Assessing the Impact of Environmental Cost on the Capital Investment Decision-Making of the Electricity Supply Commission, South Africa

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By

Toyese Titus Oyewo (21951330)

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Supervisor: Dr. Odunayo Margaret Olarewaju

Co-supervisor: Mrs. Melanie Cloete

DECLARATION

I, Toyese Titus Oyewo, declare that this dissertation is my own work. This work has not been previously submitted for another degree. All sources used have been acknowledge and referenced.

_________ _____________________ _____14/09/2020____

Student Name: Toyese Titus Oyewo Date

APPROVED FOR FINAL SUBMISSION

__________________________ _____ 16/09/2020___

Supervisor: Dr. Odunayo Magret Olarewaju Date

______16/09/2020_____

Co-supervisor: Mrs. Melanie Bernice Cloete Date

DEDICATION

This research is dedicated to the most precious mothers in my life, Mrs Victoria Odunola Oyewo and Late Mrs Emily Ayodabo Atiba, who gave me the drive and discipline to handle any task with enthusiasm and unrelenting determination and most of all, the respect they both have for education.

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ABSTRACT

The availability of energy (electricity) is a key factor in economic growth and the sustainability of production processes. The need to quantitatively measure the environmental risk and hazard associated with energy sources for the environment is useful in evaluating capital investment for decision-making. Coal (fossil fuel) is the main source of energy in South Africa, based on its availability and cost-effectiveness. Specifically, quantitative research using mathematical marginal social cost modelling to evaluate the environmental cost of emissions emanating from the Electricity Supply Commission’s (ESKOM) coal power stations is employed. It was discovered that the price of electricity has trebled over the lifespan of coal power plants. Therefore, the need to construct coal power plants with optimum levels of production was highlighted. The net present value (NPV) technique was used to evaluate ESKOM's capital investment and the marginal social cost mathematical model was developed for measuring and quantifying the emission costs associated with the lifespan of the coal power plants. Results revealed that the optimum level production of 2,150,000 Gigawatts per annum within the range of the present capacity of ESKOM of 2,292,000 gigawatts annually is required and profitable to ESKOM. The net present value yielded a positive value of R1, 448,713,000,000-00 over a period of 30 years of coal power plants’ life-span. However, various technologies used to minimize emissions were also considered and investigated to confirm the feasibility and profitability of investment in coal-powered stations using environmental management accounting and marginal social cost approaches.

LIST OF ABBREVIATIONS

ABC – Activity Based Costing

CF – Cash Flow

CO_2 – Carbon dioxide

EA – Environmental Accounting

ECA – Environmetal Cost Accounting

EMA – Environmental Management Accounting

ESKOM- Electricity Supply Commission

GWh – Gigawatt Hour

IRR – Internal Rate of Returm

Kt – Kilo Tonne

LCA – Life Cycle Assessment

M and M- Modigliani-Miller

MEMA – Monetary Environmental Accounting

MFCA – Material Flow Cost Accounting

MPC – Marginal Private Cost

MSB – Marginal Social Benefit

MSC – Marginal Social Cost

Mt – Metric Tonne

MWh – Megawatt Hour

NO_2 – Nitrogen oxide

NPV - Net Present Value

PB – Pay Back Period

PEMA – Physical Environmental Accounting

PI – Profitability Index

RI – Return on Investment

SO_2 – Sulphur dioxide

TC – Total Cost

TSB – Total Social Benefit

TSC – Total Social Cost

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CHAPTER ONE

INTRODUCTION

1.0 Chapter Overview

This chapter begins with the background to the research study, providing a basis for the study. It also covers a statement of the research problem, research questions, aim, objective, scope of the study and justification of the study.

1.1 Background to the study

Energy production is a critical infrastructure that contributes greatly to economic growth in any part of the world. The availability of sustainable and affordable energy determines the rate of economic growth that will be achieved by any nation around the globe. South Africa's economy has been facing growth challenges in recent times and there are many factors that contribute to this problem, amongst which is the energy challenge (Kohler 2013). Energy availability is one of the critical factors of any economy because of its impact on production and the real economy (Hall and Klitgaard 2011). Energy demand and consumption for both business activity and household needs have increased, largely due to urbanization and the growth of the South African economy. The sole producer of electricity in South Africa is the South African Electricity Supply Commission-ESKOM (The ESKOM Factor 2011). This organisation have been facing enormous challenges in meeting demands for electricity, which is critically required for the economic growth of the country. In the process of generating electricity, ESKOM is a significant user of South Africa's natural resources, in particular fresh water and coal. Moreover, given its current power generation mix, ESKOM has a considerable Carbon Dioxide (CO_2) footprint and is a large emitter of sulphur dioxide (SO_2) and nitrogen (NO_2) and particulates. During the 2011 financial year, the company used 327bn litres of fresh water and emitted some 230 Mt of CO_2, 1 810 kt of SO_2 and 977 kt of NO_2 (The ESKOM Factor 2011)[1].

Recently, South African has faced prospects of load-shedding which has greatly affected the operations of both small businesses and large corporations. Furthermore, this problem will continue until the two power stations -Medupi and Kusile- come online fully and produce to the full capacity of their original design of an estimated 9800 megawatts of electricity. One of the problems identified as facing ESKOM is in the area of the generation of electricity. ESKOM uses coal to generate large amounts of total electricity supply to meet the demand in the country (Joffe 2012). This can be as a result of the notion that coal is a mineral resource found in abundance in South Africa, and is also regarded as a less expensive input material for electricity generation. This assumption is not entirely correct as there are serious adverse effects of using coal to produce electricity. Apart from the sophisticated and heavy plant and machinery that is required, the environmental effects and damages caused by this activity are severe. South Africa is positioned amongst the world's first 14th biggest carbon dioxide producers, to a great extent because of its substantial reliance on coal which supplies 92 percent of the nation's electricity power[1] (Eberhard *et al.* 2016). Coal produces emissions that contaminate the atmosphere, causing a harmful effect on human health. The United Nations and the South African government have been designing ways of reducing carbon emissions. To decrease the nation's general CO_2 emissions and meet the nation's environmental change moderation objectives, National Treasury (2013) proposed the introduction of taxes on carbon emissions. The household electricity segment, creating the majority of its yield from coal-powered plants, is contributing huge CO_2 discharges will be at the receiving end of the proposed

[1] : https://www.carbonbrief.org/the-carbon-brief-profile-south-africa

carbon tax. The carbon discharges of various innovations can be differentiated using CO_2 emissions per kilowatt-hour of electricity produced. This mirrors the aggregate of CO_2 produced during the useful life of the generating plants.

This study seeks to explore the importance and methodologies for creating an environmental cost estimation system and database suitable for ESKOM to enhancethe completeness and accuracy of making capital investment decisions on the aspect of electricity generation.

1.2 Electricity Supply Commission (ESKOM)

Established in 1923, the Electricity Supply Commission (ESKOM) is the state entity that is responsible for the generation and distribution of electricity in South Africa. Eskom was formed by the Electricity Act of 1922. ESKOM controls the availability and distribution of electricity to both household and industrial consumers. The entity is the largest power utility company in Africa, with a nominal generation capacity of more than 47 000 megawatts of electricity. According to the entity's 2019 integrated annual report, ESKOM's total asset value is more that R750 billion ($52 billion). The public utility company is not only the largest in Africa, but was ranked as the 7th largest power producer in the world and 9th in terms of sales revenue of R178 billion or $12.8 billion (The ESKOM Factor, 2011)[1]. ESKOM enjoys a monopolistic market in which it is the only company in South Africa in charge of generation, transmission and distribution of electricity in South Africa.By the virtue of this, the entity is the largest public enterprise in South Africa. The same report has also mentioned that ESKOM supplies about 90% of the electricity consumption in South Africa and uses various methods to generate electricity.

1.3 Statement of the Problem

The two (Medupi and Kusile) coal power plants commissioned in 2007 with an initial cost of R80bn and R90bn respectively and an installed combined capacity to generate 9 600 MW of electricity, with an estimated useful life of 50 years (The ESKOM Factor, 2011). Both power plants were designed to be greenfield plants and will reduce both emissions and water consumption as they will be using dry cooling systems (The ESKOM Factor, 2011). According to the timeline for the construction of the projects, both power plants are estimated to be completed by December 2018. Despite the fact that these two important projects have not yet been completed, the cost of constructing Medupi has increased to R145bn and that of Kusile has soared to R161.4bn, according to the Minister of Public Enterprise's presentation to the SA Parliamentary Portfolio Committee on Public Enterprise in February 2019. It was established that the increase in cost was due to faulty design, according to ESKOM. However, beyond the reason given by ESKOM, there is evidence of an improper capital investment evaluation that considers the environmental cost of building coal power plants. Medupi would emit 0.87kg of CO_2 per KWh, while Kulise would peak at 0.90kg of CO_2 per Kwh (The ESKOM Factor 2011)[1].

Unfortunately, these emissions pose a threat to the environment and endanger human and aquatic lives. However, despite the adverse effects of coal electricity generation, ESKOM have not properly evaluated their capital investment decision in coal electricity generating plants. This could be a result of a lack of information regarding the environmental cost of their activity since the investment in electricity generation operations is capital-intensive in nature. Moreover, not only does it affect the profitability and sustainability of the organisation, it also affects the ability of the organisation to meet its responsibility (primary objective) of the production and supply of energy to consumers. These adverse effects have been evident in the recent load-shedding occurrences in the country.

Specifically, many reasons are behind the inability of ESKOM's management to consider environmental cost when making their capital investment decisions. Some of these environmental costs are emission cosst. This is termed *external cost,* which is either not known or not quantifiable in terms of monetary value. Most often, managers are either unaware of the existence of such cost or some managers mostly classified such costs as general overheads, which is not what it ought to be. This study used environmental management accounting (EMA) to quantitatively measure environmental costs (i.e. calculations according to monetary value) using relevant theories and models that have been developed internationally. In this regard, there is a need for the development of methodologies and models that would enhance the estimation and determination of an environmental cost database such that its inclusion will be guaranteed when evaluating capital investment.

By being able to do this, this study will correct the misconception about the existence of environmental cost and generating electricity by coal because of a lack of information about the environmental cost of this activity. Moreover, the monetary value of emissions that are produced by ESKOM’s electricity generation activities and the long-run cost and effect of coal electricity generation activities on capital investment evaluation is determined.

1.4 Research Questions

i. What is the environmental cost of producing electricity by coal?

ii. What is the optimum production level of electricity using coal as a method of electricity generation when factoring in environmental cost?

iii. What is the capital investment of ESKOM in coal power plants by including environmental costs of coal electricity production?
iv. What are the possible recommendations for the environmental cost of producing electricity by coal in Eskom, South Africa?

1.5 Research Aims and Objectives

1.5.1 Aims

The aim of this study is to assess the impact of environmental cost on capital investment decisions being taking by ESKOM in relation to investment coal-powered electricity production.

1.5.2 Objectives

In achieving this aim, the objectives of the study are:

i. To determine the environmental cost of producing electricity by coal;
ii. To determine the optimum production level of electricity using coal as a method of electricity generation when factoring in environmental cost;
iii. To evaluate the capital investment of ESKOM in coal power plants by including the environmental cost of coal electricity production; and
iv. To make possible recommendations on the environmental cost of producing electricity by coal in Eskom, South Africa.

1.6 Scope of the study

The study focuses on the energy sector in South Africa that produces electricity, especially as Eskom is the main power producer in South Africa. The scope of this study is limited to the assessment of the environmental cost of energy sourced from coal on the capital investments by ESKOM. Coal power plants are the generating method that are the main focus of this research. The emission discharges of ESKOM are limited to three (3) emissions: CO_2, NO_2 and SO_2, for the purpose of this study and the data used in this study spans aperiod of 20 years (2000-2019). The reason behind this is the access to data beyond this period and the study also focuses more on the democratic dispensation (post-apartheid) period.

1.7 Justification for the study

The inclusion of Information and data on environmental costs, cost savings and revenues to place investments on a level playing field with other investment options in the capital investment decisions by ESKOM is a great enabler of investment decisions and the relevance of environmental impact on the cost of investment in coal-powered electricity production investment being taking by ESKOM.

1.8 Thesis Structure

The thesis is structured in five chapters as follows:

CHAPTER ONE: Introduction- This chapter introduces the context in which this research study revolves and which seeks to assess the impact of environmental cost on the capital investment decisions of ESKOM, South Africa. It also discussed the problem and objectives to be achieved in this study.

CHAPTER TWO: Literature review- In this chapter, previous studies around the subject matter were researched and reviewed to determine their relevance to this study. Through this review, gaps in previous studies were identified and explored to be able to achieve the objectives of this research study.

CHAPTER THREE: Methodology- This chapter explains the details of the methodology used in this research study. It starts with the research design. The sources and class of data used were also explained. Chapter Three also looks at how the objectives are achieved.

CHAPTER FOUR: Result and Analysis- In this chapter, the secondary data collected is analysed to provide the accurate knowledge of various factors that affects the cost of producing electricity and the revenue generated from selling of electricity generated.

CHAPTER FIVE: Discussion, Recommendations and Conclusion- This chapter discusses the finding of the analysis in this study, recommends the way forward and reaches a conclusion.

1.9 Chapter Summary

This chapter provided a detailed background and context for this study. It introduced the concept of environmental accounting as it applies to power generation. The chapter focuses on accounting for emission discharges by ESKOM's coal power plants. The background and framework that unpinned this study namely marginal social cost and net present value techniques, were discussed in this chapter. Lastly, this chapter described the problem statement, objectives of the study and scope of this research work. Relevant literatureis reviewed in the following chapter.

CHAPTER TWO

LITERATURE REVIEW

2 2.0 Chapter Overview

Chapter two critically analyses the relevant literature related to this study. The environmental impacts and effects on capital investment decisions are highlighted, while capital budgeting techniques are also discussed with the possible environmental issues and discharges of each of the energy sources. The chapter is divided into a conceptual review, empirical review and theoretical review.

2.1 Theoretical Review

The theoretical background of several evaluation techniques that can be utilized in any capital investment and environmental cost were critically reviewed in this chapter.This thus shed more light on their various advantages, limitations and their suitable applications.

2.1.1 Capital Budgeting Theory

Different theories have been developed on capital budgeting tools. Specifically, Modigilliani and Miller's Theory, the Real Option Theory, Contemporary Capital Budgeting Theory, Interest Theory and Irvin Fisher's Theory are the main advanced theories in capital budgeting. These theories are applicable to different investments and use different approaches. The theories are discussed in detail below.

2.1.1.1 Modigliani and Miller's Theory

The M and M Theorem simply means the Modigliani-Miller Theorem, which is one of the most important theorems in corporate finance. Developed by economists Franco

Modigliani and Merton Miller in 1958, M and M theory explains that the capital structure of a business entity does not affect the overall value of the company.

$$r_E = r_a + \frac{D}{E}\,(r_a - r_D) \qquad \textbf{2.1}$$

Where:

- r_E = Cost of levered equity
- r_a = Cost of unlevered equity
- r_D = Cost of debt
- D/E = Debt-to-equity ratio

This theory looks at capital investment as a permanent commitment, which can also be referred to as equity or ordinary share (Popoola 2016). This type of investment only takes part in the residual income of the business, not interest or cost of capital like bondholder, which uses the weighted average cost of capital. In arriving at the profit from the investment, depreciation is taken into consideration in order to accumulate some savings for the replacement of the assets. Although the investor will not be able to recoup the investment, the application of the M and M theory will improve the market value of the firm (Tudor 2008). This theory is based on the assumption that in a perfect market, no risk of default, no tax, no cost of a transaction nor interest rate of borrowing is the same for both firm and investor. The earlier version of the M and M theory was full of limitations as it was developed with an assumption of perfectly efficient markets in which no tax is being paid by the companies and there are no costs of bankruptcy. Subsequently, M and M was developed in order to accommodate the limitations of the first version.

$$V_L = V_U + t_c\ X\ D \qquad \textbf{2.2}$$

Where:

- t_c = Tax rate
- D = Debt

$$r_E = r_a + \frac{D}{E} X (1 - t_c) X (r_a - r_D) \quad \textbf{2.3}$$

2.1.1.2 Real Option Theory

This theory is one of the recent capital budgeting theories. The real Option theory explains that many options are available to decision-makers, and each investment opportunity makes use of either one of these options: wait option, kill option, growth option, switch option or timing option (now or later). The theory makes use of the Net Present Value (NPV) method in evaluating capital investment (Hugo Braga, 2014).

Real Option Theory is an important new framework in the theory of investment decisions. The standard theory that it modifies is the Expected Net Present Value theory of investment decisions. According to NPV theory, the future cash flows of an investment project are estimated and if there is uncertainty about those cash flows, the expected value is determined. The expected cash flows are discounted at the cost of capital for the corporation and the results summed. If the NPV is positive, the project is worthwhile and should be pursued. If it is negative, the project should be turned down. If the NPV is zero, it does not matter to the corporation whether the project is accepted or rejected.

2.1.1.3 Irvin Fisher's Interest theory

Developed in 1930, this theory explains how NPV is the basis for the optimal allocation organisation resources that will maximize the organisation's market value (V. Kumar 2018). The NPV is based on interest or what can be referred to as the *cost of capital*.

The decision is made at the point arriving at the IRR, which is explained as the point where the future value of present cash inflow will be equal to the capital that would be outlaid. It defines capital as an asset that future economic benefit will be received from by the entity and its link of the motivation to the interest rate. This theory has led to the adoption of IRR and NPV as the best techniques of capital budgeting evaluation. However, both techniques' limitation is in the area of their reliance on wealth maximization assumptions when ranking investment alternatives. Decision-makers wanting to maximize wealth around uncertainties that exist inaccurately determines future cash flow, which has led to making an inaccurate decision because of the unavailability of complete information and data to be used in reaching a favourable and acceptable conclusion (Alao and Adebawojo 2012).

2.1.2 Environmental Cost Theory

2.1.2.1 The Theory of Political economy

The theory of Political Economy Accounting was developed in 1990 by Parker's writings, based on accounting for social and environmental publications. Parker (1990) believes that social support is essential to the existence of any corporate organization. The organization must ensure that its activities do not endanger society;, otherwise, a business entity will lose societal support, which will lead to the downfall of such an organization. Disclosure of environmental information by the organization will serve as a management tool to face whatever pressure that comes the organization's way - either social or political pressure (Hamidu, Haron and Amran 2015).

2.1.2.2 The Theory of Legitimacy

The Legitimacy theory was formed from the paradigm of political economy, which is of the assumption that corporations should discharge their social responsibility role by giving back to the community and meeting up with societal demands. The organization positively discharges its activities to achieve a favourable and good public image. Over time, the primary goal of a business entity is to maximize profit, which serves as a benchmark of its performance. Recently, this has been overtaken by a more important indicator, which is to be socially responsible to the host community. This can be achieved by avoiding every activity that is seen to be endangering society. Legitimacy theory explains the reason behind the reporting of environmental information (Alikhani *et al.,* 2014).

2.1.2.3 The Theory of Beneficiaries

The Beneficiaries theory explains the voluntary reporting of environmental information. The theory attempts to differentiate beneficiaries from the issues of the society and it also suggests the use of guidelines to examine the organizational responsibility to society through environmental information reporting. The ethical pathway of this theory stated that beneficiaries such as investors have the right to access information regarding the environment, as disclosed by the organization (Alikhani *et al.,* 2014).

2.1.2.4 The Organizational theory

The Organizational theory examines the structure and the operation of the organization concerning political, cultural and social forces that surround the corporation. The organization needs to interact with these forces in order to ensure its stability. This theory also explains that the activities of the organization are limited due to various external pressures. At the same time, the entity needs to respond to external expectations. This theory assumes that several factors must be considered when reporting environmental accounting. These include impending dangers to the environment; organizational responsibilities towards these dangers; reviewing of the interaction between the organization and the environment; the utilization of natural resources (coal); assessment of dangers to the environment; and reporting of environmental cost.

2.1.2.5 Marginal Social Cost Theory (MSC)

Marginal Social Cost theory is the use of marginal cost to determine the externality of a cost that is borne by the society or a third party apart from the manufacturer and consumer. An example is the emissions produced by coal-powered electricity (Santos *et al.* 2010). The MSC model examines the benefits or the negative impact of consuming a particular product. These costs are an external cost that is not paid for by the firm (private cost). Marginal social cost/benefit is determined when the Marginal social cost is equal to marginal cost; where the marginal social cost is more than the marginal cost, it means the production of that product at a particular point has a negative impact on the society (Santos *et al.* 2010). The MSC can also be used to determine the optimum production level that will achieve a desired profit for the firm and also maintain social benefit for the society (de Nooij 2011). Moreover, this theory will be considered based on its suitability and relevance in achieving the set objectives.

Marginal Social Cost theory is the use of marginal cost to determine the externality of a cost that is borne by the society or third party, apart from the manufacturer and consumer (Lipsey 2018). An example is the emissions that produced by coal-powered electricity. The MSC model examines the benefits or the negative impact of consuming a particular product. These costs are external costs that are not paid for by the firm (private cost). Marginal social cost/benefit is determined when the Marginal social cost is equal to marginal cost. Where the marginal social cost is more than the marginal cost, it means the production of that product at a particular point has a negative impact on society. The marginal social cost can also be used to determine the optimum production level that will achieve a desired profit for the firm and also maintain social benefit to the society (Lipsey 2018).

2.1.2.6 Theoretical Framework

This study will specifically be hinged on the following two theories: Marginal Social Cost Theory and Net Present Value (NPV) Technique.

Marginal Social Cost Theory: This is the use of marginal cost to determine the externality of a cost that is borne by the society or third party apart from the manufacturer and consumer (Santos *et al.* 2010). Emissions produced by coal-powered electricity are an example. The MSC model examines the benefits or the negative impact of consuming a particular product. These costs are an external cost that is not paid for by the firm (private cost).

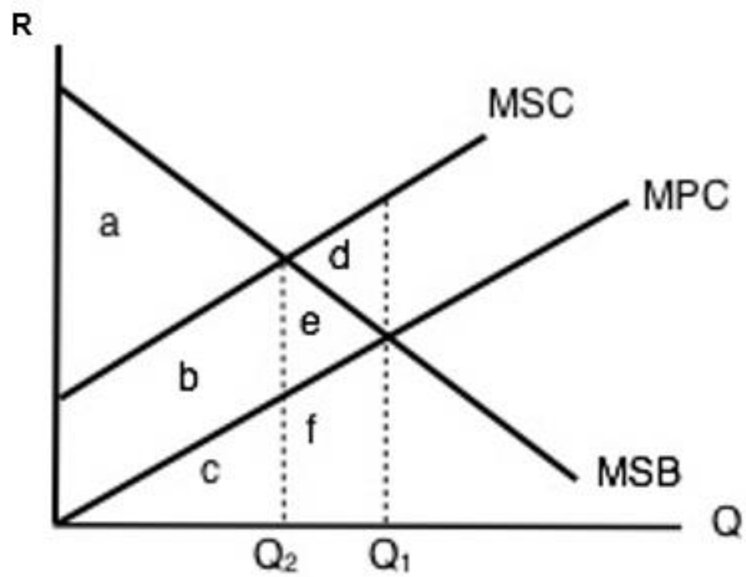

Figure 2.1: Marginal Social Cost and Marginal Social Benefit Curve (Dwivedi 2015)

Net Present Value (NPV) Technique: This theory will also be used as the model to determine the value of environmental cost to be included in capital budgeting. One of the objectives of an entity is the maximization of shareholders'' wealth and generating satisfactory returns on investment (Keay 2018). A satisfactory return on investment is dependent on the choice of the project to invest in. To achieve this management objective, various techniques have been deployed to assist managers in evaluating investment alternatives, amongst others are the Profitability Index (PI), Residual Income (RI), Net Present Value (NPV) and Internal Rate of Return (IRR).

The NPV primarily looks at the time value of money. It equates future earnings or cash flows to its value as of today (Griff 2014). Organizations mostly use it because of its effectiveness in taking inflation and timing into consideration. The ability of this evaluation method to take the timing of cash flow into the evaluation of capital investment makes it superior to other techniques. The evaluation criteria in NPV is that any investment that gives NPV above Zero is viable when evaluating a single investment. When comparing multiple investments, any investment option that results in higher NPV will be selected. It also takes risk into account when selecting the discounting factor to use. The NPV takes into consideration the expected future cash flows, the timing of the future cash flows and the risks associated with the future cash flows.

The mathematical representation of NPV is

$$NPV = \sum_{t=0}^{n} \frac{Cash\ Flow_t}{(1+r)^t} \qquad \textbf{2.4}$$

In this study, NPV was used as a capital budgeting technique to evaluate the capital investment decisions of ESKOM by incorporating environmental cost. The reason for this is that NPV uses both revenue and cost as input data for assessing capital investment, which makes it appropriate for the inclusion of calculated environmental cost in the cost input.

2.2 Conceptual Review

2.2.1 Power Generation Methods

As at March 2019, ESKOM operates 31 power stations located across the country, 1 of which is partially completed and one that is under construction. The 31 power stations utilize different technologies to generate electricity, such as coal, gas turbine, hydro, nuclear and wind.

2.2.2 Coal

With the use of burners and fuel, coal is being converted into fossil fuel to generate electricity. Almost 70% percent of the world's electricity is being generated by coal, South African is ranked 7th in the world amongst the countries that generate electricity through coal (Joffe 2012) . South Africa has coal abundance, with an estimated 100bn tons of coal. Coal provides around 85% of electricity generation in South Africa. Moreover, 13 of 15 coal power stations operated by ESKOM are in full operation, with Medupi partially completed and Kusile under construction. The total installed capacity of all the coal power stations is more than 44000 megawatts which account for 93% of total installed capacity of all the power stations in South Africa. There are many reasons for coal being used as a primary and major source of electricity generation in South Africa, one of which is that it is regarded as the cheapest source of energy along with the large deposit of hard coal resources in the country. As at 2013, South Africa's coal reserve is estimated at 32.1 billion tons. In the process of converting coal to fossil fuel, emissions are generated, which has been the shortcoming of coal technologies for electricity generation.

2.2.3 Carbon Emissions

Carbon emission is a global concern due to its adverse impact on human health, plants and the environment (De Marco *et al.* 2019). South Africa is regarded amongst the highest in carbon emissions (Okolo *et al.* 2019) as South Africa operates a highly energy-intensive economy, with considerable dependency on fossil fuels to meet its energy needs. This, together with a relatively small population, means that South Africa is a significant contributor concerning per capita emissions of CO_2 on a global scale (Oke, Aigbavboa and Dlamini 2017). Considering electricity production alone, 92% of electricity produced in South Africa is from coal combustion, complemented by nuclear energy (Oyewo *et al.* 2019). South Africa emits about 440 Mt. CO_2 per annum and is responsible for over 40% of CO_2 emitted by the African continent. South Africa accounts for about 1% of global emissions and is ranked as the 11th highest CO_2 emitter in the world (Oke, Aigbavboa and Dlamini 2017), due to the method used to generate electricity. This is a result of energy generation through coal utilization, which produces harmful emissions such as Carbon dioxide (CO_2), Nitrogen oxide (NO_2), and Sulphur dioxide (SO_2) (Yang *et al.* 2019). Currently, South Africa's economy is facing growth challenges as a result of instability in energy production (Mohammed, Mustafa and Bashir 2013). Energy availability is one of the critical factors of production in any economy because of its impact on production and the real economy (Nkomo 2005).

2.2.4 Environmental Emissions from Coal

Coal as a primary source and a major source of electricity generation produces harmful environmental emissions that are hazardous to human, aquatic and agricultural activities (Munawer 2018). The significant emissions generated by coal activities include Carbon dioxide CO_2, Nitrogen NO_2 and Sulphur dioxide SO_2 (Nazari *et al.* 2010). These emissions are needed to be accounted for and subsequently internalized At the moment, ESKOM does not include the cost of these emissions in its cost of electricity production (Chakamera and Alagidede 2018), but pays emission tax for exceeding the minimum limit. For emissions to be included in the cost of production, they needed to be giving monetary value (Nkambule and Blignaut 2017).

2.2.4.1 Carbon dioxide (CO_2)

Due to Eskom's utilization of coal in electricity generation, South African has become a significant contributor to CO_2 emissions in the world (Zhang *et al.* 2019). South Africa accounts for 25% of carbon emissions in the world. CO_2 causes harmful effects on human health, such as respiratory diseases and lung infections as a result of air pollution, which affects the quality of air intake (Munawer 2018). It also brings about global warming, which affects aquatic lives and causes drought that has a negative impact on agricultural production and which would impact food security. According to the 2019 Eskom integrated report, in the process of electricity production, 960g of CO_2 was emitted per kilowatt-hour (KWH) produced. This comes to a total of about 194000 kg of CO_2 emitted during the period. In terms of carbon emissions accounted for, it is estimated that in every one MW of electricity produced by coal, 960 kg of CO_2 is generated. Sustainable energy is the bedrock of economic growth worldwide, according to (Awodumi and Adewuyi 2020). Hence, the impact of energy supply on the growth of any economy cannot be over-emphasized. Therefore, investigation is required in this area of study. Steady energy supply has a direct impact on the development of any economy in the world. The slow growth that is being witnessed in the South African economy can be directly attributed to the challenges faced by ESKOM in the areas of the production and supply of the electricity required to stimulate the economic growth of the country (Kessides 2014). One of the causes of these problems purported by (Donnelly 2019) is the method employed by ESKOM to generate electricity, which is moastly by coal. Currently, coal is the most common method of generating energy worldwide, and is utilised extensively in the production of electricity in different countries (Huaman and Xiu 2014). The use of coal as a significant source of energy production can be traced to the availability of coal as a natural resource in the country. Despite its abundant availability, using coal to generate electricity creates emissions such as carbon dioxide (CO_2), Nitrogen (NO_2) and Sulphur (SO_2) which damage the environment and cause health challenges for humans (Munawer 2018). According to Riekert and Koch (2017), the monetary value of each of the emissions discharged by coal are projected as: Carbon (CO_2) cost 0.23c/KWh; Nitrogen (NO_2) cost 0.085c/kWh while sulphur oxide cost 0.035c/KWh. Despite these costs having been determined by several pieces of literature, none have been able to include this cost in the evaluation of the capital investment of ESKOM's prospective projects, such as the Medupi and Kusile power stations (Nonophile and James 2017). The cost of these emissions is high and needs to be taken into consideration when determining the cost of producing electricity and even during the capital investment evaluation stage. There is no indication in the literature of ESKOM taking into account the environmental cost of using coal to generate electricity, either during the evaluation of the capital investment or during the determination of the cost of producing electricity through coal. The reason for these can be traced to a lack of information about the cost of these emissions and also that these costs are regarded as external costs which are borne by the society and do not form part of the private cost of ESKOM (Dwivedi 2015). Therefore, there is a need to determine the cost of these emissions when determining the cost of producing electricity through coal, which can be subsequently included in the evaluation of the capital investment of ESKOM in coal power stations and which is the focus of this study.

2.2.4.2 Nitrogen (NO_2)

There is strong evidence that NO_2 respiratory exposure can trigger and exacerbate existing asthma symptoms and may even lead to the development of asthma over more extended periods of time (Munawer 2018). It has also been associated with heart disease, diabetes, birth outcomes and all-cause mortality, but these non-respiratory effects are less well-established

2.2.4.3 Sulphuric-dioxide (SO_2)

The other environmental impact of the use of coal to produce electricity is the emission of SO_2, one of the major pollutants derived from coal combustion processes.This substance, when treated concomitantly with a Particulate matter (PM10) results in synergistic injury in terms of human cell survival and apoptosis occurrence (Yun 2015).

2.3 Capital Budgeting Concepts

One of the objectives of an entity is the maximization of shareholders' wealth and generating satisfactory returns on investment (Degnet *et al.* 2018). A satisfactory return on investment is dependent on the choice of the project to invest IN. Due to the importance of the returns and choice of investments which are critical to the survival of the entity and its profitability, management are faced with making the best decision out of different investment options. In order to achieve this management objective, various techniques have been deployed to assist managers to evaluate investment alternatives, amongst which are the Profitability Index (PI), Residual Income (RI), Net Present Value (NPV) and Internal Rate of Return (IRR).

2.3.1 Profitability Index

This technique evaluates investment projects in relation to the benefit derived from investing a particular amount (Mellichamp 2019). It ranks projects by measuring the benefit derived from each rand that is being invested. It is also defined as the ratio of present value of changes in operating cash inflows and the present value of the cash outflows of the investment and is mathematically represented as:

$$PI = \frac{Rand\ Benefit}{Rand\ Cost} = \frac{\sum_{t=1}^{n} \frac{Cash\ Flow_t}{(1+r)^t}}{Cash\ Flow_0} \qquad \textbf{2.5}$$

Where n is number of years and **r** is expected rate of return

PI also looks at the timing of expected cash flows, which means that the time value of money is being considered. Therefore, PI can also be described as variations of NPV, which means that wherever a PI of a project equals to 1, the NPV will be equal to 0.

2.2.5.2 Net Present Value(NPV)

This is another technique used by managers to evaluation capital investment. The NPV primarily looks at the time value of money (Clews 2016). It equates future earnings or cash flows to its value as of today and is mostly used by many organisations because of its effectiveness of taking inflation and timing into consideration. The ability of this evaluation method to take the timing of cash flow into the evaluation of capital investment makes it superior to other techniques. The evaluation criteria in NPV is that any investment that gives a NPV that is above Zero is viable when evaluating a single investment, and when comparing multiple investments, it chooses any investment option that results in a higher NPV (Clews

2016). It also takes risk into account when choosing the discounting factor to use. The NPV takes into consideration the expected future cash flows, the timing of the future cash flows and the risk associated with the future cash flows.

The mathematical representation of NPV is

$$NPV = \sum_{t=0}^{n} \frac{Cash\ Flow_t}{(1+r)^t} \qquad 2.5$$

2.2.5.3 Internal Rate of Return (IRR)

The IRR technique finds the discount rate that satisfies the expected rate of return by the investor (Magni and Marchioni 2020). IRR determines the discount rate that will make the present value of future cash flows equate to capital outlay or give zero NPV. The IRR is a trial by error in which multiple discount rates are being applied until the one that gives the right expectation is arrived at.

$$Rand\ 0 = \sum_{t=1}^{N} \frac{Cash\ Flow_t}{(1+1RR)^t} \qquad 2.6$$

All the capital budgeting techniques require the determination of cash flows in order to arrive at decision-making when evaluating capital investments (Paquin, Gauthier and Morin 2016). It should be understood that it is not every cash flow that can be used when using any of the capital budgeting techniques. Therefore, cash flows are categorised into two : relevant cost and irrelevant costs. It is important to note that only relevant costs can be included in the cash flows when evaluating capital investment. Relevant costs are costs that are directly associated with the project of investment. These costs include all the incremental cost, after-tax income and expenses. Cash flow can also be classified as initial outlay, annual after tax cash flow and terminal cash flow (Paquin, Gauthier and Morin 2016).

2.2.6 Environmental Management Accounting

Environmental Management Accounting (EMA) studies are divided into two extended segments, one is the theoretical studies and the second one is empirical (Guerrero-Baena, Gómez-Limón and Fruet 2015). The theoretical study of EMA is a system that describes the form of relationship that exists between economic and environmental performance and ensures the acceptance of environmental management accounting in the corporate community. From the above statement, there is a need to link environmental activities to economic activities. This reveals that there is a relationship between the environmental performance of a business entity and the financial and economic performance of the organization. In recent times, the performance of an organization is not only measured by its profitability, but also measured by its social performance and market value, which are of more interest to the stakeholders especially current and prospective investors. In the context of South Africa, the application of environmental management tools and techniques is still limited, most especially in the area of capital investment evaluation and decisions as it relates to investment in the energy sector.

As a branch of Environmental Accounting (EA), Environmental management accounting (EMA) is an important tool to rectify the inadequacies of traditional management accounting because it gives more informed knowledge about the essence of social responsibility and assists management in making business decisions as it relates to the environment (Burritt 2004b). In this regard, it is revealed that EMA is not only useful for cost management alone, but also increases the value and the image of the company. The energy producing sector in South Africa is facing value and reputational challenges because of their environmental endangering activities, most especially the main power producer ESKOM. Therefore the adoption of EMA will enable ESKOM management to make informed and environmentally compliant investment decisions that will enable the organization to effectively price their product (electricity rate) and also improve their corporate image in terms of their social responsibility towards the environment.

Both literature and practice have shown that there is no universally acceptable definition to EMA. Nevertheless, a broader definition was proffered by IFAC as a process that entails the identification, collection and analysis of information for making business decisions.

As seen from the definitions and the application of EMA as mentioned above, it is clearer that the objective of EMA is to provide an information base that will enable the evaluation and assessment of the impact of a corporation's activities on the environment and vice versa. The provision of quantitative and monetary information as relates to waste in physical units, such as kgs, meters, litres etc with value to the management to make an informed decision, makes EMA an information support to management information. As reported by (Iredele 2018), EMA can be divided into two segments;

i. Monetary Environmental Accounting (MEMA), and
ii. Physical Environmental Management Accounting (PEMA).

The focus of MEMA is on the corporation's operations, including the environmental aspects which are stated in monetary terms. These include fines for non-compliance with environmental laws and environmental enhancement capital investment projects (Iredele 2018). PEMA explains the identification of a company's operational impacts on the environment and is measured in physical units such as emission in cubits m^3 and materials waste in kilograms (Jamil *et al.* 2015).

This function of information creation is the important fundamental of EMA, as the data provided will be at the centre of decision-making by the management and assists in effective decision-making. It is an important theory in which this study will be able to relate and provide recommendation as to the impact of environmental cost on capital investment.

Various studies have also revealed the advantages of the implementation of EMA, with ECA as a branch of EMA that includes cost reduction, innovation, green production and shareholders' value increase (Jamil *et al.* 2015). Citing the above benefits of ECA adoption, ESKOM as an energy producer will benefit immensely.

2.2.7 Techniques and Tools of Environmental Management Accounting

The techniques of EMA, both in theory and practice, are differentiated into three categories based on their focus, which are the Analysis of Cost, Appraisal and Evaluation of Investment and Managing Performance (Jamil *et al.* 2015). Appraisal and Evaluation of Investment is related to capital budgeting, which is long-term in nature and demands a detailed analysis of projected costs and revenues of the proposed investment projects (Mellichamp 2019). This study would apply this EMA technique as it relates to the evaluation and appraisal of capital investment in energy producing activities and environmental costs will also be considered.

Different tools are being used by ECA to help in cost management and analysis, namely the Life Cycle Assessment (LCA) which explains the design of a product that will allow the best use of input, expecially natural resources such as water, Activity Based Costing (ABC); and Material Flow Cost Accounting (MFCA) that examine how waste products can be minimized by ensuring the quality of input and production processes.

2.2.7.1 Activity Based Costing (ABC)

The Activity based costing technique purports that various corporation resources are not consumed in direct production, but rather in providing supporting activities in the production and distribution of the organization's product (Tsai *et al.* 2012). Some of these resources cannot be traced directly to the production of the product. In relation to power or electricity generation through coal, emissions and pollutions which form part of the environmental cost, are not included in the price of electricity (Tsai *et al.* 2012). ABC's aim is to, amongst others, measure overheads by activities, allocating them by their drivers to the final product. ABC allows business entities a more precise and relevant overheads allocation, such as environmental costs, because it is of the assumption that each cost driver should carry its costs in relation to the activities performed. (Chou 2010) reported that ABC is essential as it uncovers the significant aspects of environmental cost, such as staff salary for environmental employees, water consumption energy and disposal of waste, emissions and pollution, which are traditionally identified as production overheads.

The detection of environmentally-related costs by ABC will be followed by the identification and application in cost drivers as designed for each activity. The end result of the application of ABC in the area of cost control is very significant as the information it provides is accurate and assists management in the allocation of environmental costs to its specific activity.

2.3 Empirical Review

Past studies on decision-making for investments in energy (electricity) production have explored the obstacles and motivation to ensure adoption, such as profitability, environmental compliance and political and organizational behaviors (Trianni *et al.* 2017). In a study conducted on the Swedish pulp and paper industry, it was concluded thhat various barriers to investment decision-making are identified namely behavioral, organizational, motivation, lack of fund and others which serve as an obstacles to having long-term decisions on energy investment (Trianni *et al.* 2017). Other barriers identified by (Trianni *et al.* 2017) include low levels of priority; the availability of other investment opportunities; limited management time, limited access to funding; lower and slow rates of return; and operational activities focus. Investments in environmentally-friendly energy production may lack being placed above other projects due to the inability to be linked to core business (Owusu and Asumadu-Sarkodie 2016). In respect to the identified obstacles and the availability of an energy utilization gap, it is important for the business entity to understand the questions of the *how* and *what* of decision-making as it relates to investments in clean energy production. Hence, this proposal will focus on the impact of environmental cost on capital investment decisions in electricity generation.

Looking at the model in decision-making as recommended by (Burritt 2004a), the decision stage includes the authorised assessment, which for example happens by the application of capital budgeting techniques. The assessment requirement to apply for energy generation investments have likewise been investigated in relation to energy efficiency, showing a successive application of net present value (NPV) and particularly the pay back technique (PB) for electricity production projects (Emmanuel, Harris and Komakech 2010; Cooremans 2012). Criteria of a Pay Back time of three years or less have been recommended for Swedish industry (Brunke, Johansson and Thollander 2014).

In any case, despite the fact that it could account for an enhanced NPV or a shorter Pay Back time, not all advantages identified with a capital investment are recognized in the process of investment (V 2011; Cooremans 2012). The contention of not taking into account the advantages has been recognized with regard to energy effectiveness, enhancing investments at the same time (Moran and Kunz 2014).

2.4 Conceptual Framework

In this research, the relationship between the dependent variable, which is capital investment in the energy sector- mainly coal powered and diesel power plants- and the independent variable of environmental cost (external activities) was examined and evaluated to determine the impact of environmental costs on capital investment decisions in the energy sector in South Africa. Figure 2.2 displays the environmental cost on capital investment framework.

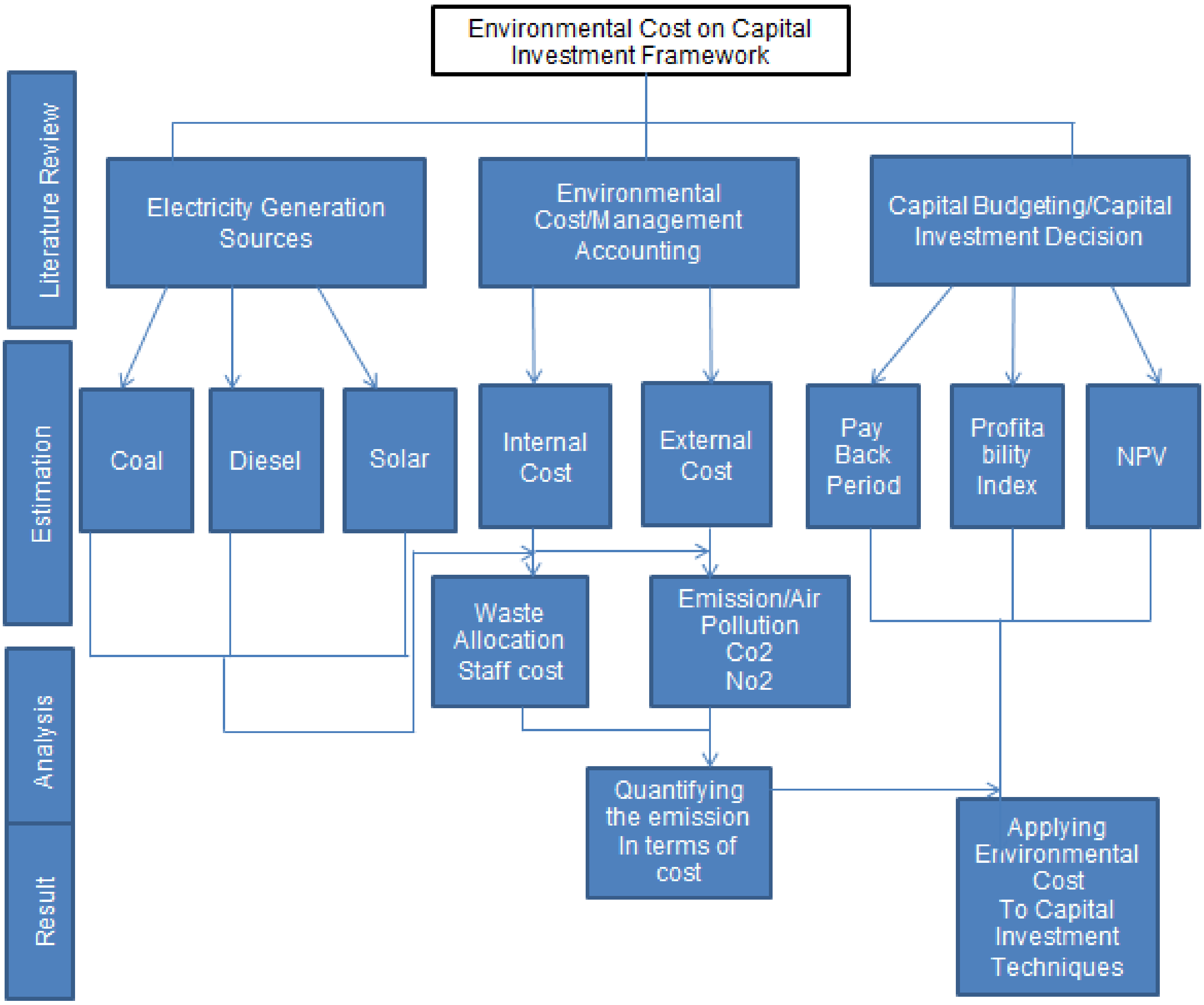

Figure 2.2: Developed Environmental costs on capital investment framework

Source: Author's design (2020)

2.5 Chapter Summary

In this chapter, various previous studies and research that present evidence that emission discharges from coal power plants are harmful to human and aquatic lives are described. Theoretical reviews of theories such as marginal social cost, real option and investment theories were conducted. This chapter showed the effect of these emissions on the environment and thatcthe cost of these emissions are not being borne by ESKOM as it is transferred to the third party or final consumers of electricity.

In order to ensure that ESKOM does not only discharge emissions, but also carries the cost of it by including the cost of these emissions in the electricity price, there is a need to reliably quantify the cost of these emissions in monetary value. Various approaches have been adopted, such as traditional cost accounting techniques which could not accurately account and assign costs to these emissions as being generated by coal power plants. Additionally, many authors have advocated for the phasing-out of coal power plants as the only solution to reduce the negative impact of coal energy. Marginal social cost is proven to be the model that can provide an accurate balance between ESKOM and the society. Marginal social cost seeks to equalize marginal cost to marginal benefit because a product such as electricity is categorized as a social amenity that is essential for basic living.

The Research methodology will be discussed in detail in the next chapter, along withthe approach to the objectives.

CHAPTER THREE

METHODOLOGY

3.0 Chapter Overview

This chapter details the methodology used in this research study. It starts with the research design. The sources and class of data used is also explained. The research paradigm adopted in this research study is post-positivism as is an apprioprate paradigm that fits into the qualitative research being conducted in this study. This chapter also looks at how the objectives are achieved.

3.1. Research Paradigm

This study follows a positivism paradigm, being a quantitative study. A paradigm is a method of explaining social reality through philosophical assumptions in the form of ontology, epistemology and axiology- belief, knowledge and system (Mukhalalati and Awaisu 2019). Positivism is refered to as evidence that can be interpreted by mathematical formula or equation. One of the aspects of positivism is post-positivitism, developed by scientists because positivism is limited. Post-positivism research principles emphasise meaning and the creation of new knowledge, and are able to support committed social movements that aspire to change the world and contribute towards social justice (Mukhalalati and Awaisu 2019). Post-positivist research is characterized by a broader research study instead of a specialised one. Moreover, it found that theory and practice are intertwined because theory cannot be ignored as a result of the fact. Furthermore, commitment and motivation are the driving force for the undertaking of the research study and it is found to be inadequate. The research ideas only focus on adopting correct mechanisms for the collection and categorization of data (Sousa 2010).

The post-positivist knows all that is understood (Mukhalalati & Awaisu, 2019). According to (Saunders, Lewis and Thornhill 2009), positivist generalizations are focused on 'actual' factors which are viewed as the true root of actions and are focused on unchangeable, sound foundations.

This true reality can be achieved and can be defined and measured. Positivism is designed to predict and monitor reality. It focuses strongly on the deterministic concept of cause and effect (causality) that stems from the deductive reasoning that a study is logically driven (V 2011).

If the hypothesis is not in line with fact, it is revised to better predict outcomes. This cause should be based only on empirical evidence (measuring and analyzing the center about empiricism) of how truth is interpreted or understood (Saunders, Lewis and Thornhill 2009). Often called the model of natural sciences, since positivism developed in natural sciences, this knowledge is evaluated against that of natural science’s empirical evidence (Sousa 2010).

3.2 Research Design

This research study was conducted as descriptive and predictive quantitative research. The following pattern of research ideas will be followed; evaluation, estimation, analysis, results and application.

3.2.1 Evaluation

This aspect dealt with the determination of activities of electricity generation that contributeto negative effects on the environment. This will also help to determine the harmful effect of each method of electricity generation used by ESKOM to produce electricity.

3.2.2 Estimation

This is the assignment of cost or value to the emissions produced by each source of electricity production. This aspect quantified the cost of each emission into the environment that is externalised by the energy producing firms. This cost will then be a factor in to the capital investment for decision-making purposes about the profitability of the proposed investment.

The result of evaluation and estimation was analysed to determine the actual impact of factoring environmental cost into capital investment decisions, which may bring about a change in the approach to the techniques used in capital investment evaluation.

The analysed outcome of the evaluation and estimation will enable the inclusion of Information and data on environmental costs, cost savings and revenues to place investments on a level playing field with other investment options in the capital investment decision and is a great enabler of investment decisions, as well as the relevance of the environmental impact for the cost of investments in the energy sector by investment institutions and corporations.

3.3 Population and Sample

This study is based on the available data on electricity generation in South African, which is primarily from coal by ESKOM as the major producer of electricity in the country. Furthermore, the emissions measured were limited to carbon dioxide and nitrogen which are external to ESKOM activities and needed to be internalised for appropriate inclusion in capital investment evaluation.

3.4 Model Specification

The marginal social cost model was utilized. ESKOM operates in the private market that involves consumers, producers and government. The external cost (environmental cost) is being borne by the consumer. The determination of tonnes of coal will be needed in each power station to generate a particular amount of electricity as the install capacity of each power station. According to data available, each power plant will consume 17million tonnes of coal per annum to generate the install capacity. The CO_2 that will be generated by 1 ton of coal is 2.17 tonnes; 0.32kg of SO_2 and 0.18kg of NO_2 (Riekert and Koch 2017). The cost per kg of each emission was determined, made possible because the total environmental cost of these two power generators has been estimated to be between R31bn to R60 billion per annum (R45bn on average): 70% of these costs are attributed to water damage, tthus the remaining 30% can be allocated to emissions (CO_2, NO_2 and SO_2) (Munawer 2018).

3.5 Nature and Sources of Data

This section explains the mode of data collection and the data subsequently analyzed for this study. The sources of data for this study were obtained from secondary sources. The secondary sources produced ESKOM data over the past 20 years, which are readily available in financial reports published on their website. These data are related to ESKOM's electricity generation from coal for these periods and subsequent emissions by this operation. This data are quantitative in nature, which is vital to this study as a quantitative research investigation.

3.6 Data Collection Techniques

ESKOM and Statistics South Africa were contacted for data on sources of environmental damages and hazards as a result of electricity generation by ESKOM using coal. Moreover, ESKOM was visited to obtain information about electricity generation using coal and on its capital budgeting practices and techniques adopted.

3.7 Approach to Research Objectives

The approach to this research entails the application of theory. It is not always complex in the design stage. However, it is shown clearly during the presentation of data and analysis. In this study, information would be obtained from primary and secondary sources such Statistic SA data on electricity production and Eskom personnel to understand the implementation and development of EMA from the understanding of those who are responsible for its implementation. From there, a framework for EMA would be developed and implementation would be informed by the data collected and literature reviewed.

This study explores the reasons behind EMA practices and described the EMA status in the energy industry. For the understanding of ECA, this research study would make use of an abductive logic reasoning approach research method. This research approach is described as a creative, imaginative or insightful moment in which understanding is grasped or is expected to be grasped (Lipscomb, 2012). This form of reasoning often generates 'correct' conclusions (Lipscomb, 2012). "It is a form of extremely fallible insights" (Pierce, 1998). Pierce (1955) as cited in Echenim, Peltier & Tourret (2013) defined abductive reasoning as a "process of inferring relevant hypotheses from data (as opposed to deductions which consists of deriving logical consequences of axioms)". Knowledge of different research norms enables the researcher to adapt a research design to accommodate for limitations. These limitations can be as a result of practical involvement in the subject matter or limited access to data.

The Exploratory Model and Analysis was applied as observed in the reviewed literature and studies on the proliferation of the application’s factor analysis This research will examine the use of factor analysis in the assessment of Environmental

Cost Impacts. These judgments will help in the interpretations of the Investment decisions in the energy sector and in turn determine the effect on capital cost.

3.7.1 Determination of the environmental cost of producing electricity using a marginal costing method (MCM)

In achieving Objective 1, ESKOM's coal power generating plants' data was used to determine the amount of emissions discharged in the form of CO_2, NO_2 and SO_2. This objective was achieved through data received from ESKOM's Annual Integrated Report (AIR) found on ESKOM's website www.eskom.co.za. It is termed a secondary sources where quantitative data and financial information regarding ESKOM's operation data using coal to generate electricity was collected. The Marginal costing method was applied to determine the types of emissions that are produced in the process of coal electricity generation. Coal power plants discharge harmful substances into the environment that affects the quality of the air and climate (Munawer 2018).

ESKOM as a form of manufacturing entity uses direct inputs to produce electricity. These inputs are termed variable cost and relevant cost in relation to the production of electricity, which are coal and water. The quantity (tonnes) of coal consumed in each power station to generate a particular amount of electricity as the install capacity of each power station was obtained. According to data obtained, 530g of coal was used to produced 1 Megawatts per Hour (MWH) of electricity and 1.46 kilolitre of water was used in the process, The CO_2 emitted by 1 ton of coal was 2.17 tonne; 0.32kg of SO_2 and 0.18kg of NO_2. The cost per kg of each emission was determined as the total environmental cost of generating electricity using coal estimated to be between R31bn to R60 billion per annum (R45bn on average). The total cost of producing 1MWh of electricity without taking the environmental cost of coal into account is:

$$TC = f(I) \quad 3.1$$

Where input cost sare coal and water, they can be refers to variable cost/relevant costs. Therefore the equation can be explicitly presented as:

$$TC = f(coal, water) \quad 3.2$$

$$TC_i = \beta_{i1}Coal_i + \beta_{i2}Water_i \quad 3.3$$

Since environmental costs are associated with using coal to generate electricity, the equation then becomes:

$$TC = f(I + C_e) \quad 3.4$$

Where Ce stands for the emissions of CO_2, NO_2 and SO_2 respectively as producing electricity through coal has negative externalities.

$$TC_i = \beta_{i1}Coal_i + \beta_{i2}Water_i + CO2_i + \beta_{i5}NO2_{\ i} + \beta_{i6}SO2_i \quad 3.5$$

$$TC_i = \beta_0 + \beta_{i1}Coal_i + \beta_{i2}Water_i + \beta_{i4}CO2_i + \beta_{i5}NO2_{\ i} + \beta_{i6}SO2_i + \mu \quad 3.6$$

Apriori Expectation:

$$\beta_1 - \beta_6 > 0 \quad 3.7$$

3.7.2. Determination of optimum production levels of electricity using the Marginal Social Cost Model (MSCM)

In achieving Objective 2, the MSCM was applied to determine the optimum production level for a desired profit for ESKOM and also maintain social benefit to the society. The quantity/level of production where marginal social benefit is equal to marginal social cost is the optimum production level. Assuming that there is no external cost (Negative), the market equilibrium is achieved at the point where marginal private cost (MPC) intersects marginal social benefits (MSB). ESKOM will derive a profit/market surplus at this intersection, which connotes the average profitable point of electricity generation capacity. With the inclusion of environmental cost/marginal social cost

(MSC), it is expected to shift the equilibrium point, as this will affect the cost of production.

$$TSC=TCi \qquad 3.8$$

$$TCi= TC = f(I + C_e) \qquad 3.9$$

Therefore, marginal social cost is

$$MSC = \frac{\Delta TSC}{\Delta Q} \qquad 3.10$$

$$MSC=\Delta(\beta_{i1}Coal_i + \beta_{i2}Water_i + \beta_{i4}CO2_i + \beta_{i5}NO2\ _i + \beta_{i6}SO2_i)/\Delta Q \qquad 3.11$$

Total social benefit (TSB) is equal to total private benefit (PB), which can also be equal to total revenue (TR) where the externalities are negative. The externalities caused by coal electricity production will give rise to negative externalities.

Since TSB=TPB=TR

TPB=quantity produced/sold multiplied by selling price per unit

$$TPB_i = \beta_{i4}Q(SP) \qquad 3.12$$

Marginal social benefit

$$MSB=\frac{\Delta TSB}{\Delta Q} \qquad 3.13$$

Therefore, the optimum quantity/production level is

$$\frac{\Delta TSC}{\Delta Q} = \frac{\Delta TSB}{\Delta Q} \qquad 3.14$$

3.7.3 Evaluation of capital investment decisions using the net present value (NPV) technique

The adoption of the net present value (NPV) technique for evaluating the capital investment using the following variables/input data was required for Objective 3:

i. *Cost outlay/initial investment*- this is the estimated investment to construct a coal power plant, which was represented by CF_i

ii. *Operating revenue/net operating revenue* - this is the difference between total revenue/total private benefit and total cost/total social cost. It was represented as CF_{oi}. The cash inflow takes into account the environmental cost of coal electricity production.

iii. *Interest rate*-an applicable interest rate was determined by using (WACC). This can be calculated by finding the average interest rate for the past 20 years. The WACC was discounted over the useful life of the plant usinga mathematical formula for the discounted factor.

From the second objective, the determined optimum production level is evaluated using financial information considered as environmental cost.

$$NPV = CF_{oi} - \sum_{t=0}^{n} \frac{CF_{oi}}{(1+r)^t} \qquad 3.15$$

3.8 Ethical Consideration

This research study was conducted in accordance with the Durban University of Technology's research ethics policy and guidelines. The ethics policy takes into account the anonymity, confidentiality, rights and voluntary participation of human subjects. Data gathered from the research have been held safely and securely.

3.9 Relaibility and validity

The reliability of this research is ensured by the fact that data used for analysis comes mainly from reports and no survey was conducted. The secondary data used removes the chance of bias in data collection and analysis and hence ensures a reliable research study. This research can be applied in any power generating organization with coal as the main source of electricity, across different countries and regions.

3.10 Chapter Summary

This research study was carried out to assess the impact of environmental cost on the capital investment decisions of ESKOM South Africa. In this chapter, details of the research methodology adopted were provided and it centers on the type of research-quantitative- research design, data collection methods and approach to objectives. It also discussedthe paradigm and model used to achieved the objectives.

The following chapter focuses on the data analysis, results and findings of this research study.

CHAPTER FOUR

DATA ANALYSIS, DISCUSSION AND INTERPRETATION OF RESULTS

4.0 Chapter Overview

In this chapter, the secondary data collected is analysed to provide an accurate knowledge of various factors that affect the cost of producing electricity and the revenue generated from selling the electricity generated.

The first step in this section involves the cleaning and sorting of secondary data ESKOM's operations obtained from different sources such as ESKOM's annual integrated results. This data set covers a period of 20 years, from 2000 to 2019, and contains information on different parameters such as numbers of coal power plants operated by ESKOM, total electricity generated, total electricity sold, cost of electricity sold, selling price of electricity, as well as the environmental cost associated with the use of coal to generate electricity. The detailed information on these data is provided in Appendix B.

4.1 Analysis to Achieve Objective 1: To determine the environmental cost of producing electricity by coal

4.1.1 Estimating Techniques used in achieving the objective

As it is always difficult to find a data set that is well-structured and ready to be used, the data obtained had some missing information, which has been completed using the moving average techniques, a well-known and accepted scientific forecasting method. Moving average is a technique that averages a number of most recent actual values, which is updated as new values become available (Stevenson, 2012).

This moving average is calculated using the formula in equation

$$Ft = MA_n = \frac{\sum_{i=1}^{n} A_{t-i}}{n} = \frac{A_{t-n} + \cdots + A_{t-2} + A_{t-1}}{n} \qquad \textbf{4.1}$$

Where:

Ft = Forecast for time period t

Man = n period moving average

At-I = Actual value in period t – i

n = Number of periods (data points) in the moving average, which was set to 3 for this purpose of this study.

4.1.2 Descriptive Analysis

This first type of statistical analysis consisted of looking at the data, sorting them out and applying some statistical tools to describe the collected data in order to provide clear and meaningful information. It is worth noting at this point that data for a period of 20 years was collected (averaged) for this study.

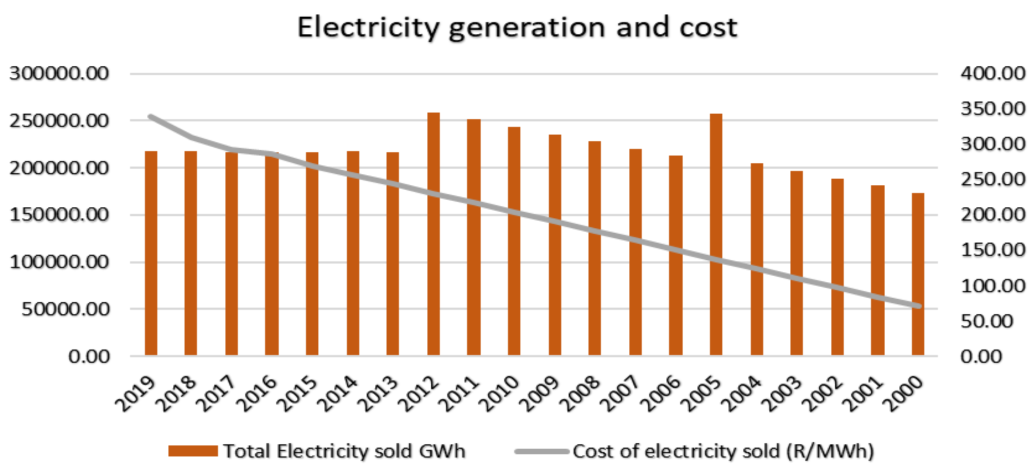

Figure 4.1: Electricity generation quantity and cost of production

Source: Author's Estimation (2020)

As a first descriptive, Figure 4.1 displays the total electricity produced per year for the past 20 years and in the secondary axis the cost per unit (in R/MWh) of electricity produced. It can be seen from this graph that production has been increasing with a fairly constant rate up to 2012, where the graphs displays a drop in the quantity produced: the average production quantity is 218 494 GWh. On the other hand, the cost of electricity produced kept a constant increase from 2000 to 2019 with a maximum cost of R339 / MWh.

The second descriptive analysis conducted was about the carbon footprint of coal usage in the generation of electricity. This analysis is displayed in Figure 4.2. On this, CO_2 emissions in Mt as well as NO_2 and SO_2 emissions in Kt are displayed to understand the quantity of these particles that were emitted every year during the generation of electricity using coal.

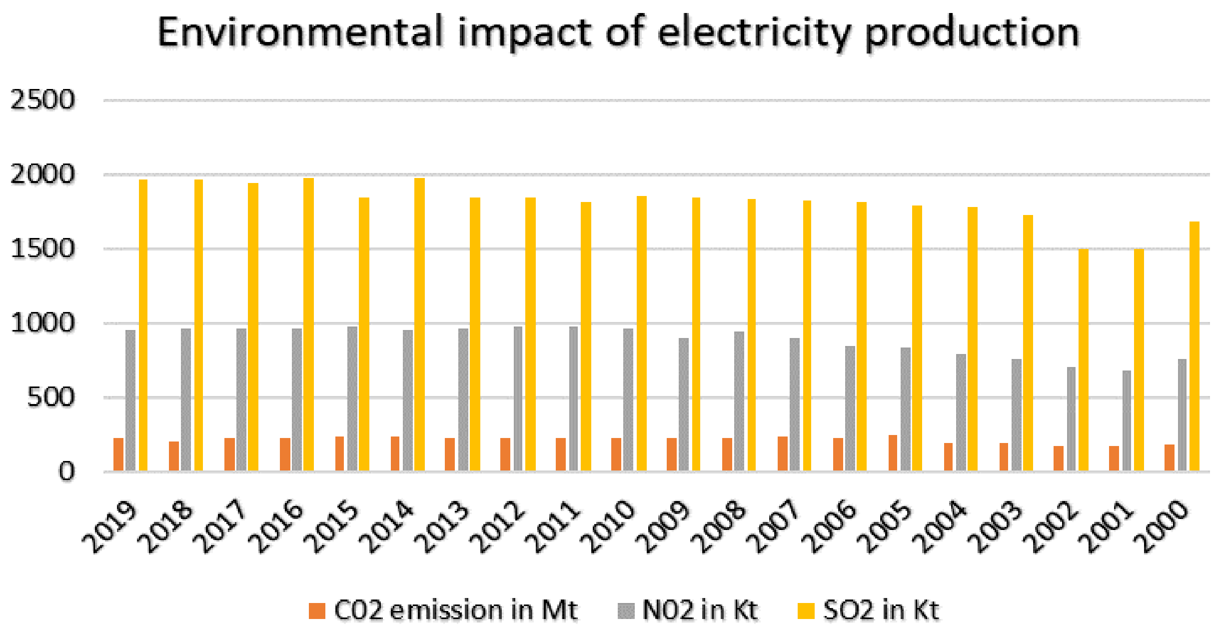

Figure 4.2: Environmental impact of electricity production

Source: Author's Estimation (2020)

Table 4.1 below displays the information used for the regression analysis, which has been pulled from the data set provided in Appendix A.

Table 4.1: Total Cost and total revenue of electricity produced for the past 20 years

Year	Total Electricity sold (GWh)	TSC (Incl Ce) in R'Bill	TSB/TPB/TR (R'Bill)
2019	217508.22	R239.78	R197.45
2018	217199.67	R232.00	R184.75
2017	216561.00	R228.89	R181.04
2016	216417.50	R228.83	R165.00
2015	216274.00	R220.70	R146.87
2014	217903.00	R223.51	R136.89
2013	216561.00	R213.59	R126.67
2012	258856.00	R221.51	R130.13
2011	251121.50	R214.23	R57.88
2010	243387.00	R210.77	R53.26
2009	235652.50	R202.06	R48.81
2008	227918.00	R199.76	R44.55
2007	220183.50	R193.70	R40.46
2006	212449.00	R186.52	R36.56
2005	256959.00	R189.66	R41.22
2004	204714.50	R171.46	R35.33
2003	196980.00	R163.76	R31.67
2002	187957.00	R144.11	R28.16
2001	181511.00	R139.97	R24.98
2000	173776.50	R151.30	R21.79

Source: (Eskom 2019)

4.2 Analysis for Objective 2: To determine the optimum production level of electricity using coal as a method of electricity generation when factoring environmental cost

The first regression analysis that has been done considered the total social cost of electricity as the dependent variable and the total amount of electricity sold as the independent variable. The scatter plot graph of this analysis is displayed in Figure 4.3. This regression modelling has yielded a polynomial regression model displayed in equation 4.1 The polynomial regression model has been selected over other trend-line options because it presents a higher R-squared valued, which is an indication of a good fit regression model. R-squared or the coefficient of determination is a statistical measure that is mostly used to measure the goodness of fit of the equation. It describes how well the model fits the data and indicates the percentage of variance of the dependent variable that the independent variable explains correctly in the model (Oyana 2020).

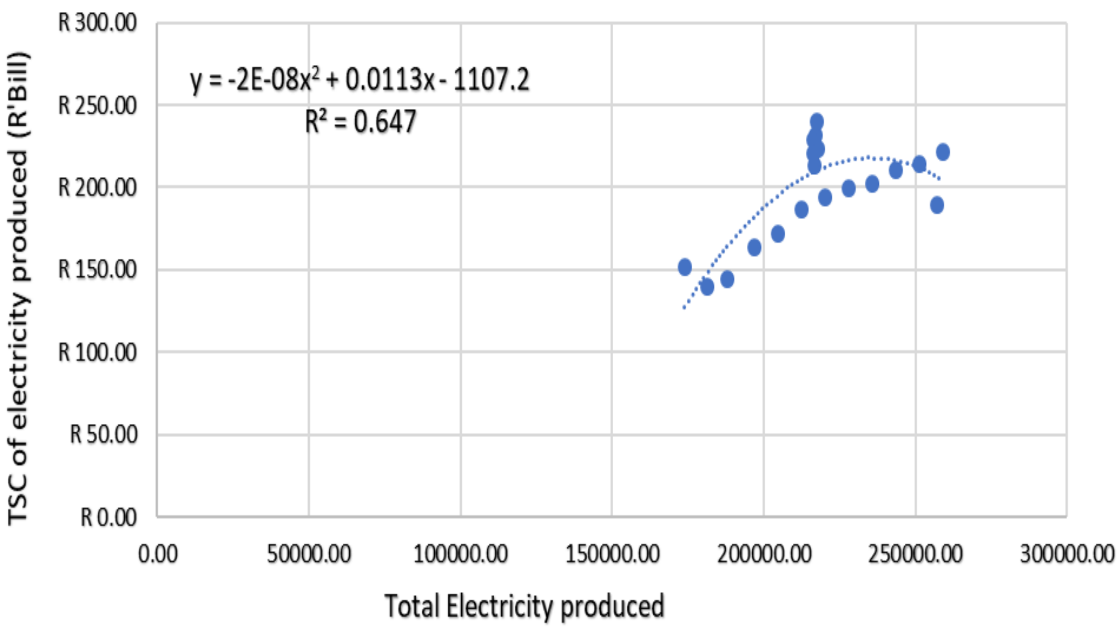

Figure 4.3: Scatter plot of cost of electricity vs Total electricity produced (sold)

Source: Author's Estimation (2020)

From this graph, the equation of the Total Social Cost (TSC) generated from the trend line can be written as:

$$TSC = -2 \times 10^{-8}Q + 0.0113Q - 1107.2 \qquad \text{Eq. 4.1}$$

The second regression consisted of the statistical model of the total social benefit (Total revenue) of the electricity sold against the total electricity sold. Similar to the previous model, the scatter plot of this regression modelling is displayed in figure 4.4 below, and the predictive equation of the total social benefit in terms of the total quantity Q is given in equation 4.2.

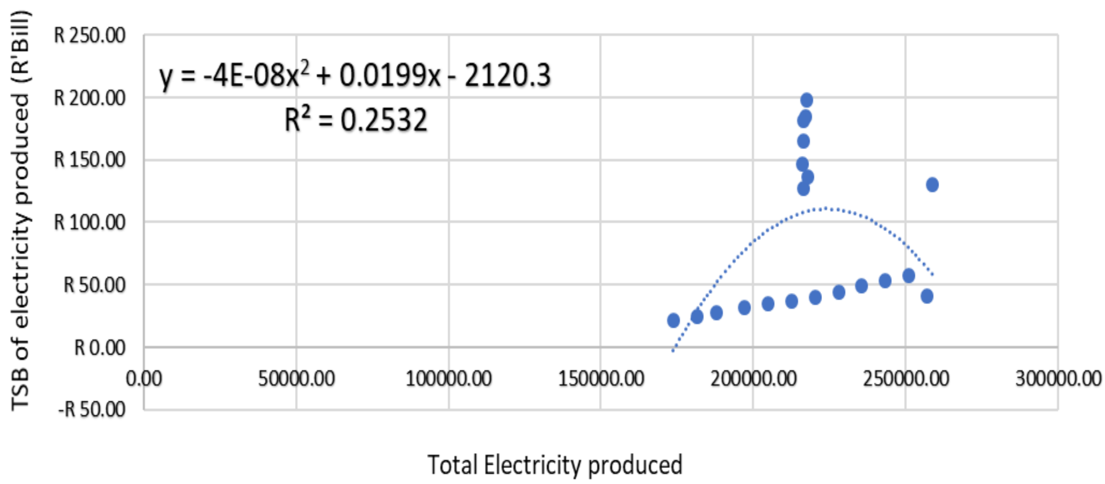

Figure 4.4: Regression analysis of the TSB of electricity vs electricity sold

Source: Author's Estimation (2020)

$$TSB = -4 \times 10^{-8}Q^2 + 0.0199Q - 2120.3 \qquad \text{Eq. 4.2}$$

As the ultimate objective of this section is to determine the optimal production level of electricity, the marginal total social cost (MSC) and the marginal total social benefits

(MSC) have been used. It is known that any production process reaches its optimal production level when the MSC equals MSB. Moreover, it is also known that MSC is the first derivative of TSC in regard to the production quantity (Q), which means the variation of MSC with a variation of one unit in the production quantity and with the same analogy, MSB is equal to the first derivative of TSB with regard to Q. With that being said, the following calculations have been done:

$$SC = \frac{dTSC}{dQ} = \frac{d\left(-2 \times 10^{-8}Q^2 + 0.0113Q - 1107.2\right)}{dQ} = -4 \times 10^{-8}Q + 0.0113 \qquad \text{Eq. 4.3}$$

$$MSB = \frac{dTSB}{dQ} = \frac{d\left(-4 \times 10^{-8}Q^2 + 0.0199Q - 2120.3\right)}{dQ} = -8 \times 10^{-8}Q + 0.0199 \qquad \text{Eq. 4.4}$$

Equating Equation 4.3 and 4.4:

$$MSC = MSB;\ therefore:\ -4 \times 10^{-8}Q + 0.0113 = -8 \times 10^{-8}Q + 0.0199 \quad \text{Eq. 4.5}$$

Therefore: $Q = 2.15 \times 10^5 = 215\ 000\ GWh$;

This means that the optimal production level is equal to $\mathbf{215\ 000}\ \boldsymbol{GWh}$

From the analysis above, marginal social cost seeks to find an equilibrium point where marginal social benefit is equal to marginal social cost. At this point, ESKOM bears the cost of emission or external cost and at this same time is able to produce at a capacity that ensures return on investment and profitability (Asiedu *et al.* 2019). The result shows that for ESKOM to be able makea profit, the optimum level of production is 2150000 Gigawatts per annum. This figure is also within the range of present capacity of ESKOM that produces 229200 gigawatts annually (The Eskom Factor 2015).

The graphical representation is shown in Figure 4.5

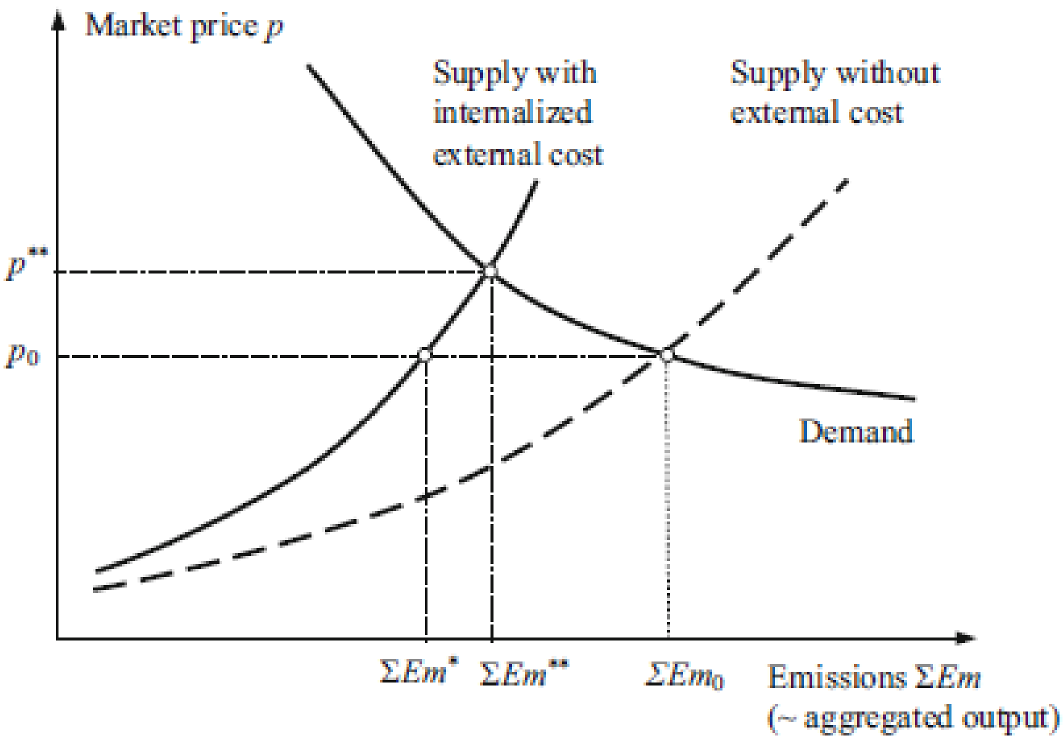

Figure 4.5 Optimum Production level with external cost internalised

Point B on Figure 4.4 is the optimum level of electricity production when emission costs are borne by ESKOM. Although ESKOM is currently running at a loss this might be due to inadequate maintenance of the plant and there are also possibilities of corruption, as reported by (Kessides, Bogetic and Maurer 2007)

4.3 Analysis to Achieve Objective 3: Evaluation of capital investment of ESKOM in coal power plants: environmental cost of coal in electricity production

The sum of the environmental cost of coal in electricity production over the additional production cost is the marginal unit cost, which describes the economic impact of the plant operator if production is to increase or decrease by one unit. The investment outlay and other expenditures are not affected by the production decision, such as personnel and administration that are irrelevant for the evaluation of short-term production decisions.

The evaluation of a long-term investment decision affects only the economic variables that might be considered. If a company plans for an incremental expansion of capacity, the cost of management should be excluded. However, the additional expected sales revenues per period are relevant to the sales generated by the investment. The capacity of electricity used is the optimum production level calculated in the second objective (Abu Jadayil, Khraisat and Shakoor 2017) The optimum production annual capacity is calculated to be 215000 Gigawatts.

The total revenue generated from the sales of the electricity at this level is determined as follows:

Selling price per Gigawatts (SP) multiplied by total Gigawatts produced at optimum level.

Selling price per gigawatt is arrived at by selling price per kilowatts multiplied by 1,000,000.Selling price per kilowatt hour is R0.92 X 1000000.

Therefore, selling price per Gigawatt is R920,000. Therefore the total revenue generated from 215000 gigawatt is 215000 GW x R920000, which gives R197, 800,000,000-00.

The interest rate used in this evaluation is 5.5%, due to the ability of ESKOM to negotiate lower interest rates on loans as a public entity and being and operator in a critical infrastructure. The capital outlay required to construct a coal power plant per Kilowatts is estimated as R47250 (Breeze 2010).

Therefore, to construct a coal power plant that can produce the optimum production of 215000 Gigawatt can be determined by multiplying the cost per Kilowatts by 1000 which is:

Total cost = 215000 X 47250 X 1000

Therefore, the total of constructing a coal power plant that will generate the optimum quantity of 215,000 GW of electricity is:

The sum of total cost = R10, 158,750,000,000.00

In determining the Net Present Value

$$\text{NPV}=CF_{oi}-\sum_{t=0}^{n}\frac{CF_{oi}}{(1+r)^{t}} \quad 4.7$$

NPV is Net Present Value

CF_{oi} is Capital outlay in the initial year

t is the duration or life expectancy of the power plant which is 30 years

r is the interest rate

CF_2 is the cash inflow which also represents the revenue generated to sales of electricity.

Since the cash inflow and revenue that is generated using the optimum capacity is equal throughout the life span of the coal plant, NPV is DCF for 30 years on 5% interest rate is 12.46

Present Value of all cash inflow over 30 years period is given by:

12.46 X197,800,000,000-00 = 2,464,588,000,000-00

Therefore the NPV is Capital outlay – Revenue,

= R10, 158,750,000,000.00 - R2, 464,588,000,000-00

= R1, 448,713,000,000-00

Findings

From the above calculation of the net present value, for a project to be accepted, it has to yield a positive NPV (Mellichamp 2019). The above result reveals that at the optimum level of production of 215000 Gigawatts, which includes the emissions cost that is internalised and borne by ESKOM, the investment in the coal power plant is still desirable (Wu *et al.* 2019). The net present value results in a positive value of R1, 448,713,000,000-00 over a 30-year period life span of the coal power plants. This also means that to some that are clamouring for the phasing out of coal power plants majorly due to it is profitability, level of investment and environmental impact, the above result does not agree with their assumption, but shows that coal power plants can still be in operation and still profitably operate as long as the optimum level of production is adhered to. Furthermore, this signifies that the investment in coal power plants is profitable.

4.4 Analysis to Address Objective 4: A Development of Model

In this research study, a mathematical model was developed for knowledge of measuring and quantifying coal power plants and the emission costs associated with it over the lifespan of the power plants, following a marginal social cost approach. A summary of the coal power station emissions and cost of the emission outcomes is presented. The important revelations from the regressions analysis between electricity generation and environmental emmsisions are summarised in Figures 4.6 to 4.8

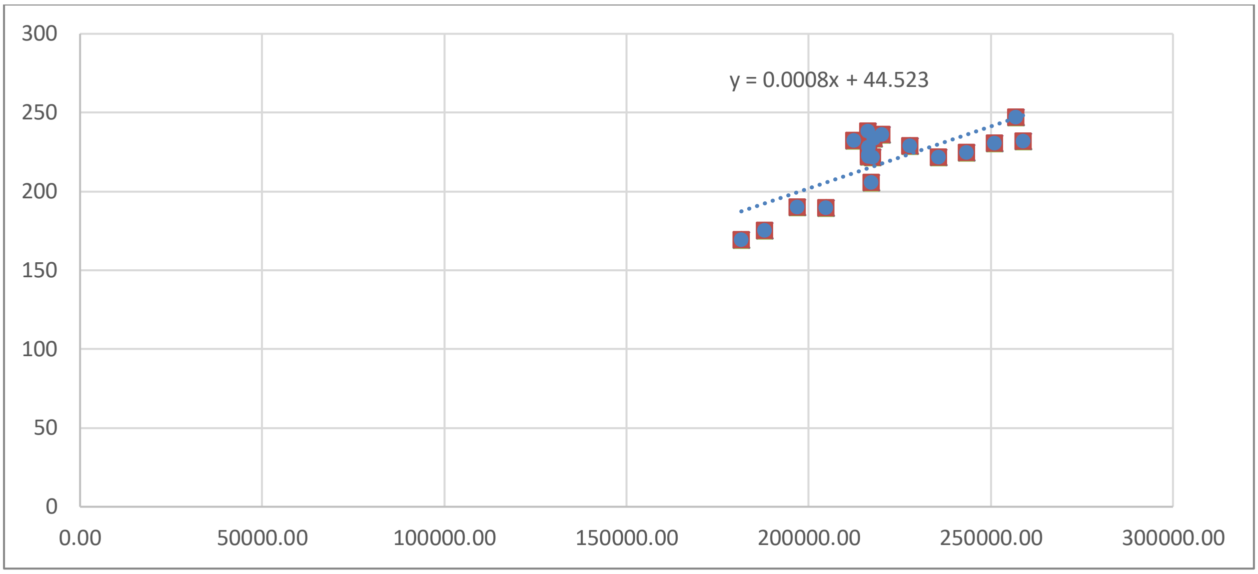

Figure 4.6: CO_2 emission in Mt Vs Electricity sold in GWh

Source: Author's Estimation (2020)

The emission discharges show that air pollution loads, CO_2 emissions were estimated at approximately 6,648 million tons over the coal power plants shown in Figure 4.6; 28,680 kilotonnes of NO_2 shown in Figure 4.7 and SO_2 emissions at 59,040 kilotonnes shown in Figure 4.8. Over 85% of the air pollutants emanated from the combustion phase.

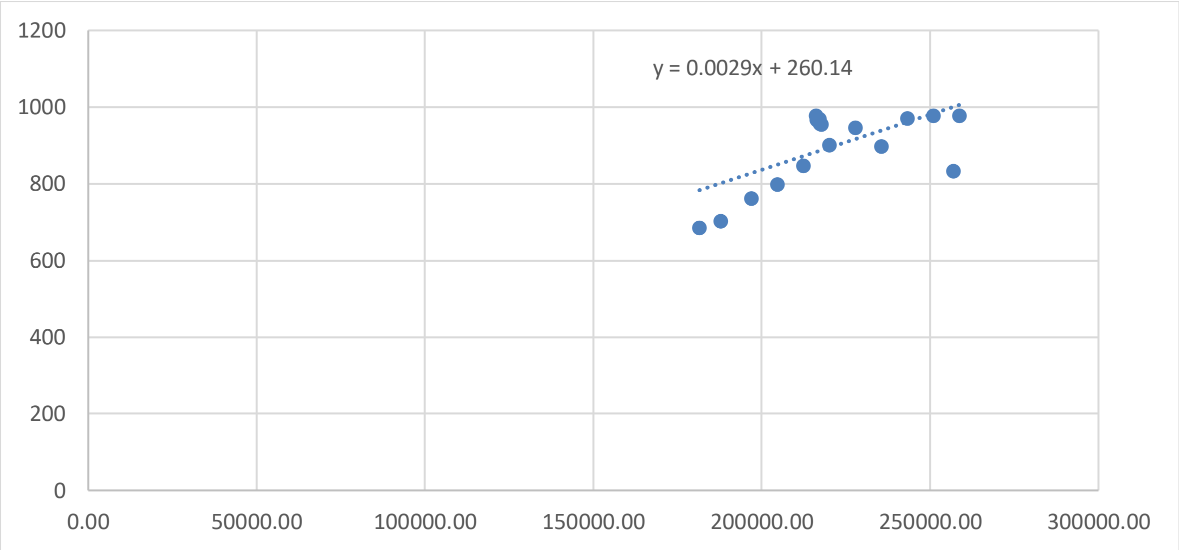

Figure 4.7 $N0_x$ emission in Kt Vs Electricity sold in GWh

Source: Author's Estimation (2020)

Allocating monetary values to the emissions yielded a base case total coal-power plants emission cost over the lifespan of ZAR7193.4 billion or 330.72c/kWh sent out. The emission costs of coal power plants ranged from ZAR139.04 to ZAR166.04 per KWh. (Nkambule and Blignaut 2017) arrived at the same amount in their previous study on emission cost. Considering the emission cost in this research study resulted in tripling the current electricity cost.

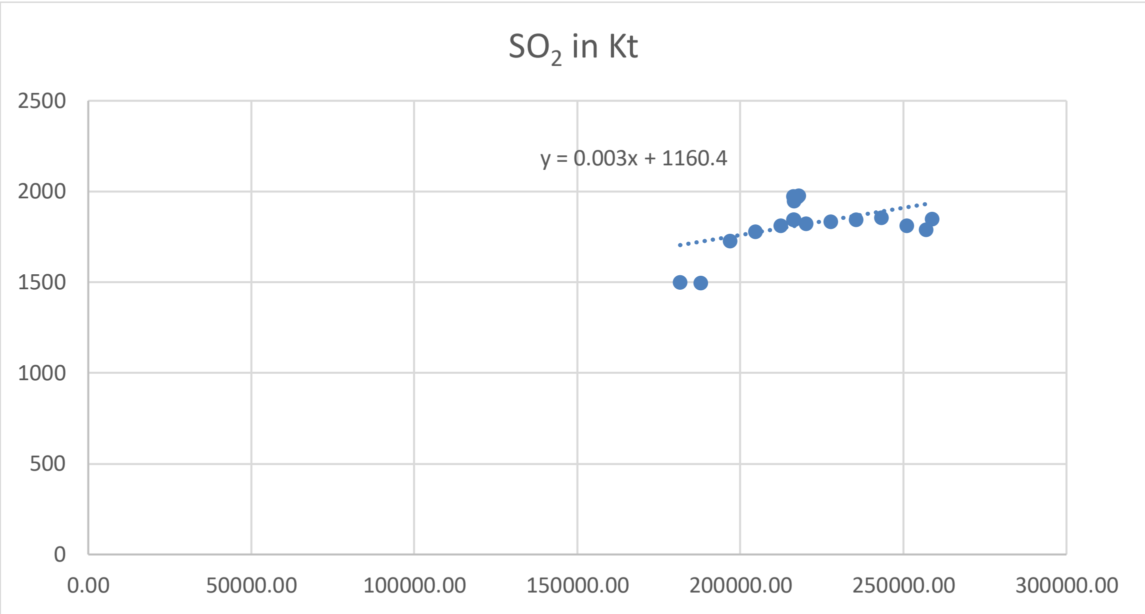

Figure 4.8 SO_2 emission in Kt Vs Electricity sold in GWh

Source: Author's Estimation (2020)

The coal power plants' emissions or external costs estimated for this research purpose is the lowest cost because other externalities such as road damage, particulates and noise pollution were not taken into account.

4.5 Chapter Summary

This chapter analyzed the data collected and presented the findings of this research study. Quantitative research was adopted as the research methodology. Moving average was used as the estimating technique in the study and regression analysis was used to analyze the data. From the findings, which are also in agreement with literature reviewed, coal power plants discharge harmful emissions and the cost of this emission can be reliably measured. It also showed that ESKOM bearing the cost of emission will increase the price of electricity and at the same time, bearing those costs cannot hinder ESKOM from operating profitably the coal power plants.

The succeeding chapter will summarize the work presented, and its significance to the study will be established. In addition, possible recommendations for curbing potential revenue losses will be proposed by the researcher.

CHAPTER FIVE

SUMMARY, RECOMMENDATIONS AND CONCLUSIONS

5.0 Chapter Overview

This chapter presents a summary of the key findings, makes recommendations and draws conclusions on concerns revealed from an assessment of the impact of environmental cost on the capital investment decisions of ESKOM South Africa. It also states the contribution of this research to existing knowledge, the study limitation and the areas for further research are also explained.

5.1 Summary of Findings

The availability of energy (electricity) is a critical factor in economic growth and the sustainability of production processes. The need to quantitatively measure the environmental risk and hazards associated with energy sources to the environment is useful in evaluating capital investmenst for decision-making. About 90% of electricity generation in South Africa is through the utilization of coal, which is regarded as a cheaper source of energy due to it is natural availability worldwide and abundant availablity in South Africa.

Capital investment decisions and techniques focused on risk and returns, but limited studies have considered the effect environmental cost on capital investment decisions. Over the years, the main focus has been on descriptive and qualitative information of environmental impacts of capital investments. This might be due to the lack of accurate information and data on environmental cost, which limits the ability of organisations to include these costs into their capital budgeting decisions. This research therefore, through the case study of ESKOM, examined the cost of emissions generated from fossil fuel and successively utilised this information to evaluate the feasibility and profitability of ESKOM's investment in coal power plants.

This research study was conducted as quantitative research, using mathematical Marginal Social Cost modelling to evaluate, estimate and analyse the environmental cost of emissions being discharged in ESKOM's coal power stations. The net present value (NPV) technique was used with the MSCM to evaluate ESKOM's capital investment in these coal power stations. In this research study, the marginal social cost mathematical model was developed based on knowledge of measuring and quantifying emission costs associated with the lifespan of the coal power plants. The model showed that in accounting for the emission cost, the price of electricity is now trebled over the lifespan of coal power plants. Therefore, the need to construct a coal power plant that takes the optimum level of production into consideration is required. Meanwhile, some technology that can be introduced to reduce the emission level should be evaluated and included in the coal power stations. **The benefit of the study is to contribute to an increased understanding of the feasibility and profitability of investment in coal-powered stations via environmental management accounting and marginal social cost approaches.**

The first chapter gives a detailed background and context for this study. It introduced the concept of environmental accounting as it applies to power generation. It focused on accounting for emission discharges by ESKOM's coal power plants. The background and framework that unpinned this study, which is marginal social cost and net present value techniques, was discussed in this chapter.

In the second chapter, various previous studies and research that presents e evidence that emission discharges from coal power plants are harmful to human and aquatic lives were reviewed. Theoretical reviews of theories such as marginal social cost, real option and investment theories were conducted. This chapter shows the effect of these emissions on the environment and the cost of these emissions are not being borne by ESKOM as it is transferred to the third party or final consumers of electricity. In order to ensure that ESKOM does not only discharge emissions, but also carries the cost of it by including the cost of these emissions in the electricity price, there is a need to reliably quantify the cost of emissions in monetary value. Various approaches have been adopted, such as traditional cost accounting techniques which could not accurately account and assigna cost to these emissions being generated by coal power plants. Moreover, many authors have advocated for the phasing-out of coal power plants as the only solution to reduce the negative impact of coal energy.

Marginal Social Cost is proven to be the model that can provide an accurate balance between ESKOM and the society. Marginal Social Cost seeks to equalize marginal cost to marginal benefit because a product such as electricity is categorized as a social amenity that is essential for basic living.

This research study was carried out to assess the impact of environmental cost on the capital investment decisions of ESKOM South Africa. In Chapter 3, details of the research methodology adopted were provided and it centers on the type of research-quantitative- research design, data collection methods and approach to objectives. It also discusses the paradigm and model used to achieved the objectives.

Chapter 4 of the study analyzed the data collected and presented the findings of this research study. Quantitative research was adopted as a method of research methodology. The Moving average was used as the estimating technique in the study and regression analysis was used to analyze the data. From the findings, which are also in agreement with the literature reviewed, this study shows that coal power plants discharge harmful emissions and the cost of this emission can be reliably measured. It also showed that ESKOM bearing the cost of emission will increase the price of electricity and at the same time, bearing those costs cannot hinder ESKOM from profitably operating the coal power plants.

This first type of statistical analysis consisted of looking at the data, sorting them out and applying some statistical tools to describe the collected data in order to provide clear and meaningful information. It is worth noting at this point that data of a period of 20 years have been collected (averaged) for this study. As a first descriptive, Figure 4.1 displayed the total electricity produced per year for the past 20 years, and in the secondary axis the cost per unit (in R/MWh) of electricity produced. It could be seen from this graph that the production has been increasing with a fairly constant rate up to the 2012, where the graphs displayed a drop in the quantity produced and the average production quantity was 218 494 GWh. On the other hand, the cost of electricity produced kept a constant increase from 2000 to 2019 with a maximum cost of R339 / MWh.

The second descriptive analysis conducted was about the carbon footprint of coal usage in the generation of electricity. On this, CO_2 emissions in Mt as well as NO_2 and SO_2 emissions in Kt were displayed to understand the quantity of these particles that were emitted every year during the generation of electricity using coal.

The emission discharges show that in the air pollution loads, CO_2 emissions were estimated at approximately 6,648 million tons over the coal power plants; 28,680 kiloton of NO_2 shown in Figure 5.2 and SO_2 emissions at 59,040 kilo tons. Over 85% of the air pollutants emanated from the combustion phase.

From the analysis above, marginal social cost sought to find an equilibrium point where marginal social benefit is equal to marginal social cost. At this point, ESKOM bears the cost of emission or external cost and at the same time is able to produce at a capacity that ensures returns on investment and profitability (Asiedu *et al.* 2019). The result shows that for ESKOM to be able to make profits, the optimum level of production is 2,150,000 Gigawatts per annum. This figure is also within the range of the present capacity of ESKOM that produces 2,292,000 gigawatts annually (The Eskom Factor 2015).

From the above calculation of the net present value, for a project to be accepted, it has to yield a positive NPV (Mellichamp 2019). The above result reveals that at the optimum level of production of 2,150,000 gigawatts, which includes the emissions cost that is internalised and borne by ESKOM, the investment in coal power plants is still desirable (Wu *et al.* 2019). The net present value results in a positive value of R1, 448,713,000,000-00 over a 30-year period life span of the coal power plants. This also means that to some that are clamouring for the phasin- out of coal power plants majorly due to it is profitability, level of investment and environmental impact, the above results do not agree with their assumption, but shows that coal power plants can still be in operation and still be profitably operated as long as the optimum level of production is adhered to. This therefore signifies that the investment in coal power planst is profitable.

5.2 Recommendations

From the findings of this research study, the following recommendations are advocated:

i. That ESKOM should collect information and data on emissions being discharged by the coal power plants operated by the entity.
ii. ESKOM should reliably assign the monetary value to each emission that is being discharged by the various coal power stations.

iii. The emission cost must be included in the cost of producing electricity through coal, as this will show the true value of electricity produced.
iv. Rather than phasing-out coal power plants due to it is environmental impact, ESKOM should plan and construct the capacity of their power plants to the optimum production level achieved in the second objective.
v. ESKOM can still continue to invest in coal power plants with optimum capacity, as this investment yielded a positive net present value result.

5.3 Conclusion

Although coal as amethod of generating electricity is an integral part of everyday human lives, the utilization of coal for electricity production comes with a negative impact on both human and aquatic life that is more than the value being paid for electricity. In this research study, a marginal social cost mathematical model was developed based on knowledge of measuring and quantifying emission costs associated with the lifespan of coal power plants. The model showed that in accounting for the emission cost, the price of electricity is now trebled over the lifespan of coal power plants.Therefore, the need to construct coal power plants that take the optimum level of production into consideration is required. Meanwhile, some technology that can be introduced to reduce the emission level should be evaluated and included in coal power stations. These technologies should be further investigated in future studies to determine the new optimum level.

5.4 Contribution to Knowledge

This research study has contributed to knowledge in three major aspects. Firstly, it has provided insight into various emissions being discharged by coal power plants. Secondly, this study diverted the attention from phasing-out coal power plants due to itsperceived negative environmental impact,. However, through the application of the Marginal Social Cost mathematical model, coal power plants can still be operated at an optimum level of production.

Thirdly, the study has contributed to knowledge by including environmental cost or emission cost into capital investment evaluation decisions on coal power plants.

5.5 Limitation of the Study

The major limitation of this research study is the inability to include more than three types of emission as more emissions are being discharged by coal power plants, such as particulates. Additionally, access to other cost impacts of emission apart from health cost are borne by society. Certain financial information data were not available to provide more accurate data for the evaluation of capital investment decisions, such costs include depreciation and amortization, labour cost and other operating expenses. It is pertinent to say that this limitation is in no form negatively affecting the potency of the findings of this study.

5.6 Suggestions for Further Research

Further research studies should be carried out to include the cost of other emissions in the environmental cost or external cost. Moreover, the direct labour cost in the power generation section should also be considered to be able to determine the true cost of electricity and lastly, costs such as operating expenses, depreciation and other production expenses should be included when evaluating capital investment decisions of ESKOM.

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DUT DURBAN UNIVERSITY OF TECHNOLOGY

Assessing the Impact of Environmental Cost on Capital Investment Decision Making of Eskom, South Africa.

Submitted in fulfilment of the requirements of the Master of Accounting degree in the Department of Management Accounting, Faculty of Accounting and Informatics, Durban University of Technology, Durban, South Africa

By

Toyese Titus Oyewo (21951330)

June 2020

Supervisor: Dr. Odunayo Margaret Olarewaju

Co-supervisor: Ms. Melanie Cloete

1

1	Year	Total Electricity sold GWh	Total Electricity sold (MWh)	Total Electricity sold (KWh)	Cost of electricity sold (R/MWh)	TC (excl. Ce) in R'Bill	CO2 emission in Mt	Cost of CO2 emission (in R'Bill)	NO2 in Kt	Cost of NO2 emission	SO2 in Kt	Cost of SO2 emission	Total external cost	TSC (Incl Ce) in R'Bill	Selling Price of electricity in Cent/KWh	Selling Price of electricity in R/KWh	TSB/TPB/TR (R'Bill)
2	2019	217508,22	217508222,22	217508222222,2220	339,00	R73,74	221,6	R24,35	956	R40,11	1968	R101,59	R166,04	R239,78	90,78	0,91	R197,45
3	2018	217199,67	217199666,67	217199666666,6670	309,00	R67,11	205,5	R22,58	968	R40,61	1970	R101,69	R164,88	R232,00	85,06	0,85	R184,75
4	2017	216561,00	216561000,00	216561000000,0000	293,00	R63,45	223,4	R24,55	964	R40,44	1946	R100,45	R165,44	R228,89	83,60	0,84	R181,04
5	2016	216417,50	216417500,00	216417500000,0000	287,00	R62,11	222	R24,40	966	R40,53	1972	R101,79	R166,71	R228,83	76,24	0,76	R165,00
6	2015	216274,00	216274000,00	216274000000,0000	269,67	R58,32	238	R26,15	977	R40,99	1845	R95,24	R162,38	R220,70	67,91	0,68	R146,87
7	2014	217903,00	217903000,00	217903000000,0000	256,56	R55,90	233,3	R25,64	954	R40,02	1975	R101,95	R167,61	R223,51	62,82	0,63	R136,89
8	2013	216561,00	216561000,00	216561000000,0000	244,41	R52,93	227,9	R25,04	965	R40,48	1843	R95,13	R160,66	R213,59	58,49	0,58	R126,67
9	2012	258856,00	258856000,00	258856000000,0000	230,21	R59,59	231,9	R25,48	977	R40,99	1849	R95,44	R161,91	R221,51	50,27	0,50	R130,13
10	2011	251121,50	251121500,00	251121500000,0000	217,06	R54,51	230,3	R25,31	977	R40,99	1810	R93,43	R159,73	R214,23	23,05	0,23	R57,88
11	2010	243387,00	243387000,00	243387000000,0000	203,89	R49,62	224,7	R24,69	969	R40,65	1856	R95,80	R161,15	R210,77	21,88	0,22	R53,26
12	2009	235652,50	235652500,00	235652500000,0000	190,73	R44,94	221,5	R24,34	896	R37,59	1844	R95,19	R157,12	R202,06	20,71	0,21	R48,81
13	2008	227918,00	227918000,00	227918000000,0000	177,22	R40,39	228,9	R25,15	945	R39,64	1832	R94,57	R159,36	R199,76	19,54	0,20	R44,55
14	2007	220183,50	220183500,00	220183500000,0000	163,95	R36,10	236,1	R25,95	899	R37,71	1820	R93,95	R157,61	R193,70	18,37	0,18	R40,46
15	2006	212449,00	212449000,00	212449000000,0000	150,63	R32,00	232	R25,49	846	R35,49	1812	R93,53	R154,52	R186,52	17,21	0,17	R36,56
16	2005	256959,00	256959000,00	256959000000,0000	137,27	R35,27	247	R27,14	832	R34,90	1789	R92,35	R154,39	R189,66	16,04	0,16	R41,22
17	2004	204714,50	204714500,00	204714500000,0000	123,95	R25,37	189,5	R20,82	797	R33,44	1779	R91,83	R146,09	R171,46	17,26	0,17	R35,33
18	2003	196980,00	196980000,00	196980000000,0000	110,61	R21,79	190,1	R20,89	760	R31,88	1728	R89,20	R141,97	R163,76	16,08	0,16	R31,67
19	2002	187957,00	187957000,00	187957000000,0000	97,28	R18,28	175,2	R19,25	702	R29,45	1494	R77,12	R125,82	R144,11	14,98	0,15	R28,16
20	2001	181511,00	181511000,00	181511000000,0000	83,95	R15,24	169,3	R18,60	684	R28,70	1500	R77,43	R124,73	R139,97	13,76	0,14	R24,98
21	2000	173776,50	173776500,00	173776500000,0000	70,61	R12,27	183,5442	R20,17	764	R32,05	1681,73	R86,81	R139,03	R151,30	12,54	0,13	R21,79

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Year	Qty of electricity produce	Cost of electricity sol	Differenc	Moving Avg of differences		Total Electricity sold GWh				Selling p	Differenc	Moving Avg of differences		
2	2019		R339,00				R217 508				90,78		5,7167		
3	2018		R309,00	R30			R217 200	R639	R309		85,06	1,46	6,9267		
4	2017		R293,00	R16			R216 561	R144	R639		83,60	7,36	5,9167		
5	2016		R287,00	R6			R216 418	R144	R144		76,24	8,33	5,88		
6	2015		R269,67	R17,33	R17		216274	R1629	R144		67,91	5,09	13,256		
7	2014		R256,56	R13,11	R13,11		217903	-R1342			62,82	4,33	12,203		
8	2013		R244,41	R12,15	R12,15		216561				58,49	8,22	9,8525		
9	2012		R230,21	R14,20	R14,20		R258 856				50,27	27,219	1,1687		
10	2011		R217,06	R13,15	R13,15		R251 122				23,05	1,1693	1,1693		
11	2010		R203,89	R13,17	R13,17		R243 387		R7 735		21,88	1,1686	1,1686		
12	2009		R190,73	R13,17	R13,51		R235 653	R7 735	R7 735		20,71	1,1681	1,1681		
13	2008		R177,22	R13,51	R13,27		R227 918	R7 735	R7 735		19,54	1,1711	1,1711		
14	2007		R163,95	R13,27	R13,32		R220 184	R7 735	R7 735		18,37	1,1667	1,1489		
15	2006		R150,63	R13,32	R13,37		R212 449	R7 735	R7 735		17,21	1,1667	1,1667		
16	2005		R137,27	R13,37	R13,32		256959	R52 245			16,04	-1,22	1,1667		
17	2004		R123,95	R13,32	R13,33		R204 715	R7 735			17,26	1,18	1,18		
18	2003		R110,61	R13,33	R13,34		196980	R9 023	R7 735		16,08	1,1	4,9933		
19	2002		R97,28	R13,34	R13,33		187957	R6 446			14,98	1,22	1,22		
20	2001		R83,95	R13,33	R13,33		181511				13,76	1,22			
21	2000		R70,61	R13,33	R13,33		R173 777				12,54	12,54			

<u>EDITING LETTER</u>

696 Clare Road

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4091

30 November 2020

To: Whom it may concern

Editing of Master's Thesis: Toyese Titus Oyewo (21951330)

The Effect of Environmental Cost on the Capital Investment Decision-Making of the Electricity Supply Commission, South Africa

This letter serves as confirmation that the aforementioned thesis has been language edited.

Any queries may be directed to the author of this letter.

Regards

MP MATHEWS

Lecturer and Language Editor: DUT

mercillenem@dut.ac.za