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The Potential Effects of the Carbon Emission Tax Imposition on South African Mining Companies' Profitability and Emission Reduction

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

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DECLARATION

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

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(Signature of candidate)

Signed on the 25th day of October 2019

ABSTRACT

The increase in the demand for electricity in the advent of industrialisation brought about an increase in the burning of fossil fuels and the rate of deforestation. This is due to the fact that coal is the most abundant and cost-effective energy source found globally. Coal contributes to approximately 40% of the world's electricity power generation. South Africa forms part of the top ten coal producers in the world. In 2014, South Africa generated approximately 92% of its electricity from coal. Inasmuch as coal is the most abundant and cost-effective energy source, it has negative impacts on the environment by means of emissions that are distributed into the atmosphere through its combustion. This is the primary means by which greenhouse gases (GHG), such as carbon dioxide (CO_2), methane (CH_4), surface ozone (O_3), nitrous oxides (N_2O), chlorofluorocarbons (CFC) and water vapour, are released into the atmosphere, and cause global warming (Schneider, 1990; Labat et al., 2004 and Boisvenue & Running, 2006).

South Africa is the highest CO_2 emitter compared to other African countries, emitting 433 173 kilotonnes. However, the country only contributes to 1.5% of the global CO_2 which is minuscule compared to 25 % contributed by China. Be that as it may, every percentage of CO_2 emitted accumulates in the atmosphere. Hence, South Africa made a voluntary commitment at the United Nations Framework Convention on Climate Change (UNFCCC) in Copenhagen to reduce the country's GHG. This was done by the South African government implementing initiatives that encourage and promote energy efficiency (EE).

South Africa also selected carbon tax as one of the country's long-term mitigation strategies. This implied that there would be the use of the "market" to reduce emissions. The carbon tax, in its nature, is a disincentive and has financial implications for the end-user. This, therefore, prompted the inception of this report.

This report seeks to evaluate the potential effects of the carbon tax on mining companies' profitability and levels of emission reduction, and to determine whether the tax will prompt the reduction of CO_2 emitted, or whether the tax will just be a revenue-raising exercise. The report will focus on South African coal, gold, platinum, and iron ore mining companies listed on the Johannesburg Stock Exchange (JSE). The data

was collected from 2010 to 2017; this coincides with the announcement made by the South African National Treasury on the Carbon Tax Policy paper. The profitability and emission data were collected from the companies' annual financial reports and from the Carbon Disclosure Project reports respectively.

The announcement made by the South African National Treasury on the Carbon Tax Policy paper in 2010 motivated numerous mining companies to work in an environmentally conscious manner. The study confirmed that the Carbon Tax Act 15 of 2019 would bring about a decrease in the amount of GHG emissions per mining company, during the project analysis period. These positive results, however, bore negative financial implications, because the carbon tax had negative impacts on the mining companies' profitability. The overall trends indicate that the gold industry could potentially be the most vulnerable to the impact of the carbon tax when compared to other commodity sectors, more especially between the years 2014 and 2015.This effect was compounded by macro-economic factors such as the gold price, fatal injuries that occurred in the mining operations resulting in stoppages and industrial actions.

Based on the findings, it is recommended that more detailed investigation is conducted into incentivising revenue recycling mechanisms on the revenue that will potentially be raised from the carbon tax, to benefit South African citizens. An additional investigation could be done to determine the impact of variable cost on the mining companies on a long-term and short-term basis. This will have to incorporate actual tax incurred by the respective company and the actual tax implications will be determined from there. The impact that the tax will have on employees' salaries could be modelled in predictive analysis. This will determine the impact of the carbon tax when translated to employee salaries and the likelihood of employees being retrenched as a result of the carbon tax imposition.

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DEDICATION

To my precious children, Ofentse and Tumisho Modiba. I hope this inspires you to do far more than I could do. I love you both so much.

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LIST OF ABBREVIATIONS AND SYMBOLS

CO_2	Carbon dioxide
C$	Canadian Dollars
DEA	Department of Environmental Affairs
DME	Department of Minerals and Energy
DMR	Department of Mineral Resources
DoE	Department of Energy
DTI	Department of Trade and Industry
GHG	Greenhouse gas
GJ/ha	Gigajoule per hectare
GW	Gigawatt
GWh	Gigawatt-hour
IDC	Industrial Development Corporation
INEP	Integrated National Electrification Programme
IPP	Independent Power Producers
IPPP	Independent Power Purchase Procurement
kg	Kilogram
KR	Icelandic Krona
kW	Kilowatt
kWh	Kilowatt-hour
MJ/kg	Megajoules per kilogram
MPRDA	Minerals and Petroleum Resource Development Act 28 of 2002
Mt	Megatonnes
MW	Megawatt
NAEIS	National Atmospheric Emissions Information System
NERSA	National Energy Regulator of South Africa
PCC	Pulverised Coal Combustion
PV	Photovoltaic
RE	Renewable Energy
REFIT	Renewable Energy Feed-In-Tariff
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
R/ZAR	South African Rand
SAPP	Southern African Power Pool
TIPS	Trade and Industry Policy Strategies
UNFCCC	United Nations Framework Convention on Climate Change
US$	United State Dollars
%	Per cent

CHAPTER 1: BACKGROUND AND MOTIVATION

1.1. Introduction

Coal contributes to approximately 40% of the world's electricity power generation. Not only is coal important for power generation but in recent years, it has been discovered that it is also a source of critical elements such as uranium, germanium, rare earth elements and yttrium (Dai & Finkelman, 2018). According to Haque et al. (2014), the major uses of rare earth elements are in the renewable energy industry, more specifically in the manufacturing of wind turbines, batteries, catalysts and electric cars. There has been an increase in the demand for such technologies, hence the opportunity of extracting them, even as by- or co-products of coal, is beneficial. The demand will further be heightened by the advent of the Fourth Industrial Revolution, which is described by Davis (2016) as cyber-physical systems that integrate technology into society and even human bodies. It is a means by which there is an increased reliance on advanced technology such as automation. The above also emphasises the importance of coal resources in sectors other than electricity generation.

In a report by Fisher and Downes (2015), it was highlighted that South Africa is one of the top ten coal producers in the world. It also showed that in 2014, South Africa generated approximately 92% and 34% of electricity and liquid fuel respectively from coal. Motiang and Nembahe (2016) further said South African indigenous energy resources are primarily from coal, amounting to 65% and it is said to be attributed to 36% globally (Fisher & Downes, 2015). The parastatal Eskom supplies 95% of the nation's electricity, dominating the country's electricity generation. The remaining 5% is distributed from municipalities, redistributors and Independent Power Producers (IPPs) (Motiang & Nembahe, 2016). These figures emphasise the intrinsic role coal plays in the growth, functionality and overall electricity supply of the South African economy. Electricity generated from coal is more economical when compared to other technologies available, such as renewable energy.

Inasmuch as coal is the most abundant and cost-effective energy source, it has negative impacts on the environment by means of emissions that are distributed into the atmosphere through its combustion. The disadvantage of coal is the amount of greenhouse gas (GHG) emissions dispersed into the atmosphere, more specifically, CO_2 emissions.

There has been compelling evidence indicating the drastic change in the climate through global warming. A number of scientists have attributed the extinction of species, the rise in sea levels and the increase in sporadic temperatures to global warming because of coal combustion (Pounds et al., 2006 and Simon, 2017).

These changes have sparked global agencies, such as the United Nations Framework Convention on Climate Change (UNFCCC), to acquire global commitment from countries in reducing the amount of GHG emissions. A staggering 2.4 million tonnes of CO_2 are released into the atmosphere per second according to a statement released by CBS in 2012 (CBS News, 2012). This number continued increasing and has been reported recently by Rice (2017) as 2.57 million tonnes per second. The increase in the demands of electrification and industrial needs have amounted to a global human CO_2 contribution of 25 billion tonnes in 2017, compared to only 9.2 million tonnes of global human CO_2 production 60 years ago (Rice, 2017).

It was through such unified initiatives that South Africa committed to reducing its overall carbon emission by implementing the Carbon Tax Act 15 of 2019, which was gazetted on 23 May 2019 and enacted on 1 June 2019 (South African National Treasury, 2017).

This research report seeks to evaluate the potential effects of the carbon tax on the mining companies' profitability and levels of emission reduction and to determine whether the tax will prompt the reduction for CO_2 emitted, or whether the tax will just be a revenue-raising exercise.

1.2 Problem Statement

The mining industry plays a pivotal role in the South African economy. It directly contributed 7.3% to the gross domestic product (GDP) in 2016 (Peyper, 2017). The mining industry is the biggest exporter compared to other sectors in South Africa. It exported 33% of the total exports of the country and in 2018, the National Treasury benefited from 24% of the value created by the mining industry. This made it the second-biggest beneficiary from the mining industry (Van Zyl, 2019).

Recently, the industry has been faced with numerous financial challenges due to the economic downturn. According to the Chamber of Mines of South Africa (2016), between 2014 and 2016, the mining industry endured a cumulative net loss of approximately R50 billion. This was due to lower commodity prices and a 4.5% increase in labour costs compared to 2016 figures. There was also a 300% increase in electricity cost over the past several years. The perceived risk of investing in mining projects has escalated, especially after the Mining Charter was gazetted on 27 September 2018.

The mining industry has become notorious for the staggering number of job losses over the past few years and it is estimated that 70 000 jobs have been lost between 2012 and 2016 (Mining Review Africa, 2017). This number of job losses is continuing to escalate because more recently, a media statement by AngloGold Ashanti indicated that 8000 jobs would be cut in 2017 (Kubheka, 2017).

Therefore, the introduction of the Carbon Tax Act 15 of 2019 will further increase the cost burden on most mining operations, especially for the marginal companies that are already operating at a loss. Mining companies are price-takers and with the introduction of the tax, there are limited options in terms of shielding against its impacts through the increased price being transferred to customers.

Tax naturally falls on the cost side of the income statement and this will potentially have an impact on the profitability of any mining company. This study seeks to analyse the potential effects of introducing the Carbon Tax Act 15 of 2019 on the profitability of mining companies and the potential impacts the tax would have on the carbon emission reduction levels.

This was done by quantifying the amount of emission reduction in relation to the overall profitability of mining operations listed in the Johannesburg Stock Exchange (JSE) from the year 2010 up until 2017.

1.3 Research Questions

The research was undertaken to answer the following questions:

- What is the impact of the carbon tax on selected companies' profitability and emission reduction?
- Are there other emission reduction technologies that promote substantial emission reduction without increasing the cost burden of mining operations?

1.4 Proposed Research Objectives

This project's research problem will be solved by addressing the following objectives:

- To determine the impact of the carbon tax on emission reduction during the study period.
- To analyse the financial implication, more especially the profitability of mining companies as a result of the tax.
- To compare other carbon reduction mechanisms and technologies used internationally and how compatible would they be in the South African economy.

1.5 Scope

The report will focus on South African coal, gold, platinum, and iron ore mining companies listed on the JSE. The specific companies of interest are shown in Table 1.

Table 1: Mining companies selected for the research.

Sector	Company Name
Coal	Exxaro Resources
	Sasol
Gold	AngloGold Ashanti
	Gold Fields
	Harmony Gold
Platinum	Anglo American Platinum
	Impala Platinum Holdings
	Northam Platinum
Iron Ore	Kumba Iron Ore

There are 388 companies listed on the JSE, of which 28 have been classified as industrial metals and mining, 25 mining, and nine oil and gas producers. Secondary data from publicly available annual company reports were used for investigating the financial implications of the carbon tax. The Carbon Disclosure Project (CDP) company emission disclosure data was used to collect the amount of CO_2 emitted by each company. The data was collected for the period from 2010 until 2017. The year 2010 is the base of the study because it coincides with the announcement made by the South African National Treasury on the Carbon Tax Policy paper in 2010 (South African National Treasury, 2013) to enact the carbon tax. Carbon dioxide was the only GHG investigated in this research because the carbon tax only pertains to this gas. The different categories that were selected are based on the contribution each sector contributes to the South African GDP.

According to StatsSA (2018), in 2018, the coal industry contributed 26%, followed by the platinum industry with a contribution of 23% and gold making an 18% contribution. This was followed by iron ore at 10%, diamonds, and other non-metallic minerals at 6.7%, chromium ore at 4.2% and manganese at 4.7%. Therefore, the top four contributors to South Africa’s GDP were selected for this research. The specific companies selected were based on the availability of financial and carbon emission data published in company annual reports and the carbon discloser projects respectively.

1.6 Research Limitations

According to the Department of Planning (2017), together with the South African National Treasury (2017), the carbon tax had not been implemented during the project period; however, it was gazetted on 23 May 2019 and enacted on 1 June 2019.

This meant that the author had to model the effects of the carbon tax on the current cash flows of the mining companies listed on the JSE. The selection criteria were driven by the availability of emission data from the CDP and publicly available company annual reports.

The sample period of the research is eight years, which is a short period compared to other conducted studies. A short period may be subject to increased errors in the data collected.

1.7 Definition of Terms

All technical terms used in this report bear the same meaning as those discussed in the Carbon Tax Policy paper (South Africa National Treasury, 2013) which are:

Allowance: any amount allowed to be taken into account for the purposes of determining the amount of carbon tax payable.

Carbon budget: a limit on total greenhouse gas emissions from a specific company, within a specific period.

Carbon tax: a tax on the carbon dioxide (CO_2) equivalent of greenhouse gas emissions imposed.

Carbon dioxide (CO_2) equivalent: the concentration of carbon dioxide that would cause the same amount of radiative forcing (the difference of sunlight absorbed by the earth and energy radiated back to space) as a given mixture of carbon dioxide and other greenhouse gases.

Combustion: the exothermic reaction of a fuel with oxygen.

El Niño: The warming of sea surface temperatures in the equatorial Pacific Ocean which influences atmospheric circulation and consequently, rainfall and temperature in specific areas around the world. El Niño is translated from Spanish as the “boy child”.

Emissions: the release of greenhouse gases or their precursors and aerosols into the atmosphere over a specified area and period.

Emission factor: the average emission rate of a given greenhouse gas for a given source, relative to the activity data of a source stream, assuming complete oxidation for combustion and complete conversion for all other chemical reactions.

Emissions intensity: an indicator of the result of the measurement of the quantity of greenhouse gas emissions in relation to an activity.

Emissions intensity benchmark: the result of the measurement in respect of an activity that creates greenhouse gas emissions:

(a) Expressed as a predetermined value of the quantity of specified greenhouse gas emissions.

(b) In relation to an activity that is differentiated from other activities by means of a product, a type of fuel or technology.

(c) Compared to the quantity of greenhouse gas emissions, in relation to an identical activity undertaken by another person.

Fugitive emissions: emissions that occur from the release of greenhouse gases during the extraction, processing, and delivery of fossil fuels.

Greenhouse gas: gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation, and include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6).

Industrial process: a manufacturing process that chemically or physically transforms materials.

Process emissions**:** greenhouse gas emissions, other than combustion emissions, occurring as a result of intentional or unintentional reactions between substances or their transformation, including the chemical or electrolytic reduction of metal ores, the thermal decomposition of substances and the formation of substances for use as product or feedstock.

La Niña**:** the cooling of sea surface temperatures in the equatorial Pacific Ocean, which influences atmospheric circulation, and consequently rainfall, and temperature in specific areas around the world. La Nina, Spanish for “the girl”, is the opposite of El Niño (South African Weather Service, 2018).

All other terms have been defined and described within their appropriate chapters.

1.8 Structure of the Research Report

The research report is organised as follows:

Chapter 1: Background and Motivation

This chapter provides a brief rationale behind carbon emission tax and its impacts on South African mining companies’ profitability and emission reduction. The chapter also explores the rationale and motivation for the research. The research questions act as a launching pad for the research objectives. Limitations of the research are also discussed as the carbon emission tax not been implemented, contrary to the initial plan as stated by the South African National Treasury. The definition of terms and the structure of the research report are outlined.

Chapter 2: Global Warming

Information for the literature review was obtained from many sources comprising books, journals, newspaper articles, and research papers. The objective of this chapter is to provide a foundation for the study and highlight the necessity for conducting the research. The first section of the chapter introduces the reader to global warming, greenhouse effects and evidence of global warming internationally.

This is done through numerous examples of past events of global warming in specific countries. It is through this evidence that the severity of carbon emissions is highlighted on an international and national scale.

The last section of the chapter discusses different emission reduction strategies. These range from clean coal technology, renewable energy to carbon pricing mechanisms. The trajectory followed by different polices to abate carbon emission is also mentioned. This is done to emphasise that emission reduction is supposed to be a multifaceted initiative. Carbon pricing mechanisms introduce both cap-and-trade and carbon tax. These are further discussed in greater detail in subsequent chapters.

Chapter 3: International Experience with Carbon Pricing Mechanisms

This chapter builds upon Chapter 2.4.4, however, it gives detailed international experiences and designs of both cap-and-trade and carbon tax.

Chapter 4: South African Carbon Pricing Mechanism

The South African energy supply dynamics are discussed, together with a carbon tax in the South African context. The assumptions and rationale behind the selection of the tax, its design and allowances are discussed in detail.

Chapter 5: Potential Effects of Carbon Tax on the South African Mining Industry

This chapter focuses on the effects that the carbon tax will have on South African mining companies. The methodology sample population and size are discussed in this chapter.

All the assumptions and justifications for selecting the specific companies listed on the JSE are discussed in detail. The financial and carbon emission data were collected from companies' annual reports and CDP respectively for the period from 2010 until 2017.The results are arranged in a manner that addresses each research objective. The profitability of each company as reported by JSE is represented by profitability calculations and these are arranged in a spreadsheet that has been attached as Appendix A.

Emission data from the CDP is also tabulated and included in Appendix A. The numerical data is further represented graphically to assist with data analysis. The results are aligned with each research objective to ensure that the problem statement has been addressed. This discussion then feeds into Chapter 6.

Chapter 6: Conclusions and Recommendations

Conclusions are drawn from the data collected with respect to addressing the core questions of whether the carbon tax affects the mining companies' profitability and how effective it is as an emission reduction instrument. Based on this information, specific recommendations were devised to address the limitations of the research and give suggestions for future research.

CHAPTER 2: GLOBAL WARMING

2.1 Global Warming Definition

Riebeek (2010) and the National Aeronautics and Space Administration (NASA) (2014) define global warming as the unusually rapid increase in the earth's average surface temperature over the last century. The Intergovernmental Panel on Climate Change (IPCC) (2014a) together with Shahzad (2015), further mention that the main cause of global warming is greenhouse gases. The build-up of these gases in the atmosphere converts the atmospheric equilibrium with the greatest effect being an increase in temperature.

This temperature increase is due to the anthropogenic release of GHGs such as carbon dioxide (CO_2), methane (CH_4), surface ozone (O_3), nitrous oxides (N_2O), chlorofluorocarbons (CFC) and water vapour (Schneider, 1990; Labat et al., 2004 and Boisvenue & Running, 2006). The primary cause of the release of GHGs is from the burning of fossil fuels and rapid deforestation. The warming of the climate has increased post industrialisation, due to an increase in the demand for electricity by humans. The surface temperature is modelled to rise by between 2°C and 6°C by the end of the 21st century (Riebeek, 2010). Figure 1 depicts the global average temperature increase from the year 1860 and the projection to the year 2020.

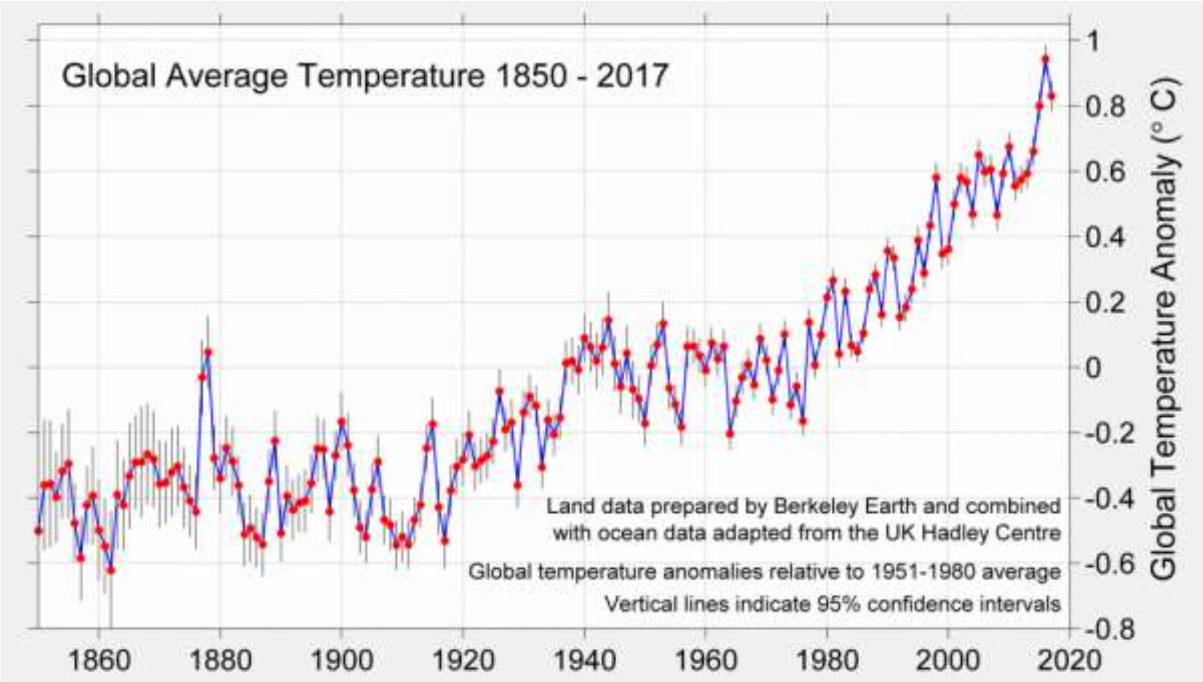

Figure 1: Global Average Temperature 1850-2017 (Berkeley Earth, 2017).

The Greenhouse Effect is a natural process that traps heat from the sun around earth, preventing the earth from becoming too cold. However, excessive amounts of GHGs released due to emissions, create a permanent blanket and trap more heat than is natural, and the greenhouse effect is thus enhanced (NASA, 2014).The causes and effects of global warming are discussed in detail below. This is followed by evidence of global warming internationally.

2.1.2 Global Warming Causes and Effects

The earth's surface temperature has varied over centuries. There have been periods of warming and ice ages, all depending on the earth's tilt or position with respect to the sun and other environmental events such as volcanic eruptions and changes in solar energy. As mentioned previously, the earth has a natural greenhouse effect that maintains the average temperature on earth. According to Riebeek (2010), this process begins with the sun, with 30% of incoming sunlight being reflected back into space and 70% being absorbed by the earth's surface (land, oceans and the atmosphere). Reflective surfaces such as roads, air and seas emit radiating heat that travels into the atmosphere and gets absorbed by water vapour and GHG. It is by this process that the heat blanket is created on the earth's surface.

The area of concern is not the natural process described above, but the excessive amount of radiated heat that is trapped because of excessive GHG emissions and an increased rate of deforestation in response to industrialisation. Forests are natural carbon absorption agents and that action is rendered obsolete when forests are removed. Deforestation accounts for 10% of the world's heat-trapping and emission agents. This, together with excessive fossil fuel use, has increased the amount of GHG molecules in the atmosphere. According to an article published by the Union of Concerned Scientists (2013), an estimated 3.0 billion tonnes of CO_2 per year is attributed to the deforestation of tropical forests for the period from 2000 to 2005.

There have been historical warmings that have taken place because of volcanic eruptions that released GHGs. The footprint of these activities is minuscule compared to the impacts of human activities and industrialisation (Kerr, 2009; Riebeek, 2010). NASA (2014) together with Loeb, et al. (2016), define climate feedbacks as processes that can either enhance or reduce the effects of climate change. The feedback that increases an initial warming is called "positive feedback." A feedback that reduces an initial warming is "negative feedback." These could be, for example, clouds, precipitation, water vapour and ice sheets acting as positive feedbacks. Then the stabilising response, being the negative feedback, is the temperature response. Feedbacks, collectively amplify the surface temperature response to external forces, but the strength of the feedbacks vary greatly.

According to Riebeek (2010), climate feedbacks may also enhance the effects of greenhouse gases by increasing the amount of warming on the planet. The increase in surface temperature has resulted in the melting of snow and ice caps. The light was reflected back into space from these bright surfaces. Now, dark surfaces have been exposed that tend to absorb heat, while water vapour, due to its abundance in the atmosphere, has the potential to increase warming by trapping a high amount of GHGs. Lastly, on land, the previously trapped CO_2 and methane are released due to the melting of snow, thus increasing the load of the GHG molecules.

Natural carbon sink mechanisms are defined as natural systems that absorb CO_2 from the atmosphere and store it in a natural reservoir. This could be in soil, tropical forests and the ocean over time (Thompson, 2012). According to Benson and Orr (2008) and Riebeek (2010), the earth continues to warm even when the source of emission has been removed, due to the remnant molecules of GHGs that are present in the atmosphere (Intergovernmental Panel on Climate Change, 2014b).

2.2 Evidence of Global Warming

Global warming has been one of the most contentious topics of our time. There have been numerous debates around its existence. A number of theorists have argued that global warming is a myth, such as Pearce (1991), Robinson and Robinson (1997). Kerr (2009) is of the belief that there has not been warming for over a decade now. Hence, there is no basis to make bold statements that there is a phenomenon called global warming. These opponents of global warming are also referred to as sceptics or contrarians (Anderegg, et al., 2010). However, with the progression of research and the advancement of technology, there is evidence indicating the effects of global warming, therefore validating its existence. There is research conducted to get a consensus or an indication of the number of researchers who accept the evidence that global warming exists. This was conducted by Cook et al. (2016) that approximately 97% of that consensus from 2412 surveyed papers results indicate that there are a number of proponents to global warming's existence and is caused mainly by human activities.

The two main effects of global warming are an increase in surface temperature and a rise in sea levels. This implies that the global hydrological cycle becomes adversely affected. Secondary effects resulting from the two primary impacts mentioned above are rainfall pattern change, manifested by periods of prolonged flood and droughts, beach erosion, the rise in infectious diseases, and the negative impact on biodiversity and agriculture (Held & Soden, 2006 and Harris, 2018). The United Kingdom Government (2018) cited research conducted by the World Meteorological Organisation (WMO), which indicated that extreme weather contributed to more than 370 000 human deaths from 2001 to 2010. Heatwaves contributed to 6000 deaths in 2001, rising to 136 000 worldwide in 2010. The estimated economic damage from natural disasters during the same period was estimated to be USD$660 billion (United Kingdom Government, 2018).

Changes in temperature and concentration of GHGs have a negative effect on numerous ecosystems, such as forests. According to Allen et al. (2010), forests provide numerous benefits to humans. These include timber, watershed protection and less obvious benefits such as recreation, aesthetic and spiritual needs. Over recent years, there has been an increase in the number of plants and trees that have died due to global warming. Allen et al. (2010) gave substantial evidence of forest mortality experienced in different countries; examples are indicated below.

a) In Uganda, tropical moist forest; in Zimbabwe, the mountain acacia (*Brachystegia glaucescens*); in South Africa, savanna trees in the Kruger National Park; and in Namibia, *Aloe dichotoma* have reduced in numbers.

b) El Niño droughts that took place in Asia from 1982 to 1983 and 1997 to 1998, destroyed large areas of tropical forest in Malaysia.

c) A multi-year drought, from 1992 to 1996, brought about the widespread death of eucalyptus trees in Australia.

d) Forest mortality due to dry conditions increased in Europe, especially oak and other tree species after extreme heatwaves and droughts.

e) Droughts and hot conditions in North America have led to insect outbreaks and the death of trees across millions of hectares.

Global warming also has an impact on plant litter decomposition. Plant litter consists of shrubs, broken leaves and stems that can be found deposited on the ground. The decomposition of plant litter contributes to 7% of CO_2 emitted. Aerts (2006) claims the increase in the decomposition of litter is directly associated with the increase in the influx of soil fauna such as earthworms, snails and some arthropods into an area. The greater the decomposition, the greater the release of CO_2 into the atmosphere. This is a disadvantage as it increases the amount of accumulated CO_2 in the atmosphere thus amplifying the negative effects of global warming.

Numerical modelling conducted by Epstein (2000), showed evidence that global warming does not only affect the immediate environment but may also have adverse health complications for humans. There is also a higher percentage of crop deaths due to pest infestation leading to food shortages. The only positive influence of high temperatures on fauna is the reduction of the snail population thus decreasing the spread of schistosomiasis, which is a parasitic disease spread by snails. However, the disadvantages outweigh the advantages. High temperatures also bring about an increase in diseases relayed by mosquitos, ticks and other blood-sucking organisms. For example, malaria, which is marked by body chills, fever aches, and anaemia and is most lethal to children. Second, dengue fever, also known as “breakbone” fever. This viral infection presents itself with flu-like symptoms that may cause fatal internal bleeding. Lastly, several kinds of encephalitis, which cause inflammation of the brain, marked by flu-like symptoms, such as fever and headaches and possible seizures (Mayo Clinic, 2017).

Predictions from numerical modelling also indicate that by the end of the 21st century, with the current rate of global warming, malaria transmission areas will increase from the current 45% to 60% as indicated by Figure 2.

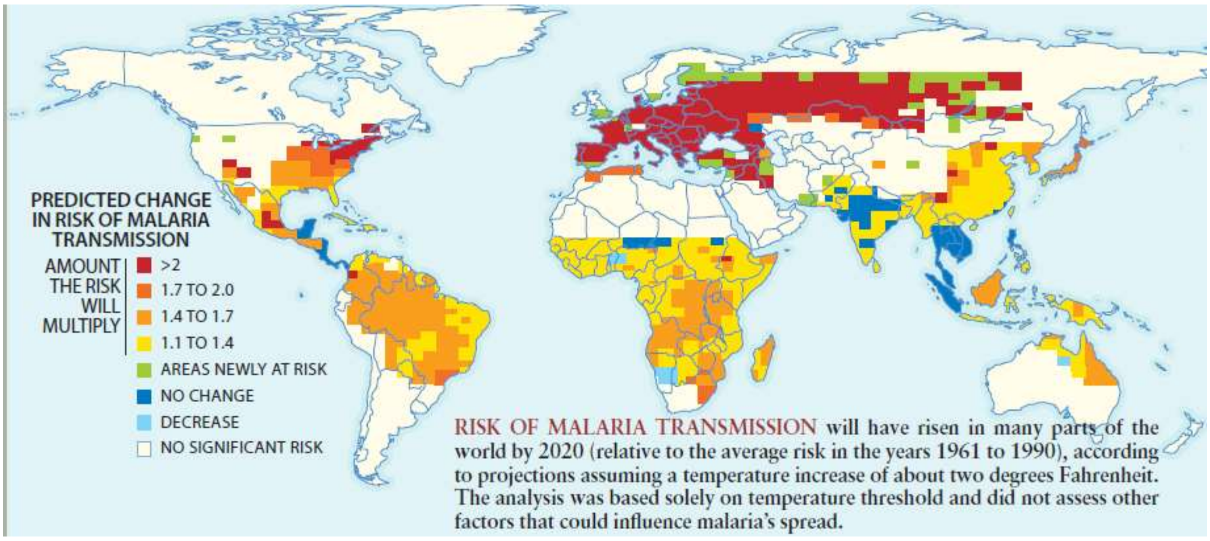

Figure 2: Predicted Change in Risk of Malaria Transmission (Epstein, 2000).

The rest of the chapter discusses evidence of global warming on an international scale. This is done through case studies and various examples of countries being impacted by global warming.

2.2.1 The Arctic and Antarctica

The IPCC has released numerous reports on the mean temperature increase due to an anthropogenic increase in GHGs over the past decade. The increase in temperature has a negative effect globally but the rate of temperature increase and its impact is more evident and pronounced in areas covered mainly by ice, such as the Arctic and Antarctica. The Arctic, found around the North Pole, consists of sea ice and there is no land. However, Antarctica is a continental landmass located at the South Pole, covered by thick ice blankets forming ice sheets (Abraham, 2018).

According to Wadhams and Davis (2000), Anisimov et al. (n.d.) and Overland et al. (2008), global warming contributes immensely to ice sheet and glacial retreat. The higher temperatures also bring about an increase in precipitation that exacerbates the entire melting process. The hydrological cycle is severely affected.

Anisimov et al. (n.d.) further discuss the impact on the melting of permafrost. This change in the hydrological cycle brings about greater runoff and the flowing water erodes the land. This, in turn, will have a negative effect on infrastructure because it may bring about flooding. When the ice sheets have melted, the landmass is exposed and it is darker when compared to the sheets of ice. This implies that more heat from the sun will be absorbed and stored, thus making it even warmer.

Abraham (2017) explored the hypothesis of ice being melted from below instead of directly from the sun's rays. The argument that was put forward was based on a study that was conducted in the Dalton Iceberg Tongue, located on Sabrina Coast, East Antarctica. The data were collected from three locations within the iceberg. The study indicated that, through global warming, the seawater becomes warmer. The colder water is found closer to the surface directly underneath the ice sheets. This is also the most saline part of the water. Freshwater enters the sea due to the melted ice. This then reduces the salinity of the water thus rendering the vertical mixing of warmer water with cold water difficult. This then causes the warmer water underneath to gradually melt the ice from beneath.

When the seawater is freshened (freshwater entering seawater), it weakens currents and the ability to trap heat and CO_2 and, therefore, more CO_2 will be released into the atmosphere.The change in water temperature also has an impact on biodiversity. There may be some advantages to the sea being warmer, such as a greater influx of some species of fish. This has the potential of making the fishing industry thrive in areas that were previously overlooked (Abraham, 2018).

However, when looking at the overall picture, the knock-on effects of the impacts of global warming may bring more harm than good. Biological habitats may be destroyed by a sudden increase in water flow resulting from flooding. This may bring about faunal extinction and migration. It may also bring about floral invasions in certain areas. Entire food webs may be affected, from small organisms to big mammals such as polar bears, penguins, walrus and seals (Vaughan, et al., 2003).Pimm (2009), discusses evidence of Adelie penguins declining in Antarctica due to the rate of snowfall.

2.2.2. Australia and New Zealand

The Great Barrier Reef (GBR) is one of Australia's tourist attractions, contributing approximately US$5.7 billion per year to Australia's GDP (National Climate Change Adaptation Research Facility (NCCARF), n.d.). It is the largest reef system in the world, with an aerial extent of 2600km. It is also measured to be approximately the same size as Germany or Italy. It is home to numerous flora and fauna such as 30 species of whales and dolphins. It is a breeding site for sea turtles and hosts more than 1500 fish species (Great Barrier Reef, n.d.).

This heritage site is under threat due to the impact of global warming. The sea surface temperature has warmed to about 0.60°C since the 1950s and an overall rise in sea level that has been rising at a rate of 1 to 2 mm per year could be 0.3 to 0.9 m higher by 2100 under mid-to-high emissions scenarios. These conditions have brought about an increase in coral bleaching. Coral bleaching occurs when corals release algae living in their tissue, causing the coral to be white in colour. This is because of ocean water being warm (NCCARF, n.d.). According to Smee (2018), the third most common reason for tourists to visit Cairns was to see the reef. The report indicated a decline in the number of tourists from 2016, which coincides with the 30% decline in coral reef due to coral bleaching.

As mentioned in the global warming discussion in Chapter 2.1, the increased concentration of CO_2 in the atmosphere tends to be dissolved in ocean water. This, together with the elevated temperature, makes it less conducive for marine flora and fauna to survive, let alone flourish. Munday et al. (2012) mention that coral reef fish require ambient sea temperatures to range between 2-4°C. If the temperature is higher than this, their aerobic capacity decreases and they will have less energy for eating and reproduction. According to Munday et al. (2012), the effects of high CO_2 levels and high temperature on coral reef fish are:

a) A decline in reproductive output, growth and swimming ability; and

b) Changed behavioural patterns with respect to their sensory ability. They may struggle with navigation for food and the most dangerous effect is they may not be able to distinguish the scent of prey from predators.

Hoegh-Guldberg et al. (2015), discuss that 33-35% of coral reefs have been completely affected by climate change. The increase in levels of carbon dioxide dissolving in the water forming carbonic acid which decreases the pH, brings about more acidity to ocean water thus killing many coral reefs. This mortality rate has a negative impact on fauna that is directly reliant on healthy corals, such as fish. The fish, in turn, will affect the livelihoods of people reliant on fishing, threatening food security and increasing poverty. There are a few historical coral bleaching episodes that occurred in the Great Barrier Reef. These took place in the years 1998 and 2002, affecting 50% of coral reefs. More recently, the National Climate Change Adaptation Research Facility (NCCARF) (n.d.), together with Wolff et al. (2017), discuss the incidence of fewer, but more violent, tropical cyclones resulting from global warming. An example was given of tropical cyclone Yasi that destroyed well over 890000km^2 of coral reef in 2011.

Inasmuch as global warming has an impact on the hydrological cycle, ecosystems, and food webs, there are other devastating effects on humans. The Royal Society (2017) investigated the impact of climate change on human health in New Zealand. It reported that global warming brings about an increase in body temperature. This may be through heatwaves leading to an increase in heatstroke morbidity and mortality rates. There is also associated flooding that comes with global warming. The high volumes of water themselves are not the only threat to humankind but the associated microbial diseases are as well. There will also be periods of drought and an increase in pollutants, more especially particulate matter will be found in the air.

The study also indicated an increase in harmful algal blooms or blue-green algae in rivers. These algae produce harmful toxins that may lead to liver failure, skin disorders, gastrointestinal and respiratory ailments when in contact with humans.

High flood runoff is also going to affect agriculture and some infectious diseases may be transmitted in the water that becomes stagnant. When there is an increase in temperature and CO_2, these are perfect conditions for pollen to thrive and this can be a deadly allergen, especially to asthma suffers. Lastly, the study indicated that mosquitos and tick-borne diseases might be prevalent in such conditions (Royal Society, 2017).

2.2.3. Canada

Evidence of climate change, reflected by the recorded average temperatures since the year 1948 to date, indicates that the average temperature has increased by 1.7°C. The higher temperatures are associated with increased rainfall, rising sea levels, warmer oceans and the acidification of the oceans (The Climate Reality Project, 2018). According to the Canadian Climate Change Impacts and Adaptation Directorate (2002), together with the Canadian Wildlife Federation, (n.d.), the increase in temperature leads to drought, especially in the Southern and Coastal regions in Canada. The entities also discuss the negative impact of temperature increase on agriculture.

The Canadian Climate Change Impacts and Adaptation Directorate (2002) reported that in 1998, the Canadian agricultural sector generated US$95 billion in domestic revenue. According to The Western Producer (2017), agriculture contributed $111.9 billion to Canada’s gross domestic product in 2016, which is translated to 6.7 % of the country’s total GDP. This emphasises the extent that agriculture contributed to the country’s GDP.

Cattle and dairy farms were the highest contributors to revenue. However, in 2001, the drought was so severe that crop yields decreased and much of livestock died. This amounted to a reduction of between 20-30% of normal herd grazing size. Table 2 is a summary of the impacts of drought in the year 2001 on different Canadian provinces on crops.

Table 2: Impacts of 2001 Drought in Canada (Climate Change Impacts and Adaptation Directorate, 2002).

Region	Loss
British Columbia	Losses in vegetable crops
	Negative effects on forage crops, especially in northern Okanagan
Prairies	Wheat and canola production down by 43% from 2000
	Decreased grain production estimated $5 billion
	Increased disease in Manitoba, bringing problems with wheat, canola, barley and wheat
Great Lakes-St Lawrence	Most crops in Ontario impacted by dry weather and disease
	Increased stress from disease, insects and hail
Atlantic	Potato harvest down by 25-45%
	Fruits (for example blueberries and strawberries) and other vegetables impacted

According to the Climate Reality Project (2018), there have been harsher wildfires reported, especially in the western part of Canada. A number of homes and buildings were destroyed leading to the displacement of people. It was recorded that well over 88 000 people were evacuated from Alberta in May 2016 and 2400 homes and buildings were destroyed. The heatwave also negatively affected people. For example, in July 2018 in the Canadian Province of Quebec, a heatwave claimed the lives of approximately 54 people, most being between the ages of 50-85 years.

The Climate Reality Project (2018) conducted a study to quantify the economic impacts ‘prairie fire’ damage may bring. It was calculated that from 1983 until 2004, the insurance claims because of severe weather amounted to US$400 million per year. These sorts of claims have been projected to cost Canada approximately US$5 billion by 2030.

A study conducted by Latifovic and Pouliot (2007), indicated the change in the duration of lake freezing and melting was affected by the increased temperature. The melting of ice sheets and permafrost bring about flooding and a rise in sea level. This was also explored by the Canadian Wildlife Federation (n.d.), together with associated incidences of landslides, especially in the mountainous areas where a large amount of snow has melted (Adaptation Bulletin, 2010).

The melting of snow has a negative impact on animals and indigenous people who rely on the firm ice sheets. The Inuit people, who are the indigenous people of northern parts of America such as northern Canada, and Alaska, as well as Greenland, and northern Russia, have been negatively affected by the melting of snow. It was reported that global warming is affecting their survival rate as some species of fish that they rely on for food are becoming extinct and the thinner and melted ice is treacherous while trying to hunt for food. In a sense, it is forcing them out of their traditional way of life (The Climate Reality Project, 2018).

The Climate Reality Project (2018) reported that numbers of polar bears are thinning due to a shortage of food. This was further emphasised by the Canadian Wildlife Federation (n.d.) where it was discussed that Pacific salmon have shifted their spawning time, resulting in fewer of them being available for bald eagles and polar bears. Elgie (2014), gave an example of mountain pine beetle infestation that occurred in the province of British Columbia in Canada. This infestation had a devastating effect on the local community because a number of mills had to be closed, resulting in job losses. Similarly, the burning of fossil fuels contributed to a C$8 billion loss per year to Canada's economy (Elgie, 2014).

2.2.4. China and Japan

China has the third-largest land area; it is highly populated and it is the highest GHG emitter. The results of the anthropogenic climate change have brought about an increase in the frequency, duration, and intensity of extreme weather patterns according to the Joint Global Change Research Institute & Battelle Memorial Institute (2009) and Puiu (2017).

Hu et al. (2003) ran a few simulations using the Coupled Model In Comparison Project (CMIP2) and the results indicated an increase in precipitation and pronounced warming in the entire country of China. Piao et al. (2010) further discuss an observed 1.2°C increase in average temperature since 1960 and the fact that northern China is warming faster than Southern China.

China has experienced an increase in sea level and ocean surface temperature over the past decade (Jang et al., 2018). This has resulted in flooding and storm surges from the Yangtze River, such as the Great Flood of 1998. This flood destroyed five million houses and over 21 million hectares of land, amounting to an economic loss of US$20 billion (Piao et al., 2010; Tong et al., 2016). The floods were also responsible for the degradation of ecological services such as the destruction of wetlands and mangroves.

Water scarcity through droughts and the disruption of the hydrological cycle contributes to food shortages. This is through the negatively affected agricultural sector. Tong et al. (2016) estimate the decline in mean crop yield across South Asia to be 8% by 2050. They further discuss the impacts that the 2001 drought had in China. Water shortages affected 33 million people and 22 million livestock in rural areas. There was an estimated crop loss of US$6.4 million. The drought was due to extreme heat that also brought incidences of heatwaves. Heatwaves have a cost implication in the labour sector in China because people are not allowed to work on very hot days. This caused additional labour costs for China of approximately US$6.22 billion between 1927 and 2005. This is projected to cost the country US$161.1 billion per year by 2100 (Tong et al., 2016).

There have been recent water crises in China brought about by an increase in algal blooms in Chinese lakes and rivers. This corresponds with the findings discussed by the Royal Society (2017) paper on the prevalence of algal blooms in Australian rivers (Chapter 2.2.2). The cyanobacteria (which largely cause the algal blooms) release toxic chemicals into the water and this causes illness in humans and the reduction of fish in the water (Zhang & Hu, n.d.).

Other recent extreme weather patterns, such as the Magkhut tropical storm in September 2018, have caused flooding and landslides in areas from the Philippines to China. These storms ultimately caused 69 deaths and led to hundreds of people being injured (Ellis-Petersen et al. 2018).

An increase in the incidence and intensity of typhoons or tropical storms has also been observed in Japan. Japan has experienced an increase in temperature and a study conducted by Takemi et al. (2016), deduced that global warming is responsible for intensifying natural disasters such as tropical storms.

An example was given of the severe landslides that took place in Hiroshima in August 2004 due to heavy rains. Another incident was the Baraki flooding that took place in September 2015.

Kiritani (2006) also noted a connection between elevated temperatures and the spread and prevalence of pests that destroy rice and fruit. There was also an increase in vector-borne diseases, such as malaria. A relationship between high temperature and food poisoning was found to be proportional because the higher the temperature, the more vulnerable people such as children under the age of 15 are to diarrhoeal diseases and malnutrition (Honda, 2007; Case & Tidwell, 2008).

2.2.5 Europe

There is a myriad of impacts associated with global warming currently affecting Europe. These include later freeze-up and the earlier break-up of river ice in regions such as Hungary. Takács et al. (2013) conducted a study on the Danube River in Budapest and the Raba River in western Transdanubia. The results indicated that there was a higher incidence of water contamination, due to the elevated temperatures. The water flow was also adversely affected.

This is in agreement with the report by Beniston (2012) that some rivers flowing into the northern parts of the Alps were drying up, especially towards the end of summer; the drier the rivers, the higher the competition for water resources. Beniston (2012) further discussed the implications of the increased temperature on the Swiss Alps. This mountain range is one of the country's premier tourist attractions; it has hydropower potential and they are referred to as "the water towers of Europe". When the snow melts in this area, it increases the volume of water flowing down the mountain, bringing about flooding, erosion of landscape and numerous natural disasters such as avalanches.

Sakalli et al. (2017) explored the impact of global warming on the soil's carbon storage potential and discovered that global warming affects the ability of soil to store enough CO_2. This is due to the increase in plant litter decomposition and the heat associated with an increase in soil organisms.

This is in agreement with the findings from the paper by Aerts (2006) discussed in Chapter 2.2.1. The United Kingdom's bird populations have been affected by elevated temperatures. This is also associated with higher sea levels and heavier rainfalls bringing about coastal surges and flooding which is also observed in other coastal regions as discussed in Chapter 2.2.3 (United Kingdom Government, 2018).

According to Altizer et al. (2013), global warming is linked to an increase in the rate of replication, development, and transmission of pathogens. This concurs with the correlation between high temperature and parasite growth. There is an increase in the occurrence of diseases such as malaria, cholera, and dengue fever (Labat et al., 2004; Webster et al., 2005; Pounds et al., 2006 and Altizer et al., 2013). Numerous studies have attributed an increase in species extinction, such as some butterflies and frogs, to global warming (Thomas et al., 2006).

The rise in temperature also leads to the melting of permafrost. Permafrost is permanent sheets of ice occurring in areas such as Greenland and the Antarctic. Underneath these massive sheets of ice is frozen soil that has been acting as a trap for CO_2 and infectious diseases. There are potential neurotoxins that potentially could be released with the melt of the permafrost (Harris, 2018). The melted ice is also exposed to radioactive plants. Harris (2018), who is in agreement with Thomas et al., (2006) gave an account of the effects of melting ice caps and releasing infectious diseases. This took place in Siberia, Russia in August 2016 where an unusual outbreak of anthrax infected 72 people and a 12-year-old boy succumbed to the illness.

It was discovered that the thawing permafrost was covering a burial site of shallow graves containing animals and humans. The infected melted ice water, therefore, percolated into the groundwater system. People in that area were reliant on groundwater as their source of water. Hence, a large number of them became infected (Harris, 2018).

The examples above do not only indicate the level of discomfort experienced by people who have been exposed to these toxins and contracting such diseases, but there are financial costs that are incurred in treatment and loss of time from their jobs, which could, in turn, make them lose their jobs (Turpie et al., 2002).

2.2.6. Kazakhstan

Kazakhstan is currently experiencing a mean temperature rise of 1°C per year. This can be equated to an annual temperature increase of 2.4°C by 2050 and 4.6°C by 2085 (Pilifosova et al., 1997 and World Bank Climate Change Portal, 2013). Kazakhstan is highly reliant on agriculture, especially sheep farming. The World Bank Climate Change Portal (2013) has discussed that there will be an increase in precipitation bringing about greater agricultural opportunities in the mountainous areas. However, this conflicts with the paper by Pilifosova et al. (1997) stating that agriculture will be negatively affected due to an increase in aridity and desertification of the area.

Pilifosova et al. (1997) agree with the ideas discussed by Yesserkepova (n.d.) around the overall negative impacts of global warming. Yesserkepova (n.d.) further discusses the rise in the sea level of the Caspian Sea combined with the more intense storm surges experienced in that area in recent years. There has also been a reduction in cold days and more hot days. The fluctuation in the weather conditions has brought about a decline in livestock that can withstand the elevated temperatures. The numbers of sheep and goats have decreased from 36.7 million headcounts in the year 1997 to 9.5 million headcounts in 1998.

2.2.7. Mexico

Mexico is the second-largest Latin American country and it is drastically affected by global warming. Climatic variations, when compared to previous decades, indicate an increase in precipitation patterns that are affecting indigenous people, similarly to the Inuit people of Canada discussed in Chapter 2.2.3. These temperatures are associated with droughts and flooding, thus increasing the morbidity and mortality rates (World Health Organisation, 2015).

The economic losses projected by 2030 will range from US$13-11.5 million by 2080. The World Health Organisation (2015) further estimates that the average temperature increases from 1990 projected to 2100 will be 5°C. This implies that approximately 252 600 people will be affected by flooding between 2070 and 2100 as a result of a rise in sea levels.

The heat will affect the soil moisture due to increased evaporation rates and when there is not enough soil moisture, the agricultural sector is severely affected (Liverman & O'Brien, 1991). According to the World Health Organisation (2015), heat-related deaths, more especially in the elderly (65 years and older), are said to increase to 54 deaths per 100 000 people by 2080.

Liverman and O'Brien (1991) together with the World Health Organisation (2015), indicating that water scarcity may lead to a large exodus of people migrating to neighbouring countries such as the United States of America. There will also be food supply shortages due to insufficient water supply, thus contributing to global hunger and poverty. Food security is highly affected in Mexico especially because the country has shifted from exporting their grains to importing maize from other countries (Liverman & O'Brien, 1991).

The World Health Organisation (2015) projected a global risk of hunger and malnutrition up to 20% by 2050. In 2012, Mexico the prevalence of childhood stunting (not developing and growing properly) for children under the age of five years was 13.6% and the wasting of children (the measure of low weight versus the height of the child) under the age of five years was 2.8%. These figures are likely to increase should ambient global warming conditions persist.

2.2.8. South Africa

South Africa, like other African countries, is more interested in addressing issues that are in relation to poverty alleviation, service delivery and the prevention of political unrest. Therefore, as discussed by Alexander (2005), South Africa may be most vulnerable to demands required to abate global warming.

The paper showed that the country's budget is partitioned mainly to redress past events, which means that many South Africans live below the breadline (Alexander, 2005; Nkhonjera, 2017). Climate change is a high risk for South Africa because the country is a semi-arid region already, predisposed to water scarcity. There is also a large migration influx to the country, coupled with rapid urbanisation, thus further putting a strain on the already scarce water resources.

The country’s national development plan may also be negatively affected by high unemployment rates, the prevalence of diseases such as HIV, poverty, and inequality (UNICEF, 2011).

A recent statement released by Statistics South Africa, (2017a) indicated that poverty is on the rise in South Africa. More than half of South African citizens are poor. The calculations were based on Upper-Bound Poverty Line (UBPL) of R992 per person per month (PPPM) according to 2015 prices. This indicated that over 30.4 million South African’s earnings fell below the UBPL. The most vulnerable demographic within the analysis were children under the age of 17 years living in rural areas such as in the Eastern Cape and Limpopo, as indicated in Figure 3.

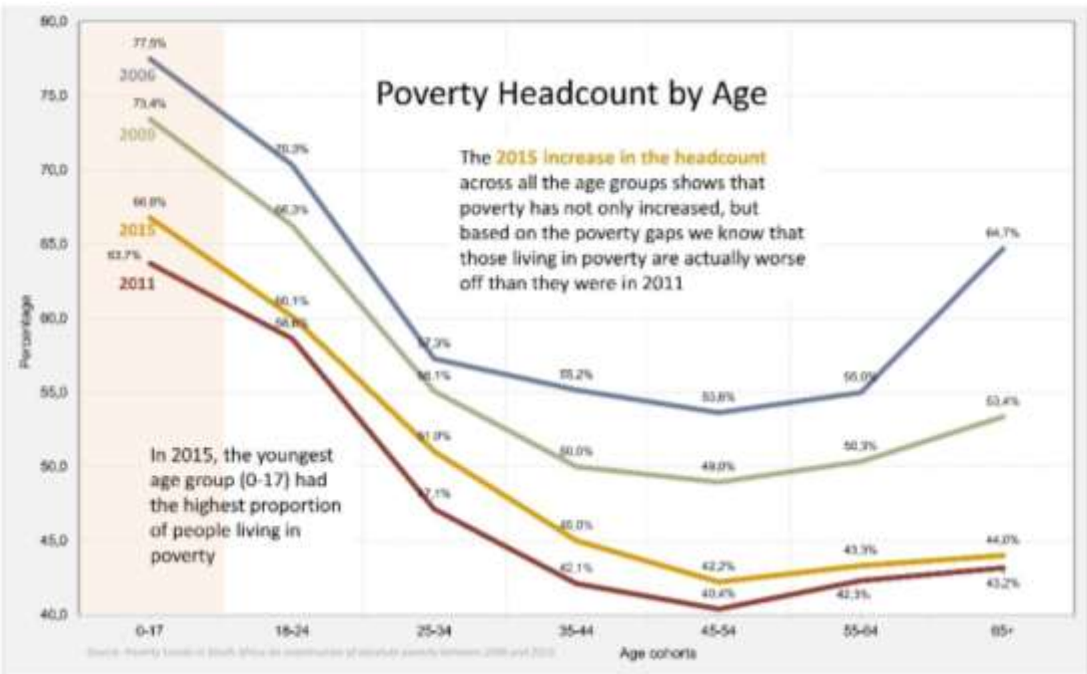

Figure 3: Poverty Headcount by Age (StatsSA, 2017a).

Table 3, adapted from UNICEF (2011), gives a summary of the impact of global warming on South African children. It gives an indication of the physiological impacts the changing environment may have on growing children.

Table 3: Impacts of Climate Change on Children in South Africa (UNICEF, 2011).

Pathway	Impacts on Children
Environmental changes associated with anthropogenic GHGs	Respiratory diseases, sunburn, melanoma, immuno-suppression
Primary climate change impacts	Heatstroke, drowning, physical injury, gastrointestinal disease, psycho-social mal-development
Ecological alterations triggered by climate change	Malnutrition, allergies, vector-borne diseases (malaria, dengue, encephalitis, Lyme disease), infectious diseases (diarrhoea)

A study conducted by Fauchereau et al. (2003) on the impact global warming has in South Africa, showed that there has been variation in the rainfall patterns in the country. There are areas that have experienced extreme rainfall events such as flooding and droughts and the team observed an El Niño Southern Oscillation phenomenon pattern. The impact of global warming has been devastating. These are in the form of natural disasters through tornadoes and flooding resulting in numerous casualties and property damage (Held & Soden, 2006). These incidences have been summarised in Table 4.

Table 4: Disasters Resulting from Rainfall (Adopted from Fauchereau, et al., 2003).

Disaster	Year	Extent of Damage
Kwa-Zulu Natal floods	25-26 September 1987	300 deaths
Southern Africa experienced prolonged periods of drought	Summer of 1982/83 and 1991/92	Severe fall in crops and livestock
Tornado in Hogsback and Umtata, Eastern Cape	1 December 1998	11 deaths and 70km radius buildings destroyed
Limpopo province SA, Mozambique & Zimbabwe	1 February 2000	600 deaths, 200 bridges and 1000km roads destroyed

Research conducted by Turpie et al. (2002) on the economic impacts global warming may have in South Africa include the reduction of water flow in estuaries west of Transkei (Eastern Cape). This will, in turn, affect the harvesting of fish. This implies habitat loss and habitat fragmentation. This in turn leads to a loss of biodiversity. When biodiversity is lost, this could filter negatively into the country's tourism contribution to the GDP. Tourists come in numbers into South Africa to see the diversified wildlife, be it on land or marine life. According to Smith (2018), the travel and tourism industry contributed 9% in 2018 to the total GDP of South Africa, once all the direct, indirect and induced benefits have been taken into account. This equates to an injection of ZAR424.5 billion to the overall SA economy in 2018. The industry also supported 1.5 million jobs in South Africa in 2017, which is 9.5% of total employment in the country.

Habitat and biodiversity losses may ultimately lead to the extinction of certain endemic species. Turpie et al. (2002) discussed a case study on the impact of the rise in sea level on tourism. This was a case in Durban. It was suggested that a 50cm rise in sea level would seriously erode Durban's beaches; the natural system is probably able to withstand a 20 cm impact, not more than that. The consequence of this rise would also affect the central business district.

The study further estimated a loss in maize production amounting to ZAR681 million due to climate change. Water shortages also affect wild animals, such as zebra, and they are forced to migrate to areas in search of water and food. There is also a diminishing number of fish species due to the increased water temperatures. When the fish yields drop, people who are directly reliant on fishing are adversely affected (Fields, 2005).

The severity of the impact global warming has on agriculture is dependent on how the impacted country is dependent on agriculture (Calzadilla et al., 2014). There are conflicting arguments on the impact of global warming North America compared to that in Africa. According to Mendelsohn et al. (1994)'s research, global warming has the potential for increasing the agricultural output value by 4-6%. This was conducted in North America and the research indicated that the increase in the amount of precipitation outside autumn months and the shorter winter proved to be beneficial to the American agricultural sector.

On the contrary, Gemeda and Sima (2015) were of the view that global warming has a negative impact on agriculture, especially in Africa. Africa is a water-scarce continent, riddled by poverty and highly reliant on agriculture. According to the Food and Agriculture Organisation (FAG) (2003), cited in Gemeda and Sima (2015), over 60% of Africans depend on agriculture and the activities associated with it to survive. Fields (2005) discussed that 40% of most African countries' GDP is from agriculture and approximately 70% of the population is directly and indirectly employed in the agricultural sector.When weather conditions such as droughts become more prevalent, crop yield and livestock become affected, thus threatening food security and increasing poverty.

Research conducted by CSIR (as cited in Bega, 2018) indicates that southern African temperatures are rising at about twice the global rate of temperature increase. This implies an increase of 2°C globally means an increase of about 4°C in southern Africa (Bega, 2018:1).

The rise in temperature will affect the water supply, which, in turn, may affect crops such as rice, wheat, beans, maize and potato (these form a major component of staple diets). In South Africa, the Western Cape province has been severely impacted by the recent droughts. The province has lost more than ZAR5 million to the economy because of drought. The drought has led to job losses in the province's agriculture sector. The 2017 third quarterly Labour Force Survey indicated that approximately 25,000 jobs were lost from the agricultural sector nationally. The South African government may be compelled to close ZAR3 billion sought by farmers that have been severely affected by droughts (Kalaba, 2019). Food security is already problematic and, if agriculture is affected in regions with low-income levels and high poverty, these numbers could be expected to rise along with higher mortality rates.

A study was conducted in South Africa by Maphangwa et al. (2012) on lichen species under the current high temperature and CO_2 concentration in the atmosphere. This investigation indicated that lichen's photosynthesising abilities were negatively affected leading to the organism dying. Although this investigation was with lichens, it confirms similar data released by Reid (2005), that there is an increase in plant species dying as a result of global warming. This is an even higher threat in Africa because some human populations are still reliant on traditional plant-based medicine. For example, in Mali, a large area containing medicinal plants was destroyed by droughts. Other impacts on human health include the increase in vector-borne diseases such as malaria, and water-borne diseases such as those relating to *E. coli* bacteria (Reid, 2005).

2.2.9. United States of America

A small temperature increase of about 1°C brings about a 4% increase in global runoff (Labat et al., 2004). The world's highest temperature recorded, 57.8 °C, was attained in 2012, according to the US Global Change Research Programme (2014). Prolonged periods of high temperature mean no night cooling can take place; instead, the heat continued to rise at night.

Such conditions are associated with more intense evaporation, in turn, bringing about higher volumes of precipitation that increase the global runoff in continental regions (Labat et al., 2004). According to the United States Global Change Research Programme (2014), this temperature rise is also associated with prolonged periods of high temperature bringing about droughts and veld fires (US Academy of Science & the Royal Society, n.d.). Hansen et al.'s (2016) paper further discusses high-intensity storms, resulting in turtle nests being washed out by hurricanes.

This may be beneficial to the agricultural sector, as the research programme discussed the longer growing seasons for crops and longer ice-free periods. This may be one good result; however, the disadvantages of climate change outweigh these positive effects. The prolonged heat periods also bring about the melting of ice sheets, which further contributes to the water runoff (US Global Change Research Programme, 2014; Hansen et al., 2016). The increased temperature is associated with higher pollen production, especially when the CO_2 concentration in the air is high. The increase in pressure from pathogens and pests affects the most vulnerable which are the poor, the elderly and children.

Numerous theorists and researchers such as Boisvenue and Running (2006); Keller (n.d.); Hansen et al. (2016) and Simon (2017) attest to the rise in sea level being attributed to the increased thermal expansion. The consequence of this is the increased intensity in hurricanes and precipitation levels. The general warming of the sea surface contributes to the slowing down of deep-water formation (Pimm, 2009; Hansen et al., 2016).

Sea level rise and an increase in coastal storm surge also bring about beach erosion (United States Global Change Research Programme, 2014). According to an article by Cave (2017), beach erosion is the phenomenon when the sea takes away the beach or removes more sand than is replenished. A study conducted by the University of Hawaii predicts that beaches on islands such as Oahu, Maui, and Kauai will retreat 6.1m by the year 2050 and 12.1m in the year 2100. Figure 4 shows a house that has been destroyed because of beach erosion.

Figure 4: A house in Sheep Pond Road Madaket Massachusetts (USA) collapsed due to beach erosion (Brace, 2015)

The average shoreline is receding at twice the normal rate due to the increase in sea levels. The study further emphasises that 70% of the current beaches are experiencing chronic erosion and it will require large capital injections estimated at US$2.9 million to remedy the problem (Cave, 2017). Another example of the rise in sea level is the increase in flooding caused by high tides in coastal areas, due to a nor'easter storm in Boston, USA (Joyce, 2018).

In the city of New Mexico, the elevated temperatures bring about a shift of snow to rain, thinner snow blankets and, in turn, the hydrological cycle will be affected, implying that the water supply will be reduced for an ever-growing population. This will tend to force citizens to convert from agricultural living to greater urbanisation (Hurd & Coonrod, n.d.).

A paper by Easterling et al. (2000) investigated the socio-economic impacts global warming had on American citizens. It was discussed that elevated temperatures and heatwaves cause damage to infrastructure. These authors also mentioned that, in 1998, hurricane Mitch caused 10 000 deaths in Central America. From 1987 until the year 2000, the USA has had more than 360 extreme weather events, each produced losses that were in excess of US$5 million. Hurricane Andrew that occurred in South Florida in 1992, caused total damage amounting to US$30 billion and Midwest flooding that took place in 1993 resulted in US$19billion damage. Climate change also affects precipitation intensities and a hailstorm in Dallas and Oklahoma City, destroyed infrastructure amounting to US$300 million (Easterling et al., 2000).

2.3 Emission Reduction Strategies

The compelling evidence discussed in Chapter 2.2 indicates that global warming is not an urban legend or myth as some theorists would like to believe. However, it is a reality this current generation will have to accept and live with. This, therefore, sparked conversations on an international scale, suggesting means by which global warming can be mitigated. Numerous emission reduction mechanisms have been employed over the years, such as implementing various policies that promote the reduction of emissions, the introduction of clean coal technology in the form of carbon capture and storage, renewable energy and carbon pricing mechanisms as indicated by Figure 5. Figure 5 highlights that there is a relationship between policy and emission reduction mechanisms.

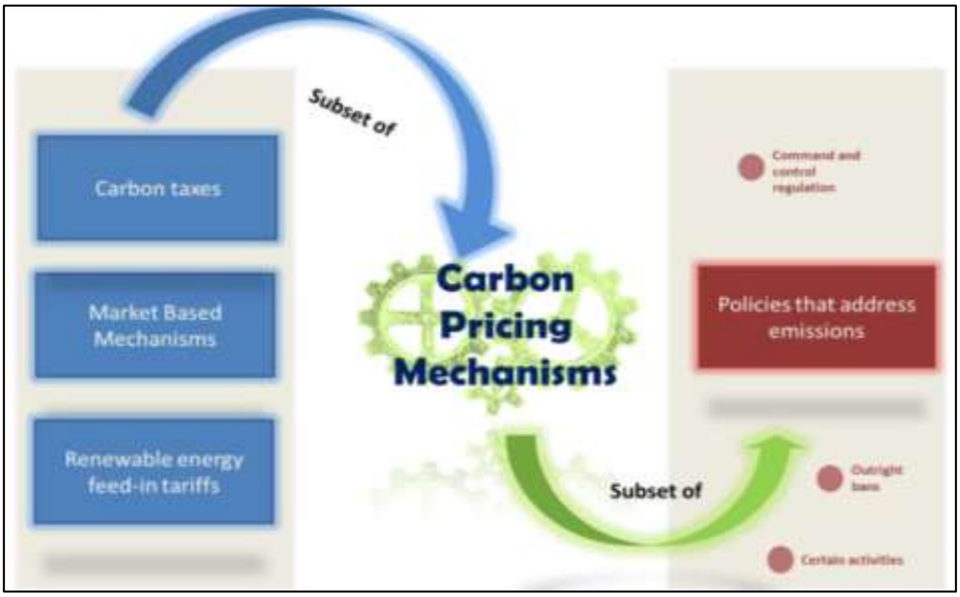

Figure 5: Carbon Pricing Mechanisms (Kilani, 2013).

This chapter discusses the different forms of energy reduction strategies. This was investigated through policies and frameworks established over the years to aid in reducing emissions. The section on policies and various frameworks is then followed by mechanisms that have been put in place such as clean coal technology, renewable energy, and carbon pricing mechanisms.

2.3.1. Climate Change Interventions Aimed at Reducing Emissions

The United Nations has had numerous initiatives aimed at curbing the effects of climate change. These include the United Nations Sustainable Development Goals; the Conference of the Parties (COP) and the UNFCCC to name a few. The United Nations defines sustainable development goals being the blueprint to achieve a better and more sustainable future for all. These goals pertain to global challenges affecting the global community such as poverty, inequality, climate, environmental degradation, prosperity, and peace and justice. Sustainable development goal 13 is aimed at taking urgent action to combat climate change and its impacts. These goals are meant to be attained by 2030 (United Nations, n.d.).

The climate change policy intervention journey commenced in 1979, with the first world climate conference. The IPCC in 1988 followed this. Then in 1990, there was a call for a global treaty on climate change, The United Nations General Assembly negotiated on a framework convention. In 1992, the UNFCCC opened at the Earth's Summit in Rio, Brazil. The UNFCC came into force in 1995 (United Nations, n.d.; UNFCCC, n.d.).

Table 5 is a summary of the 25 years of international climate policy evolution. This summarises the series of COP that took place from COP 1, Berlin, Germany in 1995 up to COP25 that is scheduled to take place from 2 to 13 December 2019 in Santiago, Chile. The COP is the supreme decision-making body of the Convention.

All States that are Parties to the Convention are represented at the COP, at which they review the implementation of the convention and any other legal instruments (United Nations, n.d.).

Table 5: 25 Years International Climate Policy Evolution (UNFCCC, n.d.).

Year	Conference of Parties
1995	COP 1, Berlin, Germany
1996	COP 2, Geneva, Switzerland
1997	COP 3, Kyoto, Japan
1998	COP 4, Buenos Aires, Argentina
1999	COP 5, Bonn, Germany
2000	COP 6, The Hague, Netherlands
2001	COP 6, Bonn, Germany
2001	COP 7, Marrakech, Morocco
2002	COP 8, New Delhi, India
2003	COP 9, Milan, Italy
2004	COP 10, Buenos Aires, Argentina
2005	COP 11/CMP 1, Montreal, Canada
2006	COP 12/CMP 2, Nairobi, Kenya
2007	COP 13/CMP 3, Bali, Indonesia
2008	COP 14/CMP 4, Poznań, Poland
2009	COP 15/CMP 5, Copenhagen, Denmark
2010	COP 16/CMP 6, Cancún, Mexico
2011	COP 17/CMP 7, Durban, South Africa
2012	COP 18/CMP 8, Doha, Qatar
2013	COP 19/CMP 9, Warsaw, Poland
2014	COP 20/CMP 10, Lima, Peru
2015	COP 21/CMP 11, Paris, France
2016	COP 22/CMP 12/CMA 1, Marrakech, Morocco
2017	COP 23/CMP 13/CMA 1-2, Bonn, Germany
2018	COP 24/CMP 14/CMA 1-3, Katowice, Poland
2019	COP 25/CMP 15/CMA 2, Santiago, Chile

It is evident from Table 5 that the plights towards climate change policies and efforts of reducing emissions have been taking place for a number of years. Policies feed into the mechanism that acts as a means of reducing emissions. The following sections give details on emission reduction technologies and mechanisms that have been employed internationally.

2.3.2. Clean Coal Technology

This is a technological advancement of reducing CO_2, SO_2 and NO_2 emissions from large, single and stationary sources. These facilities include but are not limited to, fossil fuel power plants, biomass energy facilities, synthetic fuel plants and major CO_2 emitting industries (cement, petrochemical, iron, and steel) (Coal Industry Advisory Board (CIAB); International Energy Agency (IEA), 2010). Chang et al. (2016) further define clean coal technology as technologies that enable environmentally friendly or clean use of coal, in a manner that is economically viable. These technologies emit minimal CO_2 and are referred to as near-zero emission technologies. The greatest challenge faced by such technologies is the up-front capital costs. According to case studies conducted in the United States of America, discussed in the article by Campbell, (2015), the forecast cost for Duke Energy's 595 MW Integrated Gasification Combined Cycle (IGCC) went online on June 2013, was US$1.985 billion. The actual cost was US$3.55 billion. Another example is SaskPower 110 MW Carbon Capture and Storage (CCS) project, with a cost of C$1.467 billion. It is evident that the initial capital cost is very high.

Examples of near-zero emission technologies include the following:

a) *Carbon Capture and Sequestration* or *Carbon Capture and Storage* (CCS for both) and *Carbon Capture Use and Storage* (CCUS). The above entails removing CO_2 and converting it into liquid form. This liquid is captured and stored 2-3km deep in geological strata. This technology's advancement is slow because of the high costs involved and the lack of political and financial commitment (World Nuclear Association, 2018). Three technology options could be applied in CCS. These include:

(i) *Enabling CO_2 capture Post-combustion: These systems separate CO_2 gas produced by "air-blown" combustion of any fossil fuel or biomass;*

(ii) *Pre-combustion systems process: The primary fuel in a reactor or gasifier to produce synthetic gas (syngas) which is then converted and separated into two gas streams – CO_2 for storage and hydrogen as a fuel for a gas turbine; and*

(iii) *Oxy-fuel combustion systems: These systems use "oxygen-blown" combustion to produce a flue gas with a much higher concentration of CO_2 than conventional air-blown combustion* (Coal Industry Advisory Board (CIAB) and International Energy Agency (IEA), 2010:28).

Refer to Figure 6 indicating an overview of the main technological options for CO_2 capture from power plants.

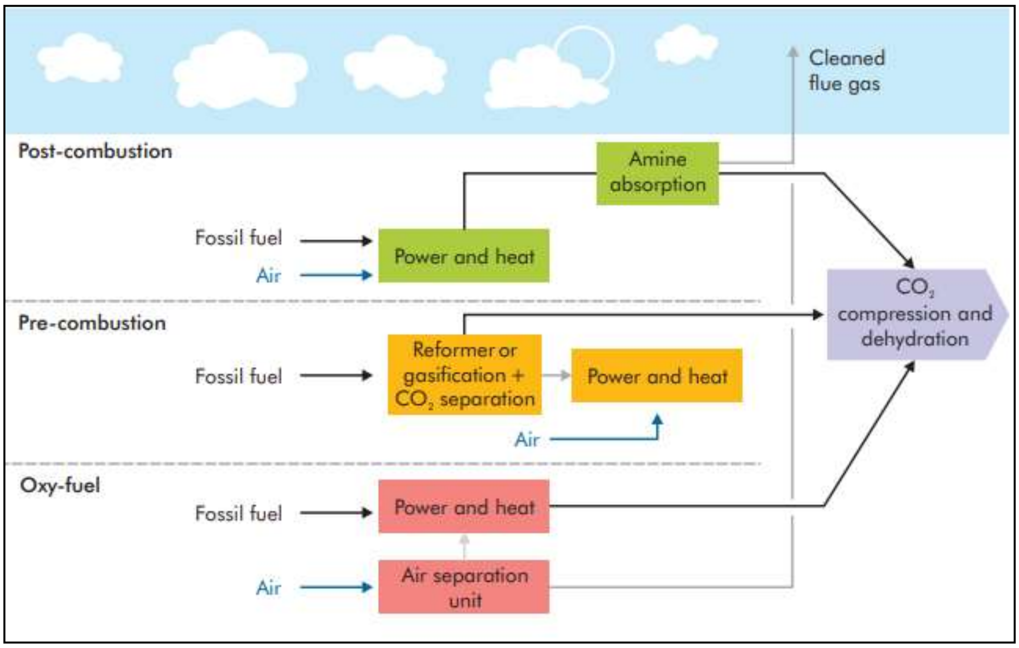

Figure 6: Overview of the Main Technology Options for CO_2 Capture in Power Plants (Zero Emission Fossil Fuel Power Plants (ZEP), 2006).

b) *Fluidised Bed Combustion*, Limestone, and dolomite are added during the combustion process to mitigate sulphur dioxide formation (Rocky Mountain Coal Mining Institute (RMCMI), n.d.);

c) *Integrated Gasified Combined Cycle (IGSS)* utilises heat and pressure to convert coal into a gas or liquid that can be further refined and used cleanly. The heat energy from the gas turbine also powers a steam turbine. IGSS, together with fluidised bed combustion, enables higher thermal efficiency of up to 50% compared to older technologies (World Nuclear Association, 2018);

d) *Low Nitrogen Oxide (NOx) Burners* reduce the creation of NOx, a cause of ground-level ozone, by restricting oxygen and manipulating the combustion process. Low NOx burners are now on 75% of existing coal power plants (Rocky Mountain Coal Mining Institute (RMCMI), n.d); and

e) Clean coal is also used for *Supercritical and Ultra-Supercritical* coal-fired plants. These are also known as High-Efficiency Low Emission (HELE) power plants. These types of power plants operate at a very high temperature of approximately 600°C and high pressure of greater than 22MPa. It is also said that, at these extreme conditions, there is no distinction between water in its liquid versus gaseous state. Seventy per cent of power plants in Japan and South Korea are Supercritical and Ultra-Supercritical plants.

2.3.3. Renewable Energy

The National Renewable Energy Laboratory (NREL) (2001), together with Demirbas et al. (2009), define renewable energy as energy sources that are continually replenished naturally and do not disturb the natural balance of the earth. These include sources from sunlight, wind, water, geothermal heat and biomass. The available renewable energy technologies use the above-mentioned energy sources and convert them into usable forms of energy.

This is mostly electricity, heat and mechanical energy (NREL, 2001). Examples of the different forms of renewable energy technologies are as follows:

a) *Hydropower*

According to NREL (2001), hydropower plants produce electricity by capturing the energy of flowing water. This is usually by constructing hydroelectric dams. A reservoir of stored water is created and when the water is released from the dam, it flows into turbines that generate electricity. There are no emissions emitted into the atmosphere from this type of electricity generation method. The disadvantage of hydropower is the impact it has on the surrounding environment on which it is built. This technology has an impact on the flora and fauna that inhabit the water. NREL (2001) further discussed initiatives done in the manner the turbines are designed to assist in fish migration and thus lower the number of fish mortalities;

b) *Solar Energy*

This form of renewable technology taps into the infinite power of the sun. Photovoltaic (PV) or Concentrated Solar Power (CSP) converts the light and heat radiating from the sun into electricity. The type of design used to generate electricity is referred to as a passive solar design. This is due to its nature of not requiring pumps, fans or any form of mechanical devices to convert solar energy into electricity (National Renewable Energy Laboratory, 2001);

c) *Wind Energy*

The South African Department of Energy defines wind power as a source of electricity that uses mechanically powered wind turbines. These may be 50m long blades, attached to an 80m long hub that generates the electricity. Wind turbine farms can produce electricity ranging from 10MW to 100MW, provided the wind speed is 13 – 90 km/h. These turbines are placed onshore or offshore in areas that have high winds and will cause less negative visual impacts or negative visual aesthetics in the environment (Department of Energy South Africa, n.d.);

d) *Biomass*

Biomass generates energy from living or previously living organisms. It utilises plant material called lignocellulose to produce energy. The main sources of energy discussed by the NREL (2001) and Demirbas et al. (2009) are wood and wood wastes, agricultural crops and their waste by-products, municipal solid waste, animal wastes, waste from food processing, and aquatic plants and algae. Biomass has the capacity to produce electricity, heat and liquid fuels. Biomass may be used directly for heat, for example burning wood for heat and to cook. This is one of the cheapest forms of energy and contributes to poverty alleviation in developing countries (Demirbas et al. 2009). Biomass may also be used indirectly, through a biological process called fermentation, when the biomass has a very high carbohydrate content, to produce alcohol such as ethanol and methanol. This is then used as fuel for vehicles and for cooking processes (NREL, 2001); and

e) *Geothermal Energy*

There are distinct layers that form in the earth; each layer is a source of very high temperature. The crust, which is the outermost layer, is 22°C, moving inward to the upper mantle which ranges from 1400°C to 3000°C. The inner mantle has a temperature of 3000°C. Then there is the outer core with temperatures ranging from 4000°C to 6000°C. Finally, the inner core has temperatures ranging from 5000°C to 6000°C (Robertson, 1966). This indicates the geothermal energy that the earth possesses. This form of renewable energy uses the heat generated by the earth and taps into an underground reservoir of water and steam, such as geysers, to generate electricity. This can be done by using geothermal heat pumps (GHPs) to create heat sources (NREL, 2001).

According to the International Renewable Agency (IRENA) (2018), the renewable energy sector has recorded an increase of 167 GW of generating capacity amounting to 8.3% in 2017 globally, compared to 2011 values, as indicated by Figure 7. This shows the growing need and use of renewable energy across the globe.

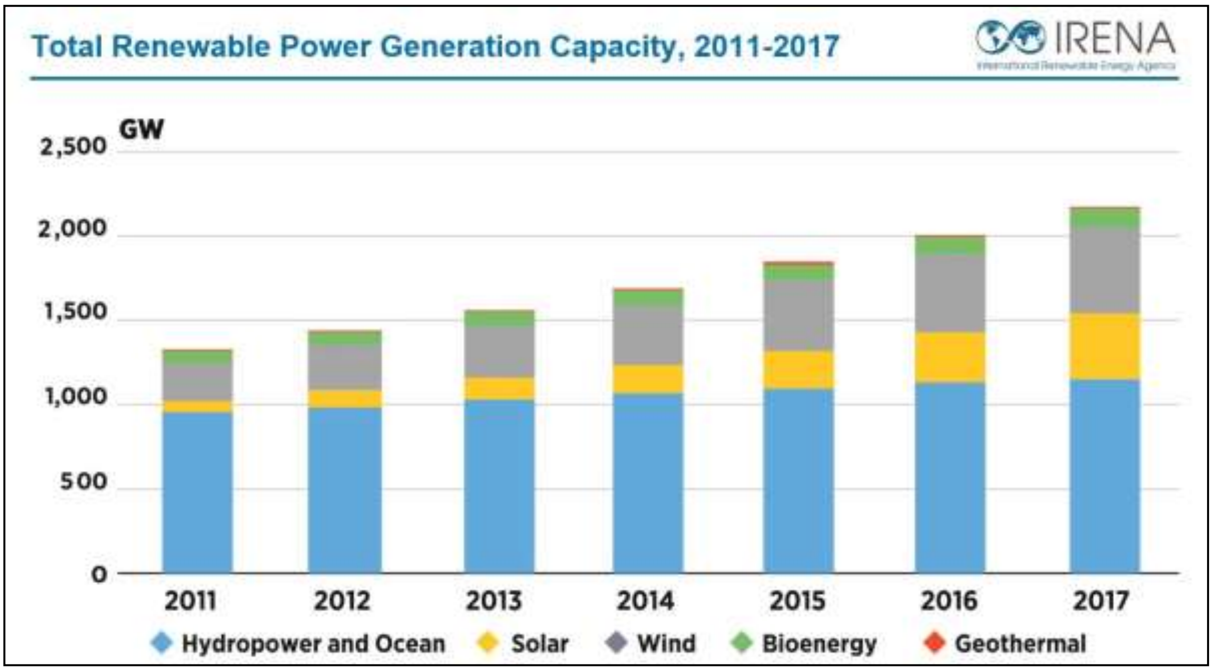

Figure 7: Total Renewable Power Generation Capacity, 2011-2017 (IRENA, 2018)

2.3.4. Carbon Pricing Mechanisms

Kilani (2003) presented three broad carbon pricing methods at the UNFCCC. These include a carbon tax, market-based mechanisms, such as emission trading, and renewable energy feed-in-tariffs. Avi-Yonah and Uhlmann (2009) also included regulatory limits to be applied to CO_2 emissions. These could be, for example, CO_2 emission standards for motor vehicles, a national ambient air quality act promulgated in the USA, and issuing permits for major sources of CO_2. In addition to the carbon tax and cap-and-trade carbon pricing mechanisms, Aldy and Stavins (2012) included an emission reduction credit system, clean energy standards and fossil fuel subsidies.

The emission reduction credit system is a voluntary system selected by companies that may not be following a market-based or policy-type of emission reduction instrument. It also uses a form of an offset system that is similar to a cap-and-trade market instrument. It works under the pretext of having certified credits that are awarded to that company depending on the amount of emissions reduced in a particular period.

Examples of such credit systems are the Clean Development Mechanism (CDM) under the Kyoto Protocol and Regional Greenhouse Gas Initiative (RGGI) that have been enacted in northeast United States that regulates the CO_2 emissions from certain power plants and provides credits to those firms (Aldy & Stavins, 2012). Companies establish clean energy standards to promote clean energy technology advancement. It is similar to the cap-and-trade system in terms of having a tradable credit system.

Fossil Fuel Subsidy, on the other hand, has been defined by Abraham (2017) as "*direct financial cost that results in consumers paying a price that is below the opportunity cost of the product, the cost also entails environmental costs like global warming and deaths from air pollution and taxes applied to consumer goods in general*" (Abraham, 2017:1). There is much negative connotation attached to such revenue-raising policies.

Agencies, such as the International Energy Agency, are of the view that the elimination of such subsidies may result in a global reduction of approximately two giga-tonnes of CO_2 by 2020 (International Energy Agency, 2010). Aldy and Stavins (2012) further argue that subsidies harm poor-income households and unfairly benefit wealthier ones. The scope of this research report will only focus on the two major market-based mechanisms, namely cap-and-trade and carbon tax.

Hepburn (2007) and Goldblatt (2010) describe the cap-and-trade emission trading system as a means by which the quantity of GHG emissions can be capped at a particular predetermined level. It allows low emitting industries to sell their extra allowances to larger emitters. It also establishes a market price for GHG emissions. Cap-and-trade also brings about an opportunity for emission reduction in relation to an increase in pollution levels, rather than placing a price on emission reduction. Due to depending on market variables, this mechanism tends to be very volatile and it has limited revenue-raising capabilities (Goldblatt, 2010).

Carbon tax, on the other hand, is described as a price instrument used to set a specific price on carbon. This is done by determining a tax rate on GHG emissions or the carbon content of fossil fuels.

It is further described as bringing about stable revenue but there is uncertainty on the emission levels (Goldblatt, 2010; Creamer, 2016). A number of economists also refer to it as a Pigouvian tax approach as it is seen as a revenue-neutral mechanism, with its major mandate not to raise revenues (van Heerden et al., 2016). Revelle (2009) also describes it as a tax rate imposed on fossil fuels suppliers. The primary contributors to the tax are the coal, oil and natural gas industries.

The extent to which these suppliers are charged depends on the amount of potential emissions generated by their product. For example, coal is charged at a premium price due to the substantial amount of carbon emitted per unit of energy.The tax does not only affect the producers and wholesalers but has a snowball effect on the consumers as well, through an increase in electricity and fuel prices.

Table 6 is a detailed comparison between the above-mentioned carbon pricing mechanisms. The comparison is divided into three categories. Namely the inherent differences between the pricing instruments, the certainty of emission reduction and price predictability.

Table 6: Comparison between the Two Types of Carbon Pricing Mechanisms (Adopted from Revelle, 2009 and Goldblatt, 2010).

Carbon Pricing Mechanism Differences	
Carbon Tax	***Cap-and-Trade Scheme***
Price instrument	Quantity of emissions instrument
Incentives to reduce pollution	Sets a maximum level of pollution
Tax set by assessing cost or damage associated with each unit of pollution	A cap and emission permit among firms that produce pollution
Cost Assist in controlling that pollution	Permits acquired through auctions
Emission Certainty	
No guarantee of achieving emission reduction targets	Firm limit on emission, e.g. *80% of 1990 levels to be reduced by 2050*
Quantity of emission may fluctuate depending on energy demands	Individual companies have flexibility for achieving emission target
Emissions will vary year to year	
Companies have flexibility to abate less & pay more	
Price Predictability	
Fixed price of carbon emission	Price of emission vary year on year
Increase permanent incentives to reduce emissions	Increase in demand from cold months may spike prices of permits
Encourages investment in alternative fuels & energy efficient technologies with high upfront cost	Price volatility may have negative effects on the market
Its effectiveness gauged by the promotion to investment in clean energy & energy efficient technologies	

It can be concluded from Table 6 that these two price mechanisms are vastly different and their success is highly dependent on the country of implementation. South Arica is a developing country and this contributed to the motivation of selecting carbon tax because it is less volatile compared to cap-and-trade and is less reliant on market performance.

There are theorists that are of the view that carbon tax will not benefit any economy unless its distributional effects are invested in the economy. Mathur and Morris (2014) and Wang et al. (2016) concurred with respect to the regressive effect carbon tax may have on an economy. This is evident downstream in poor households and in production industries that are heavily reliant on fossil fuel for energy.

They are also of the view that the carbon tax has the potential to decrease the country’s GDP and citizen's employability potential. Their suggestion is to obtain an in-depth understanding of the effects carbon tax may have on the economy.

The means by which to ameliorate the adverse economic effects of the tax would be by revenue recycling and having incentives that may be used back into the household in the form of subsidies. This will also render the process of acceptance of the subsidy well into the economy.

2.4 Conclusion

The increase in the demand for electricity, in the advent of industrialisation, brought about an increase in the burning of fossil fuels and in the rate of deforestation. This is the primary means by which GHGs such as carbon dioxide (CO_2), methane (CH_4), surface ozone (O_3), nitrous oxides (N_2O), chlorofluorocarbons (CFC) and water vapour, are released into the atmosphere, and cause global warming (Schneider, 1990; Labat et al., 2004 and Boisvenue & Running, 2006). According to an article published by the Union of Concerned

Scientists (2013), an estimated 3.0 billion tonnes of CO_2 per year is attributed to the deforestation of tropical forests for the period 2000 to 2005.

The two main effects of global warming are an increase in surface temperature and a rise in sea levels. Secondary effects resulting from the two primary impacts are rainfall pattern change, manifested by periods of prolonged flood and droughts; beach erosion, the rise in infectious diseases and the negative impact on biodiversity and agriculture (Held & Soden, 2006).

Examples of the effects of global warming include evidence of Adelie penguins declining in Antarctica due to the rate of snowfall. Hansen et al. (2016) further discussed high-intensity storms, resulting in turtle nests being washed out by hurricanes. In Canada, in 2001, there was drought so severe, that it dropped the crop yields and much livestock died. According to the World Health Organisation (2015), heat-related deaths, more especially in the elderly aged 65 years and older, are said to increase to 54 deaths per 100 000 people by 2080, in Mexico. Numerous studies have attributed an increase in species extinction, such as some butterflies and frogs, to global warming (Thomas et al., 2006).

The effects of global warming are evident internationally. It is no longer an urban legend or myth that it exists, as a number of countries are faced with environmental, physiological and financial impacts resulting from global warming. It is through this overwhelming evidence that numerous initiatives have been developed internationally to reduce the amount of GHG emissions.

Numerous emission reduction mechanisms have been employed over the years. These include implementing various policies that promote the reduction of emissions, the introduction of clean coal technology, in the form of carbon capture and storage, renewable energy, and carbon pricing mechanisms.

The United Nations has had numerous initiatives aimed at curbing the effects of climate change. These include the United Nations Sustainable Development Goals; the COP and the UNFCCC. There has been a history of over 25 years of international climate policy evolution starting with COP1, Berlin, Germany in 1995 up to COP25 that is scheduled to take place from 2 - 13 December 2019 in Santiago, Chile.

Technologies have been developed to reduce the amount of emissions due to coal combustion. As mentioned in Chapter 1.1, coal is considered the most cost-effective means to produce electricity. There are technologies that enable the continued use of coal without the negative impacts of emissions. This is through clean coal technology. These are defined as technologies that enable environmentally friendly or clean use of coal, in a manner that is economically viable. These technologies emit as little CO_2 as possible and are referred to as near-zero emission technologies.

Substituting or replacing fossil fuels with renewable energy is another means to reduce emissions. The National Renewable Energy Laboratory (NREL) (2001), together with Demirbas et al. (2009), define renewable energy as energy sources that are continually replenished naturally and do not disturb the natural balance of the earth. These include sources from sunlight, wind, water, geothermal heat and biomass.

Alternatively, to be more environmentally conscious with the continuous use of fossil fuels, as they are the most abundant and most economically viable means of electricity generation, especially in developing countries, strategies such as carbon pricing mechanisms have been introduced. These include carbon tax, market-based mechanisms, such as cap-and-trade, and emission credit systems. These could be, for example, CO_2 emission standards for motor vehicles, a national ambient air quality act promulgated in the USA and issuing permits for major sources of CO_2. In addition to the carbon tax and cap-and-trade carbon pricing mechanisms, Aldy and Stavins (2012) included an emission reduction credit system, clean energy standards, and fossil fuel subsidies.

This research focuses only on the carbon pricing mechanism, as this falls in line with the carbon tax mechanism selected by South Africa. Cap-and-trade, together with carbon tax, are discussed in detail in the following chapter. Chapter 3 further explores the international contexts and experience with respect to the two mechanisms, while Chapter 4 narrows the research down to the South African carbon tax context.

CHAPTER 3: INTERNATIONAL EXPERIENCE WITH CARBON PRICING MECHANISMS

According to the World Energy Council (2016), coal still provides approximately 40% of the world's electricity. The global coal consumption has declined by 53 million tonnes of oil equivalent (Mtoe) in 2016, or 1.7% decline when compared to previous years. The coal's share of global primary energy consumption fell to 28.1%, the lowest since 2004 (BP, 2017). This emphasises the pivotal role coal still plays in electricity generation. However, as mentioned in Chapter 2, the burning of fossil fuels has a negative effect on the environment through GHG emissions, thereby contributing to global warming. Figure 8 is a CO_2 emission chart and it is clear that China, Europe, and the United States are among the highest emitters.

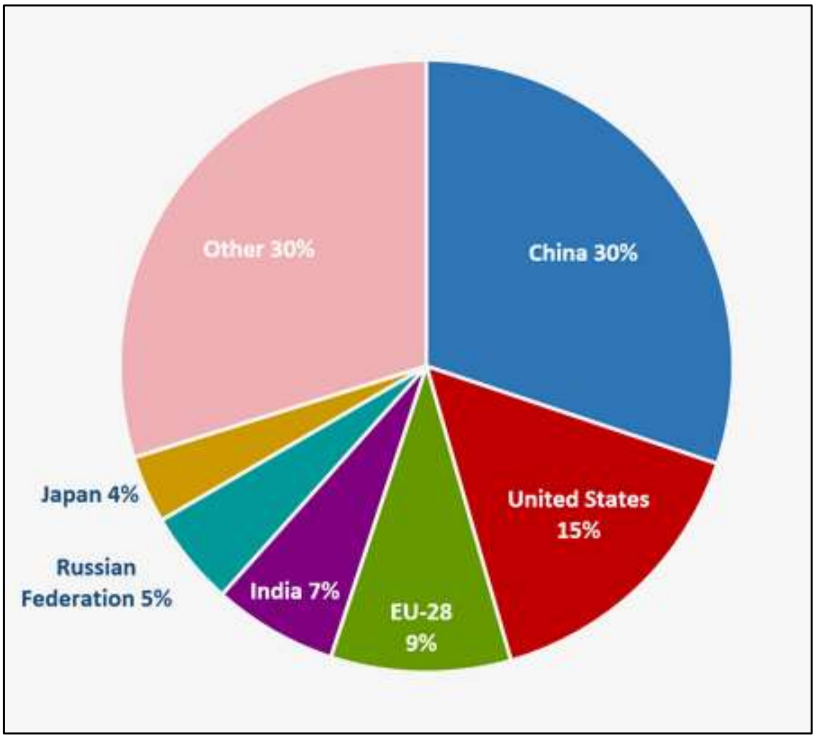

Figure 8: Global CO_2 Emissions from Fossil Fuels Combustion per Country in 2014 (World Energy Council, 2016).

In an effort to reduce emissions, the new global climate change Paris Agreement that took place on 12 December 2015 and subsequently signed in 2016, established a framework as a call to action against climate change. This framework is highly dependent on the cooperation of multinational governments, businesses, investors and civil society (Environmental Defence Fund & International Emissions Trading Association, 2016). Various countries committed to two long-term goals:

a) An average global temperature increase below 2°C; and

b) Achieving emission neutrality in the second half of the century.

In response to the Paris Agreement, a number of countries have committed to launching carbon pricing mechanisms to further supplement policies and frameworks that may have been established per country. Figure 9 indicates the countries, shaded blue, which have implemented carbon tax. The other colours represent different forms of Emission Trading Schemes (ETS).

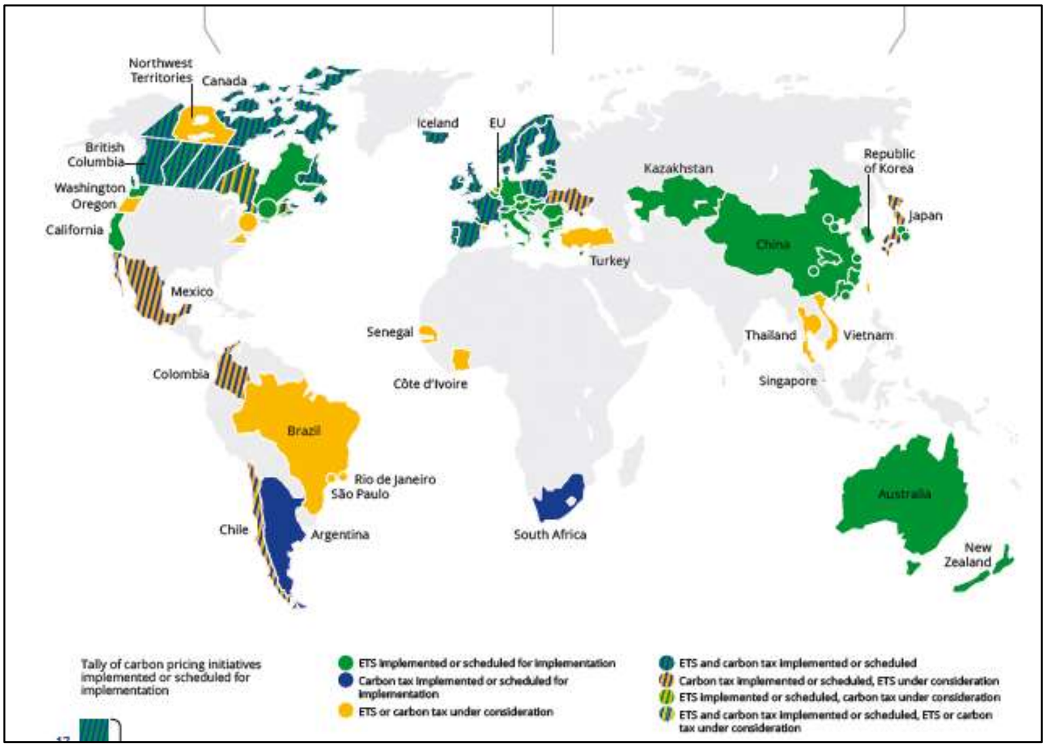

Figure 9: Regional, National and Subnational Carbon Pricing Initiatives Implemented, Scheduled for Implementation and Under Consideration (ETS and carbon tax) (World Bank Group, 2019).

The author discusses different countries that have opted to use carbon pricing as an emission abatement strategy. The discussion will focus initially on countries that have implemented the cap-and-trade mechanisms, followed by those using carbon taxes. The various cap-and-trade mechanisms will be briefly discussed only, as this form of emission reduction is not the basis of the research. Carbon tax, however, will be discussed in detail in Chapter 3.2 and in Chapter 4 because this is the carbon emission reduction instrument used in South Africa.

3.1 Cap-and-Trade Mechanism

3.1.1 Canada: Alberta Province

The Alberta emission reduction initiative has set a limit of 100 000t per annum of greenhouse gas that is permissible to be emitted. This applies specifically to oil sand producers that are in the export industry. An additional 12% emission intensity reduction is to be achieved over a six-year period. The province also gave an allocation to those entities that cannot meet the targets to have a compliance payment that is paid to the government. The funds that have been collected from this initiative have been placed in a provincial Climate Change and Emission Management Fund and constitutes approximately US$14 per tonne of CO_2 that has been collected for emission reduction. US$470 million has been collected from the Alberta Greenhouse Gas reduction programme for the years 2007 until 2013 (Aldy & Stavins, 2012; Carl & Fedor, 2016).

3.1.2 Canada: Quebec Province

According to Carl and Fedor (2016), there are similarities between the cap-and-trade systems used in Quebec Province with the California AB 32 cap-and-trade system. There has also been a collaboration between the two regions. The greenhouse gas emission annual target is set not to exceed 25000t of emission (similar to California). The initiative also incorporates auctioning of revenues and the exchange of permits.

It is said that, between the financial years of 2013 and 2014, approximately US$100 million has been raised from auction revenues and at an average permit-clearing price of US$10.50.

3.1.3 Chinese Provincial Emission Trading Scheme Pilots

Three out of the seven Chinese provinces piloted the emission-trading scheme. These provinces are Guangdong, Hubei, and Shenzhen. These three provinces are the most carbon-intensive provinces and just like with any trial, a small population was used to determine the effectiveness of the trial. Once the pilots proved to be successful, the scheme was then rolled out to the entire country. The trading scheme is similar to both the Canadian Quebec province and California emission trading initiatives. The limit to emissions is set at 25 000t per annum. The raised revenues auctioned during the year 2013 to 2014 approximated US$95 million (Carl & Fedor, 2016).

In addition to the trading scheme, Gielen and Changhong (2001) conducted a case study in Shanghai on the impact of energy and environmental policies on emission reduction. The analysis was based on linear programming called the MARKAL model that was simulated for the period 1995 to 2020. The results indicated that an additional incentive of 100 Yuan/t CO_2 emission reduction (12.5 Euro/t) results in an additional emission reduction of 11% (22 Mt CO_2), and it resulted in a significantly different technology mix than stand-alone local air pollution policies. According to the World Bank Group (2019), China is also working on the newly implemented ETS that was launched in December 2017. It aims to have a 60-65% carbon intensity reduction by 2030.

3.1.4 European Union Emission Trading System Allowance

The emission reduction initiative covers 28 states and includes the electric power sector, energy-intensive industrial sector, and aviation. The means by which emissions are reduced varies across the previously mentioned sectors. It is said that the electric power sector is required to buy all permits at an auction but there are countries that have been exempted from this by the use of “transition assistance” budgets. The industrial sectors were allocated 80% free in 2013, and it is planned to decrease this to a free allocation of 30% by 2020. The aviation sector is granted 85% free allocation until 2020. The estimated auction revenues raised in 2013 was US$4.64 billion, at an average permit price of approximately US$5.60 (Carl & Fedor, 2016: 61). The World Bank Group, (2019) further mentioned that the trading allowance scheme also aims to reduce approximately 40% below 1990 levels by 2030. Stavins (2008) mentioned that there was a collapse in the emission trading price. This, however, was not stringent enough as, emissions trading schemes do not necessarily guarantee a carbon price high enough to provide incentives to reduce CO_2 emissions.

3.1.5 Japanese Municipal Emission Trading systems

This cap-and-trade scheme has been in effect since 2010 and 2011 in provinces Tokyo and Saitama respectively. The emission reduction initiative has been aimed at large energy consumers. There are options of having a free allocation of permits and this is mainly warranted by the existing emission levels together with the levels already-achieved corporate emission reductions. It is well within the company’s prerogative to buy offsets in order to meet compliance (Carl & Fedor, 2016). The World Bank Group (2019) further stated that Japan aims at reducing 50-100 MtCO2e/year through the Joint Crediting Mechanism and 26% by 2030 (equivalent to 25.4% reduction compared to 2005).

3.1.6. New Zealand Emission Trading System

The emission trading system was launched in January 2008. It is based on a mix of free allocation and government window sales to be a compliance shortfall of US$15 at 2013 exchange rates. It has been systematically passed across the economic sector between 2008 and 2013. In 2012, approximately US$1.50 market trading permit price was generated and this reflected an oversupply. It is unknown what the government of New Zealand used the revenue for, but it is speculated that the funds were used for administrative costs (Carl & Fedor, 2016). According to World Bank Group (2019), the government of New Zealand has significantly reformed and strengthened their respective ETSs to align with their

NDCs on December 12, 2018. This was aimed to ensure that emission levels are reduced by 30% below 2005 levels by 2030. The reform also included implementation of a cap, introducing auctioning in the ETS, replacing the current price ceiling of NZ$25/tCO2e (US$18/tCO2e) with a cost containment reserve, strengthening market governance, limiting the potential use of international credits, and investigating a price floor. Aldy and Stavins (2012) further discussed that the government of New Zealand intends on linking this trading system with Australia's emission trading programme that was scheduled to be launched in 2015.

3.1.7 Switzerland Emission Trading

The cap-and-trade system used in Switzerland is an alternative to an existing carbon tax, also introduced in 2008. The emission reduction initiatives were rolled out and directed to large energy-intensive industrial emitters. There are similarities in its structure when compared to the European Union Emission Trading System. The Swiss emission trading system conducted permit auctions and raised US$9.1million in 2014. It also had a full free allocation until 2012, where no collection of revenue was done from the public. It later moved to a 20% permit auctioning that is scheduled to gradually rise to 70% by 2020. Emission permits from the power sector are fully auctioned several times per year (Carl & Fedor, 2016).

The Swiss Parliament approved the agreement to link the Swiss and EU ETS. This took place on 22 March 2019. This link between the trading schemes will prove to be advantageous in creating a level-playing field between companies in different countries, increasing market liquidity, and lowering abatement costs (World Bank Group, 2019).

3.1.8 USA Regional Greenhouse Gas Initiative

This cap-and-trade mechanism has been rolled out in the electric power generating industry in nine states. The industry has the capacity to produce 250 MW of electricity. The states of interest are Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. Each state has its own means of governing the implementation of this emission reduction programme through a regulatory mechanism called “Model Rule”. In 2013, revenues raised from permit auctions were US447 million, at an average price of US$2.91. An accumulation of US$1.94 billion was raised between 2008 and 2014 (Aldy & Stavins, 2012; Carl & Fedor, 2016: 64).

3.2 Carbon Tax Mechanism

3.2.1. Australian Carbon Pricing Mechanism

In 2008, the Australian government announced emissions trading would be the means by which emissions would be abated. An energy bill was subsequently passed in 2011. This formed part of Australia’s Clean Energy Act of 2011. The bill stated that there would be a 5% reduction in emissions by 2020 and a further 80% cut by 2050, both in relation to 1991 levels. The carbon tax was also committed to in 2011 (International Council on Mining & Metals, 2013).

There have been substantially positive results from the above abatement strategies. According to Milman (2014), 2012 data indicated a 4% drop in emission from the electricity sector and a 2.6% drop in the agriculture sector to name a few. This indicates just how effective this tool can be. However, recent articles by Taylor and Hoyle (2014) and Milman (2014) reported that Australia was going to be the first developed country to repeal the carbon tax. The Australian Government Department of the Environment (n.d) and Milman (2014) indicated that the rationale for repealing the carbon tax was as a result of the following:

a) Abolishing the carbon tax will reduce costs for businesses and households;
b) Modelling by the Australian Treasury suggests that removing the carbon tax in 2014-15 would leave the average costs of living across all households around $550 lower than they would otherwise be in 2014-15; and

c) It was also estimated that in 2014-15 retail electricity prices should on average be around 9% lower (or around $200 per household) and retail gas prices around 7% lower (or around $70 per household) than they would otherwise be.

3.2.2 Canada: British Columbia Province

According to the International Council on Mining and Metals (2013), a mandatory regulation to reduce GHG emissions was announced in British Columbia, a Canadian province. It said there would be a 12% reduction in emissions by 2012, 33% in 2020 and a further 80% in 2050, all of the reductions in relation to 2007 levels. This then brought about an announcement of the carbon tax enactment in 2008. The tax was set to start as low as C$10 per tonne of CO_2 and set to rise by C$5 per year (Elgie, 2014).

The carbon tax is “revenue-neutral” by law and it requires that equivalent cuts be applied to other taxes. Elgie (2014) further emphasised the economic successes of the tax with respect to the province cutting C$760 million in income and other taxes in order to offset the carbon tax revenue.

British Columbia province has proven that, to some degree, the carbon tax could be effective in reducing the amount of GHG emissions and, in turn, raise enough revenue that could be reinvested in other market baskets. However, this could be a double-edged sword, especially in poverty-stricken economies, because the tax would contribute an additional cost burden to civilians, as experienced in Australia. The significant lesson for South Africa is the importance of establishing a tailor-made revenue-neutral carbon tax that will not compromise the standard of living of South Africans and threaten the competitiveness of the country since it is still a developing country.

The tax in British Columbia generated C$846million in revenue between 2008 and 2009. This was also accompanied by a reduction in a variety of personal and corporate income tax, plus tax credits for low-income individuals. These cuts amounted to approximately C$1.1.billion, thus emphasising the effectiveness of the tax (Aldy & Stavins, 2012).

3.2.3 Costa Rica

The emission reduction initiatives are said to be more of an energy sales tax as compared to a traditional carbon tax. This is because the tax has not been explicitly tied to the amount of carbon content being emitted. It is one of the oldest carbon taxes as it has been operational since 1997. The revenues raised per year from the tax are approximately US200million based on a 3.5% levy, covering all fossil fuels (Pagiola, 2006; Carl & Fedor, 2016).

3.2.4 Denmark

This carbon tax is applicable to the emissions of the following industries: oil, natural gas, coal, electricity, and waste incineration. This was not the first emission reduction instrument implemented in Denmark. It was preceded by the energy tax. Carbon tax was an expansion of the energy tax and was later referred to as the "Green Tax Package". The annual revenue collected amounts to US$1billion since 2010. This was generated by a rate of US$31 per tonne of CO_2. The tax rate varies for different users, depending on the energy intensity utilised per entity. Currently, the tax rate is lower for energy-intensive industry users and higher for space heating.

The tax rate is also geared to encourage any means by which an entity may reduce their emissions, such as a company applying for an exemption through the energy-efficiency-improvement agreement by the Danish Energy Authority (Carl & Fedor, 2016).

3.2.5 Finland

This carbon tax was implemented in 1990 and makes it the oldest carbon tax globally. It only covers most fossil fuels but excludes electricity generation or commercial aviation. Approximate revenue of US$800million has been raised for a tax rate of EURO35 per tonne of CO_2 emitted, specifically on the heating fuels. Concerning the liquid transport fuels, a tax rate of EURO60 per tonne CO_2 was imposed (Carl & Fedor, 2016). From January 1, 2019, Finland changed the methodology to determine the CO_2 emission factor associated with heating fuels and fuels for work machines covered under the carbon tax component profits energy tax. In addition, the partial carbon tax exemption for combined heat and power plants was turned into a partial energy tax exemption, resulting in a small increase of the tax burden on coal to support the transition away from coal use (World Bank Group, 2019).

3.2.6 France

The carbon tax was adopted in 2014 and it covers carbon content for natural gas, fuel oil, and coal that do not form part of the European Union Emission Trading System regulation. There has been expansion with respect to the tax coverage as, in 2015; the tax was extended to transport fuels and heating oils. The 2014 tax rate was EURO7 per tonne of CO_2, with the potential to raise US$452million in revenue. The tax rate increased in 2015 to EURO14.50 and a further EURO22 by 2016. This has the potential of raising US$5.3billion worth of revenue. This places the France carbon tax as the largest revenue-raising mechanism globally (Carl & Fedor, 2016).

Since November 2018, largescale protests have been taking place, spurred by opposition to the carbon tax rate in a period when fuel prices are rising. Since its introduction in 2014, the carbon tax has increased six-fold from €7/tCO2e (US$8/tCO2e) to €44.6/tCO2e (US$50/tCO2e) within four years. Agriculture, taxis and trucks are exempt from the carbon tax to protect their competitiveness (World Bank Group, 2019).

3.2.7 Mexico

Mexico was the first Latin American country to sign the Kyoto Protocol (Gordon, et al., 2010). The carbon tax is aimed at reducing emissions from energy-intensive producers, mainly fossil fuels. It is designed in such a way that the emission is capped so that the carbon content emitted does not exceed the carbon intensity of natural gas. This implies that the coal and oil industry could be paying more as their emission is taxed at higher volumetric rates, contrary to natural gas that may face little or no tax burden.

This tax was initiated recently in 2014. This platform entails having large emitters having an opportunity to purchase Carbon Certified Emission Reductions credits.

The imposed tax rates range from 10 to 50 Mexican Peso per tonne of CO_2 (approximately US$0.80 to US$3.80). The rate is capped at 3% of the total sale and a total of US$870 million worth of revenue was estimated to be raised in 2014 (Carl & Fedor, 2016).

3.2.8 Norway

Similar to Finland, Norway has one of the oldest carbon taxes globally, active since 1991. According to the World Bank Group (2019), the carbon tax aims to reduce emissions to at least 40% below 1990 levels by 2030. The tax covers the use of oil, gasoline and natural gas.

There have been other sections that are covered by the European Union Emission Trading System and do not form part of this tax instrument. The tax covers approximately 55% of the entire Nordic economy. There is also a separate tax regime covering emission from motor vehicles, which does not form part of this tax. The tax rate since 2014 is Norwegian Krone (NKR) 25-219, amounting to $4-$67 per tonne of CO_2 produced. It is estimated that a total of US$1.58 billion worth of revenue was raised in 2013. The imposition of the tax was to encourage entities to invest in greener energy such as building electric transmitters feeding on the mainland electricity grid, which generates electricity primarily from hydropower (Carl & Fedor, 2016).

3.2.9 The United Kingdom Carbon Price Floor

The United Kingdom's carbon price floors only apply to the fossil fuels industry of Great Britain. It is an extension to the European Union Emission Trading System similar to other European countries. This carbon emission reduction mechanism is not a traditional carbon tax, but similar to the Costa Rican energy sales tax. It is, therefore, more accurate to refer to it as a carbon levy, more specifically the

Climate Change Levy because the tax rate set to each fuel has no correlation nor bearing on the carbon content and is continuously changing (Carl & Fedor, 2016).

The Climate Change Levy was introduced to render some stability in the then volatile power sector. The volatility was induced by the very low level of the European cap-and-trade system permit prices. This levy was designed to be initially revenue-neutral but it ended up being revenue negative. The specific tax rate between the financial years 2013 and 2014 was Great Britain Pounds(GBP)9.55 per tonne of CO_2, raising approximately US$1.53billion (Carl & Fedor, 2016).

3.3 Conclusion

According to Rice (2017), there are a staggering 2.57 million tonnes of CO_2 being emitted per second. These figures prompted initiatives such as the new global climate change Paris Agreement to be established in 2016. This framework is highly dependent on the cooperation of multinational governments, businesses, investors and civil society (Environmental Defence Fund & International Emissions Trading Association, 2016). Various countries committed to two long-term goals:

a) An average global temperature increase below 2°C; and

b) Achieving emission neutrality in the second half of the century.

It is evident from Chapter 3 that a number of countries have taken upon themselves to reduce the amount of emissions produced through a market-based emission reduction approach. One such approach is the cap-and-trade emission trading system defined as capping the quantity of GHG emissions at a particular predetermined level. It also allows low emitting industries to sell their extra allowances to larger emitters. Examples provided in the chapter include the Alberta emission reduction initiative that has been set to a limit of 100 000t per annum of greenhouse gas that is permissible to be emitted. The Swiss emission trading system conducted permit auctions and raised US$9.1million in 2014. It also had a full free allocation until 2012, where no collection of revenue was done from the public. It later moved to a 20% permit auctioning that is scheduled to gradually rise to 70% by the year 2020.

While carbon tax, on the other hand, is defined as a price instrument used to set a specific price on carbon. This is done by determining a tax rate on GHG emissions or the carbon content of fossil fuels. It is further described as bringing about stable revenue, however, there is uncertainty on the emission levels (Goldblatt, 2010). Examples of carbon tax discussed include the British Colombia (Canadian province) carbon tax. It said there would be a 12% reduction in emissions by 2012, 33% in 2020 and a further 80% in 2050, all of the reductions in relation to 2007 levels. The Australian carbon tax commenced in 2011 but was subsequently repealed in 2014 in order to reduce costs burden felt by households and businesses. The Australian Treasury further mentioned that the repeal of the carbon tax in 2014-15 would leave the average costs of living across all households around $550 lower than they would otherwise have been in 2014-15.

There is not a blanket approach towards the type of emission reduction instruments in each country because it depends on the country's own economic development. In the case of South Africa, being a developing country, there are numerous inherent concerns that may be brought about by the imposition of the tax, especially for the already financially constrained mining industry. Revenue-raising tools may also cause effects that are more negative, such as having households suffer due to the civil society contributing to taxes instead of buying food. The tax initiative may end up being abandoned, as transpired in Australia.

There may be some emissions that have been reduced through the initiatives, such as in Canada. However, this may be a risk, such as the volatility of using the cap-and-trade system. Where there could be entities that could just auction or trade their units to other companies without having any efforts invested in reducing the amount of emissions produced. This could just be a means in which enough credits are acquired and traded without reducing GHGs produced.

The carbon pricing mechanisms as discussed above prove that, to some degree, they could be effective in reducing the amount of GHG emissions and, in turn, raise enough revenue that could be reinvested in other market baskets such as in British Columbia. However, this could be a double-edged sword, especially in poverty-stricken economies because the tax would contribute to an additional cost burden to civilians as experienced in Australia. The significant lesson for South Africa is the importance of establishing a tailor-made revenue-neutral carbon tax that will not compromise the standard of living of South Africans and threaten the competitiveness of the country since it is still a developing country. Chapter 4 will be discussing in detail South Africa’s experience with the carbon pricing mechanism.

CHAPTER 4: SOUTH AFRICAN CARBON PRICING MECHANISM

4.1 South African Energy Supply

Eskom is the South African national utility that is responsible for electricity generation, transmission and distribution. It is the primary electric power producer, generating 91% of South Africa's electricity. Municipalities only contribute 1.77% and IPPs contribute 7.2%. Eskom procured 6300 MW of electricity from the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) to transmit until 2021 (Africa–EU Renewable Energy Cooperation Programme, 2016). Figure 10 indicates the type of renewable energy technology and its contracted capacity.

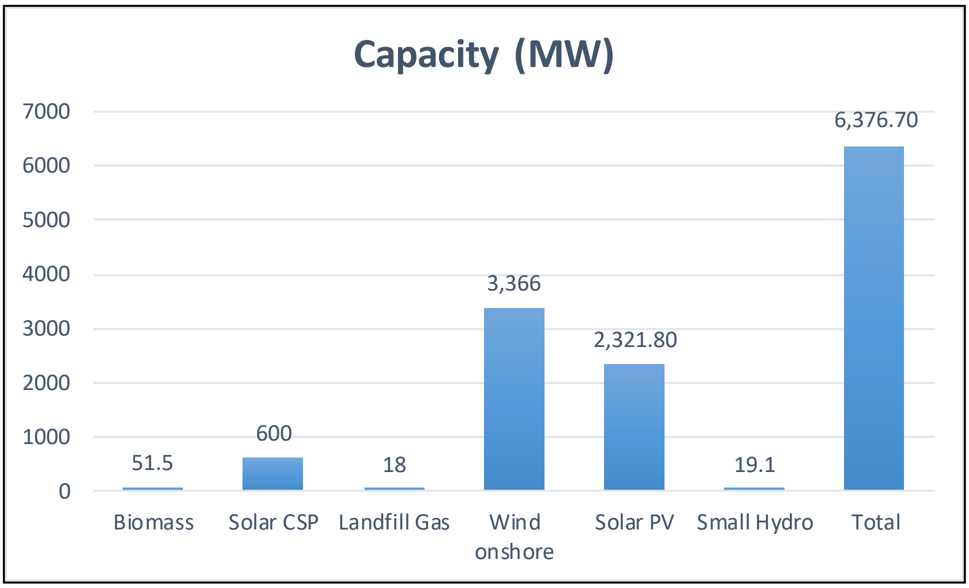

Figure 10: Total REIPPP Contracted Capacity (MW) Adapted from (Africa–EU Renewable Energy Cooperation Programme, 2016).

South Africa currently trades electricity with neighbouring countries such as Botswana, Lesotho, Mozambique, Namibia, Swaziland, Zambia, and Zimbabwe. South Africa forms part of the Southern African Power Pool (SAPP) (Africa–EU Renewable Energy Cooperation Programme, 2016).

In 2016, Eskom distributed 214 487GWh to South Africa; of which 42% was to municipalities, 23% to industrial activities and 14% to the mining industry, as indicated by Figure 11 (Africa–EU Renewable Energy Cooperation Programme, 2016; Statistics South Africa, 2017b).

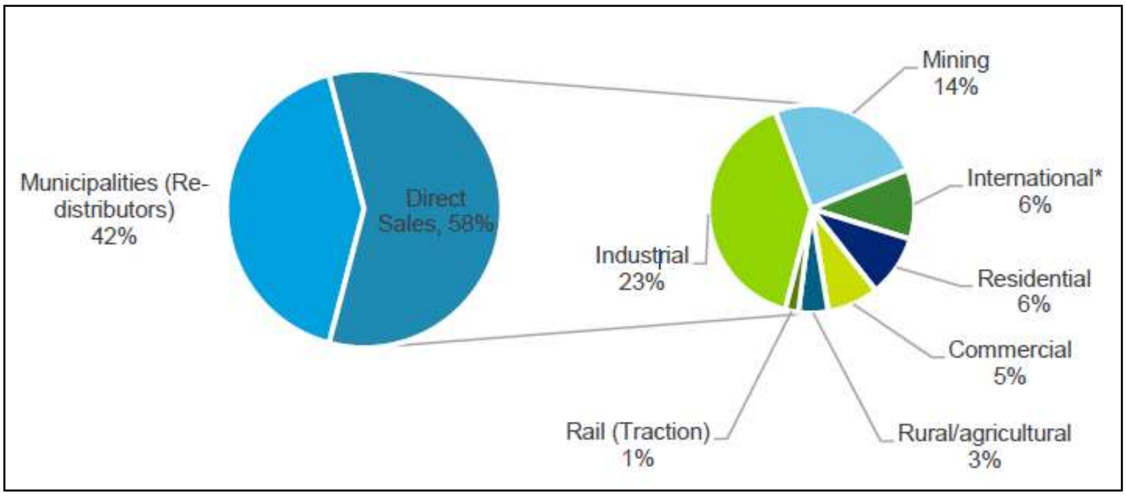

Figure 11: Composition of Eskom Sales by Customer Category, 2016 (Deloitte, 2017).

The target set by the Integrated National Electrification Programme (INEP) is to ensure that South Africa has universal access to electricity (97%) by 2025. It is aiming to achieve this through both grid connection and solar home systems. This will amount to 300 000 households having full access to electricity. In 2013, the South African electrification rates were 90% in urban areas and 77% in rural areas, giving an overall 85% of households access to electricity (Africa–EU Renewable Energy Cooperation Programme, 2016).

The South African electricity tariff was at 0.085 $US/kWh, which is below the mean for the group of 18, mostly high-income countries according to the NUS Consulting, cited in Deloitte (2017).

The company further ran a global ranking on the electricity prices depicted and the survey indicated that South Africa is currently ranked the ninth-lowest tariff in the 18 countries that formed part of the survey. These results imply that the South African electricity prices have become less competitive internationally.

4.2 Eskom's Energy Generation Sources

Coal is the main source of energy production for Eskom and coal-fired power stations produce 90% of the country's electricity. According to BP's statistical review of world energy conducted in 2017, South Africa had 9893 Mt of proved coal reserves at the end of 2016. This can be equated to approximately 116 years of proven coal reserves remaining. The South African economy is reliant on coal as a source of energy and employment.

According to Stats SA (2015), coal contributed R51billion to the South African economy compared to R31billion contributed by gold. Approximately 17% of the entire mining workforce is in employment in the coal mining industry; and 28% of coal produced in the country is exported, making South Africa the fourth largest global coal producer (Stats SA, 2015). In 2016, coal generated 85.7% of electricity, 6.7% was from renewable energy and followed by nuclear power generation at 5.2%, shown in Figure 12.

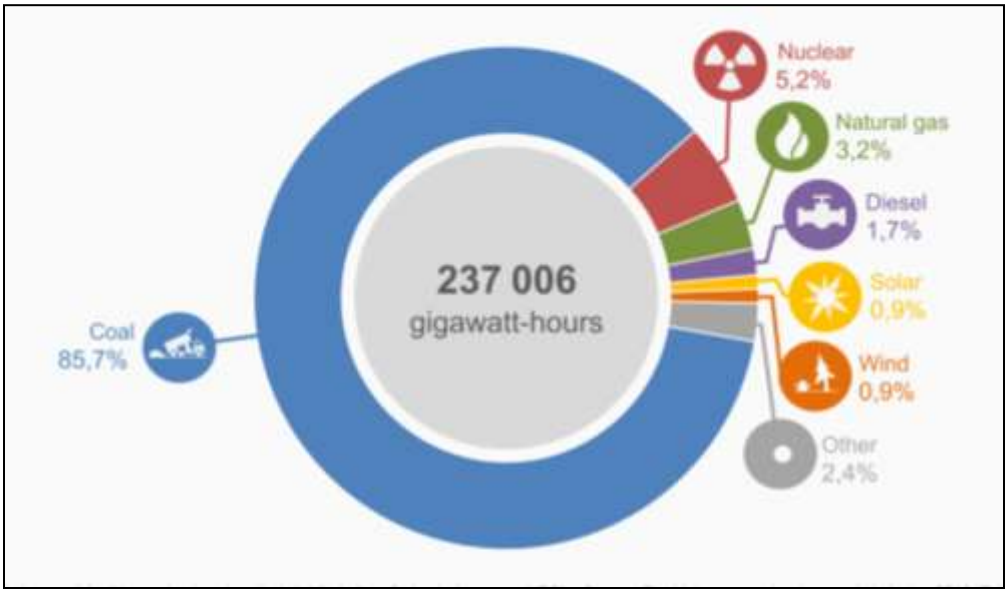

Figure 12: Total Electricity Generated by Source, 2016 (Statistics South Africa, 2017).

This will naturally have implications for the amount of GHG emissions South Africa contributes to the atmosphere. There are six GHGs present but South Africa's Intended Nationally Determined Contribution only focuses on the following three: CO_2, CH_4, and N_2O. Carbon dioxide contributes 65% of the total and this will be the gas of interest for this research (South African National Treasury, 2017).

4.3 South African Carbon Tax Background

South Africa is a signatory to the Kyoto Protocol and in 2009 the country made a voluntary commitment at the UNFCCC in Copenhagen to reduce the country's GHG emissions. South Africa is the highest CO_2 emitter when compared to other African countries, emitting 433 173 kilotonnes as indicated in Figure 13 (World Bank, 2011). This can be summarised in Figure 14, as a 1.5% global GHG emission, therefore, making South Africa the 13th largest GHG emitter (World Bank, 2011).

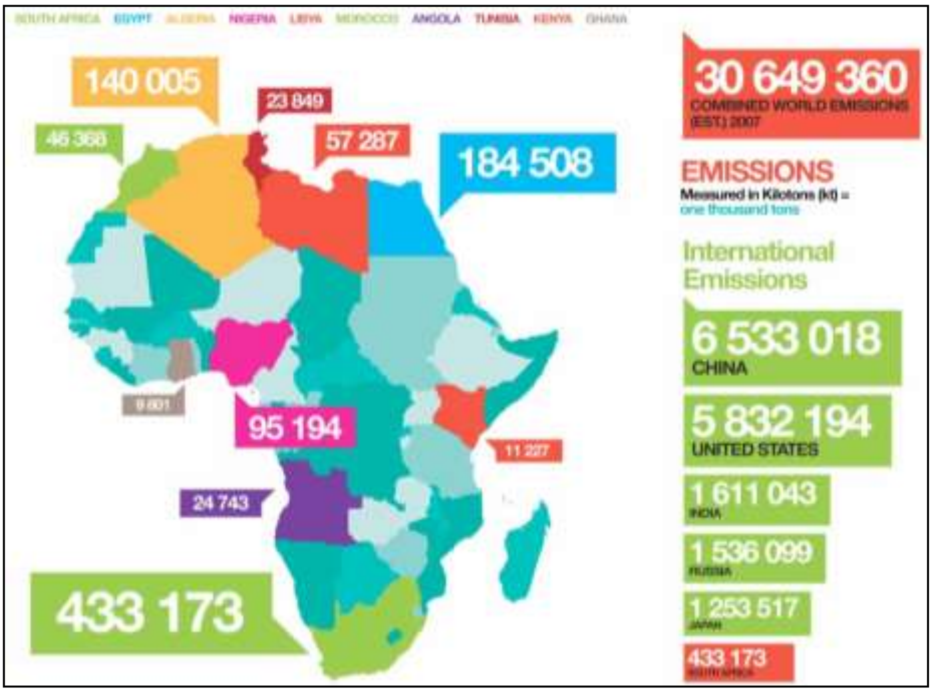

Figure 13: Africa's CO_2 Emissions (World Bank, 2011).

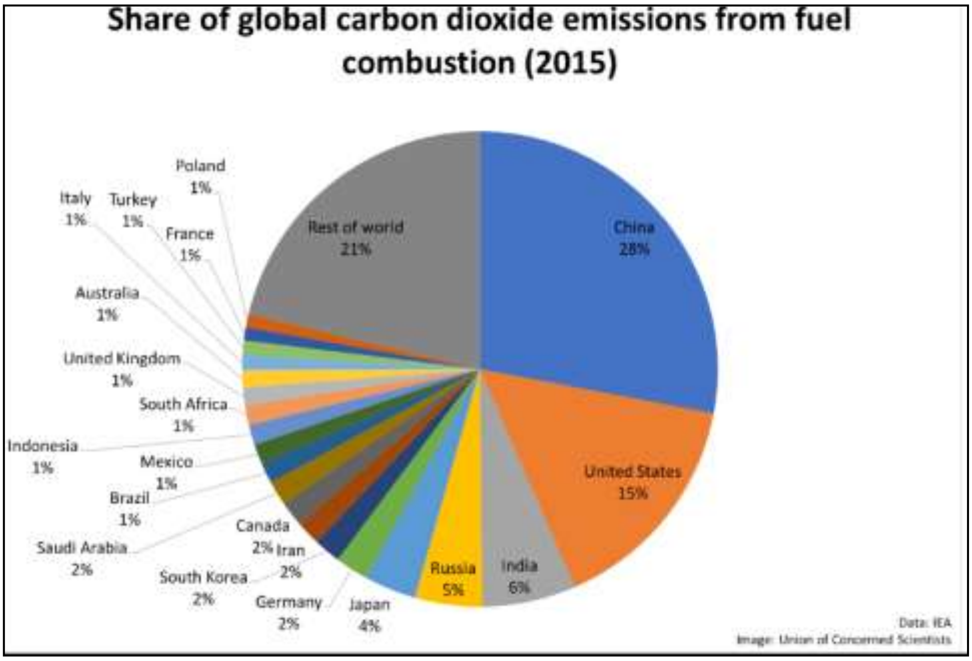

Figure 14: Global CO_2 Emissions from Fuel Combustion (Union of Concerned Scientists, 2015).

The South African government has implemented initiatives that encourage and promote EE. This includes the 2005 National EE strategy, the National EE Action Plan of 2012, the EE Target Monitoring System of 2014 and the post-2015 National EE Strategy. These are commitments in reducing carbon emissions (Dippenaar, 2018; Cliffe Dekker Hofmeyr, 2019). There are incentives associated with companies implementing, for example, renewable energy. Such an incentive is an energy savings allowance, which is a notional allowance for taxpayers that carry on a trade and that implement EE projects that successfully achieve energy savings. The allowance is calculated as 45 cents per kilowatt-hour (kWh), or equivalent, of energy savings achieved during the year of assessment, made against a baseline measured at the beginning of the year. Independent, registered and accredited professionals need to measure and verify the value of the energy savings and the allowance is not granted if a concurrent EE savings benefit is received from the government or a semi-government agency. (Dippenaar, 2018: 7). According to Hassett and Metcaf (1995) cited in Dippenaar (2018), tax incentives tend to encourage companies to invest in energy-saving initiatives that in turn reduce the amount of emissions.

An additional commitment was made through setting targets of reducing GHG emissions by 34% by 2020 and an even further reduction of up to 42% in 2025. These targets were set in relation to business-as-usual conditions (Partnership for Market Readiness, 2016). The emission reduction strategy was simplified into a trajectory broken down into “Peak-Plateau and Decline”. The peak will occur from 2020 until 2025, followed by a decade of the plateau stage and a decline will begin from 2035 onwards (South African National Treasury, 2013; Creamer, 2016 and Partnership for Market Readiness, 2016).

South Africa also selected carbon tax as one of the country’s long-term mitigation strategies. This implied that there would be the use of the “market” to reduce emissions (Winkler & Marquard, 2011). There are motivations for selecting this carbon pricing mechanism, as stated by Alton et al. (2014). They mention that if global warming was not considered and a global temperature of 2°C is attained, Africa would be the worst hit due to the presence of the tropics and the level of underdevelopment. The paper further discussed international policies such as Border Carbon Adjustment (BCA) that imposes a tax on the carbon content of imported products, which could be disadvantageous to South Africa since it is a carbon-intense country (Alton et al., 2014).

Alexander (2005) was of the view that emission control measures are arguably more frightening and stringent compared to South Africa’s GHG emissions. His 2005 paper suggests that South Africa is not in an economic state to bear the brunt of yet another monetary taxing exercise with the South African nation already burdened by past political inequalities and current capital being budgeted for poverty alleviation, malnutrition, job creation, and disease control. His premise is that South Africa should not have signed the Kyoto Protocol committing to a carbon tax, as the country’s emissions are minimal compared to larger emitters such as China and the USA, highlighted in Figure 14.

Alexander (2015) further argued that there is no substantial evidence, through various models, indicating a significant change in the South African climate as there have been no significant differences in the Kruger National Park and Karoo plant species. The paper thus concluded that South Africa would be the first casualty of the Kyoto Protocol.

The main objective of the National Climate Change Response Policy of 2011 (NCCRP) is to ensure that South Africa has the most environmentally sustainable economic growth, in line with the commitments made by the country to reduce GHG emissions as stated in the previous chapter. The carbon tax is a vital instrument in ensuring that those commitments are met (South African National Treasury, 2017). The NCCRP provides the use of both incentives and disincentives for regulation and economic-fiscal measures in providing an appropriate signal to nudge the economy towards a more environmentally conscious society (South African National Treasury, 2017).

South Africa, like the countries discussed in Chapter 2, was placed in a position to determine the most effective carbon pricing mechanism to reduce emission: carbon tax or an emission-trading scheme. According to the South African National Treasury (2017), an emission-trading scheme is currently unsuitable for South Africa due to most of the GHG emissions being contributed mainly by a few companies. This is further compounded by the oligopolistic energy market. Emission-trading schemes may also result in market volatility, as discussed in Chapter 3, and will be further scrutinised in Chapter 5.1 by referring to Alton et al. (2012). Emissions trading is also said to be complex, requiring significant institutional infrastructure and capacity building. It was concluded that carbon tax is easier to administer and will provide price certainty to drive behavioural change. The presence of carbon tax offsets will provide additional flexibility for companies to reduce their carbon tax liabilities while investing in technologies or initiatives that reduce GHG emissions.The South African National Treasury (2013:47), Watson (2018) together with Keoleian (2019) indicate that there are three categories under which emissions can be classified. These are Scope 1, 2 and 3 and have been described as follows:

Scope 1: These are direct emissions from sources that are owned or controlled by the organisation, such as on-site electricity generation, heating, cooling, company-owned vehicles, fugitive emissions (from refrigeration), natural gas combusted in a boiler at a company’s head office.

Scope 2: These are indirect, upstream emissions from purchased electricity, heat, steam or cooling consumed by the company, but generated elsewhere by a PowerStation.

Scope 3: These are all the other indirect emissions that occur along a company's value chain resulting from operations in the organisation that is not directly owned or controlled by that organisation. This could be employees commuting and business travels. Figure 15 indicates further examples of the different scopes of emissions.

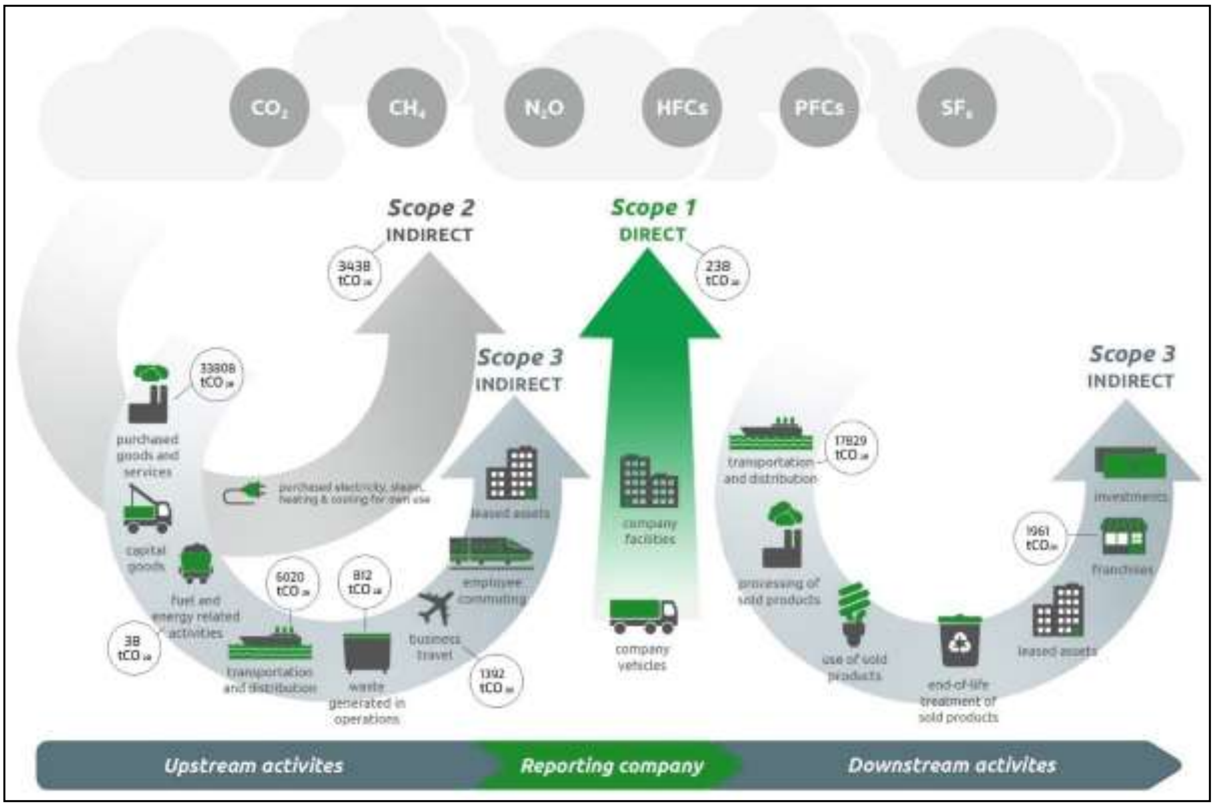

Figure 15: A Breakdown of Emission Categories (Watson, 2018).

The details of the Carbon Tax Policy paper released by the South Africa National Treasury (2013) are:

a) The tax is levied at Scope 1 emissions;

b) The tax has been set at ZAR120 per tonne CO_2 equivalent, commencing in June 2019. Given the tax-free allowances that will be discussed below, the initial effective tax rate will range from as low as ZAR6 to ZAR48 per tonne CO_2 equivalent. An annual increase to the nominal carbon tax rate of consumer price inflation plus 2%, up to 31 December 2022, in addition, an adjustment corresponding to inflation thereafter (South African National Treasury, 2017). This is in line with the Carbon Tax Policy Paper of 2013 which proposed that the tax rate of ZAR120 per tonne CO_2 be increased at a rate of 10% per year until the end of 2019 (South Africa National Treasury, 2013:15);

c) There will be 60% tax-free allowance to all sectors during the first five years;

d) Entities that trade internationally have a further 10% tax-free allowance;

e) Companies that have structural and technical limitations to bring about GHG emission reduction get a further 10% (now amounting to 80%);

f) The agriculture, forestry, and land-use departments have been given full exemption during the initial five years;

g) GHG emissions by petrol and diesel companies will be included in the current fuel tax regime;

h) Fuel used internationally in the aviation and maritime sectors will not have the carbon tax imposed on them as these sectors are covered by international agreements, but domestic aviation will be charged based on the fuel tax regime; and

i) Companies participating in the carbon budget will be awarded an additional 5% in the first phase of rolling out the carbon tax (inception up to 2022).

The carbon tax will be revenue-neutral for the first five years of implementation. Its effectiveness on emission reduction and the socio-economic impacts will be highly dependent on the tax rate, tax-free allowances, and revenue recycling measures. All the revenues raised would be recycled in an effort to support the transition to a low carbon economy and to further protect vulnerable sectors and poor households from the impacts of the tax.

The 2013 policy paper did not describe in detail how the revenues raised would be recycled back into the National Treasury. The Draft 2015 Carbon Tax Bill has addressed the intended revenue recycling strategies as follows (South Africa National Treasury, 2015):

a) There will be a reduction in the electricity levy;

b) The implementation of energy efficiency incentives is currently taking place;

c) Rooftop or embedded solar Photo Voltaic (PV) energy will get additional tax relief;

d) Low-income houses will receive additional tariffs for free basic electricity; and

e) Additional allocation will be given to public transport. This will be done to encourage a shift of freight from road to rail.

Figure 16 is the life cycle of the Carbon Tax Policy adaptation process, from the environmental fiscal reform paper published in 2006, until the revised Carbon Tax Bill that was published in 2017 and submitted to parliament in 2018.

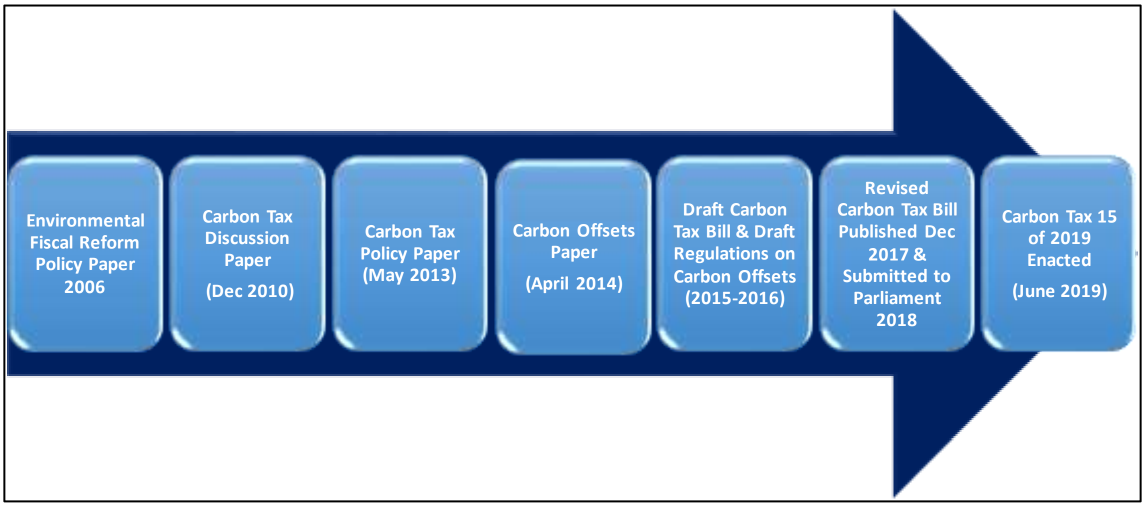

Figure 16: Carbon Tax Policy Process-Timeline Adapted from (Hemraj, 2018).

4.3.1 Carbon Tax Base

The South Africa National Treasury (2015) indicated that the carbon tax is based on fossil fuel inputs such as coal, oil, and gas by means of approved emission factors. The GHG emissions reporting should be in line with mandatory reporting requirements stipulated by the DEA. The DEA will also approve appropriate emission factors and procedures in line with information published by the IPCC. The threshold for stationary emissions will be determined by the source category stipulated by the National Environmental Air Quality Act of 2004.

Companies that will be subjected to the tax will be those with a thermal capacity of 10MW, particularly in the first implementation phase of the tax. On stationary emissions, such as liquid fuel-transport, the carbon tax will be included in the fuel tax regime. The tax liability is calculated as a tax base (total quantity of GHG emissions from combustion, fugitive and industrial processes proportionately reduced by the tax-free allowances) multiplied by the rate of the carbon tax (South African National Treasury, 2017).

The tax base is levied with respect to the sum of GHG emissions of a taxpayer within a tax period, in CO_2 equivalent resulting from fossil fuels, fugitive emission, and industrial processes and products.

These specific sources have different formulae used to calculate their individual contribution as stipulated by and indicated below (South African National Treasury, 2017: 9-11).

a) Fossil Fuel Combustion

E	A number to be determined
A	Mass of any one type of fossil fuel per tonne that is a source of GHG emissions, excluding transportation
B	GHG emission factor CO_2 equivalent per tonne

The numbers are therefore determined by the following formula:

E = (A x B)

b) Fugitive Emissions

F	A number to be determined
N	Mass in tonnes for solid fuels or volume of each type of fuel in m^3 with respect to GHG emissions
Q	GHG emission factor CO_2 equivalent per tonne

The numbers are therefore determined by the following formula:

F = (N x Q)

c) Industrial Process and Product

P	A number to be determined
G	Mass of each raw material used or product produced expressed in tonnes with respect to GHG emitted
H	GHG emission factor CO_2 equivalent per tonne

The numbers are therefore determined with the following formula:

P = (G x H)

4.3.2 Carbon Tax Allowances Explanations

a) Fossil Fuel Combustion

Entities that fall under fossil fuel industries may be granted 60% off the total percentage of GHG emissions in respect of a tax period regarding that activity (South African National Treasury, 2017).

b) Industrial Process Emissions

Chemical Processing entities may have difficulties in reducing the amount of their emissions on a short-term basis. These include companies involved in processes such as gasification, crude oil cracking and the production of cement, iron, steel, glass, and ceramics. Companies that are also producing chemicals, such as calcium carbide and titanium, may also have trouble reducing their emissions immediately. Therefore, a higher tax-free basic percentage-based threshold is provided for these emissions compared to energy combustion emissions. A basic percentage-based threshold on actual industrial processes and product use emissions of 70% is applied, below which the tax will not be payable (South African National Treasury, 2017: 22-23).

c) Fugitive Emissions

Fugitive emissions occur from the release of greenhouse gases during the extraction, processing, and delivery of fossil fuels including leaks from industrial plants and pipelines (South African National Treasury, 2017:7). This section provides for a tax-free allowance to entities that generate fugitive emissions. An additional tax-free allowance of 10% will be provided to sectors with fugitive emissions. This allowance is provided due to the limited potential for mitigation of fugitive emissions over the short term (South African National Treasury, 2017:26).

d) Trade Exposure Allowance

According to the South African National Treasury (2017: 23-24), additional tax relief is given to companies that are exporting more than 40% of their product. This is done so that the tax imposition will not affect the company's competitiveness.

An additional 10% is levied for energy-intensive and trade-intensive companies (EITI). The tax-free allowance is structured to bring about a gradual relief to the companies. The additional percentage relief (tax-free threshold) will be:

Y2 = 0.4 x (E)

E = the value of exports expressed as a percentage of sales; it must be greater than 5%, up to a maximum of 10%, as indicated in Table 7.

Table 7: Trade-Exposed, Tax-Free Threshold Relief.

Exports (E)	
0.4	
% Relief (Y2)	% of Sales
0	Below 5
2	5
4	10
6	15
7.2	18
8	20
10	25
10	30
10	35
Y2 = 0.4 x E E must be > 5%	
Maximum for Y2 =10%	

e) Performance Allowance

The South African National Treasury (2017) has discussed this section of the allowance dealing with the allocation of a tax-free allowance to entities that have proactively implemented GHG mitigation measures. An additional tax-free allowance of 5%, based on the Z-factor formula, is available to reward all companies that have taken voluntary actions to reduce their GHG emissions. The allowance is calculated using the following formula:

$$\mathbf{Z = (A / B - C) \times D}$$

Z:	Percentage to be determined
A:	The sector or subsector greenhouse gas emissions intensity benchmark as prescribed by the Minister
B:	Represents the measured and verified greenhouse gas emissions intensity of a taxpayer in respect of a tax period
C:	Represents the number 1
D	Represents the number 100

f) Carbon Budget Allowance

A taxpayer that conducts an activity that is listed in Schedule 2 in the column “Sector”, and participates in the carbon budget system during, or before, the tax period, may receive an additional allowance of 5% of the total percentage of GHG emissions in respect of a tax period (South African National Treasury, 2017). Schedule 2 is a classification that reflects the IPCC classification and is aligned with the DEA mandatory National Greenhouse Gas Emission Reporting Regulations (NGER) requirements (South African National Treasury, 2017:32).

g) Offset Allowance

A taxpayer may reduce the amount in respect of the carbon tax for which the taxpayer is liable in respect of a tax period by utilising carbon offsets as prescribed by the Minister.

The Carbon Tax Bill stipulates that a taxpayer may only receive the sum of the allowances that are capped at 95% (South African National Treasury, 2017).

4.3.3 Calculations of the Amount of Carbon Tax Payable

The amount of tax payable from each entity, as stipulated by the South African National Treasury (2017), will be calculated using of the following formula:

$$\mathbf{X = \{(E - D - S) \times (1 - C) \times R\} + \{P \times (1 - J) \times R\} + \{F \times (1 - K) \times R\}}$$

X:	Tax payable
E:	Energy combustion emissions
D:	Diesel and petrol emissions
S:	Emissions sequestered by a company as verified by the DEA
C:	Sum of the allowable tax-free thresholds related to combustion
R:	Tax rate
P	Process emissions
J	Sum of the allowable tax-free thresholds related to process emissions
F	Fugitive emissions
K	Sum of the allowable tax-free thresholds related to fugitive emissions

Example of Tax Payable Calculation (South African National Treasury, 2017:22):

"Company 1C produces electricity and heat from sub-bituminous coal mined underground. It uses 2000 tonnes of sub-bituminous coal and produces combustion emissions 3708.20 tCO_2e.

Company 1C is not trade-exposed but has outperformed its peers, has complied with information requirements for its carbon budgets and has decided to use the full carbon offset allowance. There was no use of liquid fuels or any sequestration activities by Company 1C.

Thus Company 1C is eligible for the basic 60% tax-free allowance for (energy) combustion emissions; receives the 5% allowance according to the performance allowance (Z-factor calculation) for outperforming its peers and 5% allowance for complying with carbon budgets information requirements, and is eligible for the full 10% offset allowance. The sum of Company 1C's allowances is 80% (60+5+5+10) for fossil fuel combustion emissions. The carbon tax liability for Company 1C's combustion emissions will be calculated as follows":

$E = A * B = 2000 * 1.8541 = 3\ 708.20$ tonnes CO_2e

$F = D = S = P = 0$

$C = 60\% + 5\% + 5\% + 10\% = 80\%$

$X = \{(E – D – S) * (1 – C) * R\} + \{P * (1 – J)\} * R\} + \{F*(1-K)*R\} = \{(3708.20 – 0 - 0) * (1 – 0.8) * R120\} + 0 + 0 = R88\ 996.80$

The above-illustrated calculation was used to model the potential amount that will be paid by individual mining companies selected.

4.3.4 Carbon Tax Administration, Tax Period and Payment of Tax

The South African Revenue Services (SARS) will administer the carbon tax. SARS will be assisted by the DEA in order to audit the self-reported tax liability by entities. SARS will be liaising with the DEA to access the National Atmospheric Emissions Information System (NAEIS). This system contains emission information reported by entities.

The Department of Energy reports energy use data and this information will be incorporated into the NAEIS, thus strengthening the monitoring and verification system supporting the implementation of the carbon tax (South African National Treasury, 2017).

4.4 Conclusion

South Africa, like the majority of countries globally, is highly reliant on coal for electricity generation. Eskom currently generates 91% of the country's electricity needs. The energy sources for electricity generation are 85% coal, 6.7% renewable energy and 5.2% nuclear This emphasises the major role coal still plays in electricity generation.

South Africa is the highest CO_2 emitter when compared to other African countries, emitting 433 173 kilotonnes (World Bank, 2011). This prompted the country to be one of the signatories of the Kyoto Protocol. In 2009, the country made a voluntary commitment to the UNFCCC in Copenhagen to reduce the country's GHG emissions. The South African government has implemented initiatives that encourage and promote EE. This includes the 2005 National EE strategy, the National EE Action Plan of 2012, the EE Target Monitoring System of 2014 and the post-2015 National EE Strategy.

South Africa also selected carbon tax as one of the country's long-term mitigation strategies. This implied that there would be the use of the "market" to reduce emissions (Winkler & Marquard, 2011). According to the South African National Treasury (2017), an emission-trading scheme is currently unsuitable for South Africa because most of the GHG emissions being contributed are by a few companies. This is further compounded by the oligopolistic energy market. Emission-trading schemes may also result in market volatility.

The South African National Treasury (2013:47); Watson (2018) together with Keoleian (2019) indicated that there are three categories under which emissions can be classified, these are Scope 1, 2 and 3. The South African carbon tax, that has been referred to as the Carbon Tax Act 15 of 2019 is levied on Scope 1.

The tax has been set at ZAR120 per tonne CO_2 equivalent at a 60% tax-free allowance to sectors during the first five years. Companies participating in the carbon budget would be awarded an additional 5% in the first phase of rolling out the carbon tax (inception up to 2022).

The carbon tax will be revenue-neutral for the first five years of implementation and its effectiveness on emission reduction and the socio-economic impacts will be highly dependent on the tax rate, tax-free allowances, and revenue recycling measures. All the revenues raised will be recycled in an effort to support the transition to a low carbon economy and to further protect vulnerable sectors and poor households from the impacts of the tax. The carbon tax design also has various allowances that ease the transition of implementing the tax. These allowances include the fossil fuel combustion allowance, industrial process emissions, fugitive emissions, trade exposure allowance, performance allowance, carbon budget allowance and offset allowance.

Any tax is a disincentive and has cost implications on the end-user. This could be civil society and other consumers within the country. This research aims to determine the extent of the impact that this tax would have in mining companies in South Africa. Chapter 5 has explored this aspect through acquiring and analysing data with respect to the selected companies of interest.

CHAPTER 5: POTENTIAL EFFECTS OF CARBON TAX ON THE SOUTH AFRICAN MINING INDUSTRY

5.1 Impact of Carbon Tax on the South African Mining Industry

Mining in South Africa started when Erasmus Jacobs discovered a diamond on the banks of the Orange River in 1867. Thereafter the Kimberley pipes were discovered and then the gold rushes to Barberton and Pilgrim's Rest started. In 1886, the biggest discovery was made which hailed the Witwatersrand Gold Rush and the massive development of the goldfields there (Mining Africa, 2017). This then brought about the success of the coal industry that supplied energy within the mining industry. For the past hundred years, the growth in the South African economy has been based on the wealth of the mining industry.

The mining industry directly contributed 7.3% to the South African GDP in 2016 (Peyper, 2017). The mining industry exports are the highest when compared to other sectors in South Africa. Mining accounted for 33% of the total exports of the country. In 2018, the National Treasury benefited from 24% of the value created by the mining industry. This made the treasury the second-biggest beneficiary from the mining industry (Van Zyl, 2019).

In 2017, the South African mining industry contributed over ZAR460billion to the South African economy. The industry employed approximately 464 667 employees who in turn supported 4.5 million dependents. ZAR7billion out of R126billion employee earnings were spent on skills development and ZAR2billion contributed to community development (Mineral Council of South Africa, 2017).

The South African mining industry has, however, been negatively affected by the economic downturn. Van Zyl (2018) reported on 1560 job cuts from a restructuring drive by Gold Fields, together with the Implats announcement of their plan to cut approximately 13 000 jobs. This has the potential of increasing the unemployment rate that is currently about 27%.

In February 2019, South Deep announced that it is currently losing about ZAR100million (US$7million) a month in the current operational conditions.

Therefore, the carbon tax imposition has the potential to increase the cost burden of most mining operations.

Researchers such as Alton et al. (2014), The Carbon Report (2015) and Creamer (2016) are of the view that the carbon tax is an effective policy for ensuring that carbon emissions are reduced while raising revenues that could be recycled and reinvested in initiatives that innovate less carbon-intensive power generation technologies. However, a report published by PricewaterhouseCoopers (2011), is of the view that carbon tax may not be a suitable emission reduction strategy because South Africa only contributes approximately 2% to global emissions level. The fact that South Africa is still a developing country might mean that such a revenue-raising tax could undermine the country's competitiveness and increase the cost of fuel and electricity.These effects could have a negative effect on consumers and poor households. These sentiments concur with the report published by Elgie (2014), previously referred to in Chapter 2.2 (a) on the effects that Australia could have faced.

When there is a proposal or amendment to a policy, actual economic data is computed and modelled to determine how the economy will respond to the new policy. This could be done by utilising an economic model known as the Computable General Equilibrium (CGE) model (Wing, 2004). The economic and environmental impact of the carbon tax has been modelled using CGE models by various researchers such as Winkler and Marquard (2011), Alton et al. (2014) and van Heerden et al. (2016). Alton et al (2014) used the Dynamic CGE while van Heerden et al. (2016) used the University of Pretoria General Equilibrium Model (UPGEM).

Both experiments analysed the impact of carbon tax on the South African economy based on achieving the 2025 emission targets. The results of the experiments indicated that there will be a positive influence on both the environment and the economy, should the tax be implemented.

The benefits of carbon tax implementation in South Africa are as follows (Alton et al., 2012 and van Heerden et al., 2016):

a) The gradual implementation of the carbon tax, complemented by an efficient revenue recycling mechanism will ensure both emission reduction and economic growth. This will be through ensuring that the revenues raised from the carbon tax are recycled back into the economy to be utilised in other governmental initiatives that benefit civil society. That, in turn, encourages emission reduction as companies would potentially ensure that their carbon footprint is reduced so they do not have to pay the tax;

b) The experimental results discussed in the paper indicate that the tax would bring about a 35% to 44% reduction in CO_2 emissions (depending on how revenue recycling is conducted); and

c) A cumulative reduction of between 19000-23000Mt CO_2 equivalents of emission will be reduced by the end of the implementation period of 2025.

The tax may have substantial advantages, but the models also indicated that the fossil fuel industries would be negatively affected. The results indicated that there would be a reduction in total exports, due to the compromised competitiveness of the country. The steel and manufacturing industry would be the worst affected, with up to approximately 50% decreases in exports. The mining industry would also be affected, with a decline of approximately 3% in exports.

The introduction of the carbon emission tax will bring about an additional burden to mining operations. According to the report published by the International Council on Mining and Metals (2013), the carbon tax will have an immense financial impact on mining companies' competitiveness and overall liquidity. The study, conducted in 2013, only involved analysis of the direct financial impact of the carbon tax and did not investigate the profitability of the mining companies. There was, therefore, a gap in determining the amount of emission reduction resulting from tax.

The overall results indicated that most of the impact would be felt by aluminium and coal production operations due to their emission intensity. It was also discovered that, in the short term, this mechanism will render it difficult to reduce emissions and will bring about a heavy cost burden on mining companies. This will, in turn, threaten job security in an already struggling industry.

In 2015, the CEO of the Minerals Council South Africa, Roger Baxter, presented to the Davis Tax Committee the Chamber's position on the carbon tax in order to give substantiated evidence for not supporting it. The argument that was made was the extent to which South Africa's emissions are small in comparison to global emitters.

This stems from the sentiments shared by the PricewaterhouseCoopers (2011) report. The tax is also said to affect the competitiveness of the mines, as it will contribute to the cost burden of the mining companies. The mining industry is a price-taker and an additional cost from the tax will not be passed onto consumers. Findings from a case study conducted in 2015 by Sibanye Gold, also indicated that the cumulative effect of the carbon tax could make at least five of their shafts unprofitable and this could contribute to 18% of the workforce losing their jobs (Baxter & Turner, 2015). Sasol concurs with these negative sentiments, as it has reported carbon tax may not be the most suitable tool to reduce emissions, as it will affect Sasol's capital investments. Sasol has the potential of incurring ZAR1billion loss as a result of implementing the carbon tax (Khumalo, 2018).

Huisman (2014) conducted research focusing on the potential impact of the carbon tax on the South African mining industry. The research approach was in relation to the Mineral and Petroleum Resources Development Act 28 of 2002 (MPRDA). These are the pillars or objectives of the MPRDA Act 28 of 2002 that were used against the Carbon Emissions Tax (CET):

a) Recognise the internationally accepted right of the State to exercise sovereignty over all the mineral and petroleum resources within the Republic;

b) Give effect to the principle of the State's custodianship of the nation's mineral and petroleum resources;

c) Promote equitable access to the nation's mineral and petroleum resources to all the people of South Africa;

d) Substantially and meaningfully expand opportunities of historically disadvantaged persons, including women, in order that those may enter the mineral and petroleum industries and benefit from the exploitation of the nation's mineral and petroleum resources;

e) Promote economic growth and the development of mineral and petroleum resources in the Republic;

f) Promote employment and advance the social and economic welfare of all South Africans;

g) Provide for security of tenure in respect of prospecting, exploration, mining and production operations;

h) Give effect to Section 24 of the Constitution by ensuring that the nation's mineral and petroleum resources are developed in an orderly and ecologically sustainable manner while promoting justifiable social and economic development; and

i) Ensure that holders of mining and production rights contribute towards the socio-economic development of the areas in which they are operating (MPRDA, 2002:18).

Findings from Huisman's (2014) research revealed that the CET would have a greater financial effect on small and marginal mining companies compared to larger mining companies. The tax threatened some of the fundamental requirements from the MPRDA. This research did not investigate various carbon pricing mechanisms that could be implemented in order to replace the CET and in turn shield these worst affected companies from the brunt of the tax. This gap, together with potential levels of emission reductions through different low carbon-emitting technologies sparked the author's interest and brought about the inception of this research.

5.2 Methodology Considered when Performing the Analysis

5.2.1 Sample Population, Size and Relevance of Companies Selected

Williams (2007) said the purpose and intent of conducting research are to prove or discover a phenomenon by means of data collection, analysis, interpretation, and writing upon the results acquired. There are three common approaches to research methodology, namely quantitative, qualitative and mixed-method approaches (Allwood, 2012).

Sandelowski (2000) further discussed the key differences in the sampling done in a qualitative and quantitative research approach. When conducting qualitative research, purposeful sampling is suitable, as it will aid in the understanding of perceptions or the in-depth data that is required from its participants. Quantitative analysis requires probability sampling, which is governed by principles of statistics, as numerical data is collected (Sandelowski, 2000; Fox, et al., 2009).

Considering the research questions and objectives, the most suitable research approach for this investigation is a quantitative research approach. This is due to the numerical data that was collected and analysed using various mathematical tools. Among the various methods found in this research approach, the correlational research method was used. This method "examines the differences between two characteristics of a study group" (Williams, 2007:67).

Huisman's (2014) research investigated the effects of the carbon tax on mining companies with respect to MPRDA, but contained no discussion about determining the environmental impact the carbon tax will have on the mining companies. Moreover, it did not indicate if there would be any form of emission reduction from the inception of the tax.

Fox et al. (2009) and Devane et al. (2004) discuss the importance and implications of having a suitable sample size for a population. This is vital because, if not taken into consideration, the research outcomes are most likely going to be unreliable, unrepresentative and biased. The sample population selected was from the following nine mining companies as previously discussed in Chapter 1.5:

- Exxaro Resources Limited
- Sasol Limited
- AngloGold Ashanti Limited
- Gold Fields Limited
- Harmony Gold Limited
- Anglo American Platinum
- Impala Platinum Holdings
- Northam Platinum
- Kumba Iron Ore

All companies are listed on the JSE and have emission data published from the CDP.

5.2.2 Assumption Required in Calculations

It can be assumed that Eskom, which is a parastatal, will pass 100% of the tax burden to consumers, as the state will not impose a tax on itself. Energy producers will recoup the full amount of payment from the buyer or consumer of the produced electricity, which is Eskom. The level of reduction in Scope 2 proved to be more challenging to achieve, as the electricity will be purchased from Eskom. The CET was therefore calculated based on the combined Scope 1 and 2 emissions. The influence of the proposed tax rate of ZAR120 per ton of CO_2 equivalent was calculated as proposed in the Carbon Tax Policy (South Africa National Treasury, 2013). The South African National Treasury (2015) indicated that there would be minimal relief from tax with respect to income tax for companies complying with CET.

Additional relief, in the form of a 60% emission-free threshold, will be given per year. The specific relief per industry has been summarised in Table 8.

Table 8: Proposed Emission Thresholds per Sector (South Africa National Treasury, 2015:33-38).

Sector	Basic tax free thresholds below which no tax will be levied during the first phase(2013-2019)%	Basic tax free allowwance for process emissions %	Fugitive emissions allowance %	Trade exposure allowance %	Z-factor allowance	Carbon budget allowance %	Offsets allowance %	Maximum total allowances %
Electricity	60	0	0	0	0	5	10	75
Petroleum (Coal to liquid)	60	0	10	10	5	5	5	95
Petroleum (oil Refinery)	60	0	0	10	5	5	10	90
Mining(Excluding fuels and quarrying)	60	0	0	10	5	5	10	90
Coal mining and handling	60	0	10	10	5	5	5	95
Iron and Steel	60	0	0	10	5	5	10	90
Manufacturing industries & Construction	60	0	0	10	5	5	10	90
Food Processing, beverage, tobacco	60	0	0	10	5	5	10	90
Agriculture, forestry,fishing/fish farms	60	0	0	10	5	5	10	90
Solid waste disposal on land	100	0	0	0	0	0	0	100
Aerosols	0	60	0	10	5	5	10	90

5.2.3 Data Collection Method and Tools

To ensure that the research questions have been addressed through the type of data collected, it is important to specify the data collection method and tools and to give justifications for the type of data collected. Currently, companies are not obliged to report their GHG emissions and this posed a challenge with respect to emission data that is required for this research. Therefore, the author utilised company emissions data published on the CDP repository.

The CDP is a non-profit organisation based in the United Kingdom. It was established in 2002 and operates with the vision that there should be economic development that runs parallel to the wellbeing of the planet and its residents. It is an environmental disclosure system for investors and companies in various regions. CDP is driven by enabling various organisations to be conscious of their operation's environmental footprint (Carbon Disclosure Project, 2002).

The data was collected from 2010 to 2017; this coincides with the announcement made by the South African National Treasury on the Carbon Tax Policy paper. The specific information that was collected from the company's annual reports included the Financial Statements. In reports that have financial information reported in US$, these were converted to South African Rands (ZAR) using the Oanda currency converter (Oanda, 2014).

Kothari (2004) defined analysis as a means by which measures are computed in order to establish patterns of relationships that might exist among the data groups. In this section, the author intends to apply causal analysis, which determines how one or more variables may affect another variable. This research will be establishing the potential effects of the Carbon Emission Tax imposition on the profitability of a mining company and the amount of emission reduction. Therefore, this form of analysis is the most suitable.

Chapter 5.3 has research results. The numerical data was collated and populated onto Microsoft Excel spreadsheet. This data was subsequently represented as Appendix A. The data was used to draw graphs to enhance data interpretation and analysis.

5.3 Results of Carbon Tax Impact Analysis

The following results were compiled using CDP data from 2010 to 2017 for the nine mining companies. Appendix A has a comprehensive spreadsheet containing all the emissions data and financial performances of each company of interest and has been attached on page 167. Financial figures that had been reported in US$ have been converted to ZAR and the respective exchange rates are indicated in Table 9.

***Table 9**: US$ to ZAR Exchange Rates (PoundSterling Live, 2018)*.

Rand Dollar Exchange Rates	
Year	Exchange Rate
2010	7.30
2011	7.26
2012	8.20
2013	8.91
2014	10.57
2015	13.30
2016	13.65
2017	14.07

Figures 17 to 25 represent the Scope 1 & 2 CO_2 t Combined Emissions in South Africa, not global figures. As the CDP also has global emission numbers. Figures 26 to 43 show profitability trends for the mining companies.

5.3.1 Company CO_2 Emission Per Tonne

The Exxaro Resources Limited Scope 1 and 2 combined CO_2 emissions are shown in Figure 17. The trend indicates a decline in the amount of emissions from 2.48 Mt CO_2-e in 2012 to 1.44 Mt CO_2-e in 2013. The lowest combined emissions that have been relatively constant from 2014 until 2017 is at an amount of 0.77 Mt CO_2-e.

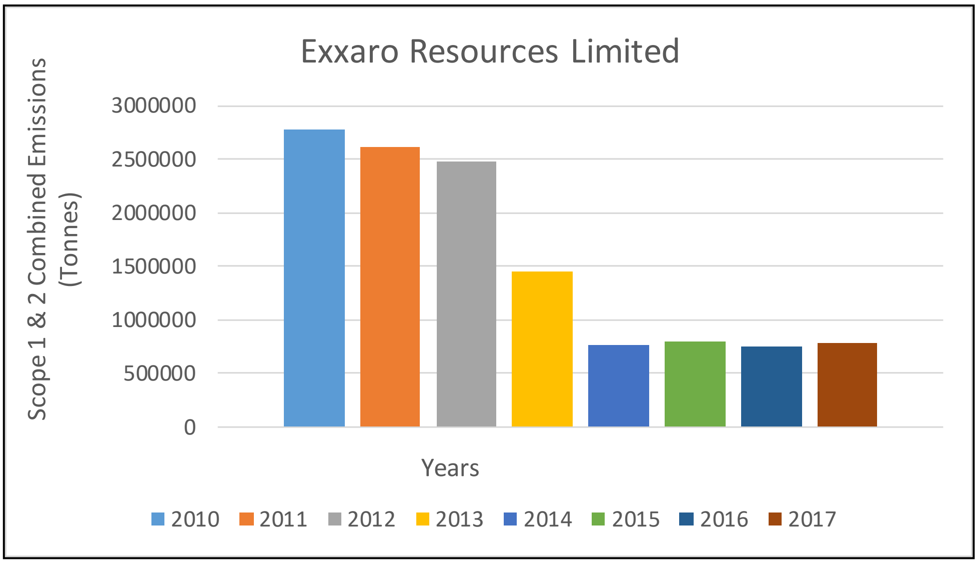

Figure 17: Exxaro Resources Limited Scope 1 & 2 CO_2 t Combined Emissions (Sources: Carbon Disclosure Project, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

This overall reduction for emission was possibly attributed to the innovative techniques that were put in place at the company's new coal plants in Limpopo, which have industry-wide applications. The 800 low energy-use houses built by the company for employees in Limpopo are proving to be green buildings that are also cost-efficient in the long run. There was also a joint-venture energy company focused on generating power for the company and country through a mix of renewable and cleaner energy sources. Less than two months after its launch, Cennergi was the preferred bidder for two wind energy projects (Amakhala 139MW and Tsitsikamma 95MW); under the Department of Energy's renewable energy independent power producers programme (REIPPP) (Exxaro Resources Limited, 2012).

According to the Exxaro Resources Limited company report, in 2012, Exxaro again performed well on both CDP measures carbon disclosure leadership index (measures only quality and completeness of response). Exxaro achieved the top score of 100 points, a first for South Africa and the company, improving its score of 94 in 2011 (Exxaro Resources Limited, 2017).

Sasol Limited CO_2 emissions seem to fluctuate throughout the study period, as indicated by Figure 18.

The emissions were exceptionally high in the year 2011 with an amount of 74 Mt CO_2-e and were the lowest in 2014 at an amount of 65 Mt CO_2-e the emissions rose again from 2015 until a slight decline in 2017.

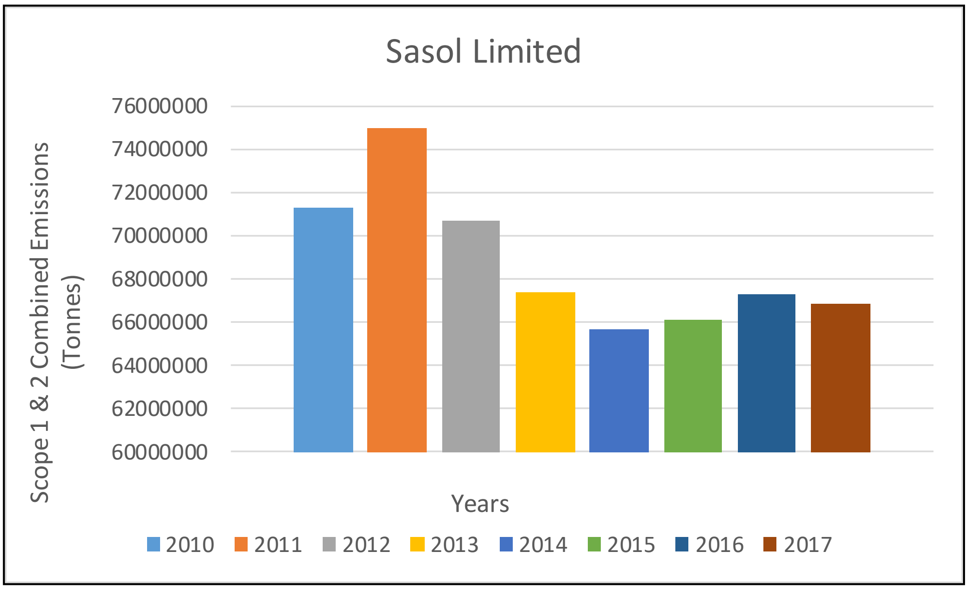

Figure 18: Sasol Limited Scope 1 & 2 CO_2t Combined Emissions (Sources: Carbon Disclosure Project, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Sasol developed a measurement reporting and verification (MVR) standard for the entire group in 2009. This enabled the employees to beware of how much the company is contributing to emissions and this was recorded in order for the amounts to be improved upon. This could have contributed to the relatively low emissions in 2010. In addition to that, in 2015 the company launched the Energy Intensity Index. This is a proactive manner of managing energy efficiency for a period of 15 years. This is reflected by the decrease in the 2015 emissions.

The company also invested in more than ZAR20billion in projects that bring about environmental improvements in relation to air quality and GHG emissions. There was also a ZAR2.6billion investment in the coal tar filtration east project in the attempt to reduce emissions. The reduction of emissions could have been encouraged by the above initiatives. During periods of higher emissions this could have been when the projects were still being commissioned (Sasol Limited, 2018).

AngloGold Ashanti Limited had high emissions of approximately 4.70 Mt CO_2-e between 2010 and 2011 as indicated by Figure 19. This amount followed a steady decline for the rest of the study period to an average of almost 2.90 Mt CO_2-e.

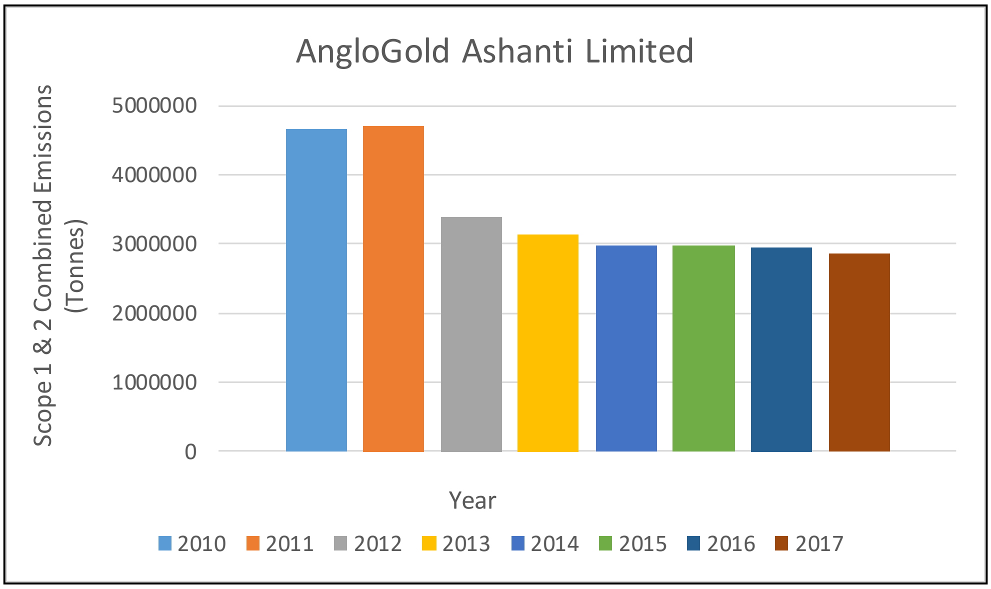

Figure 19: AngloGold Ashanti Limited Scope 1 & 2 CO_2t Combined Emissions (Sources: Carbon Disclosure Project, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

According to the 2018 company's annual report, the company was emitting larger volumes of emissions due to a drop in the gold grades. This implies that more volume of ore was mined, thus increasing the energy consumption needed for tramming, hoisting, distances trucked and the volume of ore milled in processing plants. Additionally, their underground mines used significant amounts of energy to ventilate and cool the underground workings. The ensuing drop to approximately 2.90 Mt CO2-e in the subsequent years could have been influenced by investing in energy-saving or energy switching initiatives (AngloGold Ashanti Limited, 2018).

Gold Fields Limited had high emissions between 2010 and 2014 of 6.4-5.1 Mt CO_2-e respectively; refer to Figure 20. This was followed by a sharp decline of 0.5 Mt CO_2-e in 2015 to 2017. There have been a number of initiatives that Gold Fields Limited had invested in, in the attempt to reduce carbon emissions.

These could have possibly enabled this decline in the emissions over the duration of the study.

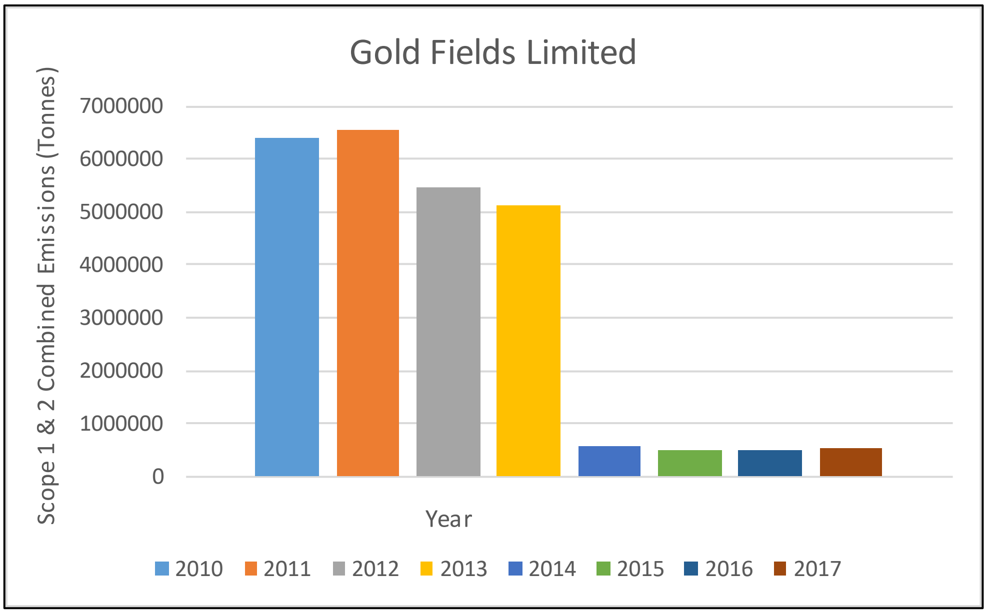

Figure 20: Gold Fields Limited Scope 1 & 2 CO_2t Combined Emissions (Sources: Carbon Disclosure Project, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Gold Fields is committed to achieving 17% carbon emission reductions each year up to 2020, equivalent to 800,000 tCO_2e of cumulative carbon emission reductions over the period. In 2016, Gold Fields revised the group Integrated Energy and Carbon Management guideline to align with ISO50001, the global energy management standard. Gold Fields started the alignment with the standard in 2017 by integrating energy and carbon management into operational and strategic aspects of the business.

The company has invested in energy efficiency and emission reduction projects during 2017 amounting to US$6million. At the South Deep mine, in South Africa, a new ventilation design was implemented at the underground mine, with five sets of three fans saving 20kW per fan. These are energy-efficient jet fans for de-stress mining and result in a Scope 2 electricity-based emission savings. They are also committed to low carbon and renewable in efforts of reducing carbon emissions. All of the company's operations, other than South Deep, are largely powered by LP gas, a low carbon energy source (Gold Fields Limited 2018).

Harmony Gold Limited combined CO_2 emissions to reach an all-time high of 5.5 Mt CO_2-e in 2011, as indicated by Figure 21. This was followed by a decline of an average of 2.8 Mt CO_2-e that has been maintained up until 2017.

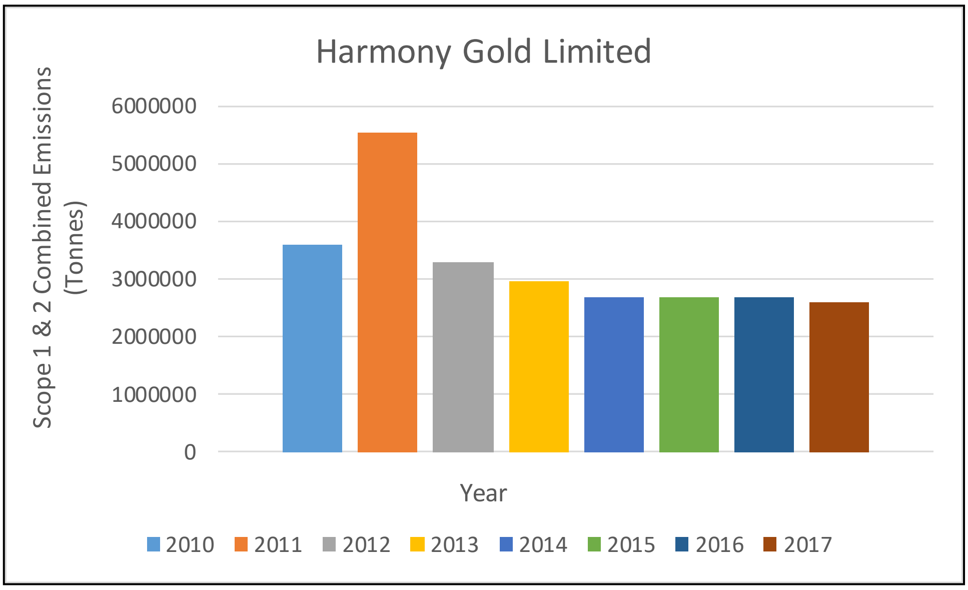

Figure 21: Harmony Gold Scope 1 & 2 CO_2t Combined Emissions (Sources: Carbon Disclosure Project, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Just like other deep-level mines, Harmony Gold experienced high-energy consumption in 2011. This was also compounded by the fact that two of the sections in Doornkop shaft namely Steyn 2 and the Kimberley-reef section were not meeting rising energy costs due to running out of reserves. These two sections have been subsequently shut.

The continued decline in the amount of emissions post-2011 was due to the multiple initiatives the company had invested such as the energy-efficient fans installed underground at Kusasalethu as well as Tshepong's optimisation of compressed air energy-saving projects (Harmony Gold Limited, 2015).Harmony Gold Limited is also implementing a bio-energy project involving the propagation of bio-crops on mine-impacted land in the Free State.

This is done to generate natural gas as a substitute for fossil fuels in the company's Harmony 1 Gold Plant elution and carbon regeneration circuits. Phase one of the project aims to deliver 71 000GJ of energy within 18 months with production being ramped up to generate 187GJ within 36 months. This project aims to turn mine-impacted land into account by creating a value-adding use for it and, in so doing, to promote skills development and job creation for communities and ensure a sustainable legacy in the Free State bidding (Harmony Gold Limited, 2018).

Harmony Gold Limited is also currently building expertise in renewable energy and participating in a group that is to develop an 18MW solar park at Kalgold in terms of the government's renewable energy power programme. The solar energy to be generated will be fed into the Eskom electricity grid (Harmony Gold Limited, 2018).

Anglo American Platinum Limited shows an upward trend for emissions, more especially in 2017. The company emitted 8.25 Mt CO_2-e compared to an average of 5.86 Mt CO_2-e emitted in previous years, as indicated by Figure 22.

Figure 22: Anglo American Platinum Limited Scope 1 & 2 CO_2t Combined Emissions (Sources: Carbon Disclosure Project, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Anglo American Platinum has pride itself on emission reduction initiatives such as ECO2MAN. The programme uses data captured from the company's mines to better adjust their energy consumption and reduce their emissions. They also strive to source more from renewable sources and capture, where possible, energy from mining processes and waste. What contributed to the spike in 2017 could possibly be due to gross global platinum demands decreasing by 4.5% or 370koz in 2017. There was a declining share of sales of the diesel engine in the western European car market. Despite this, strong vehicle sales volumes and increasingly tight emissions legislation meant that gross automotive demand declined by only 1.2% to 3.29 million ounces (Anglo American Platinum, 2018).

Impala Platinum Holdings has fluctuating CO_2 emissions as shown in Figure 23, similar to the trend displayed by Sasol Limited. The emissions had been at an average of 3.52 Mt CO_2-e from 2010 until 2014. This was followed by a temporary decline to 2.5 Mt CO_2-e in 2015. There was a subsequent increase for the last two years of the study of 3 Mt CO_2-e. According to the Impala Platinum environmental factsheet published in 2016, this emission fluctuation, more especially from 2015, was as a result of increased production levels following the end of strike action at Impala Rustenburg in 2014.

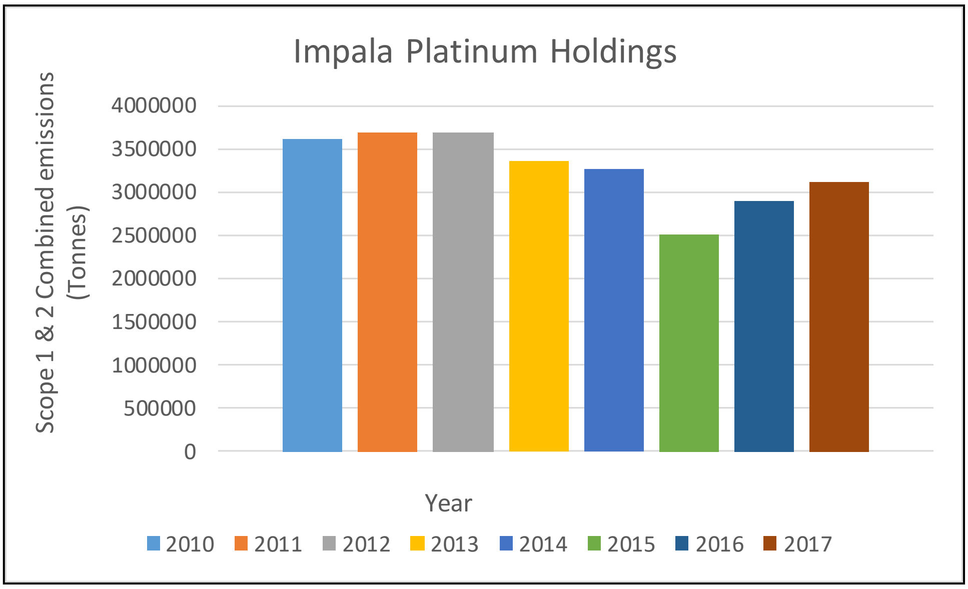

Figure 23: Impala Platinum Holdings Scope 1 & 2 CO_2t Combined Emissions (Sources: Carbon Disclosure Project, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

In 2015, emissions intensity (tonnes of CO_2 per tonne of ore milled) was 0.209, down from 0.218 in 2014. This improvement reflects positively on energy efficiency initiatives such as the conversion of all underground lighting at Impala Rustenburg to a more energy-efficient lighting source. This is estimated to reduce annual consumption by 15 GWh. The optimised use of compressed air systems at Impala Rustenburg has achieved an estimated reduction of 7.8 GWh per annum. The underground compressed air optimisation project has an estimated future annual saving of 61.3 GWh. At Impala Springs, an R250million project was initiated to address airborne emissions (Impala Platinum Holdings, 2016).

Northam Platinum Limited indicates an upward trend in the amount of combined CO_2 emissions as indicated by Figure 24, similar to Anglo American Platinum. The amounts have been increasing since 2010 from an average of 0.6 Mt CO_2-e to the highest emissions in 2017 of 0.84 Mt CO_2-e. This is attributed to the global drop in demand for platinum group metals. This trend is similar to that of Anglo American Platinum. According to the Northam integrated report released in 2018 the increase in emissions was attributed to their Zondereinde Operations smelter (Northam Platinum Limited, 2018).

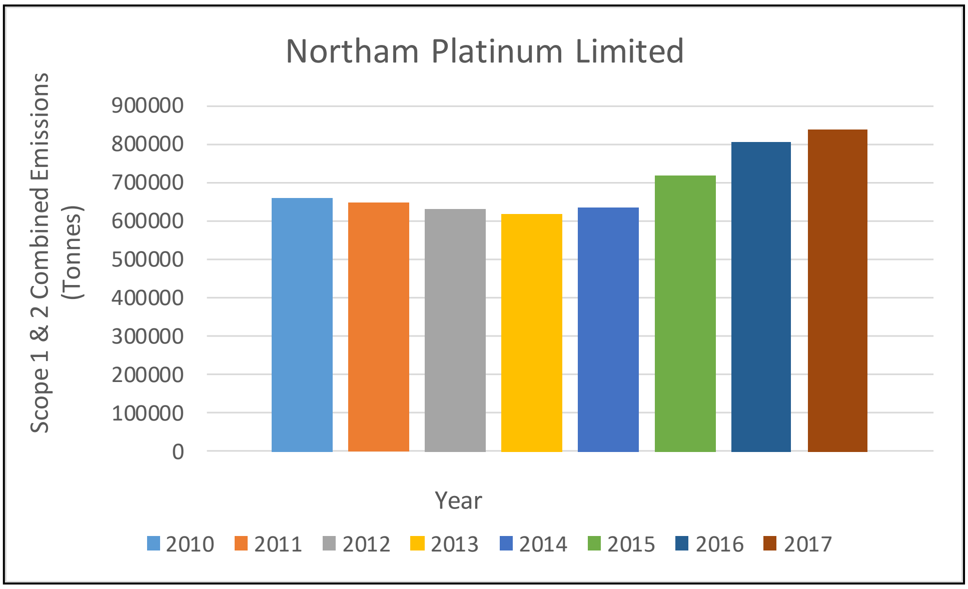

Figure 24: Northam Platinum Limited Scope 1 & 2 CO_2t Combined Emissions (Sources: Carbon Disclosure Project, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Kumba Iron Ore displays a steady increase in the amount of combined CO_2 emissions from 2010 up until the highest value in 2016. This is an increase of an amount of 0.7-1.2 Mt CO_2-e; refer to Figure 25. This increase, according to the 2018 company report was as a result of electricity purchased, the combustion of fossil fuels at operations, and GHGs emitted because of industrial processes. The subsequent decline that follows in 2017 was attributed to its energy-saving initiatives in relation to the haulage fleet.

There has been an improvement in haul truck payloads, traffic management, and improvement in direct operating hours, dynamic dispatch implementation and the calibration of engines (Kumba Iron Ore Limited, 2018).Kumba Iron Ore has also supported the South African energy market with an independent power project, namely the 100MW Kathu concentrated solar thermal plant with energy storage capability (Kumba Iron Ore Limited, 2018).

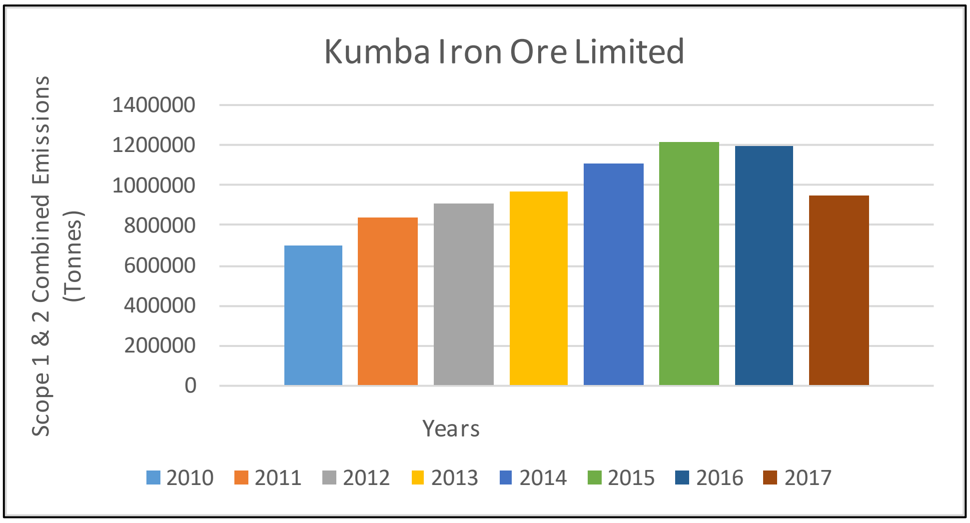

Figure 25: Kumba Iron Ore Limited Scope 1& 2 CO_2t Combined Emissions (Sources: Carbon Disclosure Project, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

5.3.1.1 Summary

The announcement made by the South African National Treasury on the Carbon Tax Policy paper in 2010 motivated numerous mining companies to work in an environmentally conscious manner. There is an overall decline in the amount of emissions from the companies of interest. The exception to the trend is in the platinum industry. There are years marked with an increase in the amount of emissions.. This could have been potentially influenced by macroeconomic factors.

A number of companies have come up with energy-saving initiatives to reduce the amount of emissions produced per year. Examples can be seen in the Exxaro joint-venture energy company that is focused on generating power for the company and country through a mix of renewable and cleaner energy sources; and Sasol Limited investing in more than ZAR20billion in projects that bring about environmental improvements in relation to air quality and GHG emissions. Sasol also invested in a ZAR2.6billion coal tar filtration east project, in the attempt to reduce emissions. At the South Deep mine in South Africa, a new ventilation design was implemented at the underground mine, with five sets of three fans saving 20kW per fan. These are energy-efficient jet fans for de-stress mining that result in a Scope 2 electricity-based emission savings.

Harmony Gold Limited is also currently building expertise in renewable energy and participating in a group that is to develop an 18MW solar park at Kalgold in terms of the government's renewable energy power programme. At Impala Springs, a R250million project was initiated to address airborne emissions and finally, Kumba Iron Ore has also supported the South African energy market with an independent power project, namely the 100MW Kathu concentrated solar thermal plant with energy storage capability.

The above is an indication that the announcement of the Carbon Tax Act 15 of 2019 and the recent implementation thereof has sparked a behavioural change in the energy intensity and emissions being generated by the mining companies of interest. This is in line with addressing the first objective of this research, which is to determine the impact of the carbon tax on emission reduction during the study period. Chapter 5.3.2 discusses the financial implication of the enactment of the carbon tax upon the selected mining companies.

5.3.2 Company Profitability Results

The different companies' financial data is also found in Appendix A, as mentioned in Chapter 5.3.1. Each company's profitability was calculated using the company's annual profit after tax data. The value was divided by the potential amount that the company will be liable to pay because of the carbon tax. The data of interest was gathered from the companies' income statements. The graphs have been arranged in the same sequence per company, demonstrating the tax paid per tonnes of CO_2 emissions, at the maximum tax reduction of 90% for mining and quarrying companies and a 95% for fossil fuel mining companies as stipulated by the South African National Treasury and Table 8 in Chapter 5.2.2.

The first graph is the tax paid per tCO_2 -equivalent at maximum tax reduction in ZAR per million. The second graph shows the impact of CET on the individual company's profitability. The graphs indicate the net profit margins percentage per company from 2010 to 2017. A comparison was also conducted to determine the impact of CET on the individual company's profitability based on the maximum reduction without any percentage reduction.

Exxaro Resources Limited has eight managed coal mines that produced 42,8Mtpa power station, steam and coking coal in 2016. Most power station coal is supplied to the national power utility, Eskom. On 31 December 2016, Exxaro had assets of ZAR59,9billion and a market capitalisation of ZAR32 billion (US$2,3billion) (Exxaro Resources Limited, 2018).

Exxaro Resources Limited would have been liable to pay a maximum of ZAR16million for the CET in 2011 should the tax have been implemented in 2010, as shown in Figure 26. The potential amount liable would have sharply declined between 2012 and 2014; then the potential liability plateaued to ZAR4million up until 2017.

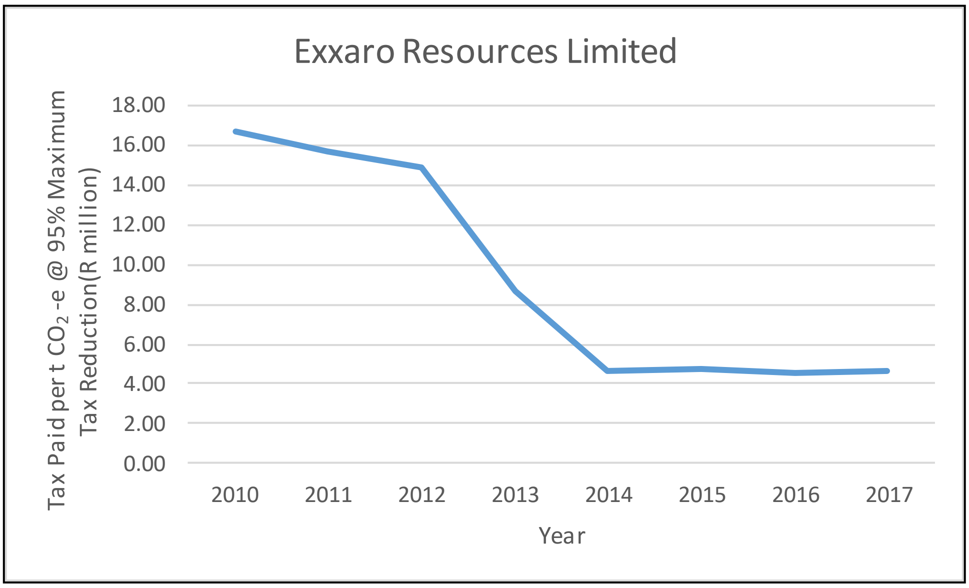

Figure 26: Tax Paid per t CO_2 -e at 95% Maximum Tax Reduction (ZARmillion) for Exxaro Resources Limited (Sources: Exxaro Resources Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Exxaro Resources Limited could have potentially lost a maximum of 1.77% in 2015 from their annual profit in 2010, as shown in Figure 27. The greatest impact could potentially have been experienced in 2014. The company could have had a loss of 0.52%. This can also be translated to approximately ZAR5million that the company would have been liable to pay.

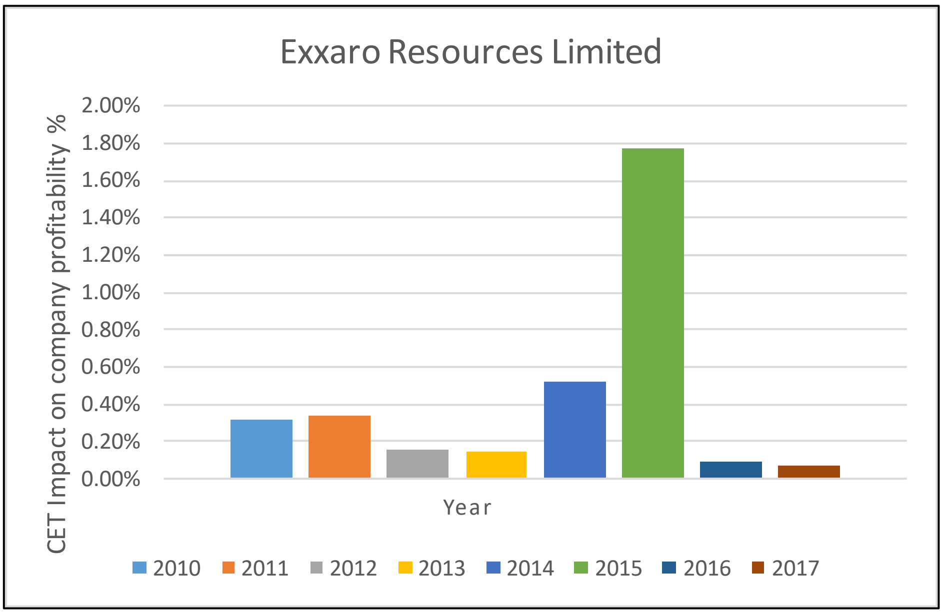

Figure 27: CET Impact on Company Profitability (%) for Exxaro Resources Limited (Sources: Exxaro Resources Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Table 10 shows the impact of CET on the company with and without the 95% tax reduction. A factor of 95% has been applied by virtue of Exxaro resources being a coal producer. There is an additional 5% that the coal producers have been given, shown in Table 8 in Chapter 5.2.3. It indicates a 35% loss in the company's profitability in 2015. This figure is very high because the company did not perform well in that year. It only made ZAR267 million compared to an average of ZAR6billion in previous years. The worst performance was in 2014 where the company made a loss of ZAR884million (Appendix A). This has a ripple effect on the profitability should the company be liable for an additional cost from CET.

Table 10: Exxaro Resources Limited Comparison of CET Impact on Profitability With and Without Reduction.

Year	Company Name	CET Impact on company profitability at 95% Discount	CET Impact on company profitability at 0% Discount
2010	Exxaro Resources Limited	0.32%	6.37%
2011		0.34%	6.71%
2012		0.15%	3.08%
2013		0.14%	2.79%
2014		0.52%	10.42%
2015		1.77%	35.39%
2016		0.09%	1.76%
2017		0.07%	1.47%

Exxaro experienced a significant decline in profit in 2014 due to labour unrest that took place between union rivalries in 2014. This was further exacerbated by the decline in commodity prices globally and the drop in demand for coal . The company further reported that there was also a sharp increase in load shedding resulting in unplanned maintenance of most of their equipment running on electricity (Exxaro Resources Limited, 2018).

Sasol is an international integrated chemicals and energy company that leverages technologies and the expertise of 31 270 people working in 32 countries. The Southern African Operations business cluster is responsible for Sasol's entire southern Africa operations portfolio. The company's operating facilities in Secunda are divided into synthetic fuels and chemicals component, Sasolburg, Natref, Sasol's joint-venture inland refinery with Total SA, and Satellite Operations, a consolidation of all Sasol's operating activities outside of Secunda. Mining extracts about 40Mt of saleable coal per annum, which is mainly used as gasification feedstock for Sasol Synfuels in Secunda and utilises coal for the Sasolburg Operations. Sasol Mining also exports some 2.8Mt of coal per annum to Europe, the Far East and other international customers (Sasol Limited, 2018).

Sasol Limited would have been liable to pay a maximum of ZAR449 million for the CET in 2011 should the tax been implemented in 2010, as shown in Figure

28. The potential amount liable would have sharply declined between 2012 and 2014 to ZAR393million.

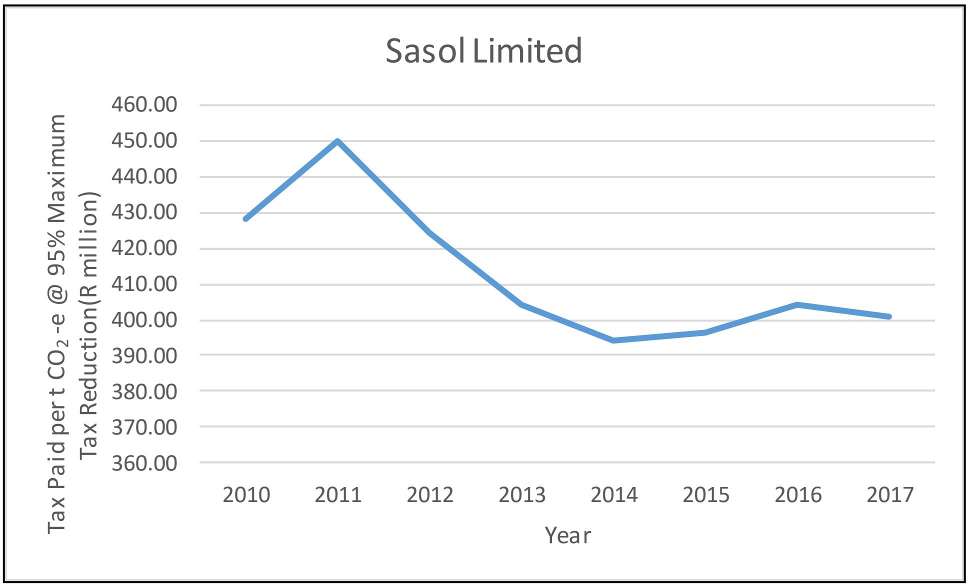

Figure 28: Tax Paid per t CO_2 -e at 95% Maximum Tax Reduction (ZARmillion) for Sasol Limited (Sources: Sasol Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Sasol Limited could have potentially lost a maximum of 2.61% and 2.69% from their annual profit in 2010 and 2016 respectively, as shown in Figure 29. An average of 1.90% over the study period could have been incurred on the company’s profitability. This can be translated to ZAR400million additional amount to be paid as tax. The decline in 2014 is similar to that of Exxaro resources as they are both coal-producing companies. There was a decline in commodity prices on the demand for coal, especially in China.

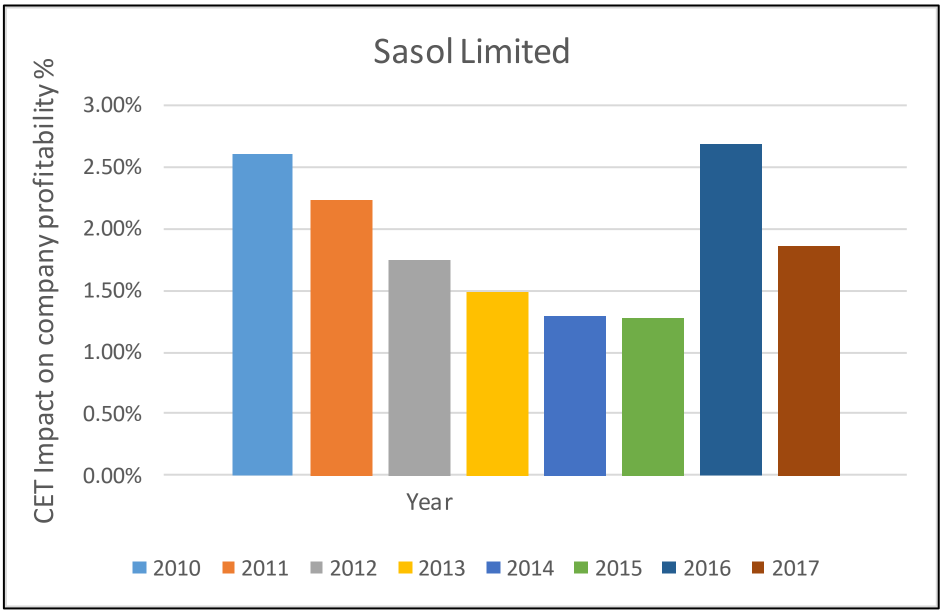

Figure 29: CET Impact on Company Profitability (%) for Sasol Limited (Sources: Sasol Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

The company could have absorbed these figures, particularly if a 95% reduction had been applied to the CET by virtue of Sasol being a coal-producing company. This may not be the case should the 95% reduction be removed from the calculations. These effects are shown in Table 11, where 54% could potentially have affected the company's profit margins. This adds up to an average loss of 37.98% over the six-year period of the project investigation.

Table 11: Sasol Limited Comparison of CET Impact on Profitability With and Without Reduction.

Year	Company Name	CET Impact on company profitability at 95% Discount	CET Impact on company profitability at 0% Discount
2010	Sasol Limited	2.61%	52.23%
2011		2.22%	44.50%
2012		1.75%	34.98%
2013		1.49%	29.75%
2014		1.30%	25.90%
2015		1.27%	25.45%
2016		2.69%	53.77%
2017		1.86%	37.27%

AngloGold Ashanti is the third-largest gold mining company in the world, measured by production**.** As of 31 December 2018, the portfolio shows 14 operations in nine countries including long-life, relatively low-cost operating assets with differing orebody types, located in key gold-producing regions around the world. The South African operations produced 487,000oz at a total cash cost of US$1,033/oz. in 2018 (Anglo Gold Ashanti Limited, 2018).

AngloGold Ashanti Limited would have been liable to pay a maximum of ZAR56million for the CET in 2011 should the tax been implemented in 2010, as shown in Figure 30. The potential amount liable would have declined steadily throughout the years of study to the lowest number of ZAR34million in 2017.

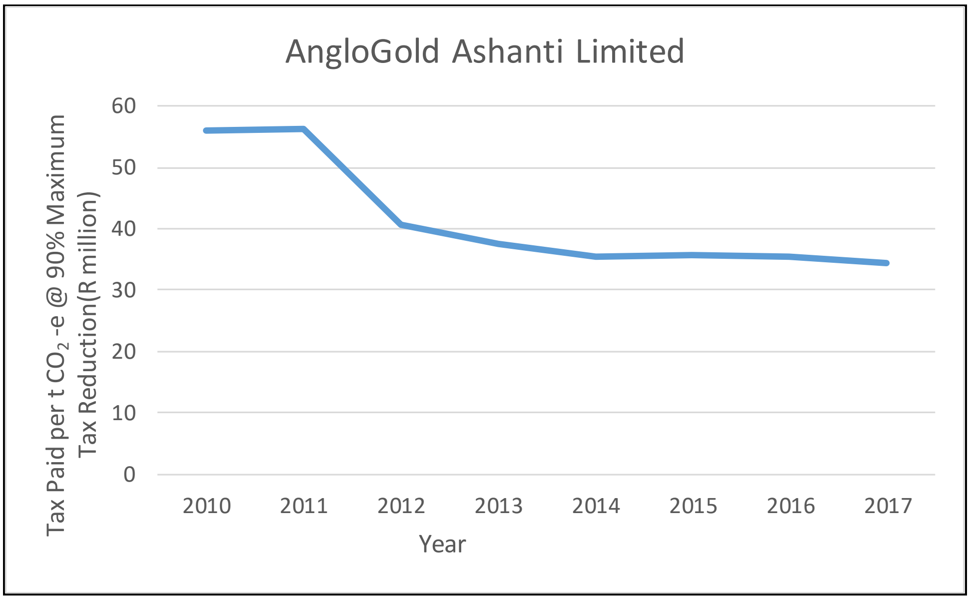

Figure 30: Tax Paid per t CO_2 -e at 90% Maximum Tax Reduction (ZARmillion) for AngloGold Ashanti Limited (Sources: AngloGold Ashanti Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

AngloGold Ashanti Limited could have potentially lost a substantial amount in the company’s profitability over a number of years. Figure 31 indicates that there could have been a maximum of a 5.95% loss in profitability in 2010. The conditions could potentially have deteriorated over the years, with numerous losses experienced by the company from 2013 to 2015, then again in 2017. The company could have had the highest potential loss of 8.63% in 2014.This implies that the company would have had to get additional funds in order to be able to pay off the tax.

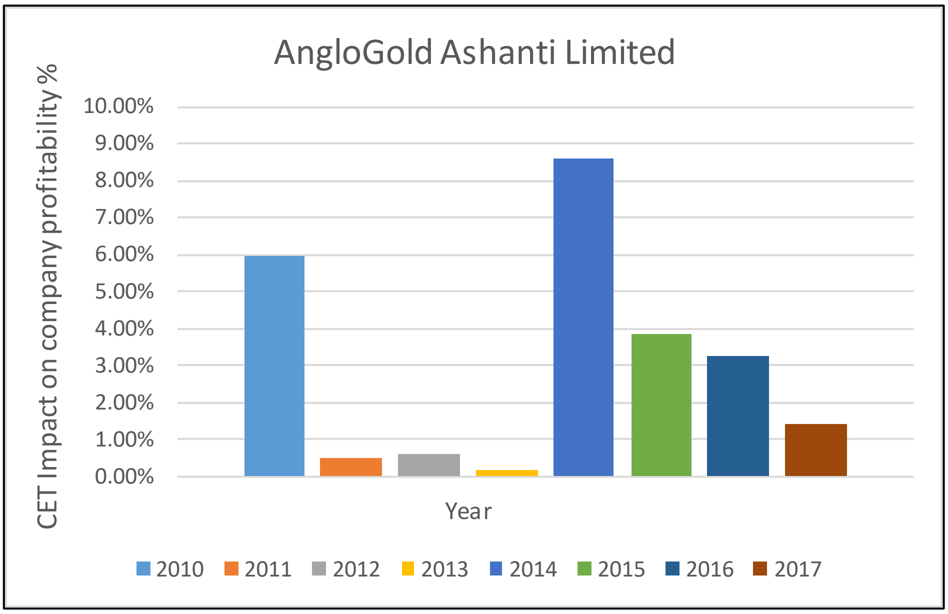

Figure 31: CET Impact on Company Profitability (%) for AngloGold Ashanti Limited (Sources: AngloGold Ashanti Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Table 12 shows the impact of CET on the company with and without the 90% tax reduction. It indicates a 59% loss in the company's profitability in 2010. The highest potential net loss could have been in 2014, at a value of 86%. This implies that additional funds would have to be acquired to pay for the CET together with all the other losses the company would have incurred. This adds up to an average loss of 4% over the six-year period of the project investigation.

Table 12: Anglo Gold Ashanti Limited Comparison of CET Impact on Profitability With and Without Reduction.

Year	Company Name	CET Impact on company profitability at 90% Discount	CET Impact on company profitability at 0% Discount
2010	AngloGold Ashanti Limited	5.95%	59.53%
2011		0.49%	4.86%
2012		0.59%	5.85%
2013		0.19%	1.92%
2014		8.63%	86.25%
2015		3.84%	38.43%
2016		3.25%	32.52%
2017		1.43%	14.28%

AngloGold Ashanti Limited has responded to lower gold prices by cutting overhead expenditure by more than two-thirds since the end of 2012. The group introduced two new, low-cost mines, sold or closed higher-cost assets and removed unprofitable ounces from its portfolio. The company also sold its Cripple Creek & Victor mine (CC&V) in the US for $820million in June of this year to reduce net debt and is now intensifying efficiency efforts to complement the cost-benefit it receives from weakening local currencies and plummeting oil prices. Other factors include safety-related interruption by government, wage negotiations and the drop in the gold price from US$1900 per ounce in the second half of 2011 to US$1080 per ounce (Steyn, 2015).

Gold Fields Limited is a globally diversified gold producer with eight operating mines and two projects in Australia, Chile, Ghana, Peru and South Africa, with total attributable annual gold-equivalent production of approximately 2Moz. Gold Fields South Deep underground gold mine has 56.2Moz gold mineral resources and 32.8Moz gold mineral reserves (Gold Fields Limited, 2018).

Gold Fields Limited would have been liable to pay a maximum of ZAR78million for the CET in 2011 should the tax been implemented in 2010, as shown in Figure 32. The potential amount liable would have a steady decline up to 2013 to

ZAR61million. This could potentially have been followed by a sharp decline to an average of ZAR5million followed by a plateau up until 2017.

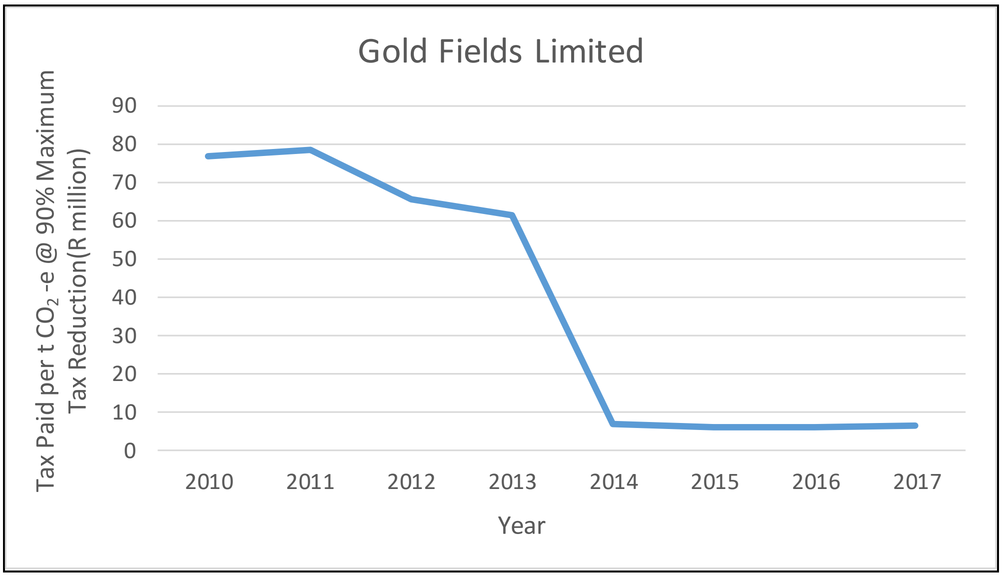

Figure 32: Tax Paid per t CO_2 -e at 90% Maximum Tax Reduction(ZARmillion) for Gold Fields Limited (Sources: Gold Fields Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Gold Fields Limited could potentially have lost a substantial amount in the company's profitability over a number of years. Figure 33 shows that there could have been a maximum of 3.12% loss in profitability in 2014. The conditions could potentially have deteriorated over the years, with numerous losses experienced by the company in 2013, 2015 and again in 2017. The company could have had the highest potential loss of 2.25% in 2013. This implies that the company would have to acquire additional funds in order to be able to pay off the tax.

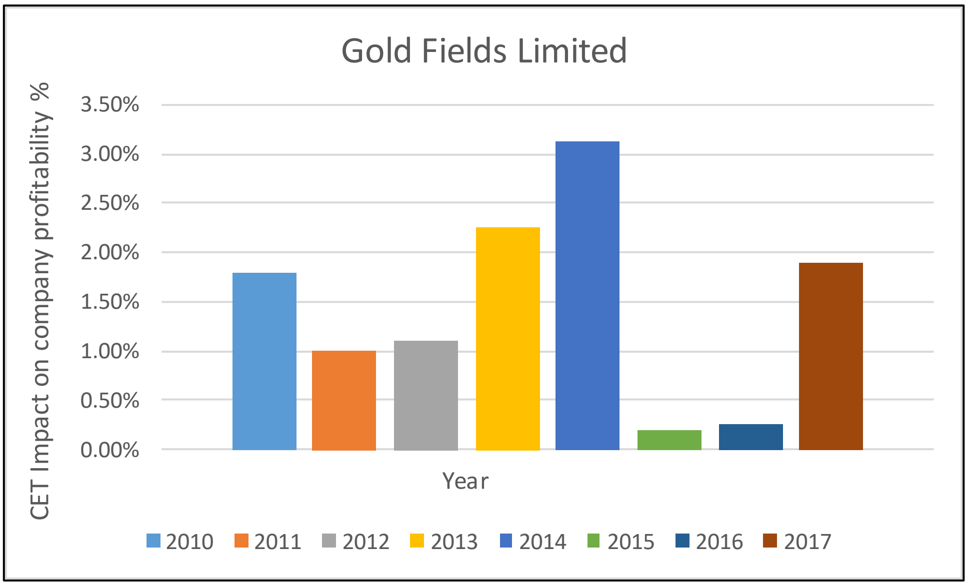

Figure 33: CET Impact on Company Profitability (%) for Gold Fields Limited (Sources: Gold Fields Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Table 13 shows the impact of CET on the company with and without the 90% tax reduction. It indicates a 31% loss in the company's profitability in 2014. The highest potential loss could have been in 2013, at a value of 22%. This implies that additional funds would have to be acquired to pay for the CET, together with all the other losses the company would have incurred. This adds up to an average loss of 3.67% over the six-year period of the project investigation.

Table 13: Gold Fields Limited Comparison of CET Impact on Profitability With and Without Reduction.

Year	Company Name	CET Impact on company profitability at 90% Discount	CET Impact on company profitability at 0% Discount
2010	Gold Fields Limited	1.80%	17.97%
2011		1.01%	10.06%
2012		1.10%	11.04%
2013		2.25%	22.50%
2014		3.12%	31.15%
2015		0.00%	2.00%
2016		0.00%	3.00%
2017		1.90%	19.00%

At South Deep in South Africa, gold sales were lower, decreasing by 34% from 9,397 kilograms (302,100 ounces) to 6,237 kilograms (200,500 ounces) due to three fatalities, which occurred on 17 and 27 May 2014 and on 28 July 2014. This was also because of safety stoppages to remediate ground support in the main mining areas across the mine. The South Deep operating costs decreased by 14% from ZAR3,089million (US$322million) to ZAR2,657million. This decrease of ZAR432million was mainly due to lower production as well as cost restructuring partially offset by annual wage increases and normal inflationary increases. The drop in the gold price from US$1900 per ounce in the second half of 2011 to US$1080 per ounce also influenced the losses made by the company (Gold Fields Limited, 2014).

Harmony Gold Limited operates in South Africa and Papua New Guinea. In 2018, the South African operations accounted for 93% of total gold production of 1.23Moz, with 7% coming from Papua New Guinea. On 30 June 2018, Harmony reported attributable gold-equivalent mineral reserves of 36.9Moz of gold and attributable gold mineral resources of 117.8Moz. At the end of 2018, Harmony employed 40 686 people in total: 32 520 employees and 5 951 contractors in South Africa, and 1 397 employees and 818 contractors in Papua New Guinea (Harmony Gold Limited, 2018).

Harmony Gold Limited would have been liable to pay a maximum of ZAR66million for the CET in 2011 should the tax have been implemented in 2010, as shown in Figure 34. The potential amount liable would have declined sharply in 2012 to ZAR39million. This could potentially have been followed by a steady decline to an average of ZAR32million followed by a plateau up until 2017.

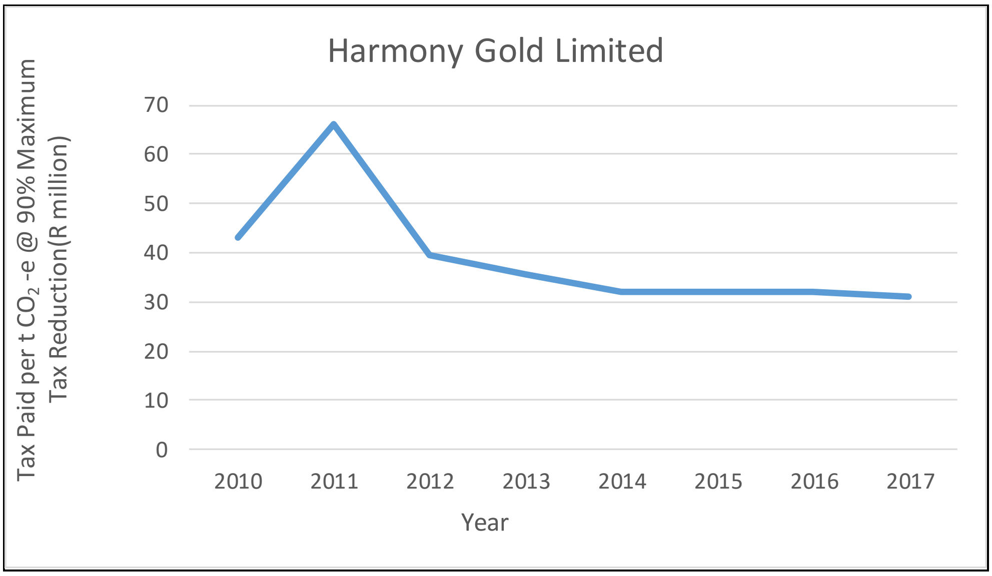

Figure 34: Tax Paid per t CO_2 -e at 90% Maximum Tax Reduction (ZARmillion) for Harmony Gold Limited (Sources: Harmony Gold Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Harmony Gold Limited potentially could have lost a substantial amount in the company's profitability over a number of years. Figure 35 shows that there could have been a maximum of a 10% loss in profitability in 2011. The conditions could potentially have deteriorated over the years, with numerous losses experienced by the company during 2010, 2013, 2014 and 2015. The company could have had the highest potential loss of 22% in 2010. This implies that the company would have needed additional funds in order to be able to pay off the tax.

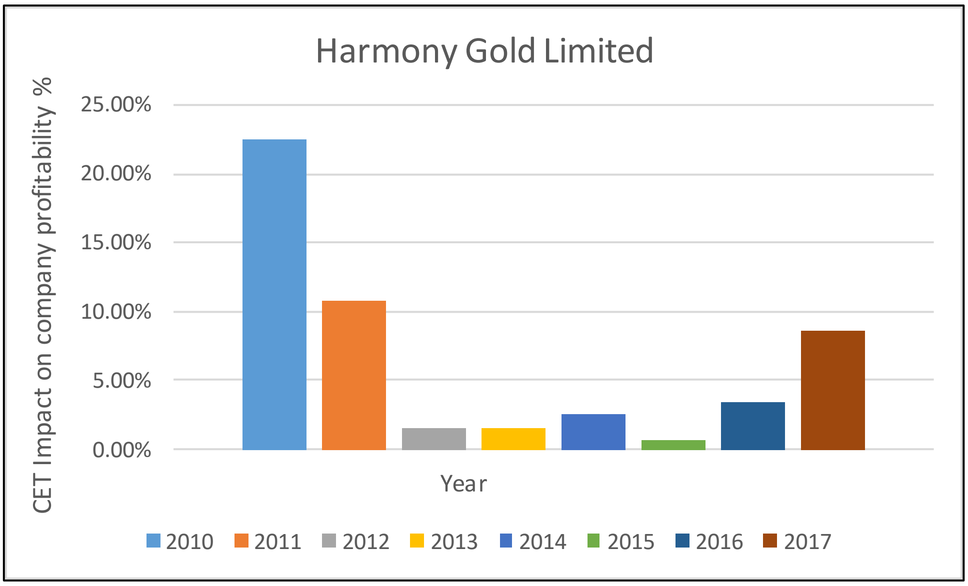

Figure 35: CET Impact on Company Profitability (%) for Harmony Gold Limited (Sources: Harmony Gold Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Table 14 shows the impact of CET on the company with and without the 90% tax reduction. It shows a 107% loss in the company's profitability in 2011. This implies that all the potential profit the company could have earned would have to be paid out for CET. The highest potential loss could have been in 2010, at a value of -224%. This means that additional funds would have needed to be acquired to pay for the CET together with all the other losses the company would have incurred. This adds up to an average loss of 3.67% over the six-year period of the project investigation.

Table 14: Harmony Gold Limited Comparison of CET Impact on Profitability With and Without Reduction.

Year	Company Name	CET Impact on company profitability at 90% Discount	CET Impact on company profitability at 0% Discount
2010	Harmony Gold Limited	22.44%	224.41%
2011		10.75%	107.48%
2012		1.49%	14.89%
2013		0.02%	0.15%
2014		0.03%	0.25%
2015		0.01%	0.07%
2016		3.39%	33.88%
2017		8.62%	86.25%

In 2013 up until 2015, Harmony Gold Limited experienced a decline in profitability due to ZAR548million, losses from the temporary closure of Kusasalethu mine amounting to ZAR1.2billion and retrenchment costs that took place in 2013. This was followed by labour disruptions at Kusasalethu mine, which cost the company around ZAR1.2billion.In 2014 the average US$ gold price received decreased by 19% to US$1 299/oz. Gold producers' response to the lower gold price was to reduce costs, delay projects, dispose of non-core assets and close loss-making operations. There was also an accident in their Doornkop operation in the same year, where nine men lost their lives attempting to flee an underground fire. There were associated falls of ground, contributing to safety stoppages at the mine. (Harmony Gold Limited, 2014, 2014, 2015).

Anglo American Platinum Limited is the world's leading producer of platinum. They produce around 37% of the world's newly mined platinum. The company mines, processes and refines the entire range of platinum group metals (PGM), which are platinum, palladium, rhodium, ruthenium, iridium, and osmium. The company had PGM sales volumes of 1,275,100 ounces of refined products in 2018 (Anglo American Platinum, 2018).

Anglo American Platinum Limited would have been liable to pay a maximum of ZAR98 million for the CET in 2017 should the tax been implemented in 2010, as shown in Figure 36. The potential amount liable would have been as low as ZAR40million from 2010 until 2016.

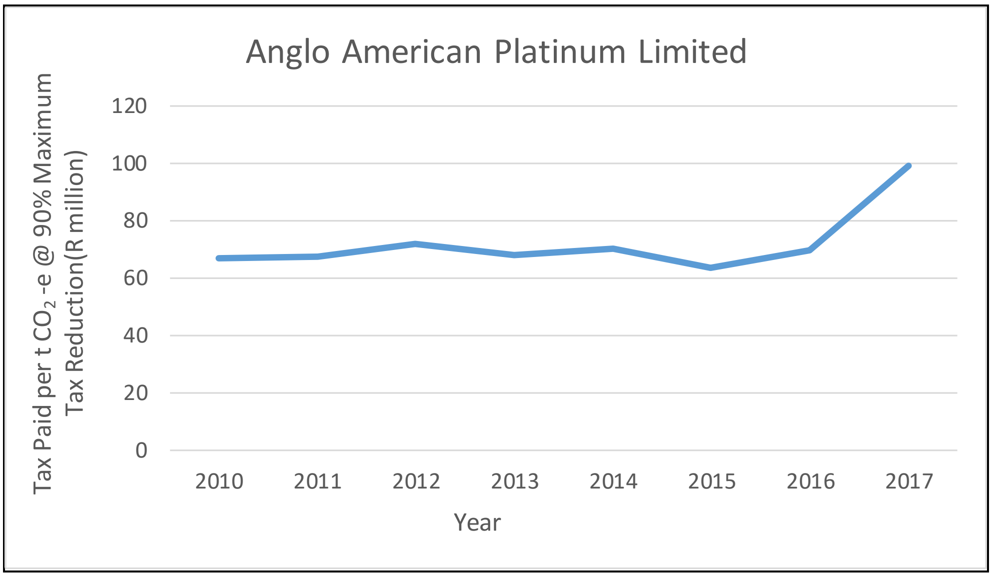

Figure 36: Tax Paid per t CO_2 -e at 90% Maximum Tax Reduction (ZARmillion) for Anglo American Platinum Limited (Sources: Anglo American Platinum Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Anglo American Platinum Limited potentially could have lost a substantial amount in the company's profitability over a number of years. Figure 37 shows that there could have been a maximum of 18.94% loss in profitability in 2014. The conditions could potentially have deteriorated over the years, with numerous losses experienced by the company in 2012, 2013, and again in 2016. The company could have had the highest potential loss of 4.5% in 2013. This implies that the company would have had to get additional funds in order to be able to pay off the tax.

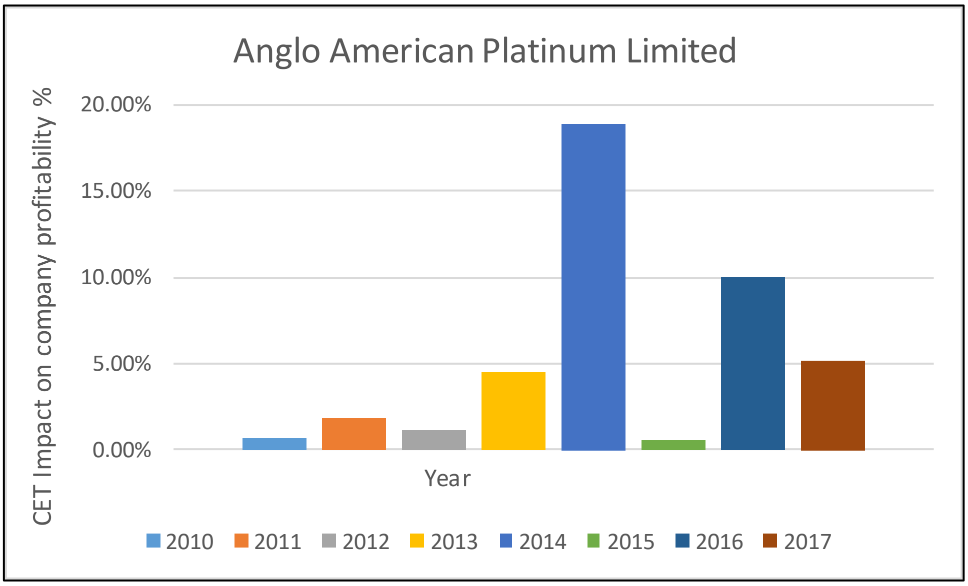

Figure 37: CET Impact on Company Profitability (%) for Anglo American Platinum Limited (Sources: Anglo American Platinum Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Table 15 shows the impact of CET on the company with and without the 90% tax reduction. It indicates a 189% loss in the company's profitability in 2014. This implies that all the potential profit the company could have earned would have to be paid out for CET. The highest potential loss could have been in 2013, at a value of 45%. This implies that additional funds would have to be acquired to pay for the CET together with all the other losses the company would have incurred. This adds up to an average loss of 38.% over the six-year period of the project investigation.

Table 15: Anglo Platinum Limited Comparison of CET Impact on Profitability With and Without Reduction.

Year	Company Name	CET Impact on company profitability at 90% Discount	CET Impact on company profitability at 0% Discount
2010	Anglo American Platinum Limited	0.66%	6.62%
2011		1.83%	18.26%
2012		1.07%	10.69%
2013		4.50%	45.00%
2014		18.94%	189.37%
2015		0.52%	5.21%
2016		10.00%	100.00%
2017		5.15%	51.45%

The substantial losses experienced in 2017 were possibly as a result of the decline in the gross global jewellery demand for platinum 2017, dropping by 7.7% or 185koz. In 2017, six employees were fatally injured in work-related incidents at the company's operations. In addition, Atlatsa Resources placed the Bokoni Mine on care and maintenance, removing loss-making production. The platinum market moved into a small surplus during the year, with primary supply from mine production across the sector falling by 1.6%, offset by an increase in recycling from the automotive industry, while gross demand declined 5% (Anglo Platinum Limited, 2018).

Impala Platinum Holdings is a leading producer of PGMs. The group is structured around five mining operations and a toll refining business. Its operations are located on the two most significant PGM deposits in the world, namely the Bushveld Complex in South Africa, and the Great Dyke in Zimbabwe. The company has total attributable resources of 133.8 million ounces of platinum. It also employs approximately 50 500 people (including 14 500 contractors) across its operations. In 2018, the group produced 2.92 million ounces of PGMs, which included 1.47 million ounces of platinum (Impala Platinum Limited, 2019).

Impala Platinum Holdings would have been liable to pay a maximum of ZAR44million for the CET between the years 2016 and 2017 should the tax have been implemented in 2010, as shown in Figure 38. The potential amount liable would have had a steady decline to the lowest value of ZAR30million in 2015. This could potentially have been followed by a steady incline to an average of ZAR34million up until 2017.

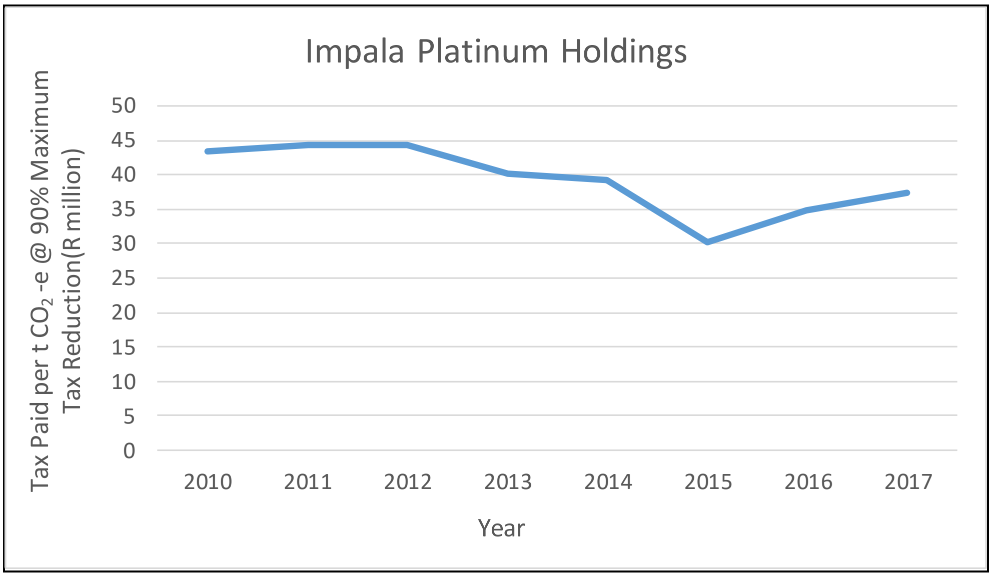

Figure 38: Tax Paid per t CO_2 -e at 90% Maximum Tax Reduction (ZARmillion) for Impala Platinum Holdings (Sources: Impala Platinum Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Impala Platinum Holdings could potentially have lost a substantial amount in the company's profitability over a number of years. Figure 39 shows that there could have been a maximum of 3.7% loss in profitability in 2013. The conditions could potentially have deteriorated over the years, with numerous losses experienced by the company in 2014 up until 2016. The company could have had the highest potential loss of 80.9% in 2016. This implies that the company would have had to get additional funds in order to be able to pay off the tax.

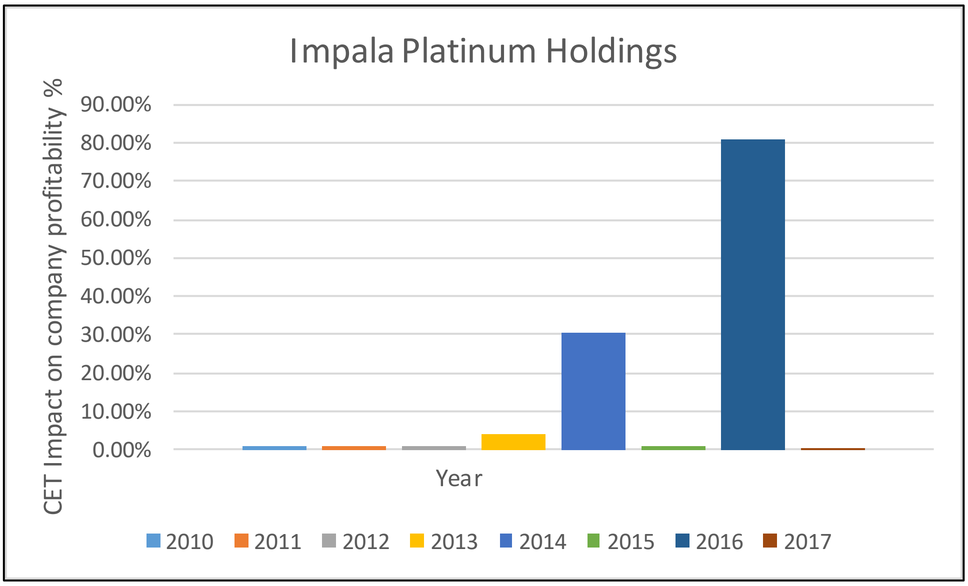

Figure 39: CET Impact on Company Profitability (%) for Impala Platinum Holdings (Sources: Impala Platinum Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Table 16 shows the impact of CET on the company with and without the 90% tax reduction. It shows a 37% loss in the company's profitability in 2013. This implies that all the potential profit the company could have earned would have to be paid out for CET. The highest potential loss could have been in 2016, at a value of 809%. This implies that additional funds would have to have been acquired to pay for the CET together with all the other losses the company would have incurred. This adds up to an average loss of 132.6% over the six-year period of the project investigation.

Table 16: Impala Platinum Holdings Comparison of CET Impact on Profitability With and Without Reduction.

Year	Company Name	CET Impact on company profitability at 90% Discount	CET Impact on company profitability at 0% Discount
2010	Impala Platinum Holdings	0.91%	9.07%
2011		0.65%	6.51%
2012		1.03%	10.29%
2013		3.74%	37.39%
2014		30.35%	303.49%
2015		0.73%	7.30%
2016		80.92%	809.16%
2017		0.46%	4.62%

Impala Platinum Limited's negative company performance in 2016 was due to Two Rivers**:** Two Rivers' mill grade continued to be impacted by mining low-grade split-reef areas and production was also impacted by community disruptions. Tonnes milled decreased by 3% to 1.7 million tonnes. Marula mine gave notice to the DMR and representative trade unions in terms of Section 189A of the Labour Relations Act of its intention to restructure the operation in a process that may impact on more than 1 000 job opportunities. The formal engagement process commenced on 28 March 2017 and jointly explored initiatives to minimise job losses as far as possible. This process was completed, impacting 980 employees and contractors. (Impala Platinum Holdings, 2017).

A major fall of ground occurred at 1 Shaft in May 2016 and tragically resulted in the loss of two lives. The fall was extensive and prompted a comprehensive investigation that was conducted by internal and external specialists (Impala Platinum Holdings, 2017). Having to implement the carbon tax could have potentially exacerbated the company's poor performance (Impala Platinum Holdings 2017)

Northam is an independent, fully empowered, integrated PGM producer. All operating mines and recycling operations are wholly owned. The company aims to produce 1 million oz. per annum. The company consists of Zondereinde, Booysendal, and Eland operations. It produced 4 601 876 tonnes of ore in 2018 (Northam Platinum Limited, 2019).

Northam Platinum Limited would have been liable to pay a maximum of ZAR10million for the CET in 2017 should the tax been implemented in 2010, as shown in Figure 40. The potential amount liable would have been as low as ZAR7million from 2010 until 2014. This could potentially have been followed by a sharp incline to the above-mentioned decline to an average of ZAR10million in 2017.

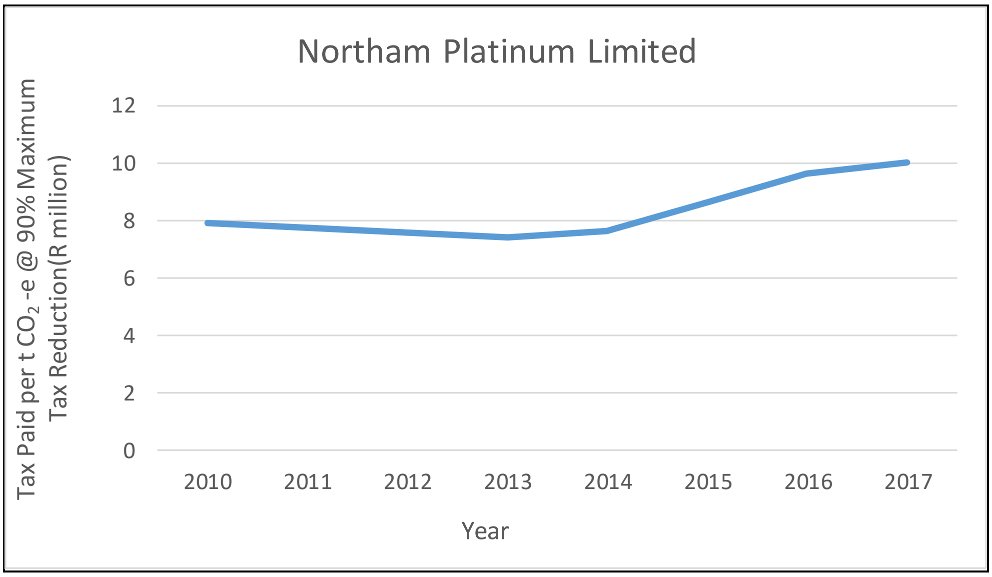

Figure 40: Tax Paid per t CO_2 -e at 90% Maximum Tax Reduction (ZARmillion) for Northam Platinum Limited (Sources: Northam Platinum Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Northam Platinum Limited potentially could have lost a substantial amount in the company's profitability over a number of years. Figure 41 shows that there could have been a maximum of 38.9% loss in profitability in 2014. This was a challenging year for the company as it only managed to make ZAR20million profit for the year, compared to an average of ZAR400million in other years. The conditions could potentially have deteriorated over the years, with numerous losses experienced by the company in 2015 up until 2017.

The company could have had the highest potential loss of 1.90% in 2016. This implies that the company would have had to get additional funds in order to be able to pay off the tax.

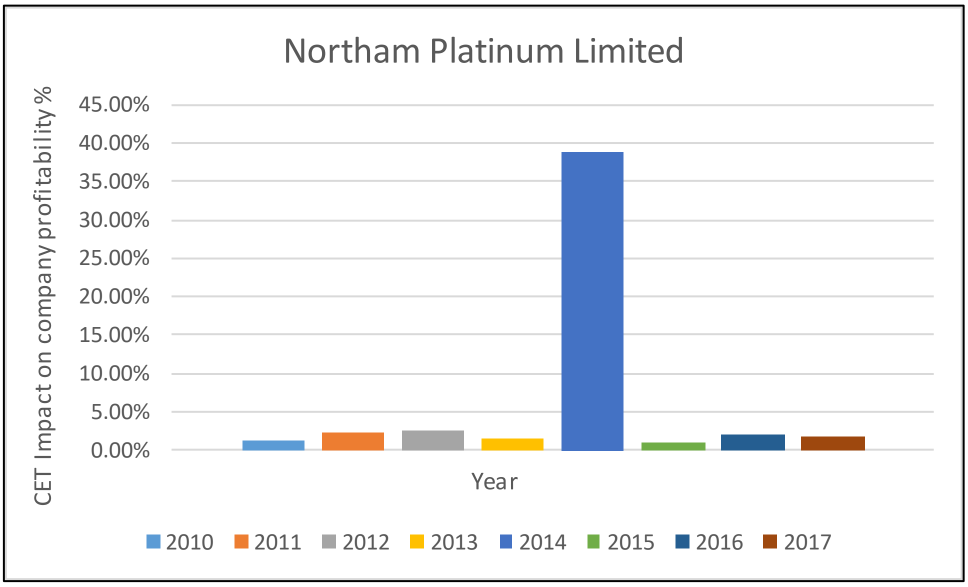

Figure 41: CET Impact on Company Profitability (%) for Impala Platinum Holdings (Sources: Northam Platinum Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Table 17 shows the impact of CET on the company with and without the 90% tax reduction. It shows a 389% loss in the company's profitability in 2014. This implies that all the potential profit the company could have earned would have to be paid out for CET. The highest potential loss could have been in 2016, at a value of 18.98%. This implies that additional funds would have to be acquired to pay for the CET together with all the other losses the company would have incurred. This adds up to an average loss of 52% over the six-year period of the project investigation.

Table 17: Northam Platinum Limited Comparison of CET Impact on Profitability With and Without Reduction

Year	Company Name	CET Impact on company profitability at 90% Discount	CET Impact on company profitability at 0% Discount
2010	Northam Platinum Limited	1.24%	12.37%
2011		2.23%	22.28%
2012		2.44%	24.36%
2013		1.40%	14.03%
2014		38.90%	388.96%
2015		0.84%	8.36%
2016		1.90%	18.98%
2017		1.58%	15.81%

The reasons behind the 2014 performance could have been due to a shaft incident that took place in Zondereinde. This compelled the shaft to be out of commission for six weeks and a one-week work stoppage in January. In terms of macroeconomics, there was a decline in the prices of PGM during financial 2015 and which has continued since the year's end of 2014. In addition, a five-month strike severely curtailed production during the early months of 2014. Recycling of metal from the used vehicle and industrial catalysts, and from jewellery, is now firmly entrenched as a key source of supply, this decreased the demand for PGMs (Northam Platinum Limited, 2015).

Kumba Iron Ore owns 74% of Sishen Iron Ore Company (SIOC). Sishen mine is a large iron ore mine located in central in Kathu in the Northern Cape. Sishen represents one of the largest iron ore reserves in South Africa and in the world, having estimated reserves of 2.43 billion tonnes of ore grading 58.6% iron metal. Kumba Iron Ore produced a 43-44Mt of ore in 2019 (Kumba Iron Ore Limited, 2019).

Kumba Iron Ore Limited would have been liable to pay a maximum of ZAR14million for the CET between 2015 and 2016, should the tax have been implemented in 2010, as shown in Figure 42. The potential liability would have been ZAR8million in 2010 and could have had a steady incline up until 2016 of

ZAR14million, as mentioned above. This could have been followed by a sharp decline in 2017 to ZAR11million.

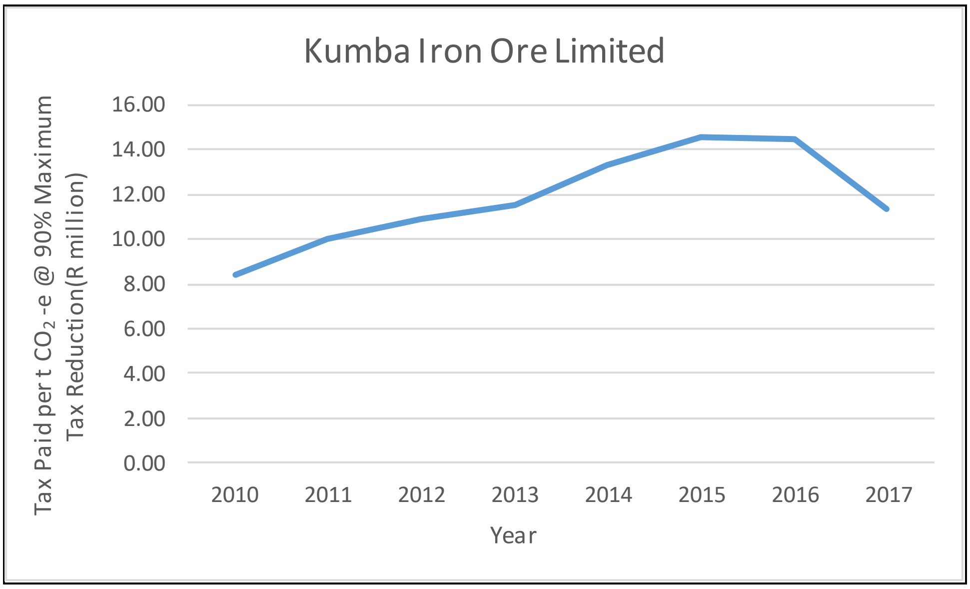

Figure 42: Tax Paid per t CO_2 -e at 90% Maximum Tax Reduction(ZARmillion) for Kumba Iron Ore Limited (Source: Kumba Iron Ore Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Kumba Iron Ore Limited potentially could have lost a substantial amount in the company's profitability over a number of years. Figure 43 shows that there could have been a maximum of 2.32% loss in profitability in 2015. This was a challenging year for the company as it only managed to make ZAR627million profit for the year, compared to an average of ZAR18 227million in other years.

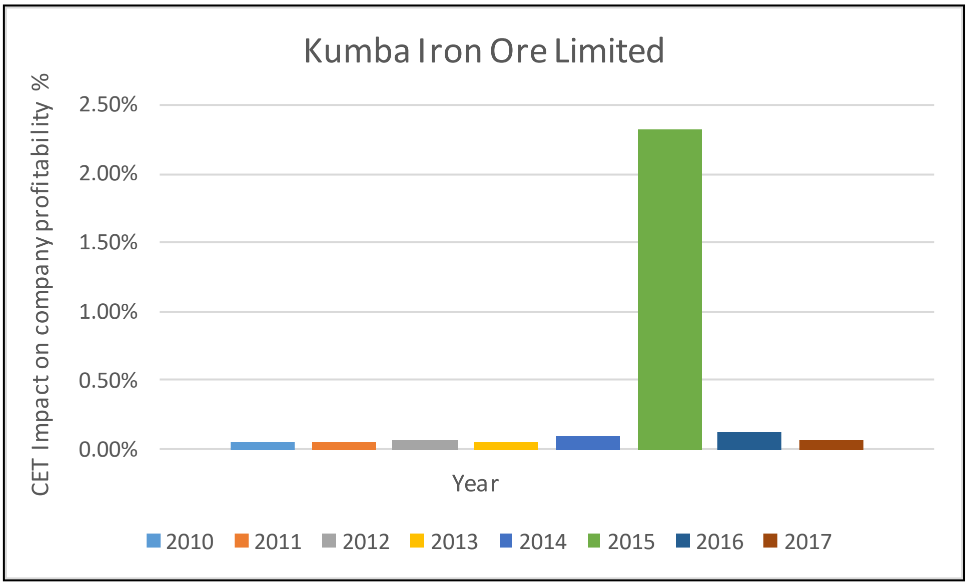

Figure 43: CET Impact on Company Profitability (%) for Kumba Iron Ore Limited (Source: Kumba Iron Ore Limited, 2010, 2011, 2012, 2013, 2014, 2015, 2016 & 2017).

Table 18 shows the impact of CET on the company with and without the 90% tax reduction. It shows the highest potential loss to the company's profitability is 23% in 2015. This implies that 23% of the potential profit the company could have earned would have to be paid out for CET. This implies that additional funds would have to have been acquired to pay for the CET together with all the other losses the company would have incurred. This adds up to an average loss of 3.54% over the six-year period of the project investigation.

Table 18: Kumba Iron Ore Limited Comparison of CET Impact on Profitability With and Without Reduction.

Year	Company Name	CET Impact on company profitability at 90% Discount	CET Impact on company profitability at 0% Discount
2010	Kumba Iron Ore Limited	0.05%	0.46%
2011		0.05%	0.45%
2012		0.07%	0.68%
2013		0.06%	0.57%
2014		0.09%	0.94%
2015		2.32%	23.24%
2016		0.13%	1.30%
2017		0.07%	0.70%

According to the Kumba Iron Ore 2016 annual report, the decline in performance was attributed by the weaker rand that partially offset losses from low ore prices. Thabazimbi mine was in the process of being transferred to ArcelorMittal SA. There were also Kumba Iron Ore employees who were involved in work-related fatal accidents. The iron ore prices fell about 35% in 2015 due to an oversupply of iron ore. There were also concerns with the lack of growth in top consumer China, forcing Kumba to cut jobs and restructure its main mine, Sishen. (Kumba Iron Ore, 2016).

5.3.3 Industry-Wide CET Impact

This section aims to investigate the overall impact of the carbon tax on different mining sectors. For this research report, the author has divided the sections into the gold, platinum, coal and iron ore as introduced in the project scope (section 1.5). The data has been arranged to represent the overall trends per industry as indicated by Tables19 - 24.

a) The gold industry

The companies of interest for this section are AngloGold Ashanti Limited, Gold Fields Limited and Harmony Gold Limited. Table 19 shows the carbon tax at a maximum 90% reduction, juxtaposed with the potential tax with no reduction. As discussed in Chapter 5.3.2, the overall impact may be as much as 10% more on the company's profitability, particularly when there is no tax reduction. Table 19 depicts the same.

The overall trends indicate that the gold industry could potentially be the most vulnerable to the impact of the carbon tax when compared to other commodity sectors. Table 19 also indicates that between 2014 and 2015, the gold industry was impacted the most. This was influenced by the fatalities that took place in the mines, labour unrest and the drop in the gold price from US$1900 per ounce in the second half of 2011 to US$1080 per ounce. In the case of Harmony Gold Limited, its Kusasalethu mine experienced a decline in profitability due to its temporary closure. The loss amounted to ZAR1.2billion; this amount was also attributed to the retrenchment costs that took place in 2013.

Gold operations have inherent additional costs of accessing the ore at depth and ensuring that the working conditions are hospitable, especially where refrigeration and ventilation is concerned. This brings about an increase in operational costs, which includes electricity costs as discussed in Chapter 5.1 by Baxter and Turner (2015). Baxter and Turner (2015) further discussed findings from a case study conducted by Sibanye Gold. This study indicated that the cumulative effect of the carbon tax could make at least five of their shafts unprofitable. This case study concurs with the findings represented in Table 19.

Table 19: CET Impact on the Gold Industry.

Sector per Year per Company	Tax Paid per Mt CO_2-e 90% at Maximum Tax Reduction (ZAR million)	Tax Paid per Mt CO_2 -e with 0% Tax Reduction (ZAR million)	Revenue (ZAR/million)	Profit after tax (ZAR million)	CET Impact on company profitability 90% discount	CET Impact on company profitability 0% discount
Gold Industry						
2010						
AngloGold Ashanti	56.06	560.64	38938	942	5.95%	59.53%
Gold Fields Limited	76.83	768.27	31565	4275	1.80%	17.97%
Harmony Gold	43.09	430.88	11284	-192	22.44%	224.41%
2011						
AngloGold Ashanti	56.36	563.64	49005	11601	0.49%	4.86%
Gold Fields Limited	78.51	785.05	41877	7806	1.01%	10.06%
Harmony Gold	66.31	663.12	12445	617	10.75%	107.48%
2012						
AngloGold Ashanti	40.74	407.4	52095	6962	0.59%	5.85%
Gold Fields Limited	65.50	655.02	45469	5931	1.10%	11.04%
Harmony Gold	39.38	393.84	15169	2645	1.49%	14.89%
2013						
AngloGold Ashanti	37.62	376.2	48978	-19602	0.19%	1.92%
Gold Fields Limited	61.59	615.91	27901	-2737	2.25%	22.50%
Harmony Gold	35.56	355.6	15902	-2369	1.50%	15.01%
2014						
AngloGold Ashanti	35.56	355.56	55154	-412	8.63%	86.25%
Gold Fields Limited	6.72		30323	216	3.12%	31.15%
Harmony Gold	32.15	67.17	15682	-1270	2.53%	25.32%
		321.54				
2015						
AngloGold Ashanti	35.78	357.77	53400	-931	3.84%	38.43%
Gold Fields Limited	5.98	59.82	33854	-3227	0%	0.02%
Harmony Gold	32.15	321.54	15435	-4536	0.71%	7.09%
2016						
AngloGold Ashanti	35.51	355.1	55760	1092	3.25%	32.52%
Gold Fields Limited	5.96	59.6	37531	2371	0%	0.03%
Harmony Gold	32.15	321.54	18334	949	3.39%	33.88%
2017						
AngloGold Ashanti	34.37	343.66	61289	-2406	1.43%	14.28%
Gold Fields Limited	6.42	64.16	38943	-338	1.90%	19.00%
Harmony Gold	31.22	312.22	19264	362	8.62%	86.25%

b) The platinum industry

The companies of interest for this section are Anglo American Platinum Limited, Impala Platinum Holdings and Northam Platinum Limited. Table 20, similarly to Table 19, shows the carbon tax at 90% maximum reduction, juxtaposed with the potential tax with no reduction. As discussed in Chapter 5.3.2, the overall impact may be as much as 10% more on the company's profitability, especially when there is no tax reduction.

The overall trends indicate that the carbon tax would have negatively affected the platinum industry in the same way as the gold industry. The effects would have affected only a percentage of the profit margin in 2010 and 2011. However, from 2012 until 2017, the companies would have had losses, suggesting that the additional amount would have to be raised to pay for the CET, over and above the loss that the individual company would have incurred. All three companies could have experienced the greatest loss in 2015, as shown in Table 20.

The possible reasons behind the experienced loss are due to the fact that there was a 5% reduced demand for platinum. This was attributed to the increase in recycling of PGM in the market. The mines were also mining lower grade ore. Further, certain mines were forced to close as a direct order from the government (Section 54) due to fatalities and there was also a five-month strike that severely curtailed production during the early months of 2014. The rest of the years were dependent on the individual company's annual financial performance.

Table 20: CET Impact on the Platinum Industry.

Sector per Year per Company	Tax Paid per Mt CO_2-e 90% at Maximum Tax Reduction (ZAR million)	Tax Paid per Mt CO_2 -e with 0% Tax Reduction (ZAR million)	Revenue (ZAR/million)	Profit after tax (ZAR million)	CET Impact on company profitability 90% discount	CET Impact on company profitability 0% discount
Platinum Industry						
2010						
Anglo American Platinum Limited	66.96	669.61	46.025	10116	0.66%	6.62%
Impala Platinum Holding	43.48	434.82	25446	4794	0.91%	9.07%
Northam Platinum Limited	7.93	79.32	3.945083	641	1.24%	12.37%
2011						
Anglo American Platinum Limited	67.34	673.41	51.117	3687	1.83%	18.26%
Impala Platinum Holding	44.32	443.16	33132	6810	0.65%	6.51%
Northam Platinum Limited	7.78	77.81	3.571048	349	2.23%	22.28%
2012						
Anglo American Platinum Limited	71.81	718.14	33538	-6720	1.07%	10.69%
Impala Platinum Holding	44.22	442.23	27593	4299	1.03%	10.29%
Northam Platinum Limited	7.56	75.64	3.684	311	2.44%	24.36%
2013						
Anglo American Platinum Limited	68.13	681.28	52.404	-1514	4.50%	45.00%
Impala Platinum Holding	40.2	401.99	30032	1075	3.74%	37.39%
Northam Platinum Limited	7.41	74.09	4.420977	528	1.40%	14.03%
2014						
Anglo American Platinum Limited	70.45	704.47	55.612	372	18.94%	189.37%
Impala Platinum Holding	39.15	391.5	29028	-129	30.35%	303.49%
Northam Platinum Limited	7.62	76.22	5.339397	20	38.90%	388.96%
2015						
Anglo American Platinum Limited	63.53	635.33	59.815	-12205	0.52%	5.21%
Impala Platinum Holding	30.21	302.07	32477	-4139	0.73%	7.30%
Northam Platinum Limited	8.64	86.4	6.035535	-1034	0.84%	8.36%
2016						
Anglo American Platinum Limited	69.6	695.97	61.96	696	10.00%	100.00%
Impala Platinum Holding	34.79	347.94	35932	-43	80.92%	809.16%
Northam Platinum Limited	9.65	96.47	6.09707	-508	1.90%	18.98%
2017						
Anglo American Platinum Limited	98.99	989.91	65.67	1924	5.15%	51.45%
Impala Platinum Holding	37.4	373.99	36841	-8098	0.46%	4.62%
Northam Platinum Limited	10.06	100.55	6.865185	-636	1.58%	15.81%

c) The Coal industry

The companies of interest for this section are Exxaro Resources Limited and Sasol Limited. Table 21, similarly to Tables 19 and 20, show the potential CET at 95% maximum reduction, juxtaposed with the potential tax with no reduction. The overall impact may be as much as 15% more on the company's profitability when the 95% reduction or allowance is not factored in.

Exxaro Resources Limited potentially could have experienced an adverse impact on its profitability, more especially in 2014. This possibly was attributed to Exxaro experiencing a significant decline in profit in 2014 due to labour unrest that took place between union rivalries that year. This was further exacerbated by the decline in commodity prices globally and the drop in coal demand. The company further reported that a sharp increase in load shedding resulting in unplanned maintenance of most of their equipment running on electricity.

In 2010 and 2016, Sasol Limited could have lost over 50% of its profit to pay for the CET. The company may have been able to cushion the blow or stay afloat for those years, however, this

Table 21: CET Impact on the Coal Industry.

Sector per Year per Company	Tax Paid per Mt CO_2-e 95% at Maximum Tax Reduction (ZAR million)	Tax Paid per Mt CO_2 -e with 0% Tax Reduction (ZAR million)	Revenue (ZAR/million)	Profit after tax (ZAR million)	CET Impact on company profitability 95% discount	CET Impact on company profitability 0% discount
Coal Industry						
2010						
Exxaro Resources Limited	16.68	333.7	17155	5235	0.32%	6.37%
Sasol Limited	427.93	8558.52	122256	16387	2.61%	52.23%
2011						
Exxaro Resources Limited	15.66	313.26	10647	4668	0.34%	6.71%
Sasol Limited	449.89	8997.72	142436	20220	2.22%	44.50%
2012						
Exxaro Resources Limited	14.87	297.33	12229	9647	0.15%	3.08%
Sasol Limited	424.22	8484.48	169446	24257	1.75%	34.98%
2013						
Exxaro Resources Limited	8.67	173.31	13568	6204	0.14%	2.79%
Sasol Limited	404.3	8086.08	181269	27182	1.49%	29.75%
2014						
Exxaro Resources Limited	4.61	92.12	16401	-884	0.52%	10.42%
Sasol Limited	393.93	7878.55	202638	30417	1.30%	25.90%
2015						
Exxaro Resources Limited	4.72	94.49	18330	267	1.77%	35.39%
Sasol Limited	396.59	7931.88	185266	31162	1.27%	25.45%
2016						
Exxaro Resources Limited	4.54	90.85	20897	5173	0.09%	1.76%
Sasol Limited	403.97	8079.30	172942	15027	2.69%	53.77%
2017						
Exxaro Resources Limited	4.64	92.72	22813	6295	0.07%	1.47%
Sasol Limited	400.95	8018.91	172407	21513	1.86%	37.27%

d) The Iron Ore industry

The company of interest for this section is Kumba Iron Ore Limited. Table 22, similarly to Tables 19, 20 and 21 shows the carbon tax at 90% maximum reduction, juxtaposed with the potential tax with no reduction. The overall impact may be as much as 10% more on the company's profitability when the 90% reduction or allowance is not factored in. Kumba Iron Ore Limited did not experience any loss with respect to profit after tax. Table 22 indicates that there would be an additional amount that the company has to pay valued to a maximum of ZAR125million in 2015.

The decline in performance was attributed by the weaker rand, which partially offset losses from low ore prices. Thabazimbi was being transferred to ArcelorMittal SA. There were also Kumba Iron Ore employees who were involved in work-related fatal accidents. The iron ore prices fell about 35% in 2015 due to a supply glut and growth concerns in top consumer China, forcing Kumba to cut jobs and restructure its main mine, Sishen.

Table 22: CET Impact on the Iron Ore Industry.

Sector per Year per Company	Tax Paid per Mt CO_2 -e 90% at Maximum Tax Reduction (ZAR million)	Tax Paid per Mt CO_2 -e with 0% Tax Reduction (ZAR million)	Revenue (ZAR/million)	Profit after tax (ZAR million)	CET Impact on company profitability 90% discount	CET Impact on company profitability 0% discount
Iron Ore Industry						
Kumba Iron Ore						
2010	8.41	84.12	38 704	18289	0.05%	0.46%
2011	10.05	100.5	48553	22298	0.0005	0.0045
2012	10.89	108.86	52505	16100	0.0007	0.0068
2013	11.58	115.75	50279	20300	0.06%	0.57%
2014	13.32	133.18	46381	14148	0.0009	0.0094
2015	14.57	145.73	45087	627	0.0232	0.2324
2016	14.44	144.44	46765	11144	0.13%	1.30%
2017	11.35	113.52	82042	16133	0.0007	0.007

5.4 Conclusion

For the past hundred years, the growth in the South African economy has been based on the wealth of the mining industry. The industry contributed over R460billion to the South African economy in 2017. This validates the importance of the industry and justifies the reason for focusing on the impact of the carbon tax. The quantitative research approach was employed, as numerical data were collected for nine mining companies. The companies analysed were Exxaro Resources Limited, Sasol Limited, AngloGold Ashanti Limited, Gold Fields Limited, Harmony Limited, Anglo American Platinum, Impala Platinum Holdings, Northam Platinum and Kumba Iron Ore. The data was collected from 2010 to 2017 from CDP and publicly disclosed annual reports of the above-mentioned companies.

The announcement made by the South African National Treasury on the Carbon Tax Policy paper in 2010 motivated numerous mining companies to work in an environmentally conscious manner. This was reflected by an overall decline in the number of emissions from the companies of interest This is in line with addressing the first objective of this research, which is to determine the impact of the carbon tax on emission reduction during the study period. It can be concluded that there is a drop in emissions as a result of the announcement of the imposition of the carbon tax. In cases with an exception, like with platinum mines, the volatile fluctuations were in response to macroeconomic factors.

A number of companies have come up with energy-saving initiatives to reduce the number of emissions produced per year. Such as Harmony Gold Limited currently building expertise in renewable energy and participating in a group that is to develop an 18MW solar park at Kalgold in terms of the government's renewable energy power programme. At Impala Springs, a ZAR250million project was initiated to address airborne emissions. Kumba Iron Ore has also supported the South African energy market with an independent power project, namely the 100MW Kathu concentrated solar thermal plant with energy storage capability.

The overall trends indicate that the gold industry could potentially be the most vulnerable to the impact of the carbon tax when compared to other commodity sectors. Table 19 also indicates that between 2014 and 2015, the gold industry would have been impacted the most. This was influenced by the fatalities that took place in the mines, labour unrest, and the drop in the gold price from US$1900 per ounce in the second half of 2011 to US$1080 per ounce. In the case of Harmony Gold Limited, its Kusasalethu mine experienced a decline in profitability due to ZAR548million losses from the temporary closure of the mine. There were also losses from retrenchment costs that amounted to ZAR1.2billion in 2013.

The platinum industry's financial performances were similar to the gold industry. The effects would have only affected a percentage of the profit margin in 2010 and 2011. However, from 2012 to 2017, the companies would have had losses, suggesting that an additional amount would have to be raised to pay for the CET over and above the loss that the individual company would have incurred. All three companies could have experienced the greatest loss in 2015. The reasons behind the experienced loss, are due to the fact that there was a 5% reduced demand for platinum. This was attributed to the increase in recycling of PGM in the market. The mines were also mining lower grade ore. There were mines forced to close as a direct order from the government (Section 54) due to fatalities and there was a five-month strike that severely curtailed production during the early months of 2014. The rest of the years were dependent on the individual company's annual financial performance.

Exxaro Resources Limited potentially could have experienced an adverse impact on its profitability, more especially in 2014. This was attributed to Exxaro showing a significant decline in profit in 2014 due to labour unrest that took place between union rivalries in 2014. This was further exacerbated by the decline in commodity prices globally and the drop in coal demand. The iron ore industry's negative impacts were compounded by the decline in performance attributed to the weaker rand, which partially offset losses from low ore prices.

Thabazimbi was being transferred to ArcelorMittal SA and there were also Kumba Iron Ore employees involved in work-related fatal accidents. There was restructuring that took place in Sishen mine.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Research Findings

Chapter 2 indicated evidence of global warming and the meteorological, physical and financial impacts it could potentially have on different countries. Chapter 2.3 further explored various means by which CO_2 emissions may be reduced which led to the discussion of different carbon pricing techniques used internationally. The discussion emphasised the selection of the carbon tax in South Africa. The report further discussed the South African mining industry and the extent to which the industry contributes to GHG emissions. Due to the mining industry's importance to the South African economy, the problem statement and related research questions discussed in Chapter 1.2 to 1.4 were set to investigate the possible impact of the implementation of a CET on the South African mining industry. The objective of this chapter is, therefore, to provide a summary of the key findings of the research reported in this document and how these findings address the research objectives that, in turn, address the research questions.

The first research question aimed to determine the impact of the carbon tax on the selected companies' profitability and emission reduction. In Chapter 5, the financial data analysis displayed an overall loss in profitability for all the companies that were analysed. Should the tax be implemented, there would be an additional cost burden that would be carried by the mining companies.

The overall trends indicate that the gold industry potentially could be the most vulnerable to the impact of the carbon tax when compared to other commodity sectors. This impact would have been more substantial between 2014 and 2015. There are various factors that compounded this effect, including fatalities in each mine, labour unrest and the drop in the gold price from US$1900 per ounce in the second half of 2011 to US$1080 per ounce. Some gold companies such as Harmony Gold Limited's Kusasalethu mine experienced a decline in profitability due to the temporary closure of the mine. There were also retrenchments that took place amounting to ZAR1.2billion in costs, in 2013. These operational challenges were also experienced by the platinum, coal, and iron ore industry.

The platinum industry was further influenced by macroeconomic factors in addition to operational challenges that are similar to those discussed in the gold industry above. These were a 5% reduction in the demand for platinum.This indicates that the profitability of each mining company could be negatively affected by the carbon tax imposition.

The second aspect of the research question was to determine the level of emission reduction as a result of the carbon tax imposition. The data analysis in Chapter 5 indicated that there would be a potential decline in the overall emissions during the project period and for the companies of interest. This could have been influenced by the number of energy-saving initiatives established by the mining companies. Examples of such initiatives have been discussed in detail in the conclusion of Chapter 5 but one example could be the ZAR250million project initiated by Impala Springs to address airborne emissions.

This is an indication that the announcement of the Carbon Tax Act 15 of 2019 and the implementation thereof has sparked a behavioural change in the energy intensity and emissions being generated by the mining companies that formed part of this analysis. The second research question was to determine whether there are other emission reduction technologies that promote substantial emission reduction without increasing the cost burden of mining operations.

Chapter 2.3 explored differed emission reduction technologies that are not a form of carbon pricing that could potentially be implemented. These include, but are not limited to, clean coal technology and Renewable Energy. Clean Coal Technology is a technological advancement of reducing CO_2, SO_2 and NO_2 emissions from large, single and stationary sources. These facilities include, but are not limited to, fossil fuel power plants, biomass energy facilities, synthetic fuel plants and major CO_2 emitting industries (cement, petrochemical and iron and steel) Coal Industry Advisory Board (CIAB); International Energy Agency (IEA), 2008). Chang et al. (2016) further define clean coal technology as a technology that enables environmentally friendly or clean use of coal, in a manner that is economically viable. The greatest challenge faced by such technologies is the up-front capital costs.

Examples of near-zero emission technologies include, but are not limited to, the following:

a) *Carbon Capture and Sequestration* or *Carbon Capture and Storage;*

b) *Pre-combustion systems processes;*

c) *Oxy-fuel combustion systems, these systems use "Fluidised Bed Combustion";*

d) *Integrated Gasified Combined Cycle (IGSS);*

e) *Low Nitrogen Oxide (NOx) Burners* reduce the creation of Nox; and

f) *Supercritical and Ultra-Supercritical* coal-fired plants.

Coal can also be upgraded by coal washing and drying and briquetting. This has been used worldwide as it is more cost-effective compared to the technologies discussed above (Coal Industry Advisory Board (CIAB) International Energy Agency (IEA), 2008). Various initiatives have been embarked upon by the research companies in an effort to reduce their carbon emissions. These include the joint-venture project focused on generating power for the company and country through a mix of renewable and cleaner energy sources, initiated by Exxaro Resources Limited. Sasol Limited is investing more than ZAR20billion in projects that bring about environmental improvements in relation to air quality and GHG emissions. At the South Deep mine, a new ventilation design was implemented at the underground mine, with five sets of three fans saving 20kW per fan. These are energy-efficient jet fans for de-stress mining and result in a Scope 2 electricity-based emission savings.

The technologies discussed above to ensure that no harmful gases are released into the atmosphere. Clean coal technology could potentially enable the country to continue utilising the readily available coal reserves as a means of electricity generation. While renewable energy, as discussed above and in Chapter 2.3.2, eliminates the use of coal to produce electricity. The capital cost of commissioning and storing the electricity generated is still problematic and may bring about additional costs to the economy in ensuring that there is an uninterrupted supply of electricity.

The above initiatives may have high capital costs, especially during the early stages of project implementation. These, however, have long-term benefits with respect to reducing the number of emissions and financial savings and incentives that can be derived from such projects. This was discussed in Chapter 4.3, for example, the energy savings allowance, which is a notional allowance for taxpayers that carry on a trade and that implement energy-efficient (EE) projects that successfully achieve energy savings. The allowance is calculated as 45 cents per kilowatt-hour (kWh), or equivalent, of energy savings achieved during the year. The company that has implemented such an initiative could receive tax rebates.

6.2 Conclusions of the Research Report

The research question set in Chapter 1.3 was to determine the potential effects of introducing the CET on the profitability of mining companies and the impacts the tax could potentially have on carbon emission reduction levels. The Carbon Tax Act 15 of 2019 would have promoted a number of mining companies to reduce their emission intensities through various initiatives set up, per operation. This was indicated by the decline in the emissions per company over the research period. This addresses the first research project objective. The tax potentially would have a negative impact on the mining companies' profitability. This addresses the second project objective. The carbon tax will bring about a cumulative reduction in emissions should the mining companies continue investing in green mining.

6.3 Recommendations for Future Research

The author suggests that more research be done to increase the preparedness of South African mining companies to the carbon tax. The areas of investigation should be:

- Investigating revenue recycling mechanisms that will assist in all the revenue that potentially will be raised from the tax to benefit South African citizens. This could be by the re-investment of raised funds into renewable energy. This will assist in lessening the burden on Eskom and the South African citizens;
- More research should be employed in clean coal technology. There should be a benchmarking exercise of how some other countries have implemented it and the cost-benefit to having low emission from coal power generation, versus having a revenue-raising tax that may not reduce the CO_2 emissions at all;
- The impact of variable cost on the mining companies should be done. This analysis could be done on a long and short-term basis. This will have to incorporate actual tax incurred by the respective company and the actual tax implications will be determined from there; and
- An additional investigation on the impact that the tax will have on employees' salaries would be very beneficial. This could be a predictive analysis that determines the impact of the carbon tax on the likelihood of mining employees being retrenched.

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APPENDICES

Appendix A: Company CO_2 Emissions in relation to Profitability

Year	Company Name	Scope 1 Emissions (t CO2 -e)	Scope 2 Emissions (t CO2 -e)	Combined Carbon dioxide emissions tons (Mt CO2-e)	Total maximum tax reduction %	Tax Paid per Mt CO2 -e Maximum Tax Reduction (R million)	Tax Paid per Mt CO2 -e with 0% Tax Reduction (R million)	Revenue (R/million)	Profit after tax (R million)	CET Impact on company profitability %	CET Impact on company profitability with no discount %
2010	Exxaro Resources Limited	542,000	2,238,794	2.78	95%	16.68	333.7	17155	5,235	0.32%	6.37%
2011		502,594	2,107,933	2.61	95%	15.66	313.26	10647	4,668	0.34%	6.71%
2012		436,681	2,041,095	2.48	95%	14.87	297.33	12229	9,647	0.15%	3.08%
2013		343,405	1,100,822	1.44	95%	8.67	173.31	13568	6,204	0.14%	2.79%
2014		235,506	532,153	0.77	95%	4.61	92.12	16401	-884	0.52%	10.42%
2015		229,762	557,624	0.79	95%	4.72	94.49	18330	267	1.77%	35.39%
2016		235,179	521,905	0.76	95%	4.54	90.85	20897	5,173	0.09%	1.76%
2017		271,657	500,990	0.77	95%	4.64	92.72	22813	6,295	0.07%	1.47%
Average		349,598	1,200,165	1.55	95%	9.3	185.97	16505	4,576	0.43%	8.50%
2010	Sasol Limited	61,768,000	9,553,000	71.32	95%	427.93	8558.52	122256	16,387	2.61%	52.23%
2011		64,166,000	10,815,000	74.98	95%	449.89	8997.72	142436	20,220	2.22%	44.50%
2012		61,396,000	9,308,000	70.7	95%	424.22	8484.48	169446	24,257	1.75%	34.98%
2013		59,880,000	7,504,000	67.38	95%	404.3	8086.08	181269	27,182	1.49%	29.75%
2014		57,577,000	8,077,610	65.65	95%	393.93	7878.55	202638	30,417	1.30%	25.90%
2015		57,840,964	8,258,004	66.1	95%	396.59	7931.88	185266	31,162	1.27%	25.45%
2016		59758453	7569059	67.33	95%	403.97	8079.3	172942	15,027	2.69%	53.77%
2017		59229420	7594850	66.82	95%	400.95	8018.91	172407	21,513	1.86%	37.27%
Average		60,201,980	8,584,940	68.79	95%	413	8,254	168,583	23,271	2%	38%
2010	AngloGold Ashanti Limited	1,183,000	3,489,000	4.67	90%	56.06	560.64	38938.2	942	5.95%	59.53%
2011		1215000	3482000	4.7	90%	56.36	563.64	49005	11601	0.49%	4.86%
2012		73000	3322000	3.4	90%	40.74	407.4	52094.6	6962	0.59%	5.85%
2013		96000	3039000	3.14	90%	37.62	376.2	48978.27	-19602	0.19%	1.92%
2014		47000	2916000	2.96	90%	35.56	355.56	55154.26	-412	8.63%	86.25%
2015		158,400	2,823,000	2.98	90%	35.78	357.77	53399.5	-931	3.84%	38.43%
2016		99481	2859692	2.96	90%	35.51	355.1	55760.25	1092	3.25%	32.52%
2017		101264	2762608	2.86	90%	34.37	343.66	61288.92	-2406	1.43%	14.28%
Average		371,643	3,086,663	3.46	90%	41.5	415	51827	-344.25	3.05%	30.46%

2010	Gold Fields Limited	1,308,764	5,093,511	6.4	90%	76.83	768.27	31565.3	4275	1.80%	17.97%
2011		1377194	5164897	6.54	90%	78.51	785.05	41876.8	7806	1.01%	10.06%
2012		622591	4835940	5.46	90%	65.5	655.02	45469.3	5931	1.10%	11.04%
2013		792618	4340001	5.13	90%	61.59	615.91	27900.6	-2737	2.25%	22.50%
2014		11708	548043	0.56	90%	6.72	67.17	30323.216	216	3.12%	31.15%
2015		6987	491472	0.5	90%	5.98	59.82	33854.086	-3227	0%	0.02
2016		7102	489525	0.5	90%	5.96	59.6	37530.675	2371	0%	0.03
2017		8714	525987	0.53	90%	6.42	64.16	38942.946	-338	1.90%	19.00%
Average		516,960	2,686,172	3.2	90%	38.44	384.38	35933	1787.125	1.40%	14.59%
2010	Harmony Gold Limited	146,036	3,444,600	3.59	90%	43.09	430.88	11284	-192	22.44%	224.41%
2011		2103211	3422823	5.53	90%	66.31	663.12	12445	617	10.75%	107.48%
2012		32851	3249167	3.28	90%	39.38	393.84	15169	2,645	1.49%	14.89%
2013		33652	2929656	2.96	90%	35.56	355.6	15902	-2,369	0.02%	0.15%
2014		31391	2648126	2.68	90%	32.15	321.54	15682	-1,270	0.03%	0.25%
2015		*31391*	*2648126*	2.68	90%	32.15	321.54	15435	-4,536	0.01%	0.07%
2016		*31391*	*2648126*	2.68	90%	32.15	321.54	18334	949	3.39%	33.88%
2017		21261	2580600	2.6	90%	31.22	312.22	19264	362	8.62%	86.25%
Average		303,898	2,946,403	3.25	90%	39	390.04	15439	-474.25	5.84%	58.42%
2010	Anglo American Platinum Limited	427,290	5,152,793	5.58	90%	66.96	669.61	46.025	10116	0.66%	6.62%
2011		457,336	5,154,402	5.61	90%	67.34	673.41	51.117	3687	1.83%	18.26%
2012		534431	5450076	5.98	90%	71.81	718.14	33538	-6720	1.07%	10.69%
2013		524028	5153339	5.68	90%	68.13	681.28	52.404	-1514	4.50%	45.00%
2014		551056	5319564	5.87	90%	70.45	704.47	55.612	372	18.94%	189.37%
2015		539333	4755068	5.29	90%	63.53	635.33	59.815	-12205	0.52%	5.21%
2016		548480	5251249	5.8	90%	69.6	695.97	61.96	696	10.00%	100.00%
2017		1764855	6484373	8.25	90%	98.99	989.91	65.67	1924	5.15%	51.45%
Average		668,351	5,340,108	6.01	90%	72.1	721.02	4241	-455.5	5.33%	53.33%

2010	Impala Platinum Holdings	693,145	2,930,324	3.62	90%	43.48	434.82	25446	4,794	0.91%	9.07%
2011		584504	3108473	3.69	90%	44.32	443.16	33132	6,810	0.65%	6.51%
2012		477062	3208182	3.69	90%	44.22	442.23	27593	4,299	1.03%	10.29%
2013		462004	2887903	3.35	90%	40.2	401.99	30032	1,075	3.74%	37.39%
2014		442926	2819594	3.26	90%	39.15	391.5	29028	-129	30.35%	303.49%
2015		340788	2176459	2.52	90%	30.21	302.07	32477	-4,139	0.73%	7.30%
2016		293647	2605841	2.9	90%	34.79	347.94	35932	-43	80.92%	809.16%
2017		321566	2795000	3.12	90%	37.4	373.99	36841	-8,098	0.46%	4.62%
Average		451,955	2,816,472	3.27	90%	39.22	392.21	31310	571.13	14.85%	148.48%
2010	Northam Platinum Limited	15,293	645,745	0.66	90%	7.93	79.32	3.945	641	1.24%	12.37%
2011		14258	634165	0.65	90%	7.78	77.81	3.571	349	2.23%	22.28%
2012		15234	615078	0.63	90%	7.56	75.64	3.684	311	2.44%	24.36%
2013		15134	602314	0.62	90%	7.41	74.09	4.421	528	1.40%	14.03%
2014		15509	619694	0.64	90%	7.62	76.22	5.339	20	38.90%	388.96%
2015		28363	691628	0.72	90%	8.64	86.4	6.036	-1,034	0.84%	8.36%
2016		36080	767835	0.8	90%	9.65	96.47	6.097	-508	1.90%	18.98%
2017		34986	802962	0.84	90%	10.06	100.55	6.865	-636	1.58%	15.81%
Average		21,857	672,428	0.69	90%	8.33	83.31	4.99	-41.13	6.32%	63.14%
2010	Kumba Iron Ore Limited	246909	454104	0.701013	90%	8.41	84.12	38 704	18289	0.05%	0.46%
2011		329906	507567	0.837473	90%	10.05	100.5	48553	22298	0.05%	0.45%
2012		387813	519329	0.907142	90%	10.89	108.86	52505	16100	0.07%	0.68%
2013		448274	516315	0.964589	90%	11.58	115.75	50279	20300	0.06%	0.57%
2014		582725	527112	1.109837	90%	13.32	133.18	46381	14148	0.09%	0.94%
2015		669441	544942	1.214383	90%	14.57	145.73	45087	627	2.32%	23.24%
2016		693961	509736	1.203697	90%	14.44	144.44	46764.9	11144	0.13%	1.30%
2017		511924	434042	0.945966	90%	11.35	113.52	82042	16133	0.07%	0.70%
Average		483,869	501,643	0.99	90%	11.83	118.26	53087	14879.875	0.36%	3.54%