“The effectiveness of using material flow cost accounting (MFCA) to identify non-product output costs”

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ARTICLE INFO Mishelle Doorasamy and Hari Lall Garbharran (2015). The effectiveness of using material flow cost accounting (MFCA) to identify non-product output costs. *Environmental Economics*, *6*(2), 70-82

RELEASED ON Tuesday, 07 July 2015

JOURNAL "Environmental Economics"

FOUNDER LLC “Consulting Publishing Company “Business Perspectives”

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The effectiveness of using material flow cost accounting (MFCA) to identify non-product output costs

Abstract

This paper analyzes the effectiveness of adopting the Material Flow Cost Accounting (MFCA) approach to highlight non-product output costs and assist managers in their strategic decision making processes with regard to implementing cleaner production processes. This paper is based on a case study of a paper manufacturing company in KwaZulu-Natal which provides evidence that MFCA technique highlights the value of non-product output costs enabling managers to assess the financial and environmental benefits of adopting CP techniques and technologies. It had been concluded that the company should integrate MFCA with the current EMS system to ensure their future sustainability.

Keywords: Material Flow Cost Accounting (MFCA), cleaner production, non-product output, strategic decisions, innovation, sustainability.
JEL Classification: O31.

Introduction

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

The company has invested large amounts of money on end-of-pipe technologies and the wastewater treatment plant to reduce the negative impact of their production processes on the environment. This has, however, not solved their environmental issues nor has it reduced their resource use in production. The technology used in the steam production process is outdated and obsolete and generates between 20 to 60 tons of unburned coal ash as hazardous solid waste daily. The company also uses large amounts of water in their production process, resulting in even larger amounts of wastewater effluents, a sign of inefficient production (Environmental manager, 2013).

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

Information needed to estimate the potential for cleaner production savings was facilitated by making use of material flow analysis, a tool of EMA to allocate environmental and material flow costs (Jasch, 2009).

The objectives of this article are twofold: firstly, to provide a brief overview on the background information about the industry and its environmental issues, quantitative data on the input resources and waste generation.

Case studies and empirical evidence of companies that have successfully implemented MFCA are also brought to the forefront, and secondly to assess the effectiveness of adopting the MFCA approach which highlights the value of the non-product output of the steam generation process. This will enable managers to make informed decisions regarding the adoption of cleaner production processes and technologies to ensure the future sustainability of the company.

1. Review of relevant literature

Contextual factors of paper and pulp manufacturing

Current levels of economic and industrial activities, as well as material consumption cannot be sustained by the earth's eco-systems therefore the need for sustainable initiatives as part of corporate environmental management framework is essential to relieve the pressure of environmental impacts (De Beer and Friend, 2006). Manufacturing is not 100% efficient therefore waste is generated during production.

Excessive production capacity, high fixed costs, cutthroat pricing schemes, increasing competition

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from foreign impacts, yet still producing more paper even though this meant higher marginal cost implications of the law of diminishing returns (Integrated Pollution Prevention and Control, 2010).

Paper and pulp manufacturing operates in a cyclical industry with global economic conditions causing volatility in paper and pulp prices. Therefore, cost reduction and improving efficiencies are considered a priority. Finding lower cost raw materials and alternative fuels, minimising waste, improving manufacturing efficiencies and implementing energy saving initiatives are some measures implemented by the industry to mitigate risks (Ince et al., 2009).

Environmental regulation impacts the paper and pulp industry in every aspect of the product life cycle, from forest management practices, to pulp and paper manufacture, to paper recycling and disposal.

Paper and pulp manufacturing is resource intensive and generates significant amounts of solid wastes, air emissions, and discharges to the water. The industry is the third largest user of fossil fuel energy and the largest user of industrial process water among US manufacturers.

Half of the toxic release inventory (TRI) are methanol, by-products of the pulping process – over 50% of the industry's release to air and 40% of releases to water. Other substance released by the industry- non-hazardous waste water and sludge, acids, chlorinated compounds, ammonia, and air pollutants associated with combustion (SOx, NOx and particulates) (Pulp and paper manufacturing, 2010; Integrated Pollution Prevention and Control, 2010).

The paper and pulp industry has improved their environmental performance dramatically since 1970. Mill managers view investments in pollution abatement technologies as "unproductive – with no marketable and quantifiable effects in terms of productivity".

According to Porter, the cost of environmental equipment is made up of capital cost and cost of non-value added activities (associated with regulatory compliance, operation and maintenance of equipment, permitting and reporting).

The United States had installed pollution-control technologies to remove specific from the air and water releases since the 1970's. However, recently pollution prevention technologies, a more conservative approach to environmental protection than pollution control, has been introduced (Bras et al., 2004).

When total quality management (TQM) was introduced by firms by designing manufacturing processes that had targets of zero defects, companies not only improved the quality of their products but also their profitability. Based on the similar principles, suppliers can now design environmental improvement into manufacturing processes. An expert in competitive strategy at the Harvard Business School, Michael Porter, observed that "like defects, pollution often reveals flaws in the product design or production process. Efforts to eliminate pollution can therefore follow the same principles widely used in quality programs: use inputs more efficiently, eliminate the need for hazardous, hard-to-handle materials and eliminate unneeded activities." Recent studies documented the economic benefits of using resources more efficiently and also reported that firms that invested in ECF and TCF bleaching technologies showed better economic performance (Thant and Charmondusit, 2010; Promoting Sustainable use of Industrial Materials, 2013).

2. Material flow cost accounting (MFCA)

2.1. Theoretical framework of MFCA. Schaltegger et al. (2010) describe Material Flow Cost Accounting (MFCA) as one of the Environmental Management Accounting (EMA) tools aimed to reduce both environmental impact and cost simultaneously. In addition, MFCA is also a tool used in organizations decision-making which is aimed at improving their business productivity by reducing costs through waste reduction.

MFCA measures the flow of raw materials in both physical and monetary units. Cost categories are material cost, energy cost, system cost, and waste management cost states Schmidt and Nakajima (2013). According to Schmidt and Nakajima (2013), a large number of companies are introducing MFCA in Japan which is aimed at reducing material losses rather recycling wastes. Reduced material input and material cost is directly is a direct result of reduced waste generation. This eventually leads to improved efficiency in processing and waste treatment cost. Hence, two key activities of environmental management are reduction of waste generation and resource consumption in order to lower environmental impact of the manufacturing process. MFCA identifies the source of waste generation as well the quantities and costs of waste generated from a process.

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

Abdel-Kader (2011) claims that MFCA is a powerful method of environmental management and was being disseminated to industries because of its potential to help organizations realize that by increasing the transparency of material losses, companies can reduce environmental impacts and improve business efficiency.

He goes on further to describe the process as, involving the detailed mapping of the material and energy flows through an organization, however the costs of wasted materials (non-product output) are not absorbed into product costs but are identified and reported separately at all stages. MFCA was developed as a tool to enhance material productivity in manufacturing operations.

This method was applied by manufacturing companies to assess the loss of materials through inefficient use of resources and to identify possible savings that could bring about economic and environmental benefits claimed Schmidt and Makajima (2013). Scavone (2006) had similar findings and adds that the aim of adopting this methodology is to successfully reduce material inputs and to achieve new measures for increasing overall efficiency which will eventually lead to positive economic and environmental improvements.

MFCA is a key management tool with an objective to manage manufacturing processes with regard to the flows of materials, energy, and data to ensure that the manufacturing process proceeds efficiently. Hyrslova' et al. (2011) define material losses that occurs during the course of corporate processes as an inseparable part of material flows (examples, defective products of poor quality, scrap, waste and damaged products). These material residues are economically and environmentally undesirable. According to Lagioia, Tresca and Gallucci (2014), the emphasis of this approach is on the transparency of material flows and on related costs. It focuses on measures that aim to identify areas of cost saving by reduced material consumption and waste disposal. The actual material costs, in production companies, constitute one of the largest costs incurred according to Scavone (2006).

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

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

Sygulla, Bierer and Gotze (2011) explained that material loss cost can be calculated by multiplying quantity of each material (Physical amount in kg) by their unit prices. Even though external recycling may assist in recovering some material cost, material loss cost is still significantly higher. Economic loss caused by material losses includes all input cost of the process, such as, energy, labor, depreciation, and material cost. MFCA assists the organization in identifying, analyzing and evaluating their economic loss by material loss.

2.2. Advantages of MFCA

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

The refusal to take action to break through technology is the direct cause of problems that are identified.

In many cases, companies that applied MFCA identified material losses to be significantly higher than they had previously realized. It has also been established that MFCA presents the opportunity for engineers/companies to aim towards cleaner production and achieving their targets of lower material losses and cost reduction (Ministry of Economy, Trade and Industry of Japan, 2010).

Furthermore, the Japanese Industrial Standards Committee (2007) argued in its proposal for international standardization of MFCA, that since MFCA forms the ultimate platform of an organizational unit, it should be considered for standardization.

2.3. Development of MFCA. According to Schaltegger et al. (2010), MFCA was first developed in Germany but has since been adopted in Japan where it gained widespread significance and became evident as a useful tool to evaluate the loss of material in both physical and monetary units.

Japan then took the leading role wishing to make a contribution to the world by making both environment and economies compatible through dissemination of an advanced environmental management accounting approach. As a result, ISO/TC207/WG8 (MFCA) was established in 2008.

Kokubu and Nashioka (2005) concur that due to great pressure being placed on organisations to improve their economic and environmental performance and also considering the large cost of raw material inputs, MFCA was established as an official international standard for organizations, ISO 14051. The effectiveness of Japanese MFCA best practices and successful case examples was communicated after ISO 14051 (international standardization of MFCA) was issued in 2011.

MFCA has been globally promoted by The Ministry of Economy, Trade and Industry of Japan (Schmidt and Nakajima, 2013). Material flows can be found in better-organized companies and this data can be used as the basis for calculating the quantities, values, and costs assigned to each element in a flow model (Scavone, 2006).

Schmidt and Nakajima (2013) mentioned in their article some pilot projects on MFCA that began in Germany in the 1990's and became widely implemented in Japan in 2000. The Japanese Ministry of Trade and Industry (METI) funded and promoted the use of MFCA. One of the first case studies was at a firm, Nitto Denko. At this stage more than 300 manufacturing companies had successfully adopted MFCA approach and have benefited economically and also reduced the environmental impact of their production processes. ISO 14051 was developed in Japan in 2011 within the ISO 14000 family, to set out standards and general principles for material flow cost accounting to provide support and guidance to companies and contribute to worldwide resource efficiency. South Africa together with a number of other countries like Brazil, United Kingdom, Finland, Malaysia and Mexico were involved in developing the norms for ISO 14051 (Ministry of Economy, Trade and Industry of Japan, 2007).

Similar to conventional cost accounting, MFCA is also based on the quantity structure explained Schmidt and Nakajima (2013). The focus of material flow accounting is on a revised calculation of production costs on the basis of material flows. Schmidt and Nakajima (2013, pp. 358-369) found some weaknesses in conventional cost accounting in that it cannot give all the required data. Monetary value flows are traced and interpreted as product cost in a conventional cost accounting (CCA) system. CCA focuses on cost figures for each product in each process whereas MFCA checks mass balances in each process. Conventional cost accounting focuses on production costs of the whole company in monetary terms whereas MFCA focuses on accuracy of cost figures of each process taking into account material losses (non-product output).

Reporting under MFCA highlights actual production costs by excluding the cost of raw material purchased that becomes waste and does not form part of the final product. Within the MFCA the usage of materials is monitored in physical and monetary units (material costs).

Generally companies focus on the input materials and the quantity of products produced from these inputs, not on the material losses generated from the specific process. Environmental costs in MFCA, refers 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) concurred that MFCA is a very important method of environmental and economic performance management.

Sygulla et al. (2011) view MFCA as a holistic, life cycle oriented approach and that is considered to be a continuous improvement process with the initial step being goal setting.

According to Sygulla et al. (2011), product cost/ manufacturing cost under MFCA could be broken down into the following costs:

MC: material cost of raw material by using fixed input prices to allow for consistent appraisal of all manufacturing steps.

SC: system costs – all costs incurred in the handling of materials with the organization, such as labor, depreciation, overhead cost.

EC: energy cost – cost for the energy to enable operation for example, electricity. They form part of material cost.

Waste treatment cost – All costs incurred in handling of material losses within the organization or specific cost centre. MFCA helps make the quantity and value of material loss more visible by calculating economic loss of non-product output. Jasch and Schnitzer (2002) reported findings that the purchase value of non-product output can measure up to between 10 and 100 times the disposal cost incurred by a company.

Company's cost on a flow oriented basis can be classified into a total of six cost segments: material costs, system costs (personnel, depreciation), end-of-pipe environmental costs and disposal costs.

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).

Therefore, much larger potential lies in reducing the costs of materials, but it is this potential that is left untouched by traditional environmental costing.

In MFCA input materials, output and non-product output (material losses) are measured and then evaluated in monetary terms. MFCA is seen as the new 'Kaizen' for many Japanese companies. Schmidt and Nakajima (2013) concurred that lessons for companies is that inconsistencies in management information will result in material losses being incorrectly calculated. Therefore accuracy and relevance of internal data as well as data collection and cost evaluation are extremely important for an organization.

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

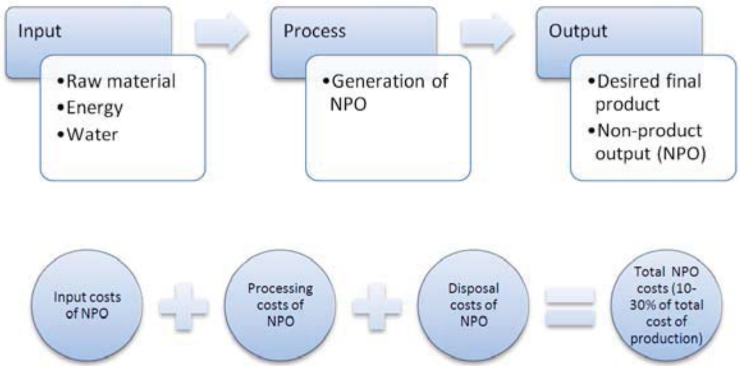
Hyrslova (2011) believes that an EMA system provides users with valuable information regarding the material purchase value of non-product output and makes it possible to track and trace where non-product outputs are created. Management can use this information to propose measures to increase the efficiency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

The purpose of material flow balance as explained by Jasch (2009) is to completely understand how much of what is put into the system becomes a product, and how much becomes non-product output (NPO). He suggests that understanding NPO is the best way to manage environmental issues. The generation of waste or NPO is a sign of inefficient production. Therefore material flows, is not only important for assessment of environmental cost, but also for production oriented cost assessment. It had been concluded that Material Flow Cost Accounting (MFCA), although in its imperfect form, is a powerful tool to ensure the future sustainability of a business.

Schmidt and Nakajima (2013) concluded that a key concept of MFCA is to distinguish between product cost and non-product output, to evaluate which streams of material end up as part of the final product and which streams of material are non-product output. Once material losses are quantified, improvement measures are identified and opportunities to reduce costs by avoiding material losses. MFCA analysis makes it possible to identify the complete costs which then allows for technical measures to be implemented in order to reduce material loss.

One of the major cost drivers reported during company workshop studies was the material purchase value of non-product output (Jonall, 2008). Thus evidences 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). Non-product outputs are a major cost factor for companies considering that polluting companies actually pays three times for non-product output. First, the cost of purchasing the raw material which ends up as wasted material. Secondly, the company incurs costs for operational use of raw material, example labor and investment cost.

Finally, the company then pays for the disposal of this wasted material (Jonall, 2008). This is the actual cost of the wasted material which most companies fail to realize. Non-product output costs can represent between 10-30% of total production costs of a company (Arlinghaus and Berger, 2002). Making them aware of this can create the need to improve material efficiency by investing in newer, cleaner production technologies. The figure below demonstrates the Non-Product Output (NPO) approach.



Source: Arlinghaus and Berger (2002, p. 6).

Fig. 1. Non-Product Output (NPO) approach

The figure above 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 explained that traditional management accounting systems focuse on output of production and give no relevance to what is lost through non-product output.

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, 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.

Material flow cost accounting (MFCA) case examples (Japanese Ministry of Economy, Trade and Industry, 2010) provides information on limitations and benefits of MFCA implementation:

There were certain limitations related to MFCA application as follows:

- Operational control of collecting MFCA information for quantification and incorporating it as part of daily activities.
- Need for an interface for linking a cost management system with a daily report, and
- Coordination with ISO 14001 activities.

Challenges of MFCA:

- Daily report improvement.
- Data collection method.
- Communication barriers between management and on-site workers.

2.4.1. Benefits of MFCA.

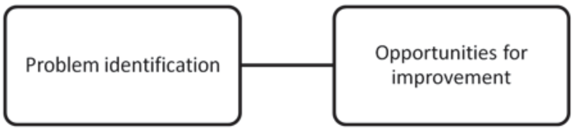


Fig. 2. represents the most important benefit of MFCA

Figure 2 shows that MFCA helps companies to identify and quantify their non-product output (material losses) by increasing the transparency of material losses throughout the process. This enables management to identify problem areas and implement measures to improve process efficiency.

This information was identified during analysis of the case examples provided.

2.5. Case studies on MFCA application. MFCA has been adopted in many case studies and resulted in environmental and economic benefits for the organization. Some of these cases have been cited below.

MFCA was carried out as a test project at a Japanese firm, Canon, on their lens production process with focus on the grinding process.

Conventional accounting revealed 1% loss on defective products, however after the application of MFCA, it became evident that a large part of the costs was due to material losses of defective products. Approximately 32% of the process costs could be allocated to material loss.

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

In a case study of Shinryo Co. Ltd, MFCA was applied to the processes from producing to packaging of brown sugar products. MFCA analysis identified minor improvement measures that could generate benefits such as improved productivity, more efficient use of resources, better customer satisfaction, reduced material loss and lower costs.

In the case study of Kodai Sangyo Co., Ltd, MFCA was targeted towards the project processing wooden materials for home-use "drain boards". At the conclusion of the case study, it had been found that information from three sources, that is, 'sales management system', 'accounting system', and 'production management system' would be required for the establishment of the MFCA management system increased the transparency of the flow of material losses in the process, and also improved the company's business performance.

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

Lagioia, Tresca, and Gallucci (2014) studied the adoption of MFCA adoption to integrate physical and monetary data in small enterprises for waste reduction decisions. They found that environmental impacts were not correctly recorded using traditional accounting systems and this led to inaccurate decision making.

Strategic, informed decision making is a key to an organization's success and this is highly influenced by the availability of an integrated data management system. This pilot test was conducted on a small Italian enterprise producing rubbish bags and operating in the plastic sector. MFCA was used to verify and assess the efficiency of the production process. However there were some problems experienced by the research team in applying the MFCA metho-dology. The company, being an SME had a traditional accounting thinking, which focused mainly on monetary information with a lack of clear flow chart of the production process in physical units. Both organizational and accounting difficulties were experienced in applying the MFCA methodology. Based on the company's financial sheets and the existing literature, assumptions and estimates had to be done. Aim was to establish the economic value of the physical amounts associated with the manufacturing process in order to show the economic value of material losses.

Considering the economic downturn, this could reduce losses, to avoid considerable costs, reorganizing and optimizing better the management of the material flow process. Also the decision to invest in cleaner production technology could be influenced by the findings of this research. Once again it had been concluded that MFCA is a powerful tool that organizations could adopt to identify physical and monetary hidden flows which will lead to environmental and economic decision making.

MFCA application increased the transparency of material losses and highlighted saving opportunities in the case studies cited. Hence, it provided useful information to assist management decision making regarding the introduction of new technologies. The need for efficient use of resources due to its increasing cost may to an extent encourage organization to adopt MFCA approach to identify saving opportunities. South African companies are not familiar with this approach, therefore is a need to increase awareness of the benefits of this new tool to organizations that generate lots of waste during their production processes. Companies can use their previous financial data and apply MFCA approach to identify the monetary and physical values of their losses in the form of non-product output costs. This will help them identify saving opportunities by investing in CP technologies that use less input resources and generate less waste, improving both environmental and economic performances. It can be concluded that there is a need for more publications on cases in South Africa that have become aware of their non-product output costs by adopting MFCA models.

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

3. Materials and methods

Data from the company records on the steam generation process for a period of twelve months were analyzed to identify non-product output costs and their environmental and economical impact on the organization. Semi-structured interviews with the Environmental Manager and the Cost Accountant of the company were conducted by the researcher to gather the relevant information with regard to the company's current cost allocation procedures.

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

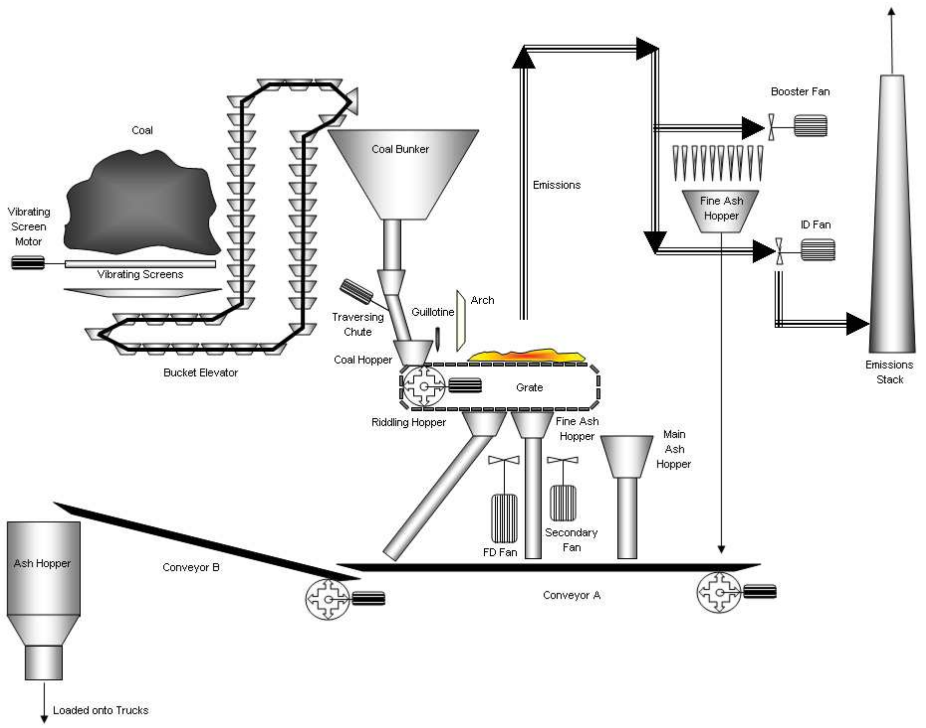
3.1. Cleaner Production Assessment (CPA). The qualitative review was conducted during the CPA stage. It involved an overview of the company's production and environmental aspects.

The CP assessment framework was used to capture data during the CP audit process as per the CP model. Analysis of the process flow chart shows inputs, outputs, and environmental problem areas of the steam generation process. Quantitative data analysis involved the calculation of NPO using MFCA, a tool of EMA.

This was used to identify potential savings options for the company should they adopt CP processes. Schaltegger et al. (2010) highlight the following warning signs of inefficiencies which become evident during the CPA: higher raw materials cost compared to those prescribed by technological standards, higher energy costs, maintenance needs and higher level of undesired output.

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

The review of steam production process to identify inputs and waste generated is depicted in Figure 3.



Ash disposal

Fig. 3. Coal fired steam boiler technological process flow chart

Figure 3 depicts the steam production process and ash disposal from the boiler plant.

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

4. Findings from the case study

4.1. Causes of waste generated during steam production process. *Identify possible causes of waste generation from the steam production process.* During the steam generation process, large amounts of unburned coal are found in the bottom of the boiler ash. Hence, the steam production process is inefficient, resulting in excessive raw material wastage.

The input/output ratio, according to technological design, is not being achieved. Therefore, the amount of coal used to generate steam is in excess to what is prescribed in the technological flow chart manual.

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

The only boiler that is functioning close to the design specification is boiler 2. In order to identify operational savings, managers need to look at ways to reduce the NPO costs caused by sub-optimal functioning of boilers.

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

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

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

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

A thorough investigation was done of the process involving the two underperforming boilers to identify possible causes of the inefficiencies identified during the CPA. It had been found that the boiler operating staff had difficulty in operating the boilers to meet steam demand. The company conducted an in-house training program to develop operating and management skills of staff involved in operating the boilers.

The programme was successful resulting in the immediate reduction in percentage of unburned coal from 25% to 2% and improved boiler efficiency from 70% to 98%.

Coal usage decreased by 27% resulting in a savings of approximately $65 000. An added benefit was reduced ash disposal to landfill by 275 tons per year. It is important to note that the case study cited above had a similar problem as the study currently being researched.

4.2. Analysis of accounting documents and records.

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

Note:

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

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

Table 1 illustrates the total cost of steam generation process from October 2012 to September 2013.

Table 1. Breakdown of total cost in rand and percentages

Total cost breakdown	Annual cost in rands	Percentage of total cost (%)
Total variable cost	86 059 302.11	91.36
Electricity	15 035 643.00	15.962
Water	100 000.00	0.106
Material purchase	70 923 659.11	75.294
Fixed cost	8 136 805.98	8.64
Total cost	94 196 108.09	100.00

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

Table 1 shows that the variable portion of the total production cost of steam is 91.36%, whereas the fixed cost portion is only 8.64% of total production costs.

Table 2 shows the variance in coal usage by comparing the actual usage to allowed usage.

Table 2. Year-to-date variance in tons and rands

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

Source: Company's financial data reports, 2013.

Table 2 shows that the actual usage of coal was higher than allowed usage of coal for the amount of steam generated, resulting in a negative variance of R1 817 009.25.

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

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

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

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

The non-product output value is calculated as follows:

Material purchased (coal) – R70 923 659.11.

Non-product output (unburned coal in the form of waste – 20% loss) = R14 184 731.82.

4.4. 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 R500000 per month, resulting in a total loss estimated to R6 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 3 shows the loss value in rands of excess coal used due to boiler operating below technological standards.

Table 3. Calculation of boiler efficiency

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

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 total 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 boilers function according to design specification. The cost of upgrading the company's existing boilers in order to achieve technological efficiency standards was estimated at an amount of approximately R5 000 000 per boiler. This estimated value was established during the interview with John Thompson boiler manufacturers. Payback period for the upgrading was calculated on the estimated cost of R20 000 000 for the four boilers.

Equation to calculate payback period:

Total investment cost/Estimated total savings per annum

Replacement costs of boilers are extremely high. Therefore, upgrading costs will be used in calculating payback period.

This will be used in strategic decision-making process.

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

5. Summary of empirical findings

Environmental costs are recognized for waste treatment and waste disposal under overhead expenses for the whole company. Only monetary information is provided for environmental costs. Physical information on type or quantity of goods or services procured was not currently available within the system. For the steam generation process, no environmental costs were included.

Production costs for the process included raw material (coal), electricity, water and fixed cost. All coal purchased was included as part of production costs. Raw material lost during production was not calculated and measured in monetary and physical terms.

The non-product output is an environmental cost to the company as this loss represents waste which is a sign of inefficiency in production.

Based on the above information regarding accounting practices for managing environmental cost, it can be concluded, that, due to the inadequacies of the company's current accounting systems, environmental costs reported by the company are significantly underestimated. The environmental costs included in financial statements are not a true and accurate reflection of the actual environmental costs. Environmental costs are allocated to overhead accounts and key managers are not held liable for these costs. This tends to discourage managers from actively managing environmental costs. Only cost paid for waste collection and removal are recognized as waste costs. Since NPO costs, based on material purchase price, are not considered a part of waste costs, these are significantly underestimated. There is limited environmental accountability.

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

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

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

Due to this break in communication, opportunities for reducing environmental costs remain unidentified.

Conclusion

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 organization.

In order to build a link between physical and monetary information systems and improve environmental and economic performance, it is essential that there be regular interaction and information sharing between the environmental and accounting departments. In terms of the management of major environmental costs:

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

Recommendations

Use of MFCA, a tool of EMA, to benchmark environmental cost.

Use of MFCA, a tool of EMA, to benchmark environmental cost against technological standards and state-of-the-art technological standards to make investment decisions.

It is suggested that information regarding material input/output and non-product of different production processes must be calculated and monetary values of NPO must be established. This information must be supplied to the cost and management accountant, who must use the MFCA model to highlight what amounts were used in production and should actually form part of production costs and what amounts of NPO should be allocated to environmental cost as wasted raw material. This model will identify areas where excess loss is incurred due to inefficient production processes.

Having being ISO 14000 accredited means that the company needs to adopt continuous improvement measures, one of which is by replacing old, obsolete technologies with CP technologies. This strategic decision will eventually lead to significant savings for the company due to resource efficiency. Environmental and economic performance will most definitely improve should the company decide to invest in CP technologies. In order for an EMA system to function properly, communication between the various departments is essential.

The environmental team needs to work together regularly to ensure that accurate information regarding production, costing and environmental costs are reflected on the system. A framework is provided later in the chapter which could be used by the company. However, it would be advisable to get an EMA specialist to integrate the company's current system with a recommended EMA system designed especially to meet the needs of the organization.

This will facilitate the change and the company would also be able to provide training and guidelines to those using the system on how to actually use the system correctly. Key information and amounts required by the managers to prepare management accounts and make investment decision regarding CP technologies could also be easily accessible by the system.

Application of MFCA model as a tool of EMA to allow the company to identify saving opportunities. *Application of MFCA model as a tool of EMA to allow the company to identify saving opportunities by implementing CP and assess environmental and economic benefits of such a system.*

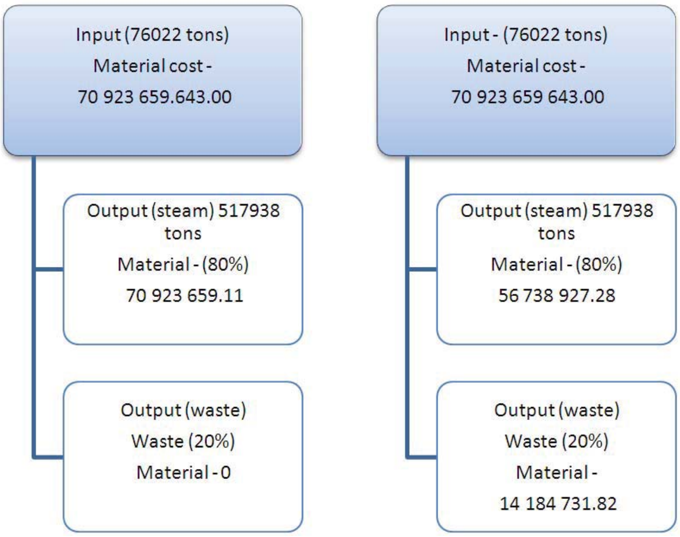
It has been suggested the company make use of the MFCA model that was initially developed for the tourism industry in Japan. This model is found to be effective in benchmarking non-product output costs and highlighting inefficiencies in current production processes which were generally hidden when traditional accounting systems were used. This resulted in incorrect decision making as 'true environmental' costs were understated. To highlight the effectiveness of this model, the researcher used company's current data on steam generation process and restated this information using the MFCA model. Calculation of material loss was done using data from the production cost schedule of the company for the year ending September 2013 and applying the MFCA approach.

Calculation as follows:

Material loss using current boilers (approximately 20 percent loss of coal) = R14 184 731.82.

Material loss using state-of-the-art boilers (standard loss 10 percent of coal) = R7 092 365.91.

Material purchase price of non-product output = R7 092 365.91.



Source: Self-generated.

Fig. 4. Conventional Accounting system and Material Flow Cost Accounting – indicating loss of material (coal) based on current technological standards (data used as per production cost schedule of company for year ending September 2013)

Figure 4 shows that the material purchase value is the most significant cost of steam production. Loss of approximately 20 percent of carbon found in bottom boiler ash being disposed-off by the company is valued at R14 184 731.82. According to technological standards, this loss should have been 10 percent. Hence, 10 percent loss is due to technological inefficiency. Therefore, R7 092 365.91 is controllable in the short-term. This savings in material cost is possible if technological standards were maintained. Benefits of adopting the MFCA model as well as empirical evidence are discussed in detail in the literature review. The MFCA model made it possible for management to identify the quantity and monetary value material losses in order to use this information to inform strategic decisions about investing in CP technologies in the future. They were able to see the possible savings as well as environmental and economic benefits of adopting CP technologies and techniques in production processes.

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