012). Mining's contribution to South Africa. pp 1-9. Annual report on South Africa's coal production pp1-4

Coal of Africa. Annual Report, 2015. Internet: www.coalofafrica.com cited 10 January 2015.

Coaltech., (2002). Guidelines on Small Scale Coal mining in South Africa. P 1-9.

Continental Coal. Annual Report, 2015. Internet: www.continentalcoal.com cited 10 January 2015.

Council for Geoscience South Africa., (2013). Coal Resources and Reserves of South Africa. P 5, 39-41.

Department of Mineral Resources. (2014). Operating and developing coal mines in the Republic of South Africa. pp 19-51.

Department National Treasury. (2010). Reducing Greenhouse Gases Emissions: The Carbon Tax Option. pp 3-4, 23-27.

Falcon R., (2012). Coal quality for trade and utilization. A lecture series delivered by the Centre for Leadership in Coal and Fuel Technology, University of the Witwatersrand, South Africa. 13th to 17th February, 2012

Gerhard, E (2015). Technical challenges faced by junior miners. A conference paper delivered by the Fossil Fuel Foundation, University of the Witwatersrand, South Africa. May 2015.

Hoadley, M, Limpitlaw, D (2004). The artisanal and small scale mining sector and sustainable livelihoods. A paper presented at the Mintek Small Scale Mining Conference, September 9, 2004. pp 5.

Hosken Consolidated Investments Limited. Annual Report, 2015. Internet: www.hci.com cited 15 January 2015.

IBM Global Business Services, (2009). Envisioning the future of mining. pp 5-19.

IEA Clean Coal Center (2012). Impacts of seaborne trade on coal importing

Countries. No 12/5 pp 1-2.

Industrial Development Corporation, (2014). Competitiveness through energy savings pp 1-2.

Izimbiwa Coal. Interim Report, (2017).

Jabu, M. (2015). The impact of infrastructure and logistics on coal industry in South Africa. Richards Bay Coal Terminal, pp 6-15

Jeffrey L.S., (2005). Characterization of the coal resources of South Africa. The journal of the South African Institute of Mining and Metallurgy. Vol 285. P 95-101.

Jurgens, V Z. (2015). Unlocking private sector investment for rail infrastructure. Business Leadership South Africa, pp 4-15

Keaton Energy. Annual Report, 2015. Internet: www.keatotonenergy.com cited 10 January 2015.

Kuyasa Mining (2015). KIPower IPP project. Internet, cited 12 July 2016.

Kruger, D. (2015). Techno Economics on Southern Africa coal infrastructure. Chamber of Mines of South Africa. pp 1-12

Landu L., (2014). Junior Mining in South Africa. Paper delivered at Fossil Fuel Foundation Conference. Johannesburg. 27th June 2014.

Liezl Bottman., (2015). Unlocking value for junior miners. Paper delivered at Fossil Fuel Foundation Conference. Johannesburg. 30th September 2015.

Lyngfelt, A, Johansson, M and Mattisson, T, (2008). Chemical-looping Combustion-Status of development. 9th International Conference on Circulating Fluidized Beds (CFB-9), May 13-16, 2008, Hamburg, Germany. pp 1-4, 9-10

Maurstad, O. (2005). An Overview of Coal based Integrated Gasification Combined Cycle (IGCC) Technology. Massachusetts Institute of Technology. Available online at http://lfee.mit.edu/publications. Publication No. LFEE 2005-002 WP. pp 1-9.

Matshela k., (2012). Fact sheet on Underground Coal Gasification and Coal Bed Methane Technologies in South Africa. Available online at: www.eskom.co.za/.../Underground%20Coal%20Gasification%20(UCG) Cited 20 August 2015.

Minnitt R.C.A., (2010). Thermal coal products in South Africa. The journal of the South African Institute of Mining and Metallurgy. Vol 585. P 593-598

Nico, S (2015). Eskom coal transportation; The impacts of logistics and infrastructure on the coal industry in South Africa. Conference paper delivered at Fossil Fuel Foundation conference. Johannesburg. 30th September 2015. pp 4-9.

OECD (2012). Competition and commodity price volatility. An OECD publication no DAF/COMP/GF(2012)11 .Available online at: www.oecd.org/competition pp 11-15.

Prevost X, M. (2002). A review of the Witbank Coal Field. M Eng. Thesis, University of the Witwatersrand, South Africa. pp 3, 9-10.

Prevost X M. (2015). Coal in the global and South African context. Conference paper delivered at Fossil Fuel Foundation Conference. Johannesburg.30th September 2015, pp 7-18.

Prevost X M. (2015). Coal distribution in South Africa and the need for transportation. Conference paper delivered at Fossil Fuel Foundation Conference. Johannesburg. 30th September 2015, pp 5-15

Robert, S P. (2004). Volatility and commodity price dynamics. The journal of future markets, vol 24 no 11, pp 1-2.

Sandersen, A. (1997). A review of the coal bed methane potential of South Africa's coal deposits and a case study from the North-Eastern Karoo basin. MSc Thesis, University of Johannesburg, South Africa. pp. 62, 76.

Seeger, M. (2007). Development of a strategic and tactical game plan for junior coal companies. PhD thesis, University of The Witwatersrand, South Africa. pp. 22-40. Pp 61-70.

Sylvie C.G., (2013). Global Coal Trade: From tightness to oversupply. Institut Francais des Relations Internationales. Vol 234. pp 2-29, 49-52.

Simonsen, H and Perry, J (1999). Risk identification, assessment and management in the mining and metallurgical industries. Journal of the South African Institute of Mining and Metallurgy, vol 38 no 223, pp. 321-327.

Smith, J V and Duns, N (2007). Untangling skills and qualifications: training engineers and related professionals capable of filling skill gaps in the mining industry. University of Melborne Australia, pp 3-7.

South African Coal Road Map., (2012). Coal in South Africa: Some key issues, pp 4- 12

South African Mining Development Association, (2014). Broad-Based Socio-Economic Empowerment Charter for the South African Mining and Minerals Industry. A paper submitted to the portfolio committee on Trade and Industry. No PCTI/20140826/CoB/SAMDA/32. pp 12-13.

Stacey, T R, Hadjigeorgiou, J and Potvin, Y (2009). Technical skills: A major strategic issue. The journal of the South African Institute of Mining and Metallurgy, vol 109 pp 245-247.

Steyn M., (2009). Coal Marketing in South Africa: The intricacies of product distribution, price, and promotion in domestic and export markets. MSc thesis, University of The Witwatersrand, South Africa. pp. 22, P 38-52.

Steyn M., (2011). Minerals Marketing. (Exxaro Coal). A lecture presented on the Masters course 'Coal Management and Marketing', University of The Witwatersrand, South Africa. 22nd June 2011. pp 1-5.

Statistics South Africa., (2012). Mineral Accounts for South Africa: 1980 – 2009. pp 2, 17. Source: world wide web.

Synman C.P., (1998). Mineral Resources of South Africa; Sixth Edition: University of Pretoria, South Africa. pp 145-148.

The Australian Department of Resources, Energy and Tourism, (2008). Risk assessment and management. pp 36-66.

Van Alphen C. (2012). Coal quality impact; Course work lecture notes delivered by Eskom Research and Innovation Centre, pp 5-15.

Van Deventer K. (2015). Conference paper delivered at Fossil Fuel Foundation Conference. Johannesburg. 30th September 2015, pp 15-20

Wescoal Holdings. Annual Report, 2015. Internet cited 5 January 2015.

APPENDICES

Appendix A

Calorific values, proximate analysis, and total sulphur contents of Witbank coal products on air-dry basis (adopted from Prevost, 2005).

COLLIERY	PRODUCT	Calorific Value	Gross Calorific value	Moisture	Ash	Volatile Matter	Fixed Carbon	Total Sulphur
Graspan: No. 2 Seam	Washed: Large nut	26.10	26.06	3.8	17.0	23.0	56.2	0.38
	Small nut	25.78	25.76	3.8	16.2	22.9	57.1	0.23
	Pea	.37	26.34	3.7	14.7	23.1	58.5	0.27
	Grain	26.84	26.82	3.6	14.1	22.2	60.1	0.19
	Duff	26.53	26.51	3.7	14.5	22.0	59.8	0.21
Greenside: No. 5 Seam	Washed: Small	28.07	28.02	3.7	11.6	34.1	50.6	0.54
No. 2 Seam	Washed: Anglo	27.44	27.40	2.8	14.7	24.4	58.1	0.44
Inkwhezi: No. 4 Seam	Unwashed:Run off mine	22.53	22.27	2.5	25.9	23.7	47.9	2.76
No. 2 Seam		23.99	23.91	2.8	22.4	21.8	53.0	0.82
Khutala	Unwashed: crushed coal	21.64	21.58	3.6	25.6	22.8	48.0	0.63

Continued…

Kleinkopje	Washed: Pea	26.78	26.74	2.9	15.6	22.1	59.4	0.42
	Anglo	27.61	27.58	2.5	14.6	24.5	58.4	0.36
Landau	Washed: Large nut	29.00	28.94	2.4	11.5	27.1	59.0	0.61
	Pea	28.72	28.77	2.2	12.5	25.0	60.3	0.55
	Pea	26.81	26.74	5.0	11.2	25.0	58.8	0.70
Leeuwspruit	Washed: 50mm	28.23	28.14	2.4	13.3	27.8	56.5	0.92
Matla	Unwashed: Crushed coal	Crushed coal	21.01	4.4	27.4	23.6	44.6	0.94
Middelburg	Washed: Export	27.39	27.34	3.0	14.7	24.3	58.0	0.52
	Unwashed: Power station	23.90	23.82	2.3	24.5	21.1	52.1	0.86
Koornfontein	Washed: Export	27.85	27.81	3.0	14.2	25.4	57.4	0.43
Kopermyn	Washed: Large nut	25.82	25.79	5.1	15.1	20.8	59.0	0.30
	Pea	26.53	26.50	4.7	14.7	21.2	59.4	0.35
	Duff	26.73	26.69	5.7	14.0	22.4	57.9	0.38
	Spiral	24.56	24.50	3.8	21.7	18.2	56.3	0.63

Continued…

Kriel: Opencast	Unwashed: Crush coal	21.59	21.62	4.4	26.1	23.7	45.8	0.74
Underground	Unwashed: crushed coal	22.86	23.81	4.6	21.6	23.8	50.0	0.67
Lakeside	Washed: Large nut	25.45	25.36	4.7	15.4	29.0	50.9	0.99
	Small nut	25.72	25.66	4.7	15.3	27.2	52.8	0.68
	Pea	25.74	25.69	4.6	15.3	26.8	53.3	0.50

Source (Prevost, 2005)

Ash analyses, phosphorus and reducing fusion temperatures of selected Witbank coal products (After Prevost, 2005).

COLLIERY	PRODUCT		SiO_2 % (ASH)	Al_2O_3 % (ASH)	Fe_2O_3 %(ASH)
Arnot	Unwashed:	Crushed coal	57.3	22.7	3.55
Arthur Taylor	Washed:	Export small	45.1	31.4	3.39
ATCOM	Washed:	Export small	47.7	30.1	5.12
Bank 2	Washed:	Anglo	51.3	31.3	2.32
		Low ash	45.8	31.2	3.55
Bank 5		Small nut	63.9	25.9	3.79
		Pea	66.2	24.8	3.50
Blackwattle	Washed:	Pea	58.8	29.3	1.50
	Unwashed:	Duff	55.3	26.7	3.20
Boschmans	Washed:	Pea	46.7	27.6	3.36
Delmas: Opencast	Washed:	Sasol	48.7	26.6	5.60
Underground		Sasol	47.7	31.1	4.50

PPC		Duff	42.6	21.9	17.5
Kelvin		Duff	44.0	33.9	4.52
Dorsfontein	Washed:	Pea	54.7	33.8	3.08
Eikeboom	Washed:	Small	50.6	38.1	2.94
Elandsfontein: No.1 Seam					
Underground	Washed:	Large nut	57.6	33.9	3.51
		Small nut	56.6	34.7	3.07
		Pea	57.6	34.4	2.84
		Grain	54.4	36.3	2.73
		Duff	57.2	34.2	3.07
Forzando	Washed:	Export	50.0	28.4	4.11
Forzando		Inland	48.1	27.4	5.02
Goedehoop	Washed:	Goedehoop	40.3	31.1	4.27

COLLIERY	PRODUCT		SIO_2	Al_2O_3	Fe_2O_3
Graspan :No.2 Seam	Washed:	Large nut	40.2	32.9	3.47
		Small nut	41.6	35.1	2.40
		Pea	41.8	37.0	1.69
Mmm					
		Grain	43.2	36.5	1.57
11		Duff	43.6	35.5	2.35
Greenside: No.5 Seam	Washed:	Small	59.7	23.6	5.04
Inkhwezi: No. 4 Seam	Unwashed:	Run of mine	39.4	31.4	9.80
No. 2 Seam		Run of mine	55.8	26.9	3.70
Khutala	Unwashed:	Crushed coal	50.5	31.0	2.87
Kleinkopje	Washed:	Pea	44.8	34.4	2.96
		Low ash	45.0	34.9	4.16
Koornfontein	Washed:	Export	44.2	33.5	2.22
Kopermyn	Washed:	Large nut	54.1	32.5	2.12
		Pea	49.2	33.0	2.64
		Duff	44.7	31.5	2.96
		Spiral	52.6	26.6	6.91
Kriel: Opencast	Unwashed:	Crushed coal	43.4	24.5	3.25

Underground	Crushed coal	47.2	26.2	3.64
Lakeside	Washed: Pea	54.4	29.6	3.17
Landau	Washed: Large nut	51.1	39.1	2.78
	Pea	52.6	37.4	3.05

P_2O_5 % (ASH)	TiO_2 %(ASH)	CaO %(ASH)	MgO %(ASH)	K_2O %(ASH)	N_2O %(ASH)	SO_3 %(ASH)	P %(COAL)	D.T (ASH FUSSION TEMP ^0C)	S.T (ASH FUSION TEMP ^0C)
0.26	1.58	6.79	2.60	0.61	0.27	3.61	0.025	1320	1340
2.37	2.03	7.70	2.15	0.64	0.24	3.75	0.137	1340	1350
1.28	1.74	7.22	2.01	0.44	0.24	3.08	0.075	1360	1370
0.95	1.80	6.25	1.89	0.65	0.15	3.25	0.064	1480	1490
2.49	2.24	7.04	2.22	0.74	0.26	3.83	0.078	1410	1430
0.15	1.23	1.67	1.32	1.59	0.45	0.03	0.008	+1600	+1600
0.17	1.41	0.54	1.25	1.71	0.40	0.08	0.008	+1600	+1600
0.13	1.97	4.70	0.87	0.52	0.02	2.22	0.008	1530	1550
0.17	1.45	8.52	0.87	0.46	0.08	2.61	0.015	1520	1550
2.75	1.31	10.9	2.54	0.62	0.24	3.78	0.194	1320	1330
1.39	1.81	7.60	2.24	0.54	0.79	3.44	0.100	1310	1330
0.98	2.18	6.70	1.52	0.84	0.55	3.75	0.098	1320	1330
1.61	1.09	7.98	1.73	0.51	0.78	4.30	0.117	1310	1320
1.13	1.81	7.22	1.68	0.84	0.54	3.68	0.099	1370	1390
0.22	1.56	4.04	0.65	0.65	0.07	1.00	0.013	+1600	+1600
1.38	2.13	2.19	0.60	0.64	0.09	1.30	0.067	+1600	+1600
0.21	1.39	0.75	0.26	0.65	0.07	0.69	0.013	+1600	+1600
0.29	1.92	0.93	0.34	0.64	0.07	0.48	0.018	+1600	+1600
0.23	1.65	0.65	0.32	0.64	0.07	0.70	0.013	+1600	+1600
0.26	1.66	0.75	0.34	0.72	0.08	0.81	0.015	1510	1520
0.31	1.65	0.7	0.3	0.74	0.07	0.80	0.017	1500	1515
0.28	1.68	0.74	0.32	0.74	0.06	0.79	0.016	1515	1520
0.29	1.81	0.81	0.35	0.76	0.11	0.86	0.016	+1600	+1600
0.42	1.69	8.57	1.97	0.54	0.32	3.91	0.022	1320	1330
0.42	1.28	10.4	2.75	0.46	0.35	3.70	0.023	1300	1310
2.24	1.46	10.4	3.26	0.65	0.49	4.17	0.129	1350	1360
3.57	2.07	10.2	2.65	0.52	0.51	5.41	0.106	1350	1360
1.47	1.41	11.4	2.73	0.71	0.19	5.22	0.109	1360	1370
1.78	1.44	8.98	2.66	0.79	0.13	4.00	0.126	1380	1400

1.52	1.60	8.27	2.69	0.87	0.12	4.15	0.098	1370	1380
1.26	1.89	7.14	2.53	1.01	0.19	4.31	0.078	1330	1340
1.38	2.12	6.68	2.29	0.96	0.11	5.03	0.087	1310	1350
P_2O_5 % (ASH)	TiO_2 %(ASH)	CaO %(ASH)	MgO %(ASH)	K_2O %(ASH)	N_2O %(ASH)	SO_3 %(ASH)	P %(COAL)	D.T (ASH FUSSION TEMP ^{0}C)	S.T (ASH FUSION TEMP ^{0}C)
0.24	1.16	3.82	2.49	1.15	0.39	2.41	0.012	1420	1460
0.81	2.03	7.60	1.52	1.32	0.62	5.13	0.092	1330	1340
0.34	2.00	4.30	1.64	0.41	0.32	3.32	0.033	1420	1450
0.95	2.89	5.64	1.81	0.83	0.22	2.48	0.106	1480	1500
2.09	1.43	7.78	1.51	0.59	0.62	3.09	0.142	1500	1510
1.48	2.04	5.65	1.62	0.87	0.18	2.66	0.052	1520	1530
2.14	1.55	7.28	2.56	0.66	0.40	5.50	0.096	1350	1370
2.38	1.58	4.40	0.92	0.45	0.20	1.27	0.157	1540	1550
3.12	2.04	6.07	1.17	0.61	0.27	1.65	0.200	1480	1500
4.02	2.03	8.17	1.65	0.46	0.22	2.77	0.246	1390	1410
2.09	2.24	4.76	1.28	0.69	0.34	1.98	0.198	1370	1380
0.92	1.77	8.55	2.32	0.79	0.27	3.30	0.105	1330	1340
1.07	1.46	11.5	2.72	0.85	0.49	4.90	0.101	1330	1340
0.28	1.81	6.29	1.34	0.49	0.09	2.13	0.019	1400	1420
1.36	1.67	0.91	0.34	0.56	0.17	0.37	0.068	+1600	+1600
1.15	1.41	1.51	0.46	0.63	0.24	0.36	0.063	+1600	+1600
P_2O_5 % (ASH)	TiO_2 %(ASH)	CaO %(ASH)	MgO %(ASH)	K_2O %(ASH)	N_2O %(ASH)	SO_3 %(ASH)	P %(COAL)	D.T (ASH FUSSION TEMP ^{0}C)	S.T (ASH FUSION TEMP ^{0}C)
0.77	1.93	1.02	0.37	0.46	0.02	0.41	0.057	+1600	+1600
0.18	1.70	9.85	3.03	0.43	0.21	2.30	0.011	1350	1370
0.46	1.89	2.45	1.07	0.93	1.51	2.65	0.025	+1600	+1600
0.38	2.05	2.39	0.92	0.91	0.77	2.52	0.019	+1600	+1600
0.73	1.97	3.67	1.26	1.21	0.61	4.55	0.050	1530	1550
0.45	2.29	3.46	1.77	1.42	2.60	3.09	0.027	1420	1450
3.01	1.37	14.5	3.19	0.94	0.25	6.90	0.175	1320	1340
0.92	1.61	7.74	2.48	0.97	0.41	4.65	0.110	1260	1280
1.48	1.74	4.79	1.06	0.64	0.12	1.50	0.095	+1600	+1600
1.05	1.89	3.89	1.39	0.60	0.10	2.30	0.112	1490	1500
2.05	1.55	9.78	2.78	0.78	0.20	3.29	0.109	1300	1320

Continued…

COLLIERY	PRODUCT		SiO_2 % (ASH)	Al_2O_3 % (ASH)	Fe_2O_3 %(ASH)
Leeuwfontein: Opencast					
(Bankfontein)	Washed:	Pea	58.2	34.9	1.29
Underground	Washed:	Pea	50.2	29.3	2.19
Leeuwpan	Washed:	Vbpdr	47.1	38.9	2.83
		Vbppci	47.5	38.9	2.14
		Rooiwal	45.1	38.2	2.50
		Lowvol	46.0	36.3	1.79
Leeuwspruit	Washed:	50mm X 0	35.0	27.7	6.00
Matla	Unwashed:	Crushed coal	47.2	30.2	3.65
Middelburg	Washed:	Export	48.8	36.0	3.32
	Unwashed:	Power station	51.7	31.2	5.84
New Clydesdale	Washed:	Pea	41.3	29.6	7.10
New Denmark	Unwashed:	Crushed coal	58.6	23.8	5.17
Optimum	Washed:	Optimum	51.3	32.9	3.80
	Blended	Power station	60.1	27.8	3.60
Phoenix	Washed:	Pea	53.1	31.5	2.15
Polmaise	Washed:	Small	50.3	33.3	4.68
Rietspruit	Washed:	Small	47.8	30.3	3.29

Source: (Prevost; 2005)

Appendix B

A rating scale can then be designed for likelihood, consequence and resultant risks for both qualitative and quantitative methods.

1. Qualitative methods

Qualitative methods of risk assessment are most commonly used as consequences and likelihoods can more easily be identified and risks between events be compared to each other. Risk matrix used in rating risk events.

		Consequence level				
		1	2	3	4	5
Likelihood level	**Descriptor**	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
5	Almost certain	A1	A2	A3	A4	A5
4	Likely	B1	B2	B3	B4	B5
3	Possible	C1	C2	C3	C4	C5
2	Unlikely	D1	D2	D3	D4	D5
1	Rare	E1	E2	E3	E4	E5

Risk rating

Extreme
High
Moderate
Low

Source: (Australian Department of Resources, Energy and Tourism, 2008)

Qualitative risk assessment techniques use descriptive terms to define the likelihoods and consequences of risk events. Bowden et al., 2001 describes the magnitude of all consequences (or subsets of consequences such as economic, financial, environmental or social) as: insignificant—level 1, minor—level 2, moderate—level 3, major—level 4, or catastrophic—level 5. Similarly, likelihoods can be determined as: almost certain—level A, likely—level B, possible—level C, unlikely—level D, or rare—level E. The meaning of these descriptions in terms of the various consequence types and likelihood levels, then needs to

be developed. Outputs from qualitative risk analyses are usually evaluated using a risk matrix format. The risk matrix incorporates the pre-determined risk acceptance threshold and is used to determine which risks require treatment and the priorities that should be applied. Using the matrix, a risk rating for a given risk event can be selected by reading across and down the matrix using the assigned likelihood and consequence descriptors.

In the example matrix, there are 25 potential risk combinations and the risk outcomes have been divided into four risk levels (ratings). Qualitative approaches have some shortcomings, it is difficult to compare events on a common basis, there is rarely clear justification of and the weightings placed on severity of consequences. Furthermore, the outputs from qualitative approaches are difficult to incorporate into financial business considerations.

2. Semi quantitative methods

Semi-quantitative risk assessments provide more details for prioritising and ranking risks, dealing with some of the shortcomings of the qualitative method. In a semi-quantitative risk matrix the likelihoods and consequences have been assigned numbered levels that have been multiplied to generate a numeric description of risk ratings. According to Bowden et al., 2001, the values that have been assigned to the likelihoods and consequences are not related to their actual magnitudes, but the numeric values that are derived for risk can be grouped to generate the indicated risk ratings. In this example, Extreme risk events have risk ratings greater than 15, High risks are between 10 and 15, and so on. An advantage of this approach is that it allows risk ratings to be set based on the derived numeric risk values. A major drawback is that the numeric risk values may not reasonably reflect the relative risk of events, due to possible orders of magnitude differences within the likelihoods and consequences classes. In this example, the risk assessment clearly indicates that there is an order of magnitude difference between likelihood classes and also between consequence classes. Using this approach, it is possible to derive numbered risk levels by multiplying likelihood and consequence levels for each cell of the matrix. For example, a risk event which is possible (likelihood level = 0.01) and would have a major consequence (consequence level = 1000) would show a risk level of 10. If the issues were comparable, then this event would pose the same risk as another event which was, for example, likely (0.1) but with lower, moderate (100) consequences.

Example of a basic semi-quantitative risk rating matrix

		Consequence level				
		1	10	100	1000	10 000
Likelihood level	**Descriptor**	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
1	Almost certain	1	10	100	1000	10 000
0.1	Likely	0.1	1	10	100	1000
0.01	Possible	0.01	0.1	1	10	100
0.001	Unlikely	0.001	0.01	0.1	1	10
0.0001	Rare	0.0001	0.001	0.01	0.1	1

Risk rating

Extreme
High
Moderate
Low

Source: (Australian Department of Resources, Energy and Tourism, 2008)

3 Quantitative methods

Quantitative methods of risk assessment could enable decision makers of junior coal companies analyse a number of risks particularly business risks in making financial decisions. By comparing those financial risk quotients with environmental, economic and social risks, they can prioritise and rank those risks as well as analyse certain key business financial models. Quantitative risk assessment does so by estimating and attributing real values to likelihood and consequences or the probability of risk events occurring with respect to the business investment.

4. A consequence table

Consequence level		Negligible	Minor	Moderate	Major	High
		Minimal if any impact for some communities. Potentially some impact for a small number of individuals. <10	Low level of impact for some communities or high impact for a small number of individuals. <10	High level impact for some communities or moderate impact for some communities.	High level of impact for some communities-s	Very high levels of impact
		0.1	**1**	**10**	**100**	**1000**
Property and infrastructure	Cost to repair or replace and lost revenue	Approximate range from $0 to $0.1million	Approximate range from $0.1 to $1million	Approximate range from $1 to $10 million	Approximate range from $10 to $100 million	Approximate range from $100 to $1 billion
Environment	Ecosystem function	Alteration or disturbance to ecosystem within natural variability	Measurable changes to ecosystem components without a major change in its functions	Measurable changes to ecosystem components with slight change in its functions	Measurable changes to ecosystem components with a major change in its functions	Long term or irreversible changes to components and functions of the ecosystem
	Habitat communities and/or	Alteration or disturbance to habitat	1 to 5% of area of habitat	5 to 30% of area of habitat	30 to 90% of area of habitat	Greater than 90% of area of habitat

	assemblages	within natural variability. <1% affected.	affected in a major way	affected in a major way	affected in a major way	affected in a major way
	Species and or groups of species including protected sites	Population size or behaviour has changed but it is unlikely that there would be any detectable change outside natural variation or occurrence	Detectable change to population size or behaviour. Recovery in less than 1 year.	Detectable change to population size or behaviour. Recovery in 1 to 2 years.	Detectable change to population size or behaviour. Recovery in 3 to 10 years	Local extinctions are imminent or population no longer viable
Economic	Commercial, fishing and aquaculture	Limited or short term reduction in activity. Limited impacts are localised.	Short term reduction in activity. Less than 1 year.	Significant reduction in say fishery activities. 5 to 30%. Recovery in 2 to 10 years.	Permanent significant reduction (30% to 90%) in sustainable yield of fishery or aquaculture**.**	Commercial fishing and aquaculture completely and permanently prohibited or destroyed**.**
	Shipping	Shipping disruption (12hours) of negligible consequence.	Port closed for 24 hours	Port closed for 1 week. Significant ongoing unexpected interruption to port business	Port closed for 1 to 4 weeks	Closure of shipping channels to all vessels. (More than 1 month). Infrastructure loss has extreme consequences.
Public health and safety	Minor injury /illness	Minor injury/illness	Minor injury/illness	Minor injury/illness		

		to less than 10 individuals	to between 10 and 100 individuals	to between 100 and 1000 individuals		
	Major injury or illness	Major injury or illness to 1 individual	Major injury or illness to between 1 and 10 individuals.	Major injury or illness to between 10 and 100 individuals	Major injury or illness to between 100 and 1000 individuals.	
	Fatality/ serious injury, disability			1 fatality or serious injury	Between 1 and 10 fatalities or serious injuries.	Greater than 10 fatalities or serious injuries

Source: (Australian Department of Resources, Energy and Tourism, 2008)

Appendix C

Clean Coal Technologies and technical response to greenhouse emissions.

Environmental Challenges	Technical Responses	Status
Carbon Dioxide (CO_2) Reduction		
Carbon dioxide (CO_2) is the main oxide of carbon produced when fuels containing carbon are burnt. CO_2 is a significant greenhouse gas; progressively reducing CO_2 from fossil fuel based power is an essential element of a global response to the risks of climate change.	In the short to medium term, substantial reductions in the green house intensity of coal-fired generation (CO_2 per megawatt hour of electricity produced) can be achieved by increasing combustion efficiency (megawatt hours per tonne of coal consumed).	The efficiency of pulverised coal generation increased substantially during the latter part of the 20th century and, with the further use of supercritical and ultra-supercritical processes, will continue its upwards advance over the next two decades. Gasification of coal offers efficiencies of up to 50% and is a primary component of 'zero emissions' systems. Circulating fluidized bed combustion technology offers similar benefits to advanced pulverised coal combustion and is well suited to co-combustion of coal with biomass.
CO_2 Emissions, Capture and Storage		

The virtual elimination of CO_2 emissions from fossil fuel based power, including coal-fired generation offers the prospect of reconciling growing energy demand with the long term global goal of stabilising the concentration of greenhouse gases in the atmosphere at an acceptable level.	'Zero- emission technologies' to enable the separation and capture of CO_2 from coal-based generation and its permanent storage in the geological subsurface.	CO_2 separation, capture and geological storage technologies have been developed beyond the stage of technical feasibility. Researchers and technicians are planning to improve these technologies and demonstrate them in integrated configurations. Deployment may start within a decade.

Environmental Challenges	Technological Responses	Status
Particulate Emissions		
Such as ash from coal combustion. Particulates can affect people's respiratory systems, impact local visibility and cause dust problems.	Electrostatic precipitators and fabric filters control particulate emissions from coal-fired power stations; both have removal efficiencies of over 99.5 %	Technologically developed and widely applied in both developing and developed countries.
Trace Elements		
Trace element emissions from coal-fired power stations include mercury, selenium and arsenic. They can be harmful to the environment and to human health.	Particulate control devices, fluidised bed combustion, activated carbon injection and desulphurisation equipment can all significantly reduce trace element emissions.	
NOX and SOX		
Oxides of nitrogen, referred to collectively as NOx, are formed from the combustion process where air is used and/or where nitrogen is present in the fuel. They can contribute to smog, ground level ozone, acid rain and greenhouse gas emissions.	Oxides of sulphur (SOx), mainly sulphur dioxide (SO2) are produced from the combustion of sulphur contained in many coals. SOx emissions can lead to acid rain, and acidic aerosols (extremely fine air-borne particles).	Technologies are available to minimise SOx emissions, such as flue gas desulphurisation and advanced combustion technologies. Emissions can be reduced by over 90% and in some instances by over 95%.

Environmental Challenges	Technological Responses	Status
Waste from Coal Combustion		
Waste consists primarily of uncombustible mineral matter (with a small amount of unreacted carbon).	Coal cleaning prior to combustion is a very cost effective method of providing high quality coal; it reduces power station waste and emissions of SOx as well as increasing thermal efficiencies. Waste can also be minimised through the use of high efficiency coal combustion technologies; the residual waste can then be reprocessed into construction materials.	Technologies developed and continually improving. Awareness of opportunities for the re-use of power station waste (for example fly ash in cement making) is steadily increasing.

Source: (World Coal Institute, 2012)