ABSTRACT
Energy usage management in the manufacturing industry is a challenge that affects environment, profitability and efficiency. The main problem is failure to account for real-time utilisation resulting in post-usage intervention which does not aid in recovering from the effects of abused energy. In Zimbabwe, this situation has compounded towards a highly frequent load-shedding system that has reduced efficiency in most manufacturing companies. This paper looks at development of an energy monitoring and targeting system that uses an hourly feedback mechanism to monitor energy usage. The result is a system that triggers a signal when the trend in energy usage is surpassing the set target. In effect, the system calculates the targeted energy for unit production using regression analysis and uses an average hourly utilisation against the throughput to raise a control signal if the utilisation exceeds the target. This concept recognises the assertion that energy that is not aligned to productivity is susceptible to over-utilisation. It is expected that, the monitoring and targeting system will reduce energy utilisation thereby benefiting the environment.

KEY WORDS
Energy monitoring and targeting system, energy management, regression analysis

1. Introduction
The aim of this paper is to reduce and manage energy usage at company X through plant assessment and development of an energy monitoring and targeting system. This tool follows coal usage, comparing it with production to indicate if energy is being utilised efficiently especially considering the rate of production. On the other hand, a targeting system is developed that uses regression analysis to determine the targets to be used for determining the energy requirements for different production rates.

2. Background of the problem
X Phosphate Industry is a company which manufactures phosphate fertilizers and industrial chemicals.

<table>
<thead>
<tr>
<th>Product</th>
<th>Uses</th>
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<tr>
<td>Single, superphosphate</td>
<td>Fertiliser making</td>
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<tr>
<td>Aluminium Sulphate</td>
<td>Water purification process</td>
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<td>Sulphuric acid</td>
<td>Industrial use, phosphates making, alum sulphate making</td>
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<td>Phosphoric acid</td>
<td>Phosphate making, industrial use</td>
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The manufacture of sulphuric acid is the first step to the production of superphosphates fertilizer. The manufacturing process of sulphuric acid requires both electrical and steam energy. An audit of the company revealed energy loss streams such as bare piping, running motors on idling equipment and continuous steam supply at low productivity levels. These are a cause for concern as they affect the bottom line and the environment. Management however, tend to overlook the effect that such slack approach to control of energy has on profitability and the environment. This is exacerbated by failure to account due to lack of a monitoring system that measure and raise a signal whenever the utilisation
exceeds targeted allowable energy utilisation for the number of units produced. The company therefore needs a targeting system that relates the amount of energy to production units. This is the system that generates the targets for different products on the production line.

3. Methodology

Literature was reviewed through searching the internet for publications and journals. There was extensive research from library textbooks, manuals and equipment specification handbooks. In addition to the afore mentioned, informal interviews were conducted with, technicians, fitters, electricians, artisans, and operators while formal interviews targeted supervisors, engineers and managers. Authority was sought to conduct site visits with an aim to review the operational efficiency of the major energy users in the plant and identifying weaknesses and opportunities for improvement. This was achieved through,

- Walk through audit for direct observations
- Collection of historic and current data for analysis
- Review of operations to identify opportunities for improvement

4. Literature review on energy management

Energy is a critical resource in industry and commerce and should therefore be managed effectively to ensure optimum usage and reduce the effects of converting energy on the environment. The flow diagram in Figure1 illustrates how the development and management of energy utilisation should be approached, first with commitment to efficient energy management, through setting goals and implementing them as well as monitoring and evaluating progress.

4.1 Energy loss reduction: Boiler and piping system

One of the primary purposes of insulation is to conserve energy and increase plant profitability by reducing operating expenses. In existing plants, the planned and conscientious maintenance of insulated steam, chilled water, and other process distribution pipelines is required to minimize financial and thermal losses. Due to poor maintenance, pipeline insulation maintenance issues tend to accumulate until major repairs are required, and extensive financial losses have been incurred [6]. Heat losses reduce the steam pressure at the terminal equipment. This situation increases the boiler load because extra steam is required to make up for the losses. Energy management systems have been developed to ensure the above intent is achieved. Changing how energy is managed by implementing an organization-wide energy management program is one of the most successful and cost-effective ways to bring about energy efficiency, environmental impact and cost improvements [2]. The energy management closed loop system below allocates fair responsibility for the management of energy to different levels within an organisation.

5. Literature review on energy monitoring and targeting system

Energy monitoring and targeting is a management technique that uses energy information as a basis to eliminate waste, reduce and control current level of energy use and improve the existing operations
procedures [3]. It essentially combines the principles of energy use and statistics.

The fundamental principle of Energy Monitoring and Targeting is that energy and other utilities are direct and controllable costs that should be monitored and controlled in the same way as other direct, production-related costs such as labour and raw materials, parts and supplies. This principle is expressed as a board-level policy in companies, which embraced Energy Monitoring and Targeting in order to derive benefits from it. The utilities used in each centre are closely monitored, and the energy used is compared with production volume or any other suitable measure of operation. Once this information is available on a regular basis, targets can be set, variances can be spotted and interpreted, and remedial actions can be taken and implemented [4]. The ultimate goal is to reduce energy costs through improved energy efficiency and energy management control. Other benefits generally include increased resource efficiency, improved production budgeting and reduction of greenhouse gas (GHG) emissions.

Elements of Monitoring and Targeting System

- **Recording**: Measuring and recording energy consumption.
- **Analyzing**: Correlating energy consumption to an output e.g. production output.
- **Comparing**: Comparing energy consumption to an appropriate standard or benchmark.
- **Setting targets**: Setting targets to reduce or control energy consumption.
- **Monitoring**: Comparing energy consumption to the set target on regular basis.
- **Reporting**: Reporting results and any variances from the targets which have been set.
- **Controlling**: Implementing management measures to correct any variances which may have occurred.

In order to generate energy targets for the future, we plot energy against production to gain more understanding of the relationship of energy and production have us with some basis for performance measurement. To do this we– In Microsoft Excel Worksheet, this is an XY chart option. We then add a trend line to the data set on the chart. (single variable regression analysis) [5]

6. Results

A comparison of coal consumption against units produced (output) reveals a close relationship which is only poorly managed in August 2011. There is low production in August and December but the trend in consumption does not reflect that scenario. These results reflect a poor management approach to linking energy usage to productivity. The signal is however raised when reduction in production is so drastic thereby necessitating a decrease in energy usage.

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The Energy Monitoring System (EMS) is updated hourly. Figure 6 above shows a window for updating the information. Production figures and coal consumption units is fed into the energy performance targeting spreadsheet in Figure 7 as the information is entered into the EMS, it updates the regression analysis graph and the energy performance measure is translated into a linear equation

\[ Y = MX + C \]  \hspace{1cm} \text{...(i)}

Where \( C \) is the base load and \( M \) is the energy per variable unit, \( Y \) is the expected energy consumption for \( X \) units produced. As the Energy Monitoring System is being updated, the obtaining Variable Target (M) and Base load (C) is automatically imported from the regression analysis graph and appears on the system. The system uses M and C to determine if the energy consumed in that hour exceeds the targeted consumption and raises a signal to alert the user to adjust energy usage parameters and align it with the obtaining production. The spreadsheet updates on a daily basis thus only reflecting accumulated hourly figures from the EMS.

7. Conclusion and Recommendation

The aim of this energy management system is to generate an energy consumption target from usage data and alert the users whenever they exceed the targeted consumption. The ultimate is a steady reduction of usage until the optimum is achieved at which stage the targeting system only monitors and maintains the consumption aligning it with fluctuating production levels.

Inspection on cleaning of tubes is done once after every four months. Shifting the schedule to once in two months can lead to heat transfer efficiency of 80%. This will improve boiler feed water range temperature from \(52^\circ\)C to about \(73^\circ\)C and thus improving boiler efficiency. Less coal will be used to heat up the water and produce steam.

\[ Q = mc \Delta T \]

Where \( Q \) = heat energy saved

\[ Q = 0.56 \times 4.18 \times (73-52) \]

\[ = 49.16 \text{ kJ/s} \]
We use the following formula to calculate the amount of coal saved per hour.

\[ X = \frac{Q + 3600}{C} \]

Assuming \( X \) is the mass of coal saved per hour, \( C \) is the carolific value of coal and \( Q \) is the heat energy saved, then, there is an annual saving of 6.12kg/hr. Phosphate Industries operates a two shift system at 21 days per month all year round. This amounts to a saving of 24 tonnes of coal per year.

The use of this monitoring and targeting system is very useful but only when the integrity of the feed data is upright. There opportunities for direct automation of the system eliminate the use of manual data capture. The system can also be developed to account for energy usage and control at planning stage rather than at post usage level.

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