USING ENVIRONMENTAL MANAGEMENT ACCOUNTING TO INVESTIGATE BENEFITS OF CLEANER PRODUCTION AT A PAPER MANUFACTURING COMPANY IN KWADAKUZA, KWAZULU NATAL:

A CASE STUDY

By

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DECLARATION

I, Mishelle Doorasamy declare that this dissertation is a representation of my own work both in conception and execution. This work has not been submitted in any form at another university or higher institution of higher learning. All information cited from published or unpublished works have been acknowledged.

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ABSTRACT

Environmental degeneration, market pressures and stricter regulation and waste legislation has placed organizations under tremendous pressure to change their current processes and adopt cleaner production (CP) techniques and technologies. However, in countries like South Africa, CP implementation still remains low. In light of this problem, the government has made efforts to promote CP among industries by forming a support structure called the RECP (resource efficient cleaner production), as a strategy to encourage organizations to embrace this change and move away from the tradition end-of-pipe technologies towards CP technologies.

This study is based on a case study of a paper manufacturing company in Kwadakuza, KwaZulu-Natal. The aim of this study was to use Environmental Management Accounting (EMA) to identify benefits of CP. Paper manufacturing consumes large amounts of natural resources and generates excessive wastes. Hence, the operational activities of paper mills have a negative environmental impact. However, the scope of this study was limited to the steam generation process and focused mainly on the efficiency of the current coal-fired boilers used in the boiler plant. The research methodology used in the study was both quantitative and qualitative involving triangulation. Data was collected by means of a questionnaire, semi-structured interviews and documentary review.

The company uses old, obsolete boilers to generate steam. It had been discovered during a cleaner production assessment (CPA) of the process that the process uses large amounts of coal and generates excessive boiler ash (waste). This boiler ash also contains approximately 20 percent unburned coal present resulting in major losses to the company. Furthermore, the company has also experienced regular breakdowns during the year resulting in loss in production and high maintenance costs.

Hence, it was concluded that the steam generation process was inefficient and that the boilers were not operating as per technological specification.

However, management was unaware of the huge losses incurred due to raw material losses, more especially the coal used in the process. Environmental costs were also inaccurately calculated and thus underestimated. Hence, the 'true environmental' costs were not considered during strategic decision making.

Over the last two decades, EMA has emerged as an important approach by organizations wanting to improve their environmental and economic performances. However, despite the many pilot projects conducted that demonstrated the positive impact that EMA has on an organization, EMA implementation remains slow and lagging in South Africa. EMA is an environmental management tool that traces environmental costs directly to the processes and products that are responsible for those costs, thereby highlighting problem areas that need to be prioritized when considering the adoption of CP. The literature review on the role and impact of implementing EMA and the benefits of adopting CP was presented to determine and outline views and findings of past researchers. Previous researchers identified that traditional costing systems did not adequately account for the actual environmental costs incurred by companies as much of these costs were hidden under overhead accounts. Hence, production costs were high, resulting in incorrect profit margins being set and ultimately impacting on company profitability. The main cause of this was that non-product output costs were added to production cost instead of being separately recorded as 'non-product' output. These costs are actually environmental costs as they represent waste.

Material Flow Cost Accounting (MFCA), a tool of EMA, was considered as an appropriate method to implement to accurately calculate non-product output costs. MFCA made managers aware of the true magnitude of their losses and inefficiencies of current technology by increasing the transparency of non-product output costs (environmental costs).

MFCA was further used to benchmark non-product output costs against technological standards and best available technological standards to highlight the economic and environmental benefits of adopting CP techniques and technologies.

Based on the findings, one recommendation is that the company should consider restructuring their conventional costing system and adopt an EMA system instead. The use of an MFCA model had been suggested. This model was used by the Economy, Trade and Tourism industry in Japan to identify non-product output and improve efficiency of production processes. In addition, findings revealed that the company should implement CP techniques in the short-term to ensure that boilers are functioning according to technological specification. This will result in economic and environmental benefits for the company. However, greater savings potential is available in the long-term, by changing current technology and adopting state-of-the-art technologies. This would, however, require greater investment needs of the company to taken into consideration during strategic decision making.

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ABBREVIATIONS

BAT – Best Available Technology

CP – Cleaner Production

CPA – Cleaner Production Assessment

CPT – Cleaner Production Technology

CT – Cleaner Technology

DTI – Department of Trade and Industry

EMA – Environmental Management Accounting

EMS – Environmental Management Systems

FCA – Flow Cost Accounting

IPPC – Integrated Pollution Prevention Control

JT – John Thompson

MFCA – Material Flow Cost Accounting

NCPC – National Cleaner Production Centre

NPO – Non-Product Output

RECP – Resource Efficiency and Cleaner Production

SD – Sustainable Development

UNDSD – United Nations Division of Sustainable Development

UNEP – United Nations Environmental Programme

UNIDO – United Nations Industrial Development Organisation

CHAPTER 1

INTRODUCTION AND OVERVIEW OF THE STUDY

1.1 Introduction and context of the study

In many developing countries, an increase in industrial activity, electricity demand and transportation results in emissions and poor air quality has become a major issue (Stringer 2010:34-35). Higher energy and raw material prices are causing cleaner production to grow in relevance and importance. Cleaner Production (CP) focuses on improved productivity and reduced impact as the result of design over the life of products, processes and services (National cleaner production strategy 2004:11; Lakhani 2007:1391). The amount of waste to landfill is increasing steadily.

Most companies are using inefficient processes and technologies that are obsolete instead of state-of-the art processes, resulting in higher production costs, which, in turn, affect their profitability and competitiveness (Schaltegger, Bennett, Burritt, and Jasch.2010:10-11). Managers of paper mills perceive investments in pollution abatement technologies as ‘unproductive’ because they have ‘no marketable and quantifiable effect in terms of productivity’ (Bras; Realff and Carmichael 2004), resulting in the omission of the use of cleaner production opportunities (Baas 2007:1216). Large savings potential and opportunities for CP to address environmental issues successfully are not easily identified by companies since there is no monitoring and data collection in place. The benefits of using Environmental Management Accounting (EMA) have been established in several business cases as an environmental and sustainability tool to collect, evaluate and interpret the information needed to estimate the potential for CP saving with particular emphasis on non-product output costs and to make decisions to choose the right CP options.

However, the level of implementation of EMA in practice is low because of the significant gap in academic knowledge concerning EMA and its role in identifying inefficiencies in the production process and benchmarking environmental costs to yield superior environmental and economic performance (Ferreira, Moulang, and Hendro 2010:920-948; Burritt, Herzig, and Tadeo 2009:431-439; Christ and Burritt 2013:165; Schaltegger *et al*. 2010:11-15; Thant and Charmondusit 2010:427-439; Chiu and Leung 2002:10; V'an 2012:3).

Although CP has proven to be a good tool, it has not yet been well implemented internally. South Africa's commitment to CP led to the formation of the United Nations Industrial Development Organisation (UNIDO) and the National Cleaner Production Centre (NCPC). The NCPC-SA strategy, which focuses on assisting industry to implement CP which requires investment in cleaner technologies, was confirmed at the CP conference which took place in Gauteng in June 2013 (Delano 2013:4). Resource efficiency and cleaner production (RECP) has been integrated into NCPC-SA centres' services. RECP includes energy efficiency, life cycle assessments and environmental accounting (South African Cleaner Production Centre 2013:2).

1.2 Definitions and terminology

For the purposes of this study, the following two definitions are relevant:

1.2.1 Environmental Management Accounting (EMA)

EMA is a broader concept of accounting and an approach to corporate environmental information management which uses accounting tools and practices to support company-internal management decision making on environmental issues and its impact on company performance (Schaltegger, Bennett, Burritt, and Jasch 2010:2).

It also provides the information needed by managers to identify CP opportunities in their companies by accurately calculating and reallocating the cost to the relevant products and processes. This will allow for inefficient processes with high environmental impact to be identified.

1.2.2 Cleaner Production (CP)

According to the United Nations Environmental Program (UNEP), CP is defined as follows: “Cleaner Production can be described as a preventative, integrated strategy in which costly end-of-pipe pollution control systems are replaced by measures which reduce and avoid pollution and waste throughout the entire production cycle, through efficient use of raw materials, energy and water and emissions of any kind at the source rather than dealing with them at a later stage”. Aims of CP are to use resources more efficiently, reduce the amount of undesired outputs and improve monetary returns by reducing material and energy consumption. Capital investment may be required to adopt CP (Schaltegger *et al*. 2010:7).

1.3 Problem statement

The paper and pulp manufacturing process of the company, on which the case study is based, consumes large amounts of natural resources and also generates excessive waste. The rising costs input resources and increasing environmental cost had a negative impact on the companies’ profitability (Cost Accountant 2013).

The company has invested large amounts of money on end-of-pipe technologies and the wastewater treatment plant to reduce the negative impact of their production processes on the environment. This has, however, not solved their environmental issues nor has it reduced their resource use in production. The technology used in the steam production process is outdated and obsolete and generates between 20 to 60 tons of unburned coal ash as hazardous solid waste daily.

The company also uses large amounts of water in their production process, resulting in even larger amounts of wastewater effluents, a sign of inefficient production (Environmental manager 2013).

To ensure their future sustainability and competitiveness, management needs to consider adopting CP techniques and technologies which will address waste issues at its source. According to the CP philosophy, which focuses on resources and resource flows, any reduction in material and energy used will result in fewer emissions (Christ and Burritt 2013:163). CP is perceived by management as a costly strategy that requires innovation with no financial returns to the company in the short-term. They are unaware of how high their environmental costs are, since the company uses conventional accounting methods to allocate costs. EMA can be used as a tool to systematically trace and accurately reallocate environmental costs to the relevant processes and products to enable managers to identify opportunities for implementing CP and thus improve their environmental and economic performance. Information needed to estimate the potential for CP savings was facilitated by making use of material flow analysis, a tool of EMA to allocate environmental and material flow costs (Jasch 2009:2).

1.4 Aim and objectives

1.4.1 Aim

The aim of the study is to use EMA as a tool to identify potential environmental and economic benefits of adopting CP techniques and technologies in a manufacturing company.

1.4.2 Objectives

Emanating from the aim, this study has the following four objectives:

- To conduct a Cleaner Production Assessment (CPA) of the companies' current production process using process flow sheet analysis in order to identify any operational inefficiencies and barriers to CP implementation, assess their current environmental performance, and to benchmark the company's environmental costs by comparing energy and mass balance indicators against technological standards and best-available technology;

- To demonstrate the role and importance of EMA in sustainable development and to assess the efficiency and environmental impact of the current technologies being used in the production process;
- To identify barriers to CP implementation and highlight the potential benefits of adopting CP technology as compared to end-of-pipe technology based on primary and secondary literature as well as empirical findings; and
- To identify CP options available to management and other stakeholders by demonstrating the potential environmental and economic benefits of CP processes and technologies, and to make recommendations that will assist the company in their strategic decision making process.

1.5 Research Questions

This study is based on the following research questions:

1. Are the boilers used in steam generation process operating efficiently? If not, what are the operational inefficiencies that was identified during the Cleaner Production Assessment (CPA).
2. What are the barriers to CP implementation?
3. Does the company use technological standards as benchmarks to assess the environmental performance of their current technology?
4. Does the company use conventional costing systems (CCS) or an environmental management system (EMA) to calculate environmental costs?
5. What are the barriers to the adoption of an EMA system and to invest in CP technologies?

6. Are environmental costs regularly measured and monitored against technological standards to ensure that technology is functioning optimally?
7. Are environmental costs reflected as production costs and hidden under general overhead costs in financial statements?
8. Are there regular communication and exchange of information between the accounting department, production department, technical managers' and the environmental team?
9. Are managers aware of the potential benefits of CP implementation?
10. Do managers take into consideration the benefits of investing in CPT during strategic decision making?

The questions listed above informed the research and guided the data collection.

1.6 Rationale for the study

Waste and emissions are a sign of inefficiency in production. Waste is expensive because of wasted material purchase value and not because of disposal fees (Jasch 2009:2). Although most companies are ISO14001 certified due to strict environmental regulations and market pressures, they are still not prepared to change production processes by moving towards CP technologies. Many have adopted end-of–pipe technology as part of their sustainable practices. However, end-of-pipe technologies only address the problems after the process. They do not address the cause of the problem. This leads to eventual accumulation of waste in landfill sites which only shifts the focus of the real problem.

In order for a company to remain sustainable and to achieve eco-efficiency in their production processes, there is an urgent need to adopt CP techniques and technologies as part of the strategy towards sustainable development.

As part of the requirement of ISO14001, it is critical that companies look at ways to achieve sustainable competitive advantage by improving their production process by implementing the use of clean technologies that reduce their raw material input, thereby resulting in lower amounts of waste or, at times, no waste at all.

This will ultimately result in improved environmental performance and increased economic performance (Radonjic and Tominc 2007:1482-1493).

Eco-efficiency results in the company saving on their input material as well as having reduced costs for disposing of waste to landfill. Hence, there is likely to be financial and environmental benefits related to CP technologies (Foelkel 2008:5).

The question then raised is that if there are both environmental and economic benefits to cleaner technologies, why are companies reluctant to adopt such technologies as part of their business processes/operations?

The issue is that most companies are seeking to achieve short-term profitability instead of trying to find ways to ensure their long-term sustainability. Investing in environmental technology is costly with no real payback. Hence, most financial managers are reluctant to take the risk of high investment costs with no viable financial return. Accountants and financial managers need to be made aware of the costs associated with unsustainable production processes, that is, ‘environmental costs’.

Managers are more focused on cost-reduction options using existing technology. Cleaner technologies are more efficient as they prevent emissions at the source.

If a solution is adopted that does not reduce environmental impact by 100%, then it is most likely to be an end-of-pipe treatment, which does not solve the problem at its source, but shifts it to another environmental media, for example, dust filters that reduce emissions to the air by capturing components which are washed out by rainwater and when the filters are dry, they are disposed of on landfill. These approaches are costly and inefficient (Jasch 2009:2). However, relatively newer technologies are unlikely to be replaced by cleaner technologies even if they can result in improved environmental and economic performance. Therefore, when benchmarking environmental costs, life-cycle of existing technology must be considered.

In the short-term, good housekeeping measures or minor improvements are preferred as part of CP strategy. In the medium-term, it makes sense that a company may change technology and get closer to state-of-the art of the industry. It is only in the long-term that companies will consider changing state-of-the art to get closer to the ideal world of zero emissions where all inputs become part of the product. Theoretical standards are used to reflect this ideal world with no waste (Schaltegger *et al*. 2010:144-145).

This study will add to the body of knowledge on CP and sustainable development. At the conclusion of this study, managers will be able to evaluate and analyse how they can improve both their environmental and economic performance in the future and attain their sustainability targets, hence the ‘triple bottom line’ approach. The ‘triple bottom line’ means that an organisations success is based on their economic, social and environmental performance. This approach states that improved competitive advantage will result in higher profitability, which, in turn, will benefit employees, managers and other stakeholders in the company.

1.7 Scope of the study/ delimitation

The study will focus on a paper manufacturing company based in Kwadakuza, KwaZulu-Natal.

The only area of investigation on CP technology during the study was limited to the boilers, as this was identified by the company as a ‘problem’ that needed to be prioritized during, the research project.

Environmental cost used in payback calculation for this project was limited to two factors: 1) Disposal cost of bottom boiler ash (transportation to landfill and handling cost of waste); and 2) Raw material (coal) loss to establish non-product output values (Material Flow Cost Accounting (MFCA) model used to evaluate this cost). The study did not apply the MFCA model to any other technology used in the production process.

This focus of this study is limited to the material loss in the form of non-product output. The energy cost will not be considered during this study.

Water cost will also be excluded from the loss analysis, as the water cost associated with the process is negligible since most of the water turns into steam and the small amount that is condensed is collected and goes back into the boilers. Hence, wastewater cost during this process is not significant enough to be considered. Therefore, based on the explanation provided, the researcher had decided to focus primarily on the coal used as raw material in calculating the value of the non-product output.

1.8 Research design and methodology

1.8.1 Research Design

A case study research methodology was followed in this study involving quantitative data assessment and exploratory qualitative research analysis technique which was applied to generate theory from collected data.

The CP assessment framework was used to capture data during the CP audit process as per the CP model. A walk through inspection of the organization's production facility was conducted to identify various waste streams and to highlight areas of concern which result in larger waste streams.

The study is based on a case study following a multi-method approach, that is, method triangulation. The researcher implemented both qualitative and quantitative data analysis methods during the study. Case study research leads to more informed basis for theory development.

According to Zikmund (2004:173), this methodology provides data for building theory that contributes to existing knowledge by analysis from another perspective.

A case study is an empirical inquiry that:

- Investigates a real-life phenomenon in depth under certain contextual conditions;
- Relies on multiple sources of evidence, converging data in a triangulating fashion; and
- Adopts prior theoretical propositions to guide data collection and analysis (Yin 2009:62).

1.8.2 Target population

Although the company employs approximately 300 employees, the study targeted only those involved in environmental management issues, production, operations, accounting and cost control.

1.8.3 Census study

Since managers are the only respondents who can provide the required data for this study, the researcher elected to conduct a census study. A census is an investigation of all the individual elements that make up the population (Zikmund 2004:369).The census included all members of the management team including top management, middle-level managers and frontline managers. The composition of the census population is shown in Table 1.1.

Table 1.1: Composition of census population

DEPARTMENT/ LEVEL	TOTAL POPULATION	SAMPLE NUMBER
Operations/Production	25	25
Plant foreman	4	4
Cost Accounting/control	10	10
Environmental manager	1	1
TOTAL	**40**	**40**

Welman, Kruger and Mitchell (2005:71) state that a sample size of 30 is adequate for obtaining valid and reliable results.

1.8.4 Data collection methods

This research involved both quantitative and qualitative methodology. Both primary and secondary sources were used to collect information for the purpose of this study.

A systematic observation, a questionnaire and interview were used to collect data. Qualitative methodology comprise of interviews, and observation, and quantitative methodology involved the use of questionnaires and quantified input and output material flows using mass flow balance.

It was suggested by Yin (2009:76) that the triangulation approach to data collection enhances accuracy as it involves a combination of three approaches, use of questionnaires, interviews and systematic observation. The triangulation method increases confidence in research data and establishes validity.

1.8.5 Questionnaire design

The literature review was used to inform the questionnaire. Questions used were predominantly Likert scale type questions, as they are easier, better analysed and allow statistics to be drawn for interpretation (Zikmund 2004:330-331). The questionnaire was formulated in English. Questions asked during interviews involved open-ended questions to allow respondents to speak their mind. Questions asked during the interview were of a more complex nature than the questions asked on the questionnaire.

1.8.6 Interviews and administration of questionnaire

Verbal, written or telephonic arrangements were used to conduct a few structured and unstructured interviews.

Interviews allow for face-to-face interaction with respondents, probe complex answers, gain the perceptions of respondents and gather more complete and precise information (Zikmund 2004:379). A reliable outcome was assured by personal distribution and collection of questionnaires. The populations used as well as data gathering methods used in the case study are appropriate for the phenomenon under investigation.

1.9 Data analysis

In order to analyse the information, the research used a number of tools such as tables, figures, models and charts. Statistical Package for Social Sciences (SPSS – version 22) – was used for descriptive and inferential statistics data analysis. Interviews were analysed using relevant statistical methods.

The case study could be repeated and the same results are expected to be achieved, hence it would seem that the case study is reliable (Quinlan 2011:197). Correct analysis procedures were used in the analysis of the data.

1.10 Ethical consideration

The study was conducted according to the research ethics policy and guidelines of the Durban University of Technology (appendix 8).

The ethics policy takes into consideration the anonymity, confidentiality, rights and voluntary participation of human subjects. Data gathered for the research will be held safely and securely. The case study was properly and thoroughly conducted (Quinlan 2011:197).

1.11 Structure of the chapters

This study is divided into six chapters.

1.11.1 Chapter 1: Introduction and overview of the study

Chapter one provided an introduction and background to the study, together with the aims and objectives of the study.

It established a framework for the research to be undertaken and also described the purpose and significance of the study and the manner in which the research would be conducted.

1.11.2 Chapter 2: Literature review on Environmental Management Accounting (EMA)

Chapter two provides the historical background of the organization and its current business activities. The company's environmental and economic performance is also discussed.

Sustainability and environmental initiatives undertaken by the company are also mentioned in this chapter. Furthermore, the development, advantages and challenges of EMA implementation is discussed.

Empirical evidence on environmental and economic benefits of adopting MFCA, an EMA tool, is also presented in the literature review.

1.11.3 Chapter 3: Literature Review on Cleaner Production (CP)

Chapter Three provides a review of the literature in which the global view and experience on EMA and CP processes is discussed. It refers to previous research that has been conducted using EMA to identify CP opportunities in companies that resulted in environmental and economic benefits to the organisations.

The material cited as evidence of theoretical framework on EMA and CP has been selected to substantiate the proposals made in the study, and refers to examples of organisations which have adopted these principles and processes.

1.11.4 Chapter 4: Research Methodology

Chapter four provides an in-depth view of the methodology employed to conduct the research, to indicate how data will be collected from various sources, how the data are integrated and analysed so as to arrive at conclusions and recommendations. It also includes the explanation of qualitative, quantitative and mixed-method research technique. A discussion of the study type, target population and sample size and selection is included in this chapter.

1.11.5 Chapter 5: Results and discussions

In chapter five, the findings of the study are discussed. It focuses on the analysis of the data and the presentation of the results. The facts uncovered are presented in this chapter.

1.11.6 Chapter 6: Recommendations and conclusions

Chapter six, the final chapter of the study, provides the conclusions of the study together with suitable recommendations.

CP options are provided to the company as well as the benefits of CP technologies and techniques will be brought to the forefront. Recommendations are made regarding areas for further study developing from this research.

1.12 Conclusion

This chapter provided an introduction and an overview of the research to be undertaken. The aims and objectives as well as a brief outline of the literature review and research methodology to be used in the study were also explained in this chapter.

The next chapter presents a detailed review on the organization’s activities and sustainability initiatives. The environmental and economic performance of the organization is also discussed.

CHAPTER 2

LITERATURE REVIEW: EMA

2.1 Introduction

This chapter is an important part of the research study as it relates to the existing body of knowledge and opinion. The purpose of the literature is fourfold, firstly, it ensures that the researcher is fully aware of what other research exists in the chosen field, secondly, it enables discussion on strengths and weaknesses of what other people have done in the relevant field, thirdly, it provides an established framework to which the researcher can refer to in order to design the current project, and, finally, it gives the researcher an opportunity to set their eventual findings alongside that which had been reported in the literature (Davies 2007:212). Prior to the collection of evidence in the work field, the relevant literature on the subject will be reviewed. This will allow the researcher to better define the research questions and explain the theories supporting the research study (Yin 2003:24).

This chapter contains background information about the industry and its environmental issues, quantitative data on the input resources and waste generation and provides an overview of the historical background of the company in this case study. Understanding the business operations and contextual factors of the organisation are important to this case study, as they provide one with a clearer picture of the environment in which the organisation operates.

Social, economic, and environmental performance are essential for a business to ensure its future sustainability. A brief overview of the company's social, economic, and environmental issues are discussed in this chapter. This will allow one to assess the level of performance of the organisation in terms of the 'Triple Bottom Line'.

Development of environmental management and the implementation of an EMA system to identify benefits of adopting CP processes are presented. Case studies and empirical evidence of companies that have successfully implemented EMA and MFCA to benchmark environmental costs against technological standards and best available technological (BAT) standards are brought to the forefront.

2.2 Company history

South African Pulp and Paper Industries Limited registered as a company in December 1936. The company further re-registered under its current name in 1973 and acquired Stanger Pulp and Paper in 1979. The company's corporate strategy is to dispose of non-core operations and to focus on conversion to reduce exposure to the declining coated wood free market to enable the company to expand in the growing and higher margin speciality paper segment. Strategic decisions are aimed at the company's commitment to substantially improve profitability and returns to all its businesses (Company history 2011:1-5). In March 2006, the manufacturing process was upgraded to 'Triple Green', first in the world, a fully integrated environmental practice introduced at a mill. The Southern African region owns about 380 000 hectares of commercial plantations with more than 35 million tons of standing timber from which it sources its wood fibre needs.

Responsible use and management of water resources are very important to pulp and paper operations. Water is used in all major process stages, including raw materials' preparation, pulp washing, and paper machines. It is used in process cooling, material transport, equipment cleaning and to generate steam for use in processes and on-site power generation. All water used is recycled many times, treated and returned to the environment. In the paper manufacturing industry globally, approximately 92% of process water is returned into the same rivers and lakes from which it was extracted (Paper and paper packaging 2011).

Growing awareness of environmental impact by shareholders, market and community has increased demand for natural and renewable products. Innovation, improved technology and lower production costs are the strategic priorities of the paper manufacturing industry (Company investor reports 2012). Innovation, improved technology and lower production costs are the strategic priorities of the paper manufacturing industry (Company investor reports 2012).

*2.2.*1 Economic and Financial Performance

South African demand for paper manufactured from mechanical and bleached chemical pulp has dropped over the last two years as advertising spent on electronic media continued to grow worldwide.

The demand for paper pulp is expected to recover with the gradual demand for paper products. Packaging paper plays an important role in an environmentally conscious world and is driven by population growth, urbanisation and higher standards of living. However, volume and prices remained flat in 2012 in the South African market. Cost saving initiatives have been strategically adopted to boost margin growth in business (Company investor reports 2012).

Stanger Mill

The mill established in 1976, is ideally situated in the heart of the KwaZulu-Natal sugar cane field. This situation facilitates the supply of bagasse fibre needed for the production process. The mill also produces approximately 30 000 tons of tissue per year. The use of bagasse, as its basic raw material to manufacture coated and uncoated wood free papers, makes Stanger Mill unique in South Africa (Paper and paper packaging Stanger Mill 2011:1-3).

Increased demands placed upon print and packaging media, new products, methods and equipment by end-users, results in paper and pulp manufacturing technology being dynamic and continually advancing.

Their ultimate goal is to achieve technological advancement through product and process development (Paper and paper packaging Stanger Mill 2011:1-3).

A first class range of paper products – high quality matt and gloss coated art papers, packaging paper and tissue is produced by the Stanger Mill.

2.2.2 Sustainability Measures

'Triple Green' Manufacturing – Environmentally integrated production process

This type of production is based on a combination of three unique, environmental 'pillars' (Southern Africa sustainability report 2012): Sugar cane fibre called bagasse is the primary source of pulp used in the production of paper products; the bleaching process is elemental chlorine-free (ECF); and the wood fibre used in the production process is obtained from sustainable and internationally-certified afforestation.

2.2.3 The Environment and Total Quality Management

Incoming and outgoing water streams are carefully managed, since water is the lifeblood of pulp and paper mills. A chemical recovery plant is used to convert recovered pulping chemicals into saleable soda ash for industrial use. The mill has also erected a bird hide on its effluent lake for bird enthusiasts to enjoy (Sustainability report 2011). The mill operates according to the International Standards Organisation (ISO 9002) Quality Systems since May 1993, and received an ISO14001 certification in 2002, to ensure conformance to environmental best practices and legislation.

The ISO system requires continuous improvement methods to be adopted and is audited annually to ensure compliance and assess effectiveness of methods implemented (Paper and paper packaging Stanger Mill 2011:1-3).

High degrees of energy and lower levels of greenhouse gas emissions from fossil fuels are achieved from extensive use of renewable energy.

A total of 13 million tons of carbon dioxide is absorbed annually by the company's plantations in South Africa. Globally, 92% of process water (recycled, cleaned and treated water) is returned to the environment. Cost of coal in South Africa increased by 13.3%/GJ together with a 19.6%kWh increase in the cost of electricity generated by Eskom which impacted greatly on the paper manufacturing industries' profit margins, whereas cost of sales dropped in Europe due to lower variable costs in the same industry (Investor reports 2012).

2.2.4 Regulatory/Legislative Costs

In 2013, new rules came into effect internationally which requires all mills' emissions to be covered by 'emission rights (allowances)'. In the pulp and paper industry, carbon dioxide allowances are based on benchmarks which are set for the top performing 10% of installations in every pulp and paper grade in terms of CO2 emissions (Sustainability Report 2013). In South Africa, carbon tax came into effect in 2013 with a 10% increase every year until 2020. However, this could give rise to unfair importation of papers which is not subject to carbon taxes. Investor reports (2012) indicated that the company had complied with all sustainability legislation and regulations of the industry.

2.2.5 Steam Generation System

This system is coal-fired steam boilers. These boilers were sponsored to the company in 1970's by a company in Kimberly that closed down. This technology is extremely old and second hand. The company currently uses four boilers to generate steam required for their processes. This process, however, generates large amounts of solid waste in the form of coal ash. This ash also contains unburned coal pieces (Environmental Manager 2013).

The coal ash is currently being offered to the local community free of charge in order to reduce the environmental impacts of storing it at the mill or dumping it at landfill. Thus, there is no direct cost incurred by the company for disposing of this waste (Environmental Manager 2013).

Boiler ash is a useful by-product for many manufacturing industries. Therefore, it is a loss to the company since they are currently unable to generate any income from this by product. The high coal content in the boiler ash, known as a non-product output, represents loss of raw materials purchased (Environmental Manager 2013).

2.3 Paper and pulp manufacturing industry

2.3.1 Sustainability and pulp and paper mills

The pulp and paper industry is an over capacitated commodities industry that is highly sensitive to global market influences on price and cost. Bras *et al.* (2004:5-7) describe the industry as one with excessive production capacity, high fixed costs, cutthroat pricing schemes, increasing competition from foreign impacts, yet still producing more paper even though this meant higher marginal cost implications of the law of diminishing returns. Paper and pulp manufacturing operates in a cyclical industry with global economic conditions causing volatility in paper and pulp prices. Therefore, cost reduction and improving efficiencies are considered a priority (Andres and Pearce 2011:1446-1454; Aziz and Layeghi 2008:1). Finding lower cost raw materials and alternative fuels, minimising waste, improving manufacturing efficiencies and implementing energy saving initiatives are some measures implemented by the industry to mitigate risks (Bras *et al.* 2004:5-7; Despeisse, Oales and Ball 2013:31-41)

Paper production uses large amounts of fresh water and other natural resources and also generates large quantities of heavily polluted effluents.

The pollution load and volume of effluent generated depend on the production technology, nature and purity of the feedstock, additive usage, extent of water usage and the efficiency of water recycling (Zarkovic *et al*. 2011:1139-1145).

Current levels of economic and industrial activities, as well as material consumption cannot be sustained by the earth's eco-systems. Therefore, the need for sustainable initiatives as part of corporate environmental management framework is essential to relieve the pressure of environmental impacts (De Beer and Friend 2006:548). Bras *et al*. (2004:5-7) state that environmental regulation impacts the paper and pulp industry in every aspect of the product life cycle, from forest management practices, to pulp and paper manufacture, to paper recycling and disposal. However, research has shown that the paper and pulp industry has improved their environmental performance dramatically since 1970.

Economic, social and environmental efficiency are viewed as necessary steps towards sustainability (Callens and Tyteca 1999:41). International best practice technologies used in pulp and papermaking are based mostly on wood-based fibres with very few technologies available for non-wood fibres which are mainly developed and manufactured in Europe and Japan (Worrell, Price, Neelis, Galitsky and Nan 2007:31). Manufacturing is not 100% efficient. Therefore, waste is generated during production.

The industry is the third largest user of fossil fuel energy and the largest user of industrial process water among US manufacturers. Half of the toxic release inventory (TRI) is methanol, a by-product of the pulping process-over 50% of the industry's methanol is released to air and 40% is released to water. Other substances released by the industry include non-hazardous waste water and sludge, acids, chlorinated compounds, ammonia, and air pollutants associated with combustion (SOx, NOx and particulates).

Fossil fuels, such as coal, oil and natural gases are primary sources of energy used in the world.

The high degree of depletion of natural resources and environmental damages, have tempted the world to try to reduce carbon emissions by 80% (Saidur, Abdelaziz, Demirbas, Hossain and Mekhilef 2011:2262-2289).

It is also a highly capital-intensive industry in the United States (US) and there is, therefore, limited opportunities for investment in new, more efficient technologies.

The industry's machines are much older and smaller than their competitors in Europe and Asia, and they tend to have a higher fixed cost per ton of paper produced. Industrial operations cause significant environmental liabilities which have financial effects. Companies, however, still find it difficult to relate environmental liabilities to financial effects (De Beer and Friend 2006:549; Liu *et al*. 2013:7-12). New European machines are less polluting, hence, less vulnerable than Americans to increasing costs of environmental regulation and control. Investor reports (2012) on a paper mill in North America indicated that through planned maintenance of equipment and process upgrades, the mill was able to improve machine efficiency and reduce production costs (Investor reports 2012). However, mill managers view investments in pollution abatement technologies as "unproductive- with no marketable and quantifiable effects in terms of productivity". According to Porter, the cost of environmental equipment is made up of capital cost and cost of non-value added activities (associated with regulatory compliance, operation and maintenance of equipment, permitting and reporting). Recently, pollution prevention technologies, a more conservative approach to environmental protection than pollution control, have been introduced. The total composition of effluents discharged and its potential environmental impacts is not completely known to many. Therefore, pollution-prevention is the only solution to help reduce the probability of unwanted surprises being released into the environment (Bajpai 2010; Despeisse *et al*. 2013:31-41).

Diverse composition of waste generated by the European pulp and paper industry include rejects, different types of sludge and boiler ashes in mills.

Strict legislation and high taxes have led to landfills being eliminated as the final destination for wastes in Europe with incineration with energy recovery becoming the preferred waste recovery method. Options such as pyrolysis, gasification, land spreading, composting and reuse in building materials are being considered. However, optimization of processes needs further research (Monte, Fuente, Blanco, and Negro 2009:293-308).

Energy consumption

Approximately 80% of the energy needs of mills is met by the combustion of fossil fuels (mainly coal) to generate steam and hot water for evaporative and heating processes. The remaining 20% is met by electricity for running electric motors, refrigeration and lighting. Energy consumption depends on how old the technology is and the range of products being produced. Certain processes are very energy intensive. Energy is an area where substantial savings can be made through simple housekeeping efforts. However, considering the price of coal and its impact on the environment, the company needs to consider the adoption of CP technologies that will improve both the environmental and economic performance of the company. This would require capital investment in more efficient boilers in the medium- to long-term (Ernst, Lynn, Maarten, Christina and Nan 2007).

The following housekeeping measures have been suggested to reduce the amount of energy needed to produce steam: improving insulation on heating and cooling systems and pipe work; regular maintenance to optimize energy efficiency of the equipment; maintaining optimal combustion efficiencies on steam boilers; and eliminating steam leaks. There are opportunities for using more environmentally benign sources of energy, such as replacing coal with cleaner fuels like natural gas and co-generation of electricity (Ernst, Lynn, Maarten, Christina and Nan 2007).

Large amounts of capital have been invested in CP research and development projects to provide a wide range of boilers to various industries to ensure that sustainability targets are achieved (Kuik 2006:126-132).

During a benchmarking study by the Pulp and Paper Research Institute of Canada (2008:137), the importance of maximum system efficiency was highlighted. It had also been found that maintenance and equipment/technology impact on operating conditions. During research, it had been discovered that many coal-fired plants do not operate according to their design specifications because of poor quality coal, poor plant maintenance and improper diagnostic tools. Savings of millions of tons of coal, reduced CO_2 emissions and improved financial performance have been identified as benefits of implementing low cost best practices (Giglio 2013:2).

2.3.2 Environmental impacts of 'coal'

According to the Australian Coal Institute, coal is the most abundant and widely distributed fossil fuel resource in the world. Coal has played a significant role in the world's social and economic performance. However, the move towards sustainability has created major challenges for the coal industry because of its environmental impact during both the production and use of coal (Mohr-Swart 2008:115). Coal, as a source of fuel, generates and releases large amounts of CO_2 which has a negative impact on the environment causing land and air pollution. Increase risk of climate change has placed organisations under tremendous pressure to use cleaner fuels in their operational activities.

In Durban, the largest contributor of Green House Gas (GHG) is the industrial sector. In this sector, a total of 52% of total industrial emissions comes from electricity consumption followed by coal which comprises of 17%. Coal is often used as fuel in the industrial sector as it is cheaper than other energy sources. Coal is, however, more carbon intensive and thus contributes to pollution to a greater extent than other fuel sources (Giglio 2013:32).
Industrial sectors that consume excessive coal, like the wood and wood products sector, as reported by the eThekwini Municipality, are targeted to switch from coal to other cleaner fuels.

Long-term projects aimed at improving boiler efficiencies by reducing electricity consumption include the introduction of combined heat and power (CHP) systems or the initiation of cogeneration systems in which waste heat is used as power in a secondary process. Pollution control measures, such as phasing out of 'dirty fuels' to reduce SO_2 emissions, were also introduced. Industries have changed from using high–sulphur coal to low-sulphur coal, and implementing 'end-of-pipe' pollution control technology (Academy of Science of South Africa (ASSAf) 2011:99-105).

Research by Thompson and Fowler (2009:vi) into the use of coal as a source of fuel in industrial technologies reported findings that carbon capture and sequestration (CCS) are essential tools needed to reduce the environmental impact of coal. There is a need for cheaper but more efficient CCS technologies. It is now possible for new and older coal burning power plants to produce power in an economical and environmentally responsible manner because of technological breakthroughs (Giglio 2013:1).

New coal power plants have been established in China, and India is also set to develop new coal generation capacity. Recent statistics revealed that world coal capacity is likely to double by 2030, and, if conventional coal technology is used, CO_2 emission is expected to grow by about 12.6 billion metric tons annually by 2030. The increased need to reduce CO_2 emissions by 50% to avoid the impacts of climate change has been the suggestion by scientists, Mathews and Caldeira. The climate scientists stated that "stabilizing climate requires near-zero emissions". Hence, the need for cleaner technology is imperative (Thompson and Fowler 2009: v). Research shows that no single technology is capable of achieving the target of zeroing global CO_2 emissions by 2050.

According to a publication *'User guidelines for waste and by-product materials in pavement construction* (2012)', boiler slag is formed from cyclone boilers that burns crushed coal.

It had been concluded that the composition of bottom ash or boiler slag particles is controlled primarily by the source of the coal and not by the type of furnace. Bottom ash contains about 20 percent of unburned material. Bottom ash usages are identified as structural fill, road base material, concrete and production of cement. It is believed that as the acceptance of the use of boiler ash increases, markets have the potential to utilize all of the bottom ash produced. However, to reduce the amount of boiler slag available, older cyclone boilers need to be retired (Coal fly ash, bottom ash and boiler slag 2014:19).

The future sustainability of companies generating large amounts of boiler ash containing unburned coal particles is questionable. There is a possibility of groundwater contamination by trace elements that are commonly associated with by-products produced during coal combustion. Bottom ash and boiler slag also contain radioactive materials called TENORM – Technologically Enhanced Naturally Occurring Radioactive Materials (Coal fly ash, bottom ash and boiler slag 2014:19).This hazardous waste has negative impacts on the company's environmental and economic performance.

2.4 Sustainability

2.4.1 Sustainable development

Sustainability became a topical issue almost two decades ago. Fore and Mbohwa (2010:314-333) point out that increased environmental problems, because of increased production and consumption, had contributed to the concept of sustainable development (SD). Early publication focused on the relevance of the environment to business and how this could be relevant for the role of accounting and alternative ways in which data can be processed. This was done using a 'Total cost assessment model'.

As sustainability developed, the question was where and how would companies derive information needed to support the operational issues of various processes to ensure that the necessary data was available when required (Bennett, Schaltegger and Zvezdov 2013:33).

This has placed companies under pressure to adopt sustainability due to industry pressure and competition; stricter environmental regulation; pressure from stakeholders to monitor activities and outputs more closely; and increasing shortages of natural resources and higher energy costs. Since sustainability focuses more on non-financial information, there is a demand for companies to adopt new information systems or adapt their existing accounting system. The international community committed itself to sustainable development at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992. SD is ultimately about development that meets the needs of the present generation without compromising the ability of future generations to meet their needs. Others had interpreted sustainability as ‘environmentalism dressed up for the 21st century.’ Sustainability was linked mainly towards creation of jobs and wealth in a fair manner and in ways that protect the environment (Environmental strategies 2013). Fore and Mbohwa (2010:314-333) concur that SD is not a business practice but rather a long-term goal of individual companies.

At the 2002 World Summit on Sustainable Development held in Johannesburg, a shift towards sustainable consumption and production was noted. Greater emphasis was placed on inefficient and wasteful use of natural resources (Resource Efficient and Cleaner Production 2013).

Issues raised at the summit clearly showed that much of the wealth generated in the country was at the expense of natural assets. Therefore, it was emphasised at the forum that businesses need to take an active role in protecting these natural assets and reducing the environmental impact of operational activities (Ambe 2007:3).

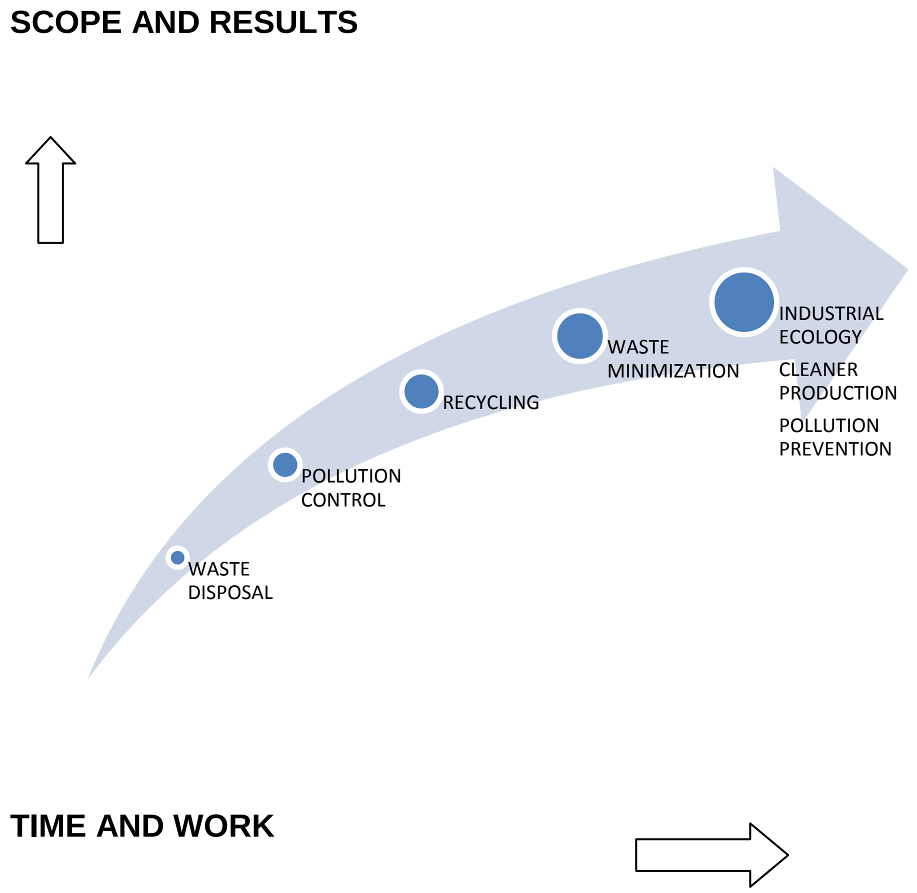
In 2006, a draft Strategic Framework for Sustainable Development in South Africa was used to reaffirm South Africa's commitment to implementing full measures to ensure that businesses cooperate and adopt a sustainable development approach to their business activities (Ambe 2007:4).

Some researchers have argued that the root cause for environmental problems is the lack of an environmental management policy (Ahmad, Saha, Abbasi and Khan 2009:iv). Environmental and social aspects of business are not adequately recognised by current accounting systems and these issues may not be fully accounted for during decision making. Non-financial information is now being used to supplement the traditional financial information flows for external reporting and internal management needs. Sustainability accounting and production has encouraged companies to review their processes and products to take into account and respond to changing cost structures and risks (Bennett, Schaltegger, and Zvezdov 2013:34).

Thereafter, the 'Triple Bottom Line' became widely accepted as a company level approach to sustainability. Hence, businesses had to focus on and manage their environmental, social and financial performance (Schaltegger *et al*. 2010:12). Sustainability, however, continues to pose a challenge to companies that are struggling to design a systematic approach to address all three aspects stated above. EMA then became recognised as a prioritized intervention that integrates the ecological and economic dimensions necessary for SD (Ambe 2007:4). EMA and the balance scorecard were introduced to industry as a means to measure sustainability factors to compare and benchmark environmental performance (Lambert, Carter and Burritt 2012:123).

Figure 2.1 demonstrates the key concepts aimed at SD.

Figure 2.1: Staircase of Concepts aiming Sustainable Development



Environmental management systems

Source: Nabais (2011:4)

Figure 2.1 highlights key concepts of SD. Each step involves more time and greater effort on the part of organisations aimed at achieving zero emissions. From the above evidence, it is clear that SD is a long-term strategy involving step-by-step processes of development and progress towards achieving the ultimate goal, as depicted in figure 2.1.

2.5 Environmental management

2.5.1 International standards of organisation (ISO 14001)

Bennett, Schaltegger and Zvezdov (2013:36) describe environmental standards such as ISO14001 and Environmental Management Accounting Systems (EMAS) as voluntary standards that act as a form of regulatory governance as they become institutionalised and internationally recognised. Its aim is to make cost relationships transparent and provide guidance during process and product design decisions by adopting conventional costing systems. They believe the purpose of ISO 14001 is to help companies implement environmental management systems (EMS) that fulfil certain criteria. Ahmad, Saha, Abbasi and Khan (2009:v) concur that the ISO 14001 EMS could be used by managers to assess and measure progress and performance by providing standard auditing, communicational and reporting protocols. Complementary standards such as ISO 9001 have been found to be the most relevant factors for adopting ISO 14001 or EMAS. Li (2004:1) found an enhanced development of EMA among companies that were ISO 14001 certified. This has also encouraged governments to promote EMA implementation within countries.

The availability of win-win possibilities and leadership by individuals in the company management had been reported as the most common internal factors that influence the implementation of standards.

"Best practices" of environmental management

Christmann (2000:663) analyzed three process-focused "best practices" of environmental management during his research to identify their direct effect on cost advantage:

- Best practice 1: Use of pollution-prevention technologies
  Pollution-prevention technology has the potential to increase the efficiency of the production through reduced input costs, substitution of less costly inputs, savings from recycling or reusing materials, and reduction of waste disposal costs;

- Best practice 2: Innovation of proprietary pollution-prevention technologies
  Internal innovation of pollution-prevention technologies contribute to the firm's cost advantage in many ways: First, managers become aware of inefficiencies in current production processes and products that were not previously recognized, by developing new pollution-prevention technologies. Second, innovation of pollution-prevention technologies has greater potential for cost-saving changes in the production process. Third, the technologies are proprietary to the firm, therefore, the firms are likely to appropriate the rents that are created by these internally developed technologies. Competitors are not easily able to imitate these internally developed pollution-prevention technologies; and

- Best practice 3: Early timing
  Addressing environmental issues earlier than competitors or before environmental regulation is established contributes positively to cost advantage by minimizing disruptions of the production process usually caused by implementing compliance technologies, allowing the firm to gain cost advantage through the learning curve effects, by addressing environmental problems early and influencing regulations can raise their competitors' costs.

Holt (2009:110-142) views ISO 14001 as a logical extension of the quality management system ISO 9001. Some researchers advocate that both quality improvement and environmental investments can have positive effects on a firm's competitiveness (Orsato 2006:129-130).

The King Commission (2002:240) cite the following nine reasons for businesses to improve its environmental performance, as per The United Nations Global Compact, noted by Mohr-Swart (2008:102):

- Implementing CP and eco-efficiency improves resource productivity;
- Clean companies are being rewarded by new economic instruments;
- Stricter environmental regulations;
- Cleaner companies are seen as low risk and also preferred by insurance companies;
- Banks are more willing to provide financial assistance to cleaner companies;
- Positive effect on company's image;
- Health and safety of employees;
- Negative impact of pollution to human health; and
- Pressure from customers for cleaner products.

Radonjic and Tominc (2007:1482-1493) conclude that ISO 14001 certified firms were more productive and achieved better environmental performance. They also found that the adoption of cleaner technologies were more likely among certified companies as ISO 14001 was considered a useful tool for technology changes in companies which were committed to the IPPC directive. Hence, it can be suggested that being ISO certified means that an organisation has committed to ensuring that it complies with the continual improvement policy and, therefore, would be more likely to consider implementing CP techniques and technologies to achieve SD.

However, even though companies are ISO 14001 accredited, many of them are unaware that this is just the start towards their commitment to SD and greater effort and change is required to actually reach targets set in their policies. Despite emerging best practices, there is still much discrepancy regarding corporate environmental strategies and its impact on environmental performance across many organisations. According to Sinclair-Desgagne (2004:7), the biggest challenge that firms are currently facing is the difficulty in integrating environmental issues into day-to-day business activities. Gil, Andres and Salinas (2007:89) argue that management commitment and awareness of environmental responsibility significantly influence corporate strategy. Sinclair-Desgagne (2004:7) suggests that all business units need to be involved in environmental goal-setting and implementation in order to successfully achieve environmental objectives. Many of the goals stated in environmental policies have not been achieved due to lack of commitment to move past pollution control and waste disposal strategies. Most companies are just content to satisfy the minimum requirements of an ISO 14001 audit without changing or improving their production processes or technologies.

2.5.2 Environmental management systems

2.5.2.1 Definition and framework of EMS

Ferenhof, Vignochi, Selig, Guillermo, Lezana, and Campos (2014:44-53) define EMS as a tool aimed at reconciling economic growth with the environment and is used to support a company with systematic processes for implementing environmental goals, policies and responsibilities, as well as regular auditing of its elements.

They recommended that EMS designed for an organization must take into consideration the operation's activities and how the company's actions impact the environment and an environmental indicator system be used to identify potential opportunities for cost reduction and improve environmental performance. ISO 14001 provides a useful framework for promoting efficient EMS which should be part of an integrated system of management.

Radonjic and Tominc (2007:1482-1493) added that EMS is an important part of the pollution-prevention approach. The manufacturing process performance is improved and impacts of process upsets and equipment failure are greatly reduced by the adoption of sound EMS. Compliance to environmental laws and regulations as well as innovation is also facilitated through EMS adoption. However, Henriques and Sadorsky (2007:119-132) disagree with the above hypothesis and found that EMS reduces the likelihood that an organisation will implement clean technologies while Total Quality Management (TQM), on the other hand, increases the chances of an organisation implementing clean technologies. They do, however, admit that EMS systems provide the platform for promoting innovation in organisations as part of their proactive environmental strategy. In addition, Ahmed *et al*. (2009:iv) advocate that EMS cannot function in isolation and needs to be incorporated into the main corporate agenda. They believe that an EMS can merely provide an administrative and systematic structure to be utilized as a sustainable environmental management mechanism, but cannot provide guidelines on how to achieve sustainability. However, the argument of whether or not proactive environmental activities increase business performance remained unresolved for many researchers (Darnall, Henriques and Sadorsky 2008:364-376).

Brent and Premraj (2007:31) found that, although studies show that environmental performance may improve by adopting a formal EMS, there were still unclear guidelines on how to effectively implement an EMS system.

It can, therefore, be concluded that one needs to have a clear definition of sustainability and integrate this as part of the strategic planning process and policy development. It is only then that an EMS could be used as a tool to successfully achieve sustainability targets.

Effective EMS for manufacturers of pulp and paper include spill prevention and control, preventative maintenance, emergency preparedness and response, and energy efficiency programmes.

EMS enables companies to implement preventative-maintenance programmes to identify and repair equipment before it fails and thereby avoid large releases to the environment. Proactive measures, made possible by adopting an EMS, tend to reduce and control unnecessary losses that would be incurred by companies. Internal audits are carried out to assess the performance of the EMS and the International Standards Organization recognizes the importance of such a system (Constantin and Teodorescu 2012). ISO 14001 has stated the key elements of an EMS and include the following:

- Vision as defined by the environmental policy;
- Objectives and targets for environmental performance;
- Programmes to achieve those targets;
- Ways to measure and monitor the system's effectiveness; and
- Periodic review of the system to improve overall environmental performance.

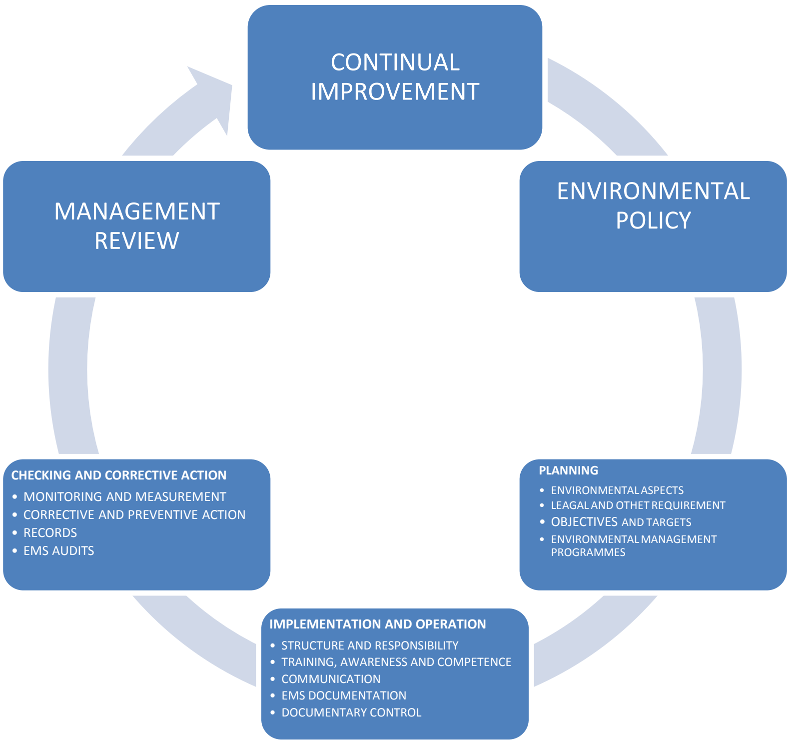
ISO 14001 focuses on the management process, not on its content and performance. Manufacturers can develop their goals and objectives to achieve continuous environmental improvement (Henriques and Sadorsky 2007:119-132).

Holt (2009) highlights the following EMA information that an EMS provides:

- Monitoring, compliance and performance data that is routinely collected;
- Increasing the visibility of cost saving options to managers; and
- Inaccuracies in the allocation of environment-related 'overhead' costs are revealed.

Figure 2.2 indicates elements of an EMS within an organisation, which is based on the principle of continual improvement.

Figure 2.2: The EMS approach: 'Embedding' Environmental Issues



Source: Holt (2009)

2.5.3 Environmental management accounting (EMA)

2.5.3.1 Development and theoretical framework of EMA

Environmental changes and future threats can generate higher costs to the company.

The strategic operational issue is that companies are not aware of the magnitude of these costs as they are generally hidden in overhead accounts. Greater transparency of these costs ensures that they are being managed in a way that results in environmental and economic benefits (Olson and Jonall 2008:54).

Initially, the reaction to environmental challenges was to disperse pollutants better to reduce their harmful impact on communities. Thereafter, the environmental management paradigm was to implement measures to control pollution and treat wastes after they have been created.

Examples include effluent treatment plants, catalytic converters and waste incineration, also referred to as end-of-pipe technologies (Environmental strategies 2013).

However, the current management accounting systems were inadequate to provide the information on monetary and physical environmental impacts. Therefore, EMA was introduced. EMA has been developed and applied for nearly two decades and has now emerged from a “twenty year niche issue” to a globally popular topic in academia and industry. Abdel-Kader (2011:63) asserts that the first publications on EMA was the World Resources Institute’s ‘Green Ledgers’ in which it had been argued that environmental-related costs were significantly underestimated and frequently accounted for as general overheads. Conventional income statements created a perception that environmental costs are limited to separately identified items such as fines and penalties, ‘end-of-pipe’ pollution control equipment and expenditure to remediate past environmental damage, all of which are defensive expenditures. Therefore any potential to improve environmental and economic performance by cost reductions, developing new revenues and managing risks are ignored, was clearly pointed out by Abdel-Kader (2011:64).

Benette, Schaltegger and Zvezdov (2013) developed a working definition for EMA as ‘a tool for transforming physical and financial measures of environmental data into information for decision making to judge environmental performance.’ Qian, Burritt and Monroe (2011:93-128) added that EMA is used to identify, collect and analyse both physical and monetary information for internal decision making.

Physical information comprises of data on use and flows of energy, water, and materials including waste, whereas monetary information is based on environment-related costs, savings and earnings, and environmental costs that are generally hidden under overheads. As per International Federation of Accountant (IFAC 2005),

EMA is defined as the development and implementation of environment-related systems and practices to manage environmental and economic performance (Schaltegger *et al*. 2010:54). Furthermore, EMA is an approach of corporate environmental management involving the application of accounting tools and practices to assist managers in decision making on environmental and economic performance (Schaltegger, Gibassier and Zvezdov 2011:2). Li (2004:1) suggests that, in a contemporary world, EMA should be used in the strategic development process to create a balancing interaction between economic, social and technological factors to ensure a sustainable environment.

In all of the definitions of EMA stated above, the types of information that should be considered by organisations and analysis techniques adopted for internal decision making to maximize profitability are highlighted. However, the main objective of an EMA system, as suggested by Scavone (2006:1276-1285), is the introduction of ongoing environmental preservation activities and disclosure of the company’s environmental position internally and to its stakeholders. EMA adoption makes it possible for an organisation to be able to generate high quality informational reports containing both monetary and non-monetary data.

Monetary data is extracted from the data base that supports financial reports and is used by management to make informed business decisions (Scavone 2006:1276-1285).

The United Nations Development Program as part of the Department of Sustainable Development reports EMA as an important management tool that is of benefit to both industry and government. They (UNEP) have embarked on several activities to educate and encourage companies of the benefits of using EMA (Environmentally Sound technologies for sustainable development 2003).

One of the activities was being part of the expert working group on EMA which introduced the international guidance and also developing training course in EMA. This publication offered a set of principles and procedures for EMA based on that which was commonly used in Financial Accounting methods with the intention of reducing the cost of adopting an EMA system (Jasch 2003:667-676). Following these international developments, South African companies have considered environmental issues in their decision-making processes regarding products and processes. It has been suggested that EMA is a valuable tool for businesses to adopt whilst responding to environmental challenges and still focusing on the triple bottom line (Ambe 2007:7). At the time of the study, there was an apparent lack of awareness and understanding of the significance of the environmental costs and their impact on the overall performance of the organization. What had been brought to the forefront was the potential savings to South African companies by implementing good environmental management by using EMA to accurately trace and identify environmental costs (Ambe 2007:11-12). It can, therefore, be concluded that Environmental Accounting can be used to demonstrate the potential for environmental investment to yield financial benefits to an organization.

Qian and Burritt (2008:244) added that multidisciplinary knowledge, information and skills as well as inter-professional communication are needed for EMA. Recent developments in EMA emphasise the greater need for accounting information when making decisions regarding environmental projects (Qian and Burritt 2008:244).

Hence, communication between the accounting department and the environmental management department is crucial if an organisation wishes to succeed in EMA implementation. Accountants play an important role as they are expected to access the data and analyse variables associated with various environmental costs.

In addition, there is also need to assess whether or not costs have been allocated and handled correctly and in accordance to environmental policies and guidelines. Therefore, in order to gain maximum benefits of EMA, an integrated system that provides comprehensive information is thus needed.

Scavone (2006:1276-1285) states that, by adopting an EMA system, a company can develop proactive environmental programmes which, in turn, improve profitability and competitiveness, reduce business costs, increase worker productivity and morale, enhance brand image, and improve relations with regulators and local communities. She believes that companies that adopt proactive measures to address environmental issues are in an excellent position to identify problems and opportunities to introduce innovative solutions. It is essential for companies to generate reliable past and future-oriented information by using environmental accounting decision tools such as EMA, to enable effective and efficient management of environmental consequences of the business operations.

Godschalk (2008:259) explains that a company can reduce its exposure to environmental risks and liabilities by being proactive and being aware of possible environmental costs and savings available during their strategic planning phase. Hence, there is an increased need for systems that can provide reliable, accurate physical and monetary environmental information.

This, in turn, would assist in meeting the needs of customers and other stakeholders that have a vested interest in the company's operational activities.

Qian, Burritt and Monroe (2011:93-128) emphasise the incompleteness of conventional management accounting approaches by using terms such as 'true', 'total', 'comprehensive', and 'life cycle'. Decisions based on conventional accounting practices only take into consideration the operational costs of waste management as compared to EMA, which generates both financial and non-financial information that is used by managers to support internal environmental management processes.

They pointed out that companies do not consider alternatives such as resource recovery and material recycling as disposal to landfill is considered as the most feasible and competitively attractive option because of the low operation costs of landfill disposal.

This is caused by incorrect calculation of actual environment cost by current management accounting systems. As a rule in environmental management, 80 percent of environmental costs are caused by 20 percent of production activities undertaken by an organisation. Under traditional accounting, these costs are blocked under overhead accounts and thus shared by all product lines, thus, leading to incorrect estimation of product prices and reduced profitability of the organisation (Bennett, Rikhardsson, and Schaltegger 2003:24). According to Jasch (2008:36), during decision making, the cost of wasted materials, capital and labour need to be added to assess the value of total corporate environmental costs.

Table 2.1 shows the internal calculation of environmental costs by a company.

Table 2.1: Environmental costs of a company

	Environmental Protection Costs (Emission Treatment and Pollution Prevention)
+	Costs of wasted material
+	Costs of wasted capital and labour
=	Total corporate environmental costs

Source: Jasch (2009)

Table 2.1 indicates that, when calculating environmental costs, the purchase value of wasted material and the production costs of waste and emissions must be considered.

Ambe (2007:6) clarifies the following shortcomings of conventional management accounting practices in environmental cost consideration during internal decision making:

- Many environmental costs were ‘hidden’ in overhead accounts;
- The allocation of environmental costs from the overhead accounts were thereafter incorrectly allocated to processes and products;
- Some environmental costs were incorrectly considered ‘fixed’ instead of ‘variable’;
- Volume and cost of wasted raw materials were incorrectly calculated;
- Relevant and significant environmental costs were excluded completely from accounting records resulting in environmental costs being understated; and
- EMA information is not considered during investment appraisal.

In response to the abovementioned shortcomings of conventional management accounting system and increased environmental challenges, EMA was suggested as a valuable business tool for implementation by organisations to create a better link between environmental and economic performance (Ambe 2007:6). This made it possible for businesses to achieve the triple bottom-line without compromising the environment.

Godschalk (2008:262) concluded that, ultimately, the internally-orientated benefits of adopting EMA are as follows: assist organisations in achieving competitive advantage, greater cost-efficiency, and improved image and customer relations. Olson and Jonall (2008:8) stress the importance of having a more structured accounting system in increasing cost efficiency and improving environmental performance. Incorrect cost allocation leads to incorrect decision making.

Therefore, tracing cost to the actual cause of it, either a process or product rather than reflecting it under overhead accounts, is extremely important, especially in strategic decision making.

Olson and Jonall (2008:8) illustrate the principle of cost allocation in the table 2.2 by demonstrating the impact of incorrect environmental cost allocation.

Table 2.2: Impact of environmental cost allocation

Examples: 1) without, 2) with Environmental overhead cost	**'Clean' process A**	**'Dirty' process B**
1) Correct environmental cost allocation		
Revenues	$200	$200
Production *costs*	$100	$100
True Environmental costs	$0	$50
True profit	$100	$50
2) Incorrect environmental cost allocation		
Revenues	$200	$200
Production costs	$100	$100
If environmental costs are overhead	$25	$25
Illusory profit	$75	$75
The latter (2) is incorrect by	-25%	+50%

Source: Olson and Jonall (2008:8)

Table 2.2 shows that if environmental costs were shared equally between both processes, an incorrect profit amount would be generated which, in turn, will impact on future investment decisions. Hence, process A would not have been given preference over project B.

Therefore, in order to ensure that transparent, accurate environmental costs are allocated to the actual process or product, an EMA system would be most appropriate to implement in the future.

Various reports, including guidelines and recommendations for implementing EMA, have been published by the United Nations Division on Sustainable Development (UNDSD) and the International Federation of Accountants (IFAC) (Schaltegger, Gibassier, and Zvezdove 2011:1). However, every company would have a different goal and vision according to its needs and available resources for environmental-related activities. Hence, EMA should be customized to suit the needs and requirements of individual organisations. It is, therefore, suggested that the current management accounting system of a company be adapted to include environmental cost information.

Table 2.3 represents a summary of the main environmental cost categories found in business.

Table 2.3: Environmental Cost Categories

1 WASTE AND EMISSION TREATMENT	2 PREVENTION AND ENVIRONMENTAL MANAGEMENT	3 MATERIAL PURCHASE VALUE OF NON-PRODUCT OUTPUT	4 PROCESSING COST OF NON-PRODUCT OUTPUT	5 ENVIRONMENTAL REVENUES
1.1 Depreciation for related equipment	2.1 External services for environmental management	3.1 Raw materials	4.1 Labour costs	5.1 Subsidies, Awards
1.2 Maintenance and operating materials and services	2.2 Personnel for general environmental management activities	3.2 Packaging	4.2 Energy costs	5.2 Other earnings
1.3 Related Personnel	2.3 Research and Development	3.3 Auxiliary materials		
1.4 Fees, taxes and charges	2.4 Extra expenditure for cleaner technologies	3.4 Operating materials		
1.5 Fines and penalties	2.5 Other environmental cost management	3.5 Energy		
1.6 Insurance for environmental liabilities		3.6 Water		
1.7 Provision for clean-up costs remediation				

Source: (Introducing Environmental Management Accounting at Enterprise Level 2001: 9)

Table 2.3 was developed by the UNDSD in 2001 and provides a framework and guidelines on environmental cost categorisation.

Hence, this information could be useful to companies that want to implement EMA as part of their continuous improvement policy.

Jasch (2003:667-676) claims that this comprehensive framework for EMA ensures that all relevant and significant costs are considered during decision making. Cost allocation by EMA could result in the following benefits: (Introducing Environmental Management Accounting at Enterprise Level 2001: 9)

- Pricing of products could change due to re-calculation of costs;
- Profit margins of products could be re-evaluated;
- Decision to phase out products because of high environmental cost;
- Processes and procedures may be re-designed to reduce environmental cost;
- Continuous monitoring of environmental performance and good housekeeping measures implemented; and
- Unnecessary costs are eliminated.

The framework for EMA proposed is by Burritt, Haun, and Schaltegger (2002:39) on categories of different EMA methods based on the attributes of the information and the uses to which the information is to be applied. The 16 categories in which different EMA methods can be positioned and understood in terms of their purpose and data source are demonstrated in table 2.4 (Bennett, Schaltegger, Zvezdov 2011:74).

Table 2.4: EMA methods

TIME	TYPE OF REPORT	PHYSICAL SHORT-TERM	PHYSICAL LONG-TERM	MONETARY SHORT-TERM	MONETARY LONG-TERM
PAST-ORIENTED	ROUTINELY GENERATED	X	X	X	X
	AD HOC	X	X	X	X
FUTURE-ORIENTED	ROUTINELY GENERATED	X	X	X	X
	AD HOC	X	X	X	X

Source: Burritt, Haun and Schaltegger (2002:43)

Table 2.4 explains the categories of EMA information generated as follows:

- Information is monetary and non-monetary (physical);
- Measure past performance or to make decisions for the future;
- Distinguished between decision involving strategic information over several years and more operational information covering shorter time periods; and
- How routinely the information is provided regularly for a recurring purpose or on an ad hoc basis for a specific non-recurring need.

Monetary EMA methods rely on corresponding physical information about materials and energy flows and are past-oriented. This type of information can provide managers with an overview of inefficiencies in material and energy usage which is useful in identifying and analysing potential improvement opportunities.

Bennette, Shaltegger and Zvezdov (2011:71-82) reported that past-oriented information is found most often in businesses.

However, once managers become aware of opportunities for efficiency improvements and other benefits, then future-oriented information will also be needed.

Firms will thus be able to achieve first mover advantage by being proactive in strategic planning. It would be up to management to decide which tools would best suit their information needs.

Hyrslova *et al*. (2011:47) states that, within the EMA framework, it is necessary to analyse the individual activities and processes to prepare material and energy balances in order to understand waste flows and express these flows in monetary units to ensure that all significant costs are considered when making business decisions. According to Jasch (2008:6), any waste generated is a sign of inefficient production based on the underlying assumption that all purchased materials must leave the company either as a product or waste and emission. Therefore, it can be concluded that an EMA system provided much more valuable information to support decision making within an organisation than a traditional management accounting system.

The concept of EMA is not clear to many individuals in an organisation and is conceived as a system that merely monitors and reports environmental costs. Jasch (2008:4) argues that “Doing environmental management accounting is simply doing better, more comprehensive management accounting, while wearing an ‘environmental’ hat that opens the eyes for hidden costs.” It should be noted that management of environmental-related costs is important even before reporting them. Hence, environmental and financial performance is managed and improved by adopting an EMA system (Schaltegger *et al*. 2010: 47).

During a study conducted by Ambe (2007:7), external factors influencing EMA adoption were discussed, as follows:

- Increased stakeholder pressure concerning environmental issues;

- Greater need for integration of physical and financial aspects of environmental management; and
- Combined financial, environmental and social consideration incorporated into concepts of sustainable development and corporate social responsibility; and greater environment-related costs.

Although environmental accounting forms an important part of industrial decision making in first world countries, there is however a lack of commitment to the environment in South Africa (De Beer and Friend 2006:22). Environmental Assessment (EA) is an integral component of environmental regulatory systems in developing countries like South Africa. It is one of the most important emerging trends in national environmental legislation. The EA process can contribute to effectiveness of the environmental regulatory system by integrating environmental considerations into the planning and appraisal of development activities. It can contribute to an improvement in environmental performance and cost effectiveness of the environmental regulatory systems.

Following great developments internationally, South Africa began to place emphasis on environmental impact during decision making on processes and products, more especially in the context of energy and raw material consumption and the resulting waste of production processes. Despite commitment from government and many organisations, the level of EMA application still remains low. Ambe (2007:11) concluded that EMA implementation in developing countries was still at its infancy stage. Conventional cost accounting systems are still used by the majority of organisations in South Africa as managers do not actually see benefits of detailed environmental costing. Company managers believe that developing new systems are expensive and traditional systems are perceived as adequate for reporting purposes.

2.5.3.2 Theoretical perspectives of EMA

There are various theories that researchers have studied to identify the motivational reasons for EMA adoptions.

The two categories most commonly researched are the social theory and the organisational theoretical perspectives. Both these theoretical perspectives are explained briefly below.

Environmental reporting and environmental audit research are sometimes based on the ‘stakeholder theory’. The stakeholder theory implies that organisations need to place greater emphasis on stakeholders and ensure that a two-way communication is facilitated as stakeholder interest is considered critical to a firm’s success (Godschalk 2008:250). Some researchers argue that, in order to ensure sustainability of the company, the legitimacy theory must be applied. This implies that a company needs to conduct their business operations in a way that is socially acceptable by the community. Schaltegger *et al*. (2010:262) believe that stakeholder relations can be improved by enhancing benefits they receive from improved environmental performance. The company needs to disclose its activities to ensure continuity. The stakeholder theory and legitimacy theory are similar in that they are both take an open system’s view of organisations (Qian, Burritt and Monroe 2011:93-128). These theoretical perspectives relate specifically to corporate environmental accounting.

On the other hand, a contrasting view to both theories mentioned above is the institutional theory that views the organisation as part of the larger system in which it operates. Qian, Burritt and Monroe (2011:93-128) argue that the institutional theory is more applicable to explaining motivations for adopting environmental management accounting in organisations. They also defined the contingency theory as a competing theory for environmental management accounting. Jalaludin, Sulaiman and Ahmad (2011:540-557) conducted a study aimed at understanding the relationship between EMA adoption and institutional pressure using multiple regression analysis.

They reported that institutional pressure in terms of training and education did, to some extent, influence EMA adoption in organisations.

Bennette, Schaltegger and Zvezdov (2013:53) discussed the impact of the contingency theory on environmental accounting. They stated that there is no single best approach to sustainability in a company.

Instead, the optimal course of action is dependent (contingent) upon the circumstances in each case and upon relevant factors such as the company's environment, technology and culture.

Qian, Burritt and Manroe (2011:93-128) argue that an organisation's contextual dynamics are just as important and needs to be considered when analysing environmental changes in organisations. Since the external business environment is characterised by uncertainty, the contingency theory seems most appropriate during analysis of environment performance of an organisation. The contingency theory is a strategic management-based organisational theory which focuses mainly on efficiency and technical organisation rather than on motivational factors for adoption of EMA. It is, therefore, evident from the above review that there is no set theory to explain EMA implementation. According to Qian, Burritt and Monroe (2011:93-128), the view of the contingency theory is that organisations are driven by task performance. They believe that the effectiveness of management control systems is contingent upon its business environment and contextual situations. Hence, it is both the contingency factors and the uncertain organisational environment that support the development of EMA within the organisation.

2.5.3.3 Challenges of EMA implementation

Several factors make it difficult for the implementation of EMA in an organisation. Poor adoption of EMA in many industries increased the need to investigate some of the challenges experienced by companies.

Ferenhof *et al*. (2014:4) mention some challenges to adopting EMA that they discovered during research: implementation of EMA has a lack of organisation incentives at the start as some companies perceive disclosure of accounting information as risky. It is only when they can actually see results in monetary terms do they realise that the business is improving because of actions taken.

Accountants are usually unaware of information improvements that could be obtained by using EMA methodology when they design an accounting system, making it difficult for effective collection and evaluation of environment-related information. De Beer and Friend (2006:32) added that deficiencies in institutional capacities, untrained staff, shortages of resources as well as inadequate base-line data and environmental monitoring have been identified as some of the shortcomings in current regulatory systems in middle-income countries. Furthermore, research shows that there are poor communication links between accounting and other departments in an organization. As a result, information used by management for decision making may be inaccurate.

Inconsistencies in the type of information system used by the accounting and technical departments also make it difficult to track and trace certain environmental costs accurately (Schaltegger *et al*. 2010:16).

During a study done in China, Li (2004:1) claimed that problems related to EMA were the poor specification of environmental accounting information, allocation of environmental costs, legislation issues, and lack of environmental accounting standards. Hence, stricter regulatory compliance is necessary for companies to implement EMA systems and procedures because, if this is optional, many organisations would not likely want to make the change even though they may be aware of the potential benefits of the systems.

They view such changes as ‘not worth their while’. Conversely, Ahmed *et al*. (2009:14) point out that “Environmental considerations are considered to be accompanied only by costs or as counterproductive to economic growth”.

Some barriers that EMA helps to overcome, as mentioned by Olson and Jonall (2008:40), are management commitment by making managers aware of actual environmental costs, information inconsistency, becoming more efficient and focused, thus resulting in improved environmental and economic performance, and promoting better quality of products through reducing the amount of defective products. In conventional cost accounting, both environmental and non-environmental costs are included under overhead accounts and hidden from management, resulting in incorrect decision making.

Figure 2.3 clearly demonstrates the four approaches to environmental accounting (Jonall 2008:19)

Figure 2.3: Internal and external reporting of financial and non-financial data

Figure 2.3 depicts the EMA approach, including the internal, external, financial and non-financial perspectives (Bartholomeo *et al*. 2000:43).

EMA, as described by Jonall (2008:19), is a combined approach representing the transition of data from financial accounting, cost accounting, and material flow cost accounting.

Material flow balances, in physical units within a defined system, form the core part of Environmental Information System.

2.5.3.4 Empirical evidence of EMA

A large number of pilot testing projects have been conducted on EMA, demonstrating its positive contribution towards companies achieving both environmental and economic targets (Qian *et al.* 2011:93-28; Khalid, Lord and Dixon 2012:3; Bennette, Schaltegger and Zvezdov 2013:44-55). A brief summary of the findings from other pilot case studies that are considered relevant, are mentioned below.

A pilot testing project of EMA on 10 case studies conducted by Jasch and Schnitzer (2002:6) showed that there is clearly lack of communication between the environmental manager and cost accountant in companies.

The environmental manager has limited access to actual cost accounting documents and although the cost controller has most of the information, they lack the ability to separate the environmental part without proper guidance. EMA is a combined approach to bridge this communication gap and provide for the transition of data from cost accounting and financial accounting to reduce the environmental impact by increasing material efficiency. Hence, it was implied that, in order to enable the sharing of environmental information, there was a need to stimulate management accounting practices, formal and informal interactions between different functions. Similar findings were reported by Albelda (2011:76-100) who explored the role of management accounting practices as facilitators of the environmental management.

The results showed that by reinforcing the four significant EMAS elements: commitment to continual improvement of environmental performance; compliance with environmental legislation; communication with stakeholders; and employee involvement, management accounting practices operate as a facilitator mechanism for environmental management. Poor communication links between the accounting and technical departments result in inaccurate cost allocation, which eventually leads to managers making incorrect operational and investment decisions. This ultimately has inverse impacts on a company's environmental and financial performances. It had been discovered subsequently that many of the businesses' costs are environment-related and that simple actions could be taken to improve environmental and business performances (Jasch and Schnitzer 2002:6). Olson and Jonall (2008:29) mentions in his review of corporate results that, when EMA methodology was applied at a Canadian Mackenzie Paper Division paper mill, environmental costs were found to be more than twice as high as those reported in the company's year-end report. This finding concludes that many important environmental costs are hidden in other accounts and supports the view that environmental costs are higher than generally perceived by management.

Porter's hypothesis of the 'win-win' scenario states that if environmental regulation was properly designed, it can inspire innovation that will allow companies to use their inputs more productively to offset the costs of improving the environmental impact. Porter suggested that a strategy aimed at enhanced resource productivity will make companies more competitive (Bras *et al.* 2004:5).

The two impediments that were identified to using environmental issues to gain competitive advantage were: ignorance about direct and indirect environmental impact; and limitations of conventional accounting systems for tracking environmental costs (Bras *et al*. 2004:5).

Schaltegger *et al*. (2010:262) are in agreement with Porter's hypothesis of a win-win situation and stated that EMA can improve efficiency, reduce costs, improve decision making, and competitive advantage.

There is however, substantial evidence that indicates that customers prefer companies that adopt measures to innovate to improve their environmental performance, and innovation also improved the image of the business enterprise giving them a competitive edge. Khalid, Lord and Dixon (2012:3) found that companies with which they do business as well as pressures from customers for environmentally sensitive workplaces play an important role in how a company reacts to environmental issues. Khalid, Lord and Dixon (2012:3) claim that, by using EMA, companies could implement proactive techniques that could prevent or reduce the environmental impact of their operational activities. Abdel-Kader (2011:67) also discovered contradictory arguments that have also been reported claiming that EMA involves complex analysis such as material balances to track and gather information on environmental costs which are expensive and may not always be cost effective.

It is evident from various case studies that many organisations are not fully aware and knowledgeable on how to actually implement EMA and, therefore, are unable to experience the benefits of EMA implementation. Since this concept is new to many industries, there is clearly a need for more structured guidelines on how to adapt current management accounting practices to include environment-related information. Governments, environmental support groups and other regulatory organizations need to promote and encourage EMA adoption in various industries. EMA implementation remains a 'niche' in South Africa as organisations are reluctant to adopt new systems unless they are compelled to do so as a regulatory or legislative requirement.

2.6 Tools of Environmental Management Accounting

2.6.1 Material Flow Cost Accounting (MFCA)

2.6.1.1 Definition and Theoretical Framework of MFCA

Schaltegger *et al*. (2010:397) describe MFCA as one of the EMA tools aimed to reduce both the environmental impact and cost simultaneously. In addition, MFCA is also a tool used in organizations' decision-making which is aimed at improving their business productivity by reducing costs through waste reduction. MFCA measures the flow of raw materials in both physical and monetary units. Cost categories are material cost, energy cost, system cost and waste management cost (Schmidt and Nakajima 2013:358-369).

According to Schmidt and Nakajima (2013:358-369), a large number of companies are introducing MFCA in Japan which is aimed at reducing material losses rather than recycling wastes. Reduced material input and material cost directly results in reduced waste generation. This eventually leads to improved efficiency in processing and waste treatment costs. Hence, two key activities of environmental management are reduction of waste generation and resource consumption in order to lower the environmental impact of the manufacturing process. MFCA identifies the source of waste generation as well the quantities and costs of waste generated from a process.

Furthermore, MFCA can be seen as an effective management tool used to help management to better understand the environmental aspects and profitability by improved material productivity and cost reduction. MFCA traces and calculates both the physical and monetary values of material flows for products and wastes (Ministry of Economy, Trade and Industry (METI) 2010).

Abdel-Kader (2011:67-68) claims that MFCA is a powerful method of environmental management and was being disseminated to industries because of its potential to help organisations realize that by increasing the transparency of material losses, companies can reduce environmental impacts and improve business efficiency. He goes on to describe the process as involving the detailed mapping of the material and energy flows through an organisation.

Hyrslova` *et al.* (2011:5-18) define material losses that occur during the course of corporate processes as an inseparable part of material flows, for example, defective products of poor quality, scrap, waste and damaged products). These material residues are economically and environmentally undesirable. However, the costs of wasted materials (non-product output) are not absorbed into product costs but are identified and reported separately at all stages. MFCA was developed as a tool to enhance material productivity in manufacturing operations. This method was applied by manufacturing companies to assess the loss of materials through the inefficient use of resources and to identify possible savings that could bring about economic and environmental benefits (Schmidt and Nakajima 2013:61). Scavone (2006:1276-1285) had similar findings and adds that the aim of adopting this methodology is to successfully reduce material inputs and to achieve new measures for increasing overall efficiency which will eventually lead to positive economic and environmental improvements.

Jasch (2009:4) goes a step further to claim that the most remarkable development on a methodological level, in the area of environmental management, has been MFCA which has influenced companies and regulators as far as Japan.

Scavone (2006:1276-1285) argues that MFCA is an adequate methodology to achieve better data and improve efficiency of production systems which lead to not only lower costs of actual material used but also to lower costs in material handling and waste disposal. Thus, material flows become more transparent, as explained previously by other authors.

Sygulla, Bierer and Gotze (2011:3) explain that material loss cost can be calculated by multiplying quantity of each material (Physical amount in kg) by their unit prices. Even though external recycling may assist in recovering some material cost, material loss cost is still significantly higher.

Economic loss caused by material losses includes all input costs of the process, such as energy, labour, depreciation, and material cost. MFCA assists the organisation in identifying, analysing and evaluating their economic loss by material loss.

MFCA has the following advantages (Japanese Ministry of Economy, Trade and Industry 2010):

1. Identifying problems: Realisation of the existence of economic loss which is hidden under conventional cost accounting; highlights conventionally uncontrolled material losses which only on-site operators are normally aware of; and assists in identifying material loss reduction options; and
2. Recognizing points for improvement: No appropriate improvement measures in place even though the company is aware of material losses; and reasons for not taking improvement actions. Management's general attitude and perception is that "standard operation", "capital investment not likely to be retrievable", "insufficient human resources", or it is 'technologically impossible'. The refusal to take action to break through technology is the direct cause of problems that are identified.

In many cases, companies that applied MFCA identified material losses to be significantly higher than they had previously realised.

It has also been established that MFCA presents the opportunity for engineers/companies to aim towards CP and achieving their targets of lower material losses and cost reduction (Ministry of Economy, Trade, and Industry 2010). Furthermore, the Japanese Industrial Standards Committee (2007:6), in its proposal for international standardization of MFCA, argued that, since MFCA forms the ultimate platform of an organisational unit, it should be considered for standardization. ISO14051 was developed in Japan in 2011 within the ISO14000 family, to set out standards and general principles for MFCA to provide support and guidance to companies and contribute to worldwide resource efficiency.

South Africa together with a number of other countries like Brazil, United Kingdom, Finland, Malaysia and Mexico were involved in developing the norms for ISO14051. At this stage, more than 300 manufacturing companies had successfully adopted the MFCA approach and have benefited economically and also reduced the environmental impact of their production processes.

Schmidt and Nakajima (2013:358-369) found some weaknesses in CCA in that it cannot give all the required data. Monetary value flows are traced and interpreted as product cost in a CCA system.

CCA focuses on cost figures for each product in each process whereas MFCA checks mass balances in each process. CCA focuses on production costs of the whole company in monetary terms whereas MFCA focuses on accuracy of cost figures of each process taking into account material losses (non-product output). Reporting under MFCA highlight actual production costs by excluding the cost of raw material purchased that becomes waste and does not form part of the final product.

Within the MFCA, the usage of materials is monitored in physical and monetary units (material costs). Generally, companies focus on the input materials and the quantity of products produced from these inputs, not on the material losses generated from the specific process.

Environmental costs in MFCA refer to all costs, either directly or indirectly related with the consumption of materials and energies and their environmental impact (Hyrslova' *et al* 2011:7). Hyrslova' *et al*. (2011:8) concur that MFCA is a very important method of environmental and economic performance management. Material costs make up the highest portion of costs (about 50%) in a manufacturing industry and, therefore, by reducing material usage, the amount of waste generated will also decrease. This will have positive economic effects (cost savings on materials and savings on disposal costs) and reduced environmental impacts (Sygulla *et al.* 2011:1). Therefore, much larger potential lies in reducing the costs of materials, but it is this potential that is left untouched by traditional environmental costing.

In MFCA, input materials, output and non-product output (material losses) are measured and then evaluated in monetary terms. Schmidt and Nakajima (2013:61) concur that lessons for companies are that inconsistencies in management information will result in material losses being incorrectly calculated. Therefore, it can be concluded that accuracy and relevance of internal data as well as data collection and cost evaluation are extremely important for an organisation.

2.6.2 Case studies on MFCA application

MFCA has been adopted in many case studies and resulted in environmental and economic benefits for the organisation.

MFCA was carried out as a test project at a Japanese firm, Canon, on their lens production process with focus on the grinding process (Ministry of Economy, Trade and Industry 2002).

Conventional accounting revealed 1% loss on defective products. However, after the application of MFCA, it became evident that a large part of the costs was due to material losses of defective products. Approximately 32% of the process costs could be allocated to material loss (Ministry of Economy, Trade and Industry 2010).

Following the successful implementation of MFCA, the approach was adopted at 17 Canon plant sites in Japan and abroad resulting in a total saving of 5.1 billion yen, equivalent to US $ 51 million, between 2004 and 2012. This saving was mainly due to more efficient use of resources resulting in improved economic and environmental performance. It was also found that between 20 to 30 percent of costs are actually non-product output costs. MFCA enabled the companies to identify material losses that were previously hidden in their production processes. It is evident that cooperation with suppliers, data exchange and high measure of trust between companies are important pre-requisites for the successful implementation of the MFCA approach (Schmidt and Nakajima 2013:358-369).

During the last decade, the importance of effective material flows increased significantly. Companies, however, require access to a measurement system to measure and compare material flows and costs in order to identify potential savings (Bengtsson and Sjoblom 2006:1).

MFCA application increased the transparency of material losses and highlighted saving opportunities in the case studies cited (Hyrslova' *et al*. 2011:9-16). Hence, it provided useful information to assist management decision making regarding the introduction of new technologies. The need for efficient use of resources due to their increasing cost may, to an extent, encourage organisations to adopt the MFCA approach to identify saving opportunities. South African companies are not familiar with this approach.

Therefore, there is a need to increase awareness of the benefits of this new tool to organisations that generate lots of waste during their production processes. Companies can use their previous financial data and apply the MFCA approach to identify the monetary and physical values of their losses in the form of non-product output costs. This will help them identify saving opportunities by investing in CP technologies that use less input resources and generate less waste, improving both environmental and economic performances.

It can be concluded that there is a need for more publications on cases in South Africa that have become aware of their non-product output costs by adopting the MFCA models.

More research based on case studies that can demonstrate effectiveness of the MFCA application in increasing transparency of environmental costs that were not visible when conventional costing systems were used could encourage the adoption of the MFCA approach by organisations that want to reduce production costs.

2.6.3 Non-Product Output

The most significant share of total environmental costs is usually non-product output costs. An EMA system can provide information needed that could be used for directing decisions towards the adoption of CP measures implementing new technologies to reduce these costs (Domil, Peres, and Peres 2010:720).

Hyrslova *et al*. (2011) believes that an EMA system provides users with valuable information regarding the material purchase value of non-product output and makes it possible to track and trace where non-product outputs are created. Management can use this information to propose measures to increase the efficiency of material use that will reduce environmental impacts and concurrently improve the economic performance of the organisation.

The purpose of material flow balance, as explained by Jasch (2009:832), is to completely understand how much of what is put into the system becomes a product, and how much becomes non-product output (NPO). He suggests that understanding NPO is the best way to manage environmental issues. The generation of waste or NPO is a sign of inefficient production. Therefore, material flows are not only important for assessment of environmental cost, but also for production-oriented cost assessment. It had been concluded that MFCA, although in its imperfect form, is a powerful tool to ensure the future sustainability of a business. Schmidt and Nakajima (2013:62) conclude that a key concept of MFCA is to distinguish between product cost and non-product output, to evaluate which streams of material end up as part of the final product and which streams of material are non-product output. Once material losses are quantified, improvement measures are identified to reduce costs by avoiding material losses. MFCA analysis makes it possible to identify the complete costs which then allows for technical measures to be implemented in order to reduce material loss.

One of the major cost drivers reported during company workshop studies was the material purchase value of non-product output (Jonall 2008:32). Thus, evidence has identified material purchase value of non-product output as the category of EMA that has the potential of the largest cost savings, as stated by Jonall (2008:40).

Non-product outputs are a major cost factor for companies considering that polluting companies actually pay three times for non-product output. First, the cost of purchasing the raw material ends up as wasted material. Secondly, the company incurs costs for operational use of raw material, for example, labour and investment cost. Finally, the company then pays for the disposal of this wasted material (Jonall 2008:42). This is the actual cost of the wasted material which most companies fail to realise. Non-product output costs can represent between 10-30% of total production costs of a company (Arlinghaus and Berger 2002:6).

Making them aware of these costs can create the need to improve material efficiency by investing in newer, CP technologies.

Not all wastes and emissions can be eliminated even if the BAT technology is used. Domil, Peres and Peres (2010:720) believe that a more suitable approach to help managers plan CP measures and investments in cleaner technologies, would be to create three different benchmarks against which companies can compare their non-product output costs.

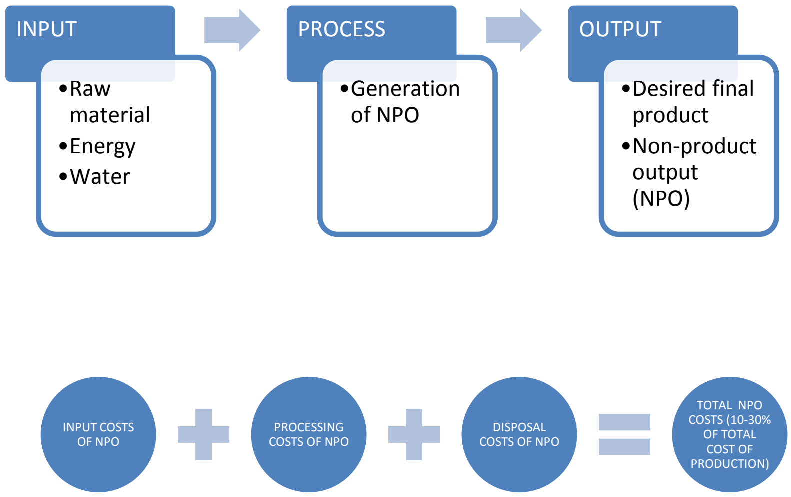
These benchmarks will be an indication as to how a company can manage and control their non-product output costs in the short-, medium, and long-terms. The first standards indicate technological norms. These represent the most efficient use of material at optimal functioning of the company's existing technology. This standard allows for waste and emissions that cannot be avoided by operating existing technology in an efficient way. These standards can be accessed from technical manuals and process flow chart analysis. Actual costs of inputs are compared to inputs if technological norms were followed. This difference is quantified and evaluated to establish how much a company can save in the short-term if the existing technology was operated efficiently. BAT levels are more stringent. These technologies are considered to be the most efficient and environmentally protective technologies that are available on the international market currently.

These standards can only be achieved in the medium-term when the company can switch to the BAT or significantly modify its existing technology.

Savings that could be possible by switching to the BAT is evaluated by the difference between actual costs of inputs and inputs for BAT norms. This benchmark reflects that some waste and pollution will be generated but at lower quantities than technological norms. This is generally the benchmark used in calculating non-product output cost in most literature. The final benchmark is the theoretical norms. This standard reflects a 100% efficiency, which requires significant technological development and is only achievable in the long-term.

Figure 2.4 demonstrates the NPO approach.

Figure 2.4: The non-product output approach



Source: Arlinghaus and Berger (2002:6)

Figure 2.4 highlights the significance of NPO cost in decision making and its impact on production capacity resulting in loss in production. Arlinghaus and Berger (2002:6) further explain that traditional management accounting systems focus on output of production and give no relevance to what is lost through NPO.

Domil, Peres, and Peres (2010:721-722) discuss the different levels of NPO costs and how these costs can be controlled within different time frames. The difference between actual NPO costs and cost for the technological norms is what most companies will be interested in for operational reasons.

This information shows deviation from technological standard costs due to inefficient use of existing technology. The NPO costs at this level can be reduced by better housekeeping, for example, better monitoring of raw material consumption, avoiding scraps and wastes and reducing energy and water consumption. This information needs to be generated on a monthly basis for companies to react faster. Level 2 NPO costs and the BAT norms need to be generated on a less frequent basis.

This can be used to work out the economic feasibility of performing technological improvement. This information will be used when considering changing technologies between 3-7 years, depending on the technological life cycle of the equipment. Total environmental costs reported must include NPO costs related to BAT. It is suggested that these costs be calculated annually for internal reporting purposes and to assist managers in making important investment decisions (Schaltegger *et al*. 2010:144).

2.7 Benchmarking and Controllability of Non-Product Output Costs

Schaltegger *et al*. (2010:144) define benchmarking as “A benchmark study is a systematic search for processes that yield superior performance. These benchmarks are then compared against current activities to gain insight on how to improve” (MacLean 2004:19). Benchmarks are used in environmental management to compare environmental performance. Benchmarking allows companies to assess their performance and identify opportunities for improvements.

Altham (2007:798-813) made a similar argument and extends this notion that benchmarking can increases environmental awareness by identifying environmental aspects that offer greatest potential for economic benefits with limited costs. Furthermore, benchmarking assists managers in identifying areas that incur large environmental costs that could be easily reduced by good housekeeping measures. It can, therefore, be concluded that since benchmarking is a process of continuous searching for best practices in completing tasks, it is also most likely that this could increase an organisations’ success in adopting CP techniques and technologies.

Previous research on a case study of a dry cleaning company that implemented benchmarking as a tool to promote CP reported findings of reduced waste generation, lower raw material consumption and improved energy efficiency (Altham 2007:798-813).

According to the UNDSD and Schaltegger *et al*. (2010:144), the most significant share of environmental costs comprises of NPO costs. In addition, they stated that there is a huge saving potential for evaluating raw materials and technologies used in processes that generate large quantities of NPO. This is generally revealed during a CPA process. Furthermore, evidence suggest that in order to assist managers in making CP investment decisions, three benchmarking models must be used to compare NPO costs. A pilot programme for the promotion of environmental management through identification of NPO costs was introduced to the case study of Zimboard Mutare, Zimbabwe.

Arlinghaus and Berger (2002:12-14) found that, by implementing action plans to reduce hidden and obvious NPO costs by identifying their original causes, the company achieved economic, environmental, and organisational benefits with little investment. It had been inferred that changes within the company not only increased transparency within the company, but also motivated staff to become more responsible and strive towards further improvements.

Table 2.5 highlights the benchmarks that companies can use to manage and reduce environmental costs in short-, medium-, and long-term.

Table 2.5: Benchmarks of companies

Material purchase value of non-product output	Ability to control cost	Method of controlling cost	Potential cost savings
Non-product output less technological standards	Short-term	Good housekeeping measures	Small to medium
Technological standards cost less state-of-the-art standards	Medium-term	Switch to state-of-the-art technology	Medium to large
State-of-the-art standards less theoretical costs	Long-term	Technological invention	Medium to large
Theoretical costs (chemicals industry)	Medium-to long-term	Switch to other raw materials and technology	Small to large
Product costs	Long-term	Product modifications	Small to large

Source: (Csutora and Palma 2009:6)

Table 2.5 also shows the relationship between NPO costs, controllability and potential savings (Csutora and Palma 2009:6)

Csutora and Palma (2009:2) explain the rationale for using benchmarks to measure inefficiencies against current activities and gain insight on how to improve by making cost reduction options more visible to managers. The life-cycle of technologies needs to be considered when benchmarking environmental costs. BAT is defined at a European level. The authors further claimed that using this benchmark recognised that some waste and pollution would always be generated even if the state-of-the-art technology was used. When existing technology is outdated, even if housekeeping measures are implemented, it is nearly impossible to achieve technological standards of NPO costs, argued Csutora and Palma (2009:5). They also reported the possibility of some 5-10% savings being realised by better monitoring and controlling of raw material input by avoiding leaking pipes and wasting energy.

Accountants are familiar with technological standards from the standard costing system. These standards highlight areas where waste and emissions can be reduced by better housekeeping, better monitoring of raw material consumption and reduction in energy and water consumption.

BAT norms reflect the most efficient, environmentally sensitive technological standards that are internationally available. This would require modification of existing technology and are thus only controllable in the medium- to long-term. The cost difference indicates the economic feasibility of performing technological improvements (Schaltegger *et al*. 2010:145-146). Annual calculation and reporting of these costs are suggested to enable new investment decisions by shareholders.

Theoretical norms represent 100% efficiency, which is almost impossible to achieve.

2.8 Conclusion

There is a lack of awareness among South African companies of the role and importance of EMA in improving environmental and economic performance and achieving sustainable development targets. Therefore, many companies are still using conventional costing systems and are unable to make informed strategic decisions of investing in CP. However, changes in legislation will greatly impact on management’s current view on CP and EMA.

This chapter has presented an analysis of keys issues on EMA that have been investigated by other researchers. Empirical evidence to support these findings was also discussed. A critical analysis was presented of the different views on the reasons for the challenges that organisations face in adopting an EMA system. Gaps in the studies were also realised during the literature review.

A literature review on CP methodology will be presented in the next chapter.

CHAPTER 3

LITERATURE REVIEW: CLEANER PRODUCTION

3.1 Introduction

The recent paradigm shift from pollution control to pollution prevention strategies has resulted in greater emphasis being placed on the adoption of CP techniques and technologies. This has placed companies under tremendous pressure to change from end-of-pipe treatment measures to now invest in CP technologies, aimed at reducing the amount of waste generated from operational activities.

This chapter reviews the literature from various sources in this study to present a basis for this investigation. It will highlight other research conducted in this field to identify the 'gap' that exists to enable to researcher to be able to build on or improve other research conducted in CP. A comparison of end-of-pipe technologies and CP technologies is also presented. Empirical evidence of improved environmental and economic performance within organisation by adopting CP is also reported.

3.2 Cleaner Production (CP)

3.2.1 Definition

CP was defined by the United Nations Environment Programme (UNEP) in 1991 and this definition still holds (Cleaner Production 2013:1).

"CP is the continuous application of an integrated preventative environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment".

Fore and Mbohwa (2010:314-333) further explain that CP refers to the production of goods and services with minimum environmental impact whilst taking into consideration present technological and economic challenges.

They believe that CP is more useful approach to pollution during industrial production.

According to Mugwindiri, Madanhire and Masiiwa (2013:1), CP is an approach to environmental management that focuses on the causes of environmental problems rather than the symptoms with the aim of improving environmental performance of products, processes and services and can be defined as an initiative to reduce waste and emissions and maximize product output by analysis of materials and energy.

3.2.2 Cleaner Production Methodology

Since the mid 1970's, businesses began to realise that prevention is the ultimate desired environmental management strategy (Environmental strategies 2013). Resources are used and waste is generated during manufacture of goods which costs businesses a lot of money. These costs can, however, be significantly reduced by improved management of materials, processes and operations (Cleaner Production Self-Help Tool 2000).

Traditionally, most organisations dealt with environmental degradation and pollution problems by ignoring the problem, dispersing the pollution so that its effects are less harmful or controlling pollution using 'end-of-pipe' treatment. The next environmental management paradigm was the pollution control approach which focused on the 'react and treat' approach which is after-the-event. However, CP is proactive technique that is based on the 'anticipate and prevent' philosophy. It has been estimated that through the use of technically sound and economically profitable procedures, 70% of all waste and emissions from industrial processes can be prevented at source (Bosworth *et al*. 2000:3).

This is because chemical and industrial products have become more complex, larger in volume and the waste more hazardous and persistent.

Hence, the strategy of “out of sight-out of mind” is no longer working well, explains Mugwindiri, Madanhire and Masiiwa (2013:2).

Biswas (2012:119-132) believes that the reduction or prevention of waste generated at source is only achievable through the implementation of any one of the five generic prevention practices: new product design, input/raw material substitution, new technology, good housekeeping, and (on-site) recycling and reuse. This can result in the supply of competitively priced goods and services.

Application of CP to production processes means conservation of resources, the elimination of toxic raw materials, and the reduction of wastes and emissions.

It can be concluded that if waste is not produced, there would be no waste control problem either. Hence, CP can be an effective measure to environmental issues. Fore and Mbohwa (2010:314-333) state that it is important to provide economic incentives to minimize pollution and waste generated by placing greater emphasis on the “polluter pays” principle. Scavone (2006:1276-1285) states that CP methodology is a useful tool to identify cost reduction opportunities by the efficient use of resources or recycling and saving within the organisation. It does, however, make good business sense to minimise or rather prevent waste and emissions, where possible.

According to Schmidt and Nakajima (2013:358-369), CP has gone a step further to now establish the monetary value of data for material flows to identify potential opportunities for savings and strategic decisions can now be made to invest in CP technology which could ultimately reduce environmental impact of residual materials and improve resource efficiency.

This system overcomes the weakness of the previous environmental methods used to calculate a material balance purely on volume basis.

CP requires resource efficiency and vice-versa. Therefore, UNIDO and UNEP have moved towards Resource Efficient and Cleaner Production (RECP) (Cleaner Production 2013).

RECP recognises the benefit of CP methods and their role relevance towards many global challenges such as reducing greenhouse gas emissions, responding to scarcity of water, fuels and other materials, and reducing environmental degeneration. Although CP has proven to be a good tool, that can improve both environmental and economic performance of the company, it has not yet been well implemented internally. South Africa's commitment to CP was declared at the world summit on sustainable development 'The Johannesburg plan of action' in 2002 (National cleaner production strategy 2004:7).

RECP encourages the application of preventative environmental strategies to processes, products and services to increase efficiency and reduce the negative environmental impact.

Three sustainability dimensions are addressed individually by RECP (Resource Efficient and Cleaner Production 2013):

- Production Efficiency: optimal and productive use of natural resources;
- Environmental Management: reducing waste and emission generated to minimize environmental impact; and
- Human Development: minimum risk to people and communities.

South Africa's commitment to CP led to the formation of the UNIDO and National Cleaner Production Centre (NCPC). The NCPC-SA strategy, which focuses on assisting industry to implement CP which requires investment in cleaner technologies, was confirmed at the CP conference which took place in Gauteng in June 2013 (Delano 2013:4).

RECP has been integrated into NCPC-SA centres' services. In addition, RECP includes energy efficiency, life cycle assessments and environmental accounting (South African Cleaner Production Centre 2013).

Nabais (2011:12) argues that CP should be included in the business strategy since it is business oriented.

She goes on to explain the following benefits to industry by adopting the CP approach: makes compliance with environmental regulations simpler; provides new market opportunities; better work environment; company image is improved; quality is improved; increased production capacity; and decrease in production costs.

Her findings also demonstrate a 'win-win' scenario for companies implementing CP as part of their business strategy. Hence, conclusions drawn by Nabais (2011:12) were similar to those advocated by Porter.

3.2.3 Cleaner Production Assessment

A Cleaner Production Assessment (CPA) involves the systematic implementation of procedures to identify inefficient resource consumption and poor waste management. This information is then used by companies to develop CP options. The UNEP and UNIDO developed the following basic steps to conduct CPA (Fore and Mbohwa 2010:314-333):

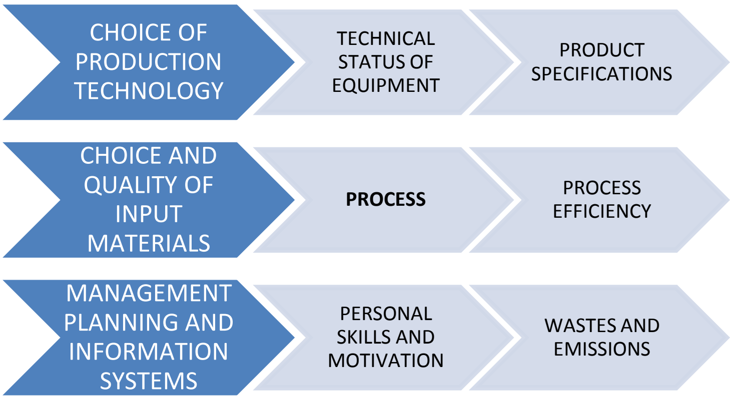
- Planning and organising the CPA;
- Pre-assessment (gathering qualitative data about the organisation and its activities);
- Assessment (gathering quantitative information about the organisation and its activities);
- Evaluation and feasibility assessment of cleaner production opportunities; and
- Implementation of CP opportunities identified and a plan to continue with CP efforts.

Nabais (2011:13), emphasises that proper procedures must be followed to ensure that the correct CP technique are applied as incorrect CP application can have negative impacts on the company.

She added that CP requires a detailed assessment to identify root causes of the problem including "careful planning, and rigorous track and check calculations"

The Institute of Environmental Engineering (APINI) and the UNEP identified possible causes of waste generation, as demonstrated by the figure 3.1.

Figure 3.1: Causes of waste generation



Source: APINI AND UNEP (nd)

Figure 3.1 highlights the causes of waste generated which companies need to consider when conducting a CPA.

The aim of this publication was to enable organisations to enjoy the benefits that CP had to offer. CP assessment methodology is used by companies to pinpoint critical points in industry and to highlight available options that could be implemented in order to improve environmental performance (Bosworth *et al*. 2000:3).

Management support and all employees are encouraged to prevent or reduce waste during the planning and organisation phase. They are also made aware of the potential benefits of the CP approach during this phase. Waste prevention and low cost options can be applied immediately and are identified and prioritised during the pre-assessment phase.

Environmental concerns and options to mitigate these are analysed in the assessment phase.

Finally, the most feasible, highly prioritised option is chosen and implemented by the company. A continuous preventative programme should be put in place to ensure that targets are successfully achieved.

Schaltegger *et al*. (2010:47) highlighted the following warning signs of inefficiencies which become evident during the CPA: higher raw material costs compared to those prescribed by technological standards, higher energy costs, maintenance needs, and higher levels of undesired output.

Several CP techniques and practices are possible, ranging from low cost or no cost solutions to high investments, and advanced clean technologies. Implementation of CP in developing countries is as follows (Cleaner Production and efficient resource use 2011):

- Good Housekeeping: to achieve proper, standardized operation and maintenance procedures and practices;
- Input Material Change: replacement of hazardous or non–renewable inputs by less hazardous or renewable materials;
- Better Process Control: operation of processes at higher efficiencies and lower rates of waste and emission generation;
- Equipment modification: production equipment modification so as achieve higher process efficiency and lower rates of wastes and emission generation;
- Technology Change: technology replacement in order to minimize the quantity of waste and emission generated during production;
- On-Site Recovery/Reuse: reuse of wasted material in the same process or another useful application within the company;
- Production of Useful By-Products: previously discarded waste can be transformed into useful material for application outside the company; and

- Product Modification: product modification in order to reduce environmental impacts of the product and its production.

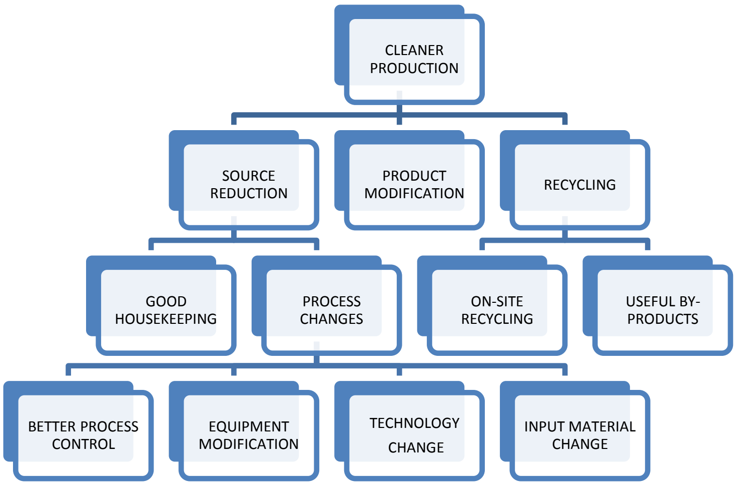
Mugwindiri, Madanhire and Masiiwa (2013:2) agree that concepts such as production technique changes, reduction in material and energy throughputs and production efficiency are embedded in the new approach of CP and pollution prevention. They also suggest that proactive maintenance strategy be implemented by companies to monitor and correct root causes to equipment failures.

Good housekeeping measures can bring about immediate benefits to the firm. Good housekeeping practices include the following (Cleaner Production Assessment 2002:79-80):

- Employee training, incentives and awareness programmes to encourage them to reduce waste and programmes to reduce loss of material input due to mishandling, obsolete and damaged stock;
- Loss prevention by avoiding leaks and spills from equipment; and
- Cost allocation procedures - enduring that all disposal and waste management costs are traced back to the department generating the waste rather than charging these costs to general overhead accounts. This will ensure that each department take responsibility for their share of environmental costs, hence, providing a motivation for reducing waste generated as they would not be accountable for their share of environmental costs.

Figure 3.2 indicates general CP techniques and their main relations.

Figure 3.2: CP techniques



Source: Nabais (2011:18)

Figure 3.2 represents the different CP techniques which can be implemented by organisations to improve their environmental performance and production efficiency.

CP link to sustainability is based on two principles: discussions on wastes and emissions should be concentrated on sources rather than symptoms, and that only by a higher degree of input material utilisation can minimization of waste and emission be obtained (Fore and Mbohwa 2010:314-333).

3.3 Cleaner Production Technologies

CP technologies are technologies introduced to eliminate or reduce air, water, and land pollution in an efficient and sustainable manner (McCray 2011:1).

During the Central Project in Europe, it had been concluded that CPT increase the resource efficiency in production, reduces consumption of input resources and the quantity of waste generated.

Furthermore, the need for end-of-pipe-technology may be eliminated resulting in major costs savings for the organisation (Access to Technology and Know-how on Cleaner Production in Central Europe 2008-2011).

Key feature of CP is the prevention of inefficient use of resources and avoiding unnecessary generation of waste (Bosworth *et al*. 2000:3). An organisation can benefit from reduced operating costs, reduced waste treatment and disposal costs. 'End-of-pipe' solutions are more expensive than investing in CP to prevent pollution and reduce resource consumption. CP technology investments have proven to be a more cost effective option that has brought about both financial and environmental benefits to companies (Bosworth *et al.* 2000:3). Technological improvements can occur in various ways: a change in manufacturing processes and technology; a change in nature of process inputs (energy sources, ingredients, recycled water etc.); alternative product development; and on-site reuse of wastes and by-products (Bosworth *et al.* 2000:4). Domil, Peres, and Peres (2010:719) believe that environmental protection projects aimed at waste prevention at its source through better utilization of raw materials are seldom recognised or implemented because those in charge are not aware that producing waste is generally more expensive than disposing them. They suggest that activity-based costing be implemented to improve internal cost calculations and allocate costs found in overhead accounts to the polluting activities.

3.3.1 Cleaner Production Technologies and End-Of-Pipe Technologies

Pollution prevention was realised to be the desired environmental management strategy since 1970 (Environmental strategies 2013). It had been concluded that the reduction and possible elimination of waste made good environmental and business sense. Frondel, Horbach, and Rennings (2004:25) investigated the characteristics of pollution-prevention technology (clean technology) as well as pollution control technology (end-of-pipe technology) and their effect on cost advantage and competitiveness of firms during their research.

Their findings were as follows: pollution prevention seeks to prevent or reduce emissions and effluent discharges through better housekeeping, material substitution, recycling or changes to the production process to minimize the creation of pollution and wastes.

Pollution control seeks to trap, store, treat, and dispose of emissions and effluents by using pollution-control equipment such as incinerators and scrubbers. McCray (2011:1) explain that end-of-pipe was the name given by ‘lazy polluters’ to the method of filtering waste or treating it with additional chemicals to mitigate harmful effects of what came out of the pipe.

An incorrect assumption made by government and industry was that end-of-pipe was an easy and profitable way out.

Clean technologies reduce emissions below required levels, resulting in lower compliance and liability costs. End-of-pipe technologies result in higher investment costs with no increase in the efficiency of production, as pollution-control technologies are non-productive assets. Environmental technologies lead to sustainable cost advantage as they are difficult to imitate by competitors as compared to end-of-pipe technologies which are off-the-shelf solutions and can be easily acquired in any market. Environmental technologies (clean technologies) require a firm’s production process to be changed whereas end-of-pipe technologies are added to existing production processes (Christmann 2000:15).

Mugwindiri, Madanhire and Masiiwa (2013:2) suggest that cleaner production technologies needed to be considered when dealing with environmental degradation from economic activities. They add that this provides developing countries with “leap-forging” possibilities rather than the highly polluting growth path taken by most industrialised countries. It had been inferred by Di Norcia (2011:4-8) that, as organisations move away from old industrial technologies towards environmentally cleaner technologies, environmental performance is reinforced.

Nabais (2011:16) addressed the difference between CP and pollution control to enable companies to assess the benefits of CP during decision making.

Table 3.1 identifies clear distinguishing factors that must be taken into consideration:

Table 3.1: Cleaner Production versus Pollution Control

CLEANER PRODUCTION	**POLLUTION CONTROL**
Continuous improvement	Temporary/immediate solutions to individual problems - 'on-off'
Progress towards continuous cycle processes- cradle to grave	Disposal of waste materials including loss of resources resulting from inefficient processes
Shared responsibility – cooperation and teamwork essential	Solutions are developed by experts and are expensive – done in isolation
Avoidance of pollution and waste is voluntary- proactive stance	Response to pollution and waste after they are generated – reactive response
Environmental problems are eliminated at their source	Waste treatment equipment and methods are used to control pollution
Involves change in practices, technologies, techniques and management attitude.	Involves technical improvements to existing technologies

Source: Self-generated

'Timing' is the key difference between pollution control and CP (Nabais 2011:16). Using CP to handle the waste problems would merely reduce the dependence of 'end-of-pipe' technologies or, in some cases, eliminate its use completely. It should be, however, noted that improvements with existing technology is possible but with minimum amounts of savings. Production process efficiency is highly dependent on what efficiency is possible with the best affordable technology. Neither the best available technology nor the best affordable technology would be able to achieve 100% efficiency in output in relation to the input. Processes without losses of energy or material, is nearly impossible to achieve. However, practical research in business organisations reveal examples where proactive prevention initiatives have brought about both environmental and financial benefits for firms as compared to reactive end-of-pipe approaches which are expensive and are camouflaged through hidden costs.

Jasch (2009:833) states that focusing on end-of-the-pipe solutions rather than cleaner technologies, which prevent emissions at its source, will not provide an accurate assessment of opportunities for potential savings of resource use. Bosworth *et al*. (2001:3) concurs that CP options are more cost effective when compared to pollution control options and savings are generated through reduced cost of raw materials, energy and waste treatment.

According to Fore and Mbohwa (2010:314-333), maintenance evaluation and implementation of techniques and technologies are crucial for waste minimization. In addition to the above, strong commitment and support from employees and management is also necessary. Information sources about technology, such as trade associations and journals, chemical and equipment suppliers, conferences and industry newsletters can be used by management and workers to educate themselves on CP techniques and technologies available on the market. This will most definitely assist them in making informed strategic investment decisions in the future.

An organization must have capabilities for process innovation and implementation to improve the efficiency of a production process and also gain cost advantage from implementing and innovating pollution-prevention technologies (Christmann 2000:18). Furthermore, it was found that CP motivated by market forces whereas end-of-pipe measures depend on regulatory measures and stringent environmental policy (Acemglu *et al*. 2012:54). Empirical evidence suggests that technological capabilities at facilities are greatly improved by organizational innovations. Environmental management system tools such as environmental audits support the implementation of CP techniques and development of such technologies. It was concluded that there is potential for substituting end-of-pipe technologies with cleaner technology by widening the cost gap between the two types of technologies, for example, by charging for the use of waste and energy.

Jasch and Schnitzer (2002:6-14) conversely stated that end-of-pipe technologies are bad for the environment as they shift the problem from one environmental medium to another instead of solving the problem at its source in addition to being an expensive and inefficient approach. However, Jonall (2008:42) points out that although prevention and environmental management costs have been high in the cases studied, they are considered low when compared to waste and emission treatment which is by far the largest cost category constituting of about three-quarters of estimated EMA costs. This ultimately means that the company has spent a lot on end-of-pipe treatment without being able to achieve their environmental performance targets. However, they are unaware of the actual costs incurred due to inaccurate environmental cost calculation.

It can, therefore, be concluded that end-of-pipe treatment is only a short-term measure, to ensure compliance with environmental regulations but are non-value added for the organisation.

3.4 Advantages Of Cleaner Production

The Department of Environment and Climate Change NSW (2011) found that CP had a positive impact on staff morale and engagement, reduced operating costs, increased profits, streamlined processes in addition to protecting the environment. Mugwindiri, Madanhire and Masiiwa (2013:1) echoed similar benefits of adopting CP: reduce the negative impact caused by waste; improve safety of workers; waste treatment and disposal costs reduced; and improves company's image. Similar findings were reported by Mendes (2011:100-106). He stated that cleaner technologies shared other possible earning/gains: human gains less risk or danger of accident, environmental gains: less pollution and reduced waste generated at the end of the production process and financial gains: less spent on maintenance and more efficient use of raw materials.

It was concluded that there were positive results in all departments in the environmental management system whereby the clean technology had been deployed.

This finding confirms that actions generated in CT should no longer be seen only as costs, as they represent a number of benefits to industries which assisted them in their endeavours in sustainable development and achieving their goals of the “triple bottom line”.

Fore and Mbohwa (2010:314-333) argue that CP efforts to reduce consumption of raw material and energy, and to prevent or minimize waste generation can improve productivity and result in economic benefits to the company. They pointed out that CP is a two-proned approach, which not only protects the environment, consumers and workers but also improves industrial efficiency as well as competitiveness. APINI (The Institute of Environmental Engineering) and UNEP also published similar findings on the benefits of CP: increased economic benefits; higher productivity; continuous environmental improvement; improved environmental performance; and greater competitive advantage.

CP technologies and equipment have been developed by many industrialised countries to decrease pollution and emissions’ quantities and to meet regulatory standards.

In order to minimize ash and gas emissions, waste water discharge and other environmental impact, pollution control methods should be substituted by CP techniques (Priority Programme for China’s Agenda 21).

3.5 Barriers to cleaner production implementation

Fore and Mbohwa (2010:314-333) identified barriers to cleaner technology adoption in Sri Lanka as: lack of financial initiative; resource unavailability, and less stringent government regulations, and policies as being some of the major issues.

The traditional focus in countries like India and many other developing countries is ultimately profit making without taking into account the environmental impact of their activities. They also found that companies often fail to implement CP projects despite the environmental and economic benefits of the approach because of limited capital availability.

Nguyen *et al.* (2010:89) had similar findings during a study in the Vietnamese power sector. They identified insufficient capital, unsatisfactory government policies and lack of domestic suppliers as the key barriers to cleaner technology adoption. Some suggestions made by Fore and Mbohwa (2010:314-333) to overcome these barriers include:

- Removal of environmental compliance and legislative costs associated with beneficial reuse;
- Development of centralised recycling facilities with major suppliers to develop better inputs by adopting a supply chain management approach; and
- Technologies could be used to promote SD.

APINI and UNEP went on to identify internal and external barriers to CP implementation. They found that CP barriers internal to the company are: lack of environmental awareness; financial obstacles; poor communication links; lack of information and expertise; management commitment is low; and competing business priorities where short-term profitability projects are preferred.

External barriers to CP were identified as follows: lack of or non-existing regulatory approaches; cleaner technologies difficult to access; and limited access to external finance.

Even though barriers are identified, these are outweighed by the real benefits of the CP approach. It has also been found that developing countries face greater challenges that inhibit CP adoption such as a lack of technological sophistication and a lack of resources and expertise to exploit CP opportunities identified (Fore and Mbohwa 2010:314-333).

According to Pandey (2007:2), a report by the Department of Environmental Affairs and Tourism of South Africa suggests that, due to limited knowledge and availability of preventative environmental technologies, end-of-pipe treatment technologies are highly influential and more widely adopted among South African industries. In order to bring about change, CP solutions need to be promoted and encouraged ahead of end-of-pipe treatment.

3.6 Case Studies on Cleaner Production

A number of research studies have been done on application of CP techniques and technologies in various manufacturing industries in both developed and developing economies and have reported environmental, social and economic benefits for companies that had adopted the CP approach.

There has been much controversy on the benefits of CP and its impact on environmental and economic performance. This has resulted in many case studies being done by experts to verify whether or not benefits of CP justify the investment cost needed to adopt such an approach, not to mention the need for additional resources to ensure successful implementation of CP techniques and technologies. However, there is sufficient empirical evidence that revealed that the CP approach does actually have a positive impact on both environmental and economic performance of an organisation.

Bosworth *et al.* (2000:3), in his publication of CP in a dairy industry, clearly state that the most significant CP benefits are only attainable through both lateral thinking and technological change.

They believe that a change in attitude of management and employees of a company are crucial in gaining the most out of CP. The Academy of Science of South Africa (2011:111) identified implementing CP processes as an opportunity to avoid solid waste and reduce greenhouse gas (GHG) emissions in the eThekwini Municipality.

They also state that promotion of CP needed to be driven by a champion, together with support from the Municipality and commitment from the organisation in order to significantly reduce wastage and quantities of waste going to landfill.

Experts have agreed that organisations do not know how much they can save by adopting cleaner production and EMA tools because they do not realise how much they actually spend to produce waste and to manage it (Scavone 2006:1276-1285). Hence, measurement and accounting for waste and emissions are necessary for cleaner production and EMA projects.

Fore and Mbohwa (2010:314-333) investigated the CP concept and its impact on environmental and business performance in the foundry industry. It has been discovered that the CP approach provided clear guidance on possible options on maximisation of resource utilisation whilst minimizing waste generation that could be considered for managerial decision making and policy formulation. Similar findings were reported by Zeng *et al*. (2010:975-983) of an overall positive impact of CP on firm's business performance.

The investigation by Schatlegger *et al*. (2010:11-17) into cleaner productions has suggested that since CP requires innovations, there is a need for requirements of EMA to move from a given, standardized set of procedures to tools that are more flexible, indicator-based approaches. CP sets a challenge for research in EMA to provide frameworks that need to be couched in terms of their theoretical foundations that focus on drivers of change as well as incentives and barriers to change in the technological, organization and accounting innovations' context and their development.

A test project undertaken by Schaltegger *et al.* (2010:17-19) in 4 companies to assess their sustainable performance after a combined application of EMA, CPA and EMS generated positive outcomes.

However, some studies revealed that EMA has made positive contribution to the enhancement of CPA / EMS projects by increasing awareness of the economic implications of the environmental impact of NPO and costs and provided a systematic method of controlling these costs in the short-, medium- and long- terms. EMA also helped to quantify monetary benefits of adopting alternator CP options. Two of the companies extended their scope of EMA to analyze other technological processes and in the process made important decisions regarding phasing out products and making new investments on the basis of the results of the EMA test project.

Research in a milk processing company by Dvarioniene, Kruopiene, and Stankeviclene (2012:1037-1045) aimed at identifying the effect on environmental efficiency by application of CP and eco-design as sustainability tools. The milk industry, similar to the paper manufacturing industry, is very resource intensive and also generates many by-products and wastes during each process. Thus, it does have a polluting impact on the environment. The company used in the case analysis was found to have used technologies that were obsolete, of low working productivity, ineffective use of raw materials, and they did not meet modern market requirements. The case study being done in this research also has the same problem with regard to old obsolete technologies being used in their production processes.

Pandey and Brent (2008:171-182) concluded that development of cleaner technologies is slower in developing countries such as South Africa, due to greater emphasis being placed on economic growth rather than environmental protection. The results of their study highlighted that technological improvements can be achieved through CP.

However these improvements were mainly through incremental innovations in the secondary process. These incremental innovations involve adoption, refinement, and enhancement of existing products and services and/or production systems, whereas radical innovation involves extremely new products or change of the production system which occurs at a lesser extent.

Despite reported benefits of CP implementation, many companies are still reluctant to shift from end-of-pipe treatment to pollution-prevention technologies. Experts have developed models and other strategies to investigate factors that encourage CP implementation and factors that limit the adoption of CP among industries and countries.

The empirical evidence above clearly indicates that, in order to survive in a dynamic business, environmental innovations play an important role. Technological and organisational innovations are crucial in order to change a company’s profile into becoming environmentally, economically and socially sustainable.

Empirical evidence also suggests that higher environmental performance is a direct result of more efficient processes, improved productivity, and reduced regulatory or compliance costs. Hence, in order to improve efficiency of production processes, there is definitely a need to ensure optimal technical efficiency. This, in turn, leads to new market opportunities and increased competitive advantage for the organisation.

Despite the fact that many companies participating in CP programmes and projects have reported improved environmental and economic or financial benefits, CP implementation remains slow and lagging, more especially in developing countries like South Africa. The recent depressing economic climate has added to the problem. Most companies prefer the old approach of ‘out of sight is out of mind’ as an easy solution to environmental issues. Organisations fail to understand that being ISO 14001 accredited means commitment to continuous improvement environmental strategies. CP is a part of this strategy that all companies need to eventually achieve.

Based on the empirical evidence reported, it is clear that most of the CP case studies were part of pilot test projects funded by external organisations like UNEP, UNDSD or UNIDO. Hence, organisations are not willing to invest large amounts of capital on projects that cannot contribute to their profit margins.

They are willing to adopt new strategies, provided that they are not incurring unnecessary expenses. It also proves that the profit motive still drives investment decisions. Social and environmental aspects of businesses are not viewed as equally important. This could very possibly be the largest barrier to the implementation of CP techniques and technologies.

The attitude and commitment of managers towards achieving sustainability targets needs to change. This can only happen if there is increased pressure from external stakeholders and CP needs to be incorporated into legislation and regulations for industries that are ISO 14001 accredited.

3.6.1 Cleaner production case studies done on boiler plants

Case study findings reported by The Cleaner Production Case Studies Directory EnviroNET Australia (2003) presented results of a CPA that was done on coal-fired boilers used by the AMH group which operated five coal-fired boilers, situated at different sites. The CPA assessment revealed differences in coal burning performances of the boilers and opportunities to improve boiler performance were identified.

It had been found that between 2% and 29% of coal used were not combusted. The unburned coal that remained in the boiler ash was disposed to landfill. Two of the five boilers revealed poor performance. The investigation showed significantly high production costs due to wasted energy and higher steam costs. A thorough investigation was done of the process involving the two underperforming boilers to identify possible causes of the inefficiencies identified during the CPA.

It had been found that the boiler operating staff had difficulty in operating the boilers to meet steam demand. The company conducted an in-house training programme to develop operating and management skills of staff involved in operating the boilers. The programme was successful resulting in immediate reduction in percentage of unburned coal from 25% to 2% and improved boiler efficiency from 70% to 98% (The Cleaner Production Case Studies Directory EnviroNet Australia 2003).

Coal usage decreased by 27% resulting in a savings of approximately $65 000. An added benefit was reduced ash disposal to landfill by 275 tons per year (The Cleaner Production Case Studies Directory EnviroNet Australia 2003).

The evidence of this case study contradicts the perception of company managers that CP options are costly to implement. CP is not always a costly approach and may be the only solution for companies facing tough economic downturns.

The UNEP conducted an investigation of the boiler house of a textile company in India, as part of the ACME project (Applying Cleaner Production to Multilateral Environmental Agreements (ACME, nd). Un-burned coal in ash was identified as a waste stream during CPA analysis. Possible causes of the waste generated were further investigated. The results indicated that improper coal sizes, inappropriate grate design, inconsistent firing rate, manual ash removal, and inferior quality of fuel as probable causes of inefficient combustion and poor boiler performance. It had also been emphasised that lack of proper maintenance of boiler drums and poor boiler insulation could also cause energy loss and impact on boiler performance. Recommended CP options to reduce unburned coal ash were: conversion to FBC boiler, ensure coal is properly crushed and sieved to achieve optimal coal size, reduce gaps between rods by modifying existing grate and use of stoker firing to achieve optimal firing rate.

The advantages of FBC Boilers was their high efficiency as fuel is burned with a combustion efficiency of over 95% irrespective of ash content and operational efficiency of 84% (+-2%).

3.7 Current Waste Legislation and Impacts on Organisation

Waste management: legislative overview

According to the National Environmental Management: Waste Act 2008 (NEMWA) (Act 59 of 2008), it had been stated that waste needed to be classified according to its characteristics to ensure responsible handling, storage, processing, treatment and disposal of waste that also satisfies legal requirements (Wood 2013:2). Boiler ash generated is normally transported via conveyor belts and stored in enclosed silos. However, an alternative option adopted by many organisations is that they allow contractors that have beneficial use for it, removes the ash and uses it in other manufacturing processes (example: brick making).

It is a legislative requirement that ash be stored in an area licensed in terms of NEMWA: GN R. 718 of 03 July 2009, Category A3 (2).

Boiler ash consists of clinker ash (hazardous group 2) and fly ash (hazardous group 1). Fly ash contains more hazardous metals and is generally used in block making. A disposal requirement is that the two ash types are separated. Boiler ash is often used as daily cover materials at landfills. The presence of unburned carbon in boiler ash is evidence of poor operating practices. It is the duty of the producer of the waste such as ash to ensure that it is disposed of correctly. Godfrey, Rivers and Jindal (2014:6-23) discussed trends in waste management in developing countries such as South Africa. Some of the following challenges faced were similar to those experienced by developed countries:

- Growing waste demands placing greater pressure on the provision of infrastructure;
- Changes in terms of socio-economic issues;

- Disposal to landfill being the dominant means for waste management;
- Problematic waste streams such as organic waste and hazardous waste;
- Low levels of recycling; and
- Inadequate environmental legislation regulating waste management activities.

In South Africa, greater emphasis was placed on recycling and recovery. Up until 2011, approximately 90% of all general and hazardous waste generated was disposed to landfill.

South Africa strongly still currently relies heavily on landfilling as its waste technology solution. About 9.8% of waste generated is recycled and 0.1% treated. Waste recycling in South Africa is mainly driven by the informal waste sector.

A survey conducted by the National Waste sector in 2012 revealed that South African private and public sectors rely heavily on land filling as a technological option to waste management.

The majority of waste technologies patented are non-South African owned indicating clearly that international companies see South Africa as an attractive market for the introduction of waste technologies. Companies have begun to protect their intellectual property due to the growing trend towards innovative waste technology (Godfrey, Rivers and Jindal 2014:8).

The People's Republic of China (2011-2015) has identified 'developing a circular economy' as the strategic area of focus to address the socio-economic development issues relating to waste management. The trend towards the circular economy together with the principle of the waste hierarchy is prompting change within South Africa. Currently, South Africa is largely at the peripheral of this global transition.

Strategic evolution towards managing waste, such as coal ash within the next 3-10 years, involves research on minimising ash and clean technologies.

3.8 Conclusion

The use of EMA to adopt CP to improve the environmental and economic performance of organisations, have gained importance over the last few years. Many pilot test projects have been undertaken by EMA and CP experts to test and identify the benefits of implementing CP. It is evident that conventional cost accounting systems do not provide accurate information on environmental costs to enable informed strategic decisions by management.

This chapter has presented an analysis of key issues on CP that have been investigated by other researchers. A review of end-of-pipe technologies and CP technologies was also done. Empirical evidence to support their findings were also discussed. A critical analysis was presented of different viewpoints on the reasons for the limited adoption of EMA and CP in industries. Gaps in the studies were also realised during the literature review.

The next chapter deals with the methodology used in collecting and analyzing data in the study.

CHAPTER 4

RESEARCH METHODOLOGY AND DESIGN

4.1 Introduction

The previous chapter provided a literature review of EMA and the impact of CP processes and technologies on environmental and economic performance of organisations. MFCA models and their role in assisting organisations in identifying possible cost savings by implementing CP technologies and in capital investment decision were also discussed. This chapter presents the research methodology and research design used in this study.

Greetham (2009:28) defines research as a process which involves the use of procedures and objective methods to obtain scientific knowledge on a specific topic and which excludes any personal feelings of the researcher. Struwig and Stead (2013:2) stress that the scientific approach adopted by researchers should be impartial, free from influences such as authority, traditional beliefs and personal preferences. Picardi and Masick (2014:10) conclude that research is a complex iterative process that focuses on ensuring that the study conducted is both reliable and valid. It basically involves putting together the most appropriate methods and techniques that will help one to answer the research question as it is the research question that drives the research.

Research methodology explains the logic behind research methods and techniques and is a systematic way to solve a research problem. Picardi and Masick (2014:8) explain research methodology as a learning process involving acquisition of new knowledge or advancing existing knowledge to enable one to find an effective solution to an existing problem. The two types of reasoning a research can use to approach a problem is by either induction or deduction (Picardi and Masick 2014:7).

In this study the researcher reviewed existing literature and what previous researchers have done in order to develop the research question that needed to be addressed. Hence, an inductive approach has been adopted.

Struwig and Stead (2013:2-3) argue that research is different from information gathering and decision making in that research is based on an open system of thought and researchers do not merely agree or disagree. Instead, they critically examine data and sources. From the above definitions, it is evident that research is conducted to develop and evaluate concepts and theories.

The first phase of conducting research is to identify what category of research is being conducted. There are two main categories that research can fall into are basic research and applied research. Picardi and Masick (2014:8) define basic research as a type of research where questions are developed to understand a particular phenomenon whereas applied research is a type of research that is conducted to solve a problem that has occurred. This study was an applied research as the aim was to reduce the environmental and economic impact of steam generation process by focusing on CP technology.

Once the category of the research has been identified, the next step is to begin the process of conducting research. Picardi and Masick (2014:9) identified a cyclical methodology comprising of seven steps for conducting research:

1. Problem identification;
2. Understanding the problem by utilizing research;
3. Develop a research problem or create a hypothesis;
4. Design a methodology for conducting the research;
5. Data collection and analysis of results;
6. Interpretation of findings and arrive at conclusions; and
7. Report finding.

The method described above has been followed in this study.

In the previous chapter, a general view of EMA, MFCA models and benefits of CP was presented with relevant examples of the implementation of CP and EMA in manufacturing industries globally.

This study is a case study involving both quantitative and qualitative methods.

A comprehensive discussion of the research approaches used is presented together with the various methods of collecting data, details of the design of the data collection instruments, the target population and sampling techniques are also included in this chapter. The statistical techniques that will be used in this study to analyse the data are also presented in this chapter.

Figure 4.1 depicts the elements of research methodology and highlights the relationship that exists and how this influences the 'plan' that guides the research process. The researcher found it appropriate to include the model below as one can clearly identify the components explained later in the chapter which will facilitate a better understanding of the study conducted.

Figure 4.1 The honeycomb of research methodology

Source: Wilson (2014:115)

The model in Figure 4.1 represents the ‘Honeycomb of Research Methodology’ and highlights the relationship that exists between the choice of research philosophy which influences both choice of the research approach and research strategy. The choice of research philosophy underpins the choice of research design. Therefore, based on the above, it can be deduced that one’s knowledge on research philosophy is essential in choosing the correct research design or to adapt research designs according to the constraints of different knowledge structures (Wilson 2014:116-117).

4.2 Research Design

Research philosophy underpins the design of the study. Research design is the plan for an entire research project involving one’s assumptions, research method, data collection techniques, and data analysis approach and can be influenced by both technical and contextual considerations (Myers 2013:25).

Components of research design include propositions of the study, the unit of analysis, the study questions and criteria for interpreting findings (Wilson 2014:118). In the study, the unit of analysis is an organization and the chosen criteria for interpreting environmental cost are technological benchmarks and state-of-the-art standards. The research question is as follows: What is the most cost effective, efficient and sustainable method of producing steam, with particular emphasis on production technology, and its impact on the organization environmental and economic performance.

This study involved scientific theory building methodology through proper data collection, analysis and evaluation on the production processes of the company concerned.

This study was a case study combined with a causal-comparative research as the aim of the researcher was to understand the reason for the excessive waste generated during the process being investigated.

The causal study was set out to determine whether the technology used in the production process had a negative impact on environmental and economic performance resulting in excessive use of resources and waste being generated due to inefficient production processes. Causal research will identify cause-and-effect relationships among variables when the research problem has been narrowly defined. These findings were then compared to technological standards and standards of best available technology. This study aimed at understanding the impact of CPT on the environmental and economic performance of the company.

Expert knowledge on EMA information was required from sources in order to ensure that information is reliable.

This study, therefore, focused on the Environmental Manager and Management Accountant as primary sources of evidence during the semi-structured interview process in order to establish the company's current costing and environmental practices.

Time horizon for the study was limited to data being collected and analyzed for a period of one year.

Planning the research design involved the selection of the following basic research methods:

Survey Questionnaire

The design and distribution of questionnaires are interdependent (Greetham 2009:202). Greetham (2009:203) states that a self-completion questionnaire can be an effective tool in collecting data in order to gain a clearer perspective, provided that the questions are clear, not too long, and easy to follow.

A survey was done using a questionnaire to establish the managers' perception of the company's environmental performance and environmental cost allocation as well as to understand their perception on implementation of CP and barriers to investing in CPT. The questionnaire was designed using the Likert scale method to collect data (Appendix 4). It has been reported that the reliability of Likert scale is preferable to other methods because a wider range of answers are permitted from the respondents (Myers 2013:125).

Semi-structured interview questions to gather primary data (Appendix 1).

Semi-structured interviews were conducted to gain a better understanding and in-depth knowledge of the variables being studied. This method of collecting information allows for probing by the researcher and to clarify any misconceptions that participants may have regarding the questions (Myers 2013:124). Responses to semi-structured interview questions were written down by the researcher in order to analyse the findings. Interviews are an important data collection technique for case studies, since well-informed respondents can provide important insights into a situation (Yin 2003:25).

For this study, interviews were used to gather historical and contextual information on environmental management and cost allocation methods of the process under investigation and it also helped to gather information on processes and activities that the company has implemented in order to address environmental issues.

Secondary data sources involved the development of a mathematical model to predict the correlation of two related variables, company records, internets, etc.

A direct observation of the processes involving fieldwork and CP assessment of boiler machines used in the steam making process was conducted during this study.

Documentary evidence was also used to analyse cost allocation methods and cost incurred in the steam production process for the period under review (Appendix 2 and 3). Documents from the technical department containing information on coal input and steam output for a period of 12 months, from October 2012 until September 2013, was also analysed by the researcher to establish operational efficiency of boiler technology used by the company currently.

The above mentioned methods were used because of the following reasons suggested by Yin (2009:102):

- Documentation – Stable and can be reviewed repeatedly;
- Interviews – Causal inferences and explanations can be achieved. Focuses directly on case study topics;
- Observation – Context of the case is well established; and
- Archival records – quantitative information accessed are usually accurate.

4.3 Research Method

4.3.1 Case study

A case study research methodology was followed in this study involving quantitative data assessment and exploratory qualitative research analysis technique which was applied to generate theory from collected data. The case can be an event, an entity, an individual or even a unit of analysis (Yin 2009:73).

Case study research has proven to be beneficial by providing an opportunity to make detailed studies of the real corporate world to improve the knowledge of management accounting and reduce the gap between theory and practice. Yin (2009:77) defines a case as ‘an empirical enquiry that investigates a contemporary phenomenon within its real life context using multiple sources of evidence’.

Some researchers have argued that a detailed, unique case study is adequate when it represents a critical case that tests theory that has already been formulated and when it is representative of a set of circumstances or context conditions of daily routine. This type of case study responds better to the need to develop theory and adopts prior theoretical propositions to guide data collection and analysis (Yin 2009:80).

Greetham (2009:222) cautions that a case study should not be a descriptive study only. The case studied needs to be analysed to provide a basis upon which suggestions are made to address and solve the problem identified and also explain why a particular action has been unsuccessful. In this study, the research has provided sufficient reasons for the excessive waste generated during the steam production process as well as the environmental and economic impact it has had on the organisation. A case study is appropriate to allow for an in-depth study of the organisation's current production processes and technological efficiency of the process under investigation, and environmental management and costing techniques (Quinlan 2011:196-197). The choice of a case study is justified by the economic importance of the organisation and its willingness to adopt new techniques (Moll *et al*. 2006).

This study is based on a case study following a multi-method approach, that is, method triangulation and involves a holistic analysis of a single organisation. Triangulation involves the use of more than one research technique/method to gather data or combine qualitative and quantitative research methods in one study (Myers 2013:9).

Yin (2009:81) outlines the following characteristics of a case study:

- Overview of case study objectives, problem statement and relevant literature on the topic being researched;
- Field procedure involving access to the organisation's site and sources of data;
- Case study questions; and
- Case study report and presentation of data collected.

The above protocol had been followed in this study.

Remenyi (2012:4) suggests that the case study approach is an umbrella term for a family of research methods with a decision to focus around a specific instance or event.

Case study research based on an organisation should clearly question why the company is not functioning as well as it should be doing? (Davies 2007:185). The main objective of this type of research is to build a theory and provide an understanding of processes and the context in which management accounting practices and control take place (Berry *et al*. 2009).

Accuracy and completeness are important to all aspects of the academic research project. A research case study needs to be an account of a situation in which there is a problem or research opportunity (Remenyi 2012:19). Remenyi (2012:7) suggested that a case study consists of the following nine dimensions:

1. Complex and challenging research questions need to be answered;
2. An empirical approach to answer these research questions;
3. Many variables are involved;
4. Quantitative, qualitative or mixed methods are used;
5. Must be presented as a narrative to facilitate the answering of the questions;
6. Clear-cut focus on a unit of analysis;
7. Context in which the research question is put and answer is sought must be recognised;
8. Not to be extended for a long period of time; and
9. Degree of triangulation is offered and enriched by multiple sources of data or evidence.

A research needs to satisfy all of the nine dimensions stated above. The above mentioned dimensions have been satisfied in this study.

Greetham (2009:222) states that a successful case study finding must be related back to the broader theoretical themes and empirical concerns in the literature. Conclusions made in this study were based on a systematic, meticulous and detailed analysis of all data collected.

4.3.2 Quantitative and Qualitative data analysis methods

The researcher implemented both qualitative and quantitative data analysis methods during the study to gather information that led to a comprehensive understanding about a phenomenon specific to individual units. In a qualitative study, the researcher collects, interprets and analyses data that cannot be easily quantified and expressed in numbers. The aim of qualitative research is to explore and gain an in-depth understanding from a situational perspective (Davies 2007:191). One should ensure that qualitative data should not analysed as though a survey had been conducted by merely 'adding up' what different respondents have said during their conversations with the researcher. Since the interaction between organization and institutional contexts are not linear, an explanatory case study is the most appropriate to study the complexity of inter relationships and provide explanations of observed practices (Nor-Aziah and Scapens 2007). Producing qualitative data implies a permanent judgement on data gathered and its position relatively to theory. This results in subjectivity from the researcher since there is a need to interpret the social reality being studied. During a qualitative study, the researcher participates and becomes immersed in the research.

Quantitative methods are described in numbers and figures that are analysed with mathematical or statistical methods. Greetham (2009:180) states that, for quantitative research, the situation being researched must me capable of being expressed in terms of numbers and can be analysed mathematically either in terms of percentages, averages or using statistical tests and mathematical models.

The coal input and steam output data, production costs and environmental costs, as well as questionnaire responses were statistically analysed in this study.

The researcher's role in a quantitative study is as an objective observer who neither participates in nor influences what is being studied. The distinguishing factor of qualitative research is the unique approach used to understand and study reality (Yin 2003:25). Generalisability, a quantitative study is context-free and, for a qualitative study, generalizations are context-based.

4.4 Target Population

Although the company employs approximately 300 employees, the study was directed towards those involved in environmental management issues, production, operations, accounting and cost control. Since the size of this population is small, a census is feasible. It had been suggested by Myers (2013:84) that it would be inappropriate to evaluate and judge the validity of a case study method by using sampling logic. Sampling logic and statistical theory are used when conducting a survey and not in case study research. In a case study, research statistical concepts, such as confidence intervals and confidence levels, are meaningless. Case study expert, Yin (2003), pointed out that it would be better to generalize case study research to theory, rather than using sampling logic to justify case study research (Myers 2013:84). It has been stated by Myers (2013:123) that there is no such thing as an ideal number of interviews. Ahuvia (2005) used data from just two in-depth interviews in a study which was published in one of the top marketing journals. What is important is that the people interviewed are able to provide relevant information and they represent the 'various voices' of the organisation (Myers 2013:123).

4.5 Census Study

Both management accounting and environmental management are of special interest and concern to this study.

In accordance with this dual interest, at least one participant from accounting division and the other from the environmental team participated in the semi-structured interviews.

Since managers are the only respondents who can provide the required data for this study, the researcher elected to conduct a census study.

A census is an investigation of all the individual elements that make up the population (Zikmund 2004:369).The census will include all senior and middle-level members of the management team.

The composition of the census population is shown in Table 4.1

Table 4.1 Composition of census population

DEPARTMENT/ LEVEL	TOTAL POPULATION	SAMPLE NUMBER
Operations/Production	25	25
Plant foreman	4	4
Cost Accounting/control	10	10
Environmental manager	1	1
TOTAL	**40**	**40**

Table 4.1 shows that the participants chosen by the researcher to be included in the study must have a contribution to make towards the key areas/topics being investigated (Quinlan 2011:196).

4.6 Data Collection Methods

During the preparation of the data collection phase, the elaboration of a protocol may be useful to raise the reliability of this phase.

Collection of documents by the researcher is normally the starting point in order to understand the organization and the corporate environment. In order to add credibility and validity to the case study, multiple sources of information were used. Yin (2003) suggests three base procedures to ensure that data reliability is established: triangulation of data collected; creation of case study database to index all documentation collected;

and establishment of evidence chain. The first and third procedures test the validity of data and procedures two and three reinforce the confidence in the data collection procedure.

The research questions are based on review of prior theory which provides strong guidance on what data should be collected and the strategies for analysing the data.

The two survey questionnaires addressed the managers' perception of the company's current environmental performance and barriers to implementing CP processes. A precise hypothesis was avoided in order to allow the researcher to use research questions as a tool to explore and generate other patterns of phenomena during the study.

Yin (2003:29) points out that this methodology allows flexibility and does not unnecessarily limit the inquiry.

The semi-structured interview questionnaire was designed for the key managers with functions of either environmental management or management accounting. The interview questionnaire was used to understand procedures and policies implemented by the company with regards to the treatment of environmental costs and to understand the company's current accounting system and how environmental costs are handled and reported. The role of the management accountant in environmental cost allocation was also established including the level of communication between the environmental manager and cost accountant was also determined during the semi-structured interviews.

The descriptive part of the research was established during the CPA of the steam generation process during which significant waste streams were identified. This process description addressed objective 1 of the research project.

Suggested research themes of survey questionnaires were as follows:

- Management and accounting of major environmental costs;
- Environmental accountability;
- Stakeholder involvement and external pressure in implementing EMA; and
- Management's attitude to and views on EMA adoption.

4.6.1 Pilot study

A pilot study was conducted to test the questionnaire and semi-structured interview questions with an Environmental Manager/Quality Controller from a Food and Cosmetic manufacturing company in the Durban area. The pilot study interviews and questionnaires were self-administered by individuals who were knowledgeable about the key concepts discussed, namely, EMA and the benefits of CP in manufacturing companies. This provided an opportunity to check the data collection instrument to minimize errors, due to improper design, poorly worded or organized questions. A pilot study is conducted to enable the respondent to feedback on the length of the questionnaire and whether the interview questions are confusing or ambiguous (Zikmund 2004:72).

During the interview with the Environmental Manager of the company, it became apparent that these questions are designed specifically for management with expert knowledge on production, accounting and environmental management. There were no changes made to the research instruments as they were found to be valid. Hence, construct validity was satisfied by pre-testing the questionnaire during the pilot study of this research. Face validity was also established by having the questionnaire reviewed by the research supervisor and an environmental accounting specialist. Both these individuals have extensive research experience in this field.

4.6.2 Sample size

This was a census study which consisted of 40 respondents.

The questionnaire was distributed to senior and middle level management that included the production, financial, environmental managers as well as technology experts and engineers which were part of the operations/production department stated in table 4.1.

It was also given to lower level managers/front line managers in order to gain an understanding of their perceptions on the company's environmental performance and costing incurred in ensuring sustainable production. The two people participating in the semi-structured interview research, the Environmental Manager and the Management Accountant, were the key informants on this topic to ensure the validity and correctness of the research (Quinlan 2011:196).

This research involved both quantitative and qualitative methodology. Sampling procedures in qualitative research are not as clearly defined as they are when gathering a survey sample intended to be an accurate representation of its population (Davies 2007:146). Both primary and secondary sources were used to collect information for the purpose of this study. A systematic observation and review of company data, a questionnaire and interviews were used to collect data.

Qualitative data relies heavily on the skills of the researcher as an analytical interpreter of accumulated evidence (Davies 2007:155). Greetham (2009:212) concurs that the most significant advantage of qualitative research is the deeper responses given that have rich implication for the study. Qualitative methodology comprises of interviews, observation, and quantitative methodology will involve the use of questionnaires and quantified input and output material flows using mass flow balance. An empirical investigation on using EMA to identify the benefits of CP will be conducted.

The empirical findings will add to the body of knowledge in this particular field of study (Myers 2013:79). The key informants in the study will supply documentation on the cost accounting principles and methods used to allocate product cost and environmental cost used by the company (Quinlan 2011:197). Available resources limited the number of interviews the researcher could conduct.

4.6.3 Data collection

Data on quantities of resources consumed and waste and emissions generated will be used from the company's recording systems that are available, for example, stock records, accounts, purchase receipts, waste disposal data, and production data. It was suggested by Yin (2009:76) that the triangulation approach to data collection enhances accuracy as it involves a combination of three approaches, use of questionnaires, interviews and documentary evidence.

The multi-method approach for the study's data was to maximize the range of information available to the researcher and provide a basis for triangulation between data sources. The triangulation method increases confidence in research data and establishes validity. Altogether, the company will draw on observation of processes and two kinds of documentary evidence, survey data and interview data. These data together will provide the research project with the in-depth and triangulated perspective necessary in case study research (Quinlan 2011:197).

4.7 Measuring Instrument

4.7.1 Questionnaire Design

Questionnaires are driven by the researcher's own agenda and are intended to facilitate communication. The researcher consulted the literature prior to designing the questionnaire. Davies (2007:82) explains that when designing questionnaires, one needs to understand that:

- The questionnaire is heavily influenced by the subject of the research;
- The questionnaire will be unique to the researcher; and
- Rules and guidelines must be followed when constructing the questionnaire.

Struwig and Stead (2013:93) caution that questionnaires should be designed to maintain the interest of the respondent and that response to a questionnaire is completely voluntary. The two types of questionnaires mentioned by Struwig and Stead (2013:93) are interviewer-administered questionnaires and self-administered questionnaires. For this study a self-administered was used to collect primary data. A completely structured approach was followed during the questionnaire design stage. Hence, the respondent could choose one or more answers. Struwig and Stead (2013:94-96) consider questionnaire design to be more of an art than a science and that a well-written question is one in which its meaning is accurately interpreted by the respondent.

Questions used were predominantly Likert scale type questions which work well, as they are easier, better analysed and allow statistics to be drawn for interpretation (Struwig and Stead 2013:92). Questions asked during the interviews were more complex in nature than the questions asked on the questionnaire. The questionnaire was constructed in English.

Table 4.2 is an example of the alternatives of a Likert-type scale question in this study.

Table 4.2: The Likert-type scale

1	**2**	**3**	**4**	**5**
Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**

A reliable outcome will be assured by personal distribution and collection of questionnaires

4.7.2 Interviews and administration of questionnaire

Interviews are often a main data source in Management Accounting research. Interviews may take on three forms: 1) informal interviews based on spontaneous questions; 2) semi-structured interviews based on a list of questions to explore along the interview; and 3) structured interview consisting on a set of carefully ordered questions asked to interviewees on a sequential manner (Simoes and Rodrigues 2008:3). Questions during interviews involved open-ended questions to allow respondents to speak their mind. The main disadvantages of open-ended questions, as explained by Struwig and Stead (2013:96), are that analysis of responses is time-consuming and that they allow for a considerable degree of interviewer bias. The researcher has, however, taken the above into account and had taken measures to reduce 'respondent bias', as explained in detail under 'validity and reliability' later in the chapter.

Rules for running an interview, as mentioned by Greetham (2009:216), are as follows:

- One needs to present oneself in a neutral fashion. Be friendly but formal;
- Openly acknowledge the extent to which the researcher is similar to or different from the target sample;
- No mental, emotional or moral barriers should be erected between the researcher and the interviewee;
- Avoid leading the interviewee and allow the interview to run a natural course;
- Try to make the interviewee as comfortable as possible and allow for the opportunity for the person to talk freely; and
- All interviews should have clearly defined beginnings, middles and ends.

Greetham (2009:212) states that questions must be planned in detail and thought about carefully beforehand, to get the most out of an interview. He believes that, during an interview, one can access material that is richer and deeper than that described using numerical data and statistics (Greetham 2009:213).

Verbal, written or telephonic arrangements were used to conduct semi-structured interviews. 'Key' informants were identified and interviewed. These are individuals who know most about a particular topic in an organisation and also those who have decision making authority in the researcher's area of interest (Myers 2013:81). Semi-structured interviews involve the use of some pre-formulated questions, but no strict adherence is required. This type of interview takes the best of both approaches, while minimising the risks (Myers 2013:121).

Interviews allow for face-to-face interaction with respondents, probe complex answers, gain the perceptions of respondents and gather more complete and precise information on the company's current environmental initiatives and cost allocation methods (Greetham 2009:212). Interview data can be drawn from six classes, as stated by Davies (2007: 106-107):

- Facts about the 'here and now';
- What the interviewee knows;
- Facts about past events;
- Feelings;
- Attitudes or opinions; and
- Beliefs.

4.8 Data Analysis

Data analysis has been identified as the most complex phase of the case study and consists of examining, categorizing, testing and relating quantitative and qualitative information in order to respond to the initial research question (Yin 2003:28).

Feedback received, together with phases of data collection and analysis, is vital to reinforce the confidence of the researcher on the choice of the way forward. The researcher collected data from various sources and used data management procedures in preparation for analysis. The study's design evolved over the course of the research, as is appropriate for an exploratory and descriptive study. Hence, there was not a clearly defined line between data collection, data analysis and preliminary write-up of findings.

Design of questionnaire and interview schedule must accommodate for various challenges the researcher is likely to face when trying to derive meanings to the responses (Davies 2007:110). Some questions were tightly phrased to ensure clear, simple responses and others open so that some issues could be explored more freely.

Therefore, one needs to be sure that appropriate data on key variables are gathered (Davies 2007:113). Content analysis can be done on anything that is written down or recorded (Davies 2007:181). Content analysis was done in this study.

During semi-structured interviews, the researcher wrote down detailed notes of the interviewers as soon as possible after the interview was conducted. A complexity arises when what people believe and know differs from what they do. The researcher had to overcome this challenge by using theory to account for this contradiction (Gillham 2010:14).

Content analysis as mainly qualitative used for the purpose of coding interview data

The method employed to analyse the data is mainly content analysis. Content analysis is a message-centred scientific research involving a summarizing, quantitative analysis of messages and emphasises the capability of providing a highly valid source of detailed information about a text.

It involves a reduction of the volume of qualitative data with the aim of making sense and finding core meanings by pattern analysis (Neuendorf 2002:10).

For the purpose of this study, content analysis was be used as a research method that utilizes a set of scientific procedures to make valid inferences from data collected. The process to identify, code, and categorise primary patterns in the text was used to reduce the collected data.

In order to analyse the quantitative information, the researcher used a number of tools such as tables, figures, models and charts. The statistical package for social sciences, SPSS – was used for descriptive and inferential statistics data analysis. Inferential techniques used in the study include the use of correlations and chi square test values; which were interpreted using the p-values. Interviews were analysed using relevant statistical methods.

A thematic approach to data analysis was used. In statistics, the ‘average’ can be represented in three ways:

- The mode – is the most frequently occurring score in the frequency distribution;
- The median – is the middle score of the frequency distribution; and
- The mean – is the most frequently used measure and is considered the right measure to use. It is calculated by dividing the sum of the scores by the number of cases that contribute to that sum.

Management’s information requirements, characteristics of the research design and the nature of the data collected, will determine the appropriate analytical technique for data analysis (Zikmund 2004:73). According to Greetham (2009:213), several procedures assisted the researcher in analyzing the data during data collection and data processing, to ensure credibility and dependability of the data and findings.

- Triangulation: Triangulation directed the researcher to find corroborating evidence in the different sources of data to assure the accuracy of facts and interpretation. Multiple sources of data used by the researcher supported a holistic perspective on the phenomenon and also reduced researcher bias since substantiation for claims were linked to data findings from various sources.
- Documenting methods and methodological choices: A systematic design focusing on multiple sources of data and appropriate data analysis activities were used to guide the research. Throughout the study, the researcher documented data collection and analysis activities, clearly indicating the sources of data, its collection method, data management, and analysis.

The researcher found that there was conflict of data from different sources and this finding was reported.

Stuwig and Stead (2013:137) state that conflicting findings should not be ignored as it can be used to view the research from a new perspective and to also broaden the interpretation of the data. It should be noted that collection of data using the multi-method approach may not necessarily converge. However, basing one's understanding of a situation on any one set of data is not wrong. However, this needs to be done cautiously (Gillham 2010:15).

The technological flow chart analysis provided the necessary information of the input, process and output of the process under observation. These results were compared to the actual raw material input and output of the process to identify inefficiencies. An EMA tool, the MFCA model was used to measure the quantity and value of the NPO costs. These NPO costs were benchmarked against technological standards as well as BAT standards. This technique assisted in identifying areas of potential savings for the company in the short-, medium- and long-terms. NPO costs were calculated using raw material purchase price.

Theory is grounded in the evidence collected, even though actual data discovered by the researcher may be specific to a specific organisation. However, these theories are generalisable in understanding how other organisations function. Explanatory case studies express theoretical and analytical generalizations as opposed to the usual statistical generalization of positivist approach. Analytical generalization exists when a previously developed theory is used as a theoretical framework to compare the empirical results of the case study (Yin 2003:28).

A key goal in the data analysis was to ensure that the data supported the findings and conclusions arrived at by the researcher.

4.9 Ethical Considerations

The study was conducted according to the research ethics policy and guidelines of the Durban University of Technology. The ethics policy takes into consideration the anonymity, confidentiality, rights and voluntary participation of human subjects. The four principles of ethical practice, namely, truthfulness, thoroughness, objectivity and relevance were adhered to during this research (Myers 2013:49). The data gathered for the research were held safely and securely. Correct data analysis procedures was used in the analysis of the data (Quinlan 2011:198).

The researcher had been given written consent by the organisation and the Institutional Research Ethics Committee (IREC) of the Durban University of Technology (appendix 8) to conduct this research and has signed the necessary documents pertaining to the confidentiality of data collected and disclosures of personal details of the respondents. The researcher has also agreed not to disclose the name of the company in the report.

4.10 Validity and Reliability

The analysis provided in the case study included relevant evidence from various sources such as documentation, direct observation, interviews and questionnaires. This is an important strategy to achieve reliability of the research (Yin 2009:43).

Validity is defined as the ability of the research instruments to measure what it is intended to measure. Reliability is defined as the degree to which measures used are free from error (Yin 2009:43). The validity of this research project is evident in the manner in which a strict focus had been maintained throughout the research project. Greetham (2009:132-133) states that validity must be established for both objective and subjective studies. The validity of this study is also evident in the multi-method approach undertaken for this research (Quinlan 2011:197).

Picardi and Masick (2014:87) recommend going beyond the multi-method technique by using a generalisability theory-based variance partitioning approach since any construct in research can be challenged on the basis of under representing or being contaminated by other factors. Therefore, it can be concluded that any experiment/study cannot be completely free of treats to validity because all research has at least one threat present in the study.

The researcher has attempted to understand all the treats to validity in order to create a sound methodology so as to maximize the accuracy of interpreting the results of the findings whilst minimizing threats to validity.

Validity and reliability are established to ensure that the case meets the quality standards of a positivist study (Myers 2013:79). In order to ensure high validity regarding primary data, interviews were conducted with two key personnel that have expert knowledge in the field of environmental issues and cost accounting procedures and methods implemented by the organization.

Hence, both the environmental manager and cost accountant were interviewed. Personal interviews and observations were chosen to gain a complete understanding of the process of material flows being researched as well as to avoid any misunderstandings. These instruments ensured high validity. The data collection methods used in the study were the correct methods employed in a case study as they yielded the data required (Quinlan 2011:197).

Struwig and Stead (2013:136-137) state that, during the research process, one needs to increase rigour in order to ensure that one's findings are credible. Struwig and Stead (2013:136) do agree that it is impossible to be 100% unbiased and separate oneself completely from a situation in order to completely understand it. There are four concepts suggested by Struwig and Stead (2013:137) to assist qualitative researches in ensuring that the credibility of a study:

- Credibility – Which refers to the trustworthiness of findings;
- Dependability – Are findings stable or consistent?
- Confirmability – Are there other data sources that confirm the findings? and
- Transferability – Could the findings be useful in environments that are similar to the study?

The criteria stated above were satisfied to ensure the quality of the findings reported during this study. The researcher collected referential adequacy material such as interview notes and documentation, which could be used to test whether themes that were developed can support the data. Detailed documentation on the research process and how data was obtained was maintained by the researcher.

This audit trail would allow an independent researcher to determine whether the findings and conclusions of the study were reasonable and appropriate. Struwig and Stead (2013:138) believe that the above measures are sufficient to ensure that a study has rigour.

Reliability of primary data was also established by using questionnaires to collect data on the company's current level of environmental performance and economic impact. This questionnaire was answered by top level and middle level managers as they provided reliable responses on the research topic and had good knowledge about the different processes. The population used as well as data gathering methods used in the case study are appropriate to the phenomenon under investigation. The Cronbach's Alpha Coefficient was used to measure the reliability of the questionnaires in this study. The overall reliability score of each section exceeded the recommended value of 0.70. The case study could be repeated and the same results are expected to be achieved. Hence, it would seem that the case study is reliable (Quinlan 2011:197). Reliability of the case study was established by using multiple sources of evidence. Therefore, the findings of this case study, is considered to be more accurate and convincing.

Some of these secondary data used in the study was found in the company's internal documents. Environmental management costs were assessed from annual reports complemented with information extracted from the firm's environmental manager and a member of the Financial Accounting and Cost Accounting Department (Management accountant). Data over a 12-month period (from October 2012 till September 2013) was used to benchmark costs against technological standards and BAT. Books, journals and articles, that are reliable sources of secondary data, were used to gather up-to-date relevant information within the subject. Comprehensive empirical research was done during the literature study.

A qualitative approach used to justify that the results of the research are valid, reliable and generalisable (Remenyi 2012:19). To get the correct information, the researcher found it important to talk to the right people with the right knowledge.

Validity and reliability tests commonly used in case studies during data collection are as follows (Yin 2009:41):

- Construct validity was established using methodological triangulation of multiple sources of evidence to identify operational measures for the concepts being investigated;
- Respondent validation during semi-structured interviews were incorporated into the findings, as participant's reactions to analyses were compared to the researcher's interpretation to establish a level of correspondence between the two sets;
- Internal validity, which is content validity, was also ensured by making use of logic models and explanation building to establish causal relationships;
- External validity was established by use of theory in single-case studies to define the extent to which the study's findings could be generalized; and
- Reliability of the case study was improved by the use of case study protocol and data collection procedures to demonstrate that the same results will be obtained should the study be repeated.

Struwig and Stead (2013:132) confirm that sampling procedures for qualitative research is different from quantitative studies as less emphasis is placed on random selection and generalisability in qualitative studies. The focus of qualitative research is on the depth or richness of data. Therefore, sampling was not considered important in this study as the researcher adopted an interpretivist approach rather than a positivist approach. The intention of this study was not to generalise but to explain a particular case in the context of one particular research setting (Wilson 2014:134). The aim is to provide new insight that has the potential for future research to enable findings to be generalised.

4.10.1 Cronbach's Alpha

Reliability refers to the property of a measurement instrument that causes it to give similar results for similar inputs. Cronbach's alpha is a measure of reliability.

More specifically, alpha is a lower bound for the true reliability of the survey. Mathematically, reliability is defined as the proportion of the variability in the responses to the survey that is the result of differences in the respondents. That is, answers to a reliable survey will differ because respondents have different opinions, not because the survey is confusing or has multiple interpretations. The following computation of Cronbach's alpha is based on the number of items on the survey (k) and the ratio of the average inter-item covariance to the average item variance (SPSS ver 17.0 from help menu).

$$\alpha = \frac{\mathrm{k}(\mathrm{cov}/\mathrm{var})}{1 + (\mathrm{k} - 1)\,(\mathrm{cov}/\mathrm{var})}$$

4.11 Design limitation

This study has the following limitations

4.11.1 Subjectivity

The picture that emerged from data collected during semi-structured interviews and survey questionnaires is a snapshot in time, and is not necessarily an accurate reflection of reality. According to ‘The Social Construction of Reality”, there is no such thing as true objectivity. ‘Knowledge’ and ‘fact’ are what are socially agreed on (Neuendorf 2002:12). All human enquiries and interpretations are subjective. This research was subject to subjectivity limitation during interviews and the analytical stages of the questionnaire. The detailed description of the case study processes during the investigation together with documentary evidence provides a richer, contextualised snapshot of the actual situation in the company. Subjectivity was overcome by careful documentation of the research and analytical procedures employed in the study. Consistency during interviews was also maintained to decrease the level of subjectivity (Chang 2007:118).

4.11.2 Generalisation

Neuendorf (2002:32) explains that 'the generalisability of findings is the extent to which they may be applied to other cases'. It should be noted that case studies provide little basis for statistical generalisation. Yin (2003:33) pointed out that case studies should be considered like multiple experiments upon which scientific facts are drawn rather than 'sampling units'. Analytical generalisation can be applied to case studies where existing theories can be used as a template with which to compare findings of a particular case. The researcher employed a theoretical framework to study the case in depth and examined other cases where the pattern found could be matched to this case study.

4.11.3 Researcher bias

The richness and complexity of data collected during case study research means that data is open to different interpretations, and potential 'researcher bias.' Struwig and Stead (2013:137) confirm that it is not possible to be 100% unbiased in a qualitative study and state that, due to the variety of contexts, cultures, and individuals' thoughts and behaviours, generalisability of findings is often difficult to achieve.

Based on the literature review, and the identified research methodologies, the next section describes the methods used to benchmark environmental costs against technological standards and BAT standards.

4.12 Benchmarking Environmental Costs

4.12.1 Method used to benchmark environmental cost

The aim of this study is to use EMA to identify environmental and economic benefits of CP. Potential saving opportunities can be identified by benchmarking current environmental costs against technological standards and BAT.

Benchmarking is a systematic search for processes that yields superior performance. These benchmarks are compared against current activities to gain insight on how to improve by using specific technologies. This was done by providing estimates of the maximum amount of financial saving that could be achieved through improving the eco-efficiency for certain technologies (Schaltegger *et al*. 2010:47).

During the analysis of cost control and cost reduction opportunities in this study, it was necessary to take into account the life – cycle of the technology. Cost control and cost reduction options were classified under three assessment periods, namely, the short-, medium- and long-terms. The following standards were established during cost control classification:

- Short-term – These cost reduction options are limited by the existing technology until the end of the technological life-cycle is reached. Only minor changes of processes and improved housekeeping measures make sense;

- Medium-term – Company can change technology and get closer to the state-of-the art of the industry; and

- Long-term – State-of-the-art technology may improve and get closer to the ideal world. No harmful emissions are produced.

The benchmarks used in this study were technologically determined (Environmental Sustainability Performance (ESP) Benchmarking 2013). The scope of this study was limited to the utilities department. This research focused primarily on the company's boilers. Therefore, environmental costs referred to during the study were limited to the NPO generated by the boilers. It had been decided to adopt a MFCA model to calculate the value of the NPO. In previous studies, it had been concluded that material purchase cost was the most significant cost of non-product outputs (Schaltegger *et al.* 2010:144).

Therefore, the MFCA accounting model established the flow of material in the boilers and used the purchase value of raw materials to calculate the monetary value for the NPO. Data of the actual material input and output over a 12-month period (financial year starting in October 2012 to September 2013) was used as a sample. Actual standards were compared to and benchmarked against two other standards, namely, technological standards of the boilers as well as BAT standards or state-of-the-art technological standards.

4.12.2 Benchmarking non-product output cost

In this study, total NPO costs included the material purchase value of wastes; costs of processing; handling and warehousing wastes; and treatment and disposal.

The material purchase value of the waste was found to be the overwhelming majority of the costs. Potential benefits in terms of savings were revealed during this analysis.

4.12.3 Environmental Management Accounting data collected using material balance to calculate value of non-product output costs

An account of the consumption of raw material in both quantity and values, by process was calculated. Losses, wastes and emissions from the process were also calculated by applying the principle “What comes into the process must equal what comes out” in this case study.

NPO was identified and quantified by applying the MFCA model. This highlighted the sources and causes of waste and emissions and potential savings of adopting CP were identified. The material purchase price was used to calculate the value of NPO in this study.

Actual material flows was quantified and found to differ from those suggested in the technological flowchart in the manual compiled by the designers of the technology. A detailed analysis of CPA was completed.

Only materials which become part of the final product should be taken into account when calculating product costs. Therefore non-product output costs took into consideration the entire value of material/energy inputs that did not become the integral parts of the final product. This was then classified under short-, medium-, and long-terms according to their controllability. This information was used to support CP measures and in planning investments in new CT.

4.12.4 Material Flow Cost Accounting (MFCA) model

After identifying the material flows and NPO, a model that is currently being used in Japan was applied to the process to highlight and quantify NPO cost and reflect this cost separately from product cost.

This would assist management of this organization in their decision making regarding investment in CP technology that could benefit the organization both environmentally and economically (Berkel 2011:4).

4.13 Conclusion

This chapter has detailed the approach and research methodology used to gather the information required. The findings of the pilot study were also discussed and no changes were made to research instruments as well as the sample size. A triangulation method of empirical study, consisting of interviews, questionnaires, and documentary evidence was used in this study. The research design combined both deductive and inductive research methods. All attempts were made to ensure that the instruments used as the research tools were valid and reliable. The procedure and standards used to benchmark the organizations environmental cost of the process was also discussed in detail. Subjectivity of participants' responses in the survey questionnaire and during interviews was reduced by employing detailed analysis of actual processes and documentary evidence.

The next chapter will make use of statistical techniques to analyse the data and a presentation and discussion of the results of this study will be provided.

CHAPTER 5

PRESENTATION, INTERPRETATION AND DISCUSSION OF FINDINDS

5.1 Introduction

This chapter presents the results of the study and the interpretation and discussion of the data. The chapter will begin with the description and overview of the steam production process and the environmental responsiveness of the paper and pulp manufacturing company.

As indicated in chapter 1, the study examined the use of EMA to identify the benefits of CP in a paper manufacturing company. This chapter is also based on specific research objectives derived from chapter 1 and relevant supporting information from the literature review (Hawkins 2010:46). The study type was both quantitative and qualitative and the sample technique was a census of senior and middle level managers. It must be emphasised that the data presented in this chapter only relates to the organisation on which the case study is based, and cannot be generalised to all organisations.

The researcher has carried out a case study within a paper manufacturing company in the Kwadakuza district, KwaZulu-Natal. The company manufactures various types of paper and packaging material using sugar cane bagasse in their pulping process. The aim of the research is to apply MFCA methodology within the steam production process in order to assess the efficiency of the production process and its environmental and economic impacts. The process input/outputs and NPO over a 12-month period, starting October 2012 to September 2013, was reviewed from the company's data schedule. MFCA was then applied to evaluate the physical and monetary values of the NPO.

Material purchase value of raw material input was used to cost the NPO. Production cost should exclude the cost of material that is wasted or becomes material loss.

Optimization of the manufacturing process can only be achieved by CT. Current cost in steam production is benchmarked against the cost of production using CT. This calculation is used to assess and evaluate the economic and environmental benefits of CP.

Cost appraisal of investing in CPT is provided to assist in the decision making process.

5.2 Documentary Review Limitation

Since the scope of EMA projects within paper manufacturing in South Africa are considered to be in their infancy stages, environmental costs for this project are limited to those incurred by the company in the steam generation process.

5.3 Research Questions and Propositions

Within the scope of this study, the following research questions were posed to achieve the objectives. They are listed as follows:

This study is based on the following research questions:

1. Are the boilers used in steam generation process operating efficiently? If not, what are the operational inefficiencies that was identified during the Cleaner Production Assessment (CPA).
2. What are the barriers to CP implementation?
3. Does the company use technological standards as benchmarks to assess the environmental performance of their current technology?
4. Does the company use conventional costing systems (CCS) or an environmental management system (EMA) to calculate environmental costs?

5. What are the barriers to the adoption of an EMA system and to invest in CP technologies?

6. Are environmental costs regularly measured and monitored against technological standards to ensure that technology is functioning optimally?

7. Are environmental costs reflected as production costs and hidden under general overhead costs in financial statements?

8. Are there regular communication and exchange of information between the accounting department, production department, technical managers and the environmental team?

9. Are managers aware of the potential benefits of CP implementation?

10. Do managers take into consideration the benefits of investing in CPT during strategic decision making?

The questions listed above informed the research and guided the data collection.

5.4 Findings:

5.4.1 Semi-structured Interviews (Appendix 1)

5.4.1.1 Company's emphasis on treatment or preventative measures when handling environmental issues

Respondents stated that pollution treatment measures were prioritised in the company. Procedures to identify and handle environmental issues were as follows:

- Measures such as root cause analysis, trials and getting the Research and Development Department involved are implemented.

The company follows the philosophy of Reduce, Re-use and Recycle. Waste identification and treatment measures involved the following procedures:

- Waste that is generated is first investigated;
- Waste is then defined in order to identify if the waste is re-usable or not;

- If the waste is not harmful and it can be re-used in the plant, the mill attempts to find a use for it internally;
- If there is no use for it internally, this waste material is sold as scrap to external parties that may have a specific use for it;
- Should the waste be identified as harmful, the company hires an environmental consultant/specialist to dispose of it; and
- Measures are then taken to find other means of production to minimize the quantity of waste generated.

Literature suggests that the procedures followed by the company are similar to other organisations. This methodology is, however, seen as insufficient to achieve CP targets set by an organisation.

Qian, Burritt and Monroe (2011:93-128) emphasise that decisions made based on conventional accounting practices only takes into consideration the operational costs of waste management as compared to EMA which generates both financial and non-financial information that is used by managers to support internal environmental management processes. They pointed out that companies do not consider alternatives such as resource recovery and material recycling as disposal to landfill is considered as the most feasible and competitively attractive option because of the low operation costs of landfill disposal.

5.4.1.2 Company's expenditure to reduce environmental impact

The company has invested large amounts of money over the years on pollution prevent treatment measures to reduce the environmental impact of their operational activities. In 2004, a major pollution problem was identified when dioxins were found in the effluent. The company invested approximately R60 million to upgrade the bleach plant and change the pulping process to chlorine free pulping, since it had been found that the chlorine used in pulp bleaching contained a toxic chemical that had a major impact on aquatic life.

Installation of upgraded water treatment equipment cost the company approximately +/- R20 million.

Cyclones are also used as a pollution control measure. However, boiler technology has not been upgraded. The company uses old boilers that were previously used in a power station in Kimberly and has invested large amounts of money on pollution control technology (end-of-pipe technology). McCray (2011:1) explained that pollution control seeks to trap, store, treat, and dispose of emissions and effluents by using pollution-control equipment such as incinerators and scrubbers. Research suggests that end-of-pipe technologies result in higher investment costs with no increase in the efficiency of production, as pollution-control technologies are non-productive assets (Integrated Pollution Prevention and Control 2010).

5.4.1.3 Employee awareness of environmental strategies

It is essential to educate and inform managers on issues of sustainability and to assess the level of awareness of environmental issues and the extent to which the environmental aspect is considered during business operations. Managers are informed and trained on sustainability issues.

This forms part of the monthly safety, health, environment and quality meeting (SHEQ) as well as sustainability forum. However, they have limited awareness on the extent to which environmental objectives have been achieved, level of the organisation’s environmental performance and corporate environmental strategy of the company. Recognition of losses of natural resources during paper manufacturing is emphasised in the company. According to Sinclair-Desgagne (2004:7), the biggest challenge that firms are currently facing is the difficulty in integrating environmental issues into day-to-day business activities. Gil, Andres and Salinas (2007:85) argue that management commitment and awareness of environmental responsibility significantly influence corporate strategy. The importance of ensuring employee awareness on environmental issues is emphasised in the literature.

5.4.1.4 Sustainability of raw materials and Corporate Social Responsibility (CSR)

Sustainability of raw materials and Corporate Social Responsibility (CSR) to identify the organisation's activities towards conserving natural resources and achievements in Corporate Social Responsibility (CSR).

The company uses sugarcane bagasse in its pulping process and has, therefore, decided to buy a 10% share in the sugar mills. The company now subsidises the mill to pay sugarcane farmers more than they would receive from other customers to ensure that the sugar-cane planted is supplied to the sugar mills. Hence, more sugar crushed means more bagasse for the paper mill. This strategy yields a saving of approximately R2 000 per ton because it is cheaper to produce the pulp rather than buying the pulp from another supplier. Approximately 15 000 tons of pulp production, takes place annually. Thus, a saving of R30 million is estimated annually. Subsidy to the sugar mill is about R4 million per annum, resulting in a net saving of about R26 million per annum. Hence, it can be concluded that the company has adopted a sustainability development approach towards natural resources.

At the 2002 World Summit on Sustainable Development held in Johannesburg, a shift towards Sustainable Consumption and Production was noted. Greater emphasis was placed on inefficient and wasteful use of natural resources (Resource Efficient and Cleaner Production 2013). Issues raised at the summit clearly showed that much of the wealth generated in the country was at the expense of natural assets.

Therefore, it was emphasised at the forum that businesses need to take an active role in protecting these natural assets and reducing the environmental impact of operational activities (Ambe 2007:3).

5.4.1.5 The Company's Environmental Management Performance based on current practices and achievements

The company's achievements are as follows:

Environmentally sustainable issues in processes and procedures are carried out by the company to manage and control costs via the Sustainability Forum. Customers look for the ISO 14001 certification. This incorporates being environmentally responsible, continuously improving and being sustainable. Hence, cost effective environmental solutions are investigated (refer to point 5.4.1.4 above). Forestry Stewardship Council (FSC) accreditation is necessary so that the company's products can be sold to their customers. This certification is carried throughout the entire life cycle of the product. If there is a break in the chain, the pulp will not be used in production as the final product would not receive FSC certification resulting in major losses for the company. Furthermore, biological treatment processes for chemical oxygen demand reduction of effluent are being implemented by the company in running its plants. The company also uses caustic to cook bagasse. Liquid called 'black liquor' is a by-product of this process. This black liquor is turned to ash and sold to customers to be used in buildings (Cost accountant and environmental manager 2014). Once again, empirical evidence suggests that the company has adopted the sustainable development approach to reduce the environmental impacts of its operations and protect the environment.

5.4.1.6 Internal and external pressures for EMS implementation

Such pressures relate to:

- Legal requirements and targets from Head Office; and
- ISO 14001

The company has implemented an EMS as an isolated management system used mainly by the environmental manager. Furthermore, the company is currently using a conventional cost accounting system.

Some researchers have argued that the root cause for environmental problems is the lack of environmental management policy (Ahmad, Saha, Abbasi and Khan 2009:iv).

Environmental and social aspects of business are not adequately recognised by current accounting systems and these issues may not be fully accounted for during decision making.

Bennett, Schaltegger and Zvezdov (2013:42) believe the purpose of ISO 14001 is to help companies implement EMS that fulfil certain criteria. Ahmad, Saha, Abbasi and Khan (2009:v) concur that an ISO 14001 EMS could be used by managers to assess and measure progress and performance by providing standard auditing, communicational and reporting protocols. Radonjic and Tominc (2007:1482-1493) add that EMS is an important part of the pollution-prevention approach. Manufacturing process performance is improved and impacts of process upsets and equipment failure are greatly reduced by the adoption of sound EMS.

5.4.1.7 Identify the role of management accountants and accounting in environmental initiatives

According to Bennett et al. (2013:36), accountants play an important role in achieving sustainability within an organisation by enhancing the quality of information by reducing information asymmetries between users and providers.

The role of the management accountant and accounting in environmental issues within the company is limited to the following:

- Allocation of funds/budgeting;
- Expenditures for environment treatment;

- Environmental superintendent is the only member of the environmental team;
- Environmental manager is responsible for monitoring and reporting of environmental achievements at the site; and
- Accounting's role in 'green' management is limited to recording and reporting and not extended to environmental costs calculation.

The findings relating to the above communication are:

- Poor communication links have been identified between the environmental manager and accounting department; and
- Environmental strategies adopted by the environmental manager are not integrated into the cost accounting system. Hence, EMS are not evaluated and allocated to the correct products and processes. Material losses are not excluded from production cost. The environmental manager needs the skills and expertise of the accounting department to accurately calculate the cost implication of processes. Therefore, an integrated cost management system is essential. Most managers are of the misconception that an integrated EMA System is being used by the company. The reason for this is because most managers are unaware of what an EMA system is and environmental and economic benefits of implementing such a system for the organisation.

Research shows that there are poor communication links between accounting and other departments in an organization. As a result, information used by management for decision making may be inaccurate. Inconsistencies in the type of information system used by the accounting and technical departments also make it difficult to track and trace certain environmental costs accurately (Shcaltegger *et al*. 2010:132). Furthermore, Qian and Burritt (2008:244) state that communication between the accounting department and the environmental management department is crucial if an organisation wishes to succeed in EMA implementation.

Accountants play an important role as they are expected to access the data and analyse variables associated with various environmental costs.

In addition, there is also need to assess whether or not costs have been allocated and handled correctly and in accordance with environmental policies and guidelines.

5.4.1.8 EMA information used in decision making

The extent to which EMA information is generated and used in decision making in the company and also to establish whether the company implements a conventional management system or an EMS system.

Environmental cost accounting, environmental life cycle costing and monetary and energy flow accounting information is not generated for every process or product. Environmental data is generated by the environmental manager, but is not being used by accountants to enhance benchmarking of costs. Analysis of the results of procedures to measure environmental performance showed that the company had not implemented an EMA system. The EMS is separate and detached from general management and, consequently, the EMS has no real management function on an overall organisational level.

It is also not linked to the cost accounting system to provide monetary values of the environmental impact and environmental costs are not accurately traced back to the products or processes responsible for those costs. Environmental costs are calculated annually as management views them as an insignificant costs that are not worth the effort and resources required for calculating these costs on a regular basis. It can, therefore, be ascertained that environmental costs currently reflected in financial statements are hugely underestimated.

Literature suggests that EMA is a valuable tool for businesses to adopt whilst responding to environmental challenges and still focusing on the triple bottom line (Ambe 2007:7).

What had been brought to the forefront was the potential savings to South African companies by implementing good environmental management by using EMA to accurately trace and identify environmental costs (Ambe 2007:11-12). It can, therefore, be concluded that Environmental Accounting can be used to demonstrate the potential for environmental investment to yield financial benefits to an organization.

Physical information comprises of data on the use and flows of energy, water, and materials including waste, whereas monetary information is based on environment-related costs, savings and earnings, and environmental costs that are generally hidden under overheads (Qian, Burritt and Monroe 2011:93-128).

5.5 Summary of empirical findings

The study yielded the following results:

The researcher, during the interview with the cost accountant of the company, discovered that the environmental costs are perceived to be insignificant and only accounted for annually using a traditional accounting system. Therefore, investment in CPT to improve environmental performance and reducing environmental cost was not viewed as a necessary measure by the organisation. It was also evident that the company only considers their waste disposal and water treatment costs as environmental costs. Scavone (2006:1276-1285) states that by adopting an EMA system, a company can develop proactive environmental programmes which, in turn, improves profitability and competitiveness, reduce business costs, increase worker productivity and morale, enhance brand image, and improve relations with regulators and local communities.

She believes that companies that adopt proactive measures to address environmental issues are in an excellent position to identify problems and opportunities to introduce innovative solutions.

It is essential for companies to generate reliable past and future-oriented information by using environmental accounting decision tools such as EMA, to enable effective and efficient management of environmental consequences of the business operations.

Their material losses are not evaluated and added to NPO costs. All raw materials used are allocated to product cost irrespective of whether they actually form part of the final product. Energy and system costs, as identified by MFCA, are also not considered when costing wastes.

Therefore, no decisions are made towards improving production processes and moving towards CPT. However, the cost of investing in CP technology is not justified, due to the inaccurate assessment of environmental costs resulting in it being underestimated. Environmental costs are also reflected under the general overhead account and are not being traced back to the product or process.

During the investigation using EMA, it had been discovered that the largest cost category was the material purchase value of NPO. It had been concluded that EMA could be used to support strategic decision making in companies for more effective product mixes, strategies and investments that improve environmental performance of a company and also highlight the potential for large cost savings.

Schmidt and Nakajima (2013:358-369) found some weaknesses in conventional cost accounting in that it cannot give all the required data. Monetary value flows are traced and interpreted as product cost in a conventional cost accounting (CCA) system. CCA focuses on cost figures for each product in each process whereas MFCA checks mass balances in each process. Conventional cost accounting focuses on production costs of the whole company in monetary terms whereas MFCA focuses on accuracy of cost figures of each process taking into account material losses (non-product output).

Reporting under MFCA highlights actual production costs by excluding the cost of raw material purchased that becomes waste and does not form part of the final product. Generally, companies focus on the input materials and the quantity of products produced from these inputs, not on the material losses generated from the specific process. Hyrslova *et al*. (2011:8) conclude that MFCA is a very important method of environmental and economic performance management.

The next section deals with primary data collection and analysis of the steam generation process to identify the possible saving opportunities and improved environmental performance by adopting CP techniques.

The first step in the process involves a CPA of the steam-generation process.

5.6 Cleaner Production Assessment (CPA)

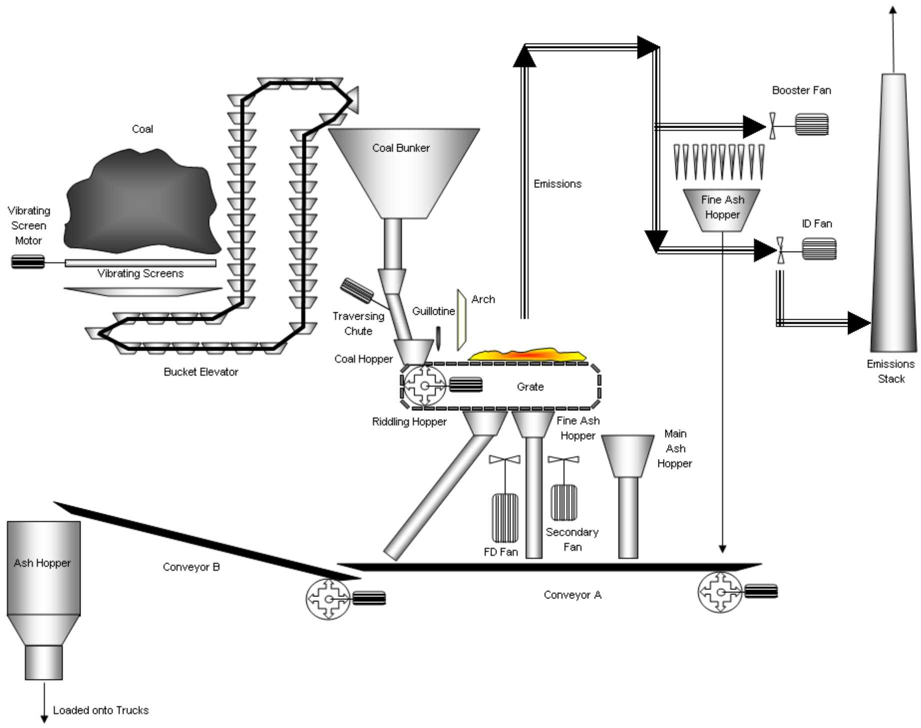
The qualitative review was conducted during the CPA stage. It involved an overview of the company's production and environmental aspects.

The CP assessment framework was used to capture data during the CP audit process as per the CP model. Analysis of the process flow chart shows inputs, outputs, and environmental problem areas of the steam generation process. Quantitative data analysis involved the calculation of NPO using MFCA, a tool of EMA. This was used to identify potential savings options for the company should they adopt CP processes. Schaltegger *et al*. (2010:143) highlight the following warning signs of inefficiencies which become evident during the CPA: higher raw materials cost compared to those prescribed by technological standards, higher energy costs, maintenance needs and higher level of undesired output.

The first step of CPA involves the process flow chart analysis of the steam generation process, to identify waste generated resulting in negative environmental impact.

The review of steam production process to identify inputs and waste generated is depicted in figure 5.1.

Figure 5.1: Coal fired steam boiler technological process flow chart



Ash Disposal

Source: Company's technological flow chart of boilers (nd)

Figure 5.1 depicts the steam production process and ash disposal from the boiler plant.

Burnt coal of the grate, dust from the dust cyclones, grit particles from the Riddling Hopper (mainly grit) and fine ash from soot blowing are waste products that are disposed off via the Ash Disposal System. Before being deposited onto the ash conveyor, the ash from the main ash conveyor is first cooled. The ash and burning coal are dropped into a containment facility. Here, water is added to cool and quench the burning coal. A paddle ash extractor is used to transfer the resulting waste onto the ash conveyor. This consists of a paddle disc that is powered by a motor:

- Boiler 1: Ash conveyor is powered by motor C081;
- Boiler 2: Ash conveyor is powered by motor C082;
- Boiler 3: Ash conveyor is powered by motor C083; and
- Boiler 4: Ash conveyor is powered by motor C084.

The ash of each boiler ash conveyor is deposited onto the main ash conveyors A and then B. Main Ash Conveyor A is powered by C086 while Main Ash Conveyor B is powered by C86A. Ash is then deposited into the Ash Hopper where it is then loaded onto trucks and disposed off onto landfill sites.

5.6.1 Coal input and steam production output of boilers

Data from the input/output schedule (Appendix 2) of the steam production process for the period under review (October 2012 to September 2013) is used to test the efficiency of the boiler technology against technological standards and BAT standards.

Table 5.1 indicates the One-Sample Kolmogorov-Smirnov Test which is performed to determine the nature of the distributions.

Table 5.1: One-Sample Kolmogorov-Smirnov Test

		Boiler 1	Boiler 2	Boiler 3	Boiler 4
N		12	12	12	12
Normal Parameters[a,b]	Mean	6.7062	6.5326	6.4092	6.5773
	Std. Deviation	.25947	2.61052	.71007	.36191
Most Extreme Differences	Absolute	.198	.341	.144	.133
	Positive	.155	.336	.110	.099
	Negative	-.198	-.341	-.144	-.133
Kolmogorov-Smirnov Z		.688	1.180	.500	.461
Asymp. Sig. (2-tailed)		.732	.123	.964	.984

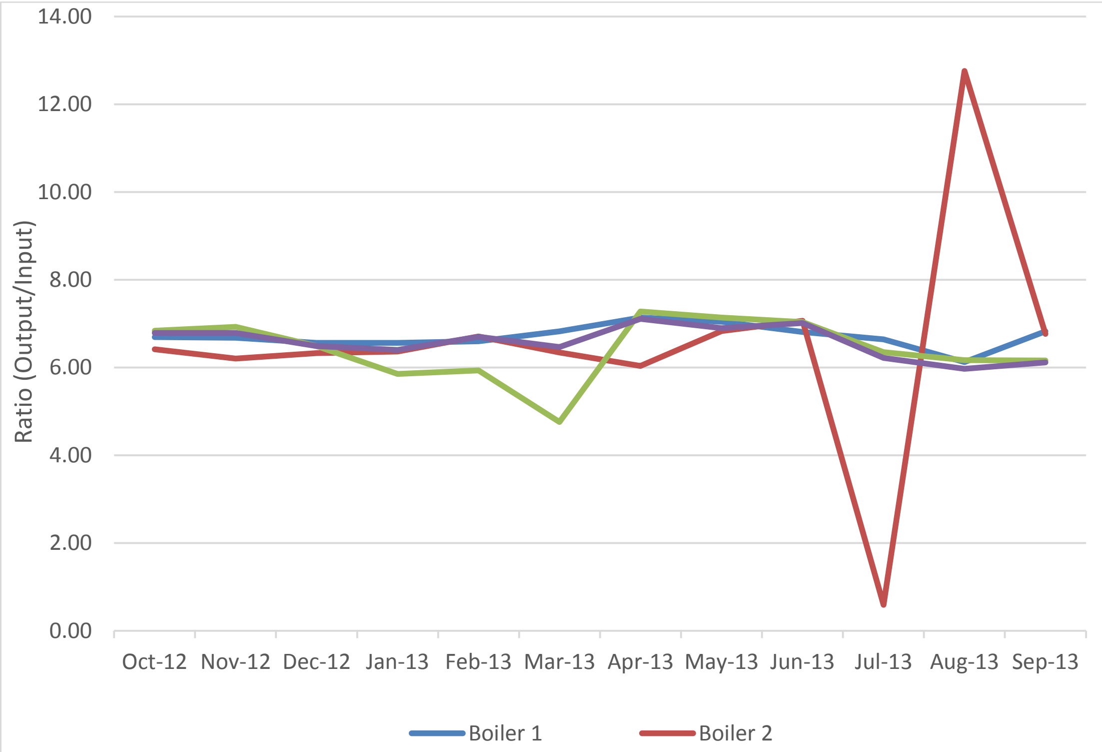
a. Test distribution is Normal.

b. Calculated from data.

Since all of the p-values are greater than 0.05, it implies that the distributions are all normal. Hence, parametric testing (t-tests) were performed.

The output to input ratio was determined and plotted in the figure 5.2.

Figure 5.2: Output to Input Ratio



The mean ratio values per boiler (table 5.2) were then determined and compared to the standards (converted to a ratio as well).

According to technological standards of the company's current boiler technology, the standards input/output ratio of coal and steam generated is 1:7. However, the input/output schedule (appendix 2A) indicates the actual amount of coal used for the 12-month period.

This ratio is compared to technological standards of 1:7 to identify technological inefficiencies of the steam generation process.

BAT standards for more efficient boilers of 1:8, as identified by a boiler technology expert from John Thompson Boilers (Speek 2014), is compared to actual standards to identify medium-term saving opportunities that the company could enjoy if they consider replacing existing technology with state-of-the-art boilers.

In comparison to Test Standard 1:7 (technological standards as identified by technical flow chart) the following one-sample statistics were found.

Table 5.2: One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
Boiler 1	12	6.7062	.25947	.07490
Boiler 2	12	6.5326	2.61052	.75359
Boiler 3	12	6.4092	.71007	.20498
Boiler 4	12	6.5773	.36191	.10447

Table 5.3: One-Sample Test

	Test Value = 7					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Boiler 1	-3.922	11	.002	-.29378	-.4586	-.1289
Boiler 2	-.620	11	.548	-.46737	-2.1260	1.1913
Boiler 3	-2.882	11	.015	-.59080	-1.0420	-.1396
Boiler 4	-4.046	11	.002	-.42266	-.6526	-.1927

Table 5.4: One-Sample Test

	Test Value = 8					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Boiler 1	-17.273	11	.000	-1.29378	-1.4586	-1.1289
Boiler 2	-1.947	11	.077	-1.46737	-3.1260	.1913
Boiler 3	-7.761	11	.000	-1.59080	-2.0420	-1.1396
Boiler 4	-13.617	11	.000	-1.42266	-1.6526	-1.1927

Only boiler 2 is not significantly different. The other 3 boilers are. An investigation of the means indicates the direction of the means (refer to table 5.2). The three means are significantly less than the standard of 7. This implies that the company's current technology is not operating according to design specification. This is therefore a sign of an inefficient production process.

Domil, Peres, and Peres (2010:721-722) state that the difference between actual NPO costs and costs for the technological norms, is what most companies will be interested in for operational reasons. This information shows deviation from technological standard costs due to the inefficient use of existing technology.

The NPO costs at this level can be reduced by better housekeeping, for example, better monitoring of raw material consumption, avoiding scraps and wastes and reducing energy and water consumption. This information needs to be generated on a monthly basis for companies to react faster.

In comparison to Test Standard 1:8 (BAT standards according to boiler technology expert), the following one-sample statistics were found.

The results follow a similar pattern for the standard of 1:8. This means that the company's current standards are much lower than BAT standards, which implies a greater saving potential should the company replace their existing boilers with state-of-art boiler technology.

In both instances, boiler 2 is closest to the two standards. Boiler 2 could probably be upgraded to state-of-the-art standards without excessive costs being incurred as the current efficiency level of boiler 2 is very close to technological standards and closer to BAT standards as compared to the other 3 boilers. Domil, Peres and Peres (2010:721-722) add that the difference between actual NPO costs and (BAT) norms need to be generated on a less frequent basis.

This can be used to work out the economic feasibility of performing technological improvement. This information will be used when considering changing technologies between 3-7 years, depending on the technological life cycle of the equipment. Total environmental costs reported must include NPO costs related to BAT. It is suggested that these costs be calculated annually for internal reporting purposes and to assist managers in making important investment decisions (Schaltegger *et al*. 2010:122).

5.6.2 Paired comparisons

Table 5.5 presents the results of the boiler comparisons.

Table 5.5: Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Boiler 1 - Boiler 2	.17359	2.73371	.78915	-1.56333	1.91050	.220	11	.830
Pair 2	Boiler 1 - Boiler 3	.29703	.66553	.19212	-.12583	.71988	1.546	11	.150
Pair 3	Boiler 1 - Boiler 4	.12888	.26159	.07551	-.03732	.29509	1.707	11	.116
Pair 4	Boiler 2 - Boiler 3	.12344	2.73905	.79070	-1.61687	1.86375	.156	11	.879
Pair 5	Boiler 2 - Boiler 4	-.04470	2.69466	.77788	-1.75681	1.66740	-.057	11	.955
Pair 6	Boiler 3 - Boiler 4	-.16814	.57483	.16594	-.53337	.19709	-1.013	11	.333

When compared to each other, the mean values are not significantly different. However, boiler 2 is closer to the standards than the rest.

5.6.3 Causes of waste generated during steam production process

Identify possible causes of waste generation from the steam production process.

During the steam generation process, large amounts of unburned coal are found in the bottom of the boiler ash. Hence, the steam production process is inefficient, resulting in excessive raw material wastage. The input/output ratio, according to technological design, is not being achieved. Therefore, the amount of coal used to generate steam is in excess to what is prescribed in the technological flow chart manual (Pulp and Paper Mills Industry Profile 2013).

The information above indicates that the three of the four boilers are functioning well below test standards of 1:7 and state-of-the-art technological standards of 1:8. The only boiler that is functioning close to the design specification is boiler 2. In order to identify operational savings, managers need to look at ways to reduce the NPO costs caused by sub-optimal functioning of boilers.

It should be noted that the total cost of material losses was limited to raw material flow only. No energy costs or water costs will be included in the calculation. Material purchase value of NPO is the most significant of all costs incurred in process steam.

Cost categories such as material cost, system cost and energy cost, are included in the total cost of the steam production process. Unburned coal/carbon content of boiler ash (solid waste) has been estimated to identify non-product output costs of raw materials that do not form part of the final product (steam). Material loss/waste is quantified and calculated using the purchase price of coal. Monetary value of NPO is calculated using the equation as follows:

Monetary value of loss = quantity loss in tons x input price of coal.

Case study findings reported by The Cleaner Production Case Studies Directory EnviroNET Australia (2003) presented results of a CPA that was done on coal-fired boilers used by the AMH group which operated five coal-fired boilers, situated at different sites. The CPA assessment revealed differences in coal burning performances of the boilers and opportunities to improve boiler performance were identified. It had been found that between 2% and 29% of coal used were not combusted. The unburned coal that remained in the boiler ash was disposed to landfill. Two of the five boilers revealed poor performance. The investigation showed significantly high production costs due to wasted energy and higher steam costs.

A thorough investigation was done of the process involving the two underperforming boilers to identify possible causes of the inefficiencies identified during the CPA. It had been found that the boiler operating staff had difficulty in operating the boilers to meet steam demand. The company conducted an in-house training programme to develop operating and management skills of staff involved in operating the boilers. The programme was successful resulting in the immediate reduction in percentage of unburned coal from 25% to 2% and improved boiler efficiency from 70% to 98%. Coal usage decreased by 27% resulting in a savings of approximately $65 000. An added benefit was reduced ash disposal to landfill by 275 tons per year. It is important to note that the case study cited above had a similar problem as the study currently being researched.

5.7 Analysis of accounting documents and records

Accounting documents and records were analysed to identify production costs and non-product output costs of steam generation process. The aim of this research is to identify potential saving opportunities by introducing cleaner production techniques and technologies.

Note:

There are two major costs considered significant in the steam generation process and would be used in calculation of payback period for investing in new boilers or upgrading existing boilers to improve efficiency. The costs are as follows:

- Cost of disposal of bottom boiler ash to landfill (transportation and handling cost of waste); and
- Loss of raw material (coal) due to inefficient processing (calculated using MFCA model proposed, which is a tool of EMA).

Table 5.6 Illustrates the total cost of steam generation process from October 2012 to September 2013

Table 5.6: Breakdown of total cost in rand and percentages

TOTAL COST BREAKDOWN	**ANNUAL COST IN RANDS**	**PERCENTAGE OF TOTAL COST (%)**
TOTAL VARIABLE COST	**86 059 302.11**	**91.36**
ELECTRICITY	15 035 643.00	15.962
WATER	100 000.00	0.106
MATERIAL PURCHASE	70 923 659.11	75.294
FIXED COST	**8 136 805.98**	**8.64**
TOTAL COST	**94 196 108.09**	**100.00**

Source: (Company's financial data reports, 2013)

Table 5.6 shows that the variable portion of the total production cost of steam is 91.36%, whereas the fixed cost portion is only 8.64% of total production costs.

Figure 5.3 is a graphical representation of the company's total cost of the steam generation process

Figure 5.3: Total cost of steam-generation process

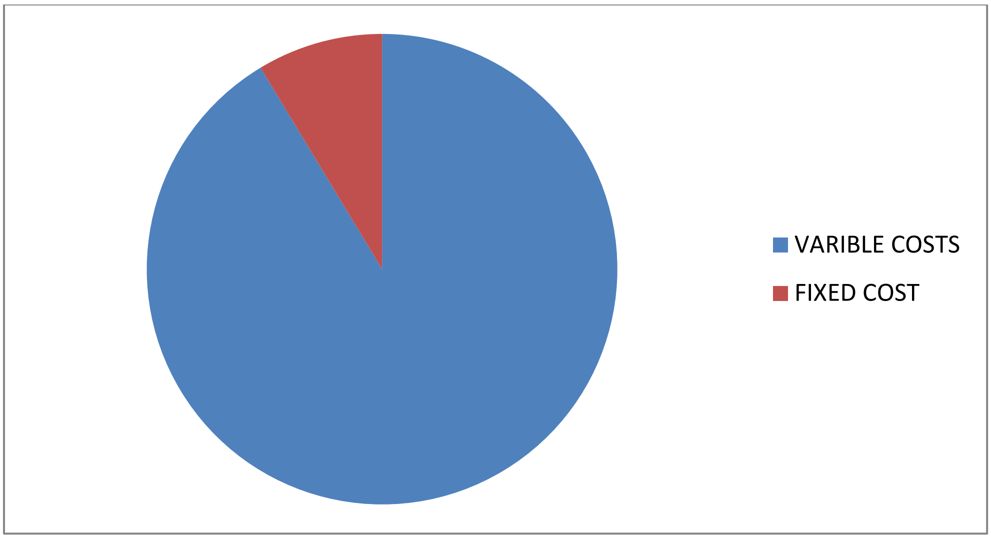


Figure 5.3 shows that majority of the costs of the steam production process consists of variable costs.

5.7.1 Breakdown and calculation of losses incurred in steam generation process for period under review, October 2012 to September 2013.

Table 5.7 shows the variance in coal usage by comparing the actual usage to allowed usage.

Table 5.7: Year-to-date variance in tons and Rand's

	Allowed usage in tons	Actual usage in tons	Variance in tons	Allowed usage in Rands	Actual usage in Rands	Variance in Rands
Coal	74,065	76,022	- 1956,696	R69,106,650	R70,923,659	- R1,817,009.25

Source: (Company's financial data reports, 2013)

Table 5.7 shows that the actual usage of coal was higher than allowed usage of coal for the amount of steam generated, resulting in a negative variance of R1 817 009.25.

Note:

Gross production of steam for the period under review was 517 938.000 tons per year.

Data presented in table 5.7 indicates that there is a minor difference between the accounting records and boiler plant records for steam generated of (517 938 – 514 848) 3 090 tons and also coal usage of (78 190 – 76 022) 2 168 tons. The difference is negligible and is, therefore, considered insignificant.

It should be noted that a negative variance in coal usage for the year end September 2013, resulting in a loss of R1 817 009.25 according to accounting records, could be attributed to the inefficiency of their current technology used in the steam-production process. The excess usage of coal impacts negatively on the environment and decreases the economic performance of the company in terms of more costs for raw material used in the steam production process.

5.7.2 Fixed cost breakdown

The company's fixed cost for the period under review (October 2012 to September 2013) was approximately 8 million Rands (R8 136 805.98). The breakdown is as follows:

- Maintenance cost of boilers – R 1 million;
- Depreciation – R 3 million;
- Service and administrative costs – R 1.4 million; and
- Personnel cost R 2.6 million.

Source: Company's production cost schedule (2013)

The organisation needs to consider high maintenance cost incurred due to the use of old, obsolete technology instead of new, CPT which is more efficient.

In cost accounting, the value of depreciation by financial accounting standards (based on the original purchase value) is continued, even after the equipment is depreciated in financial accounting.

The company experienced regular breakdown of boilers during the year, resulting in downtime and monetary loss due to production loss. The production loss in tons and monetary loss in Rands due to boiler breakdowns, was as shown in appendix 2B.

There was a loss of production to the value of R 439 101.80 for the year ending September 2013, as a result of downtime caused by boiler machines (Appendix 3).

5.7.3 Monetary value of non-product output for the year

This calculation is based on the raw material input that does not become part of the final product. In the steam production process, the coal is the raw material used to generate steam and is also the highest cost factor during analysis of this process costs. Therefore, the material purchase value of coal will be used to calculate the non-product value for the year.

During an analysis of the boiler ash, it had been established that, on average, approximately 20% of the coal used as input becomes wasted material in the form of unburned coal found in the ash (solid waste). This had been discovered during chemical analysis of the boiler ash generated during the steam production process that the carbon content of the ash is about 20% (Environmental manager 2013).

5.7.4 Costing and upgrading of boilers

An interview was conducted with the sales manager of John Thompson Boilers in Durban. This company specialises in the manufacture, upgrades and maintenance and support of water tube boilers.

Since the boilers currently used by the company are John Thompson Boilers, the researcher found it appropriate to gather the relevant information regarding the costing of replacing the boilers or upgrading the company's current boilers to state-of-art technology. John Thompson boilers are also familiar with the company's boilers as they did work on them previously. Hence, state-of-art technological efficiency levels for modern, environmentally friendly boilers used in the paper industry were established during this interview.

5.7.5 The non-product output value is calculated as follows:

Material purchased (coal) – R 70 923 659.11

Non-product output (unburned coal in the form of waste – 20% loss)

= R 14 184 731.82

5.7.6 Loss due to technological inefficiency

Input/output ratio in tons of coal used to generate steam is 7. This ratio is based on technological standards of industrial boilers. However, the company output ratio is approximately 6.3. This indicates inefficient use of resources in the production process. Hence, more input is required per output generated. This has a negative impact on the environment and also increases the costs of resources for the company.

The financial loss has been evaluated to an amount of approximately R 500 000 per month, resulting in a total loss estimated to R 6 million per annum (Cost accountant 2014)

Calculation of boiler efficiency is as follows:

Input/output efficiency of current technology for the period under review was: 1 ton coal: 6.3 tons of steam (amounts reflected in the accounting records will be used in this calculation).

Technological standard: 1 ton coal: 7 tons of steam = 1/7 = 0.143

Table 5.8 shows the loss value in Rand's of excess coal used due to boiler operating below technological standards.

Table 5.8: Calculation of boiler efficiency

Actual steam x 0.143	517938 tons x 0.143 = 74 065 tons
Actual coal usage – budgeted coal usage	76 022 tons – 74 065 tons = 1957 tons excess
Loss in Rand value	1957 tons x R933 per ton = R1 825 881

Table 5.9 shows the technological and state-of-art benchmarks for boiler technology.

Table 5.9: Benchmarks based on technological efficiency

STANDARDS	ACTUAL	TECHNOLOGICAL	STATE-OF-THE-ART TECHNOLOGY
COAL (FUEL) INPUT	1 TON	1 TON	1 TON
STEAM OUTPUT	6.3 TONS	7 TONS	8 TONS

Table 5.9 shows that boilers are operating below technological standards and that there is significant saving potential by switching to state-of-the-art technology in the future.

Figure 5.4 shows the tons of steam generated at different efficiency levels (indicated by coal usage)

Figure 5.4: Coal Usage

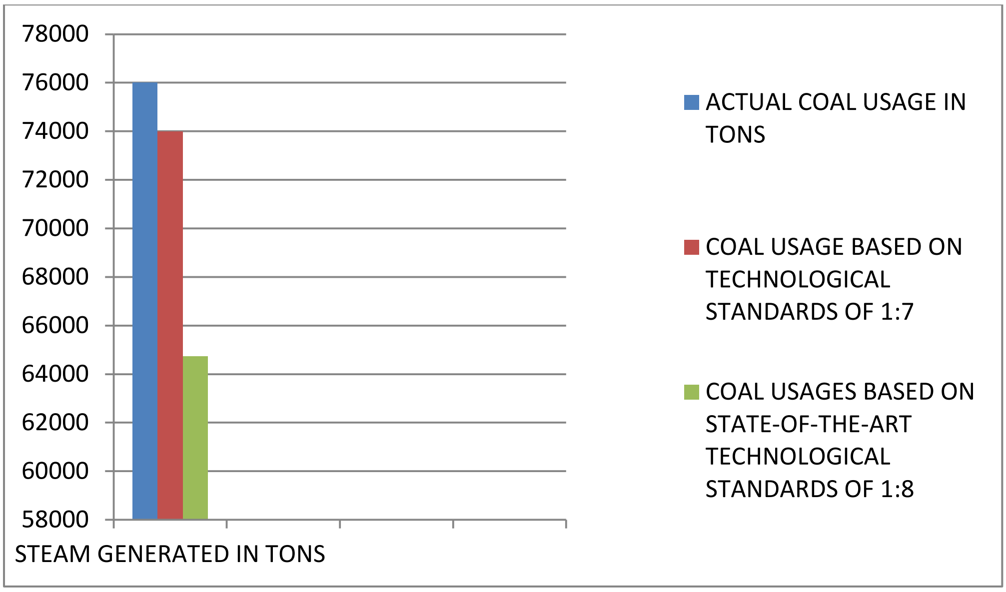


Figure 5.4 indicate that coal usage is lower when technological standards are achieved and much lower when state-of-art technology is used in the steam-generation process. This can result in savings in input resource use for the company.

State-of-the-art technological standards of 1:8 were established by most advanced boiler makers in the industry (Edgar 2014).

5.7.7 Cost benefit analysis

Cost: loss of material, financial loss due to downtime of boilers and cost of disposal of waste, loss due to technological inefficiency (approximately 1 year)

The calculation of disposal cost of ash is as follows:

Transport and labour = estimated to be approximately R 2 000 per 10 ton load of ash to dispose off at landfill 5 km away from mill (General manager DCLM 2014). Approximately 1 960 tons of boiler ash disposed off by the plant monthly.

Total transportation cost @ R2 000 per 10 ton load = R392 000 per month and R4 704 000 per annum. Standard waste generated during this process is approximately half this amount (Edgar 2014).

Therefore, an estimated amount of R2 352 000 per annum represents additional disposal cost incurred by the company due to technological and production inefficiencies.

The opportunity cost for the beneficial use of the ash, assuming ash probably has similar properties since boilers used in sugar mill, are similar to boilers used in the paper mill (sugar mill boiler ash is sold as road and driveway base or road use within 10 radius of the mill is R600 per 10 ton truck load).

Opportunity cost estimated @R600 per 10 ton load of ash = R117 600 per month and R1 411 200 per annum. This amount will not be included in the payback period calculation but needs to be considered by management as a shorter-term measure to generate revenue for the by-product instead to disposing it to landfill. This decision could improve both the economic and environmental performance of the company.

Pay loader hired for approximately 2 hrs per day to load the ash from hopper onto truck is approximately R3 500 per day (Environmental manager 2014).

Other environmental cost - nil

Note:

The boiler ash was not as yet tested for beneficial use as a budget needed to be approved for this process. This testing could only be done overseas and is expected to cost approximately R30 000. At the time of the study, management was in the process of authorising fund approval for the test. Therefore, accurate beneficial use of the coal ash could not be stated. The researcher decided to use an estimated value for calculating opportunity cost based on the type of boiler used. During research, the most frequently reported use for bottom boiler ash was as road base and driveway use.

The current market rate for 10 tons of bottom ash was used to estimate the opportunity cost of this by-product.

John Thompson Boilers were consulted to estimate values for cost of replacing boilers and upgrading the back-end equipment to reduce emissions and improve boiler efficiency and performance.

It should be noted that amounts used were estimated as actual values will depend on what the customer actually wants and which would be best suited to the industry. Each boiler is designed specifically to meet the needs of individual companies.

TOTAL COST:

1. New boiler = R60 000 000.00 per boiler (approximately R240 million)

2. Boiler upgrade = R5 000 000.00 per boiler (approximately R20 million)

TOTAL SAVINGS:

Material lost (non-product output value based on 20 percent loss of coal during steam generation process) = R14 184 731.82

Table 5.10 shows the estimated total saving opportunity should technological standards be achieved.

Table 5.10: Total estimated savings based on technological standards

Non-product output value due to inefficient production process at 10 percent excess material lost (expected loss during process is 10 percent)	R 7 092 366.00
Loss due to input/output standards below technological standards of 1:7	R 1 825 000.00
Disposal cost	R 2 352 000.00
Cost incurred in hiring of pay loader estimated (2hrs a day @R500 per hour)	R240 000.00
ESTIMATED TOTOAL SAVINGS	**R 11 509366.00 per annum**

Table 5.10 shows that the estimated saving opportunity of R11 509 366.00 is possible should the company implement measures to achieve technological standards. Technological standards may be achieved by upgrading existing boiler technology to ensure that boilers function according to design specification. The cost of upgrading the company's existing boilers in order to achieve technological efficiency standards was estimated at an amount of approximately R5 000 per boiler. This estimated value was established during the interview with John Thompson boiler manufacturers. Payback period for the upgrading was calculated on the estimated cost of R20 000 for the four boilers.

Equation to calculate payback period:

Total investment cost/Estimated total savings per annum

Replacement costs of boilers are extremely high. Therefore, upgrading costs will be used in calculating payback period. This will be used in strategic decision-making process.

Payback: R20 000 000/R11 509 366 = 1.74 years

Efficiency level using newer, upgraded technology is 1 ton coal: 8 tons steams

Savings in reduced raw material consumption = 1/8 = 0.125

Table 5.11: Boiler efficiency calculation based on state-of-the-art standards

Coal usage	517 938 tons (actual steam) x 0.125 = 64 742 tons
Actual coal usage – budgeted usage	76 022 tons – 64 742 tons = 11 280 tons
Material purchase value	11 280 tons x R933 = R 10 524 240 (savings)
Payback calculated using raw material savings only	R 20 000 000/10 524 240 = 1.9 years
Payback period calculation including savings on disposal costs	R 20 000 000/13 116 240 = 1.5 years

Source: Self Generated

Table 5.11 shows the difference in actual coal usage and coal usage based on state-of-the-art technological standards. This indicates the efficiency levels and possible savings for the company should they replace their current boilers with state-of-the-art boilers.

5.8 Environmental Costing Procedures, Reporting and Treatment by the Company

5.8.1 Current accounting practices for managing environmental cost of the company

Standard accounting information system is used for both financial and management accounting. Environmental costs are recognised for waste treatment and waste disposal under overhead expenses for the whole company. Only monetary information is provided for environmental costs. Physical information on type or quantity of goods or services procured was not currently available within the system. For the steam generation process, no environmental costs were included. Production costs for the process included raw material (coal), electricity, water and fixed cost. All coal purchased was included as part of production costs. Raw material lost during production was not calculated and measured in monetary and physical terms. The non-product output is an environmental cost to the company as this loss represents waste which is a sign of inefficiency in production. Depreciation, including that of environmental equipment like ESP's or cyclones used to reduce environmental impact of pollution and hazardous waste, forms part of fixed cost.

This cost allocation is incorrect as depreciation of environmental equipment should be recognised as part of environmental costs and not fixed overhead costs. Labour cost of handling and disposal of waste including the salary of the environmental manager should be allocated to environmental cost. However, this is not being done by the company (Environmental Management Accounting as the next step in the evolution of management accounting 2006).

Based on the above information regarding accounting practices for managing environmental cost, it can be concluded, that, due to the inadequacies of the company's current accounting systems, environmental costs reported by the company are significantly underestimated. The environmental costs included in financial statements are not a true and accurate reflection of the actual environmental costs.

However, both physical and monetary information are required for environmental reporting and for the purpose of environmental benchmarking.

A link between systems for collecting physical and monetary data is lacking. This information is required for minimizing environmental impacts and managing costs.

The environmental manager collects information about physical data, for example, mass balances and related information required for environmental management and monitoring and controlling of resource consumption but this information is not included in the accounting system and not accounted for in the financial statements. In order to access monetary information provided by the accounting system, the environmental manager would require the assistance from accountants. This information would be extremely valuable for benchmarking data to BAT standards.

There seems to be poor communication between the management accountant and the environmental manager. Management accountants tend to be constrained to thinking within the existing chart of accounts, and pay less attention to environmental costs (Chang 2007:127).

Due to this break in communication, opportunities for reducing environmental costs remain unidentified. In order to build a link between physical and monetary information systems and improve environmental and economic performance, it is essential that there be regular interaction and information sharing between the environmental and accounting departments. In terms of the management of major environmental costs:

- A monthly management report is produced by the Finance department in order to review current operations and assess performance against the budget. Hence, major environmental costs are allocated as per budget;
- A detailed breakdown of the costs are not provided and, therefore, due to incomplete information, management of environmental costs are not prioritized; and
- The problem stems from the fact that there was no prior focus on environmental cost management. The fact that senior managers feel that the environmental costs are insignificant, means that they do not know the extent of environmental costs.

5.9 Summary of current accounting practices for managing the major environmental costs

Environmental costs are allocated to overhead accounts and key managers are not held liable for these costs. This tends to discourage managers from actively managing environmental costs. Only cost paid for waste collection and removal are recognised as waste costs. Since NPO costs, based on material purchase price, are not considered a part of waste costs, these are significantly underestimated. There is limited environmental accountability.

The limitations mentioned above are not specific to this case study, but could be common to many other organisations, as discussed in the literature review. These limitations do, however, impact negatively on the company's environmental and economic performance.

5.10 Questionnaire findings (Appendix 4)

5.10.1 Introduction

This section presents the results and discusses the findings obtained from the questionnaires in this study. The questionnaire was the primary tool that was used to collect data and was distributed to senior and middle level managers of the company.

The data collected from the responses was analysed with the SPSS version 22.0. The results will present the descriptive statistics in the form of graphs, cross tabulations and other figures for the qualitative data that was collected. Inferential techniques include the use of correlations and chi square test values which are interpreted using the p-values.

5.10.2 The Sample

In total, 40 questionnaires were despatched and 37 were returned which gave a 92.5% response rate.

5.10.3 The Research Instrument

The research instrument consisted of 52 items, with a level of measurement at a scale, nominal or an ordinal level. The questionnaire was divided into 10 major questions which measured various themes, as illustrated below:

Q1	Corporate environmental strategy of the organisation;
Q2	Environmental related activities;
Q3	Reasons for the promotion of clean production by industries;
Q4	Cause of pollution/waste generation;
Q5	Perspectives of environmental management accounting;
Q6	Environmental audit assessments;
Q7	Barriers to adoption of cleaner technologies;
Q8	How old is the technology used in the company's production department?
Q9	How often are there disruptions in production due to problems with technological equipment? and
Q10	Approximately how much does the company spend on maintenance cost for technological equipment used in production per annum?

5.10.4 Reliability Statistics

The two most important aspects of precision are reliability and validity. Reliability is computed by taking several measurements on the same subjects. A reliability coefficient of 0.70 or higher is considered as "acceptable" (Willemse 2009:34-35).

Table 5.12 reflects the Cronbach's alpha score for all the items that constituted the questionnaire.

Table 5.12: Cronbach scores

		Number of Items	Cronbach's Alpha
Q1	Corporate environmental strategy of the organisation	4 of 4	.878
Q2	Environmental related activities	12 of 12	.978
Q3	Reasons for the promotion of clean production by industries	-	-
Q4	Cause of pollution/waste generation	-	-
Q5	Perspectives of environmental management accounting	5 of 5	.922
Q6	Environmental audit assessments	5 of 5	.884
Q7	Barriers to adoption of cleaner technologies	10 of 10	.837
	Overall	36 of 36	.962

The overall reliability score of each section exceeds the recommended value of 0.70. This indicates a high (overall) degree of acceptable, consistent scoring for the research.

All of the themes (sub-sections) have values that exceed the acceptable standard.

Questions 3 and 4 are scalar in nature. Cronbach's alpha was not determined.

5.10.5 Factor Analysis

Why is factor analysis important?

Factor analysis is a statistical technique whose main goal is data reduction. A typical use of factor analysis is in survey research, where a researcher wishes to represent a number of questions with a small number of hypothetical factors. For example, as part of a national survey on political opinions, participants may answer three separate questions regarding environmental policy, reflecting issues at the local, state and national levels (Stephens 2004:138).

Each question, by itself, would be an inadequate measure of attitude towards environmental policy, but *together* they may provide a better measure of the attitude. Factor analysis can be used to establish whether the three measures do, in fact, measure the same thing. If so, they can then be combined to create a new variable, a factor score variable that contains a score for each respondent on the factor. Factor techniques are applicable to a variety of situations (SPSS ver 17.0). A researcher may want to know if the skills required to be a decathlete are as varied as the ten events, or if a small number of core skills are needed to be successful in a decathlon. One need not believe that factors actually exist in order to perform a factor analysis, but, in practice, the factors are usually interpreted, given names, and spoken of as real things (SPSS ver 17.0).

Each matrix table is preceded by a table that reflects the results of Kaiser-Meyer-Olkin (KMO) and Bartlett's Test.

The requirement is that Kaiser-Meyer-Olkin Measure of Sampling Adequacy should be greater than 0.50 and Bartlett's Test of Sphericity less than 0.05. In all instances, the conditions are satisfied which allow for the factor analysis procedure (Stephens 2004:136-137).

Certain components divided into finer components. This is explained below in the rotated component matrix.

Question 1

Table 5.13 and table 5.14 represent statistical tests on the corporate environmental strategy of the organisation.

Table 5.13: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.737
Bartlett's Test of Sphericity	Approx. Chi-Square	78.302
	df	6
	Sig.	.000

Table 5.12 shows that the value of the test statistic for sphericity is large and the associated significance level is less that 0.05 (.000). Therefore, it can be concluded that the variables for question 1 are correlated.

Test results in table 5.13 also show that the test results for the KMO measure of sampling adequacy are above 0.5. Hence, it can be concluded that all factors are suitable for applying factor analysis.

Table 5.14: Component Matrix

	Component
	1
Integrated environmental issues are incorporated into the company's strategic planning process	.876
Reducing the environmental impact of products and processes forms part of the Total Quality Management (TQM) policy	.882
Environmental objectives are linked with the company's corporate goals	.860
During the development of new products, environmental issues are always considered	.856

Table 5.14 shows that correlation values between the variables in each factor are greater than 0.5. Therefore, it can be concluded that the variables for question 1 are correlated.

Question 2

Tables 5.15 and 5.16 represent statistical tests on environmental-related activities.

Table 5.15: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.772
Bartlett's Test of Sphericity	Approx. Chi-Square	953.371
	df	66
	Sig.	.000

Table 5.15 shows that the value of the test statistic for sphericity is large and the associated significance level is less that 0.05 (.000). Therefore, it can be concluded that the variables for question 2 are correlated.

Test results in table 5.15 also show that the test results for the KMO measure of Sampling Adequacy is above 0.5. Hence, it can be concluded that all factors are suitable for applying factor analysis.

Table 5.16 shows that, for question 2 on environmental related activities, two factors emerged from the analysis. The first two variables in table 5.16 constituted a factor, while the remaining ten variables formed another separate factor.

Upon further examination, it seems that the first two variables relate to ‘reactive’ environmental activities. The remaining ten variables relate to ‘proactive’ environmental activities. It is likely that these two separate factors are actually sub-factors of environmental-related activities.

Table 5.16: Rotated Component Matrix

	Component	
	1	2
Identification of environmental related-costs	.075	.936
Estimation of environmental-related contingent liabilities	.369	.824
Classification of environment-related costs	.943	.285
Allocation of environment-related costs to production processes	.964	.086
Improvements to environment-related cost management	.927	.270
Allocation to environment-related costs to production products	.972	.192
Creation and use of environment-related cost accounts	.923	.204
Development and use of environment-related key performance indicators (KPIs)	.937	.285
Product life-cycle cost assessment	.850	.415
Product impact analysis	.938	.297
Product improvement analysis	.981	.146
Assessment of potential environmental impacts associated with capital investment decision	.949	.224

Question 5

Tables 5.17 and 5.18 demonstrate management’s perspectives of environmental management accounting.

Table 5.17: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.781
Bartlett's Test of Sphericity	Approx. Chi-Square	189.674
	df	10
	Sig.	.000

Table 5.17 shows that the value of the test statistic for sphericity is large and the associated significance level is less that 0.05 (.000). Therefore, it can be concluded that the variables for question 5 are correlated.

Test results in table 5.17 also show that the test results for the KMO measure of Sampling Adequacy are above 0.5. Hence, it can be concluded that all factors are suitable for applying factor analysis.

Table 5.18 shows that correlation values between the variables in each factor are greater than 0.5.

Table 5.18: Component Matrix

	Component 1
Inclusion of environmental information in the present management accounting information system	.900
Availability of formal accounting procedures when dealing with specific environmental issues	.952
Implementing cost-benefit analysis that also takes into consideration any environmental issues when dealing with viability of projects, course of actions	.917
Undertaking environmental impact audits culminating company's activities	.748
Reporting environmental information to external stakeholders	.906

Table 5.18 indicates that all variables for question 5 are positively correlated.

Question 6

Tables 5.19 and 5.20 show the statistical tests on management's response to environmental audit assessments.

Table 5.19: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.782
Bartlett's Test of Sphericity	Approx. Chi-Square	140.274
	df	10
	Sig.	.000

Table 5.19 shows that the value of the test statistic for sphericity is large and the associated significance level is less that 0.05 (.000). Therefore, it can be concluded that the variables for question 6 are correlated.

Test results in table 5.19 also show that the test results for the KMO measure of Sampling Adequacy are above 0.5. Hence, it can be concluded that all factors are suitable for applying factor analysis.

Table 5.20 shows that correlation values between the variables in each factor are greater than 0.5.

Table 5.20: Component Matrix

	Component
	1
Safety and security audits	.910
Regular checks on operations	.898
Quality controls checks on water, air and soil	.932
ISO	.698
Environmental Impact Assessment reports (EIA)	.765

Table 5.20 indicates that all variables for question 6 are correlated.

Question 7

Tables 5.21 and 5.22 show the respondents' view on barriers to the adoption of CT.

Table 5.21: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.758
Bartlett's Test of Sphericity	Approx. Chi-Square	361.021
	df	45
	Sig.	.000

Table 5.21 shows that the value of the test statistic for sphericity is large and the associated significance level is less that 0.05 (.000). Therefore, it can be concluded that the variables for question 6 are correlated.

Test results in table 5.21 also show that the test results for the KMO measure of Sampling Adequacy are above 0.5. Hence, it can be concluded that all factors are suitable for applying factor analysis.

Table 5.22 shows that for question on barriers to the adoption of cleaner technologies, two factors emerged from the analysis. Variables 2, 8, 9 and 10 constituted a factor, while variables 1, 3, 4, 5, 6, and 7 formed another separate factor.

Table 5.22: Rotated Component Matrix

	Component	
	1	2
Relaxed regulation and law enforcement	.681	.263
Absence of incentives on economic policies	.457	.610
Higher initial capital cost	.876	-.313
Poor financial performance of cleaner technologies	.902	.117
Limited in- plant expertise	.804	.198
Difficulty to access information on CT	.877	-.256
Additional infrastructure requirements	.862	.179
Higher priorities to production expansion	.051	.965
Concern about competitiveness	-.022	.975
Management resistance to change	-.024	.954

Factor analysis is a statistical technique whose main goal is data reduction. A typical use of factor analysis is in survey research, where a researcher wishes to represent a number of questions with a small number of hypothetical factors (Willemse 2009:33). With reference to the table 5.22 (SPSS ver 17.0):

- The principle component analysis was used as the extraction method, and the rotation method was Varimax with Kaiser Normalization. This is an orthogonal rotation method that minimizes the number of variables that have high loadings on each factor. It simplifies the interpretation of the factors;
- Factor analysis/loading show inter-correlations between variables; and
- Items of questions that loaded similarly imply measurement along a similar factor.

An examination of the content of items loading at or above 0.5 (and using the higher or highest loading in instances where items cross-loaded at greater than this value) effectively measured along the various components.

It is noted that the variables that constituted questions 1, 5 and 6 loaded perfectly along one factor each. This means that the statements (variables) that constituted this component perfectly measured the component. That is, the component measured what it was that was meant to be measured.

The remaining sub-themes split along two components. This implies that respondents identified certain aspects of the sub-themes as belonging to other sub-sections.

5.10.6 Section Analysis

The following section analyses the scoring patterns of the respondents per variable per section.

The results are first presented using summarised percentages for the variables that constitute each section.

Results are then further analysed according to the importance of the statements.

Q1 Corporate environmental strategy of the organisation

This section deals with management's perception of the extent to which environmental issues are integrated into the organisation's corporate strategies.

Table 5.23 represents the corporate environmental strategy of the organisation.

Table 5.23: Corporate environmental strategy of the organisation

Question 1	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Integrated environmental issues are incorporated into the company's strategic planning process	0.00	0.00	8.57	60.00	31.43
Reducing the environmental impact of products and processes forms part of the Total Quality Management (TQM) policy	0.00	0.00	8.57	65.71	25.71
Environmental objectives are linked with the company's corporate goals	0.00	0.00	31.43	40.00	28.57
During the development of new products, environmental issues are always considered	0.00	2.86	45.71	28.57	22.86

The scoring pattern on the first and second statement indicates that 91.43% are in agreement that environmental issues are integrated into the company's strategic planning process and forms part of their TQM policy, with 8.57% remaining neutral. However, the percentage of agreement on environmental objectives being linked to the company's corporate goals and being considered during new product development dropped to 68.57% and 51.43%, respectively. A large percentage of respondents remained neutral with 31.43% for statement 3 and 45.71% for statement 4. A negative response of 2.86% was also noted on the last statement concerning environmental issues being considered during new product development.

The average level of importance for this section was 75.71%.

The first two statements average 91.43% with the last statement lowering the overall average, with only half of the respondents agreeing (51.43%). Even though the level of agreement is reasonably high, the statements relating to environmental issues are always considered during new product development and environmental objectives being linked with the company's corporate goals, scores lower in terms of the respondent's level of agreement than the other statements.

It is interesting to note that although all four statements are considered a part of corporate environmental strategy, the response to the last two statements varied significantly as compared to the first two statements. The most important levels of agreement were for the first two statements.

The uncertainty to question 1 with regards to the corporate environmental strategy of the organisation is evidenced by the large number respondents indicating a neutral view on the last two statements, with 31.43% for statement three and 45.71% for statement four. According to Gil, Andres, and Salinas (2007:89), management commitment has a substantial influence on corporate environmental strategy and that management's awareness of the responsibility to the environment during strategic decision making is important to reflect this commitment inside and outside the organisation. Lack of clear environmental goals is one of the obstacles to environmental performance measurement (Mohr-Swart 2008:174).

To determine whether the differences were significant, chi-square tests were done by variable (statement). The null hypothesis tested the claim that there were no differences in the scoring options per statement. The results are shown in table 5.24.

Table 5.24: Test Statistics

	Integrated environmental issues are incorporated into the company's strategic planning process	Reducing the environmental impact of products and processes forms part of the Total Quality Management (TQM) policy	Environmental objectives are linked with the company's corporate goals	During the development of new products, environmental issues are always considered
Chi-Square	13.943[a]	18.057[a]	.743[a]	13.114[b]
df	2	2	2	3
Asymp. Sig.	.001	.000	.690	.004

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 11.7.

b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 8.8.

Since all but one of the sig. values (p-values) are less than 0.05 (the level of significance), it implies that the distributions were not even. That is, the differences between the levels of agreement were significant. Similar scoring patterns were observed for statement 3 ($p = 0.690$).

Differences in the level of agreement clearly indicate that managers have limited knowledge on the organisation's corporate environmental strategy, more especially in areas concerning environmental objectives and new product development.

Q2 Environmental-related activities

This section deals with environmental-related activities that have been practised in the company to implement environmental management, as depicted in table 5.25.

Table 5.25: Environmental-related activities

Question 2	Never done	Being done to some extent	Neutral	Regularly done	Always done
Identification of environmental related-costs	0.00	0.00	17.14	48.57	34.29
Estimation of environmental-related contingent liabilities	0.00	11.43	20.00	42.86	25.71
Classification of environment-related costs	0.00	57.14	8.57	11.43	22.86
Allocation of environment-related costs to production processes	40.00	14.29	11.43	17.14	17.14
Improvements to environment-related cost management	2.86	54.29	8.57	14.29	20.00
Allocation to environment-related costs to production products	48.57	8.57	11.43	11.43	20.00
Creation and use of environment-related cost accounts	0.00	54.29	5.71	20.00	20.00
Development and use of environment-related key performance indicators (KPIs)	0.00	51.43	17.14	11.43	20.00
Product life-cycle cost assessment	2.86	54.29	14.29	8.57	20.00
Product impact analysis	0.00	57.14	11.43	11.43	20.00
Product improvement analysis	45.71	11.43	11.43	11.43	20.00
Assessment of potential environmental impacts associated with capital investment decision	48.57	11.43	11.43	8.57	20.00

The average level of respondents indicating that environmental activities are *regularly done* for this section is 39.76%. There are three levels of *agreement* patterns.

The highest ranked statement is “Identification of environmental related-costs” (82.86%).

A single second important statement was for statement 2 which related to the estimation of environmental-related contingent liabilities (68.57%). The remaining statements all had agreements for *regularly done* of no more than 40%.

The corresponding negative scoring level (*Being done to some extent or never done*) was above 50% for all other statements except for the first two statements.

The results revealed that, to some extent, the respondents perceived their organisation had conducted appropriate environmental-related activities.
It was apparent that 'Identification of environmental related-costs' activity was ranked the highest, suggesting a common activity within the organisation. This was followed by 'Estimation of environmental-related contingent liabilities.' Surprisingly, an average of 45.7% of the respondents indicated that the following environmental-related activities were '*never done':* Allocation of environmental-related costs to production products, product improvement analysis and assessment of potential environmental impacts associated with capital investment decisions. Literature suggests that an EMA system be implemented in order to overcome the limitation of conventional management accounting which is unable to detect hidden environmental-related costs that affect business performance (Schaltegger *et al*. 2010). In addition, Qian, Burritt and Monroe (2011:93-128) emphasise the incompleteness of conventional management accounting approaches that only take into consideration the operational cost of waste management during decision making. Product improvement analysis should also be done in order to identify new opportunities within organisations.

The chi square test results are shown in table 5.26.

Table 5.26: Chi square test results environmental-related activities	Chi-Square	df	Asymp. Sig.
Identification of environmental related-costs	5.200[a]	2	.074
Estimation of environmental-related contingent liabilities	7.400[b]	3	.060
Classification of environment-related costs	20.886[b]	3	.000
Allocation of environment-related costs to production processes	9.143[c]	4	.058
Improvements to environment-related cost management	28.571[c]	4	.000
Allocation to environment-related costs to production products	19.143[c]	4	.001
Creation and use of environment-related cost accounts	17.914[b]	3	.000
Development and use of environment-related key performance indicators (KPIs)	13.571[b]	3	.004
Product life-cycle cost assessment	28.571[c]	4	.000
Product impact analysis	19.971[b]	3	.000
Product improvement analysis	15.429[c]	4	.004
Assessment of potential environmental impacts associated with capital investment decision	19.143[c]	4	.001

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 11.7.

b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 8.8.

c. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 7.0.

The highlighted p-values are all less than 0.05, which imply that the scoring patterns were significantly different for each variable.

The values that are not highlighted indicate that the *expected* scoring patterns were similar.

Q3 Reasons for the promotion of clean production by industries

This section investigates the manager's perception of factors that promote the adoption of CP in industries.

Table 5.27 is the average rank score of the factors, ranked from the highest to the lowest levels of importance.

Table 5.27: Promotion of cleaner production

	Mean
The fear for business sustainability in the future and its uncertainties	4.54
The market pressures for cleaner products and processes	3.97
Strict legislation and environmental crime law	3.80
The greater business managers' awareness and commitments to the environmental aspects	2.94
Many emotional aspects connected with environment and the company's productive activity	2.43

The most important factor is identified as being uncertainty regarding business sustainability.

The results indicate that external factors have a more significant impact on whether or not an organisation will adopt CP than internal factors. The first three factors are external while the last two factors, rated as less important, are internal factors.

The contingency theory could be used to explain why managers have identified uncertainty regarding business sustainability as the most important factor. It can be inferred from Qian, Burritt and Manroe (2011:93-128) that there is no single best approach to sustainability since the external business environment is characterised by uncertainty. They concur that the optimal course of action will depend on factors such as company's environment, technology and culture.

According to the Institute of Environmental Engineering and the UNEP, internal barriers to CP implementation within a company are: low commitment from management, lack of environmental awareness, poor communication links and financial obstacles. Therefore, the last two constructs have been rated as less important.

Fore and Mbohwa (2010:314-333) identified barriers to CT adoption as: less stringent government regulations and policies, resource unavailability and lack of financial initiative.

This finding supports the respondents' view to a certain extent that external factors, such as market pressures, strict legislation and, most importantly, uncertainty of the businesses future sustainability, are the driving forces of CP implementation.

Q4 Cause of pollution/waste generation

This section is concerned with the most important causes of waste/pollution in the company.

Table 5.28 ranks the causes in order of being most important to least important.

Table 5.28: Causes of pollution	Mean
Input and raw material waste	7.14
Poor manufacturing	5.83
Inadequate input, product and equipment specification	4.94
Improper material handling	4.80
No suitable maintenance	4.03
Improper use of technologies	3.71
Insufficient operator training and commitment	3.37
No planning for production, purchasing and sales	2.51

The results reveal that the most important cause of pollution is input and raw material waste, followed by poor manufacturing and inadequate input, product and equipment specification. No planning for production, purchasing and sales was rated the least important cause of pollution or waste.

Literature supports this view that the most significant share of total environmental costs is usually NPO costs (Domil, Peres, and Peres 2010:720).

Material costs make up the highest portion of costs (about 50%) in a manufacturing company. According to Sygulla *et al*. (2011:1), by reducing material usage, the amount of waste generated will also decrease. Schmidt and Nakajima (2013:360) claim that by implementing MFCA, a tool of EMA, material losses can be evaluated in monetary terms, making it possible for managers to identify environmental and economic benefits of adopting CP techniques and technologies. Jonall (2008:42) states that wasted raw material is a sign of inefficient production processes or poor manufacturing. In many cases, this was generally caused by old technologies used. He added that polluting companies actually pay three times for NPO and need to take this cost saving potential into consideration when making decisions regarding investment in CPT. Other less important causes of waste are improper material handling, poor maintenance, improper use of technology and insufficient operator training.

Q5 Perspectives of environmental management accounting

This section is concerned with manager's perception of EMA practices within the organisation.

Table 5.29: Perspectives of environmental management accounting

Question 5	Totally disagree	Disagree	Neutral	Agree	Totally agree
Inclusion of environmental information in the present management accounting information system	0.00	45.71	8.57	22.86	22.86
Availability of formal accounting procedures when dealing with specific environmental issues	0.00	2.86	65.71	14.29	17.14
Implementing cost-benefit analysis that also takes into consideration any environmental issues when dealing with viability of projects, course of actions	0.00	48.57	14.29	20.00	17.14
Undertaking environmental impact audits culminating company's activities	0.00	0.00	25.71	57.14	17.14
Reporting environmental information to external stakeholders	0.00	5.71	62.86	8.57	22.86

The average level of agreement is 44.00%.

The level of agreement is fairly consistent except for statement 4 which relates to the undertaking of environmental impact audits culminating in the company's activities (74.29%). Two of the statements show higher levels of neutrality, while the remaining statements indicate higher levels of disagreement.

This finding suggests that most of the EMA practices are not being implemented within the organisation except for environmental impact audits. Since the organisation is ISO 14001 accredited, environmental impact audits are mandatory.

The company uses a traditional cost accounting system which is inadequate in incorporating environmental information into general management accounting information. Findings in question two relating to environmental activities also suggest that the EMA system is not being implemented by the company. According to Benette, Schaltegger and Zvezdov (2013:32), EMA is a tool that tracks and traces environment-related costs that are generally hidden under overheads to assist managers in decision making.

Recent developments in EMA emphasise the greater need for accounting information when making decisions regarding environmental projects (Qian and Burritt 2008:244). Previous research by Jasch and Schnitzer (2002:6) showed a lack of communication between the environmental manager and cost accountant in companies. The environmental manager has limited access to actual cost accounting documents. Although the cost controller has most of the information, he lacks the ability to separate the environmental part without proper guidance. EMA is a combined approach to bridge this communication gap and provide for the transition of data from cost accounting and financial accounting to reduce the environmental impact by increasing material efficiency.

Hence, it was implied that, in order to enable the sharing of environmental information needed to stimulate management accounting practices, formal and informal interactions between different functions are required.

Environmental reporting and environmental audit are based on the ‘stakeholder theory’ which implies that a company needs to conduct their business operations in a way that is socially acceptable by the community. It can be inferred from Godschalk (2008:250) that some firms place greater emphasis on stakeholders as they believe that this is critical to the firms’ success and to ensure future sustainability. This could explain the reason for the high level of agreement for statement 4.

Table 5.30 indicates the chi-square results for differences in the scoring patterns.

Table 5.30: Test Statistics

	Inclusion of environmental information in the present management accounting information system	Availability of formal accounting procedures when dealing with specific environmental issues	Implementing cost-benefit analysis that also takes into consideration any environmental issues when dealing with viability of projects, course of actions	Undertaking environmental impact audits culminating company's activities	Reporting environmental information to external stakeholders
Chi-Square	9.914[a]	32.543[a]	10.600[a]	9.314[b]	29.114[a]
df	3	3	3	2	3
Asymp. Sig.	.019	.000	.014	.009	.000

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 8.8.

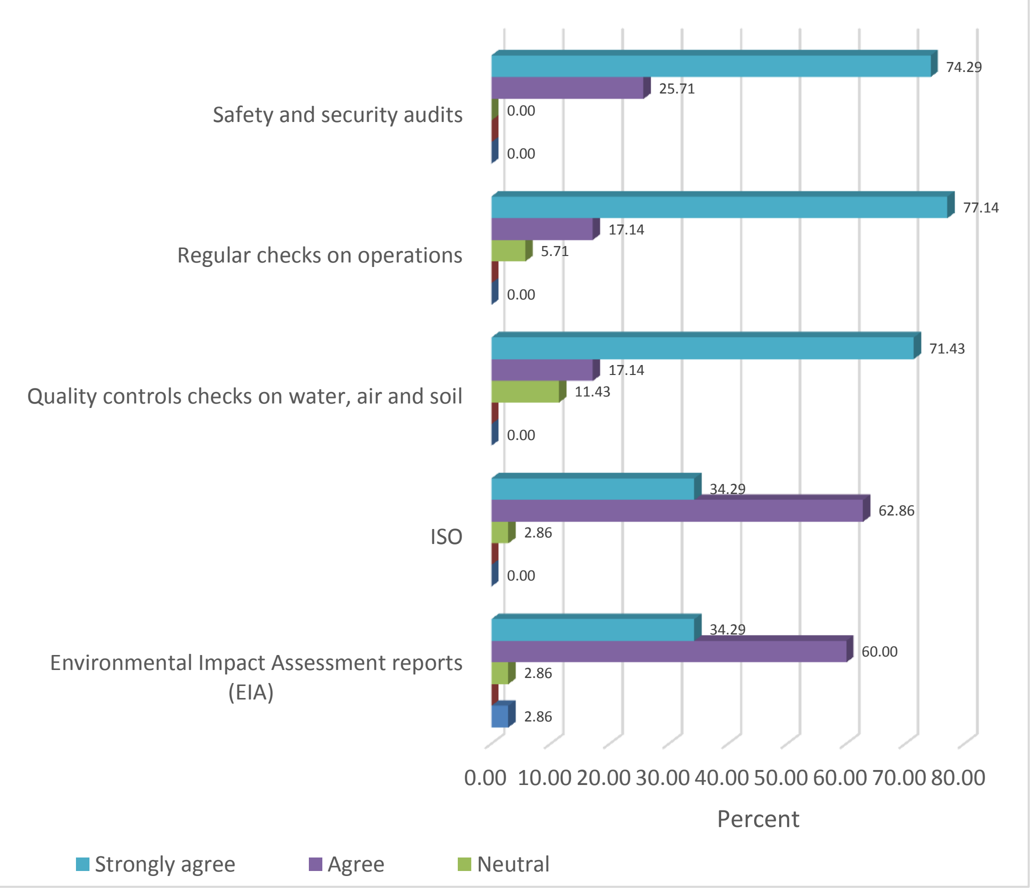
b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 11.7.

Since all of the values are less than the levels of significance ($p < 0.05$), it implies that the differences observed in the scoring per option per statement was significant.

Q6 Environmental audit assessments

This section looks at the annual environment impact and other audit assessments and whether the organisation was currently practising these assessments.

Figure 5.5: Environmental audit assessments



The average level of agreement regarding usage was 94.86%.

Respondents, in general, agree that their organisation conducts regular environmental audit assessments.

Research suggests that audits in EMS are used to validate the implementation of the management system and to check compliance with legislation, but do not measure actual environmental performance (Lundberg 2009:12).

A basic commitment of EMS, according to ISO 14001 standardisation, is continuous improvement to achieve environmental performance that is consistent with the organisation's environmental policy. The chi square results are reflected in table 5.31.

Table 5.31: Chi square Test

	Safety and security audits	Regular checks on operations	Quality controls checks on water, air and soil	ISO	Environmental Impact Assessment reports (EIA)
Chi-Square	8.257[a]	30.914[b]	23.029[b]	18.914[b]	32.086[c]
df	1	2	2	2	3
Asymp. Sig.	.004	.000	.000	.000	.000

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 17.5.

b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 11.7.

c. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 8.8.

There is a marked difference in the scoring patterns. This is observed in terms of the levels of agreement seen.

Q7 Barriers to adoption of cleaner technologies

This section deals with factors that are considered barriers to the adoption of CT, as indicated in table 5.32.

Table 5.32: Barriers to cleaner technology

Question 7	Totally disagree	Disagree	Neutral	Agree	Totally agree
Relaxed regulation and law enforcement	0.00	2.86	17.14	68.57	11.43
Absence of incentives on economic policies	0.00	14.29	60.00	14.29	11.43
Higher initial capital cost	0.00	2.86	11.43	34.29	51.43
Poor financial performance of cleaner technologies	0.00	2.86	22.86	65.71	8.57
Limited in- plant expertise	0.00	2.86	28.57	60.00	8.57
Difficulty to access information on CT	0.00	2.86	25.71	71.43	0.00
Additional infrastructure requirements	0.00	8.57	22.86	60.00	8.57
Higher priorities to production expansion	11.43	42.86	20.00	14.29	11.43
Concern about competitiveness	8.57	45.71	22.86	20.00	2.86
Management resistance to change	11.43	48.57	17.14	17.14	5.71

The average level of agreement is 54.57%.

Some statements show high levels of agreement and others do not. For example, higher initial capital cost and difficulty to access information on CT scores have higher levels of agreement as compared to ‘higher priorities to production equipment’ and ‘absence of incentives on economic policies’, which have extremely low levels of agreement.

Higher initial capital cost had the highest level of agreement of 85.72%, followed by relaxed regulation and law enforcement and poor financial performance of CT with agreement levels of 80% and 74.28%, respectively. Interestingly, limited in-plant expertise and additional infrastructure requirements had the same level of agreement of 68.57%. Similarly, the absence of incentives on economic policies and higher priorities to production expansion had the same level of agreement of 25.72%. Response relating to the last two statements: concern about competitiveness and management resistance to change revealed higher levels of disagreement of 54.28% and 60%, respectively.

Research studies had identified insufficient investment capital, lack of domestic suppliers and unsatisfactory government policies as key barriers to adoption of CT (Nguyen, Ha-Duong, Tran, Shrestha, and Nadaud 2010:1).

They also claimed that technological barriers such as the lack of infrastructure and poor technical knowledge and capabilities affected CT adoption in developing countries. Fore and Mbohwa (2010:314-333) identified barriers to CT adoption in Sri Lanka as: lack of financial initiative; resource unavailability, less stringent government regulations and policies as being some of the major issues

The chi square results for barriers to the adoption of CT are shown in table 5.33.

Table 5.33: Chi-square Test Results

	Chi-Square	df	Asymp. Sig.
Relaxed regulation and law enforcement	36.886[a]	3	.000
Absence of incentives on economic policies	22.943[a]	3	.000
Higher initial capital cost	20.429[a]	3	.000
Poor financial performance of cleaner technologies	33.914[a]	3	.000
Limited in- plant expertise	27.971[a]	3	.000
Difficulty to access information on CT	25.600[b]	2	.000
Additional infrastructure requirements	24.771[a]	3	.000
Higher priorities to production expansion	12.286[c]	4	.015
Concern about competitiveness	19.143[c]	4	.001
Management resistance to change	19.429[c]	4	.001

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 8.8.

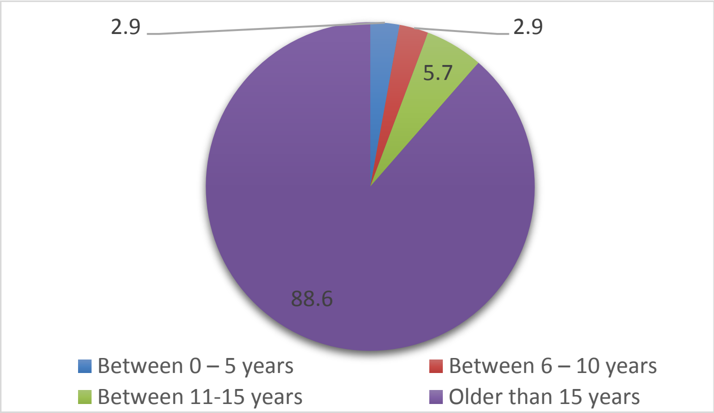
b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 11.7.

c. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 7.0.

All of the p-values are less than 0.05. Hence, the scoring patterns are different.

Figure 5.6 indicates the age of the technology used in the company's production department.

Figure 5.6: Age of technology



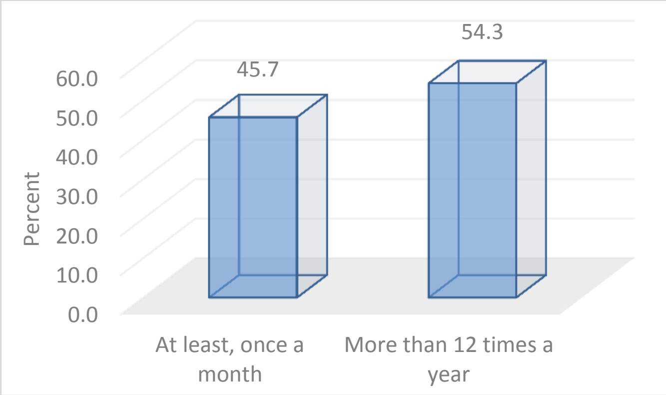
The majority of the respondents (88.6%) indicated that the technology was older than 15 years.

These findings suggest that technology used in the production department is old. According to Nguyen *et al*. (2010:64), most existing industrial plants use old technologies that are relatively inefficient, leading to a higher raw material consumption rate. Di-Norcia (2011) found that as organisations move away from old industrial technologies towards environmentally clean technologies, environmental performance can be reinforced.

The following question related to the frequency of disruptions in production due to problems with technological equipment (Figure 5.7).

Q9: How often are there disruptions in production due to problems with technological equipment?

Figure 5.7: Frequency of disruptions



The results reveal that 54.3% of respondents indicated that disruptions in production due to technological issues occur more than 12 times a year. It can be concluded that regular disruption has a negative impact on the company resulting in financial losses. Literature suggests that regular disruption blocks production capacity and leads to production losses (Arlinghaus and Berger 2002:6).

The next question relates to maintenance cost incurred by the company for technological equipment.

Q10: Approximately how much does the company spend on maintenance cost for technological equipment used in production per annum?

Figure 5.8: Maintenance expenditure

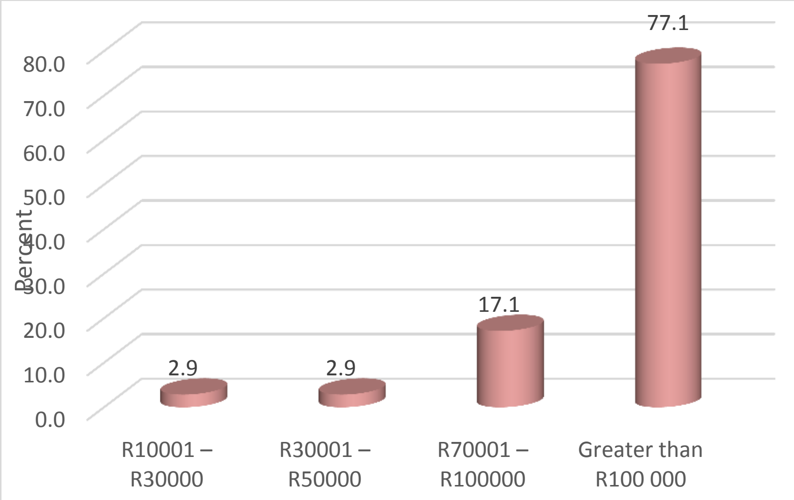


Figure 5.8 shows that 77.1% of respondents indicated that maintenance costs were greater than R100 000. Schaltegger *et al*. (2010:142) highlighted the warning signs of inefficiencies which become evident during the CPA: higher raw materials cost compared to those prescribed by technological standards, higher energy costs, maintenance needs, and higher level of undesired output. Several CP techniques and practices are possible, ranging from low cost or no cost solutions to high investments, and advanced CT.

5.10.7 Correlations

Bivariate correlation was also performed on the (ordinal) data. The results are found in the appendix 5. The results indicate the following patterns:

Positive values indicate a directly proportional relationship between the variables and a negative value indicates an inverse relationship. All significant relationships are indicated by a * or **.

For example, the correlation value for Business factors between "Integrated environmental issues are incorporated into the company's strategic planning process" and "Environmental objectives are linked with the company's corporate goals" is 0.721. This is a directly related proportionality.

Respondents agree that the more integrated environmental issues are incorporated into the company’s strategic planning processes, the more likely the environmental objectives are linked with the company’s corporate goals, and vice versa.

Respondents also agree that the allocation of environmental-related costs to production processes and classification of environmental-related costs results in improvements to environment-related cost management (correlation of 0.880 and 0.978, respectively).

Further analysis shows that assessments of environmental impact issues during capital investment decisions demonstrate greater commitment and awareness of environmental issues by the business managers (positive correlation of 0.748). Input and raw material waste seems to be positively related to poor manufacturing.

Respondents agree that improper use of technologies, are directly related to insufficient operator training and commitment (positive correlation of 0.964). In addition, findings reveal that old technologies used in production indicate management’s resistance to change (positive correlation 0.701).

Negative values, as identified in the correlation results, imply an inverse relationship. That is, the variables have an opposite effect on each other. Analysis on negative coefficients for certain variables was interpreted as follows:

The coefficient between “The fear for business sustainability in the future and its uncertainties” and “Classification of environment-related costs” is -0.664.

This finding indicates that the greater the environmental business costs, the less sustainable businesses may become, and vice versa.

Interestingly, a negative correlation exists between inclusion of environmental information in the present management accounting information system and input and raw material waste. This means that input and raw material waste decreases when environmental issues are incorporated into the company's management accounting system (- 0.656). This trend indicates an inverse relation between environmental management activities practised and input and raw material waste generated. Hence, by incorporating environmental management activities into daily business operations, input and raw material waste generated can be reduced and manufacturing can be improved.

5.10.8 Summarised overview of quantitative findings

Analysis of the results of procedures to measure environmental performance showed that the EMS is a separate and isolated management procedure, mainly used by the environmental manager and environmental administrators. It is separate and detached from general management and, consequently, the EMS has no real management function on an overall organisational level. It is also not linked to the cost accounting system to provide monetary values of environmental impact and environmental costs are not accurately traced back to the products or processes responsible for those costs. Hence, inefficient production processes cannot be identified and considered in strategic decision making. Production costs include NPO costs as environmental aspects are not excluded in financial reporting. This results in understated environmental costs and the overstatement of production costs.

In addition, findings also reveal that not all environmental aspects are quantified, and limited quantified data make it difficult to monitor environmental performance and identify possible environmental improvements.

The objectives in the strategic plan of the organisation correspond to the national environmental quality objectives.

This implies that environmental issues are incorporated into the long-term goals of the organisation which requires a strategic work plan to be implemented and budgeted.

There is a need to increase pressure on business managers to include environmental objectives in the operational planning, which seems to be currently lacking in the company. Operational activities need to be aligned to strategic objectives.

The effectiveness of the company's current system from an environmental point of view is questionable since it is difficult to assess the extent to which environmental objectives are fulfilled.

Environmental objectives in terms of targets and improvement measures are not clearly connected to the strategic objectives and absent from the general management system. Research suggests that even though a company may have well-formulated objectives and suitable indicators measuring progress towards achieving objectives, actual improvements are unlikely to be achieved unless employees are committed and motivated to work towards improving environmental performance (Lundberg 2009:14).

Managers in the company are unaware of the company's progress and performance to environmental objectives due to a lack of feedback and unclear structures.

5.11 Conclusion

In this chapter, the data was presented and the key findings were reported. The findings presented have, in respect of environmental and economic benefits of adopting CP processes and technology in a manufacturing industry, largely been in line with expected findings, as outlined in the literature review. It can be concluded that since there are significant environmental and economic benefits for the company to adopt CPT in the steam production process, the organisation should consider investing in BAT technology in the medium-term. The losses incurred in using their existing technology would not be minimized significantly even if good housekeeping measures were implemented as prescribed to ensure technological standards are met in the short-term. Since the technology used presently is outdated and obsolete, there is not much room for improvement for environmental and economic performance can increase (Christ and Burritt 2013:7).

In the next chapter, the main components of the study will be summarised and the general importance of the research will be established (Shewell 2011:126). Furthermore, possible recommendations to improve environmental and economic performance of the organisation will be proposed by the researcher.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The aim of this study was to use EMA as a tool to identify potential environmental and economic benefits of adopting CP techniques and technologies in a manufacturing company. The objectives of the study were further broken down into sub-objectives as follows:

- To demonstrate the role and importance of EMA in sustainable development and to identify the benefits of adopting CP technologies as compared to end-of-pipe technology based on primary and secondary literature as well as empirical findings;
- To conduct a CPA of the company's current production process to identify operational inefficiencies and to assess the efficiency and environmental impact of current technologies being used in steam generation process;
- To assess the company's current environmental performance;
- To investigate barriers to CP implementation according to management;
- To identify CP options available to management and other stakeholders by demonstrating the potential environmental and economic benefits of cleaner production processes and technologies;
- To benchmark the company's current environmental cost by comparing material balance against technological standards and best-available technology; and
- To make recommendations that will assist the company in their decision-making process.

In the final chapter, the aim of this research is reiterated for the appropriate contextualisation of the entire study (Moodley 2008:89).

The aim and objectives were accomplished in the previous five chapters. This chapter reports on the key recommendations and concluding remarks.

The aim of this chapter is to present a brief overview of the study, present observations and concluding remarks and make recommendations.

6.2 Conclusions

6.2.1 Conclusions from the literature review

For almost two decades now, sustainable development had become a highly prioritised concept worldwide. Excessive waste generated, natural resource depletion and environmental degeneration due to operational activities have led to the implementation of strict laws and regulation, forcing companies to comply and relook at their products and production processes. Since then, ISO 14001, the international standards for environmental management was introduced to provide guidelines to companies on how to protect the environment and improve their environmental performance.

Thereafter, it had been discovered that conventional cost accounting systems were inadequately designed to provide management with comprehensive and accurate environmental cost assessments. Previous researchers had found that managers were unaware of their actual environmental costs and these costs were seen as insignificant due to them being largely underestimated. Proper management of environmental cost was nearly impossible because it was not accurately measured. In order to overcome weaknesses of traditional costing systems, EMA was introduced. An EMA system accurately traces and tracks environmental costs to specific processes and products and provides comprehensive monetary and physical information on environmental costs. This detailed information could be used by managers to make decisions that would improve both the environmental and economic performance of an organisation.

Although this concept was introduced more than 20 years ago, EMA development still remains low in many countries.

This prompted further research to investigate challenges to EMA implementation and also many pilot projects were conducted to promote the benefits of EMA adoption. It had been discovered that managers believed that EMA was costly and needed resources which were not available. Lack of management commitment, absence of legislative requirements and pressure from stakeholders impacted significantly on the implementation of EMA.

Studies adopting EMA reported benefits such as savings on environmental costs, improved competitiveness and company image, savings on resources and improved business performance and much more.

A recent paridgm shift of environmental management from pollution control to pollution prevention led to the introduction of CP techniques and technologies. The emphasis of CP is on reducing waste at its source. CP techniques include low cost strategies, such as good housekeeping to investments involving high capital cost, such as changes in technologies, production processes or input product substitution. Many case studies have been cited in the literature review highlighting the benefits of adopting CP measures. However, in South Africa, CP is still very much in its infancy stage. Research shows that this is the only solution for companies that generate significant waste and consumed a large amount of resources. Waste is a sign of inefficiency, and inefficient production processes impact negatively on a company's profitability and environmental performance. In order to identify which processes are inefficient, there is a need to trace material and energy flows.

MFCA, an EMA tool, traces the flow of material throughout the entire production process, highlighting inefficiencies. The most significant portion of environmental costs was NPO costs. Previous research has shown that MFCA accurately traces the monetary and physical amounts of NPO costs.

It increases the transparency of environmental costs allowing managers to identify saving opportunities by adopting CP techniques or technologies.

This enables them to make informed investment decisions and to assess the benefits of adopting CP techniques or technologies.

CP adoption is also promoted by the new waste legislation. Within the next 5 to 7 years, disposal to landfill of certain wastes such as waste containing carbon will be strictly prohibited. This means that companies will have no choice but to change their production processes or technologies to reduce waste generated. Implementation of proactive environmental strategies and CP is imperative to ensure future sustainability of organisations by improving their economic and environmental performance. CP options were provided in the literature review.

Also, a comparison of end-of-pipe technologies and CP technologies were presented in the literature review.

6.2.2 Conclusions from empirical findings

The aim of this research was not only to identify environmental costs of the production process, but also to highlight scope for potential savings. During initial analysis, the focus was on what the company identified as environmental costs and also what other costs are environmental but concealed in other accounts.

a) *The first objective of this study was to demonstrate the role of EMA in sustainable development and to identify the benefits of adopting CP technologies as compared to end-of-pipe technology based on primary and secondary literature as well as empirical findings.*

A comprehensive review of the literature clearly highlighted the role of EMA in sustainable development and the benefits of adopting CP technologies compared to end-pipe technologies were also presented.

Various theories, approaches and findings on the relationship between EMA, CP, and the impact on environmental and economic performance of the organisation were discussed in detail in the literature review. Therefore, the first objective of the study has been achieved.

b) *The second objective of the study was to conduct a CPA of the company's current production process to identify operational inefficiencies and to assess the efficiency and environmental impact of current technologies being used in steam generation process*

To identify the environmental costs of the steam generation process, a CPA assessment was completed, the details of which are indicated in chapter 5.

The steam generation process revealed that large amounts of boiler ash between 20-60 tons per day are generated from the boilers. An average of 20% of this ash is made up of unburned coal. Hence, this process is inefficient and results in a financial loss to the company and impacts negatively on the environment. The 20% loss of coal becomes waste and needs to be evaluated and deducted from production cost. This was, however, not being done.

In the case study, the boilers used for the generation of steam is more than 40 years old, and are, therefore, considered obsolete, which could lead to inefficient steam production incurring high environmental costs and poor economic performance. CP is not being adopted by the company, although this strategy could improve both the organisation's environmental and economic performance. As a coal fired boiler gets older, the coal used to replace the original fuel is usually poorer in quality: lower in heating value and higher in ash than the original design fuel (Sheldon 2001:5).

Environmental and economic impact

Frequent disruptions are experienced by the company resulting in loss in production.

Losses due to downtime amounted to approximately R439 101.80 according to company records (Appendix 3). Frequent disruptions could be attributed to insufficient maintenance and poor housekeeping measures. Furthermore, the company incurs high maintenance costs for boilers. Managers are, however, unaware of the magnitude of maintenance cost. Schaltegger *et al.* (2010) confirm that these are signs of inefficiencies which become evident during the CPA.

The company has no environmental costs allocated to the steam production process. The only cost incurred according to financial records, are the fixed and variable costs according to production cost schedule. Furthermore, NPO cost was not calculated for the large amounts of unburned coal found in the boiler ash. This generally forms a large proportion of environmental costs and should have been allocated to the steam production process. Instead, the entire purchase value of the coal is indicated as production costs (as per production cost schedule). The company uses a conventional cost accounting system which is inadequate to calculate 'actual environmental' cost. Hence, environmental costs are significantly underestimated. All other environmental costs are hidden under overhead accounts. Similar shortcomings of conventional management accounting practices in environmental cost consideration during internal decision making were reported by Ambe (2007:6).

Therefore, the second object of the study has been achieved.

c) *The third objective of the study was to assess the company's current environmental performance.*

In order to assess the company's current environmental performance, various procedures and policies were investigated. The empirical results were as follows:

Corporate environmental strategy of the organisation and awareness and commitment of managers

The company is ISO14000 accredited and is committed to implementing continuous environmental improvement measures.

According to the results of the survey questionnaire, the company's current environmental performance could be rated as average considering that paper and pulp production is resource intensive and generates a lot of waste. Environmental data is collected by the company. However, not much is said about how well they manage such data and the availability of information also seems to be a hurdle to the effective management of the environment. Environmental data collection is poorly co-ordinated within the company.

Information within the company is fragmented and could not be easily obtained. The company does not have an environmental management accounting component. Consequently, financial criteria, is not taken into account when identifying environmental issues. Environmental costs were accumulated in overheads and these costs were being allocated in a manner that did not necessarily reflect their actual use and waste costs were understated as NPO costs were not considered. Waste costs typically reflected the amount paid to subcontractors to remove the waste. Hence, opportunities for improved financial performance had been overlooked because of inaccurate measurement of environmental costs. Furthermore, the organisation is unaware of the true value of their internal environmental costs of their operational activities. Organised environmental information creation and collection had not been highly prioritised by top management and data on corporate environmental management activities are often not oriented towards clearly defined objectives. Managers view the implementation of information management systems as costly. The general knowledge in the company about different environmental cost and the identification and allocation of environmental costs is limited although the general environmental awareness is good.

Environmental-related activities

Environmental-related costs and estimation of contingent liabilities are considered by the company. However, environmental costs are not systematically traced back to production processes and products.

The following weaknesses in the company's current system in calculating environmental costs were identified:

Costs of waste disposal were not consistently gathered and evaluated and the cost of handling of waste within the organisation was seldom taken into account. The material purchase value, which was included in waste, was theoretically accepted but was never actually calculated. Furthermore, the environmental and technical departments in addition to the financial and cost accounting calculation records carry out recordings of data on amounts and costs of input/output materials, etc. Technical controllers use this data rather than data contained in accounting records.

It is evident from the findings that there are inconsistencies when compared to the accounting figures. Hence, poor communication is evident. It had also been found that environmental and technical managers have insufficient information about the magnitude of operational costs. Only accountants were exposed to this kind of information. Furthermore, comprehensive cost statements for environmental costs were not available. Hence, there is a need for increased awareness of the magnitude of environmental costs, more especially the material purchase value of NPO contained in waste. This information could be used to implement measures to improve material and process efficiency.

Therefore, it can be deduced that the environmental costs reflected in the company records are incorrect as most of the costs that should be included in the cost calculation are omitted. The reason for this is strongly attributed to the conventional accounting system being used by the company.

Perspectives of EMA

Environmental information is reported to external stakeholders. However, this is not being done regularly and comprehensively as an EMA system would do. EMA will serve as a solid foundation for effective implementation of an EMS (Mohr-Swart 2008:118).

Lack of resources had been reported as most challenging in implementing environmental management systems. Difficulty in motivating staff has also been identified as a major challenge. Gil, Andres and Salinas (2007:89) argue that management commitment and awareness of environmental responsibility significantly influence corporate strategy. Sinclair-Desgagne (2004:7) suggests that all business units need to be involved in environmental goal-setting and implementation in order to successfully achieve environmental objectives.

Communication between accounting department and environmental department

The environmental manager is the only individual involved in handling environmental issues and, at times, environmental issues are outsourced to an environmental specialist. Poor inter-departmental communication is evident. There is also no link between systems for collecting financial and non-financial data..

Recent developments in EMA emphasise the greater need for accounting information when making decisions regarding environmental projects (Qian and Burritt 2008:244).

Hence, the third objective of the study was achieved.

d) *The forth objective of this study was to investigate barriers to CP implementation according to management.*

Barriers to the adoption of CPT by the company are: high initial capital cost has been identified as the major barrier to adopting CP technologies, followed by additional infrastructure requirement. It is also clearly evident that managers perceive that organisations experience poor financial performance by investing in CP technologies. Relaxed regulation and law enforcement are also contributing factors to the lack of adoption of CP technologies by companies in South Africa.

Therefore, objective four of the study has been achieved.

e) *The fifth objective of the study was to identify CP options available to management and other stakeholders by demonstrating the potential environmental and economic benefits of cleaner production processes and technologies.*

The literature review provided details of CP options available to management and other stakeholders.

Empirical evidence of previous research demonstrating potential environmental and economic benefits of implementing CP techniques and technologies has also been presented in the literature review.

Therefore, it can be concluded that objective five of the study has been accomplished.

f) *The sixth objective of the study was to benchmark the company's current environmental cost by comparing material balance against technological standards and best-available technology.*

CP analysis is the starting point by revealing which raw material streams end up in the final product and which ones are wasted. CP and EMA connect at the phase when current standards are set and reviewed. This approach is relevant for the paper manufacturing industry sector, where production volumes are high and input costs dominate product costs.

Benchmarks used in this case study to compare NPO, was limited to technological standards and BAT standards for boiler technology. Evidence has identified the material purchase value of NPO as the category of EMA that has the potential of largest cost savings, as stated by Jonall (2008:40). Good housekeeping measures of CP focus on getting closer to the technological non-product output costs. Savings of approximately 5 to 10%, by monitoring and controlling raw material consumption, have been reported in previous cases (Schaltegger *et al.* 2010:156).

6.2.3 Environmental and economic benefits achievable through benchmarking

Table 6.1 indicates the possible saving opportunities by benchmarking environmental costs to technological standards and state-of-the-art standards. Calculation of material and energy loss against benchmark standards is shown in appendix 6.

Table 6.1: Saving opportunities by benchmarking environmental costs

BENEFITS	CURRENT STANDARDS	TECHNOLOGICAL STANDARDS	STATE-OF-THE-ART STANDARDS
Non-product output costs	R7 092 365.91	R6 903 360.30	R6 040 428.60
GHG emission reduction		5199 tons	28877 tons
Total production costs of steam (517938 tons)	R94 196 108.09	R92 306 051.98	R83 676 734.98
Savings in disposal costs		R40 000.00	R229 005.61
Saving in coal usage	76 022 tons	74 065 tons	64 742 tons

Table 6.1 clearly shows that there are opportunities to improve the environmental and economic performance of the organisation by ensuring that technological standards are achieved in the short-term and by moving closer to state-of-the art technologies in the medium-term.

The sixth objective of this study has been achieved.

g) *The final objective of this study was to make recommendations that will assist the company in their decision-making process.*

6.3 Recommendations

Results indicate that the current production process is inefficient and has impacted negatively on the company's environmental and economic performance. In light of the new legislation on waste management and increased competition in the industry, the company needs to make informed strategic decisions to ensure the future sustainability of the organisation.

6.3.1 Recommendation 1

The researcher recommends the following measures to improve boiler performance and reduce environmental impact:

6.3.1.1 Benchmarking environmental costs in short-, medium-, and long-terms.

Short-term measures

Investment in CPT is expensive. However, in order to improve environmental and economic performance, the organisation needs to adopt a CP strategy. Therefore, it is advisable that, in the shorter-term, the company must ensure that their current technology is operating efficiently and according to technological standards. In the short-term, waste cannot be totally eliminated and, according to technological specifications, the loss of coal is estimated to be approximately 10%, which is R7 092 366.00. By proper housekeeping and regular maintenance of their current boilers, the company would be able to save R7 092 366 (as expected loss of coal is 10%). Excess carbon present in the waste, indicate poor operational practices. The company would also reduce the cost of disposal of ash to landfill and since disposal of carbon to landfill is prohibited, this would ease off the environmental burden to the company.

Investigation into CPT revealed that, in order to improve operational efficiency and reduce waste generated, the company would have to invest an estimated amount of R5 million per boiler (Edgar 2014). Since there are 4 boilers, the estimated payback calculated in chapter 5 (assuming all 4 boilers are optimised) to upgrade boilers to achieve technological standards is *1.74 years* (calculation done in chapter 5). According to Giglio (2013:34), companies can optimise their existing plants. This is considered as the 'low-hanging fruit' of technologies, because it makes the best possible use of what the company already has. In addition, he argues that organisations can implement low cost best practices to refurbish power plants to make them more efficient. Improved financial performance due to more efficient use of resources as well reduced CO_2 emissions, 12-14% reduction in nitrogen oxide emissions, 15-20% reduction in ammonia consumption, and increased fuel efficiency have been reported by a company located in Baldwin that participated in such a project.

Long-term measures

In the long-term, the company should consider adopting CPT.

Current estimated cost of replacing old boilers, according to Edgar (2014), is approximately R60 million per boiler (total of R240 million investment). This strategic decision will require input from all stakeholders considering the high investment cost.

In the literature review, the researcher has provided various options regarding new boilers available in the market currently.

The UNEP conducted an investigation of the boiler house of a textile company in India, as part of the ACME project. Un-burned coal in ash was identified as a waste stream during CPA analysis. Possible causes of the waste generated were further investigated.

Recommended CP options to reduce unburned coal ash were: conversion to FBC boiler; ensure coal is properly crushed and sieved to achieve optimal coal size; reduce gaps between rods by modifying existing grate, and use of stoker firing to achieve optimal firing rate.

It can, therefore, be concluded that the company can improve both economical and environmental performance by ensuring that technological standards are achieved in the short-term.

Greater savings can, however, be achieved by investing in CPT in the medium- to long-terms. This will result in higher environmental and economic performance, efficient resource consumption and improved competitive advantage being achieved by the company.

6.3.2 Recommendation 2

6.3.2.1 Regulatory and Legislative compliance

Recent legislation on waste management and impact on organisation

During a conference held by EnviroServ at Sun coast in Durban (April 2014), recent legislative changes and impacts thereof on organisations had been discussed. The changes are to be relevant to the company researched in this study. Landfill disposal previously governed by 'minimum requirements' had been amended in August 2013.

The first requirement for any waste is that the company must have it analysed in order to classify the waste so that it could be disposed off to the correct landfill site (EnviroServ April 2014). The company would, therefore, initially incur a cost of approximately between R20 000 to R30 000 to have the ash analysed.

This process could, however, be beneficial to the company as the analysis would reveal the beneficial use for the bottom boiler ash and it could be used in other processes, thereby generating additional revenue for the company. This would also reduce disposal cost by R4 704 000.

Since the government is trying to reduce the amount of waste to landfill, current waste disposal cost is likely to increase significantly in the next 3 years. This strategy is expected to force companies to try and reduce waste at its source and promote CP processes.

According to Schoonraad (EnviroServ 2014), the new legislation states that within the next 5- 10 years, waste to landfill will be prohibited.

Currently waste that contains carbon or any other type of fuel or energy that could be a useful by-product is strictly prohibited from landfill disposal. Hence, the bottom boiler ash contains approximately 20% unburned carbon and is, therefore, not legally permitted to be disposed to landfill sites. Therefore, it can be concluded that, based on current legislation and loss of raw material used in the steam production process, management needs to implement strategies to reduce bottom boiler ash produced and invest in CT in the long-term in order to ensure the future sustainability of the company.

In light of the above regulations, the company will have to have their bottom boiler ash analysed and classified. However, this is not optional as bottom boiler ash can be both hazardous and non-hazardous. Classification of the waste would be necessary to ensure that disposal is legal and meets legislative requirements. They would further have to identify a use for the carbon in the boiler ash as they would not be allowed to dispose of the ash to landfill in the near future. It has been estimated that, although the purchase price of the coal may be around R450 per ton, disposal to landfill will cost around R3 000 per ton, almost 7 times more.

6.3.3 Recommendation 3

6.3.3.1 To adopt an EMA system rather than a conventional accounting system

An improvement of the current accounting system by adopting an EMA has been suggested as this will bring about environmental benefits and ensure environmental reporting according to legislative requirements by focusing on both physical and monetary environmental cost information. Reduction of material and energy loss values is necessary to improve environmental and economic performance. Increased transparency of environmental costs and greater accuracy in calculating these costs are needed.

A general recommendation for the improvement of the data collection of environmental costs and material flow costs is also suggested. Written procedures must be developed for distribution of costs to the correct cost categories.

In addition, costs allocated for personnel expenses of the environmental team and costs incurred for environmental communication must be clearly and uniformly recorded (Cost categories of an EMA system is provided in appendix 7).

6.3.4 Recommendation 4

6.3.4.1 Use of MFCA, a tool of EMA, to benchmark environmental cost

Use of MFCA, a tool of EMA, to benchmark environmental cost against technological standards and state-of-the-art technological standards to make investment decisions

It is suggested that information regarding material input/output and non-product of different production processes must be calculated and monetary values of NPO must be established.

This information must be supplied to the cost and management accountant, who must use the MFCA model to highlight what amounts were used in production and should actually form part of production costs and what amounts of NPO should be allocated to environmental cost as wasted raw material. This model will identify areas where excess loss is incurred due to inefficient production processes.

Having being ISO14000 accredited means that the company needs to adopt continuous improvement measures, one of which is by replacing old, obsolete technologies with CP technologies. This strategic decision will eventually lead to significant savings for the company due to resource efficiency. Environmental and economic performance will most definitely improve should the company decide to invest in CP technologies. In order for an EMA system to function properly, communication between the various departments is essential.

The environmental team needs to work together regularly to ensure that accurate information regarding production, costing and environmental costs are reflected on the system. A framework is provided later in the chapter which could be used by the company. However, it would be advisable to get an EMAS specialist to integrate the company’s current system with a recommended EMA system designed especially to meet the needs of the organisation.

This will facilitate the change and the company would also be able to provide training and guidelines to those using the system on how to actually use the system correctly. Key information and amounts required by the managers to prepare management accounts and make investment decision regarding CP technologies could also be easily accessible by the system.

6.3.5 Recommendation 5

6.3.5.1 Application of MFCA model as a tool of EMA to allow the company to identify saving opportunities

Application of MFCA model as a tool of EMA to allow the company to identify saving opportunities by implementing CP and assess environmental and economic benefits of such a system

It has been suggested the company make use of the MFCA model that was initially developed for the tourism industry in Japan. This model is found to be effective in benchmarking non-product out-put costs and highlighting inefficiencies in current production processes which were generally hidden when traditional accounting systems were used. This resulted in incorrect decision making as ‘true environmental’ costs were understated. To highlight the effectiveness of this model, the researcher used the company current data on steam generation process and restated this information using the MFCA model. Calculation of material loss was done using data from the production cost schedule of the company for the year ending September 2013 and applying the MFCA approach.

Calculation as follows:

Material loss using current boilers (approximately 20 percent loss of coal)

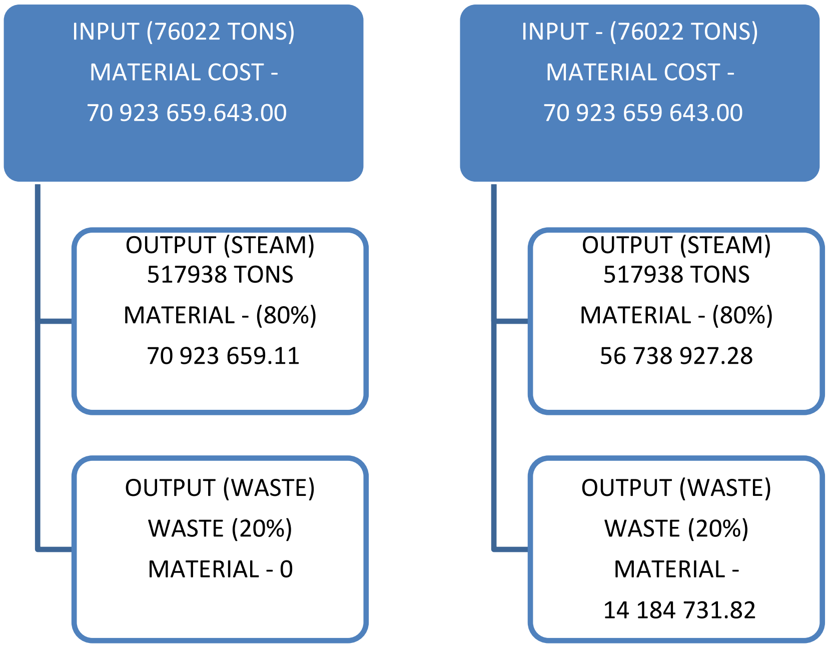
= R14 184 731.82

Material loss using state-of-the-art boilers (standard loss 10 percent of coal) = R7 092 365.91

Material purchase price of non-product output = R7 092 365.91

Figure 6.1: MFCA model

Conventional Accounting system and Material Flow Cost Accounting (Ministry of Economy, Trade and Industry of Japan (METI) 2007) - *Indicating loss of material (coal) based on current technological standards (data used as per production cost schedule of company for year ending September 2013).*



Source: Self-generated

Figure 6.1shows that the material purchase value is the most significant cost of steam production. Loss of approximately 20 percent of carbon found in bottom boiler ash being disposed-off by the company is valued at R14 184 731.82. According to technological standards, this loss should have been 10 percent. Hence, 10 percent loss is due to technological inefficiency. Therefore, R7 092 365.91 is controllable in the short-term.

This savings in material cost is possible if technological standards were maintained. Benefits of adopting the MFCA model as well as empirical evidence are discussed in detail in the literature review.

6.4 Recommendations for further research

Further research on how to improve environmental and economic performance, by adopting clean coal technologies so that no waste is generated in steam production in the future is recommended. It is suggested that the before and after data on resource use be assessed in companies implementing clean coal technologies to identify actual levels of environmental and economic performance.

6.5 Conclusion

This chapter presented a brief overview of the study, as well as the observations made on the empirical study. The study confirmed that the steam production process is inefficient and this has impacted negatively on the company's environmental and economic performance.

Current accounting practices for managing environmental costs, suggestions to improve current practices, and barriers to EMA adoption were discussed in this chapter. The results and findings were based on the analysis and interpretation of the data collected from interviewees and questionnaire responses.

The general observations deducted from the analysis of the data are that waste in the form of boiler ash is a loss to the company, since approximately 20 percent of materials are lost in the process. Moreover, environmental costs are underestimated as conventional accounting systems are used instead of an EMS. Hence, environmental cost was underestimated and not properly traced and allocated to particular processes and products. The MFCA model made it possible for management to identify the quantity and monetary value material losses in order to use this information to inform strategic decisions about investing in CP technologies in the future.

They were able to see the possible savings as well as environmental and economic benefits of adopting CP technologies and techniques in production processes.

Benchmarks were provided in order to assess the company's current environmental performance against technological standards and state-of-the-art technologies in order to find ways in order to achieve superior performance.

Controllability of environmental costs in the short-and medium-terms by implementing certain measures was also brought to the attention of management.

Conclusions were drawn and recommendations were made on how to reduce environmental cost of the steam process and achieve competitive advantage.

It is extremely important that environmental protection must not be regarded as a nuisance by the organisation, but that the significant saving potential which can improve both environmental and economic performance does not remain concealed.

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APPENDIX 1

SEMI-STRUCTURED INTERVIEW QUESTIONS

PERSONS INTERVIEWED WILL BE THE

ENVIRONMENTAL MANAGER AND THE COST AND MANAGEMENT ACCOUNTANT OF THE PAPER MANUFACTURING COMPANY

‘A chemical engineer as his profession and holding an environmental management position at the company, he is well informed about their production processes, environmental issues and the success of their environmental projects. He is, therefore the best person to advise on the contents of the survey questionnaire and to guide the research study process to address issues that are of concern to the company so that, at the conclusion of the study the company will be able to have sufficient, accurate information on CP options/opportunities to facilitate their strategic decision making process, thus improving both their environmental and economic performance. The Cost and Management Accountant is a key personnel of the company and can provide relevant information on the company’s current environmental cost allocation method and the system being used presently allowing the researcher to identify problem areas and make suitable recommendations for improvement’

1. The following questions will used to assess whether the company places emphasis on treatment measures or preventative measures when handling environmental issues.

   1.1 When pollution exists, does the company react to find ways to treat it? How’
   1.2 When the existence of major pollution did occur, what was the time frame? (Example–2009-2012).
   1.3 What are the major pollutions? What costs were involved?
   1.4 If waste exists, is it the strategy of the company to find out its origin and what should be done to prevent it from occurring.

2. Do managers have the ability to see the losses of natural resources as being significant costs included in products? If not, how can they be updated or trained to do so.’

3. The following questions are based on ‘Environment vs. Cost’.
   3.1 Are ‘environmentally sustainable’ issues in processes and procedures carried out by the company to manage and control costs?
   3.2 How is the demand for environmentally conducive solutions by customers impacting on costs?
   3.3 In terms of process re-engineering, what procedures are being implemented to reduce production cycle and impacts of operations on the environment?
   3.4 What biological processes and controls are being employed by the company in running its plants? (Example: making use of all by-products).

4. Are there any internal and external pressures for EMA implementation? If yes, what are the pressures?

5. Are the following information generated by the company?

ROUTINELY GENERATED	AD HOC INFORMATION
• Environmental cost accounting (ABC or variable costing)	• Ex-post assessment of relevant environmental costing decisions
• Material and energy flow accounting	• Environmental life cycle costing
• Environmentally induced capital expenditure and revenues	• Ex-post assessment of short-term environmental impacts
• Monetary environmental operational budgeting	• Post-investment assessment of physical environmental investment appraisal
• Environmental long-term financial planning	• Relevant environmental costing
• Physical environmental budgeting	• Relevant environmental impacts
• Long-term physical environmental planning	• Physical environmental investment appraisal
• Environmental capital impact accounting	• Monetary environmental project investment appraisal

6. Is the company embedding environmental issues into operations? If it is, why is it done? (ISO 14001 and EMAS)
7. What role do management accountants and accounting play in the following environmental initiatives?
    - Accounting participation in EMS-related activities;
    - Day-to-day interactions between environmental units and site accountants;
    - Who are members of the environmental teams?
    - Environmental achievements at the site; and
    - Accounting's role in 'green' management. (energy use, waste management, activity based costing).

8. Is EMA information being generated? If yes, by whom? What is the evidence of EMA?
9. Is EMS information being used by accountants to enhance the benchmarking of costs?
10. Did the EMS provide EMA information?
11. Is sustainability development a priority on the agenda? Motivate.

APPENDIX 2

INPUT/OUTPUT SCHEDULE OF RAW MATERIAL USED AND STEAM GENERATED

Date	Boiler 1		Boiler 2		Boiler 3		Boiler 4	
	Coal (tons)	Steam (tons)	Coal (tons)	Steam (tons)	Coal (tons)	Steam (tons)	Coal (tons)	Steam (tons)
Oct-12	1888	12630	1732	11106	1712	11706	1707	11584
Nov-12	1900	12684	1882	11673	1277	8845	1778	12066
Dec-12	1691	11095	2085	13195	1191	7727	1608	10431
Jan-13	1929	12648	2130	13559	1454	8506	1476	9446
Feb-13	1298	8565	1822	12214	705	4181	1395	9341
Mar-13	1968	13434	1466	9294	427	2031	105	679
Apr-13	1061	7574	1965	11853	1898	13815	998	7092
May-13	2364	16640	248	1694	2152	15359	1855	12790
Jun-13	2191	14916	1740	12291	1415	9956	954	6691
Jul-13	2361	15669	2518	1485	1979	12561	872	5426
Aug-13	2275	13924	2438	31091	1743	10741	1789	10675
Sep-13	1648	11240	2274	15383	1258	7747	1570	9595
Total	22573	151019	22299	144837	17210	113176	16108	105816

APPENDIX 3

Table 5.9: Breakdown of actual downtime of boilers for the year under review

PRODUCTION	PAPER MACHINE	TISSUE MACHINE	PULP MILL	TOTAL
HOURS LOST	4.9	6.5	19	30.4 HRS
PRODUCTION LOST IN TONS	8	3.3	5.4	16.7 TONS
MONETARY LOSS PER TON PER HOUR	R 2 200	R 6 200	R 2 143	R 10 543
ACTUAL TOTAL LOSS IN RANDS PER HOUR	R 17 600	R 20 460	R 11 572.20	R 49 632.20
TOTAL LOSS IN RANDS FOR THE YEAR	R 86 240	R 132 990	R 219871.80	R 439101.80

SOURCE: COMPANY’S DATA RECORDS (2013)

APPENDIX 4

SURVEY QUESTIONNAIRE – USING ENVIRONMENTAL MANAGEMENT ACCOUNTING (EMA) TO ASSESS CLEANER PRODUCTION STRATEGY IMPLEMENTED

1. Indicate the extent to which you agree or disagree with each of the following statements by placing a cross (X) in the appropriate box (1= strongly disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree)

CORPORATE ENVIRONMENTAL STRATEGY OF THE ORGAN ISATION	**1-SD**	**2-D**	**3-N**	**4-A**	**5-SA**
1.1 Integrated environmental issues are incorporated into the company's strategic planning process.					
1.2 Reducing the environmental impact of products and processes forms part of the Total Quality Management (TQM) policy.					
1.3 Environmental objectives are linked with the company's corporate goals.					
1.4 During the development of new products, environmental issues are always considered.					

2. Indicate the extent to which the company is engaged in each of the following environmental related activities by placing a cross (X) in the appropriate box. (1= never done, 2=being done to some extent, 3= neutral, 4=regularly done, 5= always done)

ENVIRONMENTAL RELATED ACTIVITIES	**1= ND**	**2= BD**	**3= N**	**4= RD**	**5= AD**
2.1 Identification of environmental related-costs					
2.2 Estimation of environmental-related contingent liabilities					
2.3 Classification of environment-related costs					
2.4 Allocation of environment-related costs to production processes					
2.5 Improvements to environment-related cost management					
2.6 Allocation to environment-related costs to production products					
2.7 Creation and use of environment-related cost accounts					
2.8 Development and use of environment-related key performance indicators (KPIs)					
2.9 Product life-cycle cost assessment					
2.10 Product impact analysis					
2.11 Product improvement analysis					
2.12 Assessment of potential environmental impacts associated with capital investment decision					

3. Rank the following reasons in order of importance, with 1 being the least important and 5 being the most important.

REASONS FOR THE PROMOTION OF CLEAN PRODUCTION BY INDUSTRIES	RANK NO.
3.1 The fear for business sustainability in the future and its uncertainties.	
3.2 The market pressures for cleaner products and processes.	
3.3 The greater business managers' awareness and commitments to the environmental aspects.	
3.4 Strict legislation and environmental crime law.	
3.5 Many emotional aspects connected with environment and the company's productive activity.	

4. Rank the following causes of pollution or waste generation in the company (1= least important cause and 8= most important cause)

	CAUSE OF POLLUTION/WASTE GENERATION	RANK NO.
4.1	Input and raw material waste	
4.2	Poor manufacturing	
4.3	Improper material handling	
4.4	No suitable maintenance	
4.5	No planning for production, purchasing and sales	
4.6	Improper use of technologies	
4.7	Insufficient operator training and commitment	
4.8	Inadequate input, product and equipment specification	

5. The following represent the five perspectives used to ascertain which elements of Environmental Management Accounting are implemented by the company. Mark those that are appropriate and applicable to your company with a cross (X) (1= totally disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree).

PERSPECTIVES OF ENVIRONMENTAL MANAGEMENT ACCOUNTING					
5.1 Inclusion of environmental information in the present management accounting information system.					
5.2 Availability of formal accounting procedures when dealing with specific environmental issues.					
5.3 Implementing cost-benefit analysis that also takes into consideration any environmental issues when dealing with viability of projects, course of actions.					
5.4 Undertaking environmental impact audits culminating company's activities.					
5.5 Reporting environmental information to external stakeholders.					

6. The following represents annual environment impact and other audit assessments. Please indicate with an (X) next to those that are currently being practiced at the company (Use 1= strongly disagree, 2= disagree, 3=neutral, 4=agree and 5=strongly agree).

Environmental audit assessments	1	2	3	4	5
6.1Safety and security audits.					
6.2 Regular checks on operations.					
6.3 Quality controls checks on water, air and soil.					
6.4 ISO 14000					
6.5 Environmental Impact Assessment reports (EIA).					

7. The following statements represent barriers to the adoption of cleaner technologies by the company. Indicate the extent to which you agree or disagree by placing a cross in the appropriate box. Choose only one option. (Use 1=totally disagree, 2=disagree, 3=neutral, 4=agree and 5=totally agree).

BARRIERS TO ADOPTION OF CLEANER TECHNOLOGIES	1=TD	2=D	3=N	4=A	5=TA
7.1 Relaxed regulation and law enforcement					
7.2 Absence of incentives on economic					

policies					
7.3 Higher initial capital cost					
7.4 Poor financial performance of cleaner technologies					
7.5 Limited in- plant expertise					
7.6 Difficulty to access information on CT					
7.7 Additional infrastructure requirements					
7.8 Higher priorities to production expansion					
7.9 Concern about competitiveness					
7.10 Management resistance to change					

8. How old is the technology used in the company's production department? Place a cross (X) in the appropriate box.

Between 0 – 5 yrs	
Between 6 – 10 yrs	
Between 11-15 yrs	
Older than 15 yrs	

9. How often are there disruptions in production due to problems with technological equipment? Mark a cross (X) in the appropriate box.

Never	
At least, once a month	
More than 12 times a year	

10. Approximately how much does the company spend on maintenance cost for technological equipment used in production per annum? Place a cross (X) next to the answer you feel is appropriate.

R0 - R10000 p.a.	
R10001 – R30000 p. a.	
R30001 – R50000 p. a.	
R50001 – R70000 p. a.	
R70001 – R100000 p. a.	
Greater than R100 000 p.a.	

Thank you for your participation

APPENDIX 5

Correlations

			Integrated environmental issues are incorporated into the company's strategic planning process	Reducing the environmental impact of products and processes forms part of the Total Quality Management (TQM) policy	Environmental objectives are linked with the company's corporate goals	During the development of new products, environmental issues are always considered	Identification of environmental related-costs	Estimation of environmental-related contingent liabilities	Classification of environment-related costs	Allocation of environment-related costs to production processes	Improvements to environment-related cost management	Allocation to environment-related costs to production products	Creation and use of environment-related cost accounts	Development and use of environment-related key performance indicators (KPIs)	Product life cycle cost assessment	Product impact analysis
Spearman's	Integrated environmental issues are incorporated into the company's strategic planning process	Correlation	1.000													
		Sig. (2-tailed)														
		N	35													
	Reducing the environmental impact of products and processes forms part of the Total Quality Management (TQM) policy	Correlation	.749**	1.000												
		Sig. (2-tailed)	.000													
		N	35	35												
	Environmental objectives are linked with the company's corporate goals	Correlation	.721**	.611**	1.000											
		Sig. (2-tailed)	.000	.000												
		N	35	35	35											
	During the development of new products, environmental issues are always considered	Correlation	.581**	.691**	.653**	1.000										
		Sig. (2-tailed)	.000	.000	.000											
		N	35	35	35	35										
	Identification of environmental related-costs	Correlation	.733**	.519**	.588**	.314	1.000									
		Sig. (2-tailed)	.000	.001	.000	.067										
		N	35	35	35	35	35									
	Estimation of environmental-related contingent liabilities	Correlation	.707**	.552**	.510**	.526**	.728**	1.000								
		Sig. (2-tailed)	.000	.001	.002	.001	.000									
		N	35	35	35	35	35	35								
	Classification of environment-related costs	Correlation	.407*	.564**	.534**	.786**	.265	.574**	1.000							
		Sig. (2-tailed)	.015	.000	.001	.000	.125	.000								
		N	35	35	35	35	35	35	35							
	Allocation of environment-related costs to production processes	Correlation	.327	.568**	.463**	.758**	.136	.386*	.912**	1.000						
		Sig. (2-tailed)	.055	.000	.005	.000	.435	.022	.000							
		N	35	35	35	35	35	35	35	35						
	Improvements to environment-related cost management	Correlation	.397*	.484**	.543**	.775**	.254	.576**	.978**	.880**	1.000					
		Sig. (2-tailed)	.018	.003	.001	.000	.141	.000	.000	.000						
		N	35	35	35	35	35	35	35	35	35					
	Allocation to environment-related costs to production products	Correlation	.383*	.616**	.530**	.733**	.213	.468**	.952**	.941**	.902**	1.000				
		Sig. (2-tailed)	.023	.000	.001	.000	.218	.005	.000	.000	.000					
		N	35	35	35	35	35	35	35	35	35	35				
	Creation and use of environment-related cost accounts	Correlation	.474**	.637**	.605**	.746**	.271	.489**	.893**	.870**	.877**	.943**	1.000			
		Sig. (2-tailed)	.004	.000	.000	.000	.115	.003	.000	.000	.000	.000				
		N	35	35	35	35	35	35	35	35	35	35	35			
	Development and use of environment-related key performance indicators (KPIs)	Correlation	.460**	.633**	.578**	.795**	.232	.492**	.902**	.891**	.886**	.929**	.969**	1.000		
		Sig. (2-tailed)	.005	.000	.000	.000	.179	.003	.000	.000	.000	.000	.000			
		N	35	35	35	35	35	35	35	35	35	35	35	35		
	Product life-cycle cost assessment	Correlation	.495**	.727**	.559**	.776**	.368*	.580**	.828**	.798**	.769**	.834**	.822**	.893**	1.000	
		Sig. (2-tailed)	.003	.000	.000	.000	.030	.000	.000	.000	.000	.000	.000	.000		
		N	35	35	35	35	35	35	35	35	35	35	35	35	35	
	Product impact analysis	Correlation	.403*	.561**	.526**	.781**	.272	.558**	.993**	.913**	.970**	.953**	.896**	.900**	.825**	1.000
		Sig. (2-tailed)	.016	.000	.001	.000	.114	.000	.000	.000	.000	.000	.000	.000	.000	
		N	35	35	35	35	35	35	35	35	35	35	35	35	35	35
	Product improvement analysis	Correlation	.349*	.587**	.467**	.747**	.151	.428*	.942**	.945**	.894**	.980**	.928**	.946**	.845**	.948**
		Sig. (2-tailed)	.040	.000	.005	.000	.386	.010	.000	.000	.000	.000	.000	.000	.000	.000
		N	35	35	35	35	35	35	35	35	35	35	35	35	35	35
	Assessment of potential environmental impacts associated with capital investment decision	Correlation	.374*	.613**	.534**	.764**	.212	.450**	.935**	.938**	.883**	.963**	.880**	.921**	.873**	.940**
		Sig. (2-tailed)	.027	.000	.001	.000	.222	.007	.000	.000	.000	.000	.000	.000	.000	.000
		N	35	35	35	35	35	35	35	35	35	35	35	35	35	35
	The fear for business sustainability in the future and its uncertainties	Correlation	.060	-.075	-.200	-.385*	.104	-.195	-.864**	-.619**	-.631**	-.648**	-.497**	-.536**	-.480**	-.653**
		Sig. (2-tailed)	.732	.668	.249	.022	.552	.262	.000	.000	.000	.000	.002	.001	.004	.000
		N	35	35	35	35	35	35	35	35	35	35	35	35	35	35
	The market pressures for cleaner products and processes	Correlation	.098	.184	.002	.195	.099	.227	.191	.088	.188	.080	.081	.061	.077	.178
		Sig. (2-tailed)	.574	.290	.990	.261	.573	.190	.271	.614	.280	.649	.645	.727	.662	.306
		N	35	35	35	35	35	35	35	35	35	35	35	35	35	35
	The greater business managers' awareness and commitments to the environmental aspects	Correlation	.088	.287	.282	.551**	-.051	.260	.756**	.757**	.748**	.781**	.780**	.797**	.645**	.761**
		Sig. (2-tailed)	.615	.094	.100	.001	.771	.131	.000	.000	.000	.000	.000	.000	.000	.000
		N	35	35	35	35	35	35	35	35	35	35	35	35	35	35
	Strict legislation and environmental crime law	Correlation	.206	.480**	.311	.637**	-.072	.210	.716**	.753**	.666**	.763**	.720**	.775**	.653**	.701**
		Sig. (2-tailed)	.236	.004	.069	.000	.680	.225	.000	.000	.000	.000	.000	.000	.000	.000
		N	35	35	35	35	35	35	35	35	35	35	35	35	35	35
	Many emotional aspects connected with environment and the company's productive activity	Correlation	.123	.312	.314	.540**	-.010	.255	.718**	.733**	.711**	.736**	.723**	.749**	.598**	.719**
		Sig. (2-tailed)	.483	.068	.066	.001	.955	.140	.000	.000	.000	.000	.000	.000	.000	.000
		N	35	35	35	35	35	35	35	35	35	35	35	35	35	35
	Input and raw material waste	Correlation	-.199	-.272	-.325	-.379*	-.076	-.214	-.603**	-.658**	-.575**	-.701**	-.650**	-.626**	-.456**	-.623**
		Sig. (2-tailed)	.252	.114	.057	.025	.665	.218	.000	.000	.000	.000	.000	.000	.006	.000
		N	35	35	35	35	35	35	35	35	35	35	35	35	35	35
	Poor manufacturing	Correlation	-.167	-.186	-.068	-.279	.145	.059	-.312	-.413*	-.296	-.402*	-.427*	-.446**	-.203	-.339*
		Sig. (2-tailed)	.338	.284	.699	.104	.405	.737	.068	.014	.084	.017	.011	.007	.241	.046
		N	35	35	35	35	35	35	35	35	35	35	35	35	35	35
	Improper material handling	Correlation	.200	.269	.305	.234	.354*	.415*	.237	.138	.257	.147	.106	.104	.300	.208
		Sig. (2-tailed)	.248	.118	.075	.177	.037	.013	.170	.428	.137	.398	.544	.553	.080	.231
		N	35	35	35	35	35	35	35	35	35	35	35	35	35	35
	No suitable maintenance	Correlation	.052	.119	.191	.139	.209	.297	.215	.115	.233	.129	.092	.105	.313	.183
		Sig. (2-tailed)	.765	.496	.272	.426	.227	.083	.215	.511	.178	.462	.600	.547	.067	.292
		N	35	35	35	35	35	35	35	35	35	35	35	35	35	35
	No planning for production, purchasing and sales	Correlation	.135	.318	.390*	.568**	.152	.446**	.816**	.784**	.831**	.780**	.692**	.720**	.719**	.814**
		Sig. (2-tailed)	.439	.063	.021	.000	.382	.007	.000	.000	.000	.000	.000	.000	.000	.000
		N	35	35	35	35	35	35	35	35	35	35	35	35	35	35
	Improper use of technologies	Correlation	.066	.246	.198	.216	.131	.257	.347*	.319	.320	.316	.157	.171	.331	.307

			Product improvement analysis	Assessment of potential environmental impacts associated with capital investment decision	The fear for business sustainability in the future and its uncertainties	The market pressures for cleaner products and processes	The greater business managers' awareness and commitments to the environmental aspects	Strict legislation and environmental crime law	Many emotional aspects connected with environment and the company's productive activity	Input and raw material waste	Poor manufacturing	Improper material handling	No suitable maintenance	No planning for production, purchasing and sales	Improper use of technologies	Insufficient operator training and commitment	Inadequate input, product and equipment specification	Inclusion of environmental information in the present management accounting information system	Availability of formal accounting procedures when dealing with specific environmental issues	Implementing cost-benefit analysis that also takes into consideration any environmental issues when dealing with viability of projects, course of actions	Undertaking environmental impact audits culminating company's activities	Reporting environmental information to external stakeholders	Safety and security audits
Spearman's	Product improvement analysis	Correlation	1.000																				
		Sig. (2-tailed)																					
		N	35																				
	Assessment of potential environmental impacts associated with capital investment decision	Correlation	.972**	1.000																			
		Sig. (2-tailed)	.000																				
		N	35	35																			
	The fear for business sustainability in the future and its uncertainties	Correlation	-.619**	-.662**	1.000																		
		Sig. (2-tailed)	.000	.000																			
		N	35	35	35																		
	The market pressures for cleaner products and processes	Correlation	.126	.035	.271	1.000																	
		Sig. (2-tailed)	.472	.843	.115																		
		N	35	35	35	35																	
	The greater business managers' awareness and commitments to the environmental aspects	Correlation	.826**	.748**	-.604**	.262	1.000																
		Sig. (2-tailed)	.000	.000	.000	.129																	
		N	35	35	35	35	35																
	Strict legislation and environmental crime law	Correlation	.812**	.777**	-.589**	.161	.844**	1.000															
		Sig. (2-tailed)	.000	.000	.000	.355	.000																
		N	35	35	35	35	35	35															
	Many emotional aspects connected with environment and the company's productive activity	Correlation	.791**	.736**	-.507**	.363*	.928**	.779**	1.000														
		Sig. (2-tailed)	.000	.000	.002	.032	.000	.000															
		N	35	35	35	35	35	35	35														
	Input and raw material waste	Correlation	-.671**	-.668**	.601**	.302	-.447**	-.342*	-.504**	1.000													
		Sig. (2-tailed)	.000	.000	.000	.078	.007	.044	.002														
		N	35	35	35	35	35	35	35	35													
	Poor manufacturing	Correlation	-.465**	-.416*	.235	.288	-.224	-.321	-.289	.723**	1.000												
		Sig. (2-tailed)	.005	.013	.174	.093	.196	.060	.092	.000													
		N	35	35	35	35	35	35	35	35	35												
	Improper material handling	Correlation	.074	.131	-.119	.362*	.191	.147	.134	.341*	.707**	1.000											
		Sig. (2-tailed)	.672	.454	.494	.032	.272	.400	.443	.045	.000												
		N	35	35	35	35	35	35	35	35	35	35											
	No suitable maintenance	Correlation	.067	.129	-.265	.116	.073	-.062	.095	-.003	.339*	.636**	1.000										
		Sig. (2-tailed)	.702	.460	.124	.508	.677	.725	.586	.986	.046	.000											
		N	35	35	35	35	35	35	35	35	35	35	35										
	No planning for production, purchasing and sales	Correlation	.772**	.779**	-.570**	.258	.738**	.535**	.695**	-.415*	.034	.474**	.435**	1.000									
		Sig. (2-tailed)	.000	.000	.000	.135	.000	.001	.000	.013	.848	.004	.009										
		N	35	35	35	35	35	35	35	35	35	35	35	35									
	Improper use of technologies	Correlation	.244	.324	-.363*	.285	.279	.285	.330	.013	.428*	.775**	.635**	.535**	1.000								

	Sig. (2-tailed)	.706	.154	.253	.213	.452	.137	.041	.062	.061	.065	.369	.327	.052	.073	.158	.058	.032	.097	.105	.097	.053	.943	.010	.000	.000	.001									
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35								
Insufficient operator training and commitment	Correlation Coefficient	.278	.471**	.376*	.432**	.262	.443**	.569**	.512**	.538**	.550**	.458**	.455**	.588**	.531**	.468**	.515**	-.337*	.270	.281	.216	.355*	-.339*	.133	.485**	.605**	.652**	.725**	1.000							
	Sig. (2-tailed)	.106	.004	.026	.010	.128	.008	.000	.002	.001	.001	.006	.006	.000	.001	.005	.002	.048	.117	.102	.213	.036	.046	.445	.003	.000	.000	.000								
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35							
Inadequate input, product and equipment specification	Correlation Coefficient	-.050	-.137	.078	-.097	.213	.221	-.046	-.190	.012	-.178	-.156	-.176	-.011	-.071	-.237	-.200	.161	.333	-.167	-.437**	-.145	.307	.672**	.490**	.506**	.284	.355*	.507**	1.000						
	Sig. (2-tailed)	.776	.433	.655	.578	.218	.202	.792	.273	.945	.305	.371	.311	.951	.686	.170	.249	.357	.051	.337	.009	.407	.072	.000	.003	.002	.099	.036	.002							
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35						
Inclusion of environmental information in the present management accounting information system	Correlation Coefficient	.438**	.692**	.498**	.743**	.160	.386*	.851**	.906**	.791**	.938**	.913**	.939**	.833**	.848**	.956**	.934**	-.510**	.046	.737**	.832**	.721**	-.656**	-.545**	.006	-.016	.627**	.204	.440**	-.358*	1.000					
	Sig. (2-tailed)	.009	.000	.002	.000	.358	.022	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.002	.795	.000	.000	.000	.000	.001	.973	.925	.000	.241	.008	.035						
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35					
Availability of formal accounting procedures when dealing with specific environmental issues	Correlation Coefficient	.676**	.865**	.698**	.672**	.549**	.525**	.640**	.666**	.581**	.728**	.774**	.759**	.806**	.650**	.696**	.734**	-.189	-.025	.405*	.511**	.381*	-.383*	-.237	.269	.176	.468**	.249	.432**	-.130	.776**	1.000				
	Sig. (2-tailed)	.000	.000	.000	.000	.001	.001	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.276	.888	.016	.002	.024	.023	.170	.118	.312	.005	.149	.010	.457	.000					
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35				
Implementing cost-benefit analysis that also takes into consideration any environmental issues when dealing with viability of projects, course of	Correlation Coefficient	.442**	.678**	.472**	.754**	.166	.393*	.826**	.874**	.789**	.899**	.923**	.957**	.870**	.836**	.935**	.894**	-.422*	.071	.759**	.791**	.715**	-.584**	-.511**	.039	.031	.654**	.147	.414*	-.298	.964**	.783**	1.000			
	Sig. (2-tailed)	.008	.000	.004	.000	.341	.020	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.011	.684	.000	.000	.000	.000	.002	.823	.860	.000	.400	.014	.082	.000	.000				
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35			
Undertaking environmental impact audits culminating company's activities	Correlation Coefficient	.718**	.671**	.608**	.475**	.786**	.692**	.462**	.440**	.453**	.451**	.464**	.454**	.563**	.462**	.390*	.448**	-.017	.065	.149	.148	.179	-.198	.066	.420*	.269	.393*	.266	.404*	.139	.412*	.732**	.421*	1.000		
	Sig. (2-tailed)	.000	.000	.000	.004	.000	.000	.005	.008	.006	.007	.003	.006	.000	.005	.020	.007	.921	.709	.391	.396	.304	.255	.706	.012	.119	.020	.123	.016	.427	.014	.000	.012			
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35		
Reporting environmental information to external stakeholders	Correlation Coefficient	.595**	.791**	.528**	.710**	.481**	.626**	.766**	.732**	.677**	.765**	.680**	.703**	.826**	.755**	.741**	.758**	-.392*	.208	.452**	.559**	.405*	-.370*	-.146	.380*	.274	.589**	.440**	.604**	-.046	.748**	.776**	.718**	.600**	1.000	
	Sig. (2-tailed)	.000	.000	.001	.000	.003	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.020	.230	.006	.000	.016	.028	.403	.024	.112	.000	.008	.000	.792	.000	.000	.000	.000		
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	
Safety and security audits	Correlation Coefficient	.448**	.387*	.486**	.170	.413*	.315	-.004	-.128	.043	-.031	.118	.046	.036	-.033	-.113	-.107	.233	.252	-.096	-.149	-.025	.073	.255	.336*	.255	-.008	.138	.281	.398*	-.059	.223	-.062	.324	.075	1.000
	Sig. (2-tailed)	.007	.022	.003	.329	.014	.066	.984	.463	.808	.859	.501	.795	.839	.853	.518	.540	.177	.143	.583	.392	.885	.678	.140	.048	.139	.965	.429	.102	.018	.738	.198	.722	.058	.667	
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Regular checks on operations	Correlation Coefficient	.464**	.534**	.432**	.136	.430**	.272	-.070	-.151	-.090	-.038	.068	-.005	.069	-.100	-.121	-.112	.330	.274	-.161	-.113	-.096	.174	.319	.368*	.249	-.079	.193	.305	.308	-.020	.325	-.036	.371*	.189	.919**
	Sig. (2-tailed)	.005	.001	.010	.435	.010	.113	.689	.388	.608	.827	.696	.975	.693	.568	.487	.520	.053	.111	.356	.518	.582	.318	.062	.030	.149	.654	.268	.075	.072	.908	.057	.838	.028	.278	.000
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Quality controls checks on water, air and soil	Correlation Coefficient	.485**	.427*	.426*	.209	.479**	.430**	.027	-.129	.061	-.041	.070	.014	.099	-.001	-.132	-.126	.206	.312	-.140	-.184	-.119	.146	.369*	.476**	.349*	.027	.218	.371*	.463**	-.102	.197	-.082	.368*	.206	.934**
	Sig. (2-tailed)	.003	.011	.010	.229	.004	.010	.877	.459	.729	.817	.690	.936	.571	.994	.449	.471	.236	.068	.422	.290	.498	.404	.029	.004	.040	.877	.209	.028	.005	.559	.256	.641	.030	.236	.000
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
ISO	Correlation Coefficient	.460**	.635**	.587**	.665**	.393*	.520**	.691**	.645**	.674**	.649**	.646**	.607**	.617**	.665**	.574**	.597**	-.353*	.323	.419*	.408*	.444**	-.335*	.028	.461**	.403*	.581**	.474**	.694**	.264	.546**	.592**	.506**	.573**	.578**	.468**
	Sig. (2-tailed)	.005	.000	.000	.000	.020	.001	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.037	.058	.012	.015	.008	.049	.872	.005	.016	.000	.004	.000	.126	.001	.000	.002	.000	.000	.005
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Environmental Impact Assessment reports (EIA)	Correlation Coefficient	.508**	.608**	.606**	.717**	.389*	.535**	.638**	.598**	.661**	.559**	.602**	.606**	.565**	.611**	.527**	.544**	-.264	.378*	.428*	.458**	.467**	-.243	-.021	.411*	.263	.514**	.315	.506**	.174	.519**	.526**	.495**	.542**	.494**	.510**
	Sig. (2-tailed)	.002	.000	.000	.000	.021	.001	.000	.000	.000	.000	.000	.000	.000	.000	.001	.001	.126	.025	.010	.006	.005	.159	.905	.014	.126	.002	.066	.002	.317	.001	.001	.002	.001	.003	.002
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Relaxed regulation and law enforcement	Correlation Coefficient	.388*	.296	.243	.285	.328	.362*	.121	.057	.205	.015	.125	.132	.153	.113	.021	-.005	.164	.413*	.170	.093	.289	.105	.116	.451**	.393*	.128	.309	.235	.110	.031	.143	.136	.342*	.152	.395*
	Sig. (2-tailed)	.021	.085	.159	.097	.055	.033	.488	.746	.238	.931	.474	.449	.380	.517	.907	.979	.347	.014	.329	.594	.092	.549	.509	.007	.019	.464	.071	.175	.528	.861	.411	.436	.045	.383	.019
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Absence of incentives on economic policies	Correlation Coefficient	.460**	.566**	.566**	.459**	.396*	.458**	.460**	.465**	.464**	.496**	.511**	.461**	.437**	.426*	.415*	.406*	-.194	.349*	.425*	.389*	.507**	-.295	.083	.530**	.389*	.478**	.572**	.649**	.147	.456**	.479**	.423*	.490**	.553**	.514**
	Sig. (2-tailed)	.005	.000	.000	.006	.019	.006	.005	.005	.005	.002	.002	.005	.009	.010	.013	.016	.264	.040	.011	.021	.002	.085	.635	.001	.021	.004	.000	.000	.401	.006	.004	.011	.003	.001	.002
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Higher initial capital cost	Correlation Coefficient	.132	-.114	.030	-.293	.267	.003	-.537**	-.587**	-.488**	-.615**	-.561**	-.561**	-.469**	-.557**	-.676**	-.609**	.487**	.071	-.614**	-.571**	-.497**	.423*	.380*	.267	.146	-.495**	.066	-.096	.259	-.608**	-.294	-.618**	.036	-.322	.392*
	Sig. (2-tailed)	.451	.513	.863	.088	.121	.987	.001	.000	.003	.000	.000	.000	.004	.001	.000	.000	.003	.686	.000	.000	.002	.011	.024	.121	.404	.003	.706	.583	.134	.000	.087	.000	.839	.060	.020
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Poor financial performance of cleaner technologies	Correlation Coefficient	.118	.156	.238	-.019	.208	.071	-.172	-.214	-.151	-.198	-.181	-.206	-.071	-.209	-.286	-.192	.185	.142	-.214	-.132	-.096	.324	.514**	.563**	.382*	-.044	.447**	.330	.379*	-.229	.018	-.243	.204	-.085	.424*
	Sig. (2-tailed)	.498	.372	.168	.915	.231	.683	.324	.217	.388	.254	.297	.236	.686	.229	.096	.269	.288	.415	.217	.448	.583	.057	.002	.000	.023	.804	.007	.053	.025	.187	.919	.160	.240	.629	.011
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Limited in- plant expertise	Correlation Coefficient	-.073	-.069	.039	-.094	.034	.022	-.146	-.213	-.135	-.234	-.330	-.327	-.194	-.205	-.311	-.238	.086	.307	-.222	-.163	-.133	.355*	.572**	.496**	.297	.009	.497**	.358*	.426*	-.314	-.292	-.384*	-.032	-.029	.234
	Sig. (2-tailed)	.676	.696	.826	.590	.846	.899	.401	.219	.439	.177	.053	.055	.264	.237	.069	.169	.624	.073	.199	.348	.445	.037	.000	.002	.083	.958	.002	.034	.011	.066	.088	.023	.854	.871	.176
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Difficulty to access information on CT	Correlation Coefficient	.008	-.052	-.020	-.365*	.125	-.091	-.536**	-.542**	-.514**	-.518**	-.437**	-.509**	-.416*	-.577**	-.599**	-.587**	.591**	.274	-.433**	-.436**	-.350*	.539**	.590**	.392*	.170	-.350*	.239	.098	.437**	-.501**	-.195	-.512**	.024	-.295	.510**
	Sig. (2-tailed)	.963	.769	.908	.031	.476	.601	.001	.001	.002	.001	.009	.002	.013	.000	.000	.000	.000	.111	.009	.009	.039	.001	.000	.020	.328	.039	.166	.575	.009	.002	.261	.002	.890	.086	.002
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Additional infrastructure requirements	Correlation Coefficient	.193	.031	.195	.027	.252	.222	-.070	-.157	.021	-.201	-.201	-.216	-.189	-.107	-.273	-.204	.166	.305	-.229	-.227	-.084	.225	.360*	.575**	.398*	.032	.486**	.317	.410*	-.270	-.103	-.294	.203	-.039	.457**
	Sig. (2-tailed)	.266	.861	.261	.878	.144	.201	.689	.369	.904	.246	.247	.212	.276	.540	.112	.241	.342	.075	.186	.190	.633	.194	.034	.000	.018	.856	.003	.063	.014	.117	.555	.087	.243	.823	.006
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Higher priorities to production expansion	Correlation Coefficient	.175	.370*	.231	.494**	.046	.305	.714**	.721**	.692**	.718**	.579**	.633**	.580**	.697**	.733**	.751**	-.519**	.198	.613**	.664**	.682**	-.464**	-.263	.192	.146	.690**	.498**	.581**	-.090	.705**	.376*	.656**	.187	.557**	-.194
	Sig. (2-tailed)	.313	.029	.183	.003	.794	.074	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.001	.255	.000	.000	.000	.005	.127	.269	.402	.000	.002	.000	.607	.000	.026	.000	.283	.001	.265
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Concern about competitiveness	Correlation Coefficient	.192	.352*	.255	.475**	.054	.339*	.722**	.715**	.699**	.718**	.586**	.641**	.612**	.713**	.747**	.751**	-.479**	.292	.668**	.647**	.742**	-.430**	-.199	.224	.177	.753**	.490**	.578**	-.029	.686**	.365*	.664**	.211	.557**	-.196
	Sig. (2-tailed)	.270	.038	.139	.004	.758	.046	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000	.004	.089	.000	.000	.000	.010	.253	.195	.309	.000	.003	.000	.869	.000	.031	.000	.223	.001	.259
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Management resistance to change	Correlation Coefficient	.090	.214	.178	.435**	.012	.289	.683**	.662**	.691**	.654**	.546**	.601**	.506**	.673**	.687**	.686**	-.473**	.262	.626**	.584**	.699**	-.435**	-.235	.166	.093	.710**	.384*	.486**	-.002	.612**	.247	.588**	.104	.432**	-.197
	Sig. (2-tailed)	.605	.217	.308	.009	.946	.092	.000	.000	.000	.000	.001	.000	.002	.000	.000	.000	.004	.128	.000	.000	.000	.009	.174	.340	.594	.000	.023	.003	.989	.000	.152	.000	.553	.010	.256
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
How old is the technology used in the company's production department?	Correlation Coefficient	.279	.257	.332	.062	.342*	.172	-.125	-.098	-.137	-.089	.003	.034	.204	-.150	-.125	-.072	.164	-.015	-.144	-.116	-.157	.177	.275	.356*	.394*	-.007	.251	.267	.350*	-.025	.330	.001	.233	.186	.416*
	Sig. (2-tailed)	.104	.135	.051	.724	.044	.324	.476	.574	.432	.611	.987	.848	.239	.390	.476	.681	.345	.930	.409	.506	.367	.310	.110	.036	.019	.969	.145	.121	.039	.885	.053	.998	.177	.285	.013
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
How often are there disruptions in production due to problems with technological equipment?	Correlation Coefficient	-.262	-.346*	-.251	-.505**	.025	-.342*	-.641**	-.621**	-.636**	-.622**	-.604**	-.637**	-.505**	-.650**	-.688**	-.604**	.368*	-.414*	-.699**	-.655**	-.644**	.319	.288	-.118	0.000	-.588**	-.121	-.202	.143	-.623**	-.357*	-.633**	-.188	-.522**	-.015
	Sig. (2-tailed)	.129	.042	.146	.002	.888	.044	.000	.000	.000	.000	.000	.000	.002	.000	.000	.000	.030	.013	.000	.000	.000	.061	.094	.500	1.000	.000	.488	.244	.413	.000	.035	.000	.279	.001	.932
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35
Approximately how much does the company spend on maintenance cost for technological equipment used in production per annum?	Correlation Coefficient	.009	-.045	.088	-.241	.135	-.057	-.333	-.372*	-.352*	-.301	-.218	-.274	-.154	-.363*	-.384*	-.364*	.365*	.020	-.408*	-.417*	-.481**	.364*	.440**	.213	.145	-.233	.053	.107	.443**	-.327	-.006	-.330	-.030	-.116	.336*
	Sig. (2-tailed)	.960	.796	.613	.163	.440	.747	.051	.028	.038	.079	.209	.112	.376	.032	.023	.032	.031	.907	.015	.013	.003	.031	.008	.220	.406	.179	.763	.542	.008	.055	.973	.053	.863	.507	.049
	N	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Regular checks on operations	Quality controls checks on water, air and soil	ISO	Environmental Impact Assessment reports (EIA)	Relaxed regulation and law enforcement	Absence of incentives on economic policies	Higher initial capital cost	Poor financial performance of cleaner technologies	Limited in-plant expertise	Difficulty to access information on CT	Additional infrastructure requirements	Higher priorities to production expansion	Concern about competitiveness	Management resistance to change	How old is the technology used in the company's production department ?	How often are there disruptions in production due to problems with technological equipment?	Approximately how much does the company spend on maintenance cost for technological equipment used in production per annum?

1.000																
35																
.887**	1.000															
.000																
35	35															
.435**	.501**	1.000														
.009	.002															
35	35	35														
.419*	.529**	.925**	1.000													
.012	.001	.000														
35	35	35	35													
.332	.476**	.296	.411*	1.000												
.052	.004	.084	.014													
35	35	35	35	35												
.516**	.541**	.609**	.591**	.589**	1.000											
.001	.001	.000	.000	.000												
35	35	35	35	35	35											
.373*	.453**	-.091	-.024	.408*	.096	1.000										
.027	.006	.604	.890	.015	.583											
35	35	35	35	35	35	35										
.482**	.444**	.249	.227	.451**	.442**	.654**	1.000									
.003	.008	.150	.189	.007	.008	.000										
35	35	35	35	35	35	35	35									
.270	.332	.092	.075	.264	.395*	.557**	.763**	1.000								
.117	.052	.598	.669	.125	.019	.001	.000									
35	35	35	35	35	35	35	35	35								
.584**	.504**	.001	-.018	.299	.284	.751**	.746**	.656**	1.000							
.000	.002	.996	.919	.081	.098	.000	.000	.000								
35	35	35	35	35	35	35	35	35	35							
.342*	.507**	.271	.325	.601**	.448**	.747**	.741**	.690**	.632**	1.000						
.044	.002	.116	.057	.000	.007	.000	.000	.000	.000							
35	35	35	35	35	35	35	35	35	35	35						
-.189	-.186	.356*	.318	.154	.480**	-.396*	.079	.181	-.310	.099	1.000					
.278	.286	.036	.063	.378	.004	.019	.654	.298	.070	.571						
35	35	35	35	35	35	35	35	35	35	35	35					
-.184	-.183	.338*	.298	.180	.474**	-.442**	.040	.149	-.332	.044	.965**	1.000				
.289	.292	.047	.082	.300	.004	.008	.819	.392	.051	.803	.000					
35	35	35	35	35	35	35	35	35	35	35	35	35				
-.264	-.205	.281	.284	.121	.388*	-.388*	.030	.150	-.330	.115	.948**	.943**	1.000			
.126	.236	.102	.098	.490	.021	.021	.865	.390	.053	.511	.000	.000				
35	35	35	35	35	35	35	35	35	35	35	35	35	35			
.463**	.420*	.231	.206	.088	.223	.201	.206	.008	.361*	.148	-.239	-.240	-.292	1.000		
.005	.012	.181	.236	.614	.199	.247	.236	.962	.033	.396	.166	.164	.089			
35	35	35	35	35	35	35	35	35	35	35	35	35	35	35		
.047	-.021	-.360*	-.451**	-.114	-.329	.491**	.369*	.270	.440**	.158	-.423*	-.510**	-.452**	.206	1.000	
.791	.903	.034	.007	.513	.054	.003	.029	.116	.008	.363	.011	.002	.006	.236		
35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	
.389*	.346*	.054	-.052	-.274	-.068	.286	.209	.203	.544**	.109	-.454**	-.458**	-.433**	.701**	.434**	1.000
.021	.042	.760	.768	.111	.697	.095	.229	.242	.001	.534	.006	.006	.009	.000	.009	
35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35	35

APPENDIX 6

CALCULATIONS FOR BENCHMARKS

Evaluating Energy as non-product output (energy loss)

Assessment of energy input- the environmentally relevant portion of equipment that converts energy (boiler plants) depends on the portion of lost energy. Since energy is required in most processes of production, it would be reasonable to only consider the transformation and transportation losses (combustion losses). When evaluating avoidable losses, the difference between the current system and state of the art must be assessed since energy losses are not completely avoidable. If there are newer and more efficient technology, available then the difference is environmentally relevant.

Calculation of energy loss in steam production:

Actual steam generated: 76022 tons coal to produce 517938 tons steam

Efficiency level (combustion) = 6.8 (Accounting records of company 2013).

Efficiency level of state-of-the-art boilers = 8 (Jeremy Edgar John Thompson 2014:2).

Steam generated from 76022 tons coal in state-of-the-art boilers 608176 tons steam.

Difference in steam generation - 608176 – 517938 = 90238 tons (Energy loss due to inefficient technology).

Technological standards of boiler efficiency = 1:7 (Technological flow chart)

Monetary value of loss of energy = Total production cost boiler plant/ Tons steam

= R94 196 108.09/517938

= R181.87 per ton of steam

Energy loss 90238 x R181.87 = R16 411 585.06

BENCHMARKS BASED ON TECHNOLOGICAL STANDARDS AND STATE-OF-THE-ART TECHNOLOGY

PERFORMANCE INDICATORS	CURRENT STANDARDS(BASED ON ACCOUNTING RECORDS)	TECHNOLOGICAL STANDARDS	STATE-OF-THE-ART TECHNOLOGICAL STANDARDS
INPUT/OUTPUT RATIO (COAL:STEAM)	1:68	1:7	1:8
STEAM GENERATED IN TONS	517938	517938	517938
COAL USAGE IN TONS	76022	73991	64742

TOTAL MONETARY VALUE OF LOSS IN STEAM GENERATION PROCESS BASED ON TECHNOLOGICAL STANDARDS AND STATE-OF-THE-ART STANDARDS

ACTUAL COAL USED	ACTUAL STEAM GENERATED IN TONS	STEAM GENERATED BASED ON TECHNOLOGICAL STANDARDS	STEAM GENERATED BASED ON STATE-OF-THE-ART STANDARDS	TOTAL COST OF STEAM GENERATION PROCESS IN TONS
76022 TONS	517938	532154	608176	R 181.87 PER TON
LOSS IN HEAT (STEAM) IN TONS		(14216)	(90238)	
LOSS OF STEAM IN MONETARY VALUE @ R181.87 PER TON		R 2 585 463.92 per annum	R 16 411 585.06 per annum	

ESTIMATED SAVING IN TOTAL PRODUCTION COST OF STEAM GENERATION PROCESS BASED ON ABOVE STANDARDS AND REDUCE COAL USAGE:

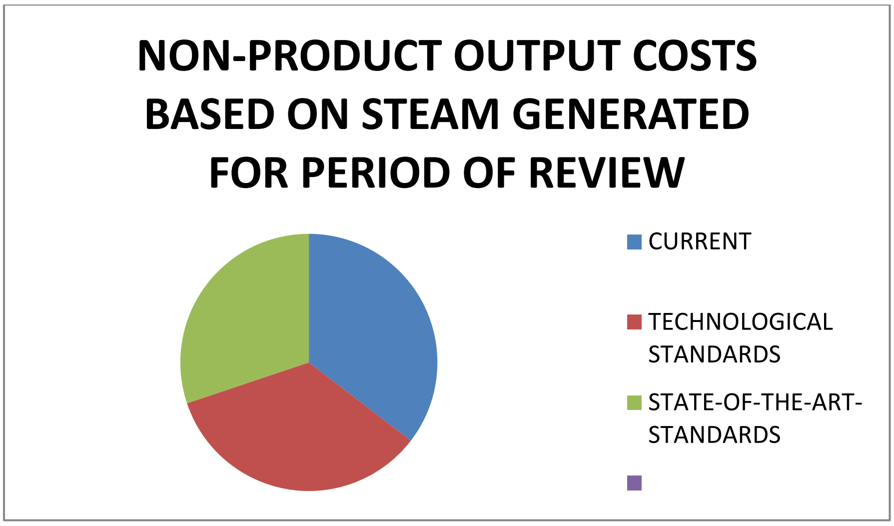
	CURRENT STANDARDS	TECNOLOGICAL STANDARDS	STATE-OF-THE-ART STANDARDS
PRODUCTION COST PER TON OF STEAM	181.87	178.22	161.56
TOTAL PRODUCTION COST	94 196 108.09	92 306 051.98	83 676 734.98

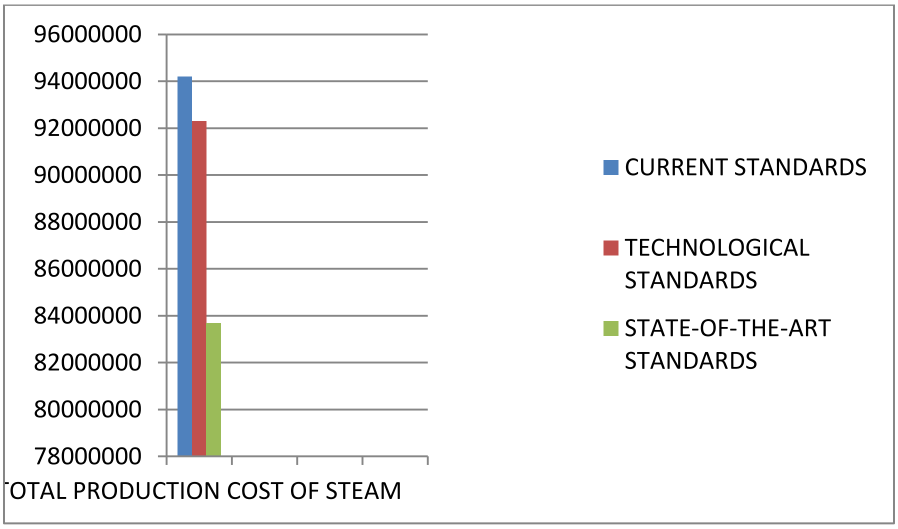
Environmental benefits of reduced coal usage – GHG's @ 2.56 emission level per ton of coal (IPPC)

	TECHNOLOGICAL STANDARDS	STATE-OF-THE-ART STANDARDS
GHG EMISSION REDUCTION	2031 X 2.56 = 5199	11280 X 2.56 = 28877

Saving in total production cost based on above calculation for period under review (estimated):

	TECHNOLOGICAL STANDARDS	STATE-OF-THE-ART STANDARDS
SAVINGS DUE REDUCED RAW MATERIAL (COAL) CONSUMPTION	R 1 890 056.11	10 519 373.11
REDUCED LOSS IN TONS	2031 @ 10% = 203.10 TONS	11280 @ 10% = 1128 TONS
REDUCED NON-PRODUCT OUTPUT VALUE (WASTE) 10 (percent loss of material purchased value loss)	R 69 033 603.00 @ 10% LOSS R 6 903 360.30 – (7 092 365.91) = R 189 005.61	R 60 404 286.00 @ 10% LOSS R 6 040 428.60 – (7 092 365.91) = R 1 051 937.31





SAVING IN DISPOSAL COSTS DUE TO REDUCED RAW MATERIAL WASTE (NON-PRODUCT OUPTUT)

Transportation cost @ R 2000 per 10 ton waste (boiler ash) to landfill:

SAVINGS IN TONS	TECHNOLOGICAL STANDARDS	TOTAL SAVINGS IN ENVIRONMENTAL COSTS
Approximately 200 tons = 20 x 10 ton loads disposed to landfill at a cost of R2000 per load	R40 000 disposal costs	R 189 005.61 + R40 000= R 229 005.61

SAVINGS IN TONS	STATE-OF-THE-ART STANDARDS	TOTAL SAVINGS IN ENVIRONMENTAL COSTS
Approximately 1130 tons = 113x 10 ton loads disposed to landfill at a cost R2000 per load	R 226 000 disposal costs	R 1 051 937.31 + R 226 000= R 1 277 937.31

APPENDIX 7

EMA SYSTEM CATEGORIES

Assignment of environmental costs using an integrated EMA system under the following categories (Jasch and Schnitzer, 2002):

1. Waste and Emission treatment
   - 1.1 Depreciation of related equipment – End-of-pipe equipment and Non-Bat equipment.
   - 1.2 Maintenance and operating materials.
   - 1.3 Related personnel
   - 1.4 Insurance for environmental liabilities
   - 1.5 Fines and penalties
   - 1.6 Fees, taxes and charges
   - 1.7 Provision for clean- up costs.
2. Prevention and environmental management
   - 2.1 External services for environmental management
   - 2.2 Personnel for general environmental management activities
   - 2.3 Research and Development
   - 2.4 Expenditure on IPPC equipment
   - 2.5 Other environmental management costs
3. Material purchase value of non-product output
   - 3.1 Raw material
   - 3.2 Packaging
   - 3.3 Auxiliary materials
   - 3.4 Operating materials
   - 3.5 Energy
   - 3.6 Water
4. Processing costs of non-product output.
5. Environmental Revenues
   - 5.1 Subsidies
   - 5.2 Other earnings (sale of by-product etc.)

The entire environmental costs of the previous year must be reflected under categories stated above. What would become visible are costs related to inefficient production such as wasted material and energy. Material Flow Cost Accounting (MFCA) model presented below will assist in identifying material and energy loss. This is one of the major environmental costs incurred by companies.

The second step after assignment of environmental costs, the company would have to survey the equipment used specifically end-of-pipe technology used to reduce impact of waste generated, example wastewater treatment, waste separation, Integrated pollution control equipment (IPPC) such as boiler plant with flue gas cleaning, and finally Non-Bat equipment, example steam supply with heat loss and old boilers that does conform to the best available technology and produces waste and emission that could be avoided. End-of-pipe equipments are generally very expensive with no immediate payback to the company whereas IPPC equipments are more expensive but they produce less waste and emissions during production.

Operating cost of IPPC equipment can increase or decrease due to higher depreciation costs but also lower material use due to increased efficiency. The depreciation cost of these types of equipment must be reflected as environmental cost.

For Non-Bat equipment, the environmentally relevant portion of the equipment is calculated by the portion of avoidable waste and emissions, example old boiler plants that cause avoidable energy losses requiring higher energy input.

APPENDIX 8

DUT
DURBAN
UNIVERSITY OF
TECHNOLOGY

Institutional Research Ethics Committee
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Durban University of Technology

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http://www.d ut.ac.za/research/i nstitutiona!_research_ethics

www.dut.ac.za

10 December 2013

IREC Reference Number: REC 74/13

Mrs M Doorasamy
P O Box 24215
Broadlands
Mount Edgecombe

Dear Mrs Doorasamy

Using Environmental Management Accounting to investigate benefits of cleaner production at a paper manufacturing company in Kwadakuza, KwaZulu-Natal: a case study

I am pleased to inform you that Full Approval has been granted to your proposal REC 74/13.

The Proposal has been allocated the following Ethical Clearance number IREC 098/13. Please use this number in all communication with this office.

Approval has been granted for a period of one year, before the expiry of which you are required to apply for safety monitoring and annual recertification. Please use the Safety Monitoring and Annual Recertification Report form which can be found in the Standard Operating Procedures [SOP's] of the IREC. This form must be submitted to the IREC at least 3 months before the ethics approval for the study expires.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC SOP's. In addition, you will be responsible to ensure gatekeeper permission.

Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Please note that you may continue with validity testing and piloting of the questionnaire. Research on the proposed project may not proceed untiiiREC reviews and approves the final questionnaire. If there are no changes to the questionnaire kindly notify IREC in writing.

Yours Sincerely

[redacted]

Prof J K Adam
Chairperson: IREC