

Energy management for improved profitability of small manufacturing enterprises

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ABSTRACT

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Approximately 75% of small, medium and micro enterprises (SMMEs) created in South Africa (SA) fail in the first year. This is a serious socio-economic problem as SMMEs in South Africa employ over 60% of the workforce and contribute over 50% of gross domestic product (GDP).

One reason for SMMEs' failure is their incapacity to contain rising production costs. One of the most significant of these rising costs is the energy cost. South Africa has experienced an effective electricity tariff increase of over 170% from 2009. But according to the Multiyear Price Determination (MYPD timelines), electricity prices are still not cost reflective and so will continue to rise.

Energy costs across all businesses contribute between 15-25% of total production costs with approximately 5-15% of total energy consumption being baseload in most small manufacturing enterprises. The threat to business profitability of energy costs eroding the profit margins is not proactively being addressed. Energy awareness, energy management and technical skills to manage energy are lacking in SMMEs.

The hypothesis of this dissertation is that systematic and effective management of energy as a resource and a production input would improve business profitability. To aid with this research, a small manufacturing enterprise energy management toolbox (SMEnT) was adapted from a publicly available Energy Management Matrix as well as a pre-assessment questionnaire traditionally used for assessing large industrial and commercial energy users.

The research methodology included principally two case studies; one that clearly demonstrated a desire to embark on an energy management journey through the adoption of

energy management best practice, and another that saw energy management as a business nuisance and disruptive to production. The SMEnT was then applied to both case studies to assist in creating a visual on energy consumption and savings potential.

Energy management best practice adoption is identified as a catalyst for energy savings in small manufacturing enterprises. Entrenching a culture within small business of managing energy and creating awareness towards its effective usage is an imperative.

The adoption of energy management opportunities resulted in energy performance improvements which translated into improved energy intensities. Reduced energy consumption and costs in turn meant reduced production costs that resulted in improved business profitability. The company in the case study that adopted energy management practices recorded an 8% cost saving from the 2011/12 baseline by merely adopting energy management best practices at no or low cost.

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LIST OF ABBREVIATIONS AND ACRONYMS

AUP	Average Unit Price
BBSDP	Black Business Supplier Development Programme
BECs	Building Energy Codes
BMF	Black Management Forum
C&I	Commercial and Industrial
CFL	Compact Fluorescent Lamp
CIS	Co-operative Incentive Scheme
DBSA	Development Bank of South Africa
DEA	Department of Environmental Affairs
DOE	Department of Energy
EBRD	European Bank for Reconstruction and Development
EE	Energy Efficiency
EEDSM	Energy Efficiency and Demand Side Management
EEMP	Energy Efficiency Management Programme
EIUG	Energy Intensive User Group
EM	Energy Management
EMO	Energy Management Opportunity
EnMS	Energy Management System
EnPI	Energy Performance Indicator
EPA	Environmental Protection Agency
ESCO	Energy Services Company
ESO	Energy Saving Opportunity
GDP	Gross Domestic Product
GHG	Green House Gas

HEM	High Efficiency Motor
HFO	Heavy Fuel Oil
HPS	High Pressure Sodium
HSRC	Human Sciences Research Council
HVAC	Heating Ventilation and Air-conditioning
ICT	Information and Communications Technology
IEEP	Industrial Energy Efficiency Project
ISO	International Organization for Standardization
ISP	Incubation Support Programme
Kg	Kilogram
kVA	Kilo-Volt-Ampere
kVAR	Kilo-Volt-Ampere Reactive
kWh	Kilo-Watt-hour
LED	Light Emitting Diode
LFO	Light Fuel Oil
LPG	Liquefied Petroleum Gas
M&E	Monitoring and Evaluation
MD	Maximum Demand
MMTR	Measuring, Monitoring, Targeting & Reporting
MW	Megawatt
MWh	Megawatt Hour
MYPD	Multiyear Price Determination
N/S	Not Supplied
NCPC	National Cleaner Production Centre
NCR	National Credit Regulator
NEF	National Empowerment Fund

NMD	Notified Maximum Demand
NYDA	National Youth Development Agency
pf	Power Factor
REC	Resultant Energy Consumption
RECP	Resource Efficiency and Cleaner Production
SAIPA	South African Institute of Professional Accountants
Samaf	South African Micro-Finance Apex Fund
SBA	Small Business Administration
SBP	Small Business Projects
SBS	Small Business Support
SEDA	Small Enterprise Development Agency
SEU	Significant Energy User
SME	Small and Medium Enterprise
<i>Sme</i>	Small Manufacturing Enterprise
SMEDP	Small Medium Enterprise Development Programme
SMEnT	Small Manufacturing Enterprise Energy Management Toolbox
SMME	Small, Medium and Micro Enterprise
SSI	Small Scale Industry
STP	Seda Technology Programme
SWH	Solar Water Heater
THRIP	Technology and Human Resources for Industry Programme
UNIDO	United Nations Industrial Development Organisation
VSD	Variable Speed Drive
ZAR	South African Rand (currency)

TERMS AND DEFINITIONS

Apparent power (S) -	is the combination of reactive power and true power. It is the product of a circuit's voltage and current (VA), without reference to phase angle.
Baseload -	is the permanent minimum load that a power supply system is required to deliver.
Baseline -	is a minimum or starting point used for comparisons.
Benchmarking -	is a measurement of the quality of an organisation's policies, products, programmes, strategies, etc., and their comparison with standard measurements or similar measurements of its peers.
Eco-Economy -	is the intersection of the economic and environmental pillars of sustainability . It focuses on resource efficiency, energy efficiency and global energy issues.
Energy Conservation -	is reducing energy consumption through using less of an energy service. Energy conservation differs from efficient energy use or energy efficiency, which refers to using less energy for a constant service.
Energy Efficiency -	is such that the energy consumption is measured for a particular level of output, volume or service level. An energy usage reduction without loss of performance is an energy efficiency gain.
Energy Intensity -	is the quantity of energy required per unit output or activity.
Energy Management -	is the process of monitoring, controlling and conserving energy in buildings, systems, processes or organisations. It includes both energy efficiency and conservation.
Energy Management Opportunity -	is also known as an energy saving opportunity (ESO) or as an energy conservation opportunity (ECO). It is that identified opportunity if once implemented would realise energy consumption and cost reduction without negatively impacting on the service level or product quality.

Energy Management System (EnMS) -	is a systematic process for continually improving energy performance.
Energy Performance Indicator -	is a way of measuring the organisation's energy performance. An EnPI is calculated by dividing the total energy consumption by an activity metric such as production volume: An EnPI may also be referred to as specific energy consumption.
Hurdle Rate -	is the 'line in the sand' that helps companies decide whether or not to pursue projects. It is the minimum rate that a company expects to earn when investing in a project.
ISO 50001 standard -	is a specification created by the International Organization for Standardization (ISO) for an energy management system.
Maximum Demand -	is the capacity of electricity usage, and it works to assess the level of capacity (load) of electricity used by customers.
Monitoring and Evaluation -	is the systematic collection, analysis and use of information from projects and programmes. It helps in improving performance and achieving results with the main goal to improve current and future management of outputs, outcomes and impact.
Notified Maximum Demand -	is the capacity reserved by the customer to provide for the maximum demand requirements in all time periods.
Simple Payback (SPB) -	is the time required for the amount invested in an asset to be repaid by the net cash flow generated by the asset. The formula for payback is: $\text{Payback} = \frac{\text{Investment}}{\text{Saving}}$
Power Factor -	is equal to the real or true power P in watts (W) divided by the apparent power S in volt-ampere (VA). Formula for Power factor (pf) is: $pf = P_{(W)} / S_{(VA)}$. It is also equal to the absolute value of the cosine of the apparent power phase angle ϕ: $PF = \cos \phi $

Real Power (P) -	is also known as true power. It is the power that performs work measured in Watts (W).
Reactive Power (Q) -	is produced when the current waveform is out of phase with the voltage waveform due to inductive or capacitive loads. It is also known as the power that does not perform work (sometimes called 'wattless power') measured in VA reactive (VAr).
Significant energy user -	is any energy using system or process with the largest potential for energy saving and/or one that consumes the largest portion of the total energy consumed in any particular plant.
Sustainability -	is considering and managing the environmental, social and economic challenges the world faces to support long-term economic success balanced with social well being and a safe environment.
Tariff -	is the pricing structure a retailer charges a customer for energy consumption.

1 INTRODUCTION

1.1 Background

1.1.1 Defining a Small, Medium and Micro Enterprise (SMME)

In attempting to define what a small manufacturing enterprise (*sme*) is, there is a need to obtain a wider and global perspective before a research-befitting definition is adopted. According to the United Kingdom's Bolton Committee 1971 report on small firms, a small firm is an independent business, managed by its owner or part-owners and having a small market share. Other statistical definitions for a small firm are based on the number of employees and/or turnover (Bolton Committee, 1971).

The United Kingdom's Companies Act of 1985, Section 248 states that a company is 'small' if it satisfies at least two of the following criteria:

- A turnover of not more than £2.8 million.
- A balance sheet total of not more than £1.4 million.
- Not more than 50 employees

In South Africa, according to the National Small Business Act no. 102 of 1996, the broad definition of SMMEs is as given in the Table 1 below:

Table 1 SA Small Business Act SMME Definition (adapted from Falkena et al., 2001)

Enterprise Size	Number of Employees	Annual Turnover (ZAR)	Gross Assets, Excluding Fixed Property
Medium	Fewer than 100 to 200, depending on Industry	Less than R4 million to R50 million depending on Industry	Less than R2 million to R18 million depending on Industry
Small	Fewer than 50	Less than R2 million to R25 million depending on industry	Less than R2 million to R4.5 million depending on industry
Very small	Fewer than 10 to 20 depending on Industry	Less than R200 000 to R500 000 depending on industry	Less than R150 000 to R500 000 depending on industry
Micro	Fewer than 5	Less than R150 000	Less than R100 000

The definition of what an SMME is could be left to one's own interpretation. However, what is common are the criteria based on number of employees, total gross asset value and total

annual turnover. Notable however, is the fact that what could be considered a small business in one part of the world could well be a medium or even large business in another part. It could also be by nature of business or type of industry.

For the purposes of this research, the focus will be on South African small enterprises that are in manufacturing; hereto referred to as small manufacturers or small manufacturing enterprises (*smes*). The criteria for defining small manufacturing enterprises (*smes*) are businesses with:

- Less than 50 employees, and
- Turnover of less than R 10 million.

In addition, because the broader subject matter is on energy, other criteria are that the firm has are the following:

- Annual energy spend greater than R250 000 but less than R3 000 000,
- At least 1x primary energy source viz; electricity, coal, HFO, LFO, LPG, kerosene or biomass (wood fuel),
- At least 1x secondary energy source viz; steam, compressed air, heat recovery systems, etc.

The adopted definition and applied criteria for a small manufacturing enterprise (*sme*) presents a significantly large industrial sub-sector. This industrial sub-sector of small manufacturing enterprises is traditionally considered insignificant in the energy efficiency targeting of business. But this ignored sub-sector presents with huge potential for energy performance improvement, cost savings, and a quantifiable aggregated contribution to the national energy demand reduction as well as national GDP growth.

According to the South African Institute of Professional Accountants (SAIPA), the SMME sub-sector employs over 60% of the South African workforce and contributes over 50% of the country's gross domestic Product (SAIPA, 2013). Seeing the contribution that the SMME sector stands to make, it would appear that every effort should be put in to ensure the sustainability of the SMME sub-sector in order to foster job creation as well as a continued contribution to the national GDP.

A viable and profitable small manufacturing enterprise would inevitably provide more jobs as well as make a generous contribution to national GDP through corporate taxation. On the

energy aspect, an energy-optimally performing SME would contribute to the energy conservation that the country so desperately needs; particularly now that there is an evident resource shortage and energy security risk.

1.1.2 SMMEs' contribution

SMMEs in developing countries play a dynamic role as engines through which the developing countries' set socio-economic growth objectives are met. It is therefore imperative that the SMME sub-sector remains a healthy one in order for it to make a prominent and significant contribution to the economy. The SMMEs impact on the economy is made through job creation, innovation, entrepreneurial skills, increased production and exports.

An estimated 22% of the adult population in developing countries is said to be employed by SMMEs. According to a United Nations Industrial Development Organisation (UNIDO) report, over 90% of private business in most African countries is represented by SMMEs that contribute to more than 50% of employment and gross domestic product (GDP) (UNIDO, 1999).

Abor and Quartey (2010) conducted a study in which they estimated that 91% of formal business entities in South Africa are SMMEs. According to this report, SMMEs contribute between 52 to 57% to GDP and provide about 61% to employment (Falkena *et al.*, as cited by Abor & Quartey, 2010). These figures clearly demonstrate the importance of these SMMEs to the nation's socio-economic growth path.

In South Africa, the importance of SMMEs to the economy was realised as early as 1995. The newly democratically elected Government conceded that the challenges of job creation, economic growth, and equity in South Africa could best be addressed by small, medium and micro enterprises (SMMEs). This fact was highlighted in the 1995 White Paper on the National Strategy for the Development and Promotion of Small Business in South Africa (Department of Trade & Industry, 1995).

How then do we ensure that this very significant sub-sector of SMEs is sustained and grown to fulfil its existential significance of job creation and substantial contribution to national GDP through the aggregation of small businesses? Measures have to be sought that will ensure the business continuity and growth of these small manufacturing enterprises; measures such as an effective management of its production input resources, and critical of all, energy.

1.1.3 Business profitability - a measure of success

The ability to endure in a much more environmentally conscious manner whilst containing social and economic challenges entails long-term economic success balanced with social wellbeing and a safe environment. This in essence defines what business sustainability is for a business to be profitable.

A measure of business profitability and sustainability is based on a number of defined metrics and indicators that include among others, business continuity and expansion, job creation and profit taking. Identifying what elements contribute to this profitability is crucial. The converse to this would be identifying those elements that contribute to business failure.

An article by Peacock (2000) entitled 'Failure and assistance of small firms' reviewed small business failures and failure rates. He identified two types of failures; namely financial failure and legal failure (Peacock, 2000). Financial failure implied that a business earned a rate of return on investment which was insufficient to cover its opportunity cost, whereas legal failure meant a business was liquidated or its owner declared bankruptcy (Peacock, 2000). Therefore, in defining what business profitability and sustainability is, the above reasoning is taken into consideration. Other measures of business profitability and sustainability would include business stagnation, compression or expansion. Business profitability is directly influenced by resource use and consumption; wastefully or efficiently.

The cost of doing business, and especially the manufacturing of products, has become more and more expensive and constrictive; particularly for small manufacturers. Efficiency drives both for efficient resource utilisation and production process efficiencies, cost savings, free resources and ways on how to access different funds and financing options, including tax rebates, are what are set to help these small manufacturers.

Significant strides have been made towards availing small business with growth prospects, such as access to cheap finance and small business management training. However, very little, if any at all, has been done in identifying the linkage between energy management in small businesses and profitability. This failure has necessitated the need for up-skilling and training of small business owners and workers on energy management.

The impact of energy security on business has recently been identified. This is additional to understanding the relationship between productivity and profitability. What remains unexplored is the introduction of energy management best practices in small businesses in

mitigating against rising energy costs. When such rising costs are contained or discounted through various measures, this contributes to a business's profitability.

1.1.4 Identifying energy as a cost

Energy is without any doubt a real cost to all business, and more so for a small business. Energy costs across all businesses contribute between 15 and 25% of total production costs with approximately 5-15% of total energy consumption in most small manufacturing enterprises being the baseload. For a small business with a target gross profit margin of between 10 and 15%, having to contain an annual energy cost of approximately 1% of gross profit margin is an imperative.

Electricity price increases contributed to 440,000 small business closures in the five years to 2011 (Secombe, 2013). Electricity consumption cost is just one of many business cost contributors. South Africa has experienced an effective electricity tariff increase of over 170% from 2009. But according to the Multiyear Price Determination (MYPD timelines), electricity prices are still not yet cost reflective and so will continue to rise.

Whilst in the past, business traditionally focused on raw materials and labour costs as the core inputs into the total production cost, energy has emerged as a considerable production cost input. There is now as much consideration and attention to any price increase of the energy resource as there are for raw materials as a commodity and human resources as labour.

There is, however, a very close correlation between raw material, labour and energy. The results of a study conducted by Ziramba (2009) implied that industrial production (use of raw material) and employment (labour) are long-run forcing variables for electricity consumption. A study conducted by Inglesi-Lotz and Blignaut (2011) showed that the electricity consumption behaviour of the manufacturing sector is sensitive to price fluctuations. More relevant though, the study also indicated that electricity is an irreplaceable input for the manufacturing sector especially (Inglesi-Lotz & Blignaut, 2011).

Figure 1 below illustrates the annual percentage increase in Eskom's electricity pricing from 2001 to 2012.

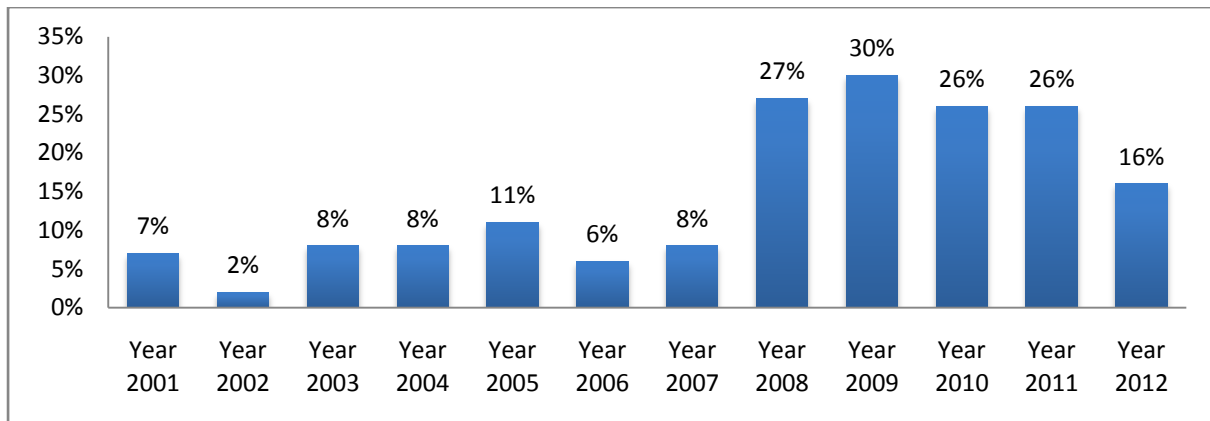


Figure 1 Annual Eskom's percentage increase (ESKOM)

Post 2008, the South African energy crisis ushered in a wave of energy price increases in part to raise capital for the much needed new-build power projects. As already mentioned, from 2009 to 2012 there was an effective 170% energy price increase. This is as evidenced in Figure 1 above.

This energy price increase had a massive impact on business' total production input costs. Small business by default did and still do not have the built-in resilience for such price shocks. This inadvertently led to some business closures for those small businesses that could not remain competitive and profitable.

Despite having a very serious threat to business profitability, i.e. energy costs eroding profit margins, small business have not proactively addressed this threat. Energy awareness, energy management and technical skills to manage energy are still lacking in SMMEs.

1.2 Energy management for small manufacturers

1.2.1 Energy management concept

Energy management principally relates to a process or means of controlling and reducing energy consumption; energy consumption reduction that can be achieved by either energy conservation and/or energy efficiency. Integral to the energy management concept is a means to measure and monitor energy consumption, aptly known as MMTR – measuring, monitoring, targeting and reporting.

Controlling and reducing an organisation's energy consumption is important in order to:

- **Reduce costs** – this is becoming increasingly important as energy costs rise.
- **Reduce carbon emissions** and the environmental damage that they cause - as well as the cost-related implications of carbon taxes and the like. An organisation's attempt at reducing its carbon footprint to promote a 'green' sustainable image is often good for the bottom line.
- **Reduce risk** – the more energy consumed, the greater the risk that energy price increases or supply shortages could seriously affect business operations and productivity as well as its profitability, or even make it impossible for any business/organisation to continue in operation. With energy management one can reduce this risk by *reducing* your demand for energy and by *controlling* it so as to make it more predictable (BizEE Software Ltd., 2010).

Energy management involves both energy conservation best practices (zero to low cost) as well as energy efficiency technologies (medium to high cost interventions). Aggressive energy management programmes with little to no required capital expenditure (Capex) have energy savings of between 5 and 15%, and retrofit activities have 30-70% energy savings (Capehart, Turner & Kennedy, 2008).

Energy is one resource that is commonplace in all production facilities. The Department of Energy (DOE, 2005) estimates that common plant systems use about 80% of all industrial energy. The DOE (2005) further estimates that it is possible to reduce energy use in these systems by 10 - 20%. Energy management opportunities to realise these savings include both human (behavioural change) as well as technological (EE plant systems) (DOE, 2005).

In order to realise this quantum of savings, common plant systems should focus on the following (Lime Energy, 2013):

- Motors and pumps.
- Compressed air.
- Steam generation.
- Process heating and cooling.

These are typically the same plant systems that are prevalent within small manufacturing enterprises. Energy savings are almost certain, but only vary in magnitude in small manufacturing enterprises that have not adopted any energy management solutions focusing on systems, processes and/or practices.

It is therefore imperative for small manufacturing enterprises to focus on optimising the energy performance of their common plant systems. Any energy and cost savings realised are better than none at all as long as the cost incurred at realising these savings is far less than the savings earned. These aggregated savings contribute to the business bottom-line and profitability.

There are significant benefits to be realised in terms of energy consumption reduction and accrual of cost savings to a small manufacturing enterprise that implements an energy management programme. Energy cost savings impact on profitability and consequently contribute to the overall business bottom-line and continued operation and sustainability.

1.2.2 Business support programmes in South Africa

Small manufacturing enterprises are for the most part aware of their skyrocketing production costs as a result of the rising energy costs. They are also cognisant of the business risk associated with energy supplies. Despite this awareness of the problem, small manufacturing enterprises remain unclear of what proactive action to take.

The introduction of energy management solutions that are supported both by policy and innovation is crucial. It is crucial to identify any such type of support that is available for the adoption and implementation of energy management in small manufacturing enterprises. Purposefully structured programmes for small manufacturing enterprises are lacking.

Information sourced from the Department of Trade and Industry's web page yields that the South African Government, through the Department of Trade and Industry, has initiated several technical and non-technical programmes and incentives aimed at supporting small businesses with their sustainability and continued operation (DTI, 2014).

Financial and non-financial support services to small enterprises are offered by established institutions such as:

- Small Enterprise Development Agency (Seda).
- South African Micro-Finance Apex Fund (Samaf).
- Khula Enterprise Finance Limited (Khula).
- National Empowerment Fund (NEF).
- Industrial Development Corporation (IDC).
- National Youth Development Agency (NYDA).

- Land Bank.
- Mafisa.

Related programmes administered by some of the other established institutions include the following:

- Black Business Supplier Development Programme (BBSDP).
- Co-operative Incentive Scheme (CIS).
- Incubation Support Programme (ISP).
- Seda Technology Programme (STP).
- Small Medium Enterprise Development Programme (SMEDP).
- Technology and Human Resources for Industry Programme (THRIP).

The Black Management Forum (BMF) has been focusing on the development of managerial leadership, accounting, business management and labour issues among others as areas to assist small business in developing competences (BMF, n.d.). But yet no such effort has been targeted at ensuring that energy management is entrenched in a small business's way of doing business.

The R800m Green Fund set aside by Government through the Department of Environmental Affairs (DEA) and administered by the Development Bank of South Africa (DBSA) stands to do very little for small manufacturing enterprises due to the very stringent criteria for funding of innovative projects which are quite uncommon in the small business sector (DEA, 2013).

Sefa, housed by the IDC which is a product of the consolidation of Khula, the South African Micro Finance Apex Fund, and small business activities services has been set up to ease funding constraints on SMEs through funding of up to R3-million per business. But this too does not speak to energy management programmes per se (IDC, n.d.).

SME risk finance company, Business Partners, set aside R1bn for SME development in its 2013/14 financial year. The company's main goal in releasing this money was to further develop the SME sector by financing SME undertakings and providing business infrastructure, advice and aftercare service (SME South Africa, 2013), but yet is still not focused on energy resource management.

There still remains a shortage of programmes and incentives targeted at introducing and supporting energy management programmes within business, and in particular the small

manufacturing sub-sector. Financial support services are more abundant even though they too are aimed at big business.

1.2.3 Energy management programmes in South Africa

Clearly, most, if not all, the current support programmes are aimed at offering non-technical support to business, including small manufacturers. There are very few technical support programmes aimed at introducing energy management into the small manufacturing sector despite the fact that energy matters have become business-centric.

The NCPC's (2012) Industrial Energy Efficiency Project (IEEP) is one such programme in South Africa that is aimed at introducing energy management practices within small manufacturing enterprises. The broader objective of the Industrial Energy Efficiency Improvement project in South Africa is to improve the energy efficiency of South African industry while achieving targeted GDP growth, and to improve the productivity and competitiveness of industrial companies.

The Industrial Energy Efficiency Project's (IEEP) key component is creating energy efficiency awareness in industry. According to the NCPC-SA's organisational highlights publication of 2012, the IEE Project launched during the 2010/11 financial year saw the implementation in 2012 of energy strategies and interventions that were initiated in the previous year, resulting in a total of 3.2 MWh energy savings (NCPC, 2012).

Table 2 below highlights the assessment results attained from small manufacturing enterprises (SME) energy audits conducted in 2012 by the NCPC's IEE programme.

Table 2 NCPC IEEP's sme energy audits results (NCPC)

Sector of SME	Annual savings		Investment	Payback
	kWh	ZAR	ZAR	Years
Clothing	735 185	794 000	246 000	0 – 4
Footwear	322 222	348 000	34 000	0 – 1
Engineering	58 519	63 200	60 000	1 – 3
Printing	395 926	427 600	530 000	1 - 3
Footwear	342 000	369 000	325 000	0 - 2

Sector of SME	Annual savings		Investment	Payback
	kWh	ZAR	ZAR	Years
Chemicals	711 111	320 000	262 000	0 - 3
Industrial textiles	354 912	550 000	277 500	0 – 3
Metals/ Engineering	132 662	80 000	85 000	0 – 2
Textiles	163 100	190 000	75 200	1 – 3
Total	3 215 637	3 142 800		

The energy management opportunities (EMOs) identified ranged from behavioural changes, operational and maintenance regime changes, right through to technology swap outs with energy efficient technologies. Energy management as a business function is also motivated for.

Table 2 above provides for business cases to be developed given the payback periods of between 0 and 4 years which fall within most businesses' hurdle rates. The kWh savings indicate only theoretical savings until actual energy retrofit projects are undertaken.

The assessment results indicate that energy savings alone do not explicitly show the resulting business profitability. Business profitability attainment as a result of conducting energy audits and implementation of energy management solutions in the small manufacturing enterprises (SME) is implied only.

It would therefore be important for the programme to indicate how many businesses were rescued from closure through this energy management programme. This would be conducted under the programme's Monitoring and Evaluation (M&E) exercise or via a purpose-designed follow-up service to these companies that had been audited and had had a report presented to them.

1.2.4 Energy management programmes outside of South Africa

Further afield, similar programmes are devised for the small manufacturing enterprises. The European Bank for Reconstruction and Development (EBRD), through its small business support (SBS) programme, has embarked on practical solutions to help small manufacturing enterprises lower their energy costs.

In Romania, where SMEs perform very badly against international averages with energy consumption being four times the EU average, mainly attributed to the obsolete technologies and little knowledge of alternatives, energy efficiency has been identified as a very important issue (EBRD, 2012).

In the United States of America, both Government and private initiatives exist in support of energy management in small businesses. According to The Green Manufacturer (n.d.), a publishing affiliate of the fabricators and manufacturers association, it has been identified that global energy management practices and standards increase plant profitability. Energy management has been shown to be a cost-effective, practical approach to improving energy efficiency in the manufacturing sector, where energy use can have a significant impact on product and operating costs. It has also been seen that with a standard set of energy management practices, applied to small enterprises, organisational performance and profitability can be increased (The Green Manufacturer, n.d.).

Government programmes such as the one anchored by the US Small Business Administration (US SBA) proposes energy management basics for small and medium sized manufacturers. A 5-step approach based on the Energy Star programme is available to small businesses to assist them in developing long-term energy management strategies for energy and cost savings (US SBA, n.d.).

1.3 Current practices and research

1.3.1 International perspective

The sustainable use of resources, guided by environmental policies and instruments focusing primarily on compliance with regard to emissions, energy efficiency, and the reduction of waste and wastewater, has been on the political agenda for over 30 years. With emissions limitations respected, and the use of resources per European inhabitant practically stabilised since 1980s, whilst in the same time experiencing a 50% economic growth, it can be said that nowadays industrial companies have successfully responded to this challenge.

Internationally, increased attention has been paid to the potential depletion of abiotic resources and the rising costs of raw materials over the last 10 years as a result. Raw materials represent the largest cost for manufacturing companies at 35-40% of total production cost, with labour costs accounting for about 20%, followed by energy costs at 10-

15%. With energy and material costs being identified as critical cost factors for a manufacturing company, a company's competitiveness in the global context will be determined by its efficient resource utilisation capacity.

Despite the clear environmental and economic advantages that can be achieved with the implementation of resource efficiency measures, manufacturing small medium enterprises have been slow at adoption. The main reasons for this failure to adopt resource efficiency measures have been identified as:

- SME decision makers' lack of resource efficiency and process optimisation awareness.
- Production process benchmark data insufficiency, inadequate alternative technologies database, lifecycle and recycling data, as well as product and material impact assessment.
- Access to technologies and innovative solutions knowledge gaps, unexplored opportunities of supply and production chains and across industry sectors cooperation (Greenovate! Europe, 2012).

1.3.2 Country perspective - India

By way of a country example, India's small-scale industry (SSI) sector factories have been observed to be less process and energy efficient than larger enterprises. When compared with other enterprises of equivalent capacity in other countries, these Indian small scale sector factories are again seen to be less resource and process efficient. Environmental management is generally disregarded in these small-scale units (Sethi & Pal, 2001).

There is evidently a lack of technical capacity in these enterprises that translates into a poor energy and environmental performance indication. There is also a lack of technical capacity to identify, assess, adapt and adopt better technologies and operating practices that would result in energy and environmental performance improvement (Sethi & Pal, 2001). Despite the evidence presented through case studies which point to the improvement in productivity as a result of employing an enhanced energy management in these enterprises, the uptake of this win-win potential is seldom actualised (Sethi & Pal, 2001)..

The small-scale industry (SSI) sector has been identified as a very important segment in the Indian industrial sector that continues to play a very crucial role in the Indian economy now and in the future. The benefits of looking at small-scale industry by using the concept of

'collective efficiency' were clearly brought into the case studies in the three energy intensive small-scale sectors (foundries, glass and brick) (Sethi & Pal, 2001).

The combined advantages that the SSI units would experience as a result of joint action present advantages. A cluster-based approach is therefore said to be one of the most effective means for demonstrating the benefits of energy conservation and productivity improvement in small-scale industries (Sethi & Pal, 2001). At a cluster level, learning is fairly fast, resulting in the formal and informal embedment of these practices into the existing organisational structures in the clusters (Sethi & Pal, 2001).

1.3.3 South African perspective

In South Africa, the effective management of energy still remains not fully explored and exploited despite the evidently increasing energy costs, as well as energy security and environmental concerns. The small, medium and micro enterprises sub-sector is one of the largest by number of business units, resulting in an aggregated significant energy-consuming sub-sector within the commercial and industrial sectors of the economy.

The SMME sub-sector presents great potential for energy savings and provision of relief on the constrained power infrastructure capacity, competing financial demands, and fast-depleting natural resources. It again begs the question as to why this sub-sector has not been proactively targeted for energy consumption and demand reduction.

The South African economy is very energy-intensive from its minerals extraction and processing right through to its primary manufacturing activities that demand much energy input. Historically, very low electricity prices in South Africa put the industrial sector in a much more competitive position internationally but this also meant that there was very little incentive to minimise energy wastage and save energy resources (Department of Energy, 2010).

This entire outlook of low energy prices and abundant energy resources changed post 2008 after the country experienced massive load-shedding and supply curtailments to industry. Every effort was being made to find short- to long-term solutions to the energy crisis that presented. The greatest effect of the energy crisis was felt in the heavily energy-dependant sectors such as the industrial and commercial sectors.

The industrial sector, within which are the small manufacturing enterprises, is a significant user of energy; accounting for more than 60% of the national electricity usage using 2006 data (DOE SA, 2010). Herein lies the potential for the largest energy and cost savings to be realised by employing energy management best practices.

As already alluded to earlier, the small manufacturing enterprise cluster within the SMME sub-sector of the commercial and industrial (C & I) sector is the cluster with extensive energy consumption by aggregation. There is therefore a need to introduce cross-cutting energy management solutions that are supported both by policy and innovation.

Whilst on the one hand the aggregation of the resulting energy savings after successful implementation of energy management solutions improves the profitability and sustainability of the SMME sub-sector, on the other hand it also frees up energy resources for increased economic activity and growth elsewhere. Small manufacturing enterprises still lack full control of their energy resources. They are, however, becoming aware of their rising production costs as well as the business risk associated with energy supplies. However, small manufacturing enterprises still remain unclear about what proactive action to take. For these small manufacturing enterprises, prudent energy management will prove decisive for their competitiveness, improved security of supply, and business continuity.

1.3.4 Gap analysis

In South Africa, as in the rest of Africa and the world, energy costs have been rising with no sign of ever slowing down or regressing. This rise in energy prices is not purely as a consequence of increasing demand fast outstripping supply but also of natural energy resources that are becoming progressively more difficult to harness and process in an environmentally-friendly manner and cost-effectively.

The year 2008 was the year South Africa woke up to the reality that energy was indeed a finite resource and that the continued exploitation of the resource was not sustainable. This pointed to the need to find other energy sources. An alternative energy source that has been identified is the creation of 'virtual power plants' where 'negawatts' are generated. Energy efficiency provides this solution. 'Negawatts' are effectively the unused energy freed up through energy efficiency. An aggregation of these 'negawatts' is pooled into virtual power plants with no infrastructure costs involved.

The South African energy crisis of 2008 also ushered in a new wave of energy price increases motivated by the need for putting up new plants. Load-shedding, as well as power rationing, that impacted on business productivity became the norm. For businesses depending on making their profits from the sale of their produce produced with energy as a critical input, this power disruption proved detrimental to the business' survival. This posed an energy security concern that needed a definite solution without postponing the problem.

Could businesses afford to curtail their production capacity in line with the available power supply or would they find alternative energy sources? The idea of 'negawatts' slowly started to take root. Energy efficiency as a concept to generate these 'negawatts' was presented to energy consumers to allow them to use less of the energy resource but still maintain their activity levels. This posed a challenge of how to incorporate this energy efficiency concept into mainstream business.

Alongside energy efficiency, energy conservation practices were also being promulgated. Both energy efficiency and energy conservation result in energy consumption reduction; therein comes a need to integrate the two under one principle of energy management. Energy management becomes the process or means of monitoring, controlling and conserving energy and using energy more efficiently in order to reduce energy consumption.

The business imperative to remain viable entails a number of management competencies, with some competencies more recognised than others. Though competencies such as product innovation and strategic raw material sourcing can be identified as commonplace in most businesses, a concerted effort towards the management of energy resources is often secondary or totally ignored. Energy management as an inherent business capability is lacking, especially in small manufacturing enterprises. The skills most prevalent in small manufacturing enterprises are mainly managerial, accounting, production and personnel management, with very little motivation for energy management.

Within businesses, especially small manufacturing enterprises, the priority is towards pushing products out of the door with very little to no regard for the contributing factors to the total production costs; production costs which include energy cost, raw materials and labour. The energy cost is still to be recognised as a critical production cost component that needs to be managed. Energy consumption and costs need to be identified as business elements with potential to impact on a business' bottom-line.

The Small Business Project's SMME growth index found that the SMME economy in South Africa is largely stagnant due to the fast rate at which new SMMEs form and fail (Business Environment Specialists, 2012). With so many surveys commissioned and conducted in the SMME sub-sector, there still lacks a focused survey on the energy-related behaviour and perception in the South African industrial sector.

A worthy survey would be one to assess and quantify the impact that adopting and implementing energy management would have in a small manufacturing enterprise. The SME Survey (Pty) Ltd conducts various surveys, led by Arthur Goldstuck of World Wide Worx, that mostly focus on Information and Communication Technologies (ICT). This similar type of research ought to be conducted for assessing the energy management impact on small business. To date, no known social research on the impact of energy management on small businesses has been conducted that the researcher could find. There also has not been any technical/academic research conducted in South Africa that the researcher could find that examined energy management in small manufacturers and its resulting impact on profitability.

The literature survey conducted by the researcher also did not yield any study reports on the correlation between the implementation of sound energy management practices and processes, and the resulting containment and/or absorption of energy price increases. Whilst the impact of energy price increases on business was well researched and documented, nothing on the impact of a counteractive energy management best practice has been done to date.

Several studies have been conducted to show the impact that energy, and in particular electricity price increases, has on business. Deloitte (2012) conducted a study to examine the economic impact of electricity price increases on the various sectors of the South African economy, and the Human Sciences Research Council (HSRC) also conducted similar research in 2008 examining the impact of electricity price increases and rationing on the South African economy.

1.4 Problem statement

The study aims to highlight the various support mechanisms available to the SMME sub-sector, ranging from financial to non-financial. Such support mechanisms are purposely provided to ensure the sustainability of small manufacturing enterprises (SMEs). Though left

out in the core offer of support mechanisms to SMEs, energy management is one such support mechanism being presented as a business imperative with equal significance as, for example, product innovation and raw material efficient utilisation.

The key research objective is to establish whether there is a relationship between energy management and business profitability. The research also focuses on issues surrounding the adoption of Energy Management Systems within small manufacturing enterprises. The research proceeds to present feasible approaches to introducing energy management practices in small manufacturing enterprises through bespoke energy management solutions and a toolbox.

In order to undertake a comprehensive and fully informed research, a number of questions are structured:

1. How receptive are small manufacturers to the introduction of energy management practices in their operations (an attitudinal analysis)?
2. How does one define energy management in a business context and then customise it for the SMME?
3. How does one deploy a sustainable energy management process and system in a small manufacturing enterprise?
4. How does one measure the profitability of a small manufacturing enterprise?
5. Does energy management improve the profitability of a small manufacturing enterprise, and will business profitability result in business sustainability?

1.5 Methodology

The research design to effectively achieve the research objectives is noted as being based on a mixed methodology of qualitative and quantitative analyses. At a high level, the analyses will be based on case studies and the activities include the following:

- Review of existing energy policy, strategy and operational plans of the case study.
- Data analysis and commentary on energy performance.
- Conduct a thorough site visit and assess major energy using systems and benchmark against best practice.
- Model cost and environmental impact of the existing systems.

- Provide a prioritised, costed action plan of recommendations that will improve energy performance.
- Outline cost-benefit analysis for business case development and investment.

1.6 Conclusion

This introductory section of the study report comprises a background to the research. An overview of what an SMME is, and SA's definition of a small manufacturing enterprise (*sme*) for the purpose of this research is also given. An overview of energy management in general was provided and as it relates to small businesses, specifically small manufacturing enterprises.

This chapter further alluded to what support programmes have been rolled out in the energy management space, especially in relation to small business. This chapter also highlighted the current practices of energy management in small manufacturers, and examined what research has been conducted regarding the subject matter 'energy management in small manufacturers' and the question as to whether energy management leads to the improvement of a small manufacturer's profitability.

This section of the report led to presenting the problem statement, research motivation and study aim and purpose. The problem statement; i.e. to establish whether there is a relationship between energy management and business profitability in small manufacturing enterprises, was stated. The research design to effectively achieve the research objectives was noted as being based on a mixed methodology of qualitative and quantitative analyses.

1.7 Overview of this document

The second section of the document is aptly headed as 'Energy management approach for small manufacturing enterprises'. This section sets out with a preamble that examines the inherent exposure to risks that small manufacturers face on the one hand, and the likely ease of adoption of energy management practices by small manufacturers on the other hand.

It proceeds to give an overview of what energy management is and how it can be adopted in the daily operations of small manufacturing enterprises. A suite of the available energy management programmes is presented and a methodology on how energy management best practice can be adapted for South Africa is then proposed.

Section three of the document presents the two case studies on which this study is principally based. This section commences by giving an introductory background to the two small manufacturing enterprises, describing the nature of business and product line as well as the operational set up. It proceeds to delve into the quantitative analysis by reviewing the historical data and onsite data gathered for both companies. Historical and onsite data logged and profiled for significant energy users (SEUs) are presented. A business case for the implementation of energy saving measures/recommendations is developed and presented as energy efficiency projects for company consideration.

In section four of the document, the case study results are presented and compared with commentary provided. Verification and validation of the study results is also explained. This is then followed by providing the significance of the study as exemplified by its practical applications.

The research concludes with a presentation of the study overview, a summary of the report findings, as well as the significance of the research. Beneficiaries to the study are identified with an indication of what the limitations of the study are and points out what could be opportunities for further research.

2 ENERGY MANAGEMENT APPROACH FOR SMALL MANUFACTURING ENTERPRISES

2.1 Preamble

As already alluded to in Chapter 1, energy costs across all business sectors contribute significantly to total production costs. Energy is no longer considered as merely an overhead. It is not also being seen as a fixed cost for which nothing can be done to reduce it, but as a variable cost that can be managed. Energy costs are now viewed with the same business relevance as raw materials and labour; but this is only so for big business. Small businesses by far still consider raw materials and labour as their only production input costs worthy of note.

With the continued rise in energy prices, small manufacturing enterprises need to find means and ways to mitigate against these price increases. Effective management of energy as a resource would result in both less wastage and an efficient utilisation of the energy resource. This would translate into paying a lower energy bill and producing and selling more products for less energy consumed.

Small manufacturing enterprises, by virtue of their inexperience at effectively managing energy resources, are prone to easily suffer the negative impact to business of any increases in energy prices, threats of energy scarcity, as well as the cost implications from environmental impacts of the use of energy resources such as carbon tax impositions. Both energy security and energy cost concerns are best addressed when an Energy Management System is put in place. For any business, knowing when and where to source energy as well as understanding where and how to consume it, are business imperatives and can result in a competitive edge.

Small manufacturing enterprises are by design 'one-man shows' that entail an expedited decision-making process. This implies that management commitment to energy management can be easier than in a highly bureaucratic business burdened by red tape. The first step to adopting energy management as a way integral to any business process is for senior management to commit to it.

2.2 Adoption of energy management in a small manufacturing enterprise

Small manufacturing enterprises often have a one-stop decision point; its one business owner. This in itself lends to a very effective decision-making process that is without extensive consultation. With the relative ease of the adoption of energy management in small businesses, the single most important ingredient for successful implementation and operation of energy management is management commitment; much easier if it only involves one person to make that decision and commitment.

The energy and costs associated with producing a product are often recovered when the finished product is sold and production costs are recovered together with a reasonable profit margin on the product. Therefore products that are becoming very expensive to manufacture but yet not sold at a premium price to recover all costs plus margin could result in a business making a loss.

With approximately 5 - 15% of total energy consumption being baseload (energy consumed at zero production) in most small manufacturing enterprises (*smes*), it becomes important for business to identify means and ways to reduce this baseload to close to zero. Baseload consumption and associated costs are costs that are not recouped directly from the sale of the product.

To effectively reduce baseload consumption and associated costs, one has to first identify areas of 'quick wins' and insignificance to the core of the business which is production. Typical SME load comprises production machinery, utilities (compressed air, chilled water, process heating and cooling), conveying, lifting, indoor climate conditioning, and lighting.

Production machinery/ tools which typically constitute the SEUs contribute approximately 40-50% of total plant load. With the tools of production or plant machinery's energy consumption often being associated with the actual product throughput, optimisation of the remaining 50% of non-production related load is where one needs to start in reducing baseload.

Small manufacturing enterprises therefore need to start looking at energy management as integral to their management processes and activities. The art of understanding how and where they use their energy, and finding means and ways to reduce energy wastage and

costs is borne out of embracing a systematic and holistic approach to managing their energy resource.

A systematic and holistic approach to how small manufacturing enterprises should manage their energy resource should start with them first understanding what energy consuming-systems and processes they have. Typical manufacturing sub-sector systems and processes are given in Table 3 below:

Table 3 Manufacturing sub-sector applicable systems & processes (adapted from Chemonic Int. Inc.)

Manufacturing sub-sector	Applicable system processes
Agro-processing	Lighting, motors, compressed air, steam systems, cooling systems, HVAC
Automotive	Lighting, motors, compressed air, steam systems, water heating, HVAC
Metal & engineering	Lighting, motors, water heating, steam systems, HVAC
Plastics, chemicals & pharmaceuticals	Lighting, motors, steam systems, compressed air, HVAC
Clothing textiles, footwear and leather	Lighting, motors, compressed air, HVAC, water heating

Systematic ways in which energy management practices and processes can be adopted are often available in varying forms and styles. Typically, it starts with management accepting that they need to do something about their energy resource. It then follows a transparent socialisation programme to all staff. Human and technological aspects to energy management are quickly recognised and tabled for further review. The process of adoption has to be unique for each case, though the framework of an Energy Management System remains the same but adaptable.

Knowing what energy systems are operational is just as critical as understanding that the influencers of the energy usage are typically all the users. Plant operators are therefore as important to review as the machinery and equipment they operate. Office staff that use little

power also need energy awareness training because by aggregation any amount of energy saved is important, especially for small manufacturers.

Figure 2 below illustrates the adoption of energy management that starts with making the commitment and remains a continuous process of a plan-do-check-act Deming cycle principle.

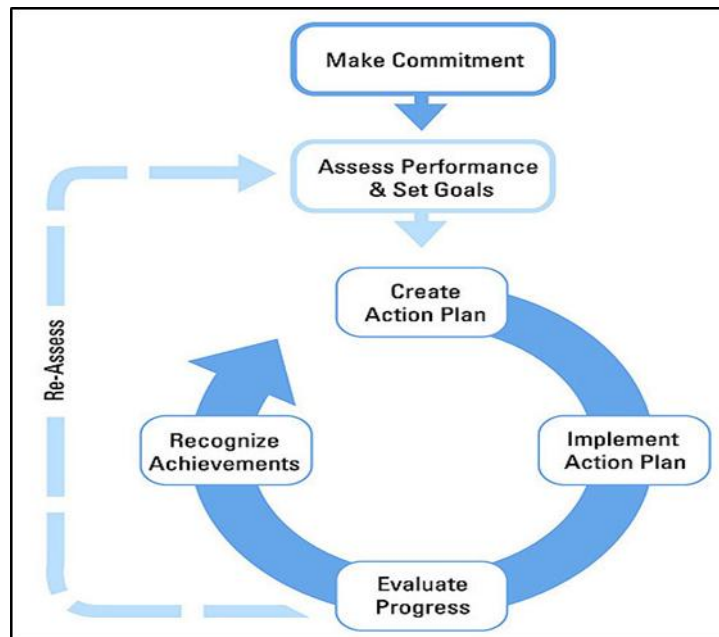


Figure 2 Energy Star guidelines for EM (EPA, n.d.)

The benefits of implementing an Energy Management System include the added benefit of continuous business improvement as well as a focus on implementable action plans that result in improved performance and savings. Implementable energy management plans result into actual savings once the identified opportunities have been carried out. For the comfort of any business that embarks on any energy management programme, various studies and industry best practice have arrived at energy savings potentials per technology and/or energy system.

Based on the type of equipment, energy systems, and processes in a facility, an estimate of the potential energy savings can be done with confidence. Energy system optimisation is conducted following an energy assessment that points to the areas of wastage or inefficiencies.

An estimate of the energy savings and payback period can be given per available energy efficiency measure or intervention. It is therefore possible to motivate small manufacturing enterprises to consider investing both their time and financial resources towards first adopting a holistic approach to managing their energy and following a programmatic approach to energy management.

Knowing what magnitude of savings one expects as well as having an idea of the payback periods can definitely motivate for action. USAID's Energy Efficiency mapping study (as cited by Chemonix International Inc, 2012) points to such savings potential, as Table 4 below illustrates:

Table 4 EE savings potentials and paybacks (adapted from Chemonix Int. Inc., 2012)

System	Available EE	Potential energy savings reached	Payback period
Heating, ventilation and air-conditioning (HVAC) systems	Maintenance of various components of HVAC system	20%	<3 years
	Retrofitting HVAC systems	20 - 30%	5 years
	Using alternative HVAC systems such as heat pumps or central air conditioning units that have a higher coefficient of performance	30 - 42.5%	5 years
Lighting	Replacing magnetic ballasts with electronic ballasts; replacing incandescent, halogen and mercury vapour lights with CFLs and LED lighting.	40%	3.6 years
Water heating	Replacing electrical geysers with solar water heaters	63%	5 years
	Replacing electrical geysers with heat pumps	67%	3 - 5 years
Compressed air	Optimising air usage, reducing air leakage, optimising system operating pressure and increasing compressor inlet pressure	20-40%	1-2 years
Motors	Replacement of motor belt drives with variable speed drives	5-10%	7 years
	Installing energy efficient motors	5-7%	6 years

System	Available EE	Potential energy savings reached	Payback period
Steam systems	Steam trap maintenance, improved boiler efficiency, isolating steam from unused lines, repairing steam leaks, optimising condensate return, minimizing vented steam	20%	1.4 years

The International Organisation for Standardisation (ISO) has identified energy management as a priority area meriting the development and promotion of an International Standard. The ISO 50001(2011) energy management standard has been developed as a framework for industrial facilities, commercial facilities, or entire organisations to manage energy - including all aspects of energy procurement and use. It provides a standardised approach to energy management. ISO 50001 (2011) specifies requirements for establishing, implementing, maintaining, and improving an Energy Management System whose purpose is to enable an organisation to follow a systematic approach in achieving continual improvement of energy performance, including energy efficiency, energy use and consumption.

2.3 Leveraging available energy management programmes

Globally, as well as locally, not much has been done to promulgate energy management best practices and supporting programmes into the small business sub-sector and in particular within small manufacturing enterprises. In as much as there are various programmes and support mechanisms for energy management aimed at large businesses that are identified as Energy Intensive Users (EIU), small businesses are often left to fend for themselves.

The adaptation of such programmes aimed at large business to suit small business involves over-simplification of intent. In as much as large corporations have in their integrated reporting a focus on the environment and social equity as part of the triple-bottom line, small business are more concerned about their financial implications. Therefore, SMEs need to be presented with a financial benefit before adopting any energy management practice.

A motivation put across to any such energy management programme that does not focus on small business but rather on big business is where the aggregated significance of small business is shown when these small businesses, in this case small manufacturing

enterprises', discrete energy spends are rolled into one representing a significant sub-sector of the economy with energy consumption worthy of note.

Clearly these SMEs cannot be ignored when it comes to engaging them with energy awareness and management practices to realise energy saving opportunities. A properly implemented and monitored energy management programme and support facility for small manufacturing enterprises would realise significant energy savings with valuable spin-offs in retained jobs, more jobs created, and profitable businesses that contribute more to GDP.

There are a large number of small manufacturing enterprises that are likely to embark on an energy saving journey after being made aware of the benefits of energy management best practices. An aggregation of their resultant discrete energy savings is therefore significant. This has been demonstrated through the National Cleaner Production Centre's (NCPC) Industrial Energy Efficiency Project (IEEP) that in 2012 alone identified an energy saving potential of well over 3.2MWh. Even though these savings would only be realised once energy saving projects are implemented, the cost saving potential does present a good business case for follow through.

Energy management allows for the immediate implementation of low-cost and no-cost interventions, as well as those higher-cost measures with short payback periods. These can be followed by medium-term and longer-term investment opportunities in energy efficiency. Relevant to all economic sectors, several commonplace Energy Management Opportunities (EMOs) have been identified for recommendation in a residential as much as in an industrial or commercial business. These EMOS include, but are not restricted to, the following:

- Intelligent energy management e.g. smart control of Energy Management Systems/smart home automation or Building Management Systems (BMS) and the marriage of IT with energy makes use of the Internet and digital devices to better monitor and control energy use.
- Passive designs, e.g. natural ventilation, use of daylight, building's shape and orientation, thermal mass, solar gains, shading, etc.
- Insulation – loft insulation, cavity wall insulation, double glazing, hot water tank and piping insulation (geyser jackets).
- Heating and cooling efficiency improvements – use of solar water geysers and heat pumps, and use of programmable communicating thermostats.
- Use of efficient pumps and motors.

- Efficient lighting design, e.g. skylights, dimmers, sensors, Light Emitting Diodes (LEDs).
- Behavioural change – for example, in Japan, people only heat one room rather than the whole house (Kaputu, 2010).

There are a number of drivers and barriers to the adoption and implementation of energy management. Some of the identified drivers include, but are not restricted to, the following:

- Fuel standards e.g. low smoke fuel technology.
- Best available technologies (BAT) e.g. improved woodstoves.
- Appliance labelling and standards e.g. Green Star.
- Policy measures, e.g. minimum energy performance standards and labels.
- Standards, e.g. SANS 204-1 (2008).
- Awareness raising programmes, e.g. Eskom's energy awareness road shows and CFL for incandescent swapping programme.
- Financial instruments, e.g. discounts, rebates, tax breaks etc.

Inspired by an extensive review of the existing literature on barriers to energy efficiency, Sorrell (2000) compiled a barrier framework (from various authors, as cited below) and categorised the various barriers as listed below:

- Imperfect information (Howarth & Andersson, 1993): Lack of information may lead to cost-effective energy efficiency measures opportunities being missed.
- Adverse selection (Sanstad & Howarth, 1994; Jaffe & Stavins, 1994): If suppliers know more about the energy performance of goods than purchasers, the purchasers may select goods on the basis of visible aspects such as price.
- Principal-agent relationships (Jaffe & Stavins, 1994): Strict monitoring and control by the principal, since he or she cannot see what the agent is doing, may result in energy efficiency measures being ignored.
- Split incentives (Jaffe & Stavins, 1994; Hirst & Brown, 1990): If a person or department cannot gain benefits from energy efficiency investment it is likely that implementation will be of less interest.
- Hidden costs (Jaffe & Stavins, 1994; Ostertag, 1999): Examples of hidden costs are overhead costs, cost of collecting and analysing information, production disruptions, inconvenience etc.

- Access to capital (Hirst & Brown, 1990; Jaffe and Stavins, 1994): Limited access to capital may prevent energy efficiency measures from being implemented.
- Risk (Hirst & Brown, 1990): Risk aversion may be the reason why energy efficiency measures are constrained by short pay-back criteria.
- Heterogeneity (Jaffe & Stavins, 1994): A technology or measure may be cost-effective in general, but not in all cases.
- Form of information (Stern & Aronsson, 1984): Research has shown that the form of information is critical. Information should be specific, vivid, simple, and personal in order to increase its chances of being accepted.
- Credibility and trust (Stern & Aronsson, 1984): The information source should be credible and trustworthy in order to successfully deliver information regarding energy efficiency measures. If these factors are lacking it will result in inefficient choices.
- Values (Stern, 1992): Efficiency improvements are most likely to be successful if there are individuals with real ambition; preferably represented by a key individual within top management.
- Inertia (Stern & Aronsson, 1984): Individuals who are opponents to change within an organisation may result in overlooking energy efficiency measures that are cost effective.
- Bounded rationality (Sanstad & Howarth, 1994): Instead of being based on perfect information, decisions are made by rule of thumb.
- Power (Sorrell, 2000): Low status of energy management may lead to lower priority of energy issues within organisations.
- Culture (Sorrell, 2000): Organisations may encourage energy efficiency investments by developing a culture characterised by environmental values. Energy efficiency opportunities are frequently overlooked due to the simple fact that industry and other consumers are unaware that they exist.

Clearly, there are a number of barriers to energy management that need to be overcome before any aspect of energy management is adopted and implemented by business. Understanding the nature of barriers one is faced with in motivating for energy management, is as important as knowing what the drivers for energy management are, to counter these barriers.

As an example, the majority of energy consumers currently have imperfect information regarding the range and performance of energy efficient technologies. This inevitably results in poor decision-making when purchasing goods or specifying equipment, and ultimately

leads to energy projects stalling. Understanding the available appliance labels or standards would help in presenting credible support. Case studies with proof of concept also would assist in overcoming the imperfect information barrier.

Business also needs to be made aware of the inherent benefits of undergoing this paradigm shift of embracing energy management; benefits that are focused on the following:

a) Business productivity:

- Energy intensity reductions.
- Operational reliability.
- Additional energy capacity for business expansion.
- Improved economic competitiveness through resource and process efficiency.

b) Business competitiveness:

- Energy and cost savings.
- Energy security.
- Innovation.
- Opportunity to gain advantage over competitors.

c) Business reputation and Corporate Social Responsibility:

- Increased energy efficiency awareness of company and staff.
- Implementation of projects that result in reduction of GHG emissions.
- Indirect social benefits: job creation/job retention and energy efficiency skills development.
- Affording clients with 'low carbon, green products' to meet their green sourcing policy.

d) Financial leverage:

- Capital investment leveraged in energy efficiency from private and public financing (energy performance contracting and shared savings model).
- Reduced payback period through leveraging grants and/or incentives (e.g. Section 12L EE tax incentive).

2.4 Adapting best practices for South Africa

One reason for SMME failure is incapacity to contain rising production costs; one of the most significant of these rising costs is the energy cost. Electricity price increases contributed to 440,000 small business closures in the five years to 2011. South Africa has experienced an effective electricity tariff increase of over 170% from 2009. But still, according to the Multiyear Price Determination (MYPD timelines), electricity prices are not yet cost reflective and so will continue to rise.

Despite the threat to business profitability, that of energy costs eroding profit margins, small businesses have not proactively contained this threat. Energy awareness, energy management, and technical skills to manage energy are still lacking in SMMEs. In mitigation of these rising production costs, businesses ought to find strategic ways to absorb, contain, and offset these rising energy prices.

A systematic approach to an effective management of energy as a resource and a production input would improve business profitability. Best practice for South Africa would be to first acknowledge the small manufacturing sub-sector as a significant energy user worthy of notice in the same measure as the energy intensive user group (EIUG) has been identified, and to ensure that any energy management programme that gets rolled out includes small businesses.

Practices to first create awareness within small businesses of the significance of energy cost as a rising production input cost as well as measures to contain rising energy costs for small businesses ought to be encouraged. Businesses ought to be made aware of the energy prices that will continue to rise now and in the foreseeable future.

Developing case studies that demonstrate energy and cost savings as well as business profitability is what will foster confidence in small businesses to consider energy management as a business imperative. Small manufacturing enterprises are often too busy trying to survive that they miss the very essence of all cost saving measures, including energy management, that lead to business sustainability.

A report by McKinsey (2012) on manufacturing resource productivity alludes to a focus on energy resource optimisation leading to production efficiency improvement. Therefore borrowing from this and such similar reports, a practical set of tools to help manufacturers

capture the resource-productivity prize ought to be developed for South Africa's manufacturing sub-sector.

2.5 Adapting existing energy management tools for SMEnT

In order to ease and simplify how the energy assessment was conducted for this research, several existing energy management tools are reviewed here. A simplified energy management tool was derived and aptly named SMEnT (Small manufacturing enterprise energy management toolbox).

An NCPC pre-site assessment questionnaire (PAQ) that is traditionally used for large energy users was adapted for small energy users. The existing NCPC pre-site assessment questionnaire is too complex and requires too much detail to be completed by the site personnel prior to an energy auditor visiting the site. A complex and highly detailed PAQ in its present form is identified as a bottleneck in the process of assessing small business. In the first instance, small businesses do not have the time to complete a 20-page document. A small business owner neither has the time nor the know-how to correctly complete such a PAQ (NCPC-SA).

In response to this challenge, salient sections of the 20-page PAQ were used to inform the SMEnT. The simplified PAQ was integrated with a standard energy management matrix. The energy management matrix is readily available in the public domain, with the Carbon Trust UK (n.d.) originally credited with its design. The energy management matrix (the 'Matrix') gives an insight into the way a company manages its energy. This Matrix is a tool that helps companies with the assessment of their organisational strengths and weaknesses across the six main areas of energy management, as follows:

- Policy and systems.
- Organising or organisation.
- Skills and knowledge or motivation.
- Information systems.
- Marketing and communications, and training and awareness.
- Investment.

For each component the company will be at level 0 (lowest), 1, 2, 3 or 4 (highest level). The Matrix is adapted into the SMEnT because it presents no challenge to small business in

understanding it. The energy auditor talks the small business through the Matrix and allows the company to score themselves at the same time as the auditors, and the scores are then compared.

2.6 Conclusion

It would therefore be best if there were reasons empirically provided to warrant a focus on any energy management programme at small businesses, and at the same time for small businesses to take notice and internalise this agenda with a new realised purpose; i.e. the purpose of adopting energy management best practices in their daily business operations and activities.

Ironically, small businesses, and in this particular case small manufacturing enterprises, have their typical traditional problems to worry about in manufacturing their products and pushing them out through the doors. Small manufacturing enterprises also have the inherent challenge of staying in business competitively. Introducing energy management as a concept to small manufacturing enterprises could well be perceived as a disruptive and unwelcome nuisance. It is therefore important that a business case around the adoption of energy management practices and processes is developed and sold to small manufacturing enterprises in a manner most acceptable. Bringing SMEs to accept that energy management would add to their resilience and business continuity, alongside all other traditional measures, has to take place in a much more persuasive yet friendly manner. A least cost, least disruptive approach to introducing energy management to SMEs has to be presented if adoption is to be warranted.

Existing case studies from past programmes, either local or international, that show the quantum of energy cost savings that could be realised from the implementation of energy management opportunities ought to be presented. When a business sees the likely gains and also understands the risk of not embarking on such energy management best practices, they would make an informed decision without unnecessary delay.

A bespoke national energy management programme targeted at SMEs would transform the energy sector in general, and yet still have significant spin-offs as value outcomes from the roll-outs of, for example, mass sector-specific technology swap outs, entrenchment of best practice regimes in operations, and maintenance and promoting of energy conservation measures that are sustainable.

Energy management opportunities can be categorised for ease of adoption by business based on their preference and focus. These categories include:

- a) Operational efficiency and behavioural change: Low/no cost savings through measuring and monitoring energy use, staff engagement, and appropriate improvements to the use and maintenance of existing equipment.
- b) Building energy efficiency: Investment in new building technologies including (Carbon Trust, UK, 2011):
 - Controls.
 - Lighting.
 - Heating.
 - Air conditioning and ventilation.
- c) Industrial/process energy efficiency: Investment in new industrial technologies and processes including:
 - Motors and drives.
 - Compressed air.
 - Process controls.
 - Refrigeration.
- d) Renewable energy: Investment in technologies to generate local renewable heat or electricity for self-use:
 - Biomass.
 - Wind.
 - Solar (PV and thermal).
 - CHP.

The following chapter presents the case studies.

3 CASE STUDIES

3.1 Introduction and methodology

The methodology for this thesis includes case studies. The extensive nature and detail involved in the case study confines the study to not more than two. Instead of a high level survey and study of a large sample of small manufacturing enterprises, the survey is restricted to two companies only.

The two case studies presented are of fundamentally similar business models as they both are small manufacturing enterprises that are one-man owned and managed. Both case studies are energy-intensive in the production value chain. Their production cost structure principally comprises raw material and a labour component.

Case studies provide a very practical research process with real-business scenarios. Contrary to what could be theoretical results from a laboratory experiment, the case study presents real-life challenges with replicable solutions. Actions that result in energy savings in one case will, under the same business conditions, realise similar savings.

One site's average energy consumption was approximately 10 times more than that of the other. Both businesses were presented with a motivation to embark on a journey to energy performance improvement. A similar plan of engagement was tabled to the owner of each business for sign-off and the study was performed under similar conditions.

The two case studies presented with typical manufacturing processes and systems such as utilities (compressed air, chilled water, etc.). They also presented with traditional practices and attitudes towards energy usage by the end-users, particularly the shop floor personnel. Operational regimes and maintenance practices of the shop floor away from the watchful eye of management is still one desiring of improvement.

The process of engagement with the case study companies involved a human interaction from management to shop floor in explaining the purpose and intended outcome of the survey. Energy awareness presentations were made to all staff and management on site, including contracted personnel such as cleaners and security guards. This was then followed by a desktop study of the site's energy costs and consumption data. An onsite survey and review of energy systems with data-logging informed the core of the survey.

A review of the historical data and onsite data gathered for both companies provided the quantitative analysis. Historical and onsite data, as well as logged and profiled significant energy users (SEUs), is presented here. A business case for the implementation of energy saving measures/recommendations was developed and presented as energy efficiency projects for company consideration.

3.2 Description of case studies

3.2.1 Karob Plastics - plastic container manufacturers

Karob Plastics is a company specialising in plastic packaging manufacturing. It has been in operation since June 2005 and operates from its own facilities in Stormill Ext. 2 industrial site, west of the Greater Johannesburg Central Business District. The company's contact details are given in Table 5 below:

Table 5 Karob Plastics contact details

Company name	Karob Plastics
Physical Address	17 Spyker Crescent, Stormill Industria Ext.2
Phone	0114741297
Fax	0114741303
Website	http://www.karobplastics.co.za/

Karob Plastics manufactures 5, 20 and 25 litre plastic containers produced in various weights. They also offer a stock holding facility for customers who require a quick turnaround. Karob Plastics currently supply the following chemical industries:

- Agrochemical.
- Petrochemicals.
- Edible oils.
- Household cleaning products.
- Concentrates.
- Food additives.

A. Products

Karob Plastics' containers are available in three different shapes: round, rectangular and square; and can be produced according to various specifications, tailored to suit customers' requirements. Karob Plastics also provides silk screen printing on the containers for customers who require their company information, contact details or directions for use on their packaging. Karob Plastic's product range is shown in Figure 3 below:



Figure 3 Karob Plastics' product range

The site has the following areas:

- Administration offices.
- Ablutions.
- Factory/production area.
- Raw material storage area.
- Finished product storage and loading open area.

The factory comprises two production lines; 5l and 25l containers and 10l bucket lines.

B. Significant Energy Users (SEUs)

- Air Compressor: 2 x 22kW air compressors at pressure setting of 7.5 bar delivering air to its major end-user (blow moulders) each using 4 - 5 bar pressure. One compressor runs continuously (8 500hrs annual) while the other idles.
- Two chiller plants complete with cooling towers (2x4kW, 2x22kW, 2x7.5kW pump motors and 0.55kW x 9 fan motors).
- Injection and blow moulders (various sized motors ranging from 4.9kW up to 30kW rated HEMs on VSDs).
- Vertical batch mixers.
- Electrical resistance - heated shrink wrapper.

- Granulators (for granulation of re-works, recyclables).

C. Site's load breakdown

The site utilities (compressed air, chilled water) contributed approximately 32% of the total load. Plant machinery was over 64%. This breakdown is illustrated in Figure 4 below.

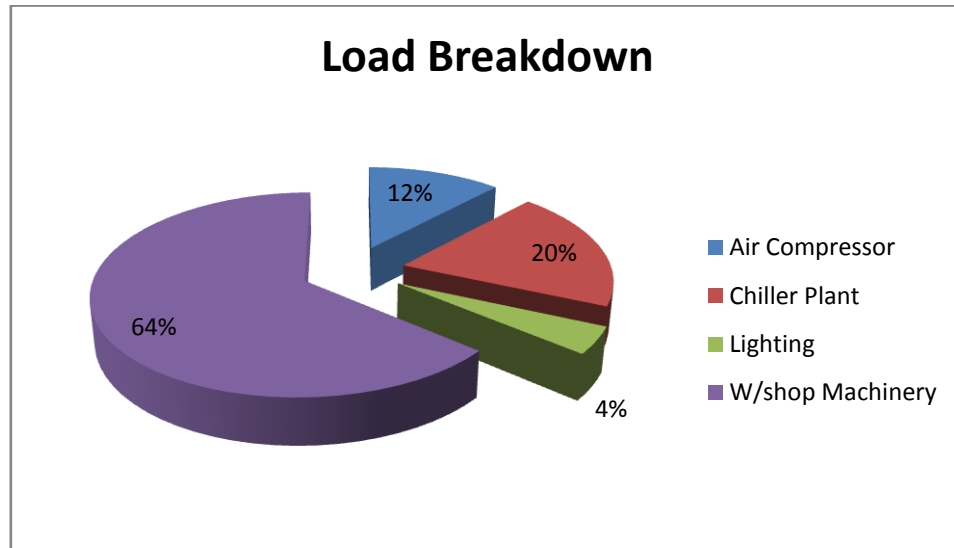


Figure 4 Karob Plastics' load breakdown

Figure 4 above illustrates the load breakdown for Karob Plastics. The percentage of plant machinery of over 64% represents a typical manufacturing facility's load breakdown where machinery often contributes over 50% of total plant load. The utilities of compressed air and chilled water represent 32% of the total plant load. This was a significant load to be focused on during the energy assessments.

D. Site layout

Karob Plastics has five granulators and 12 moulding machines that make up the plant production machinery and are identified as the significant energy users (SEUs). This is shown in Figure 5 below.

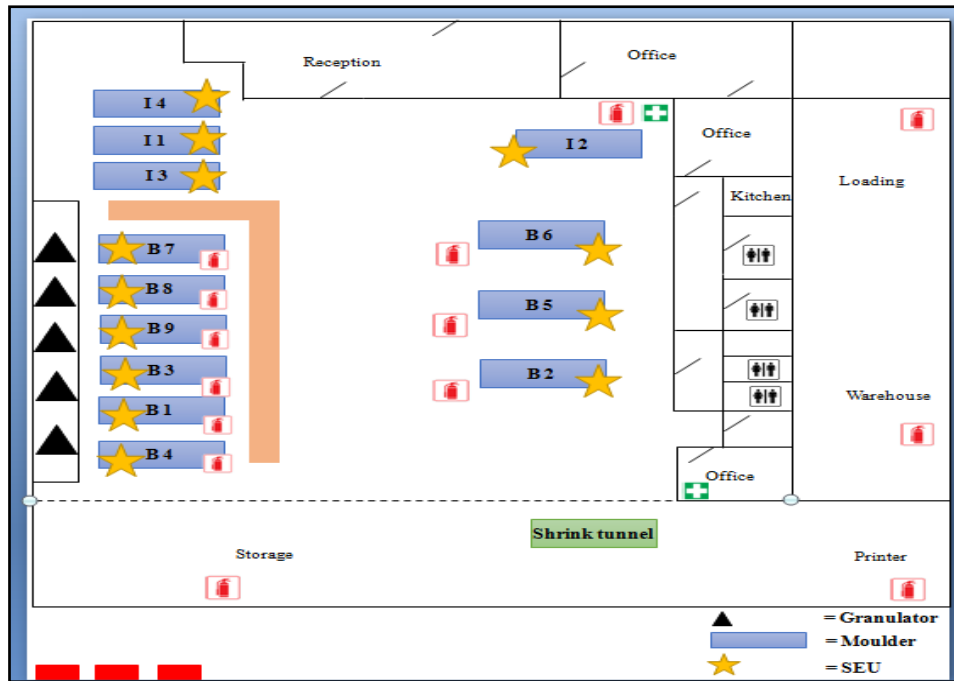


Figure 5 Karob Plastics plant layout (showing position of SEUs)

3.2.2 Staluform - steel & aluminium manufacturers

Staluform, a company specialising in formwork, was established in 1979. Initially, the main line of business focused on general engineering and metal work. Staluform has earned the trust and loyalty of its customers over the years by providing a range of goods and services, from small once-off specials to a 150 cubic meter dust separation plant.

The current emphasis falls on manufacturing of formwork for the construction industry. A secondary focal point is scaffolding and general engineering. To provide a tailor-made service to its customers the capability exists to work in either steel or aluminium. The company's contact details are given in Table 6 below:

Table 6 Staluform's contact details

Company name	Staluform Silverton
Physical Address	6 Aambeeld St, Pretoria, Gauteng 0002
Phone	0128040905
Fax	0128044372
Website	Non available

Staluform also provides a full one-stop service, from product design through to component sourcing and manufacture. The product design is done through their partners AGS Formwork.

A. Products

Standard formwork, special formwork and moulds, kerb moulds, balustrade moulds, custom designed moulds, Kwikstage scaffolding components, and Kwiklock components are the products that Staluform produces. Some of the products are shown in Figure 6 below.



Figure 6 Staluform's product range

The site has the following areas:

- Administration offices.
- Ablutions.
- Factory/ production area.
- Raw material storage area.
- Finished product storage and loading open area.

The factory comprises two fabrication workshops housed in two separate buildings.

B. Significant Energy Users (SEUs)

- Air Compressor: 1 x 25kW air compressor delivering air to a common air line into the factory. Main user of compressed air is a spray booth at ± 5 Bar constant pressure. Compressor pressure is controlled by an ON/ OFF switch.
- Bending press machines (several).
- Oil bath and CO₂ welders (several).

C. Site's load breakdown

The site utility (compressed air) contributed approximately 23% of the total load. Plant machinery was over 45%. This breakdown is illustrated in Figure 7 below.

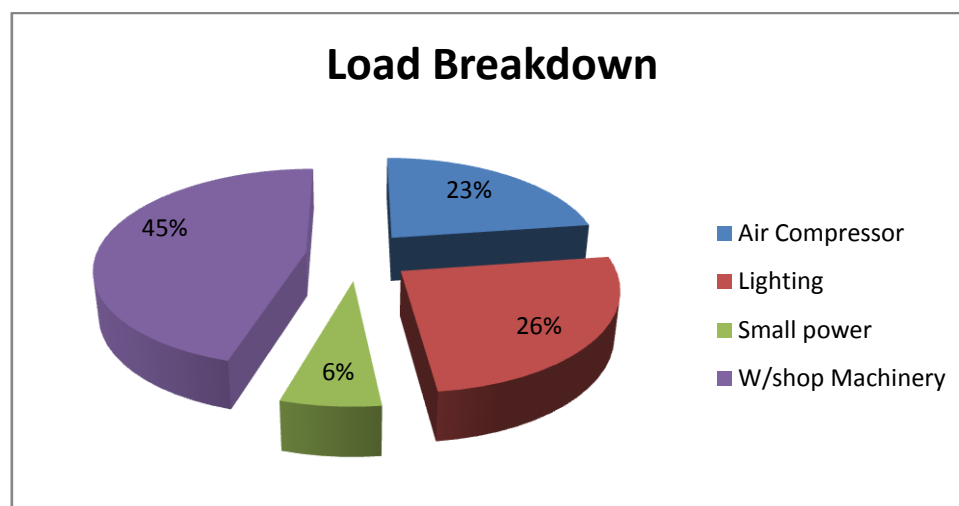


Figure 7 Staluform's load breakdown

Figure 7 above illustrates the load breakdown for Staluform. The percentage of plant machinery of over 45% is close enough to the typical manufacturing facility's load breakdown where machinery often contributes over 50% of total plant load. The utilities of compressed air represent 23% of the total plant load. However, lighting represents 26% of the total plant load. The lighting load is presently of high wattage inefficient lighting with overly lit areas. This was a significant load to be focused on during the energy assessment.

3.3 Historical data analysis and on-site energy assessments

3.3.1 Historical data analysis

As part of the baseline study to establish where a small manufacturing enterprise might be with regard to its energy consumption and use, as well as to derive relevant indicators for its energy performance, an analysis of its existing data was conducted.

3.3.2 On-site energy assessments and energy savings potential

In contrast to the desktop studies of historical data analysis, a more practical exercise involves the actual onsite survey of various aspects of the small manufacturing enterprise,

ranging from an attitudinal review of the plant energy users' (staff) attitude towards plant energy right through to operational and maintenance practices.

The energy site assessment methodology included gathering and compiling detailed site data and electrical energy balances and noting areas for increased optimisation. Attitudinal data was also gathered by way of assessment of the Site Managers' and staff knowledge and attitudes about energy, energy conservation and energy efficiency. This was coupled with an appreciation of the site's operational and maintenance regime.

Change management through staff awareness programmes/energy education was proposed, alongside the implementation of proposed energy saving measures. Staff cooperation is a significant factor in reducing inefficient energy use in an establishment such as a manufacturing site where staff are the energy users, as is the continued commitment of management and communication with staff.

3.4 Measurements, data capture and analysis

3.4.1 Karob Plastics

A. Data capture and measurement

Historical data in the form of electricity bills and production figures were gathered and analysed. The captured data were presented in the form of tables and graphs with the analysis being focused on kWh consumption, kVA demand and Rand cost, as well as at per kilogram production output. Table 7 below captures electricity consumption, demand and total cost for period 2011/12.

Table 7 Karob Plastics 2011/12 Electricity consumption figures

2011	kWh	kVA (MD)	Cost, R
Jun-11	143 758	320.6	143 758
Jul-11	205 802	342.8	243 181
Aug-11	220 639	342.3	255 820
Sep-11	211 274	323.6	183 195
Oct-11	212 574	338.4	186 316
Nov-11	226 570	393.9	203 707

2011	kWh	kVA (MD)	Cost, R
Dec-11	200 574	393.2	188 880
Jan-12	228 233	384.4	203 969
Feb-12	227 503	384	333 284
Mar-12	225 222	378.6	200 586
Apr-12	210 511	400.9	196 005
May-12	232 875	419.7	280 842
TOTAL	2 545 535 kWh		R 2 619 543

Table 7 above captures the electricity consumption for a 12-month period from June 2011 to May 2012. A 12-month period allows for a representative consumption that takes care of seasonality. The average monthly consumption for this period was 212 127kWh. The lowest consumption was recorded in June 2011 of 143 758kWh. The same month of June 2011 recorded the lowest maximum demand of 320.6kVA.

The highest energy cost of R333.28 was recorded in February 2012. This figure needed to be investigated further as the consumption did not correlate with the cost. Clearly this was a case of an overcharge. Based on the calculated Average Unit Price (AUP) of R1.03c/kWh for 2011/12 (calculated as the total energy cost in Rands divided by the total energy consumption in kWh), it gives an estimated cost for February 2012 of approximately R233 849.

An overcharge of approximately R100 000 could be attributed to estimated readings or wrong entries due to human error. This type of anomaly can only be picked up and rectified once a business embarks on routine checks of their utility bills and once it has entrenched a culture of account verification and validation as part of energy management best practice.

Figure 8 below illustrates the results of the analysis of the electricity bill focusing on maximum demand recorded per month over a 12-month period.

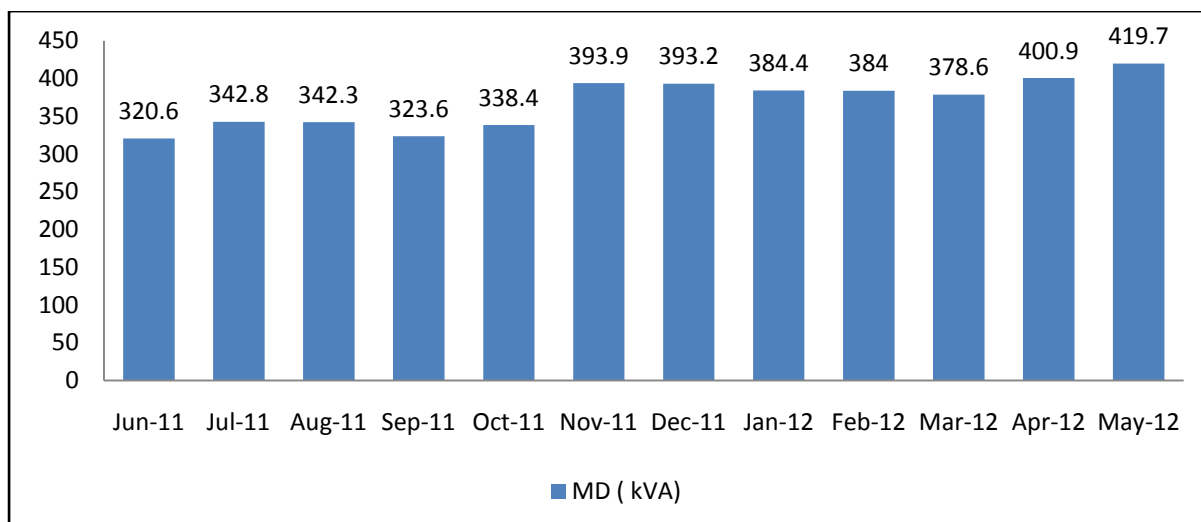


Figure 8 MD graph

The Maximum Demand (MD) of 419.7kVA was recorded in the month of May of 2012. This does have an effect on the energy cost as the kVA charge is higher with associated penalties from the electricity supplier. In terms of account verification, it can be seen that despite the month of May 2012 having the highest Maximum Demand as well as the highest energy consumption, the month has a total cost which is still less than that of February 2012. This clearly points to there being an error in the month of February 2012 bill calculations.

The graph shows a relatively constant Maximum Demand of between 300 and 400kVA, with a baseload of +300kVA. Operational best practice that staggers start-ups of electrical equipment can ensure that the notified maximum demand is not exceeded but also that the Maximum Demand per billing cycle is kept to its lowest.

The energy consumption and energy cost over the period under review followed in sync with the exception of February 2012 costs that are unusually high (clearly a case for further investigation; account verification, validation and reconciliation); Figure 9 below illustrates.

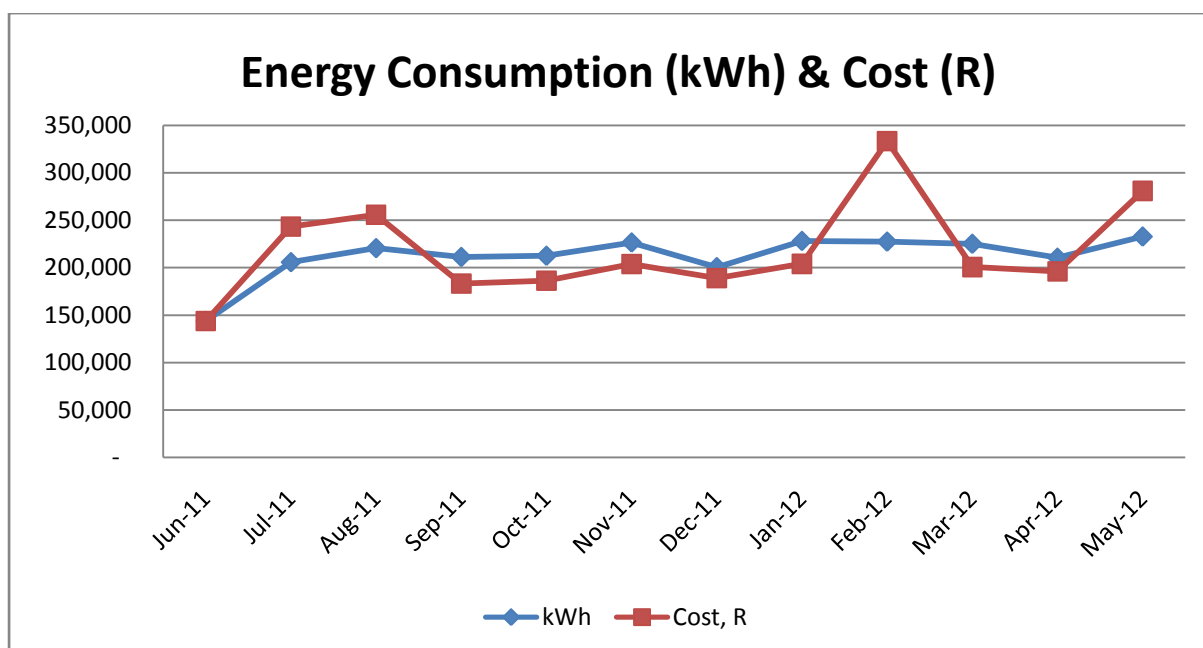


Figure 9 Baseline consumption & cost 2011/12

Even if the energy consumption and cost have been presented in a tabular form, it does help with a graphical visual representation of the same data as in Figure 9 above. Immediately the data are presented graphically, the anomaly in February can be seen and brought to attention. An energy management best practice would ensure that energy consumption data are visually displayed for all to see and to appreciate how they are utilising their energy resource and the resultant cost implications. Low-cost solutions are available that provide dashboards for the visual display of energy and production data.

Corresponding to the period for energy consumption data captured, production figures were also captured as indicated in Table 8 below:

Table 8 Production output for period 2011/12

Month, 2011/12	Production, kg
Jun-11	86254
Jul-11	123481
Aug-11	132383
Sep-11	126764
Oct-11	127544

Month, 2011/12	Production, kg
Nov-11	135942
Dec-11	120344
Jan-12	136939
Feb-12	136501
Mar-12	142220
Apr-12	135400
May-12	148640
TOTAL	1 552 416

The average production per month for 2011/12 was 129 368kg of containers with June 2011 recording the lowest production throughput of 86 254kg and May 2012 recording the highest production throughput of 148 640kg respectively. Again, the month of February 2012 with the highest energy cost did not have the corresponding highest production throughput. This immediately points to a poor energy intensity value for February particularly.

Where energy management best practice is entrenched in a business, it is not uncommon for production and energy consumption to be plotted against each other, or indeed the production versus energy consumption ratios (energy intensity) deduced to identify any deviations from the norm.

3.4.2 Staluform

A. Data capture and measurements

Historical data in the form of electricity bills and production figures were gathered and analysed. The captured data are presented in the form of tables and graphs with the analysis being focused on kWh consumption, kVA demand and Rand cost, as well as at kg production output. Table 9 below captures electricity consumption, demand and total cost for the 2011 period.

Table 9 Staluform's 2011 energy consumption

2011	kWh	kVA (MD)	Cost, R
January	15984.00	129	22751.56
February	15898.00	113	20769.90
March	19765.00	126	27163.74
April	20798.00	124	23932.99
May	18561.00	N/S	17495.95
June	31744.00	126	28248.44
July	17093.00	N/S	26554.15
August	17730.00	124	28489.89
September	18521.00	121	28400.74
October	11014.00	106	22625.21
November	17327.00	129	29064.05
December	N/S	N/S	N/S
TOTAL	204 435.00 kWh		R 275 496.62

N/S – Not Supplied

Table 9 above captures the electricity consumption for an 11-month period from January to November 2011. It is immediately identified that Staluform's energy accounting is poor as evidenced from missing energy bills (December 2011) as well as unavailable Maximum Demand figures (May and July 2011). This is despite the fact that Staluform did still pay the energy bill but appears to have immediately discarded the utility bills.

The average monthly consumption for this 11-month period is 18 585kWh. The lowest consumption was recorded in October 2011 of 11 014kWh. Despite October 2011 recorded the lowest consumption, it was not the lowest in cost; May 2011 had the lowest cost of R17 495.95. This potentially indicates an undercharge which Staluform needed to be aware of and reserve funds for payment when the accounts were reconciled by the energy supplier.

The highest energy consumption in June 2011 of 31 744kWh did not have the corresponding highest cost. The highest cost was recorded in November 2011 of R29 064.05 even though

this month did not record the highest consumption. Clearly the energy account at Staluform presented a case for account verification, validation and reconciliation.

The calculated Average Unit Price (AUP) for Staluform is R1.35c/kWh for 2011 (calculated as the total energy cost in Rands divided by the total energy consumption in kWh) for the given period.

Figure 10 below illustrates the results of the analysis of the electricity bill focusing on Maximum Demand recorded per month over a 12-month period.

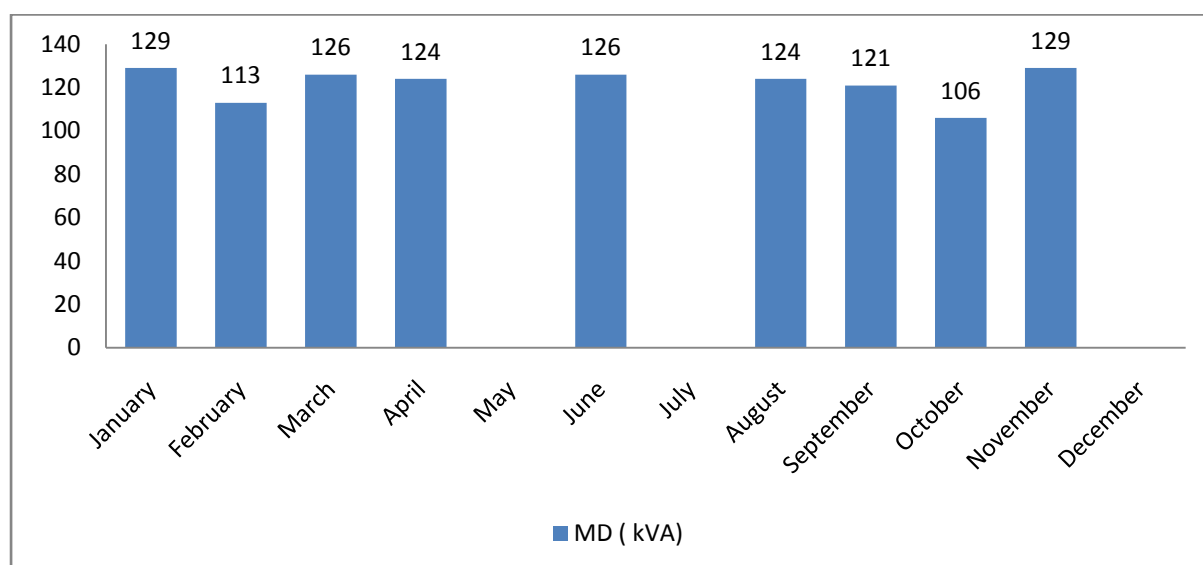


Figure 10 MD graph

The Maximum Demand for Staluform was recorded in the months of January and November (129 kVA). However, the months of May, July and December kVA figures were not supplied. This demonstrated poor energy accounting by Staluform.

As with the case study above, even if the energy consumption and cost for Staluform were presented in a tabular form, it does help with a graphical visual representation of the same data as in Figure 11 below. Immediately the data are presented graphically, the anomaly in June can be seen and brought to attention. Similar to the case study above, a visual display of energy data and metrics for all to see and to appreciate how they are utilising their energy resource and the resultant cost implications does help in forming a culture of energy awareness. For this visual display, low-cost solutions are available for immediate implementation. It supports the adage that one can control best that which one can see. Energy consumption and energy cost over period under review follow in sync. Fairly flat

consumption and cost curves indicate a constant month-to-month consumption pattern. Figure 11 below illustrates this.

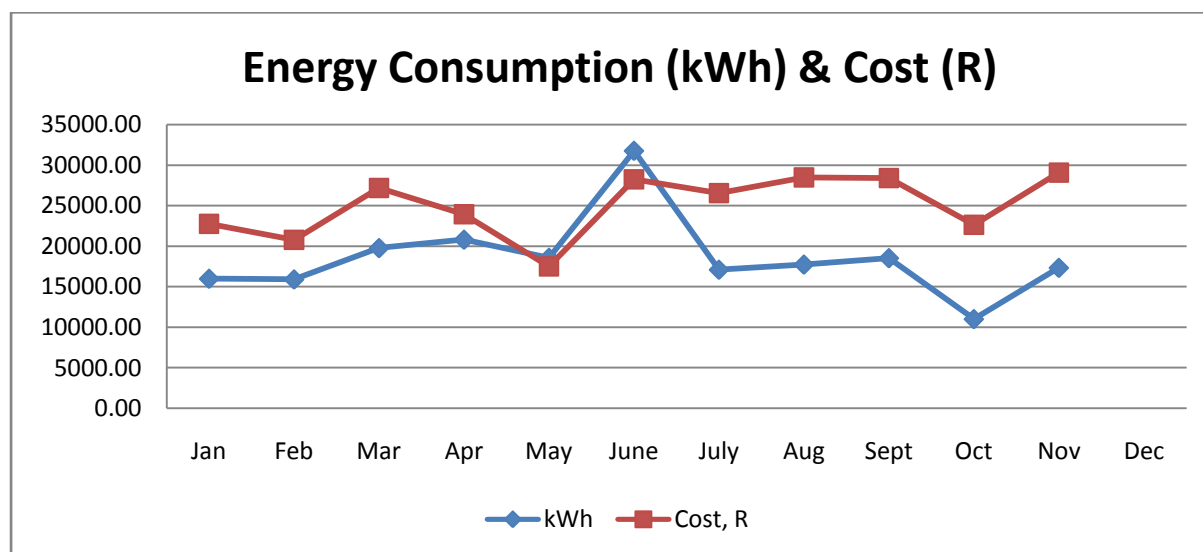


Figure 11 Baseline consumption & cost 2011

Corresponding to the period for energy consumption data captured, production figures were also captured as indicated in Table 10 below:

Table 10 Production output for period 2011

Month, 2011	Production, kg
January	10200
February	11020
March	15540
April	17210
May	15800
June	23730
July	13490
August	13520
September	15440
October	6750

Month, 2011	Production, kg
November	14100
December	N/S

N/S – Not Supplied

The average production per month for 2011 was 14 254kg of fabricated metalwork with October 2011 recording the lowest production throughput of 6 750kg and June 2011 recording the highest production throughput of 23 730kg respectively. Where energy management best practice is entrenched in a business, it is not uncommon for production and energy consumption to be plotted against each other, or indeed the production versus energy consumption ratios (energy intensity) deduced to identify any deviations from the norm.

3.4.3 Karob Plastics

A. Data analysis

Using dataloggers, the usage profiles of various pieces of equipment as well as the load profile of the entire facility were logged. Logging was over very short periods (spot-logging) to extensive durations in order to capture the graphical trends and quantitative values for subsequent analysis and commentary.

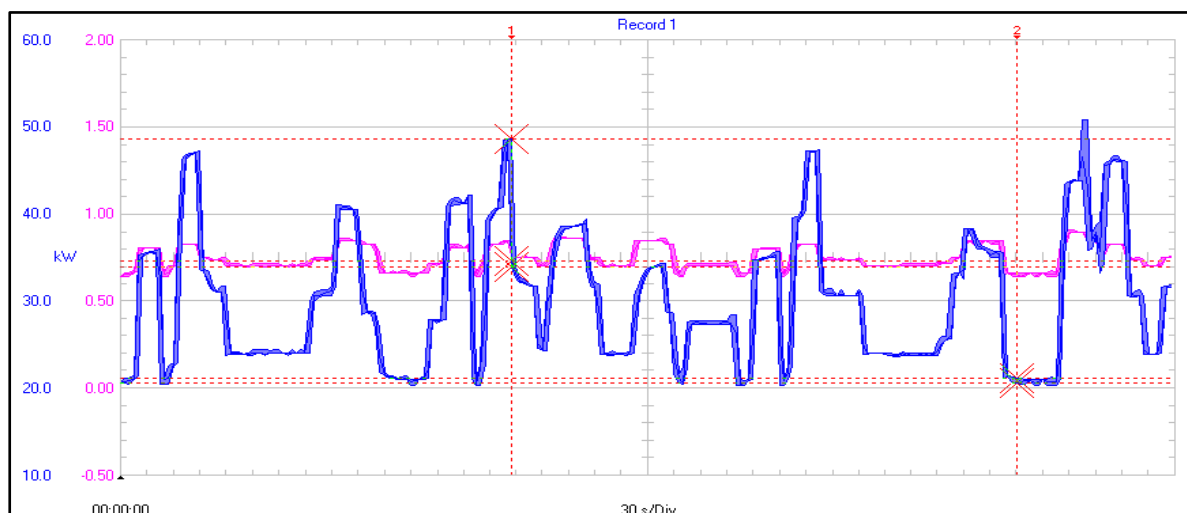


Figure 12 Blow moulder no. 4 trend

Figure 12 above shows the load profile of blow moulder number 4 with Table 11 below indicating the corresponding recorded values:

Table 11 Blow moulder no. 4 recorded trend values

Datablock		
Name	= Record 1	Record 2
Date	= 9/6/2012	9/6/2012
Time	= 1:10:27 PM	1:10:27 PM
Y Scale	= 10 kW/Div	0.5 /Div
Y At 50%	= 35.0 kW	0.75
X Scale	= 30 s/Div	30 s/Div
X At 0%	= 00:00:00	00:00:00
X Size	= 240 (240)	240 (240)
Maximum	= 50.9 kW	0.91
Minimum	= 20.2 kW	0.64
Cursor Values		
X 1 :	0d 00:01:29 [9/6/2012 1:11:56 PM]	
X 2 :	0d 00:03:24 [9/6/2012 1:13:51 PM]	
dX :	0d 00:01:55	
Y 1 :	33.9	34.5 48.7 kW
Y 2 :	20.5	21.0 21.1 kW
dY :	-13.4	-13.5 -27.6 kW

Notes and observations:

- The blue line shows the trend of the load in kW.
- The pink line shows the trend of the power factor.
- The power factor runs at about 0.6 - 0.9.
- During the logging period, the moulder produced the same product. Despite this, the load profile does not follow a definite trend.

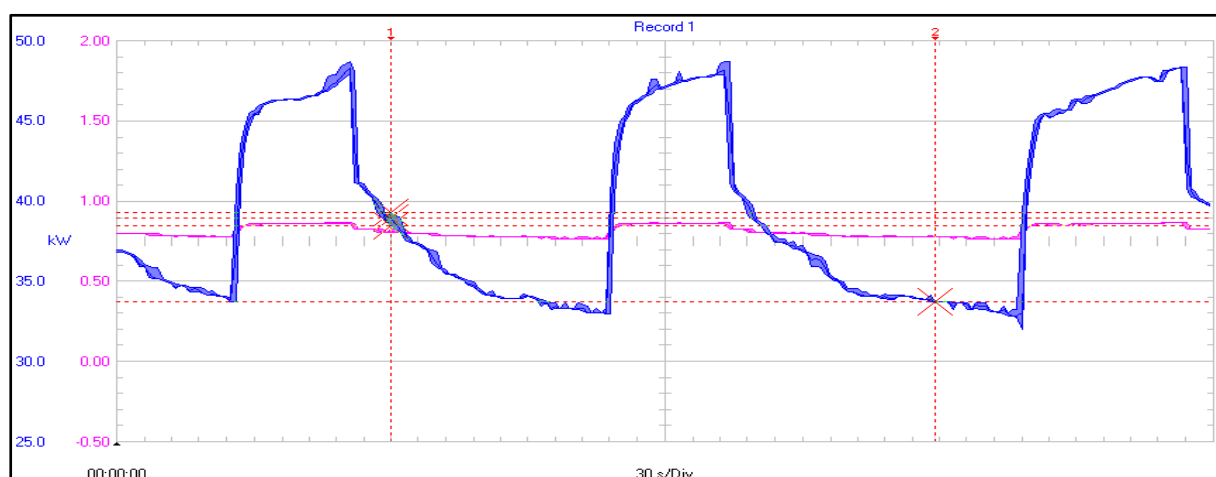


Figure 13 Compressors 1 & 2 trend

Figure 13 above shows the load profile of the air compressors 1 and 2 together, with Table 12 below indicating the corresponding recorded values:

Table 12 Compressors 1 & 2 recorded trend values

Datablock	
Name	= Record 1
Date	= 9/6/2012
Time	= 12:52:14 PM
Y Scale	= 5 kW/Div
Y At 50%	= 37.5 kW
X Scale	= 30 s/Div
X At 0%	= 00:00:00
X Size	= 240 (240)
Maximum	= 48.7 kW
Minimum	= 32.0 kW

Cursor Values	
X 1:	0d 00:01:00 (9/6/2012 12:53:14 PM)
X 2:	0d 00:02:59 (9/6/2012 12:55:13 PM)
dX:	0d 00:01:59
Y 1:	38.5 39.0 39.3 kW
Y 2:	33.7 33.7 33.7 kW
dY:	-4.8 -5.3 -5.6 kW

Notes and observations:

- The blue line shows the load profile of the air compressor in kW.
- The pink line follows the power factor of the air compressor.
- The profile looks very much what one would expect with a compressor as it goes through its duty cycles.

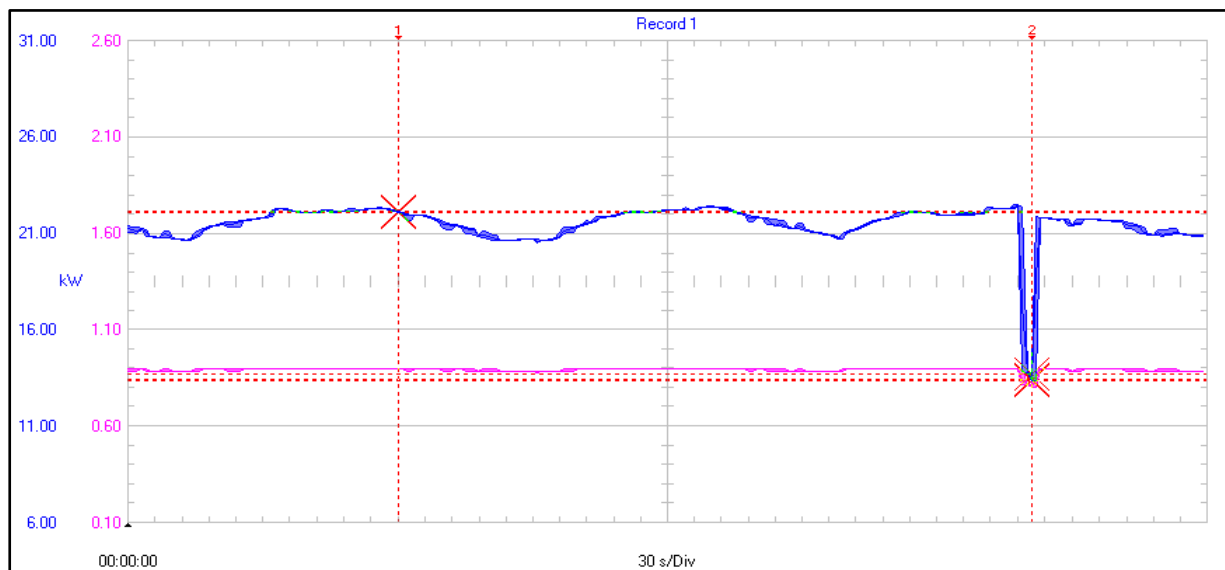


Figure 14 Compressor 1 trend

Figure 14 above shows the load profile of air compressor 1 alone, with Table 13 below indicating the corresponding recorded values:

Table 13 Compressor recorded trend values

Datablock		
Name	= Record 1	Record 2
Date	= 9/6/2012	9/6/2012
Time	= 1:00:03 PM	1:00:03 PM
Y Scale	= 5 kW/Div	0.5 /Div
Y At 50%	= 18.50 kW	1.35
X Scale	= 30 s/Div	30 s/Div
X At 0%	= 00:00:00	00:00:00
X Size	= 240 (240)	240 (240)
Maximum	= 22.51 kW	0.89
Minimum	= 13.34 kW	0.80
Cursor Values		
X 1 :	0d 00:01:00 (9/6/2012 1:01:03 PM)	
X 2 :	0d 00:03:21 (9/6/2012 1:03:24 PM)	
dX :	0d 00:02:21	
Y 1 :	22.09 22.11 22.15 kW	
Y 2 :	13.34 13.41 13.65 kW	
dY :	-8.75 -8.70 -8.50 kW	

Notes and observations:

- The blue line shows the load profile of the air compressor in kW.
- The pink line follows the power factor of the compressor.
- Compressor 1 seems to be the lead compressor as the load stays more or less constant.
- During normal operations, the compressor does not cycle at all.

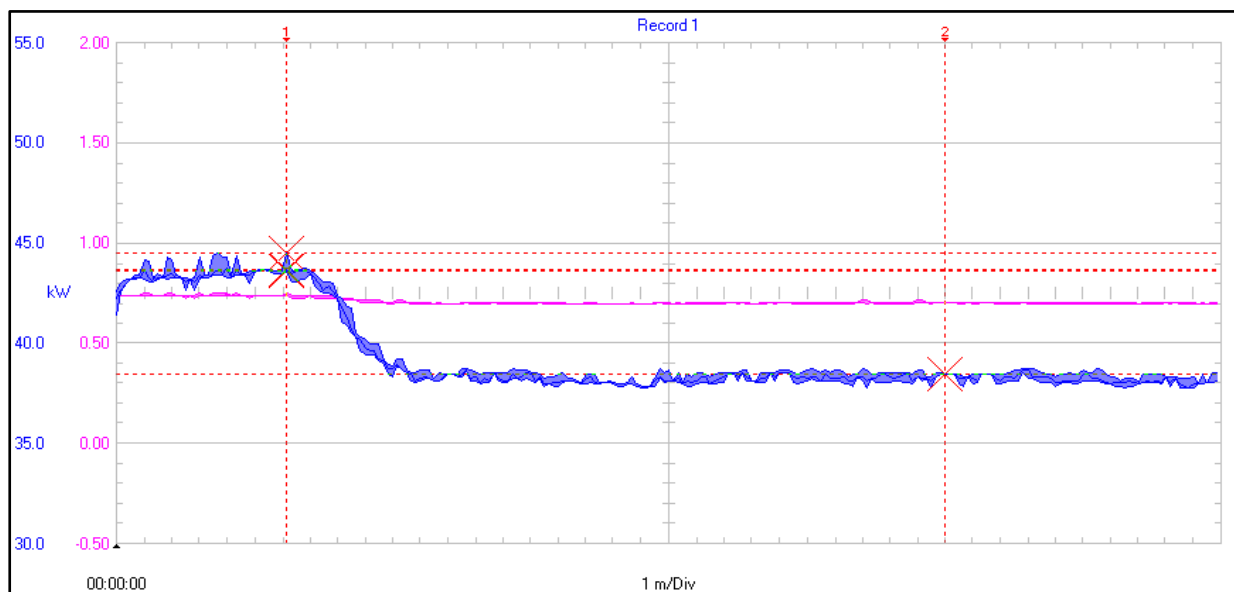


Figure 15 Main chiller trend

Figure 15 above shows the load profile of the main chiller with Table 14 below indicating the corresponding recorded values:

Table 14 Main chiller recorded values

Datablock	
Name = Record 1	Record 2
Date = 9/6/2012	9/6/2012
Time = 1:39:14 PM	1:39:14 PM
Y Scale = 5 kW/Div	0.5 /Div
Y At 50% = 42.5 kW	0.75
X Scale = 1 m/Div	1 m/Div
X At 0% = 00:00:00	00:00:00
X Size = 240 (240)	240 (240)
Maximum = 44.5 kW	0.75
Minimum = 37.7 kW	0.69
Cursor Values	
X 1 : 0d 00:01:14 (9/6/2012 1:40:28 PM)	
X 2 : 0d 00:06:00 (9/6/2012 1:45:14 PM)	
dX : 0d 00:04:46	
Y 1 : 43.6 43.7 44.5 kW	
Y 2 : 38.4 38.4 38.4 kW	
dY : -5.2 -5.3 -6.1 kW	

Notes and observations:

- The blue line shows the load profile of the refrigeration compressor in kW.
- The pink line follows the power factor of the compressor.
- This chiller has four 15kW compressors.
- It is evident from the profile graph that at least three of these compressors run all at once at any given time, depending on the compressor's duty cycle.

Energy management opportunity:

- Compressor efficiency technology could be introduced into the control circuit to optimize compressor efficiency.

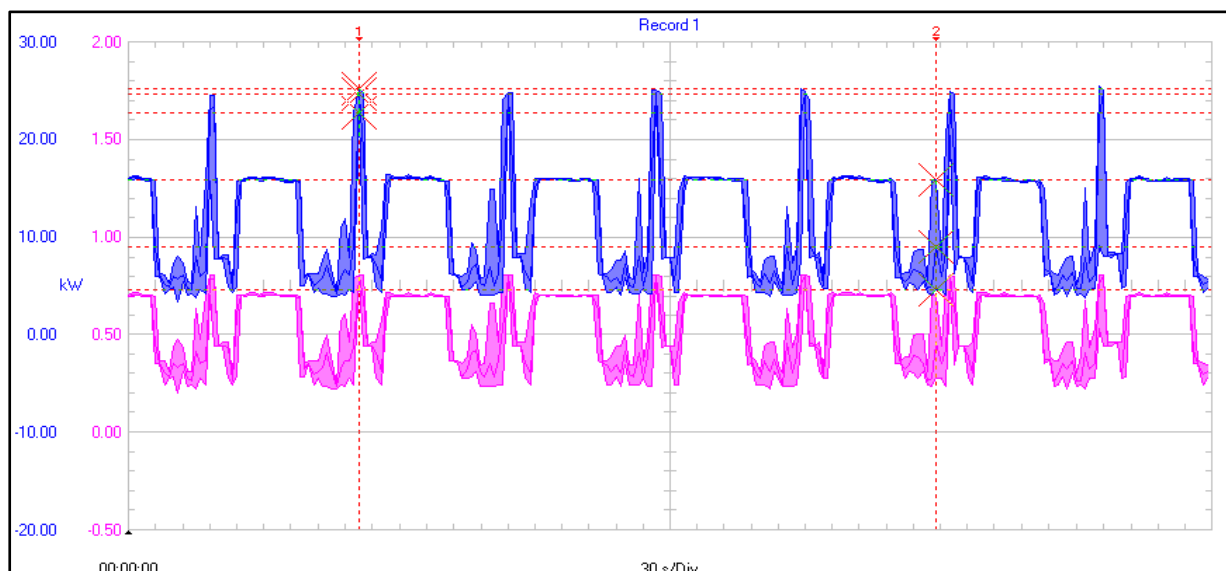


Figure 16 Injection moulder trend

Figure 16 above shows the load profile of the injection moulder with Table 15 below indicating the corresponding recorded values:

Table 15 Injection moulder recorded trend values

Datablock		
Name	= Record 1	Record 2
Date	= 9/6/2012	9/6/2012
Time	= 1:25:00 PM	1:25:00 PM
Y Scale	= 10 kW/Div	0.5 /Div
Y At 50%	= 5.00 kW	0.75
X Scale	= 30 s/Div	30 s/Div
X At 0%	= 00:00:00	00:00:00
X Size	= 240 (240)	240 (240)
Maximum	= 25.47 kW	0.81
Minimum	= 3.33 kW	0.20
Cursor Values		
X 1 :	0d 00:00:51 (9/6/2012 1:25:51 PM)	
X 2 :	0d 00:02:59 (9/6/2012 1:27:59 PM)	
dX :	0d 00:02:08	
Y 1 :	22.72 24.70 25.24 kW	
Y 2 :	4.55 9.00 15.86 kW	
dY :	-18.17 -15.70 -9.38 kW	

Notes and observations:

- The blue line shows the load profile of the compressor in kW.
- The pink line follows the power factor.
- The power factor follows the load profile quite closely.
- Sequence of the moulding process stays the same for every product produced. This pattern is in contrast to the one shown in Figure 12 above that shows the load profile of blow moulder no. 4.

3.4.4 Staluform

A. Data analysis

Using dataloggers, the usage profiles of various pieces of equipment as well as the load profile of the entire facility were logged. The logging ranged over very short periods (spot-logging) to extensive durations in order to capture the graphical trends and quantitative values for subsequent analysis and commentary.

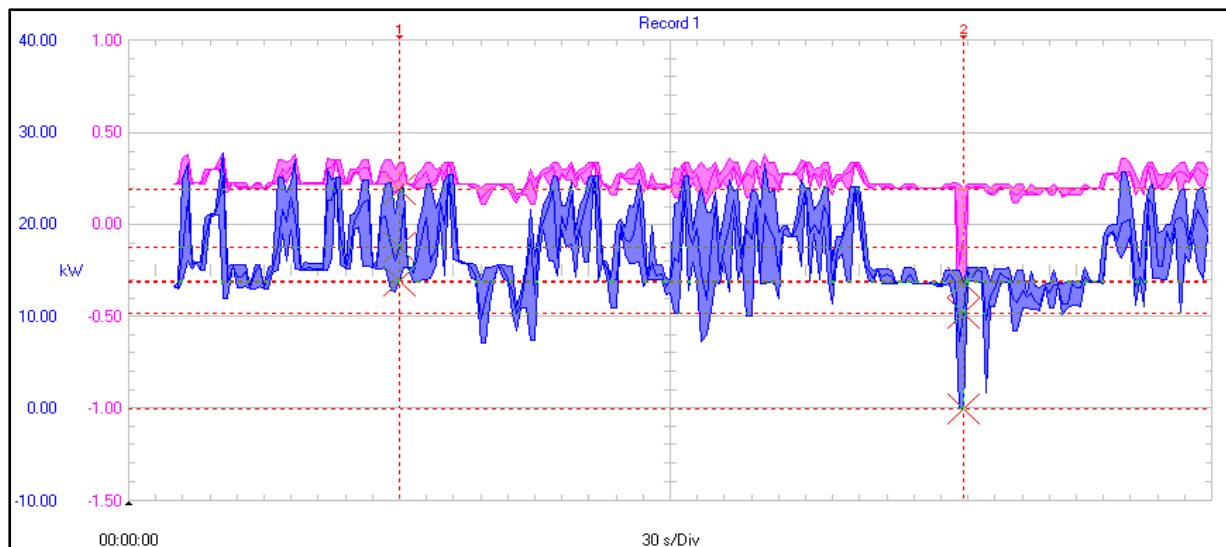


Figure 17 Older small bending press no. 2 trend

Figure 17 above shows the load profile of the older small bending press No. 2 with Table 16 below indicating the corresponding recorded values:

Table 16 Older small bending press no. 2 recorded trend values

Datablock		
Name	= Record 1	Record 2
Date	= 9/6/2012	9/6/2012
Time	= 11:37:52 AM	11:37:52 AM
Y Scale	= 10 kW/Div	0.5 /Div
Y At 50%	= 15.00 kW	-0.25
X Scale	= 30 s/Div	30 s/Div
X At 0%	= 00:00:00	00:00:00
X Size	= 240 (240)	240 (240)
Maximum	= 27.80 kW	0.39
Minimum	= -0.20 kW	-1.00
Cursor Values		
X 1 :	0d 00:01:00 (9/6/2012 11:38:52 AM)	
X 2 :	0d 00:03:05 (9/6/2012 11:40:57 AM)	
dX :	0d 00:02:05	
Y 1 :	13.70	23.90 kW
Y 2 :	-0.20	13.60 kW
dY :	-13.90	-10.30 kW

Notes and observations:

- This is the older of the two small bend presses.
- The motor runs continuously and when the press is being used consumption increases.

Opportunities for improvement:

- Not leaving the machine running when not in use.
- Further investigation of the control circuit of the machine needed.
- Optimise bend press operation.

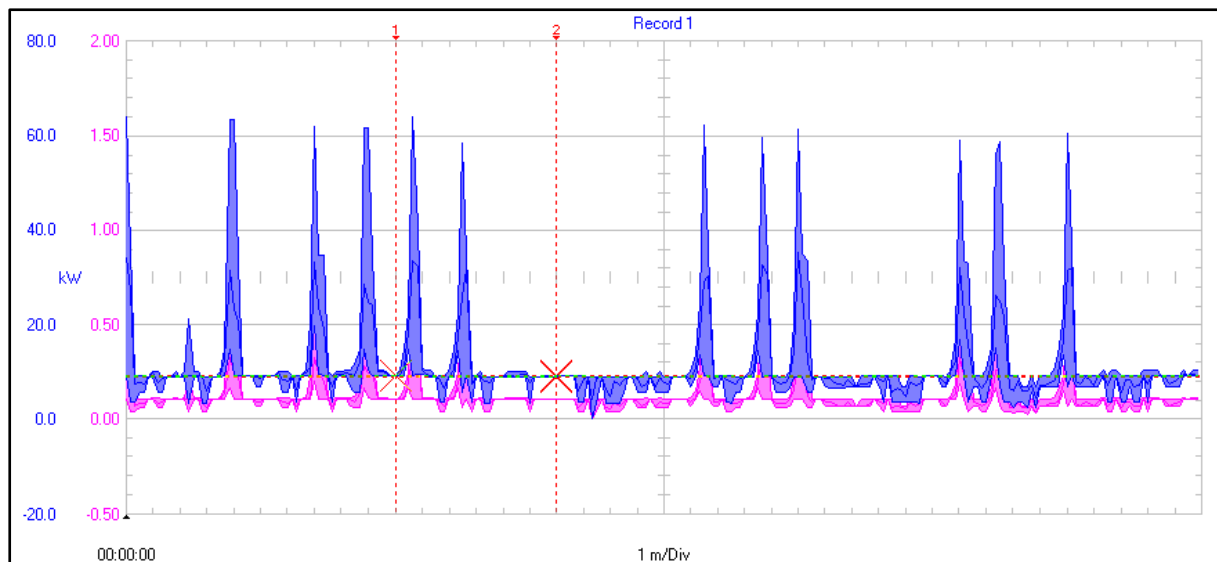


Figure 18 Newer small bending press no. 5

Figure 18 above shows the load profile of the newer small bending press no. 5 with Table 17 below indicating the corresponding recorded values:

Table 17 Newer small bending press no. 5 recorded trend values

Datablock		
Name	= Record 1	Record 2
Date	= 9/6/2012	9/6/2012
Time	= 11:25:52 AM	11:25:52 AM
Y Scale	= 20 kW/Div	0.5 /Div
Y At 50%	= 30.0 kW	0.75
X Scale	= 1 m/Div	1 m/Div
X At 0%	= 00:00:00	00:00:00
X Size	= 240 (240)	240 (240)
Maximum	= 64.1 kW	0.60
Minimum	= 0.0 kW	0.00
Cursor Values		
X 1:	0d 00:02:00 (9/6/2012 11:27:52 AM)	
X 2:	0d 00:03:12 (9/6/2012 11:29:04 AM)	
dX:	0d 00:01:12	
Y 1:	9.0 9.0	9.0 kW
Y 2:	8.9 8.9	9.0 kW
dY:	-0.1 -0.1	0.0 kW

Notes and observations:

- The kW values of the graph should be divided by 10, as the instrument was set upon a scale of 1:10.
- It should be noted that this press runs more efficiently than bend press no. 2 (the older press as illustrated in Figure 17 above).
- The spikes in the graph indicate the times when an object was bent.
- Machine occasionally left running without doing any work.

Opportunities for improvement:

- Not leaving the machine running when not in use.
- Increase frequency of bend operations by properly scheduling works.
- Intelligent motor controller to eliminate spikes and smoothing of operating curve.

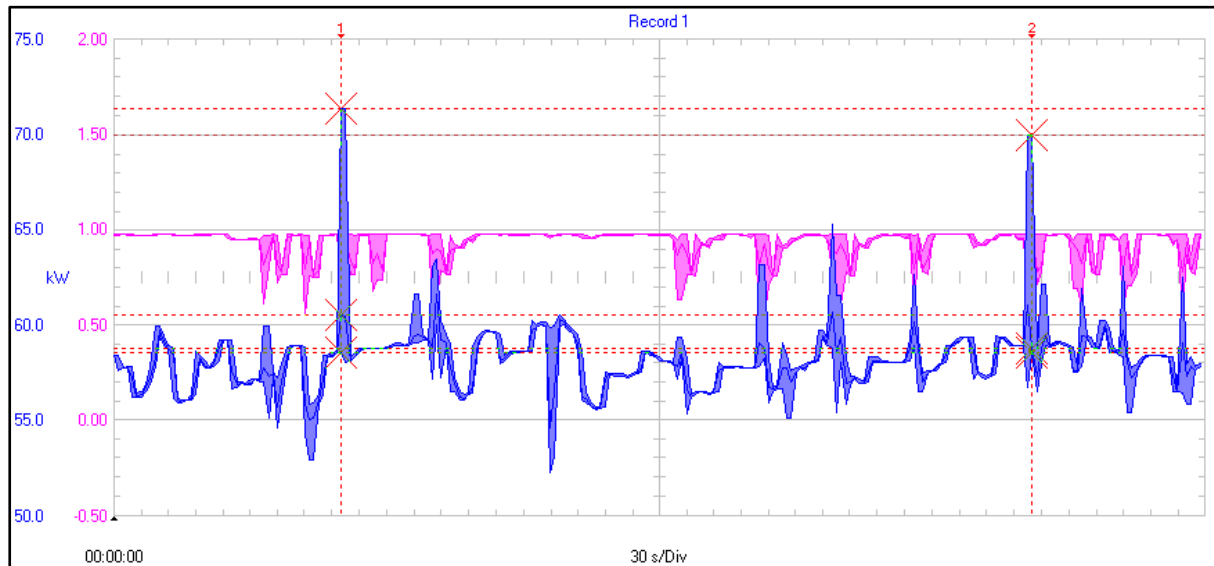


Figure 19 Big bending press trend

Figure 19 above shows the load profile of the big bending press with Table 18 below indicating the corresponding recorded values:

Table 18 Big bending press recorded trend values

Datablock			
Name	=	Record 1	Record 2
Date	=	9/6/2012	9/6/2012
Time	=	12:04:30 PM	12:04:30 PM
Y Scale	=	5 kW/Div	0.5 /Div
Y At 50%	=	62.5 kW	0.75
X Scale	=	30 s/Div	30 s/Div
X At 0%	=	00:00:00	00:00:00
X Size	=	240 (240)	240 (240)
Maximum	=	71.4 kW	0.99
Minimum	=	52.2 kW	0.55
Cursor Values			
X 1 :	0d 00:00:50	(9/6/2012 12:05:20 PM)	
X 2 :	0d 00:03:22	(9/6/2012 12:07:52 PM)	
dX :	0d 00:02:32		
Y 1 :	58.5	60.5	71.4 kW
Y 2 :	58.5	58.7	70.0 kW
dY :	0.0	-1.8	-1.4 kW

Notes and observations:

- The kW values of the graph should be divided by 10, as the instrument was set upon a scale of 1:10.

Opportunities for improvement:

- Not leaving the machine running when not in use.
- Increase frequency of bend operations by properly scheduling works.
- Right-sizing of works – machine only used for appropriate applications.

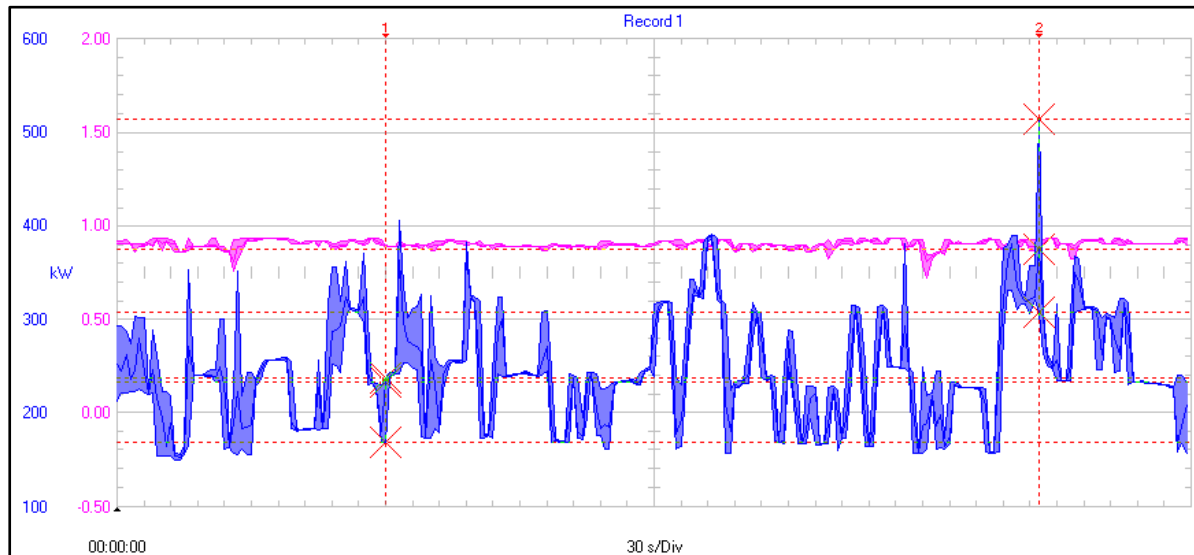


Figure 20 Main distribution board trend (during normal working hours)

Figure 20 above shows the load profile on main distribution board (DB3) during normal operations and Figure 21 below shows the load profile going into lunch break.

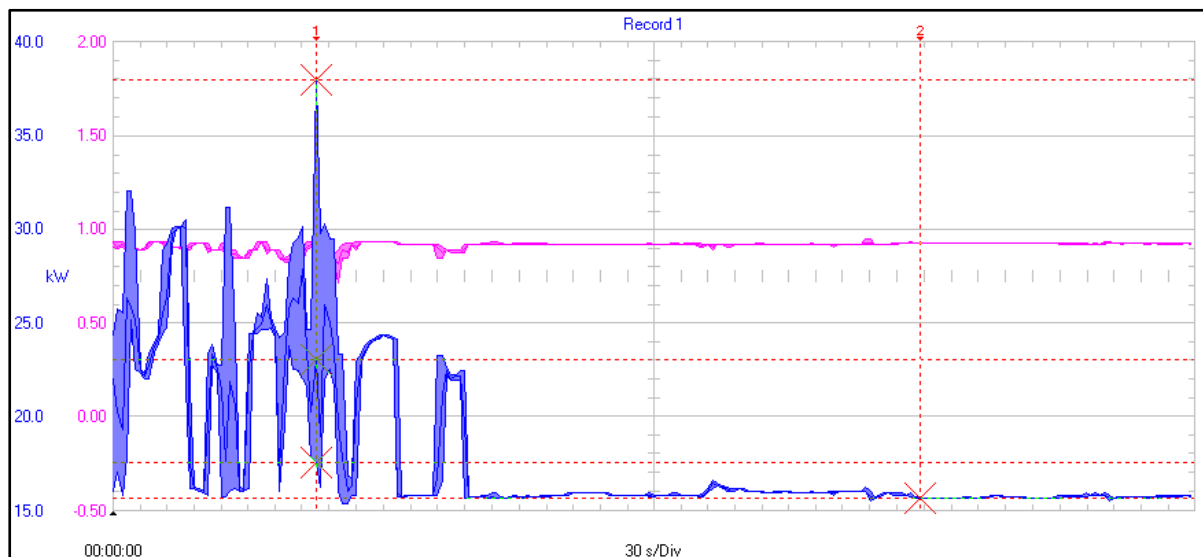


Figure 21 Main distribution board trend (at lunch break)

Table 19 below indicates the recorded values for the trend during working hours;

Table 19 DB3 recorded trend values during working hours

Datablock		
Name	= Record 1	Record 2
Date	= 9/6/2012	9/6/2012
Time	= 12:27:53 PM	12:27:53 PM
Y Scale	= 100 kW/Div	0.5 /Div
Y At 50%	= 350 kW	0.75
X Scale	= 30 s/Div	30 s/Div
X At 0%	= 00:00:00	00:00:00
X Size	= 240 (240)	240 (240)
Maximum	= 515 kW	0.94
Minimum	= 149 kW	0.72
Cursor Values		
X 1:	0d 00:01:00 (9/6/2012 12:28:53 PM)	
X 2:	0d 00:03:26 (9/6/2012 12:31:19 PM)	
dX:	0d 00:02:26	
Y 1:	168 232 237 kW	
Y 2:	307 375 515 kW	
dY:	139 143 278 kW	

Table 20 below indicates the values for the trend during lunch break.

Table 20 DB3 recorded trend values during lunch break

Datablock		
Name	= Record 1	Record 2
Date	= 9/6/2012	9/6/2012
Time	= 12:32:35 PM	12:32:35 PM
Y Scale	= 5 kW/Div	0.5 /Div
Y At 50%	= 27.5 kW	0.75
X Scale	= 30 s/Div	30 s/Div
X At 0%	= 00:00:00	00:00:00
X Size	= 240 (240)	240 (240)
Maximum	= 38.0 kW	0.95
Minimum	= 15.3 kW	0.71
Cursor Values		
X 1:	0d 00:00:45 (9/6/2012 12:33:20 PM)	
X 2:	0d 00:02:59 (9/6/2012 12:35:34 PM)	
dX:	0d 00:02:14	
Y 1:	17.5 23.0 38.0 kW	
Y 2:	15.6 15.6 15.6 kW	
dY:	-1.9 -7.4 -22.4 kW	

Notes and observations:

- The kW values of Figure 20 should be divided by 10, as the instrument was set upon a scale of 1:10
- The kW values of Figure 21 are on the correct scale.
- DB3 supplies a part of the plant load comprising mainly of welders. All the welders that are used in this section are CO₂ welders.
- Load imbalance as can be seen from the wide blue lines is mainly caused by inverter-type welders and various single phase motors such as angle grinders.
- Note that the base-load (load when no work is done during the lunch break) is about 15 kW.

Opportunities for improvement:

- Promote the use of the more efficient CO₂ welders against the less efficient oil-bath welders.
- Base load minimisation - switch off all not in-use equipment.

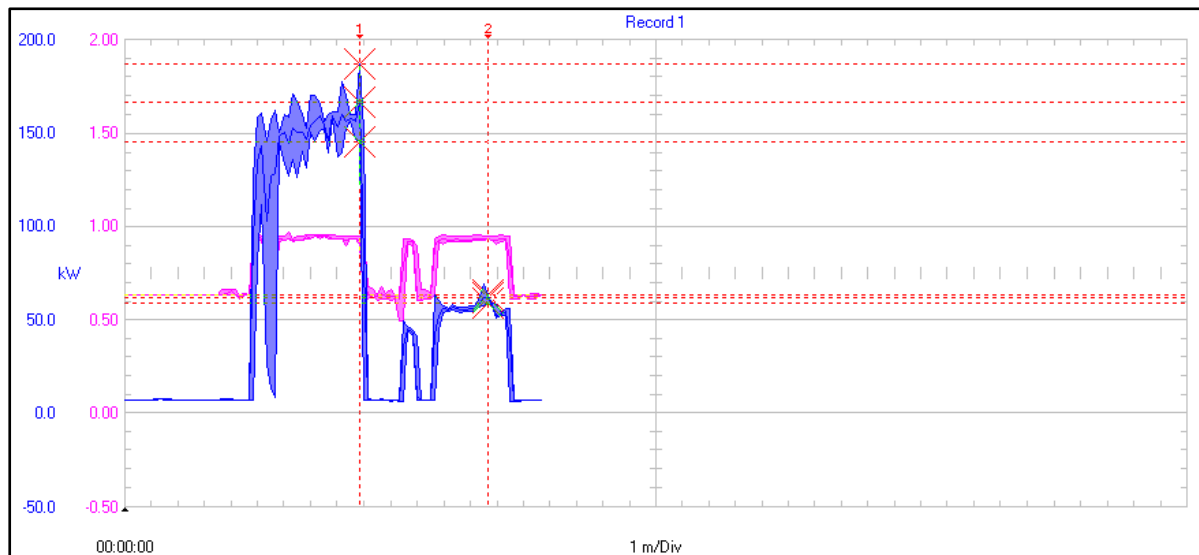


Figure 22 Oil bath & CO₂ welder partial trends

Figure 22 above shows the difference in load between an oil bath welder and a CO₂ welder with Table 21 below indicating the corresponding recorded values:

Table 21 Oil bath & CO₂ welder recorded partial trend values

Datablock		
Name	= Record 1	Record 2
Date	= 9/6/2012	9/6/2012
Time	= 11:13:51 AM	11:13:51 AM
Y Scale	= 50 kW/Div	0.5 /Div
Y At 50%	= 75.0 kW	0.75
X Scale	= 1 m/Div	1 m/Div
X At 0%	= 00:00:00	00:00:00
X Size	= 95 (95)	95 (95)
Maximum	= 187.2 kW	0.98
Minimum	= 5.9 kW	0.49
Cursor Values		
X 1:	0d 00:01:46 (9/6/2012 11:15:37 AM)	
X 2:	0d 00:02:44 (9/6/2012 11:16:35 AM)	
dX:	0d 00:00:58	
Y 1:	145.8	166.7 187.2 kW
Y 2:	58.8	61.2 63.1 kW
dY:	-87.0	-105.5 -124.1 kW

Notes and observations:

- The kW values of Figure 22 should be divided by 10, as the instrument was set upon a scale of 1:10.

- The first few seconds show the load profile of an oil bath welder. The second bit shows the load profile of a CO₂ welder.
- The oil bath welder draws about 15 kW of power whereas the CO₂ welder only draws about 5.5 kW of power for similar type of work.

Opportunity for improvement:

- Use as much as possible CO₂ welders instead of oil bath welders.
- Routine replacement of oil bath welders with CO₂ welders whenever the oil-bath welder fails.

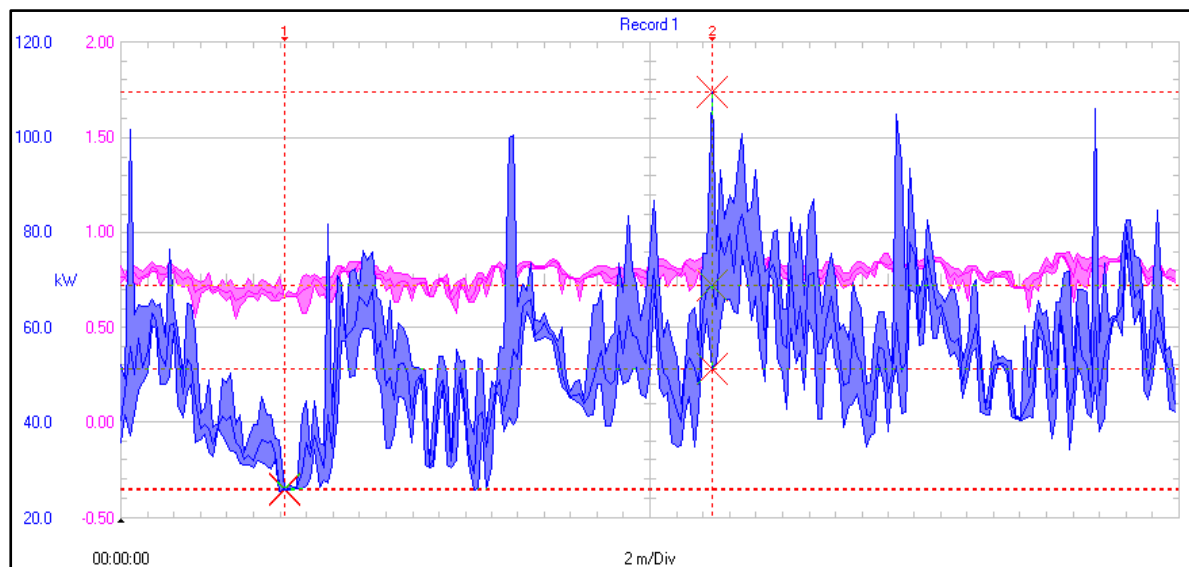


Figure 23 Load profile of entire plant

Figure 23 above shows the load profile of the entire plant with Table 22 below indicating the corresponding recorded values.

Table 22 Entire plant load profile recorded trend values

Datablock	
Name = Record 1	Record 2
Date = 9/6/2012	9/6/2012
Time = 10:33:05 AM	10:33:05 AM
Y Scale = 20 kW/Div	0.5 /Div
Y At 50% = 70.0 kW	0.75
X Scale = 2 m/Div	2 m/Div
X At 0% = 00:00:00	00:00:00
X Size = 240 (240)	240 (240)
Maximum = 109.6 kW	0.90
Minimum = 25.5 kW	0.54
Cursor Values	
X 1 : 0d 00:02:28 (9/6/2012 10:35:33 AM)	
X 2 : 0d 00:08:56 (9/6/2012 10:42:01 AM)	
dX : 0d 00:06:28	
Y 1 : 25.8 25.8 26.0 kW	
Y 2 : 51.1 68.6 109.6 kW	
dY : 25.3 42.8 83.6 kW	

Notes and observations:

- The power factor (pink line) is rather low (around 0.75). Ideally it should be close to unity. This is despite there being power factor correction equipment installed (Lovato DCRK7 digital pf controller).
- The minimum power during normal operations is 25kW with the maximum recorded during logging period of around 110kW.

Opportunities for improvement:

- Investigate further the functionality of the installed pf correction equipment.
- Optimise plant power factor.

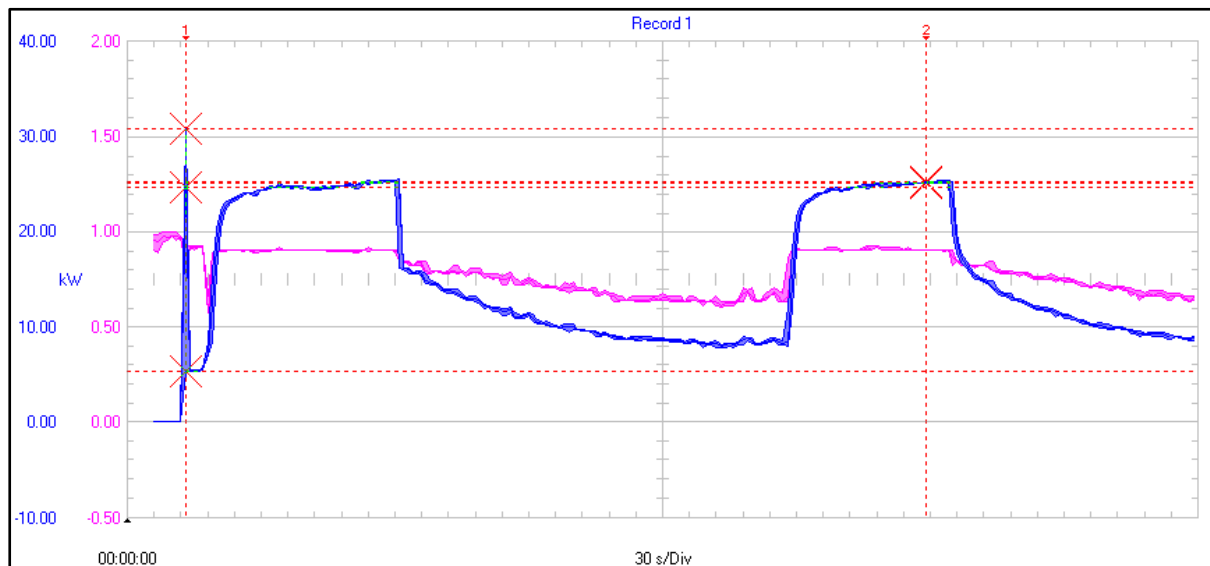


Figure 24 Air compressor trend

Figure 24 above shows the load profile of the air compressor with Table 23 below indicating the corresponding recorded values:

Table 23 Air compressor load recorded trend values

Datablock		
Name	= Record 1	Record 2
Date	= 9/6/2012	9/6/2012
Time	= 10:10:01 AM	10:10:01 AM
Y Scale	= 10 kW/Div	0.5 /Div
Y At 50%	= 15.00 kW	0.75
X Scale	= 30 s/Div	30 s/Div
X At 0%	= 00:00:00	00:00:00
X Size	= 240 (240)	240 (240)
Maximum	= 30.90 kW	1.00
Minimum	= 0.02 kW	0.57
Cursor Values		
X 1 :	0d 00:00:13 (9/6/2012 10:10:14 AM)	
X 2 :	0d 00:02:59 (9/6/2012 10:13:00 AM)	
dX :	0d 00:02:46	
Y 1 :	5.30 24.70 30.90 kW	
Y 2 :	25.10 25.15 25.30 kW	
dY :	19.80 0.45 -5.60 kW	

Notes and observations:

- The air compressor loads and unloads during normal operations.
- This indicates that the supply is sufficiently matched to the demand.
- However, there were many audible air leaks around the plant.

Opportunities for improvement:

- Find and fix the air leaks.
- Install solenoid valves to specific equipment to allow for the air supply to be switched off at the same time as with the electrical supply.

3.5 Energy Management Opportunities (EMOs)

A. Business case development

Both the desktop study (data analysis) and the onsite surveys (energy assessments), culminated in an opportunities list. A business case was developed for each energy management opportunity (EMO) and energy saving opportunity (ESO) after a detailed cost benefit analysis was conducted.

This involved a feasibility study comprising technical and financial feasibilities, complemented by implementation plans and roadmaps, with an indication of payback to motivate for uptakes. A pre-assessment and post-assessment measurement would yield no change if nothing were implemented from the identified opportunities.

Both companies (Karob Plastics and Staluform) were encouraged to identify energy saving opportunities that they could immediately implement to realise savings. Given that some of

the recommendations/energy saving opportunities were no cost and/or low cost interventions, implementation of these was assumed to be immediate.

B. Metering, Monitoring, Targeting & Reporting (M, M, T & R)

As the common adages go, 'to measure is to know' as well as 'one cannot control what they do not have sight of or have not measured', therefore it is of absolute necessity that utilities and energy supplies are metered, routinely monitored, and targets set against which progress and performance improvements are reported.

Both companies (Karob Plastics and Staluform) were advised to install metering to check utility metering as well as sub-metering to various significant energy users. To allow the companies to have sight of their consumption as well as track performance improvements, an integrated metering solution was proposed; one which provided hardware (meters), software (data acquisition and reporting tool via a dashboard) and a cost-effective communication system and protocol.

Karob Plastics had already installed a web-based energy monitoring system that was to be supplemented with additional metering. This proactive measure by Karob Plastics emphasised the site's energy concerns and alertness. Clearly, Karob Plastics wanted to see what they wanted to manage.

C. Recommendations for energy saving (ESO)

Implementation of various energy interventions and energy management opportunities could result in both reductions in energy consumption and cost with a further improvement in energy intensity. Appendix I details the calculations for the energy management opportunities (ESOs) identified below for both Karob Plastics and Staluform. All assumptions made in the calculations are provided within the energy economics of each energy management opportunity (ESO) below.

3.5.2 Karob Plastics

The identified quantifiable Energy Savings Opportunities (ESOs) for Karob Plastics are highlighted below;

A. Lighting retrofit

A comprehensive lighting re-design and analysis that includes detailed light count, illumination level measurements, lighting modelling and simulation would inform a fit-for-purpose lighting retrofit of the existing high wattage inefficient lights.

Although the lighting system at Karob Plastics makes a load contribution of only about 4% to the total site load, a complete lighting retrofit would yield about 43% savings on the current lighting load. Table 24 below tabulates the type of lighting retrofit interventions that include the introduction of low wattage, high light output (energy efficient lamps) in place of the high wattage inefficient lamps (250W HPS, T8, 36W with magnetic ballasts and low efficacy luminaires).

Table 24 Lighting count and retrofit calculations

Current			Proposed				Savings, kW
MAKE / TYPE	Qty	Total Wattage	Type	Qty	Rating, W	Total, W	
Fluorescent lights (T8, 36W)	120	4320	T5, 28W Linear Fluorescent	120	28	3360	960
9W LED Lights	12	108	No change proposed				
High Bay 250W (Mercury Vapour)	48	12000	125W Induction Lamp	48	125	6000	6000
Total (kW)		16.40	Total (kW)			9.36	7.07

A potential 43% reduction in lighting load (from existing 16.4kW to a proposed 9.4kW) shows a reduction of about 7kW, translating into an energy saving of about 25 444kWh to be expected after a lighting retrofit. This is assuming 10 hours of operation per day for 360 days of the year. The economics thereof of this EMO are computed below:

The investment cost is an estimate based on quoted prices of procuring and installing 120 new T5 fluorescents and 48 induction lamps. The saving per annum is the energy savings of 25 444kWh in Rand equivalent at the conservative unit cost of R0.49c/kWh. This is far less than the AUP purely for purposes of understating the savings.

$\text{Payback} = \frac{\text{Investment}}{\text{Saving}}$
--

- Investment: R19 800
- Saving: R12 467 / annum
- Payback: 1.6 years

B. Air compressor re-location

The two 22kW air compressors are all located in a confined space. This does result in the compressor drawing in warmer air. Figure 25 and Figure 26 below indicate the temperatures recorded during the site survey. Relocating the compressors to an area drawing cooler air (assume a 10°C difference) would result in a 2% reduction in the electrical energy required. The cost of relocating the two air compressors is estimated at a labour and material cost of R10 000 based on past reference projects where a new plinth is constructed and piping re-routed.

- Investment: R10 000
- Saving: R3 665 / annum
- Payback: 2.7 years



Figure 25 Air compressors in confined space



Figure 26 Temperature recording of compressor open space location

C. Chiller compressor control optimisation

Installing an intelligent controller such as Smartcool's ESM™, an advanced energy efficiency retrofit product can save an average of 10% kWh energy on compressor operation. Energy savings by the ESM are achieved using the compressor optimisation strategy most appropriate for the existing equipment. As a modular product, the ESM is customised for each installation, giving it complete compatibility with a wide range of equipment and controls. The estimated cost of procurement and installation of an ESM module is approximately R60 000.

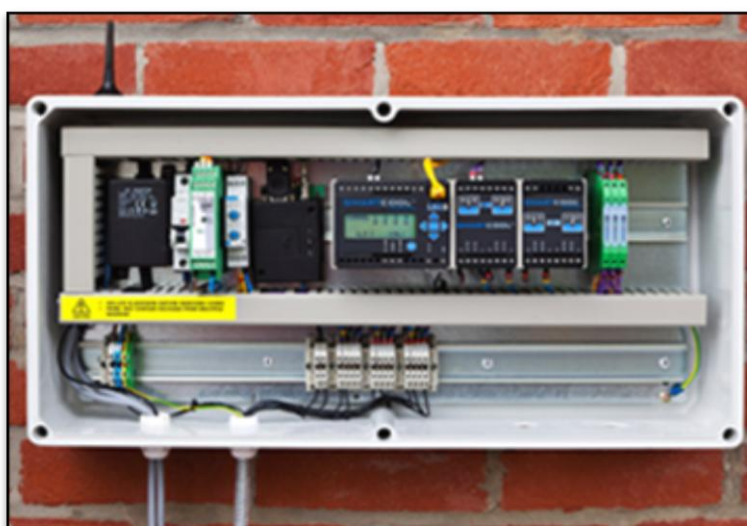


Figure 27 Smartcool's (ESM) energy saving module

- Investment: R60 000
- Saving: R24 990 / annum
- Payback: 2.4 years

D. Blow and injection moulders optimisation

Consider using Mineral Insulated (MI) band heaters instead of the Mica for the heating of the barrel. The watts/cm² ratio is higher per unit area of the MI type than it is for Mica and hence provides better response and sending of heat signal to the temperature controllers that are typically programmable.

The investment cost of R 167 700 is based on a quotation from a supplier of Mineral Insulated (MI) band heaters.

- Investment: R167 700
- Saving: R374 651 / annum
- Payback: 0.4 years

E. Solar water geysers

Consider replacement of the electrical resistance heated hot water system with a solar water geyser. It is assumed that the facility would only require a 300l capacity solar water geyser that is estimated to cost approximately R28 000 to procure, fully install and commission.

The saving is exactly the offset cost of using the three (03) currently installed electrical resistance heated geysers with 3kW elements each. The electrical geysers are not on timers and are assumed to run for 18 hours per day for 360 days of the year. The unit cost of electricity is also assumed to be R0.49c/kWh.

- Investment: R28 000
- Saving: R29 673 / annum
- Payback: 0.9 years

F. Recommended best practices

Good operational regimes and maintenance practices should be included as components in energy management as no/low cost measures. These include:

- Motors and motorised systems
 - High Efficiency Motors (HEMS)

Replacement of standard efficiency motors IE-1 with High (IE-2) and Premium (IE-3) Efficiency Motors when motor, that has had three rewinds, fails. Note, however, that most, if not all, the motors at the Karob Plastics site are HEMS (IE-2) and are all driven by variable speed drives (VSDs). The move should now be to move to premium efficiency motors (IE-3).

- Energy awareness programme
 - Change management

There are two parts to energy management; behavioural changes in consumption habits to reduce consumption and technological interventions to improve energy efficiency. Straightforward behavioural changes can be brought about through change management programmes. A good example of behaviour change is to not use electrical resistance heaters for space heating as evidenced in Figure 28 below.



Figure 28 Electrical resistance heater used for space heating

This soft intervention releases the lowest cost opportunities as described under the energy management matrix section.

- Training

Identifying onsite energy champions and allocating energy management and cost saving responsibilities entails that training is afforded to the selected site representatives. As mandated by the energy management matrix, all energy users need to receive specific energy training integrated into other professional/job development activities. Energy-related workshops similar to the ones conducted for safety and health need to be conducted for all personnel, with special training afforded to operational staff in order to facilitate a sharing of knowledge across the operation.

- Load shifting
 - Scheduled production

As a no cost measure, production can be scheduled to achieve full plant production capacity both during off-peak time of use and low season pricing. This has inherent benefits of reduction in energy costs.

3.5.3 Staluform

The identified quantifiable Energy Savings Opportunities (ESOs) for Staluform are highlighted below;

A. Lighting retrofit

A comprehensive lighting re-design and analysis that includes detailed light count, illumination level measurements, lighting modelling and simulation would then inform a fit-for-purpose lighting retrofit of the existing high wattage inefficient lights.

For a lighting system such as the one at Staluform, with a load contribution of about 26% to the total site load, a detailed lighting audit is proposed. Interventions that include the introduction of low wattage, high light output (energy efficient lamps) in place of the high wattage inefficient lamps (400W HPS, T12 with magnetic ballasts and low efficacy luminaires), lamp re-positioning, and lighting controllers are proposed.

Daylight harvesting is also to be considered as can be evidenced from Figure 29 below where natural light is abundant despite the continued use of artificial lighting.



Figure 29 Use of artificial lighting in abundant natural lighting

A potential 50% reduction in lighting load (from existing 28kW to proposed 14kW) translates into an energy saving of about 50 418kWh to be expected after a lighting retrofit.

- Investment: R29 990
- Saving: R24 705 / annum
- Payback: 1.2 years

B. Compressed air system optimisation

- Indicative compressed air costs

Compressed air is arguably the most expensive utility on a plant because the compressed air system efficiencies are only around 15%. This means that if the one compressor at Staluform operates continuously for an hour to produce compressed air at 15% efficiency, it will consume an equivalent of $(25/0.15) = 166.7$ kWh. The cost of one (01) hour of compressed air calculated at estimated tariff (R0.49/kWh) can therefore be estimated to be R81.67. This means that compressed air can be estimated to cost R12 252 per month or R147, 029 per annum (for a 5hr/day 360-day year operation).

Given the above estimated costs of compressed air (almost 50% of the entire plant's utility cost which is estimated at an average of R25 045 per month), it becomes very clear that the plant air needs to be used in the most economical way possible and only in applications where it is absolutely essential with minimised air leaks in the system. Energy savings are subject to conducting an onsite air leak detection to quantify loss associated with system

leaks. An ultrasonic leak detection survey will ensure that all audible and inaudible leaks are detected and repaired.

However, based on an estimated system loss contribution of 25% of the system demand being recovered after a leak detection and sealing exercise, the plant stands to save approximately R9 000 per annum. The estimated cost to hire an ultrasonic leak detection instrument, locate the leaks, and seal them is approximately R30 000.

- Investment: R30 000
- Saving: R9 189 / annum
- Payback: 3.3 years

C. Conversion to CO₂ welders

Conversion from oil bath to CO₂ welders has an inherent benefit of reducing the load by 67% (from 15kW to 5kW) with a corresponding reduction in energy consumption for the same work output. There is also an improvement in these machines' 'idle efficiency' (machines draw some power whether welding or not). Inverter-based welding power sources as found in CO₂ welders operate at higher efficiencies, averaging 85% against the standard rectifier-based (75%) and converter-based (55%) power sources.

- Investment: R25 000
- Saving: R17 640 / annum
- Payback: 1.4 years

D. Plant power factor optimisation

The plant records generally show a poor power factor of about 0.75, primarily because of the type of loads (inductive) on the plant and their contribution to electrical system inefficiency. Operation of idling (as evidenced in the plant) and/or lightly loaded induction motors also contribute to a low power factor. A poor power factor not only causes power system losses in the distribution system but also increases utility bills (increased Maximum Demand charges, KW demand billing, reactive power kVAR charges and power factor (pf) penalties where applicable). The power factor ultimately determines the kW billing charge.

Onsite power factor (pf) can be improved by either procuring higher pf welding equipment (typical welder pf ranges between 0.6 – 0.7) or installation of pf correction equipment also

known as kVAR generators (capacitors). To improve the current pf of 0.75 to the optimal 0.95, capacitors of 76.8kVAR at R200/kVAR capacitor cost need to be installed.

A standard power factor correction table (see Appendix I) is referenced to estimate the required VARs. The factor from the table to improve pf from 0.75 to 0.95 is 0.553. The required kVAR is calculated as apparent power x table factor (139kVA x 0.553). It is assumed that the plant's apparent power kVA is approximately 140kVA, which translates to approximately 105kW true or real power at 0.75pf. The investment cost is arrived at when the average cost per kVAR is multiplied with the required VARs (R200/ kVAR x 76.8kVAR).

The monthly energy demand charge is approximately R13/kVA. Therefore a demand reduction from 140kVA to 110kVA (105kW/0.95pf) results in a 30kVA reduction, with a cost offset of approximately R4 600 per annum (30kVA x R12.7/kVA x 12months).

- Investment: R15 360
- Saving: R4 579 / annum*
- Payback: 3.4 years

*with continued savings thereafter; this is not an energy saving but merely a cost saving.

E. Recommended best practices

Good operational regimes and maintenance practices should be included as components in energy management as no/low cost measures. These include the following:

- Smart-metering (check meters and sub-meters)

To fully take control of the utility bills, smart check-metering is implemented in conjunction with sub-metering of individual electrical systems to maximise the monitoring and reporting capabilities. A check-meter is installed at the main incomer to check the main Municipality/ utility meter for any discrepancies and ensuring billing accuracy. Low cost entry-level energy management entails the physical reading of the meter, whilst a medium cost solution would be an integrated metering solution with data acquisition and online reporting software.

Architected into a tiered reporting structure, the software enables management to observe cost implications and site engineers and factory managers to observe power quality and consumption implications.

- Metering, Monitoring, Targeting and Reporting (MMTR)

An investment in an integrated metering solution, comprising field instruments/hardware (meters), data acquisition and reporting tool (software), coupled with dedicated communication systems and protocols can be a significant medium to high cost investment with an intangible return on investment (opportunity cost recoveries and proactive usage due to created visibility of utilities can have up to 2-5% energy cost savings). This would, however, require a comprehensive meter audit.

- Motors and motorised systems: High Efficiency Motors (HEMS)

Replacement of standard efficiency motors IE-1 with High (IE-2) and Premium (IE-3) Efficiency Motors when motor that has had three rewinds fails.

- Energy awareness programme
 - Change management

There are two parts to energy management: behavioural changes in consumption habits to reduce consumption and technological interventions to improve energy efficiency. Straightforward behavioural changes can be brought about through change management programmes.

A good example of behaviour change is to switch off lights during daytime when natural light is sufficient to illuminate the working space. Figure 30 below illustrates the unnecessary continued use of artificial light instead of the utilisation of natural light.

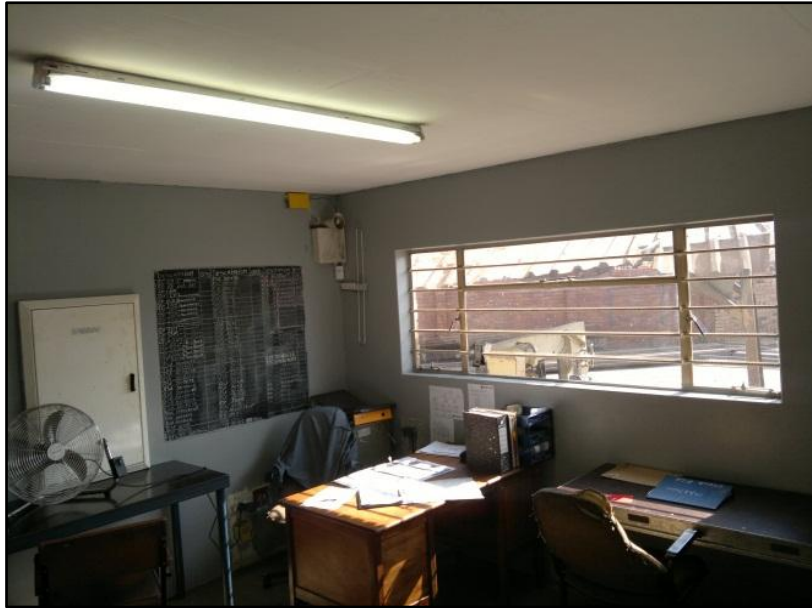


Figure 30 Artificial lights on despite sufficient natural light incident

This soft intervention releases the lowest cost opportunities as described under the energy management matrix.

- Training

Identifying onsite energy champions and allocating energy management and cost saving responsibilities entails that training is afforded to the selected site representatives. As mandated by the Energy Management Matrix, all energy users need to receive specific energy training integrated into other development activities. Energy-related workshops similar to the ones conducted for safety and health need to be conducted for all personnel, with special training afforded to operational staff in order to facilitate a sharing of knowledge across the operation.

- Load shifting: scheduled production

As a no cost measure, production can be scheduled to achieve full plant production capacity both during off-peak time of use and low season pricing. This has inherent benefits of reduction in energy costs.

3.6 Conclusion

The two case studies presented were Karob Plastics, a plastics container manufacturer, and Staluform, a metal formwork manufacturer. Both case studies are small manufacturing enterprises that are one-man owned and managed with an energy-intensive production value chain. The two case studies presented with typical manufacturing processes and systems such as utilities (compressed air, chilled water, etc.). The sites' load breakdown charts were presented with significant energy users (SEUs) identified and listed respectively.

The case studies' practices and attitudes towards energy usage by the end-users, particularly the shop-floor personnel, were reviewed. Operational regimes and maintenance practices influence end-user energy usage. Proposing operational regime changes and maintenance best practices impact positively on energy performance.

The comprehensive audit process involved a human interaction from management to shop-floor in explaining the purpose of the audit and preparing for the intended outcome of the survey. Energy awareness presentations were made to all staff and management on site, including contracted personnel such as cleaners and security guards.

A desktop study of the site's energy costs and consumption data provided the data for analysis. This provided the base energy data for the case studies. A full review of the historical data included the production output data. Regression analysis was performed with the energy and consumption data to ascertain their correlation.

Onsite data were gathered for both case studies as inputs into the quantitative analysis. Onsite data included logging of energy systems as well as capturing nameplate data of the energy components such as motors, lamps and heaters, etc. Historical and onsite data were also logged and profiled significant energy users (SEUs) were then presented. Energy management opportunities complemented with best practices were recommended as a result of the energy assessment/audit.

A business case for implementation of energy saving measures/ recommendations was developed and presented as energy efficiency projects for company consideration. Technical and financial feasibilities of the identified Energy Management Opportunities (EMOs) provided a business case to the companies for consideration.

4 RESULTS AND APPLICATION

4.1 Results

Presented below are potential energy and cost saving opportunities identified through the energy assessments. Only after actual adoption of the recommended interventions can actual savings be realised. During the energy assessment period, Karob Plastics went on to implement some no cost and low cost interventions whilst Staluform did not.

Some of the immediate interventions taken up by Karob Plastics involved some best practices regarding maintenance and operational regime changes, as well as behavioural changes. Notably, Karob Plastics managed to relocate the air compressors into an open space to allow for cool air movement.

At the time of the final site assessment, Karob Plastics had started to record energy performance improvements, as well as realising energy savings through waste minimisation arising from switching off of non-essential loads and non-productive machinery.

4.1.1 Karob Plastics - quantification of EMOs

Karob Plastics had commenced their journey to energy performance improvement way before the energy survey was even commissioned and were presented with the following marginal quantifiable energy management opportunities (EMOs) at time of audit with so much having been done already:

- A 20% reduction in electrical energy usage from the base consumption of 2 545 535 kWh per annum.
- A 17% reduction in energy costs from the base cost of R2 619 543 per annum.
- A >20% reduction overall CO₂ emissions.
- Total energy cost savings identified amount to R445 446 per annum as detailed in Table 25 below: below.
- Total energy savings identified amount to 507 744 kWh per annum as detailed in Table 25 below.

A summary of the EMOs at Karob Plastics arising from the energy assessment is presented in Table 25 below.

Table 25 Karob Plastics' identified EMOs

No.	Description of measures	Estimated Annual Savings		Estimated cost (R)	Payback period (years)	No cost, low, medium or high cost
		(R/year)	(kWh/year)			
1	Energy efficient lighting with electronic control gear, daylight harvesting through use of polycarbonate clear sheets & optimal light re-positioning	12467	25444	19800	1.6	low - medium cost
2	Chiller compressor control optimisation	24990	51000	60000	2.4	medium - high cost
3	Air compressor re-location	3665	7480	10000	2.7	low - medium cost
4	Blow & injection Moulders optimisation	374 651	392 716	167 700	0.4	high cost
5	Electric hot water system replacement with solar hot water geyser	29673	31104	28000	0.9	low - medium cost
Total		R445 446	507744	R285 500		

As evidenced from Table 25 above, based on the estimated cost of the interventions and the estimated annual savings, the overall payback is just under 0.5 years. This very short payback time is motivation enough for the proposed interventions to be implemented without delay by Karob Plastics.

4.1.2 Karob Plastics - Energy Management Matrix

Apart from the actual quantification of energy saving opportunities Table 25 above, a review of the site's maturity in their energy management continuum was also conducted through the use of an Energy Management Matrix as shown in Table 26 below.

The Matrix is a tool that helps companies with the assessment of their organisational strengths and weaknesses across the six main areas of energy management. In a continuing pursuit of efficient and sustainable production the auditors examined the site for:

- Policy and systems:
 - Energy policy in place with an action plan and regular review. Commitment of management as part of a business and environmental strategy with clear targets and accountability.
- Organising or organisation:
 - Energy management fully integrated into management structure. Clear delegation of responsibility for energy consumption.
- Skills and knowledge or motivation:
 - All energy users receive specific energy training integrated into other development activities. Workshops and operations among the group facilitate a sharing of knowledge.
- Information systems:
 - Comprehensive system sets targets, monitors consumption, identifies faults, quantifies savings and provides budget tracking.
- Marketing and communication and training and awareness:
 - Communicating the value of energy efficiency and the performance of energy management within the organisation and outside.
- Investment:
 - Positive discrimination in favour of 'green' schemes with detailed appraisal of all new build and refurbishment opportunities.

Table 26 Karob Plastics' energy management matrix (with Auditor's site rating)

Level	Energy Policy or Policy & Systems	Organising or Organisation	Skills & Knowledge or Motivation	Information Systems	Marketing & Communications or Training & Awareness	Investment
4	Energy Policy, action plan and regular review have commitment of top management as part of a business & environmental strategy	Energy Management fully integrated into management structure. Clear delegation of responsibility for energy consumption	All energy users receive specific energy training integrated into other development activities. Workshops facilitate a sharing of knowledge	Comprehensive system sets targets, monitors consumption, identifies faults, quantifies savings and provides budget tracking	Communicating the value of energy efficiency and the performance of energy management within the organisation and outside	Positive discrimination in favour of 'green' schemes with detailed appraisal of all new build & refurbishment opportunities
3	Formal energy policy but no active commitment from top management	Energy Manager accountable to energy committee representing all users	Key energy users receive regular and specific training. Brief awareness training provided to all energy users	Monitoring and targeting reports for individual areas based on sub-metering, but savings not effectively reported to user	Programme of Staff awareness and regular publicity campaigns	Same payback appraisal criteria employed as for all other investment
				X		X
2	Unadopted energy policy set by senior manager or senior departmental manager	Energy Manager in post, reporting to ad hoc committee but line management authority unclear	Key energy users receive awareness training, also occasional system-specific training	Monitoring and reporting targets based on supply meter data. Energy unit has ad hoc involvement in budget setting	Some adhoc staff awareness training	Investment using short term payback criteria only
1	An Unwritten set of guidelines	Energy Management the part-time responsibility of someone with only limited authority or influence	Key employees participate occasionally in awareness training. Some information passed informally to energy users	Cost reporting based on invoice data. Engineer compiles reports for internal use within technical department	Informal contacts used to promote energy efficiency	Only low cost measures taken
		X				
0	No explicit policy	No energy management or any formal delegation of responsibility for energy use	Energy users rely on their existing knowledge	No information systems. No accounting for energy consumption	No promotion of energy efficiency	No investment in increasing energy efficiency in plant
	X		X		X	

Table 27 below captures the scoring from the energy management matrix above into a tabular format.

Table 27 Energy management matrix comparison scoring

Focus Area	Optimum Level	Site's own assessment 1	Auditor's Assessment
Energy policy or policy & systems	4	1	0
Organising or organisation	4	1	1
Skills & knowledge or motivation	4	0	0
Information systems	4	3	3
Marketing & communications or training & awareness	4	0	1

Based on the energy Auditor's own score of the site, Karob Plastics scored a total of eight (08) points out of a possible twenty four (24) points, leaving significant room for improvement. An outstanding potential improvement of about 66% thus points to the many opportunities onsite that Karob Plastics could immediately start to formulate into an action plan.

Tabular data when represented in a graphical form is much more visually appealing and easily understood and acted upon. Figure 31 below is a graphical representation of Table 27 above of the energy management matrix scoring.

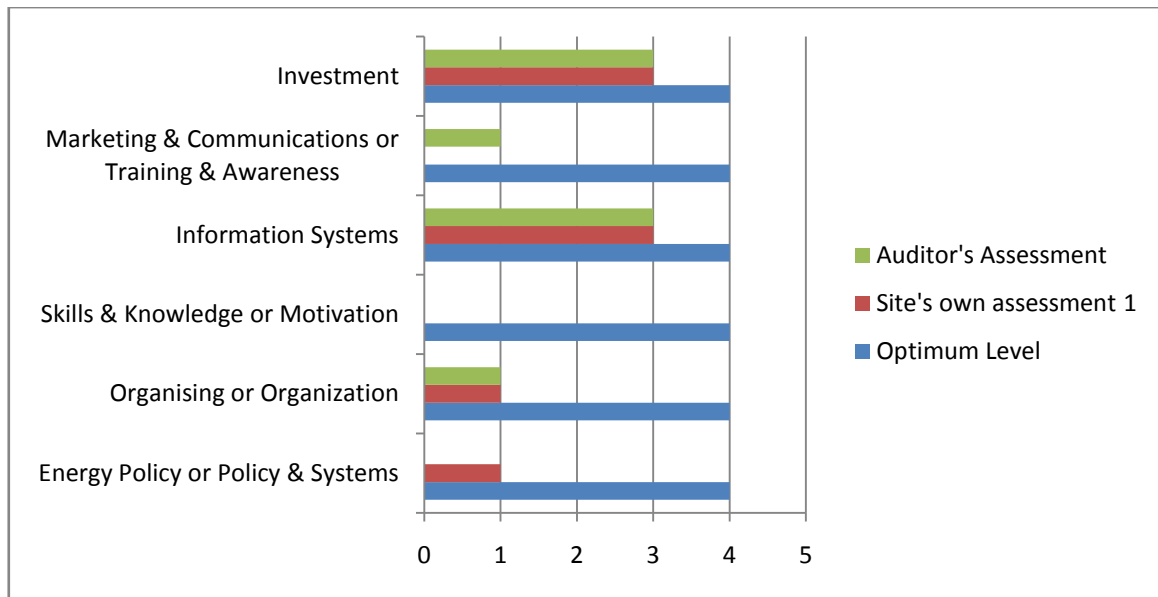


Figure 31 Graphical representation of site's energy management matrix rating

Output from the Matrix shows that energy management by the site is presently carried out on an adhoc or informal basis without a formalised Energy Management System in place. However, effort has been demonstrated in terms of information systems and energy-related investments. Energy consumption and costs are monitored and tracked through an installed data acquisitioning and reporting tool (Power-star), principally to check that no major exceptions to the norm have occurred (over-charge) and to maintain visual on the energy utility.

A strategic approach is to be adopted for the alignment of the company to industry best practice in energy management/ attainment of the matrix objectives. In brief these strategies are:

- Development of a formal energy management policy.
- Provision of corporate support by way of tools and dissemination of information.
- Corporate setting of broad-based reduction targets.
- Manufacturing site responsibility for ownership of energy management programs, including site-specific target setting, energy reviews and implementation.
- Development of some staff awareness training, incorporated into site based activities.
- Application of investment appraisal to energy efficiency in a way equivalent as to all other cash-generating projects (e.g. integrated metering solution).

4.1.3 Staluform - quantification of EMOs

Staluform presented with close to a 50% opportunity for energy consumption reduction from the baseline. This indicated that Staluform had not embarked on any proactive measures to reduce their wastage and operate more efficiently. Staluform was presented with the following energy management opportunities (EMOs):

- A 47% reduction in electrical energy usage from the base consumption of 204 435.00 kWh per annum.
- A 19% reduction in energy costs from the base cost of R275 496.62 per annum.
- A >47% reduction overall in CO₂ emissions.
- Total energy cost savings identified amount to R56,100 per annum as detailed in Table 28 below.
- Total energy savings identified amount to 105 170 kWh per annum as detailed in Table 28 below.

Table 28 Staluform's identified EMOs

No.	Description of Measures	Estimated Annual Savings		Estimated cost (R)	Payback Period (years)	No cost, low, medium or high cost
		(R/year)	(kWh/year)			
1	Plant pf optimisation	4,579		15,360	3.4	low - medium cost
2	Energy efficient lighting with electronic control gear, daylight harvesting & optimal re-positioning	24,705	50,418	29,990	1.2	low - medium cost
3	Conversion to CO ₂ welders	17,640	36,000	25,000	1.4	low - medium cost
4	Compressed air system (CAMP) – leak detection/ end-use optimisation	9,189	18,754	30,000	3.3	low - medium cost
Total		R 56,113	105,172 kWh	R 100,350		

For Staluform, the overall payback for the identified energy management opportunities is just under two (02) years. This is well within most business' hurdle rate.

4.1.4 Staluform's Energy Management Matrix

Apart from the actual quantification of energy saving opportunities (table above), a review of the site's maturity in their energy management continuum was also conducted through the use of an Energy Management Matrix. The Matrix is a tool that helps companies with the assessment of their organisational strengths and weaknesses across the six main areas of energy management. In a continuing pursuit of efficient and sustainable production the Auditors examined the site for:

- Policy and systems:
 - Energy policy in place with an action plan and regular review. Commitment of management as part of a business and environmental strategy with clear targets and accountability.
- Organising or organisation:
 - Energy management fully integrated into management structure. Clear delegation of responsibility for energy consumption.
- Skills and knowledge or motivation:
 - All energy users receive specific energy training integrated into other development activities. Workshops and operations among the group facilitate a sharing of knowledge.
- Information systems:
 - Comprehensive system sets targets, monitors consumption, identifies faults, quantifies savings and provides budget tracking.
- Marketing and communication and training and awareness:
 - Communicating the value of energy efficiency and the performance of energy management within the organisation and outside.

- Investment:
 - Positive discrimination in favour of 'green' schemes with detailed appraisal of all new build and refurbishment opportunities.

The Matrix forms one of the main discussion items during pre-audit interviews with management and staff, and covers the six key issues/energy management components. For each component the company will be at level 0 (lowest), 1, 2, 3 or 4 (highest level).

Table 28 Staluform's energy management matrix (with Auditor's site rating)

Level	Energy Policy or Policy & Systems	Organising or Organisation	Skills & Knowledge or Motivation	Information Systems	Marketing & Communications or Training & Awareness	Investment
4	Energy Policy, action plan and regular review have commitment of top management as part of a business & environmental strategy	Energy Management fully integrated into management structure. Clear delegation of responsibility for energy consumption	All energy users receive specific energy training integrated into other development activities. Workshops facilitate a sharing of knowledge	Comprehensive system sets targets, monitors consumption, identifies faults, quantifies savings and provides budget tracking	Communicating the value of energy efficiency and the performance of energy management within the organisation and outside	Positive discrimination in favour of 'green' schemes with detailed appraisal of all new build & refurbishment opportunities
3	Formal energy policy but no active commitment from top management	Energy Manager accountable to energy committee representing all users	Key energy users receive regular and specific training. Brief awareness training provided to all energy users	Monitoring and targeting reports for individual areas based on sub-metering, but savings not effectively reported to user	Programme of Staff awareness and regular publicity campaigns	Same payback appraisal criteria employed as for all other investment
2	Unadopted energy policy set by senior manager or senior departmental manager	Energy Manager in post, reporting to ad hoc committee but line management authority unclear	Key energy users receive awareness training, also occasional system-specific training	Monitoring and reporting targets based on supply meter data. Energy unit has ad hoc involvement in budget setting	Some adhoc staff awareness training	Investment using short term payback criteria only

Level	Energy Policy or Policy & Systems	Organising or Organisation	Skills & Knowledge or Motivation	Information Systems	Marketing & Communications or Training & Awareness	Investment
1	An unwritten set of guidelines	Energy Management the part-time responsibility of someone with only limited authority or influence	Key employees participate occasionally in awareness training. Some information passed informally to energy users	Cost reporting based on invoice data. Engineer compiles reports for internal use within technical department	Informal contacts used to promote energy efficiency	Only low cost measures taken
		X				X
0	No explicit policy	No energy management or any formal delegation of responsibility for energy use	Energy users rely on their existing knowledge	No information systems. No accounting for energy consumption	No promotion of energy efficiency	No investment in increasing energy efficiency in plant
	X		X	X	X	

Based on the Energy Auditor's own score of the site, Staluform scored a total of two (02) points out of a possible twenty four (24) points, leaving significant room for improvement. Interestingly enough, Staluform's own personnel scored themselves not more than two (02) points; in effect agreeing with the Auditor and in a way admitting to how little the site has moved along its energy management continuum. Table 29 below illustrates this. An outstanding potential improvement of over 90% thus points to the many opportunities onsite that Staluform could immediately start to formulate into an action plan.

Table 29 Energy management matrix comparison scoring

Focus Area	Optimum Level	Site's own assessment 1	Site's own assessment 2	Site's own assessment 3	Auditor's Assessment
Energy Policy or Policy & Systems	4	0	0	0	0
Organising or Organisation	4	0	0	1	1
Skills & Knowledge or Motivation	4	0	0	0	0
Information Systems	4	0	1	0	0

Focus Area	Optimum Level	Site's own assessment 1	Site's own assessment 2	Site's own assessment 3	Auditor's Assessment
Marketing & Communications or Training & Awareness	4	0	1	1	0
Investment	4	1	0	0	1

As with the other case study, tabular data in Table 29 above are represented in a graphical form for visual appeal and to make the data easily understood and catalyse fast action. Figure 32 below is a graphical representation of Table 29 above of the Energy Management Matrix scoring for Staluform.

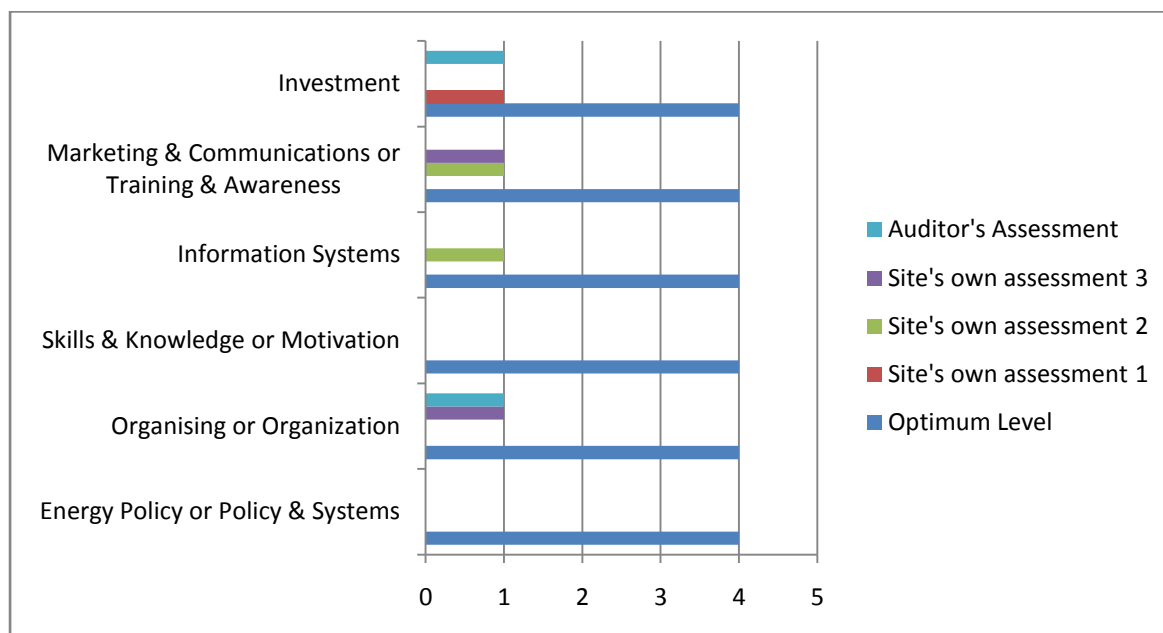


Figure 32 Graphical representation of site's energy management matrix rating

Output from the Matrix shows that energy management by the site is presently carried out on an *ad hoc* or informal basis without a formalised Energy Management System in place. Only projects with quick returns and/or low upfront costs are implemented, most often with sectional heads having taken the initiative and instituted some changes (e.g. lamp swap outs). Energy costs are monitored and tracked, principally to check that no major exceptions to the norm have occurred (i.e. over-charge).

A strategic approach is to be adopted for the alignment of the company to industry best practice in Energy Management/attainment of Matrix objectives. In brief these strategies are the following:

- Development of a formal energy management policy.
- Provision of corporate support by way of tools and dissemination of information.
- Corporate setting of broad-based reduction targets.
- Manufacturing site responsibility for ownership of energy management programmes, including site-specific target setting, energy reviews and implementation.
- Development of staff awareness training, incorporated into site-based activities.
- Application of investment appraisal to energy efficiency in a way equivalent with all other cash-generating projects (e.g. integrated metering solution).

4.2 Comparison of results

4.2.1 Karob Plastics vs. Staluform

Energy intensity, as well as baseload, is used as the common platform on which to compare the two case studies.

Linear regression of the two case studies' energy consumption vs. production yields the energy models (graphs and equations) that provide quantitative results for further analysis and commentary.

Figure 33 below is a plot of the energy consumption against production for Karob Plastics.

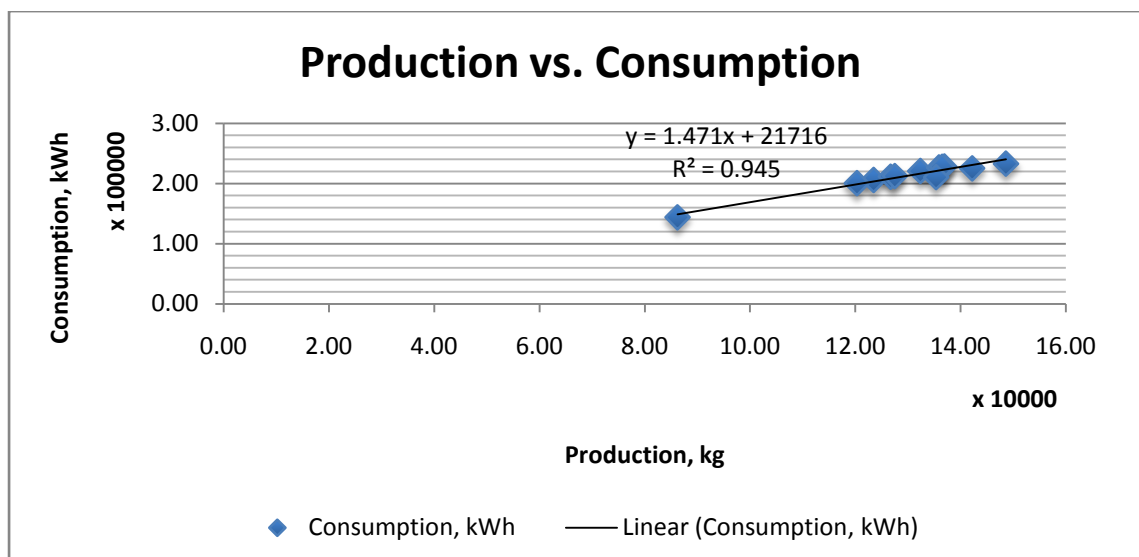


Figure 33 Karob Plastics' energy model (2011 data)

Summary Table 30 below shows the results of this linear regression.

Table 30 Karob Plastics' regression analysis values

Slope	1.47
Baseload (intercept)	21 716
R ²	0.94

R² shows the amount of variance of Y (electricity consumption) explained by X (production).

An R² value of above 70% and approaching unity (1) is an indication of a good model. In this case, production explains 94% of variance in electricity consumption. There is a clear correlation between the two parameters (production and electricity consumption). In essence, production is a driver for energy consumption, and there might not be any other driver influencing electricity consumption.

The best-fit line indicates a positive gradient of 1.47, which is a positive correlation coefficient. This shows that production and electricity consumption are related in a positive linear sense. The Y-intercept indicates the baseload; that is the energy consumption at no production. This model estimates a baseload of 21 716 kWh which translates into a Rand cost of approximately R22 367.48 not associated with active production.

This baseload represents approximately 10% of the average monthly consumption (212 127kWh). This is a significant amount of energy consumption not being attributed to production. There is a need to put in place measures to reduce or effectively eliminate this

baseload; measures such as switching off equipment when not in use, utilisation of plant to its full production capacity, as well as active monitoring of the night time load which is inherently wasteful due to the absence of responsible supervisory oversight.

Figure 34 below is a plot of the energy consumption against production for Staluform:

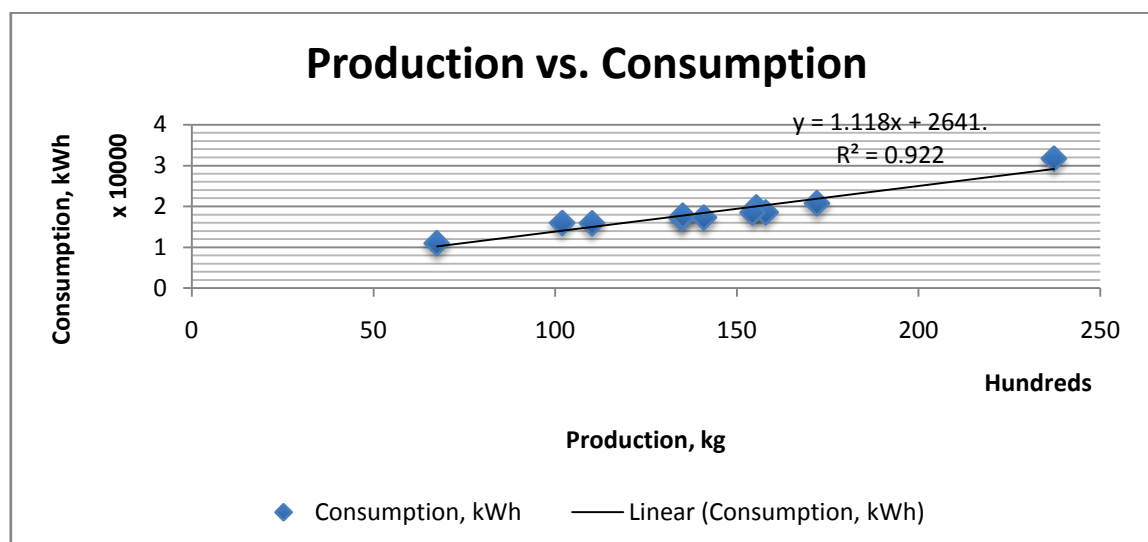


Figure 34 Staluform's energy model (2011 data)

Summary Table 31 below shows the results of this linear regression.

Table 31 Staluform's regression analysis values

Slope	1.19
Baseload (intercept)	2 641
R^2	0.92

R^2 shows the amount of variance of Y (electricity consumption) explained by X (production).

An R^2 value of above 70% and approaching unity (1) is an indication of a good model. In this case, production explains 92% of variance in electricity consumption. There is a clear correlation between the two parameters (production and electricity consumption). In essence, production is a driver for energy consumption, and there might not be any other driver influencing electricity consumption.

The best-fit line indicates a positive gradient of 1.19, which is a positive correlation coefficient. This shows that production and electricity consumption are related in a positive linear sense. The Y-intercept indicates the baseload; that is the energy consumption at no production. This model estimates a baseload of 2 641 kWh which translates into a Rand cost of approximately R3 565.35 not associated with active production.

This baseload represents approximately 14% of the average monthly consumption (18 585kWh). This is a significant amount of energy consumption not being attributed to production. There is need to put in place measures to reduce or effectively eliminate this baseload; measures such as switching off equipment when not in use, utilisation of plant to its full production capacity, as well as active monitoring of the night time load which is inherently wasteful due to the absence of responsible supervisory oversight.

4.2.2 Karob Plastics (2011/12) vs. Karob Plastic (2012/13)

Data are compared for Karob Plastics over an overlapping period from 2011 to 2013 and presented in two separate tables.

Table 32 below shows the figures for the first 12-month, 2011/12 period from June 2011 to May 2012; whilst Table 33 shows another 12-month period of 2012/13 running from March 2012 to February 2013. The overlap in months from March 2012 to May 2012 ensures continuity within same business conditions for at least a 3-month period. This creates further confidence in the comparison.

Table 32 Energy consumption and production figures for 2011/12

Month, 2011/12	Production, kg	Consumption, kWh
Jun-11	86254	143758
Jul-11	123481	205802
Aug-11	132383	220639
Sep-11	126764	211274
Oct-11	127544	212574
Nov-11	135942	226570
Dec-11	120344	200574

Month, 2011/12	Production, kg	Consumption, kWh
Jan-12	136939	228233
Feb-12	136501	227503
Mar-12	142220	225222
Apr-12	135400	210511
May-12	148640	232875
TOTAL	1552416	2545535

As can be deduced from the figures in Table 32 above, based on the 2011/12 production and energy consumption figures over a period of 12 months, the average monthly energy consumption is 212 127kWh with the corresponding average production of 129 368kg.

This gives an energy intensity figure of 1.64kWh per kg. At an average unit price (AUP) of R1.03 per kWh, the associated energy cost of producing 1kg of product is R1.69.

In comparison to Table 32 above, consumption and production figures for the 12-month period over 2012/13 are captured and tabulated in Table 33 below.

Table 33 Energy consumption and production figures for 2012/13

Month, 2012/13	Production, kg	Consumption, kWh
12-Mar	142220	225222
12-Apr	135400	210511
12-May	148640	232875
12-Jun	157030	262433
12-Jul	168400	258570
12-Aug	153160	247870
12-Sep	175110	262269
12-Oct	182400	287362
12-Nov	191800	275333

Month, 2012/13	Production, kg	Consumption, kWh
12-Dec	74115	119185
13-Jan	114200	176342
13-Feb	171500	266838
TOTAL	1813975	2824810

Based on the 2012/13 production and energy consumption figures over a period of 12 months, the average monthly energy consumption is 235 400kWh with the corresponding average production of 151 164kg.

This gives an energy intensity figure of 1.55kWh per kg. At an average unit price (AUP) of R1.03 per kWh, the associated energy cost of producing 1kg of product is R1.60.

Figure 35 below is a plot of the energy consumption against production for Karob Plastics using 2011/12 data:

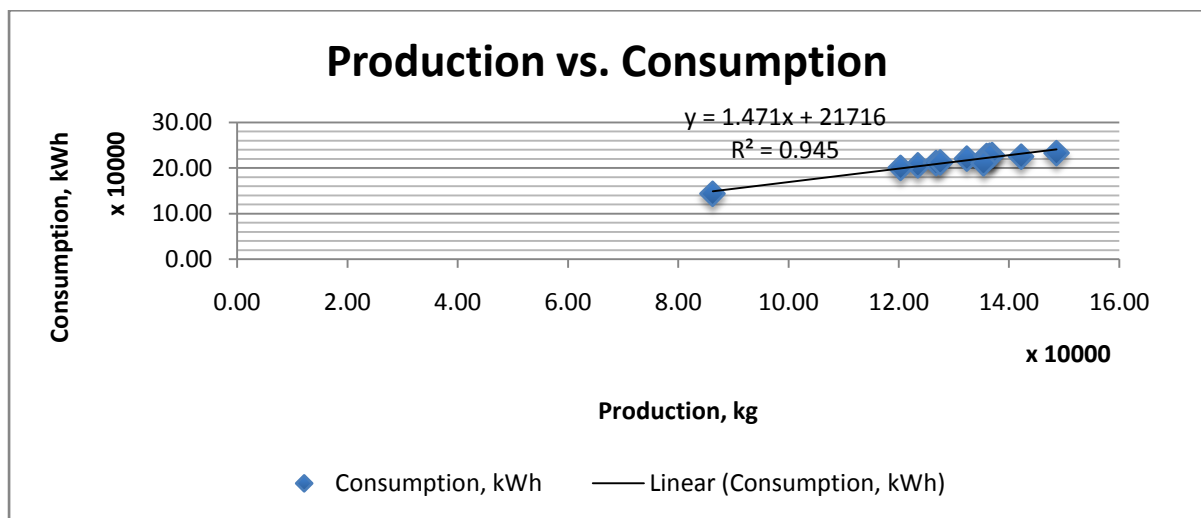


Figure 35 Karob Plastics' energy model (2011/12 data)

The derived model from the regression analysis above indicates a baseload of 21 716kWh (as energy consumption at zero production). This baseload is about 10% of the total average monthly consumption of 212 127kWh.

Figure 36 below is a plot of the energy consumption against production for Karob Plastics using 2012/13 data:

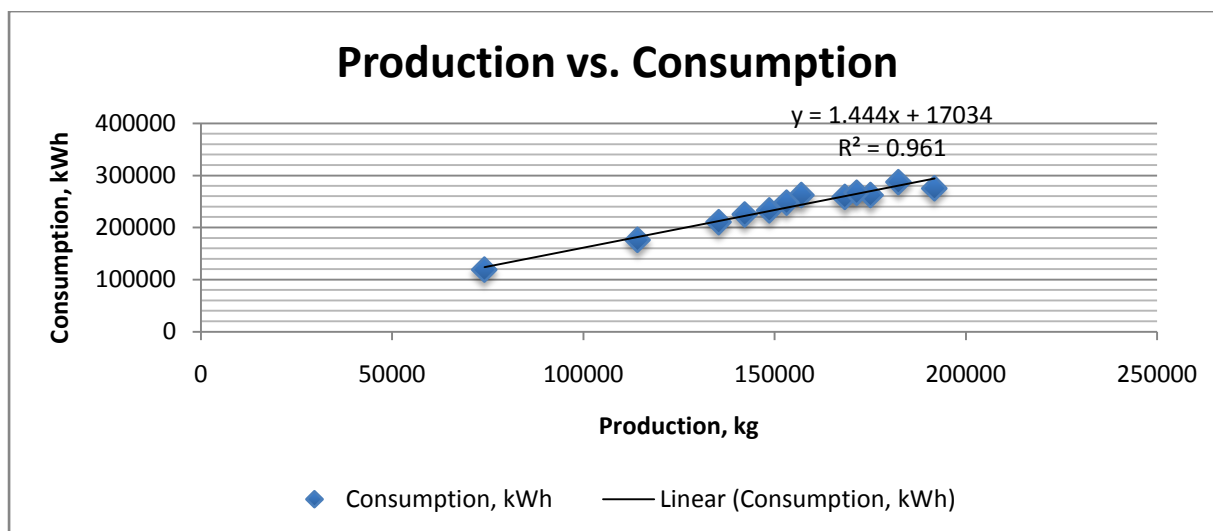


Figure 36 Karob Plastics' energy model (2012/13 data)

The derived model from the regression analysis above indicates a baseload of 17 034kWh (as energy consumption at zero production). This baseload is about 7% of the total average monthly consumption of 235 400kWh.

4.2.3 Energy performance improvement of responsive case study (Karob Plastics)

The 2011/12 baseload of 21 716kW translates into a Rand cost of approximately R22 367.48 not associated with active production, whilst, the 2012/13 baseload of 17 034kWh translates into a Rand cost of approximately R17 545. The reduction in the baseload realised in 2012/13 from the 2011/12 baseline has a saving of R4 821 per month or R57 863 per annum.

4.2.4 Energy intensity improvement of responsive case study (Karob Plastics)

When compared with the 2011/12 cost of production of R1.69 per kg, the 2012/13 cost of production of R1.60 per kg represents a 9c per kg saving. Given an average monthly production of 140 266kg, the 9c per kg saving translates into a sizeable R12 623 saving per month or R151 487 per annum.

4.3 Verification and validation

The historical data acquired for both case studies in terms of production volume, electricity consumption and cost were checked for accuracy and verified through a simple intensity ratio to identify any anomalies in the presented data.

The study set out with the hypothesis that the introduction of energy management concepts, work practices and initiatives would improve the energy performance and intensity to warrant profitability and sustainability in a small manufacturing enterprise. The two case studies under review met the requirements for the study.

One case study had already started to embrace energy management and was already on their journey to adopting energy management opportunities (EMOs). The other case study was not in the least interested in energy management which they perceived as a nuisance to their production activities. Energy management best practice, typical small manufacturing enterprise production cost structure, and typical small manufacturing enterprise non-optimised baseload consumption all compare well with the results of this study.

The results of the one responsive case study (Karob Plastics) on energy performance improvements through the reduction of the baseload is arrived at through an analysis of a representative data sample of 21 continuous months with a 3-month overlap. The same representative data sample of 21 continuous months with a 3-month overlap was analysed for energy intensity improvement through the reduction of unit of energy input per unit of product output. This 21-month uninterrupted assessment assured the quality of the study as site operations and energy performance was monitored without any interruption and under same conditions for the overlap months.

4.4 Application

4.4.1 Small manufacturing enterprises sector-benchmarking

Typically, a manufacturing enterprise has the core of its production process consuming a significant portion of its energy. Process core operations are for the most part rigid as they align to product quality, volumes and even environmental and health compliances.

This implies that recommendations to optimise process core operations and systems have to be vetted by process engineers, production managers and even manufacturing executives before any changes are effected. What remain are the non-process core auxiliaries that are essential to the process but not critical to the product.

With the understanding of how much of a facility's energy consumption is typically non-core and not tied to the restrictions of production, it is possible to benchmark possible expected energy consumption reduction, be it in plastic forming or metalwork; reductions that do not

compromise production and quality. Savings potentials per production form can also be benchmarked given the typical savings associated with technology within a sub-sector as stated in chapter 2 Table 4.

4.4.2 Energy performance tracking

Energy performance indicators (EnPI) essentially indicate the direction of performance as to whether it is improving or regressing. With clearly understood metrics put in place that are tracked through a well-established tracking system, the energy performance of a discrete piece of equipment as well as that of an entire facility or establishment can be observed.

For similar production processes and products, it is possible to benchmark the industry with conclusive performance indicators such as kWh/tonne of finished product or GJ/unit of product. These are then tracked over time to assess energy performance.

4.4.3 Monitoring and target-setting

Energy consumption reduction targets are set based on either calculated savings potential or aspirational targets informed by a clear understanding that nothing has been done in the past to reduce the facility's energy consumption.

Once targets are set and agreed to, the next step is to find ways to monitor the set targets. Monitoring of these targets would involve the use of manual or fully automated systems. Monitoring tools in the form of data loggers and metering units, when deployed, give a visual on energy. A visual prompts a more proactive than a reactive approach to management of energy resources.

4.4.4 Bespoke low-cost, easy to implement Energy Management System for small manufacturing enterprises

To ease the process of adoption of an energy management regime by a small manufacturing enterprise, it becomes imperative that a low-cost, easy to understand and implement Energy Management System is developed. Small manufacturing enterprises have neither the inherent resources nor the know-how to adopt and implement energy management best practices and systems.

A thoroughly watered down Energy Management System, though still based on the energy management standard ISO 50001, can be adapted from the ISO standard and developed

specially for the small business. This would accelerate the adoption of a systematic approach to energy management given that small business neither has the resources nor the inherent skills to deploy an effective implementation of an Energy Management System. Instead of presenting energy management as a resource intense, complex system focused at the attainment of the triple bottom-line of social equity, environmental and financial benefits, SMEs would be most receptive to an economic/financial benefit only, with social and environmental aspects coming in as consequential.

4.4.5 SMEnT – A small manufacturing enterprise energy management toolbox

A toolbox should guide a small manufacturing enterprise on its energy management continuum. Understanding the 'DNA' of a small manufacturing enterprise, as well as what the building blocks are for an energy management process and system, informs the contents of a small manufacturing enterprise energy management toolbox (SMEnT). Using historical data, baselines to help track progress and providing feedback to motivate for further action are developed.

4.4.6 Aggregated energy savings within the SMME subsector and SME cluster

On a global scale, the practical application of this research is to quantify the energy savings potential inherent within the small manufacturing enterprises cluster and what the resultant aggregated energy savings would be across the entire SMME subsector. Given that the Energy Intensive User Group of South Africa, an association of large scale, high intensity energy consumers, currently account for approximately 44% of the electrical energy consumed in South Africa (EIUG), it indicates how the larger balance of electrical energy consumed is lying elsewhere. In this case, a significant aggregated portion lies within the SMME.

The three largest energy-consuming economic sectors in South Africa still remain as industry, residential and transport, with the industrial sector being the largest user of these three sectors. The industrial sector is divided into various sub-sectors; namely the manufacturing industry, the commercial sector, agriculture, and mining. The aggregated electricity consumed in the industrial sector in 2012 was approximately 47% of the total National Consumption with the manufacturing industry alone contributing 27% of it (DOE, 2012).

Nearly 10% (580 000) of the SMMEs are within the manufacturing sector (Chemonics International, 2012). This represents a significant energy savings potential in a subsector that has not embarked on the journey to reduce their energy consumption through energy efficiency and conservation measures as propagated through energy management best practice.

4.5 Conclusion

Small manufacturers' inherent lack of resilience to rising energy costs means that their failure to act to counter these rising energy prices and resulting high production costs could result in the erosion of business' profit margin and spell potential business failure.

The study highlights the consequence of business failing to act and counter the rising energy costs through the adoption of, and putting into action, energy management best practices. Rising production costs, due partly to rising energy costs, can easily be discounted through counter measures that involve the deployment of energy management practices and systems.

The two case studies were selected for their similarities in business operation and yet still having fundamental differences in their attitude towards energy management. This fundamental difference in attitude towards energy presented a best case for verification. The one company was found to have already focused on their energy management continuum but had yet to embrace energy management best practice. This responsive case study embarked upon a systematic and holistic approach to energy management. In so doing, it provided the validation that indeed energy management does improve the profitability of a business entity.

Validation of energy performance improvement for the one responsive case study was through its production cost component of energy. The energy cost component was significantly reduced and contained through a well-managed energy intensity measure; which continues to improve over time.

Where some energy management opportunities are proactively implemented, monitored and evaluated, energy performance improvement is expected, while where implementation of proposed solutions is postponed, there still remains uncontrollably higher energy consumption with poor energy performance indicators presenting.

High baseload energy consumption which occurs at zero production is therefore expected to reduce as a consequence of minimisation of energy wastage. A low baseload translates into a lower production fixed cost component.

5 CONCLUSION TO THE RESEARCH

5.1 Overview

The business imperative to remain in business entails a number of management competences, with some competences more recognised than others. Though competences such as product innovation and strategic raw material sourcing can be identified as commonplace in most businesses, a business' internal capability and concerted efforts towards the management of energy resources is often missing, secondary or totally ignored.

Admittedly, energy management as an inherent business capability is lacking, especially in small manufacturing enterprises. The skills most prevalent in business, and more so in small manufacturing enterprises, are mainly managerial, accounting, production and personnel management but with very little motivation for energy management up-skilling and capacitating. Within business, especially small manufacturing enterprises, the priority is towards pushing products out of the door with very little to no regard for the contributing factors to the total production cost; production costs which includes energy cost, raw materials and labour.

Energy cost is still to be recognised as a critical production cost component that needs to be managed. Energy consumption and costs need to be identified as business elements with the potential to impact on a business's bottom-line as well as posing a risk to its continued operation and production. There is a need, therefore, to bring energy management to the fore and make it an integral part of every business.

On a global scale, energy management programmes targeted at small manufacturing enterprises have been rolled out in tandem with a corresponding monitoring and evaluation programme to report on impacts. On a South African national scale, there are fewer programmes both at policy and implementation level that are run by both Government and the private sector that support energy management in small manufacturing enterprises.

Though identified as an emerging field, energy management has ascended to the top of management agenda in big Corporates, pushed up mainly due to increasing energy costs, energy security concerns, as well as global environmental concerns both for climate change and pollution.

The case for adoption of energy management in small manufacturing enterprises is compelling. The question as to whether the adoption of energy management best practices does impact on the profitability of a business significantly to warrant action is to answered with an emphatic 'yes'. The ability for small manufacturing businesses to endure in a much more environmentally conscious manner whilst containing social and economic challenges entails long-term economic success balanced with social well-being and a safe environment.

This ability to endure means sustainability wherein profitability is identified as one of the pillars alongside social and environmental concerns. Energy management, which is defined as the careful management of resources including reducing total energy use (energy conservation) and using energy more efficiently (energy efficiency), fits into the intersection of the environmental and economic pillars of sustainability.

Strategic management of energy generally still remains not fully exploited despite the evident increasing energy costs, energy security, and environmental concerns. Mainstreaming energy management through policy direction and relevant programmes by Government is to be expected. Big business' corporate social responsibility of involving their supply chain in energy efficiency and conservation is what will bring in the small business.

5.2 Findings

Much of the effort in small business enterprise development has been more concerned with the management of other resources, such as personnel. Small businesses also concern themselves more with such aspects as accounting and finance. However, they are least involved with the management of energy as a resource.

The more significantly higher the energy consumption and cost is for a business, the more attention is given to energy as a production cost. With Karob Plastics' energy consumption being of the magnitude order of 10 times that of Staluform, it is not surprising that Karob Plastics had already commenced on the journey to becoming more energy efficient.

The company (Karob Plastics) that went on to embrace energy management best practice adopted a holistic and systematic approach to energy management, resulting in a continuous improvement process in its energy performance and improved energy intensity (kWh per unit of product).

Despite the clear environmental and economic advantages that can be achieved with the implementation of resource efficiency measures, manufacturing SMEs have been slow at adoption. Small manufacturing industry groups and government bodies mandated to examine small business should benefit from understanding the benefits associated with small business of resource efficiency. The main reason for the failure to adopt resource efficiency measures has been identified as lack of information and critical knowledge. Other concerns include the following:

- SME decision-makers' lack of resource efficiency and process optimisation awareness.
- Production process benchmark data insufficiency, inadequate alternative technologies database, lifecycle and recycling data, as well as product and material impact assessment.
- Access to technologies and innovative solutions knowledge gaps, unexplored opportunities of supply and production chains and across industry sectors' cooperation. (Greenovate! Europe, 2012).

5.3 Significance of the research

The literature survey did not reveal any specific previous research that had been conducted to find out whether introducing energy management in a small manufacturing enterprise improved its profitability. The literature survey did, however, yield existing programmes that companies have embarked on in introducing energy management into business operations with a full understanding that it yields energy consumption reduction and cost savings.

This current research was aiming at establishing the link between implementing energy management and the resulting business profitability; this by way of a mixed research methodology of quantitative surveys and qualitative studies.

This research confined itself to eco-economic research examining environmental and economic intersecting issues and not the socio-political, socio-environmental or socio-economic issues which are outside the scope of this research. This eco-economic research therefore allows for other researchers to focus on particularly the socio-political aspect that also has a bearing on small business existence.

What the research further provides are various literature sources with relevance in the topical subjects of energy management concept and programmes, small manufacturing

enterprises, business profitability and sustainability. This literature sources should benefit other researchers and business.

5.4 Limitations to the study

The research was an eco-economic research (technical research) focusing on the economics of small business and the energy/environmental impact and production cost implications of doing and staying in business. It was not a socio-political commentary which in itself is a subject matter worthy of extensive research.

As technical research, it did not attract as much interest as would have a socio-political research that stands to directly address areas of typically common interest such as job creation and enterprise development of SMMEs. This meant that solicitation of information from certain institutions was not treated with urgency or importance; and often with no response. The literature survey revealed other significant research on topics such as SMME's access to finance, its role in job creation, its share of contribution to GDP, capacity building of SMME management, as well as on the closest topic to this study, that of investigating the impact of rising electricity prices on business.

However, nothing had been done previously on investigating the economic effect of implementing energy management in SMMEs. This meant therefore that the study commenced with a clean slate with no references and as such was a much steeper learning curve.

Because SMMEs are typically identified with variability in operations and economic existence, it becomes challenging to draw conclusions based on two case studies only. Additional to that, the other case study, Staluform, would not engage further to allow for a second assessment, as did Karob Plastics.

As such, the study was limited in comparing any resultant energy performance improvements and intensity changes that could have been brought about from the first engagement with the site. However, based on the literature survey, industry practices and the parameters investigated in this study, sufficient evidence is gathered that supports the findings of this study.

5.5 Recommendations for further research

As an emerging field, energy management is still an unknown factor in most small businesses for which the main focus is in production. Ensuring that energy management takes root with small manufacturing enterprises calls for both a deliberate effort to disseminate energy awareness as well as a demonstration of the benefits.

Seeing that not enough is yet known about energy management and that the benefits of energy management to small business' profitability are little known, therein lies the need to further research the topic and provide more empirical evidence in an attempt to answer the research question as to whether energy management does indeed improve the profitability of small manufacturing enterprises, and if it does improve profitability, how so and at what cost?

The existing literature on energy management has highlighted a focus on energy management programme rollouts across all economic sectors without any bias towards small manufacturing enterprises. It also lacks in detail with regard to quantification of benefits in terms of showing the improvement in the profitability of small business enterprises arising therefrom. There is therefore a need for research into what percentage of the identified energy savings opportunities eventually is implemented and what kWh energy savings are realised.

There is also a need for further research into existing energy programmes to inform the advancement of these energy management initiatives aimed at big business to be targeted towards small manufacturing enterprises. Furthermore, for those programmes that have conducted energy assessments on small businesses, they need to further demonstrate the resulting business profitability of these small manufacturing enterprises through documented case studies with real energy savings.

Given that according to the Multiyear Price Determination, energy prices will continue to rise; research on the effects on business of paying cost-reflective tariffs versus the cost of unserved energy due to power deficits and the resultant curtailments should be conducted.

Research of the entire manufacturing sub-sector's reaction to energy price increases, as well as the effects of a mass roll-out energy management programme aimed at this sub-sector, ought to be commissioned either by Government as the key stakeholder or by the manufacturing circle as an interest group.

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APPENDICES

Appendix I – Calculations

Karob Plastics

1. Lighting retrofit

Current			Proposed				Savings, W	Investment	
MAKE / TYPE	Qty	Total W	Type	Qty	Rating, W	Total, W		Unit cost, R	Total cost, R
Fluorescent lights (T8, 36W)	120	4320	T5, 28W Linear Fluorescent	120	28	3360	960	65	7800
9W LED Lights	12	108	No change proposed						
High Bay 250W (Mercury Vapour)	48	12000	125W Induction Lamp	48	125	6000	6000	250	12000
Total (kW)		16.4	Total (kW)				9.36	7.068	19 800

kWh savings calculation:

Assumption: 10 hours of operation per day for 360 days of the year

kWh savings = 10 hrs x 360 days x 7068W/1000 = 25444kWh

Cost savings = kWh savings x unit rate = 25444kWh x 0.49c/kWh = R12 467

2. Compressor Optimisation

Load		kW	Operating hrs/annum	KWh
Air Compressor		44	8500	374000
	Air compressor relocation			
2% saving	7480		kWh	
Rand saving	3665.2			
cost	10000			
SPB	2.7			

3. Chiller plant

Load		kW	Operating hrs/annum	KWh
Chiller Plant		60	8500	510000
	chiller compressor optimisation			
10% saving	51000		kWh	
Rand saving	24990			
Cost	60000			
SPB	2.4			

Staluform

1. Lighting retrofit

Current				Proposed				Savings, W	Investment	
Type	Qty (fittings)	Rating, W	Total W	Type	Qty (fittings)	Rating, W	Total W		Unit cost, R	Total cost, R
T8 Linear 2x 58W Fluorescent	91	58	10556	T5 Linear 2 x 28W Fluorescent	91	28	5096	5460	65	11830
T12 Linear 2x 75W Fluorescent	7	75	1050	T8 Linear 2 x 36W Fluorescent	7	36	504	546	80	1120
16W CFL	7	15	105	9W LED	7	9	63	42	160	1120
400W HPS	38	400	15200	200W Induction Lamp	38	200	7600	7600	400	15200
125W MV	3	125	375	75W Induction Lamp	3	75	225	150	150	450
45W U-Globe	9	45	405	22W PL-Type CFL	9	22	198	207	30	270
				TOTAL				14005	R29 900	

kWh savings calculation:

Assumption: 10 hours of operation per day for 360 days of the year

kWh savings = 10 hrs x 360 days x 14005W/1000 = 50 418kWh. Cost savings = kWh savings x unit rate = 50 418kWh x 0.49c/kWh = R24 705

2. Compressed air system optimisation

	reduction	total kW saved	kWh/day	kWh/yr	
Compressed air system optimisation			208.375	75015	
	25%			18753.75	kWh saving
				0.49	c/kWh
				9189.34	R, value saving
Investment	R30000	SPB	3.3		

3. Conversion to Co2 Welders

	reduction	total kW saved	kWh/day	kWh/yr	
Conversion to CO ₂ Welders		10	100	36000	
				36000	kWh saving
(from 15kW to 5kW)	67%			0.49	c/kWh
				17640	R, value saving
Investment	R25000	SPB	1.4		

Appendix II - Power factor correction table; adapted from the website (Blair)

Original Power Factor	Desired Improved Power Factor																				
	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
50	0.098	1.01	1.03	1.06	1.09	1.11	1.14	1.17	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.44	1.48	1.53	1.59	1.73
51	0.937	0.96	0.99	1.02	1.04	1.07	1.09	1.12	1.15	1.18	1.2	1.23	1.26	1.29	1.32	1.36	1.4	1.44	1.48	1.54	1.69
52	0.893	0.92	0.95	0.97	1	1.02	1.05	1.08	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.35	1.39	1.44	1.5	1.64
53	0.85	0.88	0.9	0.93	0.95	0.98	1.01	1.03	1.06	1.09	1.12	1.14	1.17	1.21	1.24	1.27	1.31	1.35	1.4	1.46	1.6
54	0.809	0.84	0.86	0.89	0.91	0.94	0.97	0.99	1.02	1.05	1.08	1.1	1.13	1.16	1.2	1.23	1.27	1.31	1.36	1.42	1.56
55	0.769	0.8	0.82	0.85	0.87	0.9	0.93	0.95	0.98	1.01	1.04	1.06	1.09	1.12	1.16	1.19	1.23	1.27	1.32	1.38	1.52
56	0.73	0.76	0.78	0.81	0.83	0.86	0.89	0.91	0.94	0.97	1	1.02	1.05	1.09	1.12	1.15	1.19	1.23	1.28	1.34	1.48
57	0.692	0.72	0.74	0.77	0.8	0.82	0.85	0.88	0.9	0.93	0.96	0.99	1.02	1.05	1.08	1.11	1.15	1.19	1.24	1.3	1.44
58	0.655	0.68	0.71	0.73	0.76	0.79	0.81	0.84	0.87	0.89	0.92	0.95	0.98	1.01	1.04	1.08	1.11	1.15	1.2	1.26	1.41
59	0.619	0.65	0.67	0.7	0.72	0.75	0.78	0.8	0.83	0.86	0.89	0.91	0.94	0.97	1.01	1.04	1.08	1.12	1.17	1.23	1.37
60	0.583	0.61	0.64	0.66	0.69	0.71	0.74	0.77	0.79	0.82	0.85	0.88	0.91	0.94	0.97	1	1.04	1.08	1.13	1.19	1.33
61	0.549	0.58	0.6	0.63	0.65	0.68	0.71	0.73	0.76	0.79	0.82	0.84	0.87	0.9	0.94	0.97	1.01	1.05	1.1	1.16	1.3
62	0.516	0.54	0.57	0.59	0.62	0.65	0.67	0.7	0.73	0.75	0.78	0.81	0.84	0.87	0.9	0.94	0.97	1.02	1.06	1.12	1.27

63	0.483	0.51	0.54	0.59	0.61	0.64	0.67	0.69	0.72	0.75	0.78	0.81	0.84	0.87	0.87	0.9	0.94	0.98	1.03	1.09	1.23
64	0.451	0.47	0.5	0.53	0.56	0.58	0.61	0.63	0.66	0.69	0.72	0.75	0.78	0.81	0.84	0.87	0.91	0.95	1	1.06	1.2
65	0.419	0.45	0.47	0.5	0.52	0.55	0.58	0.6	0.63	0.66	0.69	0.71	0.74	0.77	0.81	0.84	0.88	0.92	0.97	1.03	1.17
66	0.388	0.41	0.44	0.47	0.49	0.52	0.55	0.57	0.6	0.63	654	0.68	0.71	0.74	0.78	0.81	0.85	0.89	0.94	1	1.14
67	0.358	0.38	0.41	0.44	0.46	0.49	0.52	0.54	0.57	0.6	0.62	0.65	0.68	0.71	0.75	0.78	0.82	0.86	0.91	0.97	1.11
68	0.328	0.35	0.38	0.41	0.43	0.46	0.49	0.51	0.54	0.57	0.59	0.62	0.65	0.68	0.72	0.75	0.79	0.83	0.88	0.94	1.08
69	0.299	0.33	0.35	0.38	0.4	0.43	0.46	0.48	0.51	0.54	0.57	0.89	0.62	0.65	0.69	0.72	0.76	0.8	0.85	0.91	1.05
70	0.27	0.3	0.32	0.35	0.37	0.4	0.43	0.45	0.48	0.51	0.54	0.56	0.59	0.63	0.66	0.69	0.73	0.77	0.82	0.88	10.2
71	0.242	0.27	0.29	0.32	0.35	0.37	0.4	0.43	0.45	0.48	0.51	0.54	0.57	0.6	0.63	0.66	0.7	0.74	0.79	0.85	0.99
72	0.214	0.24	0.27	0.29	0.32	0.34	0.37	0.4	0.42	0.45	0.48	0.51	0.54	0.57	0.6	0.64	0.67	0.71	0.76	0.82	0.96
73	0.186	0.21	0.24	0.26	0.29	0.32	0.34	0.37	0.4	0.42	0.45	0.48	0.51	0.54	0.57	0.61	0.64	0.69	0.73	0.79	0.94
74	0.159	0.19	0.21	0.24	0.26	0.29	0.32	0.34	0.37	0.4	0.43	0.45	0.48	0.51	0.55	0.58	0.62	0.66	0.71	0.77	0.91
75	0.132	0.16	0.18	0.21	0.24	0.26	0.29	0.32	0.34	0.37	0.4	0.43	0.46	0.49	0.52	0.55	0.59	0.63	0.68	0.74	0.88
76	0.105	0.13	0.16	0.18	0.21	0.24	0.26	0.29	0.32	0.34	0.37	0.4	0.43	0.46	0.49	0.53	0.56	0.6	0.65	0.71	0.86
77	0.079	0.11	0.13	0.16	0.18	0.21	0.24	0.26	0.29	0.32	0.35	0.37	0.4	0.43	0.47	0.5	0.54	0.58	0.63	0.69	0.83
78	0.052	0.08	0.1	0.13	0.16	0.18	0.21	0.24	0.26	0.29	0.32	0.35	0.38	0.41	0.44	0.47	0.51	0.55	0.6	0.66	0.8
79	0.026	0.05	0.08	0.1	0.13	0.16	0.18	0.21	0.24	0.26	0.29	0.32	0.35	0.38	0.41	0.45	0.48	0.53	0.57	0.63	0.78

80	0	0.03	0.05	0.08	0.1	0.13	0.16	0.18	0.21	0.24	0.27	0.29	0.32	0.36	0.39	0.42	0.46	0.5	0.55	0.61	0.75
81		0	0.03	0.05	0.08	0.1	0.13	0.16	0.18	0.21	0.24	0.27	0.3	0.33	0.36	0.4	0.43	0.47	0.52	0.58	0.72
82			0	0.03	0.05	0.08	0.11	0.13	0.16	0.19	0.21	0.24	0.27	0.3	0.34	0.37	0.41	0.45	0.5	0.56	0.7
83				0	0.03	0.05	0.08	0.11	0.13	0.16	0.19	0.22	0.25	0.28	0.31	0.34	0.38	0.42	0.47	0.53	0.67
84					0	0.03	0.05	0.08	0.11	0.13	0.16	0.19	0.22	0.25	0.28	0.32	0.35	0.4	0.44	0.5	0.65
85						0	0.03	0.05	0.08	0.11	0.14	0.16	0.19	0.23	0.26	0.29	0.33	0.37	0.42	0.48	0.62
86							0	0.03	0.05	0.08	0.11	0.14	0.17	0.2	0.23	0.26	0.3	0.34	0.39	0.45	0.59
87								0	0.03	0.06	0.08	0.11	0.14	0.17	0.2	0.24	0.28	0.32	0.36	0.42	0.57
88									0	0.03	0.06	0.08	0.11	0.15	0.18	0.21	0.25	0.29	0.34	0.4	0.54
89										0	0.03	0.06	0.09	0.12	0.15	0.18	0.22	0.26	0.31	0.37	0.51
90											0	0.03	0.06	0.09	0.12	0.16	0.19	0.23	0.28	0.34	0.48
91												0	0.03	0.06	0.09	0.13	0.16	0.21	0.25	0.31	0.46
92													0	0.03	0.06	0.1	0.13	0.18	0.22	0.28	0.43
93														0	0.03	0.07	0.1	0.14	0.19	0.25	0.4
94															0	0.03	0.07	0.11	0.16	0.22	0.64
95	TABLE VALUES X kW LOAD = KVAR OF CAPACITORS NEEDED TO CORRECT FROM EXISTING TO DESIRED POWER FACTOR															0	0.04	0.08	0.13	0.19	0.33

96																	0	0.04	0.09	0.15	0.29
97																		0	0.05	0.11	0.25
98																			0	0.06	0.2
99																				0	0.14

SMEnT – small manufacturing enterprise energy management toolkit

Electronic/ web-based questionnaire/ self –assessment tool

Are you...?

1. An SMME (Small Medium Micro Enterprise)?
2. With less than 200 employees?
3. With turnover of less than R 50 million?
4. With annual Energy Cost greater than R 250,000 ?
5. With atleast 1x Primary energy source viz; Electricity, Coal, HFO, LFO, LPG, Kerosene or Biomass (woodfuel)?
6. With at least 1x Secondary energy source viz; Steam, Compressed air, Heat recovery Systems, etc?

If you have answered YES to all of the questions above then you are classified as an SMME. Please complete information below and proceed to complete the self energy assessment tool and submit:

COMPANY DETAILS:

Name Of Organisation: *

Contact Person Name: *

Address: *

Telephone: *

E-mail:*

ENERGY MANAGEMENT MATRIX

The **Energy Management Matrix** (“Matrix”) can give an insight into the way a company manages its energy. This Matrix is a tool that helps companies with the assessment of their organisational strengths and weaknesses across the six main areas of Energy Management: For each component the Company will be at level 0 (lowest), 1, 2, 3 or 4 (highest level).

Energy Management Matrix						
Level	Energy Policy or Policy & Systems	Organising or Organization	Skills & Knowledge or Motivation	Information Systems	Marketing & Communications or Training & Awareness	Investment
4	Energy Policy, action plan and regular review have commitment of top management as part of a business & environmental strategy	Energy Management fully integrated into management structure. Clear delegation of responsibility for energy consumption	All energy users receive specific energy training integrated into other development activities. Workshops facilitate a sharing of knowledge	Comprehensive system sets targets, monitors consumption, identifies faults, quantifies savings and provides budget tracking	Communicating the value of energy efficiency and the performance of energy management within the organisation and outside	Positive discrimination in favour of „green“ schemes with detailed appraisal of all new build & refurbishment opportunities
3	Formal energy policy but no active commitment from top management	Energy Manager accountable to energy committee representing all users	Key energy users receive regular and specific training. Brief awareness training provided to all energy users	Monitoring and targeting reports for individual areas based on sub-metering, but savings not effectively reported to user	Programme of Staff awareness and regular publicity campaigns	Same payback appraisal criteria employed as for all other investment
2	Unadopted energy policy set by senior manager or senior departmental manager	Energy Manager in post, reporting to ad hoc committee but line management authority unclear	Key energy users receive awareness training, also occasional system-specific training	Monitoring and reporting targets based on supply meter data. Energy unit has ad hoc involvement in budget setting	Some adhoc staff awareness training	Investment using short term payback criteria only
1	An Unwritten set of guidelines	Energy Management the part-time responsibility of someone with only limited authority or influence	Key employees participate occasionally in awareness training. Some information passed informally to energy users	Cost reporting based on invoice data. Engineer compiles reports for internal use within technical department	Informal contacts used to promote energy efficiency	Only low cost measures taken
0	No explicit policy	No energy management or any formal delegation of responsibility for energy use	Energy users rely on their existing knowledge	No information systems. No accounting for energy consumption	No promotion of energy efficiency	No investment in increasing energy efficiency in plant

EM Matrix scoring

1. Policy & systems: indicate level ☐

Energy Policy in place with an action plan and regular review. Commitment of management as part of a business & environmental strategy with clear targets and accountability

2. Organising or Organization: indicate level ☐

Energy Management fully integrated into management structure. Clear delegation of responsibility for energy consumption

3. Skills and Knowledge or Motivation: indicate level ☐

All energy users receive specific energy training integrated into other development activities. Workshops and operations among the group facilitate a sharing of knowledge

4. Information systems: indicate level ☐

Comprehensive system sets targets, monitors consumption, identifies faults, quantifies savings and provides budget tracking

5. Marketing and Communication and Training & Awareness: indicate level ☐

Communicating the value of energy efficiency and the performance of energy management within the organisation and outside

6. Investment: indicate level ☐

Positive discrimination in favour of „green“ schemes with detailed appraisal of all new build & refurbishment opportunities.

(Auto-generate a spider chart showing the 6 areas with company's current status)

UTILITY CONSUMPTION AND COSTS: ELECTRICITY

Please provide electricity consumption and cost data for a full calendar year as follows:

Year/ month	Consumption, kWh	kWh Cost, R	Max. Demand	Demand Cost, R
January				
February				
March				
April				
May				
June				
July				
August				
September				
October				
November				
December				
TOTAL				

Annualised Load Factor =

Please state the cost breakdown of your electricity bill:

Demand Charges (R/kVA)	
Availability Charges (R)	
Energy costs (c/kWh)	
Others charges (please state)	
Is the company exploiting opportunities of Time Of Use Rates?	☐ yes ☐ no ☐ don't know

Other Fuels (e.g. Gas, Coal, HFO, etc)

Year/ month	UoM(m3, tonnes, litres, etc)	Cost, R
January		
February		
March		
April		
May		
June		
July		
August		
September		
October		
November		
December		
TOTAL		

PRODUCTION DATA: THE PRODUCTIVITY INFO NEEDS TO BE POPULATED FOR THE SAME PERIOD AS THE UTILITY CONSUMPTION AND COSTS DATA.

Year/ month	UoM (Pax, kg, litres, pieces, etc)
January	
February	
March	
April	
May	
June	
July	
August	
September	
October	
November	
December	
TOTAL	

(Auto-generate a linear regression chart plotting Utility Consumption vs. Production)

ENERGY USING SYSTEMS

Please provide a high-level description of your process and list major energy consuming systems (SEU), i.e. Boilers, HVAC, Refrigeration, Crushers, Extruders, etc.

Indicate what percentage of your total energy consumption would you associate with each of the Top 5 energy using system

(approximated):

System 1: _____ = _____ %

System 2: _____ = _____ %

System 3: _____ = _____ %

System 4: _____ = _____ %

System 5: _____ = _____ %

Auto-generate a pie chart_Load breakdown)

UTILITY SAVING OPPORTUNITIES

Has the site identified any utility saving opportunities recently?

☐	Yes	☐	No
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If Yes, please give details. Also identify if specific feasibility reports exists.

--

What is the current status of these opportunities (e.g. implemented, awaiting authorisation, abandoned) and give reason why for status?

--

For those opportunities that have been implemented, Indicate Percentage of Implemented opportunities vs. identified opportunities:

--

For those opportunities that have been implemented, approximately how much kWh reductions do you envisage (kWh savings):

--

(Compare kWh savings above with baseline annual energy consumption total from Utility Consumption table and calculate the resultant energy consumption)

Resultant energy Consumption, $RES_{kWh} = \text{Baseline annual energy consumption} - \text{kWh savings}$
--

From the Energy Management Matrix scoring, Refer to table below:

EM Matrix score	X in percentage
24	2
<24 but >20	5
<20 but >12	10
<12 but >6	15
Less than 6	25

Energy savings potential untapped in kWh = x% of Resultant energy consumption RES_{kWh}

Equate energy savings potential untapped in kWh to Energy cost savings in Rands assuming an AUP or quoting unit charges prevailing

Appendix IV - SMEnT worked example

Energy Management Matrix

The Energy Management Matrix ("Matrix") can give an insight into the way a company manages its energy. This Matrix is a tool that helps companies with the assessment of their organisational strengths and weaknesses across the six main areas of Energy Management: For each component the Company will be at level 0 (lowest), 1, 2, 3 or 4 (highest level).

EM Matrix scoring

1. Policy & systems: indicate level

1

Energy Policy in place with an action plan and regular review. Commitment of management as part of a business & environmental strategy with clear targets and accountability

2. Organising or Organisation: indicate level

3

Energy Management fully integrated into management structure. Clear delegation of responsibility for energy consumption

3. Skills and Knowledge or Motivation: indicate level

3

All energy users receive specific energy training integrated into other development activities. Workshops and operations among the group facilitate a sharing of knowledge

4. Information systems: indicate level

4

Comprehensive system sets targets, monitors consumption, identifies faults, quantifies savings and provides budget tracking

5. Marketing and Communication and Training & Awareness: indicate level

4

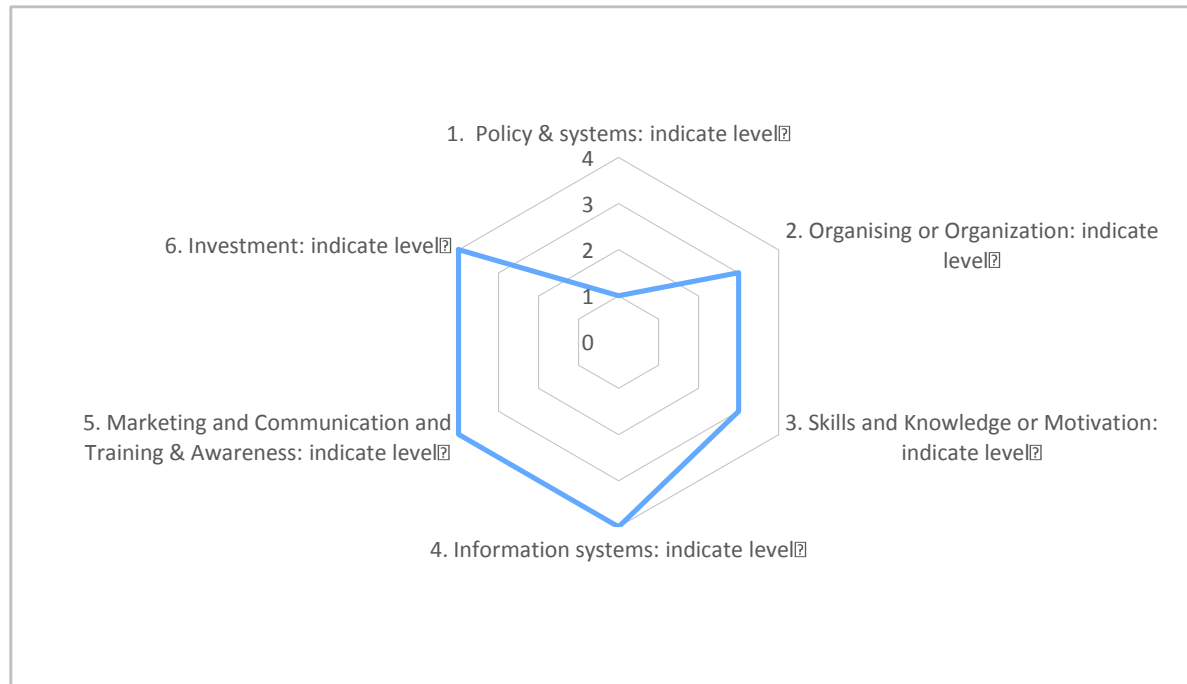
Communicating the value of energy efficiency and the performance of energy management within the organisation and outside

6. Investment: indicate level

4

Positive discrimination in favour of „green“ schemes with detailed appraisal of all new build & refurbishment opportunities.

EM Matrix score =	19
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Utility Consumption and Costs

Electricity

Please provide electricity consumption and cost data for a full calendar year as follows:

Year/ month	Consumption, kWh	kWh Cost, R	Max. Demand kVA	Demand Cost, R
January	100	10	1	33
February	90	9	1	6
March	90	9	1	22
April	80	8	1	3
May	90	9	1	3
June	80	8	1	3
July	90	9	1	3
August	100	10	1	3
September	111	11	1	3
October	100	10	1	4
November	85	8.5	1	4
December	166	16.6	1	4
TOTAL	1 182	93	1	91

Baseline annual energy consumption (kWh)	1 182
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Cost Breakdown of the Electricity bill:

Demand Charges (R/kVA)	150
Availability Charges (R)	15
Energy costs (c/kWh)	1.5
Others charges (please state)	0.15
Is the company exploiting opportunities of Time Of Use Rates?	No

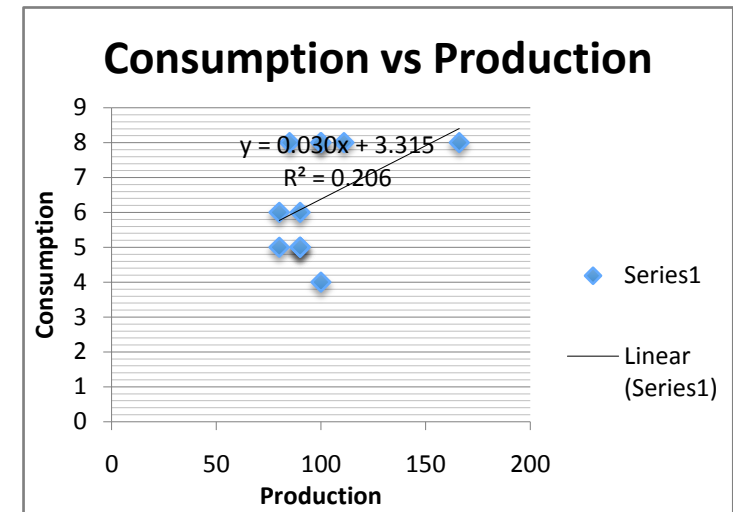
Productivity Records

The Productivity Info needs to be populated for the same Period as the Utility Consumption and Costs Data.

Year/ month	UoM (Pax, kg, litres, pces, etc)
January	4
February	6
March	5
April	5
May	5
June	6
July	5
August	8
September	8
October	8
November	8
December	8
TOTAL	76

Production vs. Consumption plot

Consumption, kWh	UoM (Pax, kg, litres, pces, etc)
100	4
90	6
90	5
80	5
90	5
80	6
90	5
100	8
111	8
100	8
85	8
166	8

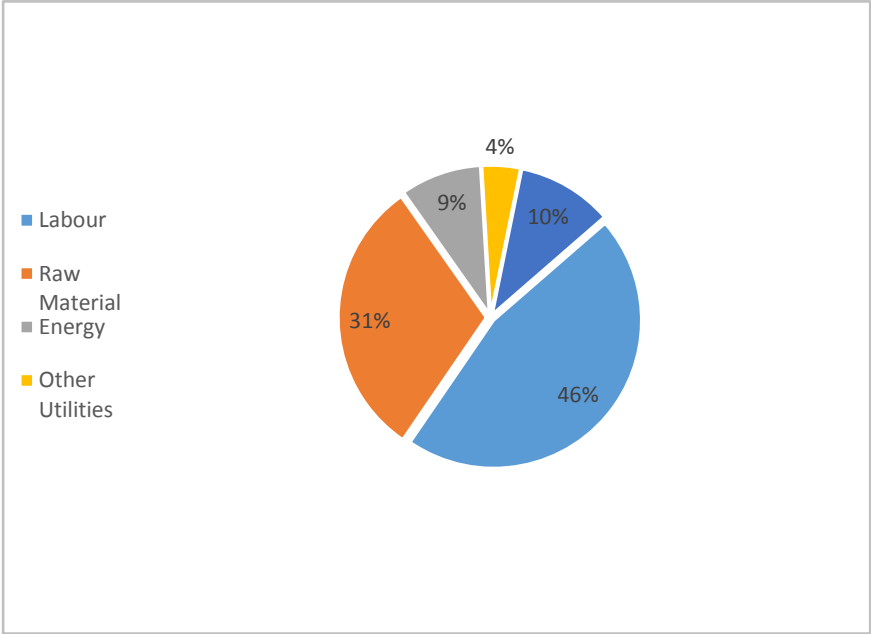


TOTAL PRODUCTION COST ESTIMATION

Please provide a high-level indication of your discrete production input costs including labour, material, energy input as well as other resources (e.g. water), and overheads such as office space rent;

Production input 1:
Production input 2:
Production input 3:
Production input 4:
Production input 5:

Labour	Rand	38 778	00	46%
Raw Material	Rand	25 900	00	31%
Energy	Rand	7 444	00	9%
Other Utilities	Rand	3 500	00	4%
Overheads	Rand	8 789	00	10%
Total		84 411	00	



Energy Using Systems

Please provide a high-level description of your process and list major energy consuming systems (SEU), i.e. Boilers, HVAC, Refrigeration, Crushers, Extruders, etc.

Indicate what percentage of your total energy consumption would you associate with each of the Top 5 energy using system (approximated):

System 1:

System 2:

System 3:

System 4:

System 5:

Lighting	Rand	8 000.00	800.00	kWh	34%
Aircon	Rand	5 000.00	500.00	kWh	21%
Steam Boiler	Rand	7 000.00	700.00	kWh	30%
air compressor	Rand	1 500.00	150.00	kWh	6%
others	Rand	2 000.00	200.00	kWh	9%
Total		23 500.00	2 350.00	Total	

Significant Energy Users (SEU)



UTILITY Saving Opportunities

Has the site identified any utility saving opportunities recently?

No

If Yes, please give details. Also identify if specific feasibility reports exists.

N/A

What is the current status of these opportunities (e.g. implemented, awaiting authorisation, abandoned) and give reason why for status?

N/A

For those opportunities that have been implemented, Indicate Percentage of Implemented opportunities vs. identified opportunities:

N/A

For those opportunities that have been implemented, approximately how much kWh reduction do you envisage (kWh savings):

N/A

(Compare kWh savings above with baseline annual energy consumption total from Utility Consumption table and calculate the resultant energy Consumption)

Resultant energy Consumption, RES_{kWh} = Baseline annual energy consumption - kWh savings

Resultant energy Consumption, RES_{kWh} = 1 182 (baseline annual energy consumption since no kWh savings have been identified and implemented yet)

From the Energy Management Matrix scoring, Refer to table below:

EM Matrix score	X in percentage
24	2
<24 but >20	5
<20 but >12	10
<12 but >6	15
Less than 6	25

Energy savings potential untapped in kWh = x% of Resultant energy consumption RES_{kWh} :

Energy savings potential untapped in kWh = 10% of 1 182

Energy savings potential untapped in kWh = 118.2 kWh

Equate energy savings potential untapped in kWh to Energy cost savings in Rands:

Potential cost savings =	Energy savings potential untapped in kWh	X	Unit cost of energy (c/kWh)
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