ENERGY SAVING MECHANISMS IN THE MINING INDUSTRY: A CASE STUDY OF SWITCHING OFF NON-ESSENTIAL POWER

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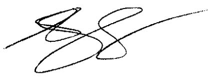
DECLARATION

Hereby I, Soobramoney Govender declare that this research report is my own original work and that all sources have been accurately reported and acknowledged, and that this document has not previously been submitted to any university in order to obtain an academic qualification.



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ABSTRACT

The world today is facing many energy challenges such as power outages experienced internationally and in South Africa. The demand for energy is constantly increasing and is creating environmental problems such as climate change, which is presently a major concern to society. This study is an attempt to establish how energy saving mechanisms such as the elimination of non-essential power can add economic value within the mining industry. This paper examines the effect of non-essential power and how it could assist companies to reduce their energy consumption, aid local power utilities in a crisis and maintain normal production levels.

This research report was based on an investigation for power saving opportunities at a mining company during a power crisis. The paper looks at energy efficiency and the barriers to the adoption of energy savings.

Companies in general do not have a structured way of addressing non-essential power saving. Companies are not aware of the value such initiatives could have on corporate responsibility and sustainable reporting. The benefits of energy efficiency and non-essential power on the triple bottom line are not clearly documented in literature. When comparing the impact of non-essential power on the triple bottom line, it became obvious that further research is required in order to prove whether it influences the social aspect. The impact of power generation on the global environment has not been clearly calculated and linked to the value of saving power. The literature review highlighted that companies are focusing on long-term initiatives instead of smaller initiatives, which requires less effort. During the investigation of the mining company, it was found that not much effort was made during the design stages in separating the electrical circuits from non-essential and essential power.

The author concludes that switching off non-essential power held economic and environmental benefits for the mining company. The author therefore concludes that switching off non-essential power impacts positively on the economic and environmental part of the triple bottom line. It was found that the elimination of non-essential power is

easy to implement with minimum investment and effort. Furthermore, the savings from these initiatives could easily be measured to calculate the return on the investment.

OPSOMMING

Ons kry deesdae al meer te doen met uitdagings soos internasionale en plaaslike kragonderbrekings in die energiebedryf. Die aanvraag vir energie verhoog deurlopend en veroorsaak omgewingsprobleme soos klimaatsveranderinge, wat ‘n groot bekommernis is vir die samelewing. In hierdie studie word gepoog om vas te stel hoe energie besparings meganismes soos die eliminering van nie-noodsaaklike krag ekonomiese waarde kan voeg tot die mynboubedryf. Die uitwerking wat nie-noodsaaklike krag het en hoe dit maatskappye kan help om kragverbruik te verlaag terwyl produksievlakke steeds gehandhaaf word, is hier ondersoek. Plaaslike kragvoorsieners kan ook baat vind hierby in krisistye.

Hierdie navorsingsverslag is gebaseer op ‘n ondersoek van krag besparings geleenthede by ‘n mynmaatskappy gedurende ‘n krisistydperk van kragonderbrekings. Die verslag kyk na die doetreffendheid van energieverbruik, asook na die hindernisse wat ondervind word in die inwerkingstelling van energie besparings inisiatiewe.

Maatskappye het in die algemeen nie ‘n gestruktureerde metode om die probleem rakende nie-noodsaaklike krag aan te spreek nie. Hulle is nie bewus van die nut wat sulke inisiatiewe kan hê op korporatiewe verantwoordelikheid en volhoubare verslaggewing nie. Die voordele wat energiebesparing en die eliminering van nie-noodsaaklike krag op die ekonomie, gemeenskap en omgewing het, word nie duidelik geboekstaaf nie. Verdere navorsing moet gedoen word om die impak van energiedoeltreffendheid en nie-noodsaaklike krag op die sosiale aspek te bewys. Die uitwerking wat kragopwekking op die globale omgewing het is nog nie bereken en verbind met die waarde daarvan op kragbesparing nie. Die verslag beklemtoon dat maatskappye fokus op langtermyn inisiatiewe in plaas daarvan om te kyk na kleiner inisiatiewe wat minder moeite en tyd sal verg.

Die ondersoek by die mynmaatskappy het getoon dat daar nie klem geplaas is op die onderskeiding tussen nie-noodsaaklike en noodsaaklike krag met die installering van die elektriese stroombane tydens die ontwerpstadium nie. Daar is gevind dat die

afskakeling van nie-noodsaaklike krag ekonomiese en omgewingsvoordele vir die maatskappy inhou.

Daar is tot die slotsom gekom dat die afskakeling van nie-noodsaaklike krag in die algemeen dus ‘n voordelige uitwerking het op die ekonomie en omgewing. Dit is maklik om te implementeer met minimum moeite en belegging. Die besparings deur middel van hierdie inisiatiewe kan ook maklik gemeet word om die opbrengs op die belegging te bereken.

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GLOSSARY

Appliance Labeling	Labels denoting energy consumption of appliances
Energy Intensity	Energy use per unit of output or activity
Constructive	Tending towards, resulting in positive conclusions
Energy Efficiency	Reduction in energy consumption verses industries drive for increased throughput
Triple Bottom-line	The creation of profit i.e. economic value to the shareholder and the engagement of social involvement and environmental responsibility in the area in which you operate.
Load Shifting	Involves the modification of time at which a customer uses electricity
Load Shedding	A load agreement allows utility for power interruption to a portion of a customer's premises for a limited period in return for compensation.

LIST OF ACRONYMS

CERES	Coalition for Environmentally Responsible Economies
CDM	Clean Development Mechanism
CO_2	Carbon Dioxide
CDP	Carbon Disclosure Project
CSIR	Council for Scientific & Industrial Research
CV	Calorific Value
DME	Department of Minerals and Energy
DNA	Designated National Authority
DTI	Department of Trade and Industry
DSM	Demand Side Management
EE	Energy Efficiency
ESCO	Energy Service Company
GC	Global Compact
GHG	Green House Gases
GW	Gigawatt (10^9 Watts) unit of electric power
HVAC	Heating, Ventilation and Air Conditioning
IPCC	Intergovernmental Panel on Climate Change
IEP	Integrated Energy Plan
NERI	National Energy Research Institute
NER	National Electricity Regulator
NO_x	Oxides of Nitrogen
PJ	Petajoule (10^{15} Joules) unit of energy
TBL	Triple bottom line
REDs	Regional Electricity Distributors
SABS	South African Bureau of Standards
SAI	Sustainable Agriculture Initiative
SO_2	Sulphur Dioxide
STANSA	Standards South Africa
UNEPFI	United Nations Environment Programme Finance Initiatives
USS	Universities Superannuation Schemes

CHAPTER 1
INTRODUCTION AND STATEMENT OF PROBLEM

1.1 INTRODUCTION

“Perhaps the most neglected area for implementation is the promotion of public awareness about the costs and benefits of energy efficiency. Major energy savings can only be achieved through changes in people’s behaviour, and that depends on informing them about what options exist. The World Summit on Sustainable Development (2002) sensitised the nation about the impact that energy use has on the world’s weather systems. In this era of climate change South Africa needs to take more urgent measures to reduce energy usage than in the past. It is hoped that this Energy Efficiency Strategy will provide a blueprint for this venture” (Minister of the Department of Minerals and Energy [DME], 2005a).

The above quotation aptly captures the essence of this report and it is in this context that this report is articulated.

Society is witnessing an increasing demand for cleaner water, cleaner air, fewer toxins and many other environmental benefits. The result of this is the sustainability approach relating to the triple bottom line. The focus for business is no longer solely on the economic benefits or the bottom line but rather there are two more dimensions to consider which is the social and environmental responsibility.

The world summit on sustainable development held in South Africa in 2002 required a commitment from major energy users, companies and associations to commit to reducing global energy consumption. Pursuant to this, the South African Government held a parliamentarian forum in 2005 on energy saving.

This energy saving forum was quite apt in view of the fact that in 2005 South Africa started to experience major power outages. During this period there was extensive media coverage of power crises on an international and national level (Kenny, 2005). These power outages had several economic repercussions for industry. This lead to concerns regarding domestic energy infrastructure. The cost of building new power stations would be astronomical and therefore alternatives were being explored. These events led to a plethora of energy saving initiatives.

The energy crisis in the Western Cape was unexpected and as a result, the series of power outages that followed had a negative impact on businesses and industry. The mining industries were under extreme pressures to meet commodity targets. This meant a greater need for power and more importantly uninterrupted power.
The magnitude of the power crisis was such that Eskom had to force their intense energy users to reduce their power consumption drastically. In some industries, there was a complete shutdown of power and in certain critical mining operations; a significant reduction in power usage was required.

The company under investigation (Company X) was greatly affected by the power crisis. This company was inundated with international production orders. The failure to supply these orders would result in damage to the image and reputation of the company. The market is competitive and therefore a loss of customers would mean a loss of industrial competitiveness.

The management team of company X realized that the consequences of the power crisis could be severe and reacted by trying to ascertain if it was possible to reduce non-essential power by an arbitrary 30% of total consumption. The savings could be made available to Eskom for re-distribution in the national grid while ensuring that production could continue unhindered.

There was a flow of ideas on how to address the use of non-essential power and it became apparent that this could add value to the sustainability of the mining company under study. However there were many barriers relating to the adoption and implementation of these energy saving mechanisms, the major barrier being time and effort.

The aim of this study is to establish how energy saving mechanisms such as the elimination of non-essential power can add value to the bottom line within the context of the mining industry, i.e. whether it is economically viable.

1.2 RESEARCH QUESTION

Whether the reduction of non-essential power is possible, and if so, would it be economically viable? The report will evaluate the findings of Company X and seek to identify whether energy saving initiatives would add value to this company.

1.3 DELIMITATIONS OF STUDY

The report does not cover the social aspect of the triple bottom line and its impact on energy efficiency as there is limited availability of information. Further the author did not find this aspect relevant to the statement problem. The discussion of the power outages in the Western Cape revealed valuable information such as the need to build new power stations to increase generating capacity and to build thermally efficient low cost housing (DME, 1998). This was also irrelevant to the topic. The author found that there were many drivers to energy efficiency. However for the sake of brevity only those drivers pertinent to this report were discussed. The discussion of the mining industry was focused on the distribution of energy in the mainstream processes and not on the mining methodology which is extremely complex and not the subject of this report.

1.4 PLAN OF STUDY

This report consists of four main chapters. Chapter 1 introduces the topic and underlines the statement of problem.

Chapter 2 sets out the literature review which has subsections focusing on energy efficiency, drivers of energy efficiency, barriers to energy efficiency, selection of energy saving initiatives, measuring energy efficiency and a general overview of mining.
Section 2.1 provides an overview of energy efficiency. The conservation of energy has become a worldwide crisis. This section provides an overview of energy efficiency from a global and South African perspective.
Section 2.2 focuses on the drivers of energy efficiency. There are quiet a few drivers of energy efficiency however this section is limited to the discussion of the economics of energy efficient initiatives, the concept of corporate citizenship, energy security and climate change.

Section 2.3 provides a discussion of the barriers to energy efficiency. These barriers include market, competitive markets, information, financial, technological and infrastructure barriers, consumer behavior, poverty, government regulation, marketing barrier, supply monopolists and shortage of skilled people.
Section 2.4 focuses on the selection of energy initiatives using the methodology of Wulfinghoffs and Capehart, Turner and Kennedy.
Section 2.5 provides an analysis of energy efficiency indicators which are used to measure efficiency.
Section 2.6 provides a general overview of mining and looks at how the mining sector consumes energy at the different process levels.

Chapter 3 discusses a case study of a mining company which focused on the reduction of non-essential power.

Chapter 4 is a conclusion of this report.

CHAPTER 2
REVIEW OF RELATED LITERATURE

2.1 ENERGY EFFICIENCY

2.1.1 Introduction

This section provides a discussion of energy efficiency from a global and South African perspective. It defines energy conservation, energy intensity and discusses energy efficiency from a mining perspective. It looks at the potential of using less energy to produce the same level of output.

“Over the long term, the most effective way to conserve energy is by using energy more efficiently” (Bush, 2001).

All energy saving incentives and energy efficiency solutions endeavour to contribute to economic development and the improvement of social well-being. However, there remains a gap and that is the issue of sustainable development and its implications for policy. There should be a trade-off between energy requirements of the poor and the promotion of efficiency and competitiveness of the whole economy by providing low cost and high quality energy inputs (Sparks, 2006: 87).

Energy conservation can be defined as the reduction of energy use and the reduction of services received. For example, changing the thermostat settings and reducing lighting levels. The importance of energy conservation is that it can contribute to mitigation against climate change (Nadel & Geller, 2001).

Modern economic theory defines efficiency as the outcome of competitive market exchanges and improving equipment and systems in order to receive the same or increased output and with less energy input (De Canio, 1994). Population growth, economic growth and the advancement of technology appear to be the drivers of energy demand. In the light of this, carbon free energy sources and renewable energy sources become important.

After the 1973 oil crisis, energy efficiency measurement and monitoring became an important part of energy strategy in many countries. The 1997 Kyoto Protocol witnessed a commitment from many countries whereby they agreed to a timetable of GHG emission reductions for 2008-2012 (Ang, 2005). The object of this agreement was to get countries to take measures that would ensure there is energy efficiency in all sectors of the economy.

The White Paper on Energy Policy of South Africa (1998) requires a commitment from government to improve the situation of low income and rural populations who have access to less efficient and less healthy fuels. This would depend on the response from stakeholders to pricing and financing of energy services, availability of efficient appliances, appropriate appliance and fuel combinations.

There are untapped cost effective investments that could have a major impact on energy use and GHG gases. There are some utopian models of energy efficiency that raises many questions. For example, if energy efficient technology is so cost effective then why is it not so prevalent at companies? In addition, why are companies finding it so difficult to implement if it is so profitable? This could be because businesses are slow or not taking immediate action in implementing energy efficiency strategies. Hence, the need to inform and educate businesses about the benefits energy efficiency can have on an operation.

Energy intensity is the reduced energy use per unit of economic activity within a particular sector. The greater the energy efficiency, the greater the economical benefits for industry to become internationally competitive. The South African National Energy Association estimates that greater energy efficiency could result in savings between 10% and 20% of current consumption. This in turn can lead to an increase of between 1.5% and 3% in the GDP (Nkomo, 2006:86).

Environmental issues for South Africa’s energy sector relate to bulk energy supply, the household sector, and the transport sector. In households, the primary concern is indoor air pollution and the negative health affects of burning coal and wood fuel. In the transport sector, the main concern is the emissions of noxious gases.

One of challenges facing sustainability within the energy sector is the achievement of social and economic efficiency. The White Paper (1998) focuses on increasing access to affordable energy, managing energy related environmental impact and improving energy governance.

The aforementioned indicates that there are very little incentives for industry or households to adopt energy efficiency measures. However, there is scope for energy saving in industrial sectors. These opportunities lie in energy management, providing incentives to adopt technologies, conducting energy assessments to areas for energy savings. However, the challenge lies in the adoption and promotion of economically efficient energy measures. Energy efficient policies should provide firms with incentives such as tax deductions, subsidies to replace old technology with energy efficient technology and so forth.

2.1.2 Energy efficiency from a global perspective

“Saving energy can increase profits, but managers often overlook the potential benefits” (De Canio, 1994).

Much has been written about the science, technology and policies for promoting energy efficiency (Geller, 1981). Many good initiatives have been implemented but many companies still have a problem reaping the benefits. For example, there are some energy initiatives with investment risk ratings in companies that have a higher rate of return than the average investment projects (Geller, 1981). Essentially what this means is that your returns are greater on energy efficiency projects as opposed to other projects in the company with the same investment risk rating. Therefore, it would be beneficial to a company to actively embark on energy efficiency projects. Energy investment costs include transaction costs, administration cost and adjustment costs. These costs are difficult to measure and therefore companies experience difficulty in identifying the benefits because these types of costs could be construed as barriers (De Canio & Watkins, 2001).

The Rocky Mountain Institute (2006) investigated ways on how to save energy. The problem with some of the energy saving methods is that companies are finding it difficult to implement due to several barriers. For example, lack of funds, fear of changing the process and limited understanding of the methods. The Rocky Mountain Institute reported (2006) that in case studies examined by them, worker productivity increased by six to fifteen percent after the incorporation of energy efficient technologies.

Some industrialized countries have initiated energy conservation programs such as providing advice on investments in energy efficiency, offering to arrange for contractors to carry out such work, financing such investments with low or zero interest loans, and providing rebates to consumers for the purchase of energy efficient appliances and to appliance dealers for promoting efficiency improvement sales. This would encourage energy efficiency (Reddy, 1990).

Energy efficiency initiatives are not solely focused on the environment alone. An improvement in energy efficiency sometimes leads to other efficiency improvements within an organisation such as reduced process waste, lower environmental compliance costs, increased equipment reliability, increased worker productivity, minimisation of operation and maintenance costs. Improvements in energy efficiency invariably lead to economic growth (Reddy, 1990).

However, there are some energy conservation programmes being implemented in the GCC countries such as the demand side management programme. Saudi Arabia has implemented the demand side management programme, which includes electricity tariffs, higher petroleum product prices, and national energy programmes (Mahomed, 2005).

Moving on to the economic benefits of energy efficiency, in the United States the Environmental Protection Agency (herein referred to as EPA) stated that an estimate in increased productivity could result in revenues ten times higher than the energy costs savings. The EPA estimates that every $1 invested in energy upgrades yields 2-3$ in increased asset value for buildings (Nadel, Thorne, Sachs, Prindle & Elliott, 2003). The EPA's main concern is the threat of global warming caused by GHG emissions. The EPA considers the GHG emissions to be a clear and present danger to the health and the global environment. The EPA suggests that reductions in GHG emissions could be achieved through the implementation of energy-saving measures that would be profitable at current prices of energy. The EPA has set up profitable energy-saving technology programmes for business to adopt on a voluntary basis. For example, the Green lights program. This program focuses on lighting systems.

It therefore becomes apparent that it is in society's best interest to use energy more efficiently and to reduce CO_2 emissions.

2.1.3 Energy efficiency South African perspective

The world summit on sustainable development held in South Africa in 2002 required a commitment from major energy users, companies and associations to commit to reducing the energy consumption using various methods by 2015.

It must be mentioned that South Africa is party to the UN Framework Convention on Climate Change, which was ratified on 29 August 1997. South Africa is therefore required to report on national emissions and environmental policymaking. It is further noted that South Africa assented to the Kyoto Protocol on 31 July 2002.

2.1.4 Energy efficiency Cape regional perspective

Electricity supply is separated into three categories: generation, transmission and distribution. The primary source of power generation begins at the power station. The secondary stage of power supply is via the transmission networks. The third level is the distribution of low voltage power to consumers. This is a universal process and the relevance of this process is to provide an understanding of how electricity is generated and supplied in South Africa.

Eskom in South Africa does most of the generation, transmission and distribution. However, the municipalities also do distribution. The Western Cape is not the only province to experience distribution problems and therefore there is a national energy crisis. Distribution problems also occurred in Johannesburg and this was attributed to poor maintenance of transformers, cables and switchgear. City Power is responsible for these problems in Johannesburg. Eskom was responsible for the energy crisis in the

Western Cape as its power station in this province is located at the Koeberg power station.

Koeberg Power Station is the only nuclear power station on the African continent. Situated at Duynefontein, 30km northwest of Cape Town on the Atlantic coast. Koeberg ensures a reliable supply of electricity to the Western Cape, one of the fastest growing regions in South Africa. It has operated safely for more than 21 years until 2005.

An energy crisis at Koeberg began as a result of incidents that occurred during the period November 2005 to July 2006, which caused a major catastrophe. These incidents included an electrical switching fault, a fire that broke out under the transmission lines in a farmer's field near Wellington and a slight chemical imbalance in a standby safety system at the Koeberg power station (Kenny, 2005).

The effects of these outages had severe repercussions for the business community and the economy. The Cape Town Chamber of Commerce and Industry (herein referred to as The Chamber) stated that the total loss to business in the Western Cape was estimated at R5.6bn (Gass, 2006). The Chamber had stated in a report the following: "Millions of rands down the drain, times wasted, disruption of computer systems, traffic controls and many, many other costly inconveniences". Examples of complaints the Chamber received: accountants who needed to meet the 28 February tax deadline, bakers who could not provide bread, cold storage facilities for stock that resulted in ruined stock, fish companies who lost millions in spoilt goods, manufacturers who lost tens of thousands a day in lost production and damage to equipment, employees on commission lost income, and many other businesses. These are just a few examples of the disastrous effect the energy crisis at Koeberg had on the Cape economy (Sacob, 2006).

During the winter, in June 2006, Eskom distributed 5 million compact fluorescent lights to help curb the electricity consumption (Phasiweand & Stewart, 2006). Lamps with electronic ballasts use 12% to 25% less electricity than with magnetic ones. They also make up to 75% less noise and do not flicker. Compared to other lamps, a compact fluorescent lamp lasts up to ten times longer and used 75% less energy while producing the same amount of light (Sherry, 2003).

The effects at the Koeberg power station clearly demonstrate that South Africa does not have enough power stations to cope with the load as demand for energy supply is on the increase. The South African government was criticized in the media for failure to plan 10 years ago for the demands of an economy that grew at 4.9% in 2005 (Mathews, 2006). It was predicted 10 years ago that more power stations were needed. It takes about 8 years to build a big base load station. In 1983, Majuba was the last power station ordered in South Africa. However, these power stations were never built as a result of poor planning by the government and Eskom (Kenny, 2005).

Namibia was affected by the Koeberg crisis, as this country is reliant on Eskom for its electricity. However, because of the Koeberg crisis, Namibia was without power for only two hours (Mercury Foreign Service, 2006). This is, to phrase it colloquially, a drop in the ocean compared to the disastrous effect the crisis had on the Cape Province and the South African economy.

2.1.5 Energy efficiency mining perspective

In the mining industry, energy efficiency can be defined as a dichotomy because on the one hand, there is a need to reduce energy consumption and on the other hand, industry needs to increase production output.

A number of targets and constraints are being put into place by government to get the large energy users to use energy more efficiently. Government has asked large energy users (mining and industry) to reduce their final energy demand of 15% by 2015, 11% through low-medium cost technical interventions and an additional 5-15% through energy and waste management (DME, 2005a).

It is clear that the mining industry in South Africa already has a strategy specified by government. This strategy was introduced in March 2005. The idea behind the strategy is to link energy initiatives with socio-economic development plans. This strategy provides for the immediate implementation of cost effective initiatives. The ultimate aim of the strategy is to contribute towards providing affordable energy for all the people of South Africa and to minimise the negative effects energy usage has on human health and the environment (DME, 2005b).

At the parliamentarian forum on energy legislation and sustainable development held in October 2005, in Cape Town it was mentioned that there are advantages in treating access to energy services as a human right. The states obligation towards human rights is to respect, protect and to promote. South Africa’s obligation towards human rights is embodied in chapter 2 of the Constitution (Act 108 of 1996).

At the parliamentarian forum, it was discussed that by adopting a human rights approach it would be possible on the basis of equality that the entire population inclusive of the disadvantaged would have access to modern energy services. In lieu of the fact that the mining sector is such a high intense energy user, it would be apt to state that the mining sector should play a role in this process through their corporate social investment by providing electrification, education and village infrastructure.

It could be argued that government alone cannot achieve these targets and that is where corporate citizenship and the concept of the triple bottom line become relevant to the mining industry. The reason for this assertion is because mining companies are in a position to affect change positively not only for their own benefit but also for the greater good of society. This assertion is substantiated in the aims of the Carbon Disclosure Project discussed in section 2.2.3. The following paragraph is an example of a typical mining process that can reduce energy consumption.

2.1.5.1 Comminution: a process in mining

The comminution process involves blasting, crushing and grinding. The demand for sustainable development and the reduction of CO_2 emissions implies a need for an increase in energy efficient comminution.

Comminution is one of the most important steps in the mining and processing of mineral ores. Comminution describes the processes involved in size reduction. Size reduction is important for the underground and surface mining operations.
The relevance of comminution is that the majority of energy consumed in mining occurs during the comminution process and is the largest single source of GHG emissions. Suggestions are that the optimisation of the comminution circuit can yield energy and

cost benefits (Valery & Jankovie, 2002: 287). Optimising the size distribution of blasted rock fragment for specific downstream operations can save a substantial amount of energy. These operations could be the mill processing, leaching or waste dumping (Valery & Jankovie, 2002: 287). A study has suggested the introduction of high intensity blasting; high pressure grinding rolls and stirred milling technology could provide energy savings in excess of 45% (Valery & Jankovie, 2002: 287). The drilling and blasting process is the first comminution process. This process efficiently breaks rock to facilitate extraction of the mineral contained within or below it. This process is the most energy efficient method of size reduction.

The comminution of energy consumption is relative to the type of ore and to the size of the grinding product. The crushing process consumes low levels of energy and milling consumes large amounts of energy. Crushing produces, material coarser than 5mm and milling produces fine products, which is below 0.1mm.

Figure 2.1 shows that when most of the energy is consumed for milling, consumption rises sharply for product sizes below 1mm.

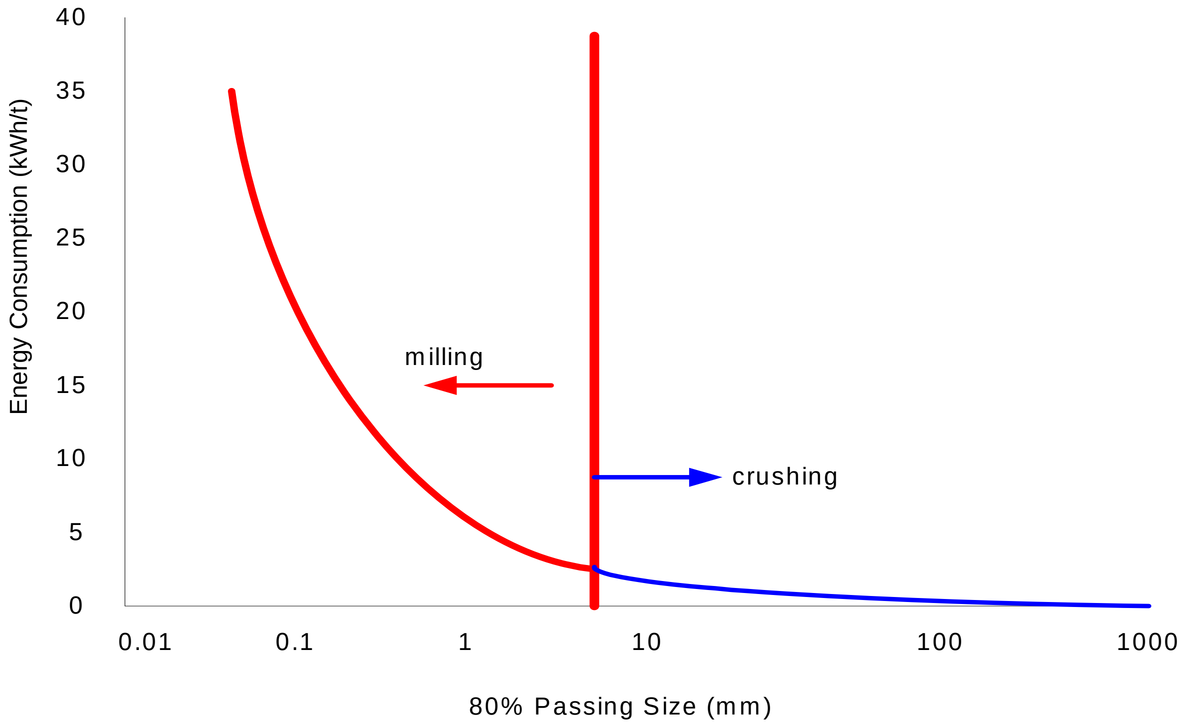


Figure 2.1: Comminution energy consumption as function of product size
Source: Valery & Jankovie, 2002

Based on the above Figure 2.1, significant energy savings can be achieved if there is a reduction of energy required for the production of fine particles. This could be achieved by comminuting less material, more efficiently (Valery & Jankovie, 2002: 288). The comminution of less material can be achieved through ore sorting, using optical, radiometric, magnetic and principles, using dense medium separation or froth separation and improved mining practice to reduce dilution by waste.

It must be noted that comminution circuits are not designed to minimise energy consumption. However, it has been suggested that in order to comminute more efficiently, circuits can be made to be more energy-efficient by identifying their design or operating conditions.

2.1.6 Summary

This section has provided an overview of energy efficiency from a global perspective and a South African perspective. It discussed the power outages experienced in the Western Cape and the need for energy efficiency thereof. It also discussed energy efficiency from a mining perspective.

2.2 DRIVERS OF ENERGY EFFICIENCY

2.2.1 Introduction

This section provides a discussion of the drivers of energy efficiency. The drivers of energy efficiency are sustainability, energy pricing, economic impacts, quality of life, energy safety and security, long term strategy, environmental company profile, environmental management systems, climate change and corporate citizenship to name a few.

The effects of industrial competitiveness and the expansion of industries are increasing the amount of CO_2 emissions. The role played by CO_2 in global warming has led to it becoming a major concern for energy intensive industries. As a result, strategies and long term planning relating to energy efficiency has to be enforced in order to address these issues.

The reasons for considering factors which affect energy conservation and invariably energy efficiency is necessitated by one fundamental concept and that is sustainability. Sustainability involves long-term thinking and planning to meet present day needs without compromising future generations (Smith, 2004). Sustainability could be implemented in all parts of an organisation or business enterprise. For example, a facilities organization could focus on green buildings and sustainable transportation programmes whilst a finance team could focus on triple bottom line factors to demonstrate performance beyond financial results and to make that information public.

This section only discusses the drivers pertinent to this report, namely the economic effects energy efficient initiatives have on industry; climate change and the environment; concept of corporate citizenship and energy security.

2.2.2 The economic effects of energy efficient initiatives on industry

At the heart of energy, saving measures lays a crucial factor, and that is industrial competitiveness. The definition of competitiveness within the industrial context is the ability to maintain or expand market position based on its cost structure (Reinaud, 2004: 17). Increasing costs for companies / industries can lead to a loss of competitiveness and therefore a loss of output.

The impact of CO_2 emissions affects the competitiveness of industry because of global pressures exerted by environmental lobby groups to reduce their emissions. This would mean curtailing industry growth.

The energy intensive users in the industrial sector include the cement, steel, aluminium, pulp and paper and oil refining industry (De la Rue du Can, 2007). These industries are perceived to be the main sources of GHG emissions. In order to utilise energy efficient measures economically, a company would have to take into account the difference in total costs between energy efficient measures and their current operations. If a company had to invest in energy efficient options, there should be a minimisation of cost. The cost of reducing CO_2 could reduce profitability and therefore companies are opposed to energy efficient options (Reinaud, 2003).

Energy intensive users have to deal with the following factors in terms of competitiveness (Reinaud, 2004: 17):

- Industries ability to reduce CO_2 emissions cheaply
- Influence on industry's current cost structure and profitability margins
- Industry's exposure to international markets (imports/exports, freight prices)
- The possibility to increase product prices

The concept of competitiveness and cost varies between industries. Industry competitiveness would depend on what is produced, how it is produced and to whom it is sold.

For example electricity generators operate their plants according to marginal costs and in so doing optimise their production portfolio. The revenue of a power plant depends on the wholesale power price. It is uneconomical to operate a power plant if the market price is below a plant's marginal production costs. The profitability of a power plant would depend on the wholesale market price. The wholesale market prices are determined by wholesale power demand and the industry's short-run marginal costs. According to Reinaud (2004: 42-43) the value of carbon emission allowances should be reflected in the short-run generating costs of fossil-fired plants. The reason for this is that emissions from generation have to be offset with allowances held or purchased on the CO_2 market. If the market price does not cover the incremental cost which includes the value of allowances, then it would be advantageous for the power producer not to over produce power (Reinaud, 2004: 41-42). This situation is not the case in South Africa as Eskom is the supply monopoly of power in South Africa.

Energy efficiency can reduce GHG emissions, improve air quality and electric reliability and has economic potential for businesses and corporations. The economic potential lies in energy efficiency measures that are cost effective. However, market failures and barriers play a role in the efficacy of this potential.

2.2.3 Climate change and the environment

The increase of GHG is a major driver of the promotion of energy efficiency standards. Improvements in energy efficiency aids in the reduction of CO_2 emissions. In the USA, the National Commission on Energy and the Pew Centre on Global Climate Change conducted a study that highlighted the need for improvements in energy efficiency strategies that will reduce CO_2 emissions. This study indicated that there are two ways in which CO_2 emissions could be reduced (Ang, 2005) namely: Fuel switching and reductions in energy consumption by decreasing production or decreasing energy intensity.

Industrial emissions take place at two levels, namely process emissions (indirect) and energy related (direct) emissions. GHG emissions are energy related whilst process emissions results from chemical reactions emitted during the production process of a product (Reinaud, 2004: 23).

A study at the US National Academy of Science concluded that energy related emissions of CO_2 could be reduced by as much as 37% through the adoption of energy efficient technologies that are cost-effective (Howarth, 1993).

In 2001, the UN Intergovernmental Panel on Climate Change (IPCC) issued its Third Assessment Report that highlighted the fact that greenhouse gases from economic development are altering the earth’s climate to such an extent that it will create severe changes to the natural environment (Dlugolecki, 2003).

There is scientific evidence showing that climate change poses a serious global risk (Suter, 1999). In 1972, a group of European economists published a report, which predicted major consequences because of human’s over-consumption of the earth’s resources. According to this report, the solution to this problem was the abandonment of economic development. Thus essentially, the more successful economic development was, the more harmful this was to the earth’s resources. However, later reports focused on the establishment of environmental standards that was commensurate with the rapid economic development-taking place (Suter, 1999).

The Stern Report (Stern, 2006) reveals that the current level of greenhouse gases in the atmosphere is about 430 parts per million (ppm) CO_2. The result of this is that the world has already warmed by more than half a degree Celsius and it could lead to a further increase in global temperatures. It was estimated that by 2050, the level of greenhouse gases in the atmosphere would reach about 550 ppm CO_2. This is further exacerbated by the fact that the demand for energy in growing economies is on the increase, which would indicate that the level of 550 ppm CO_2 could be reached by 2035.

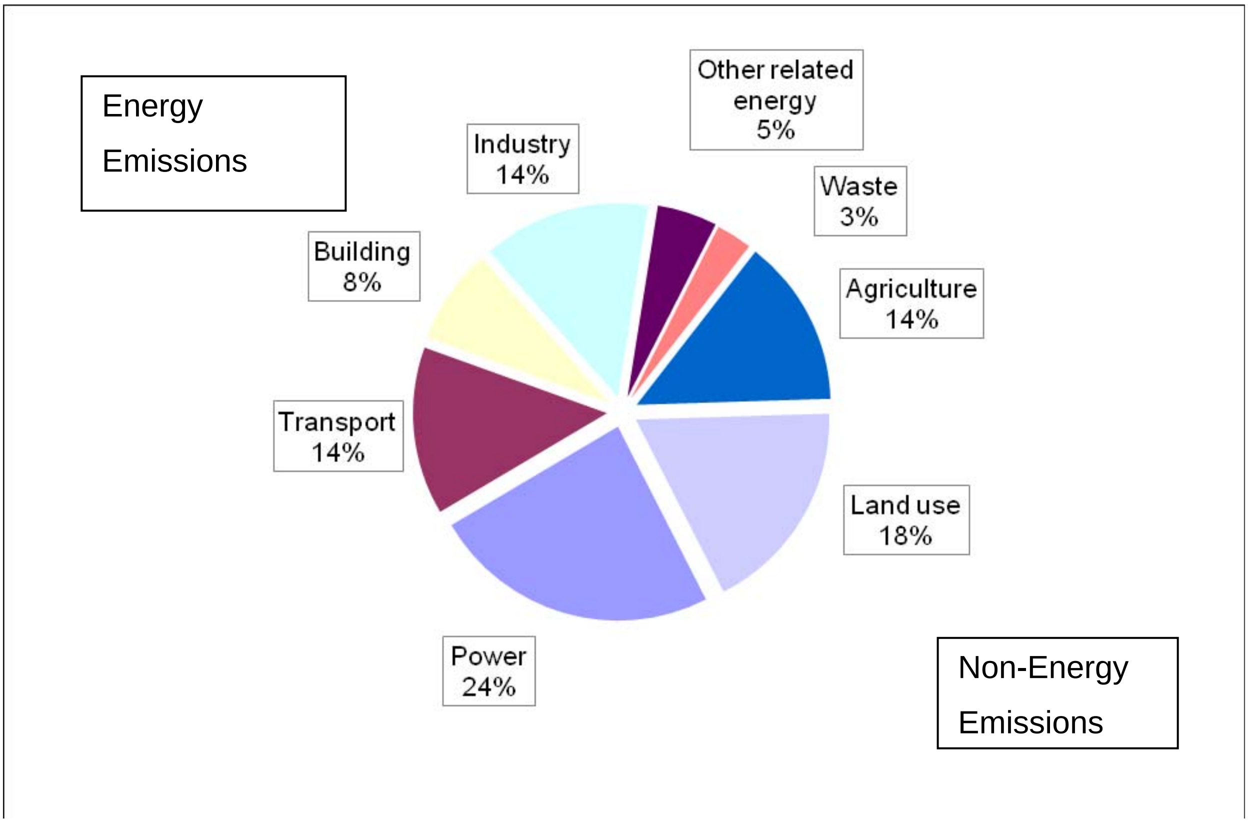


Figure 2.2: Greenhouse-gas emissions in 2000
Source: Stern, 2006

From the Stern Report it can be deduced that the consequences to climate change cannot be easily predicted, however this report is an awakening to what must be done presently.

The Carbon Disclosure Project (herein referred to as CDP) is a good initiative, which addresses climate change and its implications thereof. The CDP aims to involve institutional shareholders and corporate business on specific risks and opportunities presented by climate change. The reason for involving shareholders is to get them to take measures to deal with the problem of greenhouse gas emissions. It is the CDP's objective that shareholders are the owners of major contributors to climate change and therefore they are in a critical position to effect positive change regarding the problem of greenhouse gas emissions.

In March 2002, 35 institutions that controlled over $4.5 trillion of assets (Dlugolecki, 2003) globally signed to support the CDP venture. These included Abbey National, Allianz Dresdner, Aviva, Connecticut RPTF, Co-operative Insurance Society, Credit Suisse, Henderson ING, Jupiter, and Legal and General to name a few. However, in 2007 there was a subsequent change to 315 investors with assets totalling $41 trillion (Kiernan, 2007) as opposed to $4.5 trillion of assets in March 2002.

According to the CDP, there are four key climate change related effects linked to shareholder value (Dlugolecki, 2003):

- Extreme weather events such as severe droughts or floods that could disrupt core markets or damage assets
- Regulatory action to limit emissions affecting significant carbon emitters. The result of this delay projects or increases operating costs and capital
- Consumer reaction to corporate reputation on climate change that could affect sales
- Climate responsive technologies, goods and services. This is a factor in credit rating, stock-market valuation, and viability of markets

The CDP sent out questionnaires / surveys to a number of investor participants around the world. The focus of the survey was on each company's GHG emissions. The CDP looked at FT500 companies. The USA accounts for 238 FT500 companies and their attitude was an unfavourable one towards this survey. 34% did not respond and 23.5% declined to answer. In Germany, 80% of companies answered the survey, UK a 97% response and Australia a 100% response. Russia, Mexico and Asia outside Japan, were poor in responding, which reflects that attention to environmental issues remain inadequate in the corporate agenda.

The overall findings of the survey were that investors failed to take into account climate change and carbon finance issues in their asset allocation. Half of the FT500 companies have already identified climate change as a serious issue and are developing strategies to curb greenhouse gas emissions. The leaders in this sector are Statoil, BP, DuPont, Hypovereinsbank, ING and Swiss Re. These companies have formulated strategies such as investing in renewable and low carbon technologies. It therefore follows that companies who start early in implementing strategies to reduce GHG emissions are better positioned to achieve cost effective risk management solutions and to exploit any profit opportunities (Dlugolecki, 2003).

The World Resource Institute studied seventeen companies and only three companies mentioned in their annual reports that climate policies and regulations could affect future business operations. These three companies were British Petroleum, Conoco and Phillips Petroleum. Unilever has set GHG targets such as an annual 3% CO_2 reduction. Danone, Nestle and Unilever have joined forces to form the Sustainable Agriculture Initiative (SAI). SAI involves testing and developing sustainable agriculture practices. This includes consumption of natural resources and energy. Deutsche Telekom, NTT DoCoMo, BT and Vodafone have pursued market opportunities in mobile communications that allow for greater efficiency in the management of remote vehicle fleets, reduced vehicle transport, and streamlining of overall efficiency through telekoms logistic networks (Dlugolecki, 2003).

Sweden has been active in promoting initial agreements on emission reductions of certain gases and has been successful in reducing emissions. They introduced innovative policies to the world to deal with reduced emissions. One of these policies was the green taxing policy wherein there was a tax on CO_2 emissions in the 1990's. Sweden has one of the lowest electricity prices amongst the OECD countries (Blau, 2003).

It becomes clear that in order to slow down Global warming, the industrialized nations should drastically reduce their GHG emissions.

It is therefore imperative to have a plan of action that can impact positively on climate change while reaping the benefits for not only companies but for the planet as a whole.

2.2.4 Concept of corporate citizenship

Corporate citizenship is synonymous to corporate governance and corporate responsibility. Corporate governance refers to the fiduciary duties of companies and directors. In order for corporate responsibility to be properly effected, there must be good governance and management accountability (Piedade & Thomas, 2006: 65-74). Embodied in corporate responsibility is the requirement for companies and industry to effect positive change in attaining energy efficiency. The notion of corporate responsibility is illustrated in the triple bottom line and within the context of this report. It was evidenced in the Carbon Disclosure Project discussed in section 2.2.3.

The concept of corporate governance was published in The King's Report in 2002 (Micheal, 2003). The aim is to promote high standards of corporate governance in South Africa. The report distinguishes between accountability and responsibility. It notes that companies experience difficulty when having to account for profitability. It further notes that there is a shift away from the single bottom line to the triple bottom line (Micheal, 2003).

Legislation in many countries is becoming more stringent concerning corporate governance. Regulation requires organisations to produce codes of ethics and to report on their social, environmental and financial performance. For example, in the United States, the Sarbanes-Oxley Act of 2002 requires US companies to disclose the existence or non-existence of their code of ethics (Piedade, et al., 2006). The Dow Jones Sustainability World Index allows socially responsible investors to invest in companies with good citizenship records (European Commission, 2003: 12-15). Companies listed on the JSE in South Africa, have a duty to report on their triple bottom line.

The following four points relates to what corporate responsibility means in the business context (Grayson & Hodges, 2001):

The development of technology and communications, which result in, companies 'having no place to hide.' In this way, companies can become more transparent to the public.

The increased prominence of multinationals globally and the growth in their value and visibility of their brands which make them more susceptible to scrutiny.
Demographic change and development, which encompasses issues such as an ageing population in the developed world, skewed income distribution, limited access to health, education and jobs.
The revolution of values and the decline in deference for institutions.

There are many corporate responsibility initiatives around the world such as the United Nations Global Compact (herein referred to as the GC), which also focuses on corporate citizenship. The GC is a non-regulatory body that relies on public accountability, transparency and the enlightened self-interest of companies, labour and civil society to implement their initiatives. The GC primarily focuses on advancing responsible corporate citizenship so that business can be part of the solution to the challenges of globalisation. The former UN General Secretary, Kofi Anan advocated for a more sustainable and inclusive global economy (United Nations, 2004).

The GC involves social actors, namely (United Nations, 2004):

- Governments who define the principles on which the initiative is based
- Companies, whose actions it seeks to influence
- Labour in whose hands the concrete process of global production takes place
- Civil society organisations representing the wider community of stakeholders
- The United Nations, which represents the world's only global political forum

The GC encourages partnership projects with UN agencies and civil society organisations in support of global development goals. The GC requests that companies embrace, support and interact within their sphere of influence a set of core values in the areas of human rights, labour standards, the environment and anti-corruption.

The following principles demonstrate whether one is a participant in the GC:

- Demonstrating leadership by advancing universal principles and responsible corporate citizenship.

- Producing practical solutions to contemporary problems related to globalisation and managing risks by taking a proactive stance on critical issues.

These principles can be extrapolated as a guideline for companies measuring their performance in terms of the triple bottom line.

“I believe the distinction between a good company and a great one is this: A good company delivers excellent products and services; a great one delivers excellent products and services to make the world a better place” (Smith, 2004). This quotation best sums up the idea behind the triple bottom line.

The triple bottom line was a term coined by John Elkington in 1995 (Elkington, 1997). There have been various descriptions of what defines the triple bottom line namely “social, environmental and economic performance” “sustainable development, sustainable environment, sustainable communities” “impact on society, the environment, and economic sustainability,” “people, planet, profit” (minerals, 2007).

Corporate responsibility and the TBL are pivotal to the notion of accountability. An apt analogy is the manner in which the South Africa government operates and that is the process of checks and balances. This means that the government of South Africa is accountable to the people. The President is not above the law and must act within the ambit of the law (The Constitution Act 108 of 1996). In the same vein, from the corporate perspective, companies cannot act ‘carte blanche’. They are accountable to their stakeholders, shareholders, investors and the community, and must therefore act in a responsible manner. Stakeholder groups such as socially responsible investors, non-governmental organisations, green consumers, and government regulatory bodies require information related to the social and environmental dimensions of the triple bottom line. There is an increasing need for financial and non-financial information related to corporate responsibilities.

The TBL reporting provides a platform or channel for companies to reveal to the public that they are engaging in legitimate environmental and socially responsible activities. Most companies define the triple bottom line but it is very rare that anyone talks about the measuring, calculating and reporting of the triple bottom line. It can therefore be stated that although the TBL is a step towards increasing the awareness of multiple competing objectives for companies, it appears to be an inadequate representation of organisational sustainability. This can be attributed to the fact that there is difficulty in attempting to quantify the environmental and social dimensions of organisational performance. It is apparent that companies do not have a measurement tool, on how to calculate the triple bottom line (Norman & MacDonald, 2003).

2.2.5 Energy security

The demand and supply of energy has become a worldwide crisis. This is evident by the power outages being experienced on a global scale. Energy security is therefore of paramount importance.

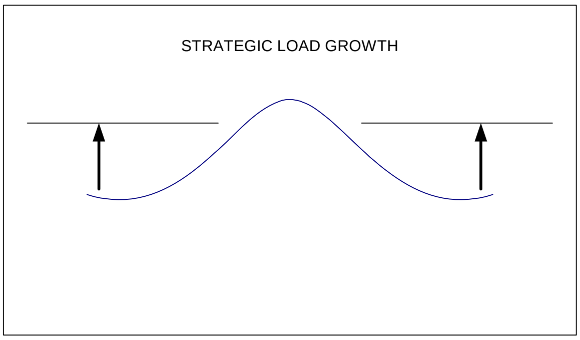
On a global note, California experienced unscheduled interruptions of power and blackouts covering hundreds of thousands of consumers. California's population as at 2000 was about 34 million. In 1998, its power system had a capacity of 52,349 MW. California's electricity prices were quite high in comparison with other states in the US. The energy crisis occurred during the period of January 2001 and February 2001. The following factors which contributed to the California crisis were: electricity demand was underestimated; natural factors in that the weather conditions led to shutdown of nuclear plants; defects in deregulation in that the plan implemented involved old generators being forced to sell plants off without ensuring that new owners would sell electricity at a reasonable price. This led to spike increases in electricity prices and owners waiting for the last minute to sell at an exceedingly high price thereby creating imperfect market conditions (Reddy, 2001).

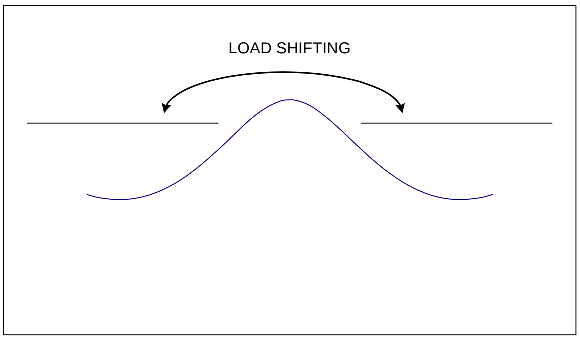
In South Africa, the National Energy Regulator has raised the concern that there could be a run out of peak power in the near future. Eskom has raised various initiatives to reduce the need for peak power. The real concern is that this problem could hinder South Africa's steady growth of 4-6% of GDP (Nortjie, 2005). Support for this contention can be found in the economic frustration in the Western Cape as a result of the power outages.

The 2010 World Cup is fast approaching and therefore the supply of energy becomes a concerning factor. Given the serious power failure experienced in Cape Town, it becomes imperative to ensure that this does not happen during the World Cup. The Minerals and Energy Minister, Buyelwa Sonjica announced on 22 August 2006, the department would ensure that there would be enough energy supply to cater for the 2010 Soccer World Cup (Mathews, 2006a). The department is to implement an energy efficiency campaign, which was successful in the Western Cape during the power crisis. After the Koeberg crisis, Eskom embarked on an ambitious energy saving programme. Eskom encouraged consumers to use electricity sparingly, for example, extensive media coverage that conveyed pointers such as switching off appliances when not in use, installing fluorescent lights, using oil heaters and installing geyser blankets. Essentially this is non-essential power. Eskom emphasized that the more energy is consumed, the more power needs to be generated. As a result, more power stations need to be built. This could mean higher tariffs for the consumer.

It has been suggested that demand side management can be used to limit the growth of energy demand and this could be an initiative for industry to implement. It was mentioned earlier that Saudi Arabia has implemented demand side management.

Demand side management is a measure used to secure energy for the short term. It is described as measures taken to reduce energy consumption, which is achieved through energy conservation, energy efficient measures and technologies, load shedding and load shifting (New Era, 2006).





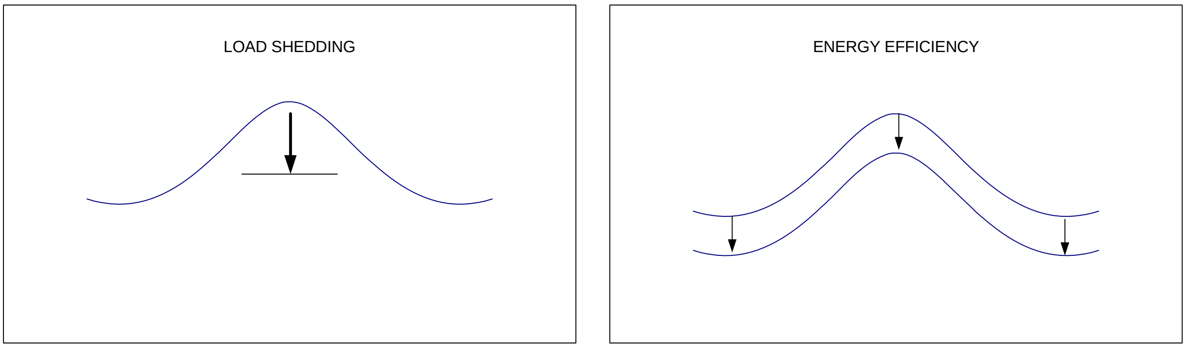


Figure 2.3: DSM options

Source: Acharya, 2007

Figure 2.3 illustrates the following concepts: Strategic Load Growth, Load Shifting, Load shedding and Energy Efficiency. Strategic load growth refers to the creation of additional electricity sales this is achieved through growth initiatives which utilities use if they have surplus power (Acharya, 2007). Load shifting refers to shifting demand peaks from one time to the other on a permanent basis. This can be achieved through tariff setting, ripple control of electric water heaters or other devices and industrial demand management strategies, however, it must be noted that load shifting does not reduce electricity consumption but Eskom prefers to use this option during peak electricity demands (Brand, 2006). Load shedding refers to the temporary reduction of consumption and demand from the grid on an ad hoc basis through forced load shedding in emergencies or pre-arranged voluntary means. Energy Efficiency is the decrease of energy consumption of a particular end - use with the aim of reducing energy consumption and peak load demand (Acharya, 2007).

It can be deduced that demand side management offers great opportunities to match supply and demand of electricity.

2.2.6 Summary

This section has discussed the drivers of energy efficiency. It discussed energy concerns from an economic and environmental perspective, and the concept of corporate responsibility from a general and global point of view and energy security. It discussed the events relating to power outages and as a result, the need to ensure that there is sufficient supply of energy. Demand side management was defined and discussed as an initiative that industry could use to implement as a measure to curtail energy consumption. It is evident that the reduction of CO_2 emission is dependent upon the reduction of energy consumption.

2.3 BARRIERS TO ENERGY EFFICIENCY

2.3.1 Introduction

This section deals with barriers to energy efficiency. The following barriers will be discussed: market barriers; competitive markets; information; financial; technological and infrastructural; consumer behaviour; poverty; government regulation; marketing, supply monopolists and shortage of skilled people (Rohdin, Thollander & Solding 2006:3).

Energy efficiency initiatives and policies require active participation from different levels of energy actors. These energy actors can be categorised as energy consumers, i.e. individuals, households, firms, farms, factories, equipment manufacturers, producers/distributors of energy carriers, financial institutions and governments to name a few. However, within these levels of actors, there exist barriers to implementation of energy efficiency initiatives.

Institutional economists identify the following barriers for energy efficiency (Brown, 2001).

2.3.2 Market barriers

A leading energy researcher (Brown, 2001) defines market barriers as ‘obstacles that are not based on market failures but which nonetheless contribute to the slow diffusion and adoption of energy-efficient innovations’ (Brown, 2001: 1197-1201). This could be because of incomplete information, low priority of energy issues, capital market barriers and incomplete markets for energy efficient products.

Market failures and barriers influence energy efficiency. Market failures occur when there is a flaw in the way markets operates. Market failures can be caused by:

- Misplaced incentives
- Distortional fiscal and regulatory policies
- Unpriced costs such as air pollution
- Unpriced goods such as education, training & technological advances
- Insufficient & incorrect information (Brown, 2001)

The full potential benefit of energy policies and climate mitigation can be underestimated if the market imperfections are not considered. The obstacles to clean energy technologies are the following: The low priority of energy issues among consumers, Capital market imperfections and incomplete markets for energy-efficient features and products.

Capital market barriers can restrict efficiency purchases. Various energy producers and consumers have different access to financial capital and at different rates of interest. Generally, energy suppliers can get capital at lower interest rates than energy consumers. This results in an interest rate gap. The differences in these borrowing rates may reflect the differences in the knowledge base of lenders and the financial risk of the potential borrower. Electricity and gas utilities in the USA are able to borrow money at low interest rates. However, low-income households are not in a position to borrow funds, which leads to a higher discount rate for valuing improvements in energy efficiency.

2.3.3 Competitive markets

An example of a neoclassical model in terms of competitive markets is one where individuals / industry considers the total costs of their decisions in buying energy-using equipment. Competitive producers could increase their profits if the value of energy savings derived from the improvement of energy efficiency exceeded the cost of the improvement. Market barriers impede the adoption of certain energy-efficient technologies. Consumers use high discount rates in evaluating the present value costs of energy-using technologies. A consumer would therefore opt for the lesser price and therefore energy efficient technologies should be affordable to the consumer (Howarth & Anderson, 1993).

2.3.4 Information

Information barriers regarding the price of information, energy savings and its accessibility thereof. There is a problem in decision makers obtaining this information and having the ability to understand it in order to effect change. This uncertainty can lead to decision makers remaining with inefficient mechanisms regarding energy conservation (Ellen, Moors, Karel & Philip, 2005).

Consumer behaviour plays a vital role in determining the extent to which energy efficiency measures are effective. Consumers often lack all-important information regarding available energy efficient technologies and are therefore not in a position to evaluate the investment of energy efficient technology and the consequences of their decisions (Howarth, et al., 1993).

2.3.5 Financial

Financial barriers can take the form of a lack of capital to buy new energy efficient equipment. An organisation may not be in a position to afford the initial start up costs for energy efficient equipment (Blau, 2003; Sherry, 2003).

2.3.6 Technological and infrastructure barriers

Energy efficient technologies are available but the problem is that it is not available everywhere and may function differently in different environments. There is also a lack of awareness in widely adopted technologies, for example the use of a heat pump. This involves the use of one unit of electricity to move 2.5 units of heat from the earth and transferring them indoors for heating. A Swedish Construction related services and project Development Company presented this idea. However, in this example, you get a total efficiency of less than 1(40%* 2.5=1) and it would therefore be better to use an oil burner that works in efficiency of close to 1 in the house (Blau, 2003: 14). The supply of energy using equipment may create barriers to the development and adoption of energy efficient technologies. Some private firms are unable to capture complete social benefits of research and development expenditures. In this respect, it is suggested that government should intervene by supporting research and development (Howarth, et al., 1993). There is an efficiency gap between the actual level of investment in energy efficiency and the lower level that would be cost beneficial for the consumer. Consumer and businesses often choose not to purchase highly cost effective technologies. In the US, a case study conducted identified consumers who were given a choice of two refrigerators that were identical in all respects except for energy efficiency and price. The energy efficient model cost $60 more than the standard model. The energy efficient model saved 410-kilowatt hours per year, which is more than 25% of energy usage. However, despite awareness of the efficiency, most consumers purchased the inefficient model (Brown, 2001).

The EPA's study on efficient lighting investment revealed that there is potential for profitable energy-saving investments in lighting. However, this potential is not being realized due to certain barriers. These barriers to investment could be capital rationing and lack of organizational resources for energy managers who reduce utility bills (Brown, 2001).

Innovative energy efficiency technologies are rapidly increasing. Many companies and industries are developing new technologies to improve the use of energy. The barrier here lies in the technology not being proven as there are many processes involved in getting technology approved (Reddy, 1990: 15). The Oregon Public Utility Commission advocated a financial incentive that sought to increase market penetration of new energy-efficiency technologies by giving its utility, Pacific Power & Light Co (PP&L), a profit incentive to promote conservation (Oregon Public Utility Commission News, 1990).

2.3.7 Consumer behaviour

At the level of energy consumers, the barriers could be attributed to cultural barriers such as ignorance, poverty, and cost-sensitive consumers. It could be stated that the lack of education in energy efficiency initiatives could hamper the progress thereof. If people or energy consumers are not educated adequately, they will be unaware of the benefits of energy efficiency initiatives. They will therefore not be in a position to understand the costs benefits and hence live in oblivion to the cost effectiveness of conservation measures.

A suggested method to overcome this type of barrier is to make use of the print and electronic media to educate consumers (Reddy, 1990). This can be achieved by providing information through door-to door canvassing, leaflets, newspapers, magazines, radio and television. Eskom's marketing strategy after the Koeberg aftermath in the Western Cape is an apt example of educating the South African nation on how to conserve energy. Eskom sponsored television adverts that conveyed messages on how to conserve energy, for example, switch off lights that are not in use (non-essential power), and use the microwave as it utilizes less current as opposed to the stove and the use of fluorescent lights. This is a simple yet effective example of an attempt to educate consumers on how they can play an active role in energy conservation. It will later be discussed under findings how a company can benefit from this method of reducing the use of non-essential power thereby impacting positively on the triple bottom line.

2.3.8 Poverty

In terms of the poor, they are at a disadvantage as some are forced to live on the fringes of society. This means that they do not have access to proper energy supplies and therefore make use of whatever they can. For example, most of the shack dwellers make use of kerosene and often this leads to burning of the shacks which in turn leads to the CO_2 emissions in the air thereby impacting on global warming. In order to reap the benefits of an energy efficiency programme there has to be an initial cost, which will have a long-term benefit. However, people living on the fringes of society do not have the means to contribute towards energy conservation. It could therefore be seen that low-income households lack the finances to make use of energy efficient technologies (Howarth, et al., 1993). It therefore becomes apparent that poverty is definitely a barrier as it could be argued that people who are poverty stricken would not be in a position to even make the initial cost.

2.3.9 Government regulation

Government plays a major role regarding barriers to implementation as government regulations can place constraints on energy saving initiatives. This means that all initiatives must be planned and implemented according to the standards set by government. All governments differ concerning their energy policies and therefore the barriers would be dependent on the type of regulation endorsed.
With regards to appliances, most governments have regulations covering labelling. For example, it is obligatory for manufacturers to label appliances regarding their energy performance. This enables the prospective purchaser to make an informed decision when purchasing an appliance. However, this can be seen as a constraint for the manufacturer as this is an additional cost (Blau, 2003; Ellen, et al., 2005).

2.3.10 Marketing barrier

Producers/distributors of energy carriers, that is electricity, coal and petroleum products focus much of their attention on supply that they spend little time on the utilization and whether or not these carriers are efficient. This creates a marketing barrier in that the efficiency of these carriers cannot be marketed, as they are not specified. There is the recommendation that an energy service company can overcome this barrier. An energy service company can identify the efficiencies of the energy carriers and then market it effectively (Reddy, 1990).

2.3.11 Supply monopolists

Supply monopolies being state owned power generation plants; controlled transmission networks and controlled distribution. This is in a market were there are many buyers but only one seller. When you have a monopoly, you can ask any price you like.

Supply monopolies are seen as barriers to energy efficiency improvement. There are often laws that prevent the production of energy carriers by any other producers. For example, in South Africa, Eskom is the supply monopoly of power. This is a barrier with regard to the production of energy carriers. In the USA, the supply monopoly existed until the enactment of two laws, namely:

- The Public Utility Regulatory Policies Act of 1978 (PURPA). This Act promotes cogeneration and requires an electric utility to purchase electricity from qualifying co generators and small power producers at the utility's avoided cost.
- The Regulation Governing Independent Power Producers of 1988. This was aimed at promoting small power producers who use renewable energy sources.

These laws have been successful as many co generators could produce electricity at lower cost than utilities. This law provides financial benefits of cogeneration to co generators as there is a cost saving for co generators. It has been recommended that the barrier of the supply monopoly can be overcome by measures that involve incentives to encourage and reward independent producers to produce energy carriers (Reddy, 1990: 13). It can be clearly seen that supply monopolies are barriers to energy efficiency as the monopoly prevents other suppliers from entering the market.

2.3.12 Shortage of skilled people

The formulation and implementation of energy efficiency programmes requires highly technical and managerial skills. However, most countries have a shortage of skilled workers in the energy sector and this creates a barrier in terms of adequately implementing energy efficiency programmes. Companies and industries involved in the energy sector should embark on intensive training programmes that could improve the efficiency element (Blau, 2003). Apart from a shortage of skilled workers, there is a lack of training facilities and trainers. One of the factors that were revealed during the investigation of the Koeberg crisis was a defective management system.

South Africa has an abundant supply of resources but the management of this is a critical issue. South Africa has the capability to provide energy nationally but the challenge lies in how this is implemented.

2.3.13 Summary

This section has discussed a number of barriers to energy efficiency and its influences in the decision-making process. It also discussed barriers relating to the local South

African situation such as: poverty, government regulation and shortage of skilled people.

2.4 SELECTION OF ENERGY SAVING INITIATIVES

2.4.1 Introduction

This section provides a discussion of methodologies involved in the selection of energy saving initiatives. It will look at how to select energy saving initiatives and why this is an important part of energy management. There are divergent views on how to select energy saving initiatives. These divergent views will be discussed under the methodology of Wulfinghoff's and Capehart, Turner and Kennedy's method.

Energy saving initiatives involves the accumulation of ideas and suggestions related to energy efficiency and energy saving. These ideas are predicated upon the best initiatives, which would curtail energy consumption in the most economic way.

2.4.2 Wulfinghoffs method

According to Wulfinghoff's method (1999:1), the energy initiative process starts with an idea. The next step is to assess whether or not this idea has potential savings, provides good rates of return, is reliable and allows for flexibility. Wulfinghoff (1999) has tried approximately 400 various energy efficient ideas, which have been tried and tested. Table 2.1 shows a brief summary of how his initiatives are evaluated and selected.

Table 2.1: Selection scorecard for energy initiatives

	Rating 1	Rating 2	Rating 3	Rating 4
Savings potential	<0.1%	0.1% - 0.5%	0.5% - 5%	>5%
Rate of return	<10%	10% - 30%	30% - 100%	100%
Reliability[a]	Very risky	Failure prone	Reliable	Foolproof
Ease of retrofit[b]	Very challenging	Difficult	Routine	Easy

Source: Based on Wulfinghoff, 1999.

[a] Reliability rating indicates the likelihood of the measure being effective throughout its promised service life. Rating 4 is called Foolproof. The equipment or materials will last as long as the facility and easy to administer. Rating 3 is called Reliable. The equipment has a long service life, it is not vulnerable to damage, negligence, or poor operating practice. It is easy to maintain. Rating 2 is Failure Prone. The equipment needs skilled maintenance or is vulnerable to damage or poor operating practice. It

requires constant supervision. Rating 1 is Very Risky. The equipment has poor or unknown reliability. It requires frequent maintenance.

[b] Ease of retrofit or ease of initiation indicates how easy it is for the staff to accomplish the measure properly. Rating 4 is easy. It requires minimal effort with no extra skills. Rating 3 is routine. Not much effort or skill is required. Rating 2 is difficult. It requires major staff effort. Rating 1 is challenging and can be unpleasant. It is likely to be resisted.

In all energy conservation programmes ratings become a priority. After the above rating each rating is separated into three categories: New Facilities, Retrofits and Operation and Maintenance. Each category is further divided into four alphabet's A/B/C/D.

Table 2.2: Rating of new facilities

	Description	Explanation
A	Do it wherever it applies	It requires minimal cost and has no significant disadvantages
B	Do it in most cases	It requires significant cost but the payback is quick. It does not require special skill and therefore there is no need to increase the staff complement
C	A very costly approach with the payback being relatively long	It may require substantial effort and special skill
D	A small benefit in relation to its cost	It may have a high risk and be difficult to maintain

Table 2.3: Rating of retrofits

	Description	Explanation
A	Do it wherever it applies	It is simple and quick. The cost is minimal when compared with its benefits. The present staff will be in a position to manage the risks with ease
B	Do it in most facilities where it applies	The paybacks are quick. It is easy to accomplish but requires a substantial amount of money, effort and training. However, it might have some shortfalls that would require significant attention
C	Expensive and difficult	The savings is small in relation to the money, effort, skill, or management attention required. The risks are clear and manageable
D	Expensive and provides very little benefit	It is also risky because it is difficult to accomplish correctly and is unpredictable

Table 2.4: Rating of operation and maintenance

	Description	Explanation
A	Simple, quick, and foolproof	This must be done to prevent damage or major efficiency loss
B	A well-managed facility	The paybacks are quick. It is fairly easy to accomplish and not too risky. It requires a substantial amount of money
C	Requires a substantial amount of money	It also requires effort and special skill. The benefit derived is small
D	The benefit is small in relation to the cost	It is quite difficult to accomplish and has the potential for serious adverse side effects

2.4.3 Capehart, Turner and Kennedy's method

Capehart, Turner and Kennedy (2003) use a 5-step process with regards to selecting energy initiatives namely: eliminate combination, change equipment, person, place, or sequence and improve.

The elimination process involves asking the question whether or not certain factors are necessary. It therefore requires a prioritisation list and things or items, which are not necessary, are thus eliminated from the process.

The combination process involves the amalgamation of machinery or equipment. For example, machining operations combined with jig fixture modifications. This would reduce the material handling process thereby saving process storage energy. This process could also save time and energy.

In the "change equipment, person, place or sequence" process, substantial energy savings are envisaged. The advancements of new technology pave the way for improved performance of equipment. For example, new electric welders are considered to be more efficient that the old electric welders. The changing of persons means to get people who are more skilled. The change of place means to use a more appropriate place and the sequence to be changed to a manner that improves the use of energy consumption.

The “improve” step involves an ongoing process of change. This process looks at how energy is used and on this basis seeks ways in which energy can be improved. In essence, this process looks at better ways of consuming energy.

2.4.4 Summary

This section has discussed two of the many methods involved in selecting energy saving initiatives. It looked at Wulfinghoff’s and Capehart, et al., methodology. There is a myriad of ideas but the initiative to be selected must be the one that would be most efficient and at the same time be able to yield the best economic results.

2.5 MEASURING ENERGY EFFICIENCY

2.5.1 Introduction

Energy efficiency is often measured in terms of thermodynamic indicators, physical-based indicators and monetary based indicators. The US Department of Energy established indicators to track changes in energy intensity of the US economy. Energy indicators were developed by the International energy agency (IEA) since 1995 and is being utilised in most countries today such as Australia, Canada, Denmark, Japan and Sweden to name a few (Schipper, Unander & Marie-Lilliu 2000:4). However, it must be noted that there is no direct way to measure energy efficiency (De La Rue Du Can, 2007).

Energy efficiency indicators provide the links between energy use and some monetary/physical indicators measuring the demand for energy services. Monetary based indicators are used when energy efficiency is measured at a high level of aggregation. These indicators are given ratios between energy consumption in an energy unit and an economic activity in a monetary unit. An example of a monetary-based indicator is the energy gross domestic product (GDP) ratio and industrial energy use per unit of industrial monetary output (Ang, 2005).

The aim of this section is to discuss the measurement of energy efficiency at different levels. This is illustrated by using an energy efficiency indicator pyramid, which explains energy consumption in industry from a macro to a micro level.

2.5.2 Why should we measure energy efficiency?

The importance of measurement to the success of energy efficiency in South Africa is becoming more apparent. Large financial investments are being made in energy saving projects and an increasing number of employers are realizing the need for energy efficiency to maintain and sustain their operations (Den Heijer, et al., 2002).

Measurement is designed to quantify and assess the savings that result from energy projects in an objective manner. If the project impacts are known, stakeholders can identify focus areas for energy initiatives as well as potential problems.

Measurement encourages investment in energy-efficiency and reduces the risk for investors. It provides credibility and broad based acceptance to the energy market. It provides valuable feedback to stakeholders. It encourages better design and management of projects. Cost reports on savings can therefore easily be done monthly and annually.

2.5.3 Energy efficiency indicators

There are different indicators for different sectors namely:

a) Descriptive indicators such as energy by fuel
b) Basic normalized indicators which shows sectoral energy uses divided by population or GDP
c) Comparative indicators which shows similar features of different countries by the introduction of suitable normalization
d) Structural indicators which measures the distribution of economic or human activity in varies different modes
e) Decomposition indicators shows how different components of total energy use influences total emissions

f) Causal indicators looks at which types of fundamental economic, demographic and geographical forces affects energy uses the most

g) Consequential indicators such as carbon emissions, measures the relationship between human activity and energy use (Schipper, et al., 2000:4).

Figure 2.4 illustrates an indicator pyramid. This indicator pyramid is based on work conducted at the University of Utrecht. It illustrates the progression from a large number of technical energy efficiency at the bottom of the pyramid through the process of aggregation to a number of energy intensities of key economic activities in the middle. It is important to understand physical efficiencies of individual energy use processes because energy efficiency strategies seek to improve these processes (Schipper, et al., 2000).

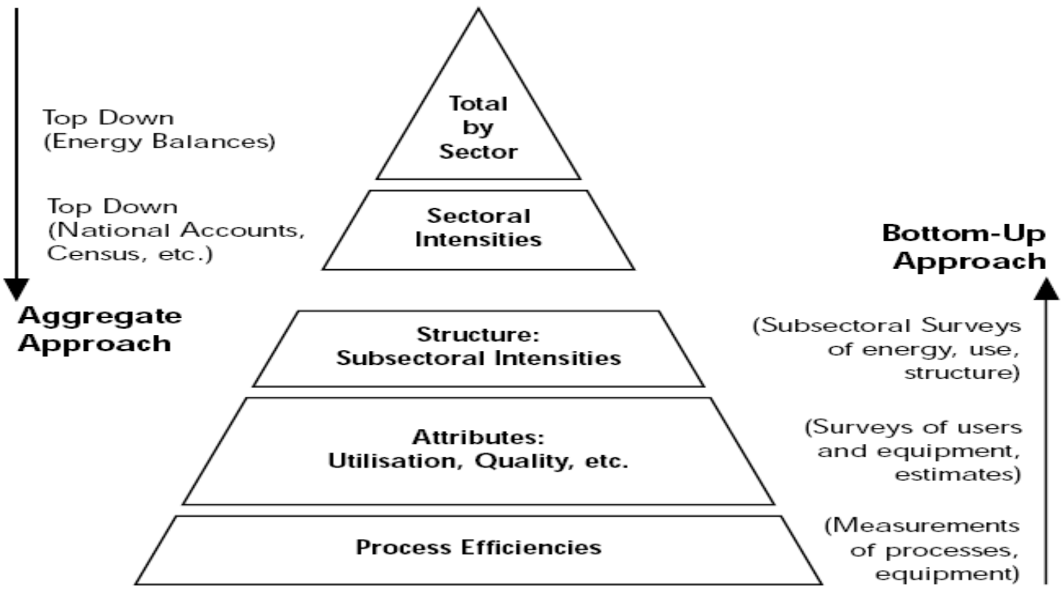


Figure 2.4: Energy efficiency indicator pyramid

Source: Blok [n.d.] in De la Rue du Can, 2007

Table 2.5: Sectoral structure and energy intensities analysis of levels for industry

Level of aggregation	**Energy efficiency indicators**	**Units of measure**
National economy	Energy intensity of GDP	Energy consumption per unit of GDP
Macro sectors	Energy intensity in industry	Energy use per unit of value added in industry
Sectors	Energy intensity in industrial sectors	Energy use per unit of value added in industrial sector
Sub sectors	Sub-sector energy intensity	Energy consumption per unit of value added in the industrial sub sector
Individual Plant	Plant energy intensity	Energy consumption per unit of economic output
Technological Process	Specific energy consumption	Energy consumption per unit of physical output

Source: De la Rue du Can, 2007 & Asia Pacific Energy Research Centre, 2000

Table 2.5 is essentially an energy efficiency analysis measure for the industrial sector. The industrial sector comprises various different sub sectors which contribute to the consumption of energy. Energy efficiency indicators are used in these sectors to provide a tool to measure energy efficiency at the different levels of aggregation.

2.5.4 Summary

This section has discussed the measurement of energy efficiency indicators at different levels in industry. By understanding the way in which energy consumption can be measured, the benefits of energy savings can be identified. These benefits could include tracking and evaluation of performance and progress of all energy saving activities, which would identify focus areas and potential problems. It encourages investment and reduces the risk for financial investors. It assists in tackling barriers to implementation and provides a level of confidence in the initiative by providing valuable feedback to stakeholders regarding savings and how it is influenced.

2.6 GENERAL MINING

2.6.1 Introduction

The aim of this section is to provide a basic overview of mining. However for the sake of brevity this section is restricted to the mining processes with reference to their energy consumption areas using different types of commodities that can be recovered in mining and were they are used.

2.6.2 Basics of mining

Mining is ranked as the primary or basic industry of early civilisation. Mining can be defined as a process involved with the extraction of minerals (U.S. Geological Survey, 2000).

The large amounts of minerals lead to wealth creation. The essence of mining in extracting mineral wealth from the earth is to drive excavations from the surface to the mineral deposit.

The following process takes place during excavations: There are openings into the earth and this allows personnel to enter into the underground deposit. There are two types of mines, namely surface mines and underground mines. In a surface mine the excavation used for mining is entirely open or operated from the surface. In the underground, mine the excavation consists of openings for human entry below the earth's surface. The details of the procedure, layout, and equipment used in the mine dictates the mining method. This is determined by the geologic, physical, environmental, economic, and legal circumstances that pertain to the ore deposit being mined.

The steps contributing to mineral extraction are rock breakage and material handling. Breakage consists of drilling, blasting and cleaning. Material handling consists of loading or excavating and hauling (horizontal transport) and sometimes hoisting (vertical or inclined transport). Figure 2.5 shows the production cycle:

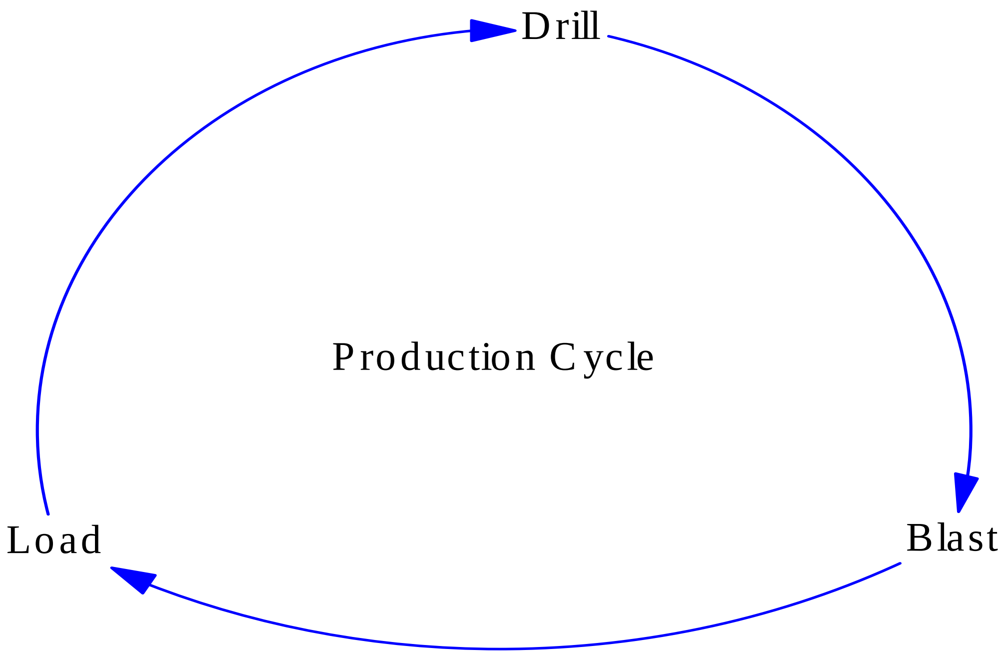


Figure 2.5: Mining production cycle

Once the material is blasted and loading commences, the process of mining then progresses into to three basic areas, namely, materials handling, extraction and beneficiation and processing. Research done by the U.S department of Commerce (BCS, 2002) using eight different commodities namely: Coal; potash, Soda Ash, and Borates; Iron; copper; Lead and Zinc; Gold and Silver; Phosphate Rock; Limestone and other Crushed Rock, has revealed that energy for mining is consumed differently as indicated in Figure 2.6.

These commodities require huge amounts of energy to extract and prepare for the first saleable product. These commodities have the potential to yield energy and environmental improvements through research and development.

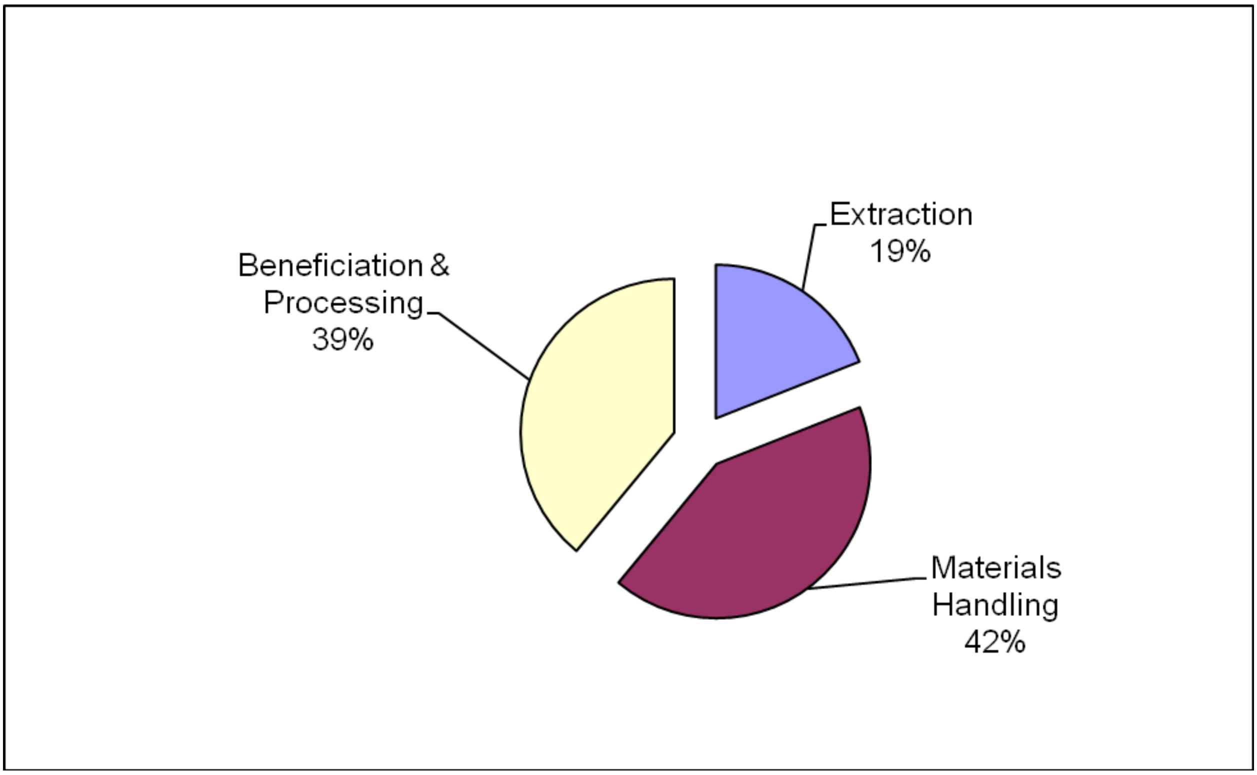


Figure 2.6: Estimated energy consumption by stage

Source: The National Mining Association, 1998a

2.6.3 Summary

This section has provided a basic overview of mining; by discussing, the processes involved namely, the production cycle and the stages involved in energy consumption.

CHAPTER 3
A CASE STUDY

3.1 INTRODUCTION

The company under study is a heavy minerals mining and beneficiation business that operates in South Africa. It draws its technological expertise and financial strength of a powerful international mining and natural resources company that is listed on the London stock exchange.

The business encompasses mining, mineral concentration and separation, and smelting operations. Three heavy minerals are produced. At full capacity, 18 million tons per annum of ore is mined to produce 200 000 tons of titanium slag, 120 000 tons of high purity pig iron, 25,000 tons of rutile products and 125 000 tons of zircon. The operation generates significant export earnings.

The products are used to produce floor and wall tiles, welding rods, toothpaste; pigment in paints and used to manufacture cast iron products such as engine blocks.

The business is geographically a decentralised business, which is located in separate parts of the West Coast of South Africa. The company is safety driven and therefore safety is given the highest priority in the business. The companies' strength lies in mining.

The following case looks at the total annual energy consumption of this company. It identifies the trends in energy usage at the different processes involved in the consumption of energy. It explains the structured process the energy committee of this undisclosed mine followed in order to identify wastage in energy usage. This wastage was termed non-essential power.

The Eskom power supply crisis in the Western Cape started in November 2005 that included unplanned outages, trips and rolling blackouts that lasted up to four hours.

Eskom required assistance from major consumers with regard to load shedding or planned outages during peak periods especially during the winter of 2006.

The mining company under study could not contribute in this manner, as it would severely disrupt the mining operation and process plants that will result in not achieving customer commitments.

It was therefore decided to classify the power requirements of the operation as either essential power, power required to run the different plants, or non-essential power that can be switched off without affecting operations. The management team emphasized that the shedding of non-essential power should not compromise safety or the general plant operation.

3.2 ENERGY CONSUMPTION

Table 3.1: Annual energy consumption

Commodities	**Year to date - Consumption**
Total Electricity (MWh)	610,941
Diesel (1000 litres)	9,299
Illuminating Paraffin (1000 litres)	8,409
Petrol (1000 litres)	140
Liquid Petroleum Gas (tons)	33

Table 3.1 shows the annual energy consumption at the undisclosed mining company. In 2005, the mining company’s energy consumption cost amounted to R161 million per annum. The total energy consumption was 2 867 Tera Joules. It is clear this operation is an intensive energy user.

The operation under study is a surface mine which uses diesel as the main commodity in the material handling operation, which is primarily driven by large earth moving equipment. The large conveyors are used to move the product, which is driven by high-powered motors.

The extraction plant users large pumps and motors, which results in huge amounts of electrical consumption. The extraction plant processes on averages 1.2-1.4 tons of raw material to obtain 1 ton of usable product.

The beneficiation and processing plants are driven by power to drive the motors and pumps, however the plants use illuminating paraffin as the main commodity to dry the product.

It is interesting to note that from 2003-2005, that at certain parts of the operation the main fuel consumption seems to closely follow the production output. Essentially this means that if production output increases the corresponding commodity increases.

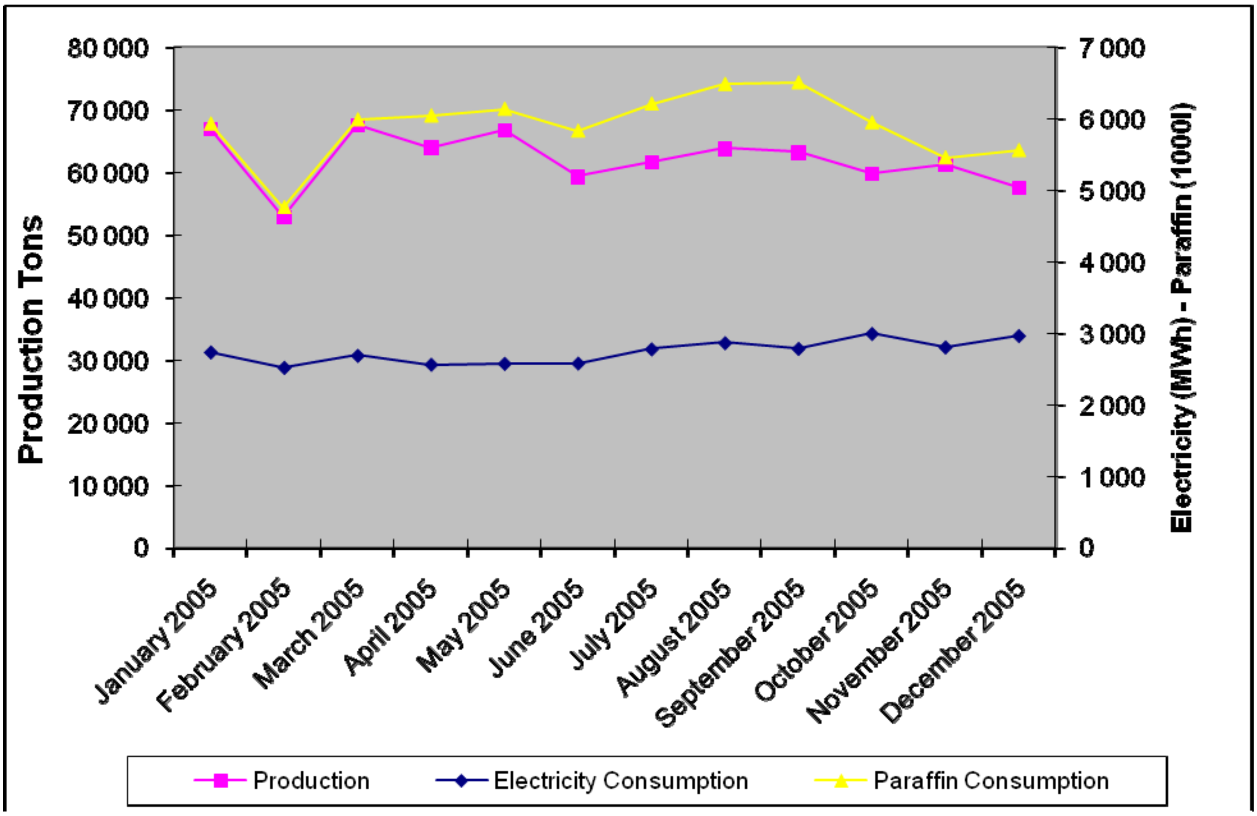


Figure 3.1: Drying process depicting produced tons vs. commodity consumed

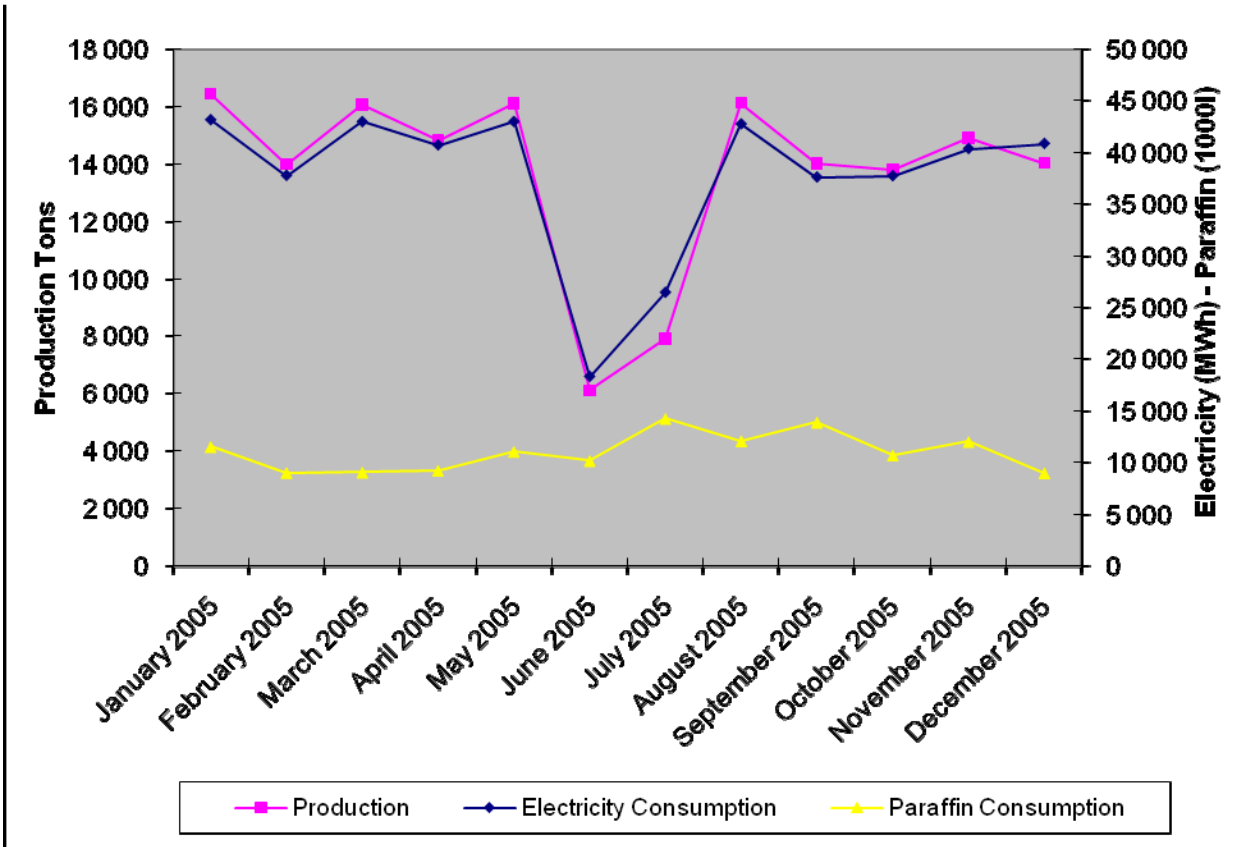


Figure 3.2: Smelting process depicting produced tons vs. commodity consumed

The drying process depicts produced tons versus commodity consumed in Figure 3.1; the main fuel is illuminating paraffin. The power consumption seems to stay constant over the year, averaging around 2800 MWh per month. However, the Illuminating paraffin tends to follow the production trend on a month-to-month basis. The increase usage of Illuminating paraffin in July to September is mainly due to the winter months when more heat is required in the driers.

In the smelting process depicting production tons produced versus commodity consumed in Figure 3.2, the process changes. The power consumption is the main commodity in the process and this closely follows the production trend. However, the illuminating paraffin stays constant and averages around 11000 litres per month.

3.3 IDENTIFYING OPPORTUNITIES

Various audits were performed at the different plants to identify essential and non-essential power consumptions. These audits also highlighted the company's commitment to conserve energy as far as possible and to enhance the awareness among all employees.

Once it became evident that the energy crisis in the Western Cape could threaten the business process the senior management responded to the crisis by taking a decision to commit a senior member of the management team to drive an energy efficiency campaign. The objective was to identify all essential and non-essential power in the operation.

The senior manager working with his peers had to identify suitable energy champions within the organisation to be part of an energy committee, who would be responsible for the campaign.

Management made the assumption that if the energy efficiency campaign worked as expected an arbitrary target of at least 30% of total power consumption could be identified as non-essential power. The 30% number became the target for the energy committee.

The objectives were to communicate the idea and reasons why the energy saving program was necessary to make employees aware of the difference of essential and non-essential power. Convincing employees on the need to save energy was not difficult since everyone was aware of the power crisis and rolling blackouts in the Western Cape region. It was necessary to advise employees on the potential effects the power outages were having on the business. The management ensured employees understood that senior management was fully committed to making the program work.

The energy committee followed a process in the execution of their duties. One of their main duties included the communication across all disciplines and departments in the organisation. This took place in the form of focus groups and monthly meetings with different site coordinators. The team realised to get the maximum amount of ideas it was necessary to include as many employees in the organisation as possible. The committee carried out energy evaluations on most of their process plants and facilities. The purpose of the evaluation was to identify the types of energy being used not only power usage.

The employees were requested to send their ideas to a central location for evaluation. At the central location, the ideas were captured into a database. The data was separated into general ideas relevant to all areas as outlined in Table 3.2, ideas in beneficiation and processing as outlined in Table 3.3, ideas in extraction process as outlined in Table 3.4 and ideas in materials handling areas as outlined in Table 3.5.

It was necessary to understand how the energy is being used and evidence of possible wastage. Once potential energy savings were identified all available information on the nametags of the equipment were recorded.

Reporting and monitoring of data was crucial to the process of energy saving. It became necessary to capture data from all available energy information. The electrical bills were gathered and captured at a central point. The purchasing and usage of commodities such as diesel, petrol, liquid petroleum gas and illuminating paraffin were collected and recorded. A special spreadsheet was created to capture the information. Once the monthly data became available in a user-friendly format, it highlighted areas of maximum usage and focus points became clear to the energy committee. The data had to be cleaned and sorted before being captured. The spreadsheet was edited a number of times to ensure it reflected the relevant data.

Training of employees was necessary; when the committee started discussing the issue of energy saving employees viewed energy saving as mainly power saving. The key employees and 50 line managers were trained on a one full day course on energy saving, energy identification and energy wastage. On each particular site, senior engineers were asked to attend an intense week course on energy management. The idea behind this initiative was to have key personnel available to carryout calculation and advise line personnel if necessary.

Table 3.2: General ideas relevant to all areas

Observations	**Descriptions**	**Potential improvements and savings**
Electrical motors	Electrical motors accounts for a large portion of the operations electrical consumptions	Changing the motors to high efficiency results in a price premium paid for high efficiency motors, which can be recovered in less than two years. Running motors at less than full load decreases the efficiency of the motor. A full costing plan is therefore necessary
Drive efficiency	Drive efficiency is important to ensure motors and gearboxes are correctly lubricated and maintained	Alignment of couplings and transmissions will result in a significant increase in efficiency. If belt drives are used it must be properly tensioned
The application of variable speed drives (VSDs) to the system	A variable speed drive is a device that can control the speed of an electric motor	Most conventional motors are running constantly at full speed, but a VSD equipped unit means it can operate at variable speeds to suit the process requirements. In most applications, the installation of a VSD to an electric motor can greatly reduce the amount of energy consumed. Once it has been established that equipment such as fans or pumps in any systems that don’t need to run at full capacity for all of the time then a VSD installation could reduce the energy consumption and costs
Maximize pump efficiency	On many occasions’ pumps can be found running when not in use. The flow rates and pressures are more than required. The pumps are not matched correctly to the system characteristics and the pipe layouts are not optimized	Up to 20-30%, energy savings can be achieved through improving the average pumping system efficiency. Delivering more fluid than necessary wastes energy both in pumping the increased volume and by overcoming the additional friction in the pipes

Table 3.3: Ideas in beneficiation and processing

Observations	**Descriptions**	**Potential improvements and savings**
Eliminate disintegrator, 400 kW (drive power)	Is this process necessary? It was mentioned that other smelters have eliminated disintegration with improved scrubbing	The installed equipment is 10 year old technology and there are more efficient disintegrators on the market i.e. improved rotor design. One could install a VSD to control the motor or replace the drive system with a more efficient motor. The installed unit is significantly oversized. A rough estimate indicated a saving of R 30 million
Reduce or eliminate iron ladle heating	The ladles used for transporting iron currently require paraffin heating due to interruptions in the process	Process optimization could reduce or eliminate this heating, i.e. reduction of temperature variations
Control flow of furnace cooling water	Process changes have reduced flow rates significantly (change from pressurized cooling to film cooling). Initially an orifice plate was installed in the cooling water lines to reduce flow. This does not allow control of flow and the plate is probably worn contributing to significant overflow condition	Significant savings of pump energy could result from VSD installation and control of furnace cooling water
Make use of carbon monoxide (CO) gas rather than flare the highly valuable furnace gas into the atmosphere	Significant energy in the form of CO gas a by-product from the furnaces is flared. The CO gas was originally used to pre-heat feed to the furnaces but this system caused process instability and was switched off	The flared CO gas could be used to produce power in gas turbines and the hot turbine exhaust could be used to pre-heat furnace feed. Calculations done by a company Promethium Carbon highlighted a possibility of 15MWh being generated with the flare CO gas
Control of fuel (paraffin) and air flow in the slag mill dryers	Currently fuel and airflows in the dryer are uncontrolled regardless of product feed rate and moisture content. In addition, feed to the plant is uncovered and moisture content varies depending upon recent precipitation	Covering the feed stock could allow fuel/air flow to the drier to be consistently reduced. Installing a VSD to control the fan speed on the mill air classifier will reduce in fuel consumption

Replace compressed air product transport with enclosed conveyor	Compressed air is used to transport ilmenite product about 150 meters horizontally and to raise it up by about 60 meters. A 200-m^3/min compressor is dedicated to this air transport system. Air used to transport this product has to be dried to instrument air specification. Air transport lines are quickly worn by abrasive flow. The cost is estimated at R200-300 000 per year	The recommendation is to replace the air system with an enclosed conveyor resulting in savings of around R 20 million

Table 3.4: Ideas in extraction processes

Observations	**Descriptions**	**Potential improvements and savings**
Capture and re-use heat that is presently wasted	Capture heat (150-200°C) from fluidized bed dryer stacks to preheat inlet air	Capture the reactor heater exhaust heat for preheating and atomizing air for primary drying
Eliminate electric heating	The use of power is becoming a problem in South Africa and the use of paraffin or waste heat will be an advantage in the process	Redeploy the current paraffin reheaters to second condenser heater. Decommission electric heaters currently used to heat the second condenser and use either waste heat or more efficient reheaters. Eliminate electric heaters and optimize heating efficiency using insulation, fan control and exhaust heat capture
Use wasted water column to generate on-site power	Install a water turbine to generate power in pipeline to the mine	This pipeline currently pumps water up over the hill near the separation plant and then falls downhill to the mine that has an excess drop above that needed for a siphon to work
Improve HVAC	Improve humidity control of induced roll magnet separators and electrostatic separators. The humidity of the input air varies due to atmospheric conditions inside the (unsealed) building at the top floor. Hot air from the top of the building is fed to atomizers that increase humidity of air fed to the banks of separators	Could more conventional HVAC humidity control maintain optimum humidity in separators? A better system would use louvers in vent ducts to reduce flow rate at exhaust fans to save fan energy. A potential saving of around R 6 million is possible
Eliminate water from present slurry transport	There would seem to be significant opportunity in the way slurry is created then moved. Presently water is added to the process. Then slurry is pumped up using centrifugal force, then once uphill, a cyclone removes the now unneeded water before spiral separation is used	The recommendation was to find another way to move slurry up the hill without adding water. Possible solutions were the options of using a wet elevator or an Archimedes screw

Eliminate evaporation ponds and reduce makeup water	Seepage from the evaporation ponds is preventing the facility from operating at zero discharge. The seepage rate (approximately $50m^3$/hour) roughly equals the makeup rate for the facility	The facility has plans of reaching zero discharge through a construction of a neutralization plant and, ultimately, a reverse osmosis plant. This will eliminate the need for evaporation ponds, Reduce makeup water demands to the plant, and Reduce pumping costs and energy consumption

Table 3.5: Ideas in materials handling

Observations	**Descriptions**	**Potential improvements and savings**
Conveyors in the mining environment	This particular mine is using twenty one kilometres of conveyor to move the product	The mine is ensuring there are no seized rollers or poor alignment and bad maintenance; this could result in losses of up 20% efficiency. Without maintaining optimum loaded conveyors, inefficiencies creep in when there is slip on the drums or the scrappers/side seals are over tight. Conveyors are loaded at optimum levels to prevent waste of energy
Eliminate conveyor inefficiency	Currently hard materials, i.e. calcrete, are not processed for their heavy mineral content. They are mined, conveyed to the plant, and then separated out before being conveyed to the tailings facility	This process wastes conveying capacity and therefore gives reduced energy efficiency per ton of good product produced. A proposed alternative to mill hard materials and recover heavy minerals will derive value from this material and boost energy efficiency per ton produced
Eliminate water seepage from slimes dam	Significant water losses are occurring via seepage from the slimes dams. Calculations performed indicated that 150 m^3/hour is lost to seepage	These losses could be minimized by improving the effectiveness of the thickeners to discharge high solid content slimes to the dam
Eliminate aeration of seawater at intake point	Seawater intake supplies water to the mine to meet process water demands. Lower pumping rates reported at low tide suggest inefficient pumping of aerated water. The flow rate at the seawater intake varies from 500m^3/hour at low tide to 600m^3/hour at high tide. The reduction in flow rate appears to be the result of aeration at the pump intake during low tide	Pumping aerated water is highly inefficient. It is recommended that the aeration problem be resolved by either increasing the head on the pump intake by deepening the intake basin or extending the pump intake into the bay

3.4 PRIORITISING OPPORTUNITIES

The following steps guided the committee as set out by Capehart, et al., 2003:

- **Eliminate**: This basically meant questioning the process and its usage of power thereafter eliminating the wastage or unnecessary usage of equipment for example air conditioners, lights burning in the day, process equipment such as drying ovens running when not in use to name a few. Non-essential power falls into this category. This could also be referred to the low hanging fruit of energy saving. This elimination of waste power does not take much investment to show quick returns.
- **Combine/Change equipment**: This part of the process will take less than three years to implement and required detailed evaluations. Once these projects were identified, the committee decided to invite Energy Service Companies (ESCO) to carry out the detailed evaluation. The reasoning behind this process was that Eskom was offering a part payment for potential projects that could reduce the peak consumption.
- **Improve**: This process of improving was identified as long-term projects that could only materialise greater than 3 years. An energy project of this nature required proper scoping and a detailed feasibility study to ensure it is viable. Projects that fall in this category was taken to be projects requiring Carbon Credit funding or a large portion of demand side management funding from Eskom in order to ensure it passes the companies standard rate of return to ensure it is a good investment.

3.5 SELECTING THE BEST INITIATIVES

Once the initiatives were captured the committee was faced with hundreds of suggestions, it became clear that some prioritising methods were necessary to actually select the best initiatives. The energy efficiency manual had over 400 ways to save energy and money. The manual (Wulfinghoff, 1999) used a scorecard system, which divided the scorecard into different stages.

Stage 1: Savings potential, this was expressed as a percentage of the total utility cost. Rating range was <0.1% to >5%.

Stage 2: Rate of return on investment, this estimates the percentage saving in cost per year. Rating range is <10% to >100%.

Stage 3: Reliability indicates the likelihood that the measure will remain effective throughout its promised service life. The rating ranges from being foolproof, reliable, to failure prone or very risky.

Stage 4: Ease of retrofit or ease of initiation, indicates how easy it is to accomplish the initiative. Rating range being easy, routine, difficult or very challenging.

Stage 5: Traps and tricks, alerts the user of factors that threaten success. It provides hints on how to get it right the first time and keep the initiative effective over the long term.

Stage 6: Cost, indicates the amount of money required. It provides a basic idea of the cost of equipment and labour.

Stage 7: The suggested initiative was rated and prioritised according to New Facilities, retrofits and Operation and maintenance. The rating range was A,B,C or D.

3.6 INSTANT SAVINGS

In applying the above process, a few quick solutions were possible. These solutions were implemented without much effort. A few worked examples are shown below to highlight the savings achieved.

Table 3.6: Conveyor staircase with lights on during the day

Description	**Calculation**	**Savings**
A standard mining conveyor with a staircase on its side is installed with lighting. A typical staircase conveyor will have 110-watt high pressure sodium lamps every 5 meters. These conveyors average lengths of anything in the range of 500 meters to 2 kilometres, in some case it could be longer	On a 1-kilometre conveyor it amounts to 200 lamps consuming 22 kWh at R0.157 kWh (South Africa Eskom rates). This amounts to R3.45 per hour	The total cost for lighting a 1-kilometre staircase conveyor with 110-watt lamps for 24 hours, 365 days a year amounts to R 30 257 These lights were put onto day/night switches. This immediately reduced the consumption and cost by 50%

Table 3.7: High mask lights

Description	Calculation	Savings
Certain areas of the mine are equipped with high mask lights. In this particular mine there is 12 high mask lights that consume six kWh per pole	This amounted to 12 high mask lights * 6kWh per pole = 72 kWh	The cost being total consumption of 72 kWh*24 hours per day *365 days per year * R0.157 kWh (South African Eskom rates) = R 99 023.04 per year. These lights were fitted with day/night switches and connected to a separate circuit for non-essential switching

Table 3.8: Industrial geyser

Description	Calculation	Savings
Most old plants and mines are fitted with large industrial geysers. The purpose of these geysers is to provide hot water to employees for showering. These geysers operate 24 hours per day, 365 days per year. The reason for this is mainly due to production shift changeovers	The staff change house had an 80 kWh geyser installed. With some research and capital, the geyser was changed to seven smaller units using three kWh per geyser	This installation immediately reduced consumption by 56 kWh, which amounted to a saving off 56 kWh* 24 hours * 365 days * R 0.157 kWh = R 77 017.92 per year. The installation was further improved to be controlled for staff loading and maintaining temperature

Table 3.9: Long mining conveyors

Description	Calculation	Savings
In practically every mine, the raw material is handled and transported using long conveyor belts. These belts extend for many kilometres depending on the transporting distance. In this mine the total length of conveyor belts amounts to	Thus for a 1 kilometre conveyor with 400 watt high pressure sodium lamps fitted 50 meters apart, the cost is as follows. 20 lamps * two sides of the conveyor * 400 watt * 24 hours* 365 days * R0.157 kWh = R 22 005.12	If the total of all conveyors were used in the calculation at this particular mine. The result is as follows. R 22 005.12 * 21 kilometres of long conveyor belt = R 462 107.52 per year. The immediate action was to ensure that the conveyors had

approximately 21 kilometres. Every long conveyor belt is fitted with 400-watt high-pressure sodium lamps. The lamps are fitted with one on either side of the conveyor. Therefore every 50 meters of the conveyor will be fitted with 2* 400 watt high-pressure sodium lamps		day/night switches and the switches worked effectively. This had an immediate impact of 50% on the consumption and cost

3.7 OTHER OPPORTUNITIES

The audits identified other areas were energy was being wasted. For example:

- Standby motors were running continuously together with the main unit, indicating poor operating procedures. However, these issues were corrected.

- The starting of big pumps was not controlled properly; the pumps were switched in at any time of the day. A control system was installed to delay the starting conditions while controlling the peak power curve.

- The laboratories were installed with single solid hot plate stoves that were switched on in the morning every day, because of the time it took for these stoves to warm up the operators believed it would be simpler to have the stove switched on continuously. Immediately this practice was evaluated and changed to a gas stove, which warms up the samples much faster and could be switched off immediately after use.

- Ladle toasters are used in smelter plants to warm iron ladles to prevent thermal shocking of the refractories. Two ladle toasters is used daily, presently only one ladle toaster is used and as far as possible during off peak periods.

- Light circuits where split from the essential load. During the crisis, the non-essential power was immediately turned off, dropping the system power demand by 2.53 MW.

3.8 PROCESS ADOPTED IN A POWER CRISIS

When the power crisis happened and all electrical load was switched off by Eskom, all standby generators were started to ensure essential load is maintained and constraint production is maintained.

The awareness of overall plant consumption was a general weakness at all the sites. A visual display of power usage was proposed which are being installed at the different sites. This will aid in determining when to start various plants or sections thereof and give up to date power consumption information.

Table 3.10 below approximates the non-essential power that was shed during peak periods including cost and coal conversion. This exercise has highlighted many areas for improvement towards sustainable energy efficiencies.

Table 3.10: Saving on non-essential power and coal conversion

Site	Non essential power [MWh]	Cost conversion (R 157/MWh)		Coal conversion	
		Per day	Per annum	Per day	Per annum
Material Handling	1.5	R 8 478.00	R 3 094 470.00	12.456 ton	4546.44 ton
Extraction	0.2	R 753.60	R 275 064.00	1.66 ton	605.9 ton
Beneficiation and Processing	0.89	R 3 353.52	R 1 224 034.80	7.39 ton	2 697.35 ton
TOTAL	2.59	R 9 759.12	R 3 562 078.80	21.5 ton	7.85 million ton

*Assuming 346g of coal is requires to produce 1kWh (Eskom, 2006)

3.9 SUMMARY

The findings have revealed that there are possible savings that can be achieved by following a structured process as is evidenced above. In this limited period of one year, a total of 2.59 MWh was identified and could be switched off without affecting production output. This is equivalent to a saving of 7.85 million tons of coal per annum. It is clear that by identifying non-essential power and taking steps to eliminate the wastage yields economic and environmental benefits.

CHAPTER 4
CONCLUSION

4.1 SUMMARY

The sustainability of the environment for generations to come partly depends on our global commitment to the conservation of energy. This report has discussed some of the energy challenges facing the world today and has highlighted the ways in which these energy challenges could be curtailed.

The literature review provided a discussion on the economic effects energy efficiency initiatives have on industry.

It has been discussed that industrial competitiveness influences energy saving initiatives. This means that the more industries need to compete, the more likely it will increase its production which invariably leads to greater CO_2 emissions. The Stern Report (2006) has revealed that the current level of green house gases in the atmosphere is reaching alarming proportions.

The Carbon Disclosure project is an initiative aimed at getting companies who are major contributors to GHG emissions and climate change, to be active participants in energy savings and other initiatives such as corporate citizenship and corporate governance. Corporate citizenship and corporate governance aims at invoking corporate responsibility in companies. This means that companies have certain duties that require mandatory compliance. Companies are now responsible and accountable for their actions. Corporate responsibility provides for companies to get involved in the environmental and social aspects of the communities in which they operate. This has been a move away from the bottom line to the triple bottom line. The triple bottom line allows companies to reveal to the public that their business involves legitimate environmental and socially responsible activities.

In view of the fact that industries and companies are major contributors to GHG emissions, it becomes clear that energy efficiency options should be employed by them. This report has discussed some energy efficient options. However, the findings revealed that the switching of non-essential power is the simplest and most economically viable option available to industries. The report has provided an overview of energy usage in the different processes in the mining industry.

It has been discussed that there are many energy efficient initiatives available for industry to implement. However there are barriers to the implementations of such energy efficiency initiatives. These barriers are market barriers, information, financial, technological, infrastructure barriers, consumer behaviour, poverty, government regulations, marketing, supply monopolistic and shortage of skilled people.

This report has identified and discussed two methods of selecting energy efficiency projects, i.e. that of Wulfinghoff, as well as that of Capehart, Turner and Kennedy. The report then discussed the measurements of energy efficiency. The findings and analysis are based on a mining company that was investigated. The method of switching off non-essential power was implemented by the company X. The company used the steps set out in Capeharts method and by using the methodology of Wulfinghof.

The results revealed that by switching off non-essential power company X had saved a total of 2.59 MWh of energy and this could be broken down to 1.5 MWh in material handling, 0.2 MWh in extraction and 0.89 MWh in beneficiation and processing.

In one year, this amount of energy could be switched off without affecting production output. This means that there is a potential saving of 7.85 million tons of coal per annum, which was not required. Evidently, this is an economic benefit to company X.

When comparing this saving to the original arbitrary number of 30% set out by management, the savings amount to a total of 2.59 MWh*24*365= 22688 MWh/annum. This is equal to a saving of 3.71 percent of the annual consumption as indicated in Table 3.1. It is important to note that although the 30% saving was not achieved, the target set out by government in the energy strategy of 2005 was achieved with not much effort. There is enough ideas and suggestions in the database to achieve at least 20-30 percent savings over the next few years.

4.2 CONCLUSION

It is therefore submitted that energy saving initiatives such as the switching off non-essential power is possible as is evidenced by the value it added to company X in the case study. It can be inferred from the findings of this report that mining companies are in a position to benefit greatly from identifying and switching off non-essential power. It is clear from the findings that without the support from top management the chances for individual sections or departments to adopt and sustain this initiative would probably be ineffective.

It is further submitted that this initiative serves two purposes, namely, it is economically viable as it has the potential to yield economic benefits; and at the same time allows energy conservation to take place.

One of the tasks of management theory is to question conventional ideas and suggestions on how business might experiment to improve their material wealth. One element of this wisdom is that to be energy efficient requires funds and inadvertence burdens to industry. Although this might be true in certain types of energy saving initiatives, it is not true for some of the initiatives being proposed in this report particular the identifying of non-essential power and the elimination of wastage.

The conclusion can be drawn that the only reason this quick solutions are not identified and removed is due to flaws in the internal decision making rather than with the lack of opportunities.

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