“Identifying environmental and economic benefits of cleaner production in a manufacturing company: a case study of a paper and pulp manufacturing company in KwaZulu-Natal”

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Abstract

The purpose of this paper is to demonstrate how companies could improve their environmental performance by adopting cleaner production technologies (CPT) and techniques. The methodology used in this research was a case study. This study involved both qualitative and quantitative research methods. The study was based on the steam production process using coal-fired boilers in a paper manufacturing company in KwaZulu-Natal. The study found that the company would save on input resources and reduce the amount of waste generated by adopting CPT. Environmental management accounting (EMA) supports CP strategies by effectively providing information for the optimization of products and production systems.

Keywords: environmental management accounting (EMA), cleaner production (CP), cleaner production technology (CPT), innovations.
JEL Classification: O32.

Introduction

Continual expansion of industrial production and higher levels of energy and material consumption has resulted in serious environment degradation. Hence, there is an increased need for sustainable development and the capacity to continue in the long term (Pandey and Brent, 2008). National produces have placed greater emphasis on the manufacturing costs of their products in their accelerated search for competitiveness and generation of positive margins. Many organizations when analyzing the cost spreadsheets are astonished by the so called “environmental cost” (Foelkel, 2007). Therefore the need for reducing energy and material inputs per unit of output is crucial for a company to achieve sustainable competitive advantage (Schaltegger et al., 2010).

Environmental costs traditionally understood as those costs incurred to analyze, treat, dispose and control waste waters air emissions and solid wastes generated by the industrial activity (Foelkel 2007). However, stringent environmental legislation and market pressures have raised questions by managers as to whether their present technologies and products will be acceptable in the future or not and to find new opportunities according to sustainable development requirements (Radonjic` and Tominc, 2007).

Organization with very advanced management systems seldom monitor the efficiency of energy usage and material flows of their processes and therefore have difficulty to effectively manage their resources efficiently. CP is being implemented globally and in South Africa as an environmental and productivity oriented initiative (Pandey and Brent, 2008). Senior managers are reluctant to adopt CP, as they perceived it to be a risky strategy and are resistant to devote their resources of CP implementation due to lack of verified information on the real benefits of CP (Schaltegger et al., 2010).

EMA is a tool used by organizations to manage environmental costs identifying potential cost, savings, hence improving both environmental and financial performance through enhanced accounting (Schaltegger et al., 2010). In addition, EMA is used to provide information about materials and energy flows and their monetary effects as well, which will be needed by management for planning and assessing more efficient CP options for the company.

Significance of the study. Paper is a key component of a South Africa’s natural economy as well as an essential commodity of today’s society. The pulp and paper industry is a major source of pollution to the environment due to the very nature of its operational practices/activities. Small scarce mills which are popular in developing countries like South Africa usually cause high levels of environmental pollution because of outdated technologies, poor operation and maintenance practices.

The creation of a more sustainable means of production requires a shift in attitude towards convenient waste management practices by moving away from control towards prevention (Avsar & Demirer, 2008).

Local industries and government are slack in enforcing regulations and companies get away with environmentally damaging practices. Lack of available capital to invest also affects the ability to implement CP projects. There is a clear trend of the role of new technologies and its importance globally. However in South Africa there is a lack of technological sophistication which inhibits the adoption of CP. The level of clean technology investments differ substantially among industries in South Africa (Fore and Mbohwu, 2010).

Cleaner production (CP) can be described as a preventative, integrated strategy in which costly end-of-pipe technology control systems are replaced by measure which reduce and avoid pollution and waste throughout the entire production cycle, through efficient use of raw materials, energy and water. Sustainability and efficiency are in line with CP. Research projects and action plans have been adopted to improve the development of environmental technologies and to overcome some of the barriers of clean production. However, companies seem to view CP concept with sceptism.

1. Aim and objectives

1.1. Aim. The aim of this study is to demonstrate that a company can improve their environmental performance by adopting cleaner production techniques and technologies.

1.2. Objective. Emanating from the aim, this study has the following objectives:

- To conduct a cleaner production assessment (CPA) of the companies steam production process using current boilers using technological flow chart analysis in order to identify any inefficiencies in the process. Is the input/output ratio of coal used and steam generated according to technological standards?
- Identify the role and importance of EMA as an environmental management tool to support CP strategies.
- Assess their current environmental performance against technological standards.
- To make recommendations to management on measures that could be implemented to save on resource input and reduce waste generated (unburned coal in boiler ash).

1.3. Definition and theoretical framework of cleaner production. In order to achieve sustainable competitive advantage, businesses need to adopt cleaner production processes. According to the United Nations Environmental program (UNEP), cleaner production (CP) is defined as 'the continuous application of an integrated preventative environmental strategy to processes, products and services to increase overall efficiency and reduce the risk to humans and the environment (Fore and Mbohwu, 2010).

Although a growing number of organizations in both manufacturing and service sectors demonstrated the potential to successfully reduce the operating costs as well as environmental impacts at the same time, the implementation of CP has been slow and lagging. Pilot studies by CP experts remain merely as niche examples and decision makers in companies have failed to adopt this as a corporate strategy. It has been identified that there is clearly a shortcoming in the discrimination of information about the economic and environmental potential of CP (Schaltegger, 2010).

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). Higher energy and raw material prices are causing cleaner production to grow in relevance and importance.

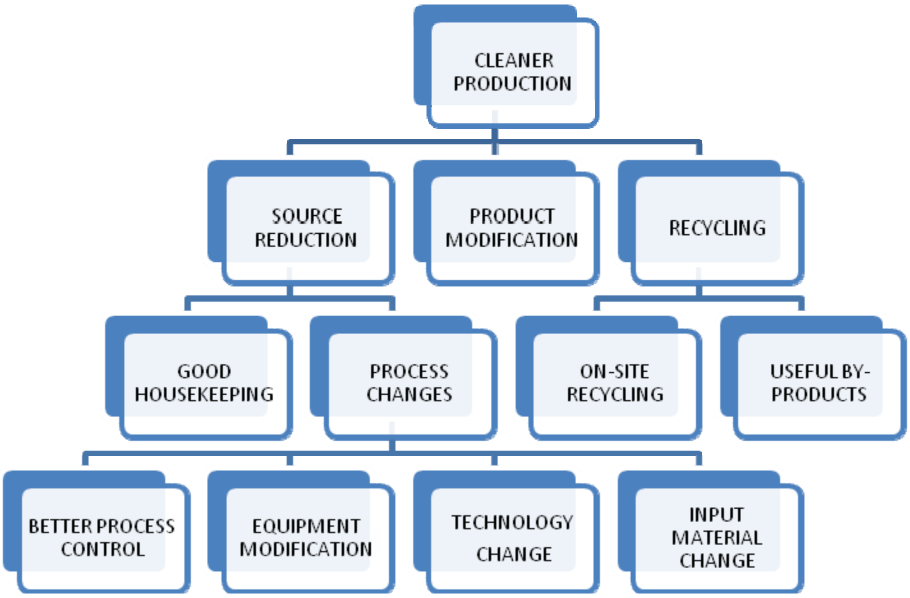
Cleaner production (CP) focuses on improved productivity and reduced impact as the result of design over the life of products, processes and services (National cleaner production strategy, 2004: Lakhani, 2007). The amount of waste to landfill is increasing steadily.

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 et al., 2010). 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). 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.

Nabais (2011) 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.

Figure 1 indicates general CP techniques and their main relations.



Source: Nabais (2011).

Fig. 1. CP techniques

Figure 1 represents the different CP techniques which can be implemented by organizations 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 utilization can minimization of waste and emission be obtained (Fore and Mbohwa, 2010).

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

1.4. The role and importance of environmental management accounting (EMA) in cleaner production (CP). The United Nations development program, as part of the Department of sustainable Development, reports EMA as an important management tool for businesses to adopt whilst responding to environmental challenges and still focusing on the triple bottom line (Ambe, 2007). They (UNEP) have embarked on several activities to educate and encourage companies of the benefits of using EMA.

Following these international developments, South African companies have considered environmental issues in their decision making processes regarding products and processes. 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 (Ferreira et al., 2010; Christ and Burritt, 2013; and Ambe, 2007).

A study conducted by Jonall (2008) by reviewing, articles in academic journals revealed that the EMA method identified material purchase value of non-product output costs to be the largest cost category. It was concluded that EMA can support decision making in a company towards improved environmental performance through structured costs assessments, more effective product mixes, strategies and investments.

Scavone (2006) states that by adopting an EMA system, a company can develop proactive, environmental programs 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.

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

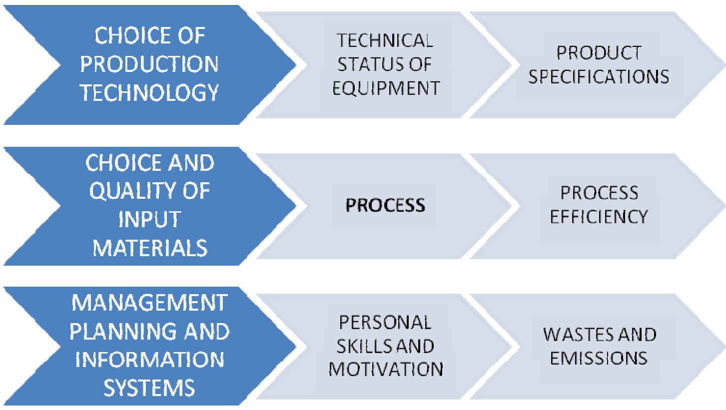
It was found that EMA has made a positive contribution to the enhancement of CPA and EMS projects by increasing awareness of the economic implications of the environmental impact of non-product output and costs and provided a systematic method of controlling these costs in the short-, medium- and long- terms. EMA also helped to quantify monetary benefits of adopting alternative CP options.

The benefits of using environmental management accounting (EMA) in practice as an environmental and sustainability tool to collect, evaluate and interpret the information needed to estimate the potential for cleaner production saving with particular emphasis on non-product output costs and to make decisions to choose the right CP options have been established in several business cases. 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 a production process and benchmarking environmental costs to yield superior environmental and economic performance (Ferreira et al., 2010; Burritt et al., 2009; Christ and Burritt, 2013; Schaltegger et al., 2010; Thant and Charmondusit, 2010; Chiu and Leung, 2002; V'an, 2012).

1.5. 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 United Nations Industrial Development Organization (UNIDO) developed the following basic steps to conduct CPA (Fore and Mbohwa, 2010):

- planning and organizing the CPA;
- pre-assessment (gathering qualitative data about the organization and its activities);
- assessment (gathering quantitative information about the organization 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.

The Institute of Environmental Engineering (APINI) and the UNEP identified possible causes of waste generation, as demonstrated by the Figure 2.



Source: Introduction to cleaner production concepts and practices (APINI AND UNEP, n.d.).

Fig. 2. Causes of waste generation

Figure 2 highlights the causes of waste generated which companies need to consider when conducting a CPA.

CPA 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., 2001).

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) 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).

2. Research methodology

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 (Zikmund, 2004). The research was a census study. Managers involved in environmental management issues, production, operations, accounting and cost control were used to collect data.

Both primary and secondary sources were used to collect information for the purpose of this study. A systematic observation and review of company records, a questionnaire and interviews were used to collect data.

It was suggested by Yin (2009) that the triangulation approach to data collection enhances accuracy and increases confidence in research data and establishes validity.

The data collected from the responses were analyzed with SPSS version 22.0. Inferential techniques included the use of correlations and chi-square test values; which are interpreted using the p-values.

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. Hence, it would seem that the case study is reliable (Quinlan, 2011). Reliability of the case study was established by using multiple sources of evidence. Therefore, the findings of this case study, are considered to be more accurate and convincing.

Secondary data used in the study were 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).

An investigation into the production of steam using coal was conducted and quantitative data analysis for the period under review (October 2012 to September 2013), was based specifically on this process.

Research process undertaken to achieve objective of the study was as follows:

1. CP analysis will be the starting point by which identification of which raw material streams end up in the final products and which are washed.
2. A material flow cost analysis as a tool of EMA will be used to assess and quantify the amount of non-product output during the process of steam production.
3. Using technological flow charts to benchmark non-product output costs.
4. To value non-product output cost coal that did not form part of the final product but is generated as waste was evaluated. This waste was valued at materials purchase value. In the case study solid waste will be the unburned coal generated from the steam production process. Hence this waste needed to be accurately quantified and a money value needed to be established/assessed for this loss.
5. EMA was used to identify costs savings for the company and to support managers in their selection of CP measures and in planning investments in cleaner technologies.

2.1. Discussion of findings. *2.1.1. The first step in the process involves a CPA of the steam-generation process.* The CP assessment framework was used to capture data during the CP audit process as per the CP model. Analysis of the process flow charts show 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.

2.1.2. Findings. 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. It had been found that this process currently generates approximately 20 to 60 tons of the unburned coal ash clearly from the baler. This represents solid wastes in the form unburned coal which has a negative environmental impact. Coal generates the highest of CO_2 and creates highest amount of pollution than any other fossil fuel. Thus it is of major significance to not allow the organization but also towards the literature of cleaner production assessment projects in KwaZulu-Natal.

Data from the input/output schedule 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.

Table 1. Input and output schedule of the steam production process

Boiler 1		Boiler 2		Boiler 3		Boiler 4	
Coal (tons)	Steam (tons)	Coal (tons)	Steam (tons)	Coal (tons)	Steam (tons)	Coal (tons)	Steam (tons)
22573	151019	22299	144837	17210	113176	16108	105816

According to technological standards of the company's current boiler technology, the standards coal and steam input/output ratio generated is 1:7. However, the input/output schedule 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.

In comparison to test standard 1:7 (technological standards as identified by technical flowchart) the following one-sample statistics were found. 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.

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

Table 2. One-sample statistics

(tons)	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

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. 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.

2.1.3. Causes of waste generated during steam production process. 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.

The information above indicates that the three of the four boilers are functioning well below test standards of 1:7. 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.

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.

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 and fill (transportation and handling cost of waste); and
- loss of raw material (coal) due to inefficient processing (calculated using material flow cost accounting method, which is a tool of EMA).

Note: Gross production of steam for the period under review was 517938.000 tons per year.

It should be noted that a negative variance in coal usage for the year end September 2013, resulting in a loss of R1817 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.

2.1.4. Monetary value of non-product output 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).

The researcher discovered that 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 organization. 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.

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.

2.1.5. Costing and upgrading of boilers. An interview was conducted with the sales manager of John Thompson Boilers in Durban. 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.

2.1.6. The non-product output value and loss incurred through technological inefficiency. Table 3 illustrates the total cost of steam generation process from October 2012 to September 2013.

Table 3. Paired samples test

		Paired differences (tons)					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

Material purchased (coal) – R 70923659.11.

Non-product output (unburned coal in the form of waste –20% loss) = R 14184731.82.

2.1.7. 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 500000 per month, resulting in a total loss estimated to R6 million per annum (Cost accountant, 2014).

2.1.8. Calculation of boiler efficiency is as follows: Input/output efficiency of current technology for the period under review was:

1 ton of coal: 6.3 tons of steam (amounts reflected in the accounting records was used in this calculation).

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

Table 4 shows the loss value in Rand's of excess coal used due to boiler operating below technological standards.

Table 4. Breakdown of total cost in rand and percentages

Total cost breakdown	Annual cost in rands (R)	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).

The study yielded the following results:

2.1.9. 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 (approximately1 year).

Table 5. Calculation of boiler efficiency

Actual steam x 0.143	517938 tons x 0.143 = 74065 tons
Actual coal usage – budgeted coal usage	76022 tons – 74065 tons = 1957 tons excess
Loss in Rand value	1957 tons x R933 perton = R1 825881

The calculation of disposal cost of ash is as follows:

Total cost:

Boiler upgrade = R5 000000.00 per boiler (approximately R20 million)

Total savings:

Material lost (non-product output value based on 20 percent loss of coal during steam generation process) = R14184731.82.

Table 6. 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)	R7092366.00
Loss due to input/output standards below technological standards of 1:7	R1825000.00
Disposal cost	R2352000.00
Cost incurred in hiring of payloader estimated (2hrsaday@R500per hour)	R240000.00
ESTIMATEDTOTOALSAVINGS	R11509366.00 per annum

An estimated saving opportunity of R11509 366.00 (Appendix 1) 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 million per boiler. The 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 million for the four boilers.

Equation to calculate payback period:

Total investment cost/Estimated total savings per annum.

Payback: R20 000000/R11509 366 = 1.74 years.

2.1.9. Results and findings from questionnaire.

Q1 barriers to adoption of cleaner technologies. This section deals with factors that are considered to be barriers to the adoption of cleaner technologies.

Table 7. 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 inplant 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

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 cleaner technologies with agreement levels of 80% and 74.28%, respectively. Interestingly, limited inplant 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 cleaner technologies (Nguyen, Ha-Duong, Tran, Shrestha, and Nadaud, 2010, p. 1).

They also claimed that technological barriers such as the lack of infrastructure and poor technical knowledge and capabilities affected cleaner technology adoption in developing countries.

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

Q2: How old is the technology used in the manufacturing process.

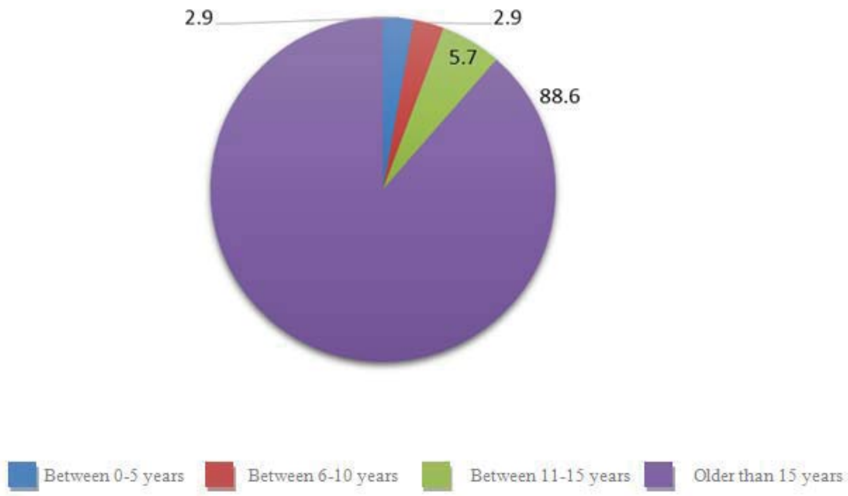


Fig. 3. Age of technology

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, p. 2) 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 organization 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.

Q3: How often are there disruptions in production due to problems with technological equipment?

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, p. 6).

The next question relates to maintenance cost incurred by the company for technological equipment.

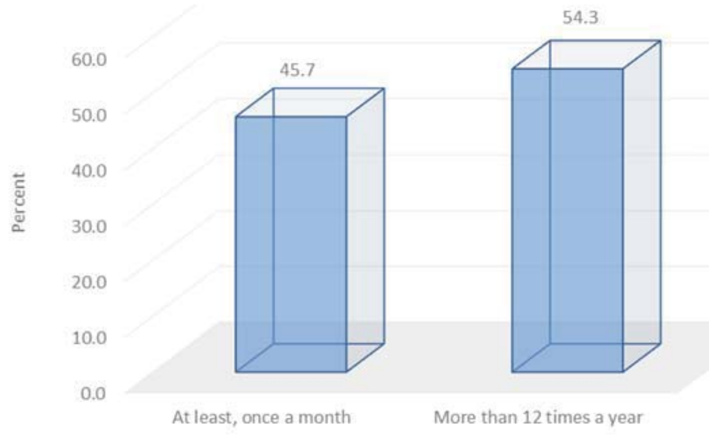


Fig. 4. Frequency of disruptions

Q4: Approximately how much does the company spend on maintenance cost for technological equipment used in production per annum.

Maintenance cost was approximately R1million a year. Schaltegger et al. (2010) 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 clean technologies.

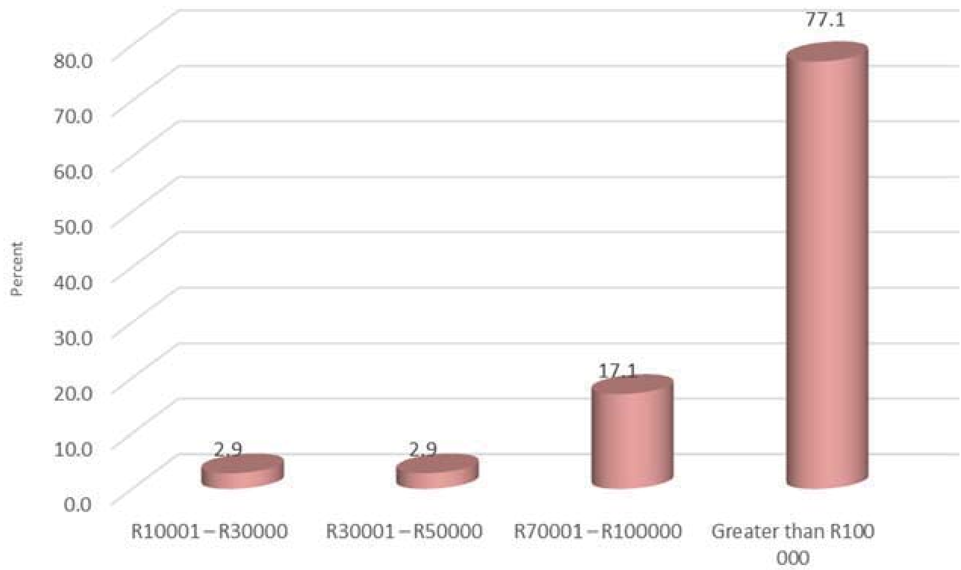


Fig. 5. Maintenance expenditure

2.2. Summarized overview of empirical findings. The steam generation process is inefficient and results in a financial loss to the company impact 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 organization'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, p. 5).

2.2.1. Environmental and economic benefits achievable through benchmarking. Table 8 indicates the possible saving opportunities by benchmarking environmental costs to technological standards.

Table 8. Saving opportunities by benchmarking environmental costs

Benefits	Current standards	Technological standards
Non-product output costs	R7 092 365.91	R6 903 360.30
GHG emission reduction		5199 tons
Total production costs of steam (517938 tons)	R94 196 108.09	R92 306 051.98
Savings in disposal costs		R40 000.00
Saving in coal usage	76 022 tons	74 065 tons

Table 8 clearly shows that there are opportunities to improve the environmental and economic performance of the organization by ensuring that technological standards are achieved in the short-term.

2.3. Recommendations. The researcher recommends the following measures to improve boiler performance and reduce environmental impact:

2.3.1. Benchmarking environmental costs in short-term. **Short-term measures.** Investment in CPT is expensive. However, in order to improve environmental and economic performance, the organization 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 (assuming all 4 boilers are optimized) to upgrade boilers to achieve technological standards is *1.74 years*.

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.

2.3.2. 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.

Conclusion

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 adopt an EMA system to accurately identify environmental costs and make informed decisions regarding the adoption of CP technology. Possible savings and environmental benefits of adopting CP technologies and techniques in production processes were identified using EMA.

Benchmarks were provided in order to assess the company's current environmental performance against technological standards in order to find ways in order to achieve superior performance. Conclusions were drawn and recommendations were made on how to reduce environmental cost of the steam process and achieve competitive advantage.

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