Benchmarking: A Strategy to Improve Environmental Performance by using Material Flow Cost Accounting Emprical Study Based on a Paper Manufacturing Company

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ABSTRACT- ***A growing number of organisations have incorporated environmental strategies as part of their corporate business strategies, hoping to improve their competitiveness.To ensure their future sustainability and competitiveness, management needs to consider adopting Cleaner Production (CP) techniques and technologies which will address waste issues at its source and ensure more efficient use of resources. However, management is not keen on this strategy as they perceive CP as a costly strategy that requires innovation with no financial benefits to the company. The aim of this paper is to benchmark the company's environmental costs by comparing material balance indicators against technological standards and best-available technology. The results are based on a case study which focused on the boiler technology used in the steam generation process. It had been found that benchmarking enabled managers to evaluate and analyse how they can improve both their environmental and economic performance in the future and attain their sustainability targets.***

Keywords--- Environmental Strategies; Benchmarks; Material Balance; Best-Available Technology; Cleaner Production Techniques; Technological Standards; Competiveness; Sustainability.

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1. INTRODUCTION

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. Strategies to reduce dependence and use of energy from fossil fuels needs to be introduced (Stringer, 2010).

Inefficiency in production processes can affect both their profitability and competiveness. It was concluded after a global evaluation of a joint cleaner production programme by UNIDO and UNEP, that cleaner production strategy is still very appropriate for companies in both developed and developing countries (Berkel, 2011).

Most companies are using inefficient processes and technologies that are obsolete, which therefore consume more energy and resources than if they were using state-of-the art processes. This ultimately results in higher production costs which in turn affects their profitability and competitiveness. A direct consequence of these inefficiencies is rapid environmental degeneration, excessive amounts of pollution and waste generation which in turn is hazardous to human health and affects quality of life (Schaltegger*et al*., 2010; Despeisse, Oales and Ball, 2013).

Audits into cleaner production assessments of production centres found that there are large savings potential and opportunities to be enjoyed but companies are not aware of it since there are no monitoring and data collection in place. As the old saying goes, 'what you do not measure you cannot manage'.

The environmental and sustainability accounting tool, Environmental Management Accounting (EMA) gives companies the opportunity to collect, evaluate and interpret the information needed to estimate their potential for cleaner production saving and to make decisions to choose the right CP options (Schaltegger*et al*., 2010).

Companies implementing EMA systems needed to know exactly what they had to gain by using it and its role in CP. The concept of EMA was developed to show accountants how much they can save on environmental costs with particular emphasis on non-product output costs. This was facilitated by making use of material flow analysis, a tool of EMA. By identifying, assessing and allocating environmental and material flow costs, EMA allows managements to identify opportunities for cost saving (Jasch, 2009).

This process can assist in identifying inefficiencies in a production process and benchmark environmental costs to yield superior environmental and economic performance. Private environmental costs lead to higher prices and reduced competitiveness. Therefore there is clearly a trade off between a firms environmental costs and their economic performance (Pons, Bikflavi, Llach and Palcic, 2013).

1.2 Significance of 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). 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 cleaner production 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 cleaner production techniques and technologies as part of the strategy towards sustainable development (Despeisse*et al*., 2013). 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).

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. Accountants and financial managers need to be made aware of the costs associated with unsustainable production processes, that is, *'environmental costs*' (Environmental Sustainability Performance (ESP) Benchmarking, 2013).

Managers are more focused on cost-reduction options using existing technology. Cleaner technologies are more efficient as they prevent emissions at 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, disposal to landfill sites. These approaches are costly and inefficient (Jasch, 2009). 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 cleaner production 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 and Csutara, 2012).

This study will add to the body of knowledge on cleaner production 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 by implementing the benchmarking strategy.

1.3 Theoretical Background

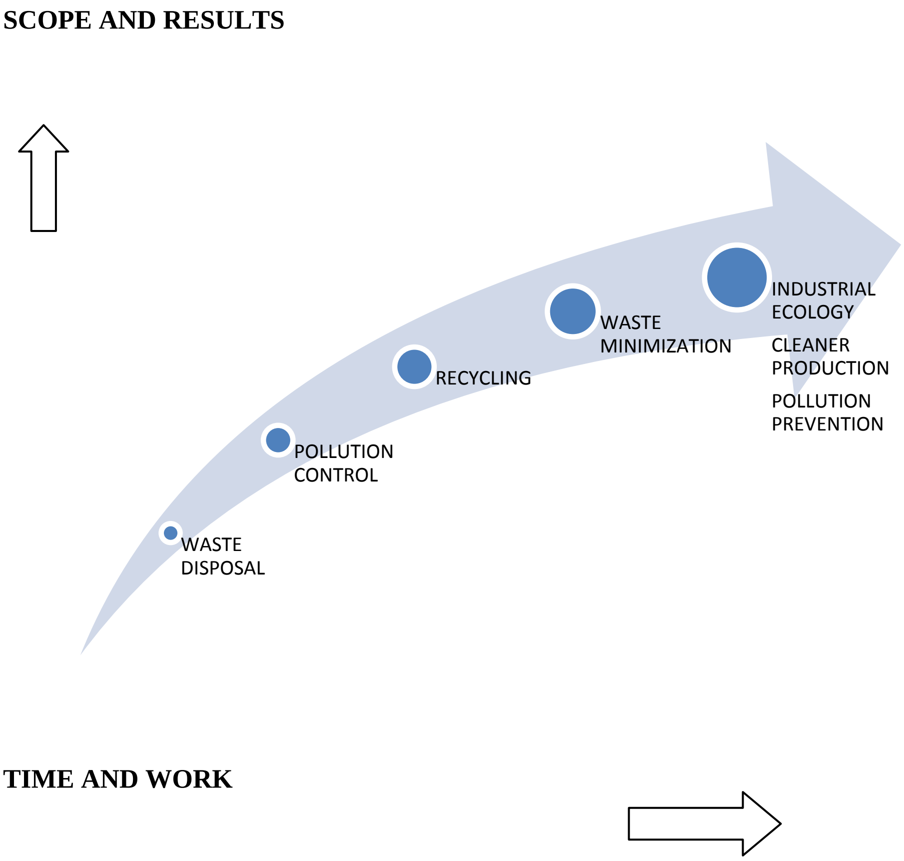
1.3.1 Role of Environmental Management Accounting (EMA) in cleaner production implementation

In order to achieve sustainable competitive advantage, businesses need to adopt CP processes. According to the United Nations Environmental Program (UNEP), 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; Pons *et al*., 2013).

A test project undertaken by Schaltegger*et al*.(2010) to assess the sustainable performance of companies after a combined application of EMA, CPA and Environmental Management system (EMS) generated positive outcomes 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 (V'an 2012).

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).

Figure 1 demonstrates the key concepts aimed at sustainable development.



Source: Nabais (2011:4)

Figure 1: Staircase of Concepts Aiming Sustainable Development

1.3.2 Environmental management systems

Figure1highlights key concepts of sustainable development. Each step involves more time and greater effort on the part of organisation aimed at achieving zero emissions, hence a long-term strategy.

2. MFCA AND NON-PRODUCT OUTPUT COSTS

Material flow cost accounting, a tool of EMA, facilitates the quantification and establishment of the cost of non-product outputs. This important information assists companies in their strategic decisions regarding CP implementation for the future (Schmidt, 2012).

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 (Buhner, 2013).

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 (Ministry of Economy, Trade and Industry (METI), 2007).

Environmental costs in MFCA refer to all costs, either directly or indirectly related with the use/consumption of materials and energies and their environmental impact (Hyrslova' *et al*., 2011). Hyrslova' *et al*. (2011) concur that MFCA is a very important method of environmental and economic performance management. Material costs makes 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 impact (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.

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 (Lagioia, Tresca, and Gallucci, 2014).

Schmidt and Nakajima (2013) conclude that a key concept of MFCA is to distinguish between product cost and non-product output, to evaluate which streams of material ends 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.

Non-product output costs can represent between 10-30% of total production costs of a company (Arlinghaus and Berger, 2002). Making managers aware of this can create the need to improve material efficiency by investing in newer, cleaner production technologies.

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

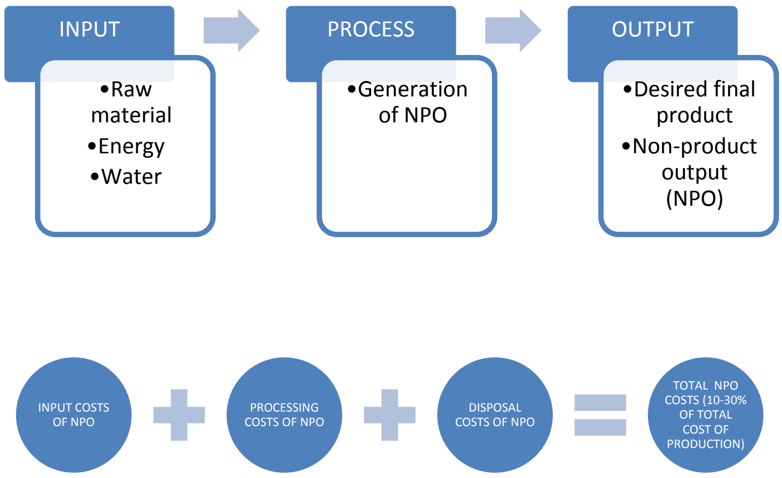
These benchmarks will be an indication as to how a company can manage and control their non-product output costs in the short-, medium, and long-terms. The first standards indicate technological norms.

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. Best available technology (BAT) levels are more stringent.

These technologies are considered to be the most efficient and environmentally protective available on the international market currently (Schaltegger*et al*., 2010; Jasch, 2009).

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

Savings that could be possible by switching to 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 (Schmidt, 2012; Jasch, 2009). Figure 2 demonstrates the Non-Product Output (NPO) approach.



Source: Arlinghaus and Berger (2002)

Figure 2: The Non-Product Output Approach

Figure 2 highlights the significance of non-product output cost in decision making and its impact on production capacity resulting in loss in production. Arlinghaus and Berger (2002) further explain that traditional management accounting systems focus on output of production and give no relevance to what is lost through non-product output.

Domil, Peres, and Peres (2010) discuss the different levels of non-product output costs and how these costs can be controlled within different time frames.

The difference between actual non-product output 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 non-product output 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 non-product output costs (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 non-product output 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 (Schalteggeret *al*., 2010).

2.1 Benchmarking and Controllability of Non-Product Output Costs

Schalteggeret *al*. (2010) 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).

Benchmarks are used in environmental management to compare environmental performance. Benchmarking allows companies to assess their performance and identify opportunities for improvements.

Altham (2007) 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 cleaner production techniques and technologies.

According to the UNDSD and Schaltegger et al. (2010), the most significant share of environmental costs comprises of non-product output costs.

In addition, they stated that there are huge saving potential for evaluating raw materials and technologies used in processes that generate large quantities of non-product output. 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 non-product output costs. A pilot programme for the promotion of environmental management through identification of non-product output costs was introduced to case study of ZimboardMutare, Zimbabwe.

Arlinghaus and Berger (2002) found that by implementing action plans to reduce hidden and obvious NPO costs by identifying its 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 1: Highlights the benchmarks that companies can use to manage and reduce environmental costs in short-, medium-, and long-term.

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

Table 1 shows the Relationship between non-product output costs, controllability and potential savings (Csutora and Palma, 2009)

Csutora and Palma (2009) explained 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. Life-cycle of technologies needs to be considered when benchmarking environmental costs. BAT is defined at a European level. They further claimed that using this benchmark recognised that some waste and pollution would always be generated even if state-of-the-art technology was used. When existing technology is out-dated, even if housekeeping measures are implemented, it is nearly impossible to achieve technological standards of non-product output costs, argued Csutora and Palma (2009). 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). 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.

2.2 Future Sustainability of Boiler Plants

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).

During a benchmarking study by the Pulp and Paper Research Institute of Canada (2008), 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 CO2 emissions and improved financial performance have been identified as benefits of implementing low cost best practices (Giglio, 2013; Avsar and Demirer, 2008).

The future sustainability of companies generating large amounts of boiler ash containing unburned coal particles is questionable. This hazardous waste has negative impacts on the company’s environmental and economic performance (Coal fly ash, bottom ash and boiler slag, 2014).

3. RESEARCH DESIGN AND METHODOLOGY

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 (Yin, 2009). These finding were then compared to technological standards and standards of best available technology. This study aimed at understanding the impact of cleaner production technology on the environmental and economic performance of the company.

Documentary evidence was also used to analyse cost allocation methods and cost incurred in steam production process for the period under review.

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 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 Environmental Management Accounting tool, the Material Flow Cost Accounting (MFCA) approach was used to measure the quantity and value of the non-product output costs. These non-product output costs were benchmarked against technological standards as well as Best Available Technology (BAT) standards. This technique assisted in identifying areas of potential savings for the company in the short-, medium- and long-term. Non-product output 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 generalizable 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 2009).

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

3.1 Benchmarking Environmental Costs

3.1.1 Method used to benchmark environmental cost

The aim of this study was to identify potential saving opportunities for the company by benchmarking current environmental costs against technological standards and best available technology.

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.

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-term. The following standards were established during cost control classification (Schaltegger et al., 2010; Jasch, 2009):

- 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. 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 are limited to the non-product output generated by the boilers.

It had been decided to adopt a Material Flow Cost Accounting (MFCA) method to calculate the value of the non-product output. In previous studies, and it had also been established that material purchase cost was most significant cost of non-product outputs (Schalteggeret al., 2010). 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 best available technology (BAT standards) or state-of-the-art technological standards.

3.2 Benchmarking Non-Product Output Cost

In this study, total non-product output costs included material purchase value of wastes; Costs of processing; handling and warehousing wastes; and treatment and disposal.

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.

3.2.1 Environmental Management Accounting Data Collected Using Material Balance to calculate value of non-product output costs

Non-product output was identified and quantified by applying the Material Flow Cost Accounting methodology.

This highlighted sources and causes of waste and emissions and potential savings of adopting cleaner production was identified. Material purchase price was used to calculate the value of non-product output 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 cleaner production assessment (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 integral parts of the final product. This was then classified under short-, medium-, and long-term according to their controllability. This information was used to support CP measures and in planning investments in new cleaner technology.

3.2.2 Material Flow Cost Accounting (MFCA) Model

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

This would assist management of this organization in their decision making regarding investment in cleaner production technology that could benefit the organization both environmentally and economically.

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

Current cost in steam production is benchmarked against the cost of production using cleaner technologies. This calculation is used to assess and evaluate the economic and environmental benefits of CP.

Cost appraisal of investing in cleaner production technology is provided to assist in the decision making process.

4. DATA ANALYSIS AND DISCUSSION OF FINDINGS

The company's material losses are not evaluated and added to non-product output 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 cleaner production technology. 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 general overhead account and are not being traced back to the product or process.

The company uses traditional costing systems and has not yet implemented an EMA system. Schmidt and Nakajima (2013) 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. 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. 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.

4.1 Coal Input and Steam Production Output of Boilers

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 and BAT standards.

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 1) 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 boiler technology expert (Martin Speek, John Thompson Boilers 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.

Statistical testing of the data revealed that 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 1:8 (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 company's current standards are much lower than BAT standards, which implies 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 two 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.

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. 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).

4.1.1 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. 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 and state-of-the-art technological standards of 1:8. The only boiler that is functioning close to the design specification is boiler two. In order to identify operational savings, managers need to look at ways to reduce the non-product output 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 non-product output 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 non-product output is calculated using the equation as follows:

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

4.2 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 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).

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

4.3 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 2: 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	1957tons x R933 per ton = R1 825 881

Table 2 shows the loss value in Rands of excess coal used due to boiler operating below technological standards.

Table 3 shows the technological and state-of-art benchmarks for boiler technology.

Table 3: 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 3 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 2 shows the tons of steams generated at different efficiency levels (indicatedby coal usage)

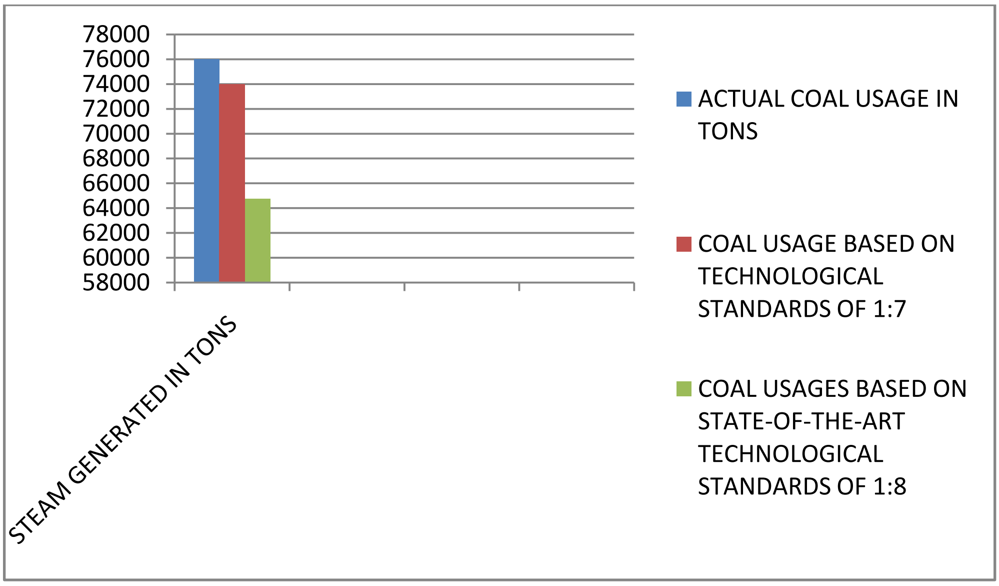


Figure 3: Coal Usage

Figure 3 indicate that coal usage is lower when technological standards are achieved and much lower when state-of-art technology is used in 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, John Thompson Boilers (Jeremy Edgar 2014).

4.4 Cost Benefit Analysis

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

The calculation of disposal cost of ash (as per appendix 2):

NOTE

- 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 (approx. R240 million)

2. Boiler upgrade = R5 000 000.00 per boiler (approx. 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 4 shows the estimated total saving opportunity should technological standards be achieved.

Table 4: 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 4 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 functions according to design specification. Estimated cost of approximately R5 million per boiler upgrading existing boilers plants was established during the interview with John Thompson boiler manufacturers. Payback period is calculated based on the estimated cost of R20 million 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: 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

5. CONCLUSION AND RECOMMENDATION

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. Material purchase value was included in waste was theoretically accepted but was never actually calculated. 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 notavailable. Hence, there is a need for increased awareness of the magnitude of environmental costs, more especially the material purchase value of non-product output contained in waste needs to be established. 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.

To benchmark the company's current environmental cost by comparing material balance against technological standards and best-available technology

Benchmarks used in this case study to compare non-product output were limited to technological standards and BAT standards for boiler technology. Evidence has been found that has identified material purchase value of non-product output as the category of EMA that has the potential of largest cost savings as stated by Jonall (2008). Good housekeeping measures of CP focus on getting closer to the technological non-product output costs. Savings of approximately of between 5 to 10% by monitoring and controlling raw material consumption have been reported in previous cases (Schaltegger et al., 2010).

5.1 Environmental and Economic Benefits Achievable Through Benchmarking

Table 6 indicates the possible saving opportunities by benchmarking environmental costs to technological standards and state-of-the-art standards.

Table 6: 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 clearly show that there are opportunities to improve 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 objective of this study has been achieved.

To make recommendations that will assist the company in their decision making process.

6. RECOMMENDATIONS

The final objective of the study was to make recommendations that will assist the company in their decision making process.

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.

6.1 Recommendation

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

6.1.1 Benchmarking environmental costs in short-, medium-, and long-term

Short-term measures

Investment in cleaner production technologies is expensive, however in order to improve environmental and economic performance organisations needs to adopt a cleaner production 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.

Long-term measures

In the long-term the company should consider adopting cleaner production technologies.

Current estimated cost of replacing old boilers according to Jeremy Edgar (John Thompson Boilers 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.

It can therefore be concluded that the company can improve both economical and environmental performance b y ensuring that technological standards are achieved in the short-term.

Greater savings can however be achieved by investing in cleaner production technology in the medium to long-term. This will result in higher environmental and economic performance, efficient resource consumption and improved competitive advantage being achieved by the company.

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APPENDIX A

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 B

Article on Benchmarking

- 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 1960 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 (Jeremy Edgar 2014).
- Therefore, an estimated amount of R2 352 000 per annum represent 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, is similar to boiler 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 R3500 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 and 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.