Assessing the Impact of Waste Legislation on Mills Operating Coal- Fired Boiler Plants in Developing Countries

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ABSTRACT---- ***The purpose of this article is to assess the impact of current waste legislation on the sustainability of mills operating coal-fired boiler plants that generate boiler ash as waste. This article is based on a case study of a paper and pulp manufacturing company in Kwa-Zulu Natal. Results of the finding indicate that companies operating coal-fired boiler plants will need to adopt cleaner production technology and techniques to reduce boiler ash waste in order continue business operations in the future. Current waste legislation will not allow companies to dispose of boiler ash to landfill sites within the next 5 to 7 years. Ultimately, management needs to consider investment in cleaner technologies as a strategy to improve environmental and economic performance to ensure their future sustainability.***

Keywords---- Waste legislation, sustainability, cleaner production techniques, cleaner technologies, boiler ash, environmental and economic performance.

1. INTRODUCTION

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

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). Bras et al. (2004) state that environmental regulation impacts the paper and pulp industry in every aspect of the product life cycle, from forest management practices, to pulp and paper manufacture, to paper recycling and disposal. However, research has shown that the paper and pulp industry has improved their environmental performance dramatically since 1970.

In many developing countries, an increase in industrial activity, electricity demand and transportation results in emissions and poor air quality have become a major issue (Stringer, 2010).

Higher energy and raw material prices are causing cleaner production to grow in relevance and importance (National cleaner production strategy, 2004; Lakhani, 2007). The amount of waste to landfill is increasing steadily.

Most companies are using inefficient processes and technologies that are obsolete, instead of state-of-the art processes resulting in higher production costs which, in turn affects their profitability and competitiveness (Schaltegger et al., 2010). Managers of paper mills perceive investments in pollution abatement technologies as 'unproductive' because they have 'no marketable and quantifiable effect in terms of productivity' (Bras et al., 2004l) and cleaner production opportunities cannot be seen (Baas, 2007).

1.1 Problem Statement

Paper and pulp manufacturing process of the company on which the case study is based on, 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.

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 which generate 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.

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. 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.

1.2 Aim and Objectives

The aim of this study is to identify the sustainability of the mill using their current technology, that is, coal-fired boilers to generate steam.

Objectives:

- Establish if the current technology (boilers) used to generate steam is functioning efficiently as prescribed by technological standards. A Cleaner Production Assessment (CPA) will be used to assess the efficiency of this process by comparing the current input/output standards of the quantity of coal used to generate steam to technological standards.
- Identify possible causes of the large quantities of waste generated (unburned coal in boiler ash).
- Evaluate their current waste management processes and assess their current environmental cost allocation system.
- Discuss the impact of the new waste legislation on the future sustainability of the mill.
- Make recommendations to management on how to improve their environmental and economic performance to ensure that their business operations are sustainable in the future.

2. LITERATURE REVIEW

2.1 Sustainability of pulp and paper mills

The industry is the third largest user of fossil fuel energy and the largest user of industrial process water among US manufacturers. Fossil fuels, such as coal, oil and natural gases are primary sources of energy used in the world. The high degree of depletion of natural resources and environmental damages, have tempted the world to try to reduce carbon emissions by 80% (Saidur, Abdelaziz, Demirbas, Hossain and Mekhilef, 2011).

The industry's machines are much older and smaller than their competitors in Europe and Asia, and they tend to have a higher fixed cost per ton of paper produced. Industrial operations cause significant environmental liabilities which have financial effects(De Beer and Friend, 2006; Liu et al.,2013).

Investor reports (2012) on a paper mill in North America indicated that through planned maintenance of equipment and process upgrades, the mill was able to improve machine efficiency and reduce production costs (Investor reports, 2012). However, mill managers view investments in pollution abatement technologies as "unproductive- with no marketable and quantifiable effects in terms of productivity". According to Porter, the cost of environmental equipment is made up of capital cost and cost of non-value added activities (associated with regulatory compliance, operation and maintenance of equipment, permitting and reporting). Recently, pollution prevention technologies, a more conservative approach to environmental protection than pollution control have been introduced. Total composition of effluents discharged and its potential environmental impacts is not completely known to many. Therefore, pollution-prevention is the only solution to help reduce the probability of unwanted surprises being released into the environment (Environmentally friendly production of pulp and paper, 2010; Despeisse et al.,2013).

However, changing from pollution-control to pollution-prevention technologies takes time, money, and a holistic approach to managing the environmental issues associated with pulp and paper manufacturing. Pollution-prevention technology investments can be costly and often compete for capital funds together with other projects that would also improve the company's profitability. In order to remain competitive, mills will have to respond with new technologies and if this decision results in the firm incurring high costs, these costs are most likely to be passed on to purchasers (Bajpai, 2010). Therefore paper companies must consider how much capital needs to be invested in order to reduce operating costs (Environmentally friendly production of pulp and paper, 2010).

Recent survey of recovery boilers found that over 70% were more than 25 years old and will therefore have to be rebuilt or replaced in the next decade. Minor renovations, replacement of individual pieces of equipment and the elimination of bottlenecks will have to proceed at a greater rate than major renovations or expansions. It can be concluded that integrating pollution-prevention strategies into pulp and paper manufacturing need to be part of the capital planning process that integrates a long-term vision for environmental progress with improvements in quality, productivity and lower operating costs (Bras et al., 2004; Oh, 2010).

2.2 Sustainability of pulp and paper mills

Approximately 80% of the energy needs of mills are met by the combustion of fossil fuels (mainly coal) to generate steam and hot water for evaporative and heating processes (Benchmarking energy use in Canadian pulp and paper mills, 2008). The remaining 20% is met by electricity for running electric motors, refrigeration and lighting. Energy consumption depends on how old the technology is and the range of products being produced. Certain processes are very energy intensive. Energy is an area where substantial savings can be made through simple housekeeping efforts. However, considering the price of coal and its impact on the environment, the company needs to consider the adoption of cleaner production technologies that will improve both the environmental and economic performance of the company. This would require capital investment in more efficient boilers in the medium- to long-term (Ernst, Lynn, Maarten, Christina and Nan, 2007).

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

Large amount of capital have been invested in cleaner production 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 (Giglio, 2013).

2.3 Environmental Impacts of 'Coal'

According to the Australian Coal Institute, coal is the most abundant and widely distributed fossil fuel resource in the world. Coal has played a significant role in the world's social and economic performance.

However, the move towards sustainability has created major challenges for the coal industry because of its environmental impact during both the production and use of coal (Mohr-Swart, 2008).

Coal, as a source of fuel, generates and releases large amounts of CO2 which has a negative impact on the environment causing land and air pollution. Increase risk of climate change has placed organisations under tremendous pressure to use cleaner fuels in their operational activities.

In Durban, the largest contributor of GHG is the industrial sector. In this sector, a total of 52% of total industrial emissions comes from electricity consumption followed by coal which comprises of 17%. Coal is often used as fuel in the industrial sector as it is cheaper than other energy sources. Coal is, however, more carbon intensive and thus contributes to pollution to a greater extent than other fuel sources (Giglio, 2013). Industrial sectors that consume excessive coal, like the wood and wood products sector, as reported by the eThekwini Municipality, are targeted to switch from coal to other cleaner fuels. Long-term projects aimed at improving boiler efficiencies by reducing electricity consumption include the introduction of combined heat and power (CHP) systems or the initiation of cogeneration systems in which waste heat is used as power in a secondary process. Pollution control measures such as phasing out of 'dirty fuels' to reduce SO2 emissions were also introduced. Industries have changed from using high–sulphur coal to low-sulphur coal, and implementing 'end-of-pipe' pollution control technology (Academy of Science of South Africa (ASSAf), 2011).

Research by Thompson and Fowler (2009) into the use of coal as a source of fuel in industrial technologies reported findings that carbon capture and sequestration (CCS) are essential tools needed to reduce the environmental impact of coal. There is a need for cheaper but more efficient CCS technologies. It is now possible for new and older coal burning power plants to produce power in an economical and environmentally responsible manner because of technological breakthroughs (Giglio, 2013). New coal power plants have been established in China, and India is also set to develop new coal generation capacity. Recent statistics revealed that world coal capacity is likely to double by 2030, and, if conventional coal technology is used, CO2 emission is expected to grow by about 12.6 billion metric tons annually by 2030. The increased need to reduce CO2 emissions by 50% to avoid the impacts of climate change has been the suggestion by scientists, Mathews and Caldeira. The climate scientists stated that "stabilizing climate requires near-zero emissions". Hence, the need for cleaner technology is imperative (Thompson and Fowler, 2009). Research shows that no single technology is capable of achieving the target of zeroing global CO2 emissions by 2050.

According to a publication *'User guidelines for waste and by-product materials in pavement construction* (2012)', boiler slag is formed from cyclone boilers that burns crushed coal. It had been concluded that the composition of bottom ash or boiler slag particles is controlled primarily by the source of the coal and not by the type of furnace. Bottom ash contains about 20 percent of unburned material. Bottom ash usage identified as structural fill, road base material, concrete and production of cement. It is believed that as the acceptance of the use of boiler ash increases, markets have the potential to utilize all of the bottom ash produced. However to reduce the amount of boiler slag available, older cyclone boilers needs to be retired (Coal fly ash, bottom ash and boiler slag, 2014).

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

2.4 Sustainable Development

At the 2002 World Summit on Sustainable Development held in Johannesburg, a shift towards Sustainable Consumption and Production was noted. Greater emphasis was placed on inefficient and wasteful use of natural resources (Resource Efficient and Cleaner Production, 2013). Issues raised at the summit clearly showed that much of the wealth generated in the country was at the expense of natural assets. Therefore, it was emphasised at the forum that businesses need to take an active role in protecting these natural assets and reducing the environmental impact of operational activities (Ambe, 2007). In 2006, a draft Strategic Framework for Sustainable Development in South Africa was used to reaffirm South Africa's commitment to implementing full measures to ensure that businesses cooperate and adopt a sustainable development approach to their business activities (Ambe 2007).

Some researchers have argued that the root cause for environmental problems is the lack of environmental management policy (Ahmad, Saha, Abbasi and Khan, 2009). Environmental and social aspects of business are not adequately recognised by current accounting systems and these issues may not be fully accounted for during decision making. Non-financial information is now being used to supplement the traditional financial information flows for external reporting and internal management needs.

Sustainability accounting and production has encouraged companies to review their processes and products to take into account and respond to changing cost structures and risks (Bennett, Schaltegger, and Zvezdov, 2013).

2.5 Cleaner Production Technologies

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

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

During the Central Project in Europe, it had been concluded that Cleaner Production Technologies increase the resource efficiency in production, reduces consumption of input resources and the quantity of waste generated. Furthermore, need for end-of-pipe-technology may be eliminated resulting in major costs savings for the organisation (Access to Technology and Know-how on Cleaner Production in Central Europe2008-2011).

Key feature of CP is the prevention of inefficient use of resources and avoiding unnecessary generation of waste, explained Bosworth et al. An organisation can benefit from reduced operating costs, reduced waste treatment and disposal costs. 'End-of-pipe' solutions are more expensive than investing in cleaner production to prevent pollution and reduce resource consumption. CP technology investments have proven to be a more cost effective option that has brought about both financial and environmental benefits to companies (Bosworthet al*., 2001*). Technological improvements can occur in various ways: a change in manufacturing processes and technology; a change in nature of process inputs (energy sources, ingredients, recycled water etc.); alternative product development; and on-site reuse of wastes and by-products (Bosworth et al., 2001). Domil, Peres, and Peres (2010) believe that environmental protection projects aimed at waste prevention at its source through better utilization of raw materials are seldom recognised or implemented because those in charge are not aware that producing waste is generally more expensive than disposing them. They suggested that activity based costing be implemented to improve internal cost calculation and allocate costs found in overhead accounts to the polluting activities.

2.6 Advantages of Cleaner Production

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

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

Cleaner production technologies and equipment have been developed by many industrialised countries to decrease pollution and emissions quantities and to meet regulatory standards. In order to minimize ash and gas emissions, waste water discharge and other environmental impact, pollution control methods should be substituted by cleaner production techniques (Priority Programme for China's Agenda 21).

2.7 Cleaner production case studies done on boiler plants

Case study findings reported by The Cleaner Production Case Studies Directory EnviroNET Australia (2003) presented results of a cleaner production assessment 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. It had been found that the boiler operating staff had difficulty in operating the boilers to meet steam demand. The company conducted an in-house training programme to develop operating and management skills of staff involved in operating the boilers. The programme was successful resulting in immediate reduction in percentage of unburned coal from 25% to 2% and improved boiler efficiency from 70% to 98%. Coal usage decreased by 27% resulting in a savings of approximately $65 000. An added benefit was reduced ash disposal to landfill by 275 tons per year.

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

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

Advantages of FBC Boilers: High Efficiency as fuel is burned with a combustion efficiency of over 95% irrespective of ash content and operational efficiency of 84% (+-2%).

2.8 Current Waste Legislation and Impacts on Organisation

Waste Management: Legislative Overview

According to the National Environmental Management: Waste Act 2008 (NEMWA) (Act 59 of 2008), it had been stated that waste needed to be classified according to its characteristics to ensure responsible handling, storage, processing, treatment and disposal of waste that also satisfies legal requirements (Wood, 2013). Boiler ash generated are normally transported via conveyor belts and stored in enclosed silos. However, an alternative option adopted by many organisations is that they allow contractors that have beneficial use for it, removes the ash and uses it in other manufacturing processes (example: brickmaking). It is a legislative requirement that ash be stored in an area licensed in terms of NEMWA: GN R. 718 of 03 July 2009, Category A3 (2).

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

- Growing waste demands placing greater pressure on the provision of infrastructure;
- Changes in terms of socio-economic issues;
- Disposal to landfill being the dominant means for waste management;
- Problematic waste streams such as organic waste and hazardous waste;
- Low levels of recycling; and
- Inadequate environmental legislation regulating waste management activities.

In South Africa, greater emphasis was placed on recycling and recovery. Up until 2011, approximately 90% of all general and hazardous waste generated was disposed to landfill. South Africa strongly still currently relies heavily on landfilling as its waste technology solution. About 9.8% of waste generated is recycled and 0.1% treated. Waste recycling in South Africa is mainly driven by the informal waste sector. A survey conducted by the National Waste sector in 2012 revealed that South African private and public sectors rely heavily on land filling as a technological option to waste management.

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

The People's Republic of China (2011-2015) has identified 'developing a circular economy' as the strategic area of focus to address the socio-economic development issues relating to waste management.

The trend towards the circular economy together with the principle of the waste hierarchy is prompting change within South Africa. Currently South Africa is largely at the peripheral of this global transition.

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

3. RESEARCH METHODOLOGY

The study is based on a case study following a multi-method approach, that is, method triangulation. The researcher implemented both qualitative and quantitative data analysis methods during the study. Case study research leads to more informed basis for theory development. According to Zikmund (2004), this methodology provides data for building theory that contributes to existing knowledge by analysis from another perspective(Yin, 2009).

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

Statistical package for social sciences, SPSS version 22 was used for descriptive and inferential statistics data analysis. Inferential techniques used in the study include the use of correlations and chi square test values; which were interpreted using the p-values. Interviews were analysed using relevant statistical methods. A thematic approach to data analysis was used.

3.1 Scope of the study

The study focused on a paper manufacturing company based in KwaZulu-Natal. The only area of investigation on cleaner production technology during the study was limited to the boilers, as this was identified by the company as a 'problem' and that needed to be prioritized during the research project. Therefore, based on the explanation provided, the researcher had decided to focus primarily on the coal used as raw material in calculating the value of the non-product output.

4. ANALYSIS OF RESULTS AND FINDINGS

4.1 Findings

Cleaner Production Assessment

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 1: Calculation of boiler efficiency

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

Table 1 shows the loss value in Rands of excess coal used due to boiler operating below technological standards.

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

4.2 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)

Reason for the Loss

The Cleaner Production Assessment (CPA) of the steam generation process revealed that large amounts of boiler ash between 20-60 tons per day are generated from the boilers. This ash is removed by the community members who use it in other manufacturing processes, example brick making. The ash that is not removed by contractors, are disposed off to landfill. Disposal of waste to landfill is costly as the company incurs transportation and handling cost for the waste being disposed.

An average of 20% of this ash is made up of unburned coal. Hence this process is inefficient and resulting in financial loss to the company as well as impacting negatively on the environment. As a coal fired boiler gets older, the coal used to replace the original fuel is usually poorer in quality: lower in heating value and higher in ash than the original design fuel (Sheldon 2001). In the case study, technology used is obsolete, which could lead to inefficient production processes incurring high environmental costs and poor economic performance. Cleaner production is not being adopted by the company, although this strategy could improve both the organisations' environmental and economic performance.

Cost of waste/material loss will be based on the purchase price of coal. Therefore the amount of coal used for the 12 month period in tons multiplied by cost price of coal will used to calculate the material cost of the process. Thereafter 20% of this cost will be allocated to material loss value as 20% of coal used as input material do not transform into steam. This 20% becomes waste and needs to be evaluated and deducted from production cost.

Calculation done (Appendix 1) indicated an estimated total cost of disposal of bottom boiler ash for transportation to landfill R392 000 per month and R4 704 000 per annum for a total estimated average of 1960 tonnes of ash generated per month based on year to date calculation for period under review (October 2012 – September 2013). Additional handling charges for pay loader and equipment used for disposal of ash is estimated R20 000 per month and approximately R240 000 per annum.

Table 2 indicates the possible saving opportunities by benchmarking environmental costs to technological standards.

Table 2: Saving Opportunities by Benchmarking Environmental Costs

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

Source: Self Generated

Table 2 clearly shows that there are opportunities to improve the environmental and economic performance of the organisation by ensuring that technological standards are achieved in the short-term.

4.3 Possible Causes of Waste and Inefficient Production Process

Coal (Raw Material)

The quality of coal needs to be considered as a possible cause of material loss. Poor quality coal would reduce efficiency levels of the boiler resulting in larger amounts of unburned coal generated as bottom boiler ash (waste). It had been established during an interview with the sales manager of John

Thompson Boilers that steam production process will using coal-fired boilers will generate waste, however the expected norm for unburned coal present in bottom boiler ash is approximately 10 to 13 percent using efficient, modern, newer boilers (Jeremy Edgar April 2014). The company generates boiler ash which contains approximately 20 percent unburned coal particles and this is clearly a sign of inefficiency and loss to the company.

According to Sheldon (2001), coal-related issues affecting the operation of a boiler are:

Temperature imbalance – too much or too little heat transferred from combustion zone to the feed water or from convective section to the saturated steam;

Slagging –The slag formed reduces overall heat transfer, efficiency and steam production by impeding the transfer of heat to water to generate steam. This ultimately results in inefficient operations and reduced economic performance.

Corrosion and abrasion –Damage to boiler walls increases the need for future maintenance and repairs in addition to reducing the economic performance of the boiler.

Coal quality characteristics directly affect boiler design, reduce the availability of the unit, increase direct maintenance cost, and decrease the utilization efficiency by increasing the fixed costs on a unit of production. John Thompson Boilers are able to assess the quality of coal used in the steam generation process by doing a coal specification test.

Inferior quality fuels have a negative impact on operational flexibility making the boiler more susceptible to slag deposition and heat balance upsets.

According to Schaltegger et al. (2010), warning signs of inefficiencies are: Higher raw materials cost compared to those prescribed by technological standards; higher energy costs; maintenance needs; and higher level of undesired output. Therefore, it can be concluded that the steam production process is inefficient.

4.4 Waste Management and Environmental Costing Procedures Implemented by the Company

Cost of disposal and handling of boiler ash was not indicted as environmental costs in the company's financial statement. Environmental cost related to steam production process was nil. Environmental costs were hidden as production costs (excess raw material waste in form of unburned carbon in ash). This cost was allocated to raw material usage in the production cost statement (An amount of R7 092 366.00 was incurred due to obsolete technology used in the process). This resulted in excess waste generated, higher disposal cost and poor environmental performance. The salary of the environmental manager and other staff members involved in environmental issues are also not included in environmental costs. Depreciation of end-of-pipe technologies used to treat pollution and reduce impact of production processes are also not included in environmental costs.

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.

4.5 Findings from Survey Questionnaire

Reasons for the promotion of clean production by industries

This section investigates the manager's perception of factors that promote the adoption of CP in industries:

The most important factor is identified as being uncertainty regarding business sustainability (Mean value of 4.54). The results indicate that external factors have a more significant impact on whether or not an organisation will adopt CP than internal factors.

The contingency theory could be used to explain why managers have identified uncertainty regarding business sustainability as the most important factor. It can be inferred from Qian, Burritt and Manroe (2011) that there is no single best approach to sustainability since the external business environment is characterised by uncertainty. They concur that the optimal course of action will depend on factors such as company's environment, technology and culture. According to the Institute of Environmental Engineering and the UNEP, internal barriers to CP implementation within a company are: low commitment from management, lack of environmental awareness, poor communication links and financial obstacles. Therefore, the last two constructs have been rated as less important.

Fore and Mbohwa (2010) identified barriers to CT adoption as: less stringent government regulations and policies, resource unavailability and lack of financial initiative. This finding supports the respondents' view to a certain extent that external factors, such as market pressures, strict legislation and, most importantly, uncertainty of the businesses future sustainability, are the driving forces of CP implementation.

Cause of Pollution/Waste Generation

This section is concerned with the most important causes of waste/pollution in the company.

The results of the survey questionnaire reveal that the most important cause of pollution is input and raw material waste (Mean value of 7.14), followed by poor manufacturing (5.83) and inadequate input (4.94), product and equipment specification. No planning for production, purchasing and sales was rated the least important cause of pollution or waste (2.51).

Literature supports this view that the most significant share of total environmental costs is usually NPO costs (Domil, Peres, and Peres, 2010). Material costs make up the highest portion of costs (about 50%) in a manufacturing company.

According to Sygulla*et al*. (2011), by reducing material usage, the amount of waste generated will also decrease. Jonall (2008) states that wasted raw material is a sign of inefficient production processes or poor manufacturing. In many cases, this was generally caused by old technologies used. He added that polluting companies actually pay three times for NPO and need to take this cost saving potential into consideration when making decisions regarding investment in CPT. Other less important causes of waste are improper material handling, poor maintenance, improper use of technology and insufficient operator training.

Environmental Issues Addressed

The data analysed indicate that all of the environmental issues stated in the question are recognised and being addressed by the company to improve environmental performance.

The average level of agreement for this section was 87.86%.There are fairly high levels of agreement with all of the statements, with the average being lowered due to a 60% agreement level for minimizing physical impacts of operations.The analysis indicates that 85.75% of the respondents agree that the company has invested sufficiently in improving its environmental performance. It can be perceived that managers may consider further investments to improve environmental performance in the future. However, not much can be done to improve environmental performance with the above information as the company currently uses a traditional cost accounting system. This system is adequate to provide additional information needed to make future investment decision to reduce environmental costs. Shaltegger et al. (2010) argue that more accurate awareness of process and product cost is an insufficient reason and offer uncertain benefits. Accountants need to know how much they can save with particular emphasis on non-product output costs.

5. CORRELATIONS

Respondents also agree that the allocation of environmental-related costs to production processes and classification of environmental-related costs results in improvements to environment-related cost management (correlation of 0.880 and 0.978, respectively).

Further analysis shows that assessments of environmental impact issues during capital investment decisions demonstrate greater commitment and awareness of environmental issues by the business managers (positive correlation of 0.748). Input and raw material waste seems to be positively related to poor manufacturing.

Respondents agree that improper use of technologies, are directly related to insufficient operator training and commitment (positive correlation of 0.964). In addition, findings reveal that old technologies used in production indicate management's resistance to change (positive correlation 0.701).

Negative values, as identified in the correlation results, imply an inverse relationship. That is, the variables have an opposite effect on each other. Analysis on negative coefficients for certain variables was interpreted as follows:

The coefficient between "The fear for business sustainability in the future and its uncertainties" and "Classification of environment-related costs" is -0.664.

This finding indicates that the greater the environmental business costs, the less sustainable businesses may become, and vice versa.

Interestingly, a negative correlation exists between inclusion of environmental information in the present management accounting information system and input and raw material waste. This means that input and raw material waste decreases when environmental issues are incorporated into the company's management accounting system (- 0.656). This trend indicates an inverse relation between environmental management activities practised and input and raw material waste generated. Hence, by incorporating environmental management activities into daily business operations, input and raw material waste generated can be reduced and manufacturing can be improved.

Patterns reflected on the correlation sheet reveal that there is a positive correlation between the company's environmental performance and environmental activities implemented to reduce environmental impact and pollution.

Hence, it can be concluded that environmental activities practiced by the company has had a positive effect on the company's environmental performance. Interestingly, the company's investment in improving environmental performance also has a high positive correlation to environmental activities adopted. It can be inferred that as investments in pollution prevention activities increases, environmental performance also increases.

6. RECOMMENDATIONS

6.1 Recommendation 1

Environmental Revenue

In the short-term this boiler ash can be used as a by product in other industries. Since the company is offering this free of charge to the community, they are not incurring any waste disposal cost, but it is an opportunity cost of lost revenue through sale of this by product. The approximated cost of this ash is R600 per 10 ton truck load. This rate is currently being paid to a local distributor in Clairwood for boiler ash from TongaatHullett sugar mill.

6.2 Recommendation 2

It is suggested that the company implement some form of EMA system by restructuring the accounting system, and allocating the major environmental costs to responsibility centres.

Radonjic and Tominc (2007:1482-1493) added that EMS is an important part of the pollution-prevention approach. Manufacturing process performance is improved and impacts of process upsets and equipment failure are greatly reduced by the adoption of sound environmental management systems. An additional field of a non-financial nature could be introduced into the system to link the monetary and physical information system.

This will also enable the company to monitor resource consumption and identify opportunities of potential savings.The purpose would be to record quantitative information in relation to the purchase of goods and waste disposal including non-product output costs.

Potential saving opportunities have been identified (table 2), should the company upgrade their current technology or move towards cleaner production in the future.This capital investment decision will not only improve environmental and economic performance but also ensure future sustainability of the organisation and greater competitive advantage as highlighted in previous case studies discussed in the literature review.

Information obtained during informal interviews with boiler manufacturing experts confirm that by changing to newer, cleaner technology, the company would greatly reduce waste, improve process efficiency and reduce resource consumption. The boilers currently used by the company, has also been identified as a major cause for the environmental issues.

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.

According to Giglio (2013) companies can optimise their existing plants. This is considered as the 'low-hanging fruit' of technologies, because it makes the best possible use of what the company already has. In addition, he argues that organisations can implement low cost best practices to refurbish power plants to make it more efficient. Improved financial performance due to more efficient use of resources as well reduced CO_2 emissions, 12-14% reduction in nitrogen oxide emissions, 15-20% reduction in ammonia consumption, and increased fuel efficiency have been reported by a company located in Baldwin that participated in such a project.

6.3 Recommendation 3

Regulatory and Legislative compliance

Recent legislation on waste management and impact on organisation

During a conference held by Enviroserv at Suncost in Durban (April 2014), recent legislative changes and impacts thereof on organisations had been discussed and was deemed to be relevant to the company. Landfill disposal previously governed by 'minimum requirements' had been amended in August 2013.

The first requirement for any waste is that the company must have it analysed in order to classify the waste so that it could be disposed off to the correct landfill site (EnviroServ April 2014). The company would therefore initially incur a cost of approximately between R20 000 to R30 000 to have the ash analysed.

This process could however be beneficial to the company as the analysis would reveal beneficial use for the bottom boiler ash and it could be used in other processes, thereby generating additional revenue for the company. This would also reduce disposal cost by R4 704 000. Since the government is trying to reduce the amount of waste to landfill, current waste disposal cost is likely to increase significantly in the next 3 years. This strategy is expected to force companies to try and reduce waste at its source and promote cleaner production processes.

According to Johan Schoonraad (EnviroServ 2014), the new legislation states that within the next 5- 10 years, waste to landfill will be prohibited.

Currently waste that contains carbon or any other type of fuel or energy that could be a useful by-product is strictly prohibited from landfill disposal. Hence the bottom boiler ash contains approximately 20% unburned carbon and is therefore not legally permitted to be disposed to landfill sites. Therefore it can be concluded that based on current legislation and loss of raw material used in the steam production process, management needs to implement strategies to reduce bottom boiler ash produced and invest in cleaner technologies in the long-term in order to ensure the future sustainability of the company.

In light of the above regulations, the company will have to have their bottom boiler ash analysed and classified. However this is not optional as bottom boiler ash can be both hazardous and non-hazardous. Classification of the waste would be necessary to ensure disposal is legal and meets legislative requirements. They would further have to identify a use for the carbon in the boiler ash as they would not be allowed to dispose of the ash to landfill in the near future. It has been estimated that although the purchase price of the coal may be around R450 per ton, disposal to landfill will cost around R3000 per ton, almost 7 times more.

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APPENDICES

Appendix 1

ARTICLE ON WASTE LEGISLATION

- 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.