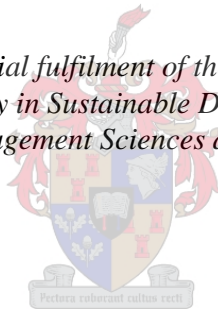


EXPLORING THE IMPACTS OF RENEWABLE ENERGY AND ENERGY EFFICIENCY POLICIES ON THE MINING SECTOR

by
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Declaration

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Abstract

Worldwide, energy has been, and continues to be, key to economic development. However, the current global consensus is that energy-related carbon dioxide emissions would, at current rates, put the world onto a potentially catastrophic trajectory which could lead to global warming of 5 degree Celsius or more compared to pre-industrial times. There is a critical need for a low-carbon development or a move away from conventional fossil fuels energy sources.

This study explores impacts of policies that South Africa developed in order to champion sustainable energy strategies based on energy efficiency and non-conventional energy sources, including renewable energy. The mining sector, because of its energy-intensive nature, was chosen. In order to achieve this objective three approaches were carried out: (i) a critical review of literature on energy efficiency (EE) and renewable energy (RE) ; (ii) two case-studies that demonstrate the impacts of the policies; and (iii) action research on a sample of mines using survey questionnaire and interviewing.

The research results show that the need to have security in energy and the need to be competitive and grow revenue are significant in deciding to carry out EE and RE initiatives in the mining sector. The results also show that safety followed by production are the priorities and are accompanied by a range of other demands, such as cost reduction and legislative requirements. It is, therefore, within this context that EE and RE initiative will always be carried out in the mining sector. The research concludes that, under the current market framework, South African EE and RE policies are not as effective as hoped they would be. The research, therefore, recommends that a percentage of the mines' revenue could be dedicated to EE and RE initiatives. In addition, South Africa needs to come up with a new type of productive endeavour that would lead to less extractive industries, including mines.

Opsomming

Energie is, was en sal wereldwyd altyd die sleutel wees tot ekonomiese ontwikkeling. Nieteenstaande, word dit wereldwyd aanvaar dat die huidige energie opwekking se koolstofdiksied vrystelling moontlik kan lei tot aardverwarming van 5 grade Celsius of meer wanneer vergelyk met word met pre-industriële tye. Daar is 'n kritiese behoefte aan lae koolstofdiksied vrystelling ontwikkelings of 'n beperking van konvensionele fossielbrandstof energiebronne.

Hierdie studie analiseer die impak van die Suid Afrikaanse beleid wat ontwikkel is om volhoubare energie te bevorder wat effektief en onkonvensioneel is, insluitend hernubare energie. Die mynsektor, as 'n groot verbruiker van energie, vorm die kern van die studie. Die studie is voltooi in drie fases naamlik: (1) kritiese oorsig van die literatuur oor energiedoeltreffendheid (EE) en hernubare energie (RE); (2) twee gevallestudies wat die impak van die beleid bevestig; en (3) praktiese navorsing deur middel van vraelyste en persoonlike onderhoude met seker myne.

Die navorsing bevestig dat die behoefte aan bestendige energie teen kompeterende pryse wat die mynsektor in staat stel om inkomste te groei, 'n beduidende invloed het op die besluit om EE of RE inisiatiewe te onderneem. Die resultate bevestig verder dat beroepsveiligheid en produksie uitsette die eerste prioriteite vir die myne is. Dit word verder beïnvloed deur kostebesparings en wetlike vereistes. Enige EE en RE inisiatiewe wat onderneem word sal in hierdie konteks plaasvind. Die navorsing kom tot die slotsom dat, onder huidige marktoestande, Suid Afrika se EE en RE beleid nie so effektief is as waarop daar gehoop is nie. Die navorsing beveel derhalwe aan dat 'n persentasie van myne se inkomste geormerk moet word vir EE en RE inisiatiewe. Verder meer, Suid Afrika moet streef na tipes produksie wat minder natuurlike grondstowwe onttrek, insluitend die myne.

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List of Acronyms and Abbreviations

CCS	Carbon Capture and Storage
CDP	Carbon Disclosure Projects
DSM	Demand-Side Management
EE	Energy Efficiency
EEA	Energy Efficiency Accord
EELN	Energy Efficiency Leadership Network
ESCO	Energy Service Company
ETS	Emissions Trading System
GHG	Greenhouse Gas
LTMS	Long-Term Mitigation Strategy
MEC	Mining-Energy Complex
NDP	National Development Plan
NERSA	National Energy Regulator of South Africa

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Chapter 1 - Introduction

1.1 Introduction

Worldwide, the key to economic development has been energy (Winkler, 2006). Based on how it has been sourced, produced and used, resulted in an energy system with major environmental and social problems. *“The combusting transport and disposal of energy sows as they go through different conversion processes results in harmful emissions. These emissions in turn cause local, regional and global environmental problems, including serious, even fatal human health hazards...Reducing the environmental and social burden is thus a major concern for the energy sector”* (Winker, 2006:1). It is for this reason that the concept of sustainable development, which involves economic, social, and environmental developments, has increasingly become so important.

Since the discovery of some of the world’s biggest gold deposits and many other minerals, South African development can be attributed to mining and its associated industries. Based on its small deposits of natural gas and oil but very large coal deposits, the country relies heavily on coal for most of its energy needs. For this reason, its electricity system is based almost exclusively on its coal reserves. This status has changed little since the country had its first democratic elections in April 1994. As recently as 2010, coal was still dominating the country’s primary energy supply by contributing 67% thereof, followed by crude oil and petroleum (19%), solid biomass and waste (10%), nuclear (2%), gas (2%) and hydro (<1%) (Unlimited Energy, 2013).

By providing heat and power for industry, transportation and household use, energy production in the country has been, and still is, contributing to the social and economic development of South Africa. However, both economic and political forces have always (largely) driven the energy sector (Winkler, 2006). It is for this reason then that these forces have had such a profound impact on the country’s energy policies.

The distribution of energy resources may result in significant social, environmental and economic inequalities (Wu et al., 2012). It is important to consider the correlation of energy consumption to human development in a developing country such as South Africa. In order to determine the level of human development, the United Nations Development Programme (UNDP) compiles a measure of human well-being for each and every country, annually. This measure, termed the Human Development Index (HDI), is a summary composite index that measures a country's average achievements in three basic aspects of human development, namely, longevity, knowledge, and decent living. Longevity is measured by life expectancy at birth; knowledge is measured by a combination of the adult literacy rate and the combined primary, secondary, and tertiary gross enrolment ratio; and standard of living by a Gross Domestic Product (GDP) per capita (UNDP, 2004). The HDI is clearly a reductionist measure, incorporating just a subset of possible human choices; additional choices include political freedom, guaranteed human rights and self-respect. However, given how widely these additional choices differ across countries, it is difficult to measure their impact on human development.

The HDI ranges from a theoretical minimum of zero (for a life expectancy = 25 years, complete illiteracy and a GDP per capita = US\$100 at purchasing power parity) to a theoretical maximum of 1 (for a life expectancy = 85 years, 100 % literacy and a GDP per capita = US\$40 000 at a purchasing power parity). In practice, the observed range is 0.3 – 0.7 (Teller, 2009). Charting the HDI against the yearly electric consumption per capita, the UNDP concluded that 4 000 kWh per should constitute a threshold. The choice of this value is based on the fact that no country, barring four cases (South Africa, Saudi Arabia, Russia and South Korea), with an electric consumption below 4 000 kWh has an HDI above 0.9. All countries consuming more than this value have an HDI greater than 0.9. This realisation leads to the question: Can the HDI be increased without raising the country's energy consumption? If not, what is the role of energy conservation and efficiency?

In the past, the improvements in the human quality of life meant greater use of energy; however it is no longer possible under the current supply constraints

and climate change conditions. Good quality life can be achieved on much lower energy consumption levels. According to the UN Human Development Report (2008), it is possible to find opportunities for the synergic development of energy and society, by shifting the focus of the economy to satisfying basic human needs.

Studies show that the relation between the HDI and energy consumption per capita is not linear. At low human development levels, increase in energy consumption usually leads to large increases in a country's HDI. However, as a country develops, the importance of energy establishing higher HDI diminishes. "Therefore for high and medium human development levels, simply increasing energy consumption is not enough to maintain its development progress. In this case, a combination of factors such as more efficient energy use, development of energy-saving technologies, establishing appropriate social welfare systems and others are necessary to achieve and maintain high HDI" (Wu et al., 2012:112). This means that policies targeting efficient energy use both on personal and company-based level and promoting energy-efficient technologies are needed for maintenance of high HDI. At the same time, low HDI countries should reduce energy poverty by creating essential infrastructure, changing their energy consumption mix and establishing access to modern energy sources. Energy consumption, therefore, has a distinct and critical social dimension.

The rate of energy use (power consumed) strongly affects or determines national wealth and human development, as all rich societies use a huge amount of energy. Although energy efficiency helps, it is not, in itself, an answer. The critical point to make is that fossil energy use made and continues to make developed countries rich. But, what energy sources will make the next generations rich? Will the billions of poor people in the world ever access enough fossil energy to develop their potential? It is, then, reasonable to conclude that only large scale, low cost, low carbon energy sources and renewable energy sources can provide energy security and long-term wealth. Renewable power is, therefore, critical for human well-being.

The South African economy is largely based on very energy-intensive mineral extraction and processing; referred to as the mineral-energy complex. For this reason, the industrial and mining sectors are the heaviest consumers of energy, accounting for more than two-thirds of national electricity consumption (Energy Research Centre, 2009). *“In South Africa, the mining industry is estimated to use 6% of all the energy consumed; in Brazil, the largest single energy consumer is mining giant Vale, which accounts for around 4% of all energy used in the country; and in the United States, the mining industry uses 3% of industry energy”* (Cole, 2011:15).

In South Africa, the energy supply sector can be divided into coal, liquid fuels and electricity, and all of these are derived from fossil fuels. Therefore, our existing energy systems release carbon dioxide and other greenhouse gases (GHGs) when combusted, with deleterious effects on human health and the natural environment. The most serious of these effects is the unprecedented change in the Earth’s climate. Faced with this catastrophe, the whole world in general, and South Africa in particular, must shift to low- or zero-carbon energy sources in an effort to mitigate the impacts of climate change.

South Africa is the 13th largest emitter of carbon dioxide (CO₂) in the world, and, given the developing nature of its economy, it is expected that emissions will grow as development goals are pursued. The country’s per capita emissions currently exceed the world average (5 tonne per capita) and are about 10 tonne per capita (National Treasury, 2010). South Africa, classified as a non-Annex 1 developing country, is not explicitly required to undertake specific emission reduction commitments in the first commitment period of the Kyoto Protocol. However, the country announced a willingness to undertake nationally appropriate mitigation actions to deviate from business-as-usual GHG emissions by 34 % by 2020 and 42 % by 2025, provided there is adequate funding, technology transfer and capacity building efforts offered by developed countries.

The low carbon sources can be provided by greater efficiency in energy consumption (energy efficiency), which reduces demand for energy, and for

zero-carbon sources renewable energy sources can be used. Many countries, including South Africa, have introduced legislation and policy to advance the use of these measures.

1.2. Rationale for the Study

The global community, including South Africa, is faced with four main challenges with respect to energy, namely: (a) energy security; (b) combatting climate change; (c) reducing pollution and public-health hazards; and (d) addressing energy poverty. *“Greening the energy sector, including by substantially increasing investment in renewable energy, provides an opportunity to make a significant contribution to addressing these challenges”* (UNEP, 2011:206). A critical step in attaining ambitious emissions-reduction targets of keeping the concentration of greenhouse gases (GHGs) at 450 parts per million (ppm) in the year 2050, is a move away from fossil fuels to renewable energy, together with significant improvements in energy efficiency. In order to achieve this, the International Energy Agency (IEA) *“projects that renewable energy would need to account for 27 per cent of the required CO₂ reduction, while the remaining part would result primarily from energy efficiency and alternative mitigation options such as carbon capture and sequestration (CCS)”* (UNEP, 2011: 207).

The South African Government has suggested three forms of mitigation measures, namely:

- a) Interventions in energy supply to reduce emissions (e.g. renewable energy);
- b) Interventions to reduce energy demand (e.g. energy efficiency); or
- c) Changes in economic structure to reduce energy demand (DEA, 2011:23)

These three options must, therefore, direct policy and strategy positions of the South African Government in dealing with climate change mitigation. In this research, the mining sector will be used to test if these interventions are used and the desired effects are achieved.

In 2008 South Africa experienced a mismatch between demand and supply of electricity when demand far outstripped supply. This resulted in Eskom implementing demand side interventions in addition to government's decision to build two new power stations, Medupi and Kusile, in order to encourage more efficient use of electricity by its residential, industrial and commercial customers. This aggressive demand side management (DSM) programme hopes to save 800 MW by 2025. In an effort to diversify the energy mix, nuclear, pumped storage, and gas fired stations (open cycle and combined cycle) and electricity imports from neighbouring countries will be considered (Eskom, 2014).

To fund this expansion programme and decision to diversify the energy mix, the country has seen dramatic price rises since 2008. This *“includ[ed] 31.3% in 2009/10 resulting in an average of R0.33/kWh, which incorporated a R0.02/kWh environmental levy, and 24.8% in 2010/11 resulting in an average electricity price of R0.42/kWh”* (Edkins *et al*, 2010:1-2). Furthermore, the National Energy Regulator of South Africa (NERSA) approved 25.5% and 25.9% price rises for the 2011/12 and 2012/13 financial years respectively, in line with the multi-year price determinant (MYPD). By 2013 the average price electricity stood at about R0.66/kWh, representing a dramatic increase never experienced in the country.

Given these massive increases, South Africa has, in a period of just less than six years, relinquished that enviable position of providing the cheapest electricity price in the world. To deal with these enormous price hikes, mining companies are forced to look at a number of options, including own generation from renewable energies, and energy efficiency and conservation, which could be voluntary or with pressure from government. South Africa's ability to ensure a secure electricity supply has been impacted by high domestic electricity demand growth which coincides with substantial growth in demand for energy (and electricity) in the rest of the world. Over the last decade the country's reserve margin (reflecting the capacity adequacy of the current system) has deteriorated as supply has not kept pace with demand growth.

Whenever energy efficiency, conservation and renewable energy options are suggested to most mining companies, a question of economics comes into picture. However, given the escalating cost of existing fuel sources and the diminishing energy security, both government and the mining sector will be forced to look into these options.

The mining industry is also contributing a considerable amount of GHG emissions, with serious climate change implications. It is for this reason, in addition to cost reduction and energy security, that mining companies must pursue renewable energy and energy efficient alternatives. There is commitment by the global community, including South Africa, to address climate change through mitigation and management. To this end, most, if not all mining companies have committed to energy efficiency targets and to improve water management on operations. *“All of them face significant business risk if they ignore climate change. Impacts are already being seen through extreme weather events causing mine closures (e.g. India in March 2010), research shifting focus to energy and water efficient technologies, and government and shareholders becoming more demanding of reporting requirements”* (Cole, 2011).

Requiring only improved management of the status quo, energy efficiency is the simplest and cheapest of all available options. *“It results in cost savings for the operation as less energy is used. But energy efficiency is limited in reducing GHG emissions and more substantial emissions reduction would be gained by utilizing clean energy instead of high carbon energy”* (Cole, 2011). As big users of electricity, mining companies can drive both energy efficiency and new large-scale renewable energy projects in South Africa.

As a demonstration of a commitment to reducing their GHG contributions, most mining companies in South Africa are participating in the Carbon Disclosure Project (CDP) and are signatories to the Energy Efficiency Accord (Acclimatise, 2010). The risk of mining companies' dependence on one power supplier was highlighted in 2008 when the electricity crisis severely affected mines and all other industries. Combined with the need to reduce their carbon

footprints, this risk encouraged mines to be self-sufficient, with some mines considering investing in their own power generation facilities, specifically from renewable energy. The upsurge of interest in renewable energy sources among South African mining companies can, therefore, be traced to three main factors:

- there is a need to generally reduce dependency on Eskom after the 2008 electricity crisis,
- the national utility's year-on-year electricity rate hikes are hitting companies' pockets and
- companies feel somewhat pressured to reduce their carbon footprints.

In South Africa, the mining sector's involvement in the energy efficiency and renewable energy, in the context of this report, can be benchmarked against the following:

- a) The Green Economy Framework – a framework characterised by greater public-private partnerships (PPPs) for procurement of services such as renewable energy and energy efficiency, and declared a “ground-breaking way” by its protagonists, combining economic development, social welfare and environmental protection (Gaylor, 2012:5). South Africa, a party to many international conventions and agreements, including the United Nations Framework Convention on Climate Change (UNFCCC), has made a commitment in its Long-Term Mitigation Strategy (LTMS) of “peak, plateau and decline” in GHG emissions through economic instruments (taxes and incentives to promote the uptake of the accelerated technologies and social behaviour, e.g. carbon tax). In terms of the “peak, plateau, decline” trajectory, emissions “*should peak in the years 2020 to 2025 by between 500-550 Mt CO₂-eq, remain stable until around 2035, and decline to a 2050 level of 200 – 400 Mt CO₂-eq*” (DEA, 2011:29).

Can South African mining companies assist the country in its efforts to procure services such as renewable energy and energy efficiency in order to honour its LTMS ambitions?

- b) The Energy Efficiency Strategy and Accord – recognition by both government and businesses that there must be improvements in energy efficiency in order for the country “to remain competitive internationally whilst dealing effectively with potential electricity capacity shortages, environmental concerns and steadily rising price of all energy sources” (NBI 2005). This initiative is to be led by the business sector and it is voluntary. In this Accord, industry, especially mining, agrees “to establish methodologies to take into account increased production so that the pursuit of improved energy efficiency does not hamper industrial growth” whilst government agrees “to develop strategies, including the provision of fiscal and other incentives with signatories to incentivise the achievement of agreed sectoral targets by industry on a sector or enterprise basis” (Energy Efficiency Accord, 2005). The question is: Should the South African state rely on a voluntary initiative like EEA for energy efficiency? Or should an initiative like EEA be made mandatory to mining companies?

Following the 2005 Energy Efficiency Strategy of the Republic of South Africa, a voluntary Energy Efficiency Accord (EEA) between a number of companies, especially in the industrial and mining sectors, and the government was signed. As the Accord targeted heavy energy users during the first three years, few leading companies outside the mining and industrial sectors signed the Accord. The energy efficiency potential of the Accord was bound to be very significant when it is considered that about 19 out of the 36 signatories have the collective electricity usage of over 56 560 GWh, which is about 24% of the national electricity consumption (DME, 2008).

In terms of the National Energy Efficiency Strategy, the industrial sector has a final energy demand reduction (target) of 15%. The Department of Minerals and Energy undertook the first assessment study of the Accord in 2008, which was followed by the second one under the Department of Energy in 2012. In both assessments, there was no definitive or conclusive

evidence that the Accord was working. Instead each party, government and industry, blamed the other for failure on some of the indicators of the Accord. In addition, this thesis moves from the premise that the indicators of the Accord, especially measurements thereof, were not properly set. For the Accord, now replaced by the Energy Efficiency Leadership Network (EELN), to be a success, a different set of indicators and measurements are needed. This study will show the importance of these indicators and measurements premised in the elimination of wastage (energy cost, cost reduction, competitiveness, legislation, cost of production disruption, etc.), technology (processes and systems), and behavioural change (staff and management awareness, skills development, government and corporate support, etc.).

1.3. Research Objectives and Key Questions

The research objectives can be classified into two categories. Firstly, to explore opportunities to introduce energy efficiency and renewable energy initiatives in the mining sector, and secondly, to get a better understanding of what drivers and barriers of energy improvements and renewable energy initiatives within the mining sector need to be investigated and measured.

To meet these objectives, the thesis undertook to:

- 1) Determine the appropriateness and effectiveness of South African policies, strategies and plans in achieving the EE and RE targets in the mining sector.
- 2) Estimate the mining sector's potential and actual contribution to South Africa's EE and RE targets.
- 3) Determine the major economic, technical and regulatory opportunities and hurdles in implementing EE and RE initiatives in the mining sector.

In order to achieve the above objectives, the following research questions were answered:

- a) What are the EE and RE targets in South Africa in general, and in the mining sector in particular?
- b) What are the policies, plans and strategies in achieving these EE and RE targets?

- c) What are some of the EE and RE initiatives that mining companies can be, and are, involved in to try to achieve their EE and RE targets?
- d) What are the drivers and barriers for these initiatives?
- e) What role can the state play in the achievement of these initiatives?

1.5. Overarching Research Approach / Design / Strategy

Based on the objectives this research primarily comprised a literature review as well as empirical research in the mining sector. Two mining companies, namely Exxaro Resources and AngloGold Ashanti, are used as case studies to demonstrate the empirical work done on the ground. The research dealt substantially with analysis of legislation, especially as regards the South African context. The quantitative and qualitative data collection, analysis and evaluation involved a sample of nine mines, including two case-studies, attempting to meet both the energy efficiency and renewable energy targets as spelled out in the Energy Efficiency Accord and the Long-Term Mitigation Strategy. The approach, therefore, focussed on content analysis of text, and is empirical in nature when it comes to sampled mines and case studies (Mouton 2011).

The study utilised a methodical approach that includes both qualitative and quantitative aspects. In order to achieve this, data for the study was collected via semi-structured interviews, and in addition, respondents were required to complete a quantitative questionnaire. The use of this approach is an attempt to attain a holistic view of the complex and interrelated set of factors that affect EE and RE improvements.

1.6. Scope and Research Limitations

The focus of the research was limited to a sample of nine mines in South Africa, namely: Mponeng, Tau Tona, Bathopele, Khomanani, Venetia, Sishen, Grootegeluk, Thabazimbi and South Deep. The reason for this selection is that these mines are part of a national business initiative termed the Energy Efficiency Leadership Network (EELN), formerly known as the Energy

Efficiency Accord (EEA). The scope of the research was, therefore, focused on mines that have similar objectives and expectations with regard to energy efficiency improvements.

The research was based on many assumptions that gave rise to a number of limitations. These assumptions, without being exhaustive, included the following:

- ✓ Both government and mining companies are committed to Energy Efficiency Accord, now the Energy Efficiency Leadership Network.
- ✓ Both government and mining companies are genuinely serious about energy efficiency and renewable energy, and they do not merely oblige due to international pressure.
- ✓ Mining companies can first think about ecological sustainability before being defensive and selfish about profits.
- ✓ Government understands its role in shaping the South African economy

The only two limitations foreseen, which needed some serious management, were:

- ✓ Confidentiality and Competition. Getting all the information the researcher needed from mining companies was not easy because of the confidential and competitive nature of the industry.

1.7. Chapter Outline

This report consists of five main chapters. Chapter 1 introduces the topic and outlines the problem statement. The objectives, as well as the limitations, of the research are also discussed.

Chapter 2 sets out the literature review and has sections focussing on overall energy and energy efficiency in South Africa, Renewables and Long-Term Mitigation Strategy, and Renewables and Energy Efficiency Approaches in the mining sector. It closes with the conclusion and recommendations.

Chapter 3 discusses the Methodology used in this research. Chapters 4 and 5 present both Exxaro and AngloGold Ashanti as case studies for Energy

Efficiency and Renewables. Chapter 6 presents and discusses the Results of the Research, and Chapter 7 discusses Conclusions and Recommendations.

Chapter 2 – Literature Review

2.1 *Energy in the South African Economy*

The South African energy policies make more sense when considered in three different periods (Davidson, 2006): a) during the apartheid regime; b) the period following the democratic elections of 1994, up to 2000; and c) from 2000 onwards. *“During the apartheid period, due to the political isolation of the country, energy policies were mostly centred on energy security. After the advent of democracy, energy policies were directed to addressing the injustices faced by the majority of the population who had previously been denied basic services – equity and justice were therefore the primary goals. From 2000 onwards, energy policies focused on trying to achieve the targets and timetables that the government set itself after 1994. These targets relate to job creation, and economic security, and recognise that development paths have to proceed in a sustainable manner and protect both local and global environments”* (Davidson, 2006: 5-6).

2.1.1. Apartheid Regime Energy Policies

During this era, because of what the apartheid government termed ‘separate development’, a euphemism for racial discrimination, most policies were characterised by security, secrecy and control. Because of its role in economic and political security, the industries sector’s needs were given high priority, which resulted in concentration on electricity and liquid fuels. It was during this time, in the 1950s, that the apartheid government decided to produce liquid fuel from coal through the government-owned Sasol, and decided to refine crude oil locally (Davidson, 2006). Sasol’s creation in 1954 was, therefore, informed by the need to produce liquid fuels. In the era before 1954, all refined oil products were imported and distributed by BP, Caltex, Mobil and Shell. The Moss gas plant followed Sasol in 1992, and both were heavily subsidised by the government. In terms of electricity, Escom, the forerunner of Eskom, produced electricity and supplied the industrial and commercial sectors, and mainly white households. It was only in 1992 that Escom was

changed into Eskom in terms of the Electricity Act of 1987, and was now controlled by the Electricity Council with more representative stakeholders. This Council appointed Eskom's management board.

2.1.2. Post-Election Period (1994 – 2000)

The democratic government made a commitment to provide basic services to the poor and disadvantaged majority of South Africa. One of the main components of such basic services was modern energy, especially electricity. This led to the democratic government focussing its attention on electrification and liquid fuels. It was because of this focus that the government-funded National Electrification Programme, the aim of which was to electrify rural and urban low-income households deprived of access by the apartheid government, was implemented between 1994 and 1999.

In 1998, the White Paper on Energy (DME, 1998) was published. The White Paper accepted the international energy agenda whilst recognising national energy and economic demands. It purported to identify appropriate energy supply through diversity and managing energy-related environment and health effects. For the first time, the building of thermally efficient houses was considered as an opportunity to promote energy efficiency and conservation. In the industrial, commercial and mining sectors greater efficiency was encouraged both for its environmental benefits and for its cost benefit such as increasing international competitiveness. The White Paper estimated savings of between 10% and 20% of current consumption of energy efficiency initiatives are embarked upon. In order to realise these savings, however, the following barriers have to be removed: inappropriate economic signals; lack of awareness; information and skills; lack of efficient technologies; high economic return criteria; and high capital costs (Davidson, 2006).

It was on the supply sector side that the White Paper was more robust. On the electricity side it “*proposed restructuring the electricity distribution industry into independent regional distributors, at the same time making a commitment to the goal of universal household access to electricity*” (Davidson, 2006:8).

The privately owned coal industries, supplying almost 72% of South Africa's primary energy, were deregulated in 1992. This allowed these industries greater competition in the market and left government with only the role of monitoring the industry. As will be shown later, this led to Eskom being provided only with low-quality coal whilst coal of high quality was shipped to overseas markets.

In the liquid fuels space, while the White Paper proposed minimum government intervention and regulation and emphasised international competitiveness and investment, inclusion of local black interest in ownership and appropriate environmental and safety standards were proposed. As part of cross-cutting issues, integrated energy planning, facilitation of international energy trade and cooperation, and a balance between environmental health and safety and development goals were to be encouraged.

The White Paper also encouraged the search for other energy sources. Nuclear energy was to be considered, for example, but this depended on the environmental and economic merits of the various alternative energy sources. Renewable energy was considered to be advantageous for remote areas that were not economically feasible for grid electricity supply. *“The government would facilitate the sustainable production and management of solar power and non-grid electrification systems largely targeted at rural communities. The promotion of appropriate standards, guidelines, codes of practice and suitable information systems for renewable energy would be considered”* (Davidson. 2006: 9).

2.1.3. From 2000 to Date

In the gas and electricity sectors, the drive to return some regulation to the deregulated market intensified after 2000. However, there was also a concern to extend social benefits to communities through electrification. This resulted in what came to be known as the “poverty tariff”, which entailed provision sufficient to cover basic lighting, media access and some water heating. The Integrated Energy Plan (IEP) was published at the end of 2003. The plan

offered a framework for decision-making on energy policies, different energy sources and technologies in the country.

The IEP takes into account the balance between supply and demand, and it is regarded as the primary planning process that has to provide the foundational framing and form the basis of other sub-sectoral planning. In order to determine the long-term electricity demand and detail how this demand should be met in terms of generating capacity, type, timing and cost, the Integrated Resource Plan (IRP2010) for electricity between 2010 and 2030 was promulgated in May 2011. One of the main purposes of the IRP2010 is to reduce carbon emissions by diversifying the national energy generation mix. As a further drive to reduce carbon emissions, the government's National Climate Change Policy was approved and gazetted in October 2011. The main purpose of the National Climate Change Policy is to make a fair contribution to the global effort to achieve the stabilisation of CO₂ concentrations in the atmosphere at a level that prevents dangerous anthropogenic interference with the climatic system. South Africa supports a global shared vision to keep temperature increase to 2 degrees Celsius.

There is currently work under way, commissioned by the National Planning Commission, to develop a plan to be called a New Power Plan (NPP), which is meant to revise or replace the IRP2010. The NPP is necessary because many of the assumptions in IRP2010, including the anticipated demand growth and data on technology availabilities and costs, are now out of date and no longer valid. The new assumptions included in the NPP are lower demand, updated investment costs of renewable and nuclear technologies and the availability of natural gas from LNG, shale, West Coast Ibhubesi and a pipeline from Northern Mozambique. Based on these assumptions, the NPP has an installed capacity in 2030 of 341 TWh (50 GW peak) compared to 454 TWh (67.8 GW peak) anticipated in IRP2010 (ERC, 2013). The modelling assumes that carbon emissions will follow the 2025 peak, plateau and decline trajectory implied by the country's Copenhagen pledge (deviation from business-as-usual GHG emissions by 34 % by 2020 and 42 % by 2025 with adequate

funding, technology transfer and capacity building assistance by developed countries.

In October 2010, the South African government announced a new policy aimed at enhancing growth, employment creation and equity, called the New Growth Path (NGP). Its principal target was to create five million jobs over the next five years. To achieve this and other targets a package of interventions that addresses a range of challenges in the economy, was needed. The first intervention was the development of the National Development Plan (NDP) – Vision 2030 in November 2011. The NDP (NPC, 2011) believes that growth in the renewable energy sector as envisaged in the IRP and the country carbon emissions reduction will enable South Africa’s resilient, low-carbon economy and just society.

The programmatic approach of the NGP and the vision of the NDP allow for the intervention in the industrial sector, through the Industrial Policy Action Plan (IPAP). The IPAP is formed by a three-yearly iteration process and acts as a blueprint for government’s collaborative engagement with its social partners from business, labour and civil society. The IPAP endeavours to better align trade and industry policies in green and energy saving industries, encourage localisation in the renewable energy generation programme, and develop an energy-efficient and low-carbon growth strategy. The IPAP 2013/14 – 1015/16 is in its fifth iteration and includes the Manufacturing Competitive Enhancement Programme (MCEP) that will provide enhanced manufacturing support. The Production Incentive (PI) programme will include a Green Technology Upgrading Grant of 30–50% for investments in technology and processes that improve energy efficiency and greener production processes.

In 2002, the South African Government hosted the World Summit on Sustainable Development (WSSD), and the concept of sustainable development took centre stage. It is defined as a “*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*” (WSSD, 2002:4). Therefore, it often thought of as

development that brings together social, environmental and economic objectives. This concept has since taken many interpretations, but the South African Government's interpretation thereof has remained that of the WSSD. However, to date, the South African Government is still struggling to integrate environmental objectives into non-environmental policy-sectors. It is important to realise that the environmental sector alone will not be able to secure environmental objectives, and each sector must therefore include environmental policy planning objectives in their actions.

The South African Government considers the use of renewable energy as part of sustainable development. In 2002, a White Paper on renewable energy (DME, 2002) was, therefore, published. It aimed to ensure investment of equitable level of national resources in renewable technologies, introduce suitable fiscal incentives for renewable energy, and facilitate a good investment climate for the renewable energy sector. Following this White Paper; appropriate legal and regulatory frameworks were to be developed:

- i. For pricing and tariff structures, in order to support the integration of renewable energy into the energy economy, and attract investors;
- ii. To integrate independent power producers into the existing electricity system; and
- iii. To develop and implement appropriate standards, and codes of practice for the appropriate use of renewable technologies.

Despite these commitments, the expansion of renewable energy in the country has mostly taken place in the rural areas in places where there is no access to the national grid. It is almost exclusively through the fitting of solar home systems for poor households. If South Africa is to achieve its objective of sustainable development it needs to substantially increase the supply of renewable energy to all its citizens, irrespective of their economic status. Winker (2006:42) summarises the passing of these phases as follows: *“The fundamental drivers of energy policy in South Africa have shifted from supply-side to the demand-side. During the apartheid years, top-down planning and concerns around energy, and security (amongst other factors) led to large investment in synthetic fuels from coal, nuclear power generation and*

predominantly coal-fired electricity generation. Since the first democratic elections in 1994, socio-economic development has become the key driving factor for all policy.”

In conclusion, this document argues that the 1998 White Paper on Energy was a game-changer, not only in the energy sector, but in all economic sectors in the country. From it emerged legislative and regulatory frameworks that ensured that both greater energy efficiency and renewable energy initiatives are promoted, especially in the power and industrial sectors, but also in the household sector.

2.2 Energy Efficiency Strategy for the Republic of South Africa

South Africa is a developing country, endowed with rich deposits of minerals and fossil fuel in the form of coal. Its economic development is consequently based upon the extraction and processing of these resources. These processes are heavily dependent upon energy as their driving force, and this has resulted in the country's core industries being concerned with energy-intensive activities, such as iron and steel production and other raw material processing. Coal is inevitably used as the major source of primary energy to meet the demands of these industries. Since the acceptance of the need for sustainable development, energy efficiency has become one of the most cost-effective ways of meeting the demands of sustainable development. This realisation led to the South African Government realising the Draft Energy Efficiency Strategy in 2004.

The vision of the Strategy is stated as follows: *“To encourage sustainable energy sector development and energy use through efficient practices, thereby minimising the undesirable impacts of energy usage upon health and the environment, and contributing towards secure and affordable energy for all”* (DME, 200:4).

In line with the concept of sustainable development, which is thought of as development that brings together social, environmental, and economic

objectives, the South African Energy Efficiency Strategy has social, environmental, and economic sustainability as its goals:

1. Social sustainability

- Improve the health of the nation – controlling substances such as oxides of sulphur and nitrogen, which are known to have adverse effects on human health.
- Job creation – the implementation of the strategy and the energy efficiency sector itself will lead to nationwide employment opportunities.
- Alleviate energy poverty – provision of energy services to the community at an affordable cost.

2. Environmental Sustainability

- Reduce environmental pollution – reduction of harmful atmospheric emissions and odorous gases.
- Reduce CO₂ emissions – reduction of greenhouse gas emissions, thereby combating climate change.

3. Economic Sustainability

- Improve industrial competitiveness – appropriate energy efficiency measures will improve export performance.
- Enhance energy security – energy efficiency measures will increase the country's resilience against external energy supply disruptions and price fluctuations.
- Defer the necessity for additional power generation capacity – the strategy implementation will contribute 34% towards Eskom's 2015 demand reduction target of 7.3 GW.

The Strategy planned on implementing sector programmes, such as the mining sector, in a three-phase approach, namely: 2004-2007, 2007-2010, and 2010-2014. "The projected usage is forecast at the present increase in economic development and without any additional efficiency interventions" (DME, 2004:11). The target is not a mandatory requirement, but rather a guideline to which to aspire. It is based on the assumptions that there will be 13% population growth per annum, a 2.8% economic growth over a period, a 2.8% GDP growth average per annum, and limited fuel switching (DME, 2004). These sectoral

targets are also based upon the different growth rate elasticities for each sector. The final targets are 15% for the industrial sector, 15% for the commercial and building sectors, 10% for the residential sector, and 9% for the transport sector.

As stated in the White Paper on Energy Policy, government should promote energy efficiency and be able to measure the effectiveness and efficiency of measures implemented. To this end, the following implementing instruments have been suggested as appropriate to meet specific needs within each economic sector:

1. Support Mechanisms: efficiency standards; appliance labelling; certification and accreditation; education, information and awareness; research and technology; regulation; energy audits; and energy management systems.
2. Policy, Mandate and Governance – appropriate legislation and regulations for the governance and implementation of this Energy Efficiency Strategy.
3. Finance Instruments - financing the public sector implementation plan, Energy Service Companies (ESCO), Clean Development Mechanism (CDM), Demand Side Management (DSM), and energy.
4. Stakeholders – a number of diverse role players in the fields of energy supply, conversion, efficiency and regulation to be prompted to take a leading role in their areas of responsibility.

In the mining/industrial sector, the emphasis is still on the support mechanisms where the industrial sector programme has norms and standards, energy audit schemes, energy management best practices, technology information and research, promotion of energy service companies, and the maximisation of the value of energy efficiency investments, as output activities. According to the Energy Strategy, it will be against these outputs that the success, or otherwise, of the strategy will be measured in the industrial sector, including the mining sector.

2.3 Energy Efficiency – a global perspective

Globally energy efficiency, guided by a range of policy imperatives as well as specific decision-making drivers, contributes to greater efficiency in the use of energy resources. For most developed countries, policies to increase energy efficiencies have been introduced in the public sector, the residential sector, in industry, transport systems as well as electricity generation and transmission. For the successful implementation of energy efficiency policies and strategies, legislation to enforce or guide these policies and strategies must be put in place in order to ensure development of a targeted implementation strategy; a distinction must be made between two streams of energy efficiency activities. *“Firstly, business-based energy efficiency, whereby utilities may engage in energy efficiency services for corporate objectives such as to improve market positioning, retain customers, improve public relations and increase profitability from new business areas. These are referred to as energy efficiency services. Secondly, public interest energy efficiency, whereby governments may implement public interest energy efficiency for market failure reasons and several other objectives such as reduced environment damage, increase overall system efficiency, as well as other macro-economic benefits”* (Winkler, 2010:3-4).

In the Organisation for Economic Co-operation and Development (OECD) countries' well-designed policies, that focus primarily on buildings, appliances, vehicles, and industrial operations and less on changing consumer behaviour, have resulted in substantial energy savings. In the USA, since the 1973 oil crisis, energy security has been the main driver for the establishment of an energy efficiency policy. In the years 1975-80, a number of federal laws established financial incentives, educational efforts, setting of efficiency standards, as well as budgetary provisions for energy efficiency R&D and grants. These were followed more recently by minimum efficiency standards on a wide range of household appliances and major types of equipment used in the commercial and industrial sectors (Winker, 2010).

In many states in the USA, just like in South Africa, electric utilities are required to run energy efficiency programs, also known as demand-side management (DSM) programs, funded through a small surcharge on electricity sales. In order to remove the financial disincentive that utilities have to promote energy savings by their customers, some utilities are allowed to earn more profit on their energy efficiency programs instead of building new power stations or other energy supply facilities. Another way is to allow for independent entities or state agencies rather than utilities to implement these programs (Winker, 2010).

In the European Union (EU), there is an EU Action Plan for energy efficiency whose sole purpose is the reduction of energy consumption in energy-intensive sectors such as buildings, manufacturing, energy conversion and transport.

In developing countries like South Africa, the energy efficiency programs will not be the same as in the developed countries discussed above. For developing countries, solutions for meeting energy demand requirements should be in a manner more suitable to their internal markets, such as the Argentinian efficiency of street lighting improvement program, Argentina Efficient Street lighting Program (ASLP). South Africa's efficiency programs should, therefore, be determined by the country's internal market of the energy sector.

2.4 Renewable Energy and the LTMS

In preparation for climate negotiations and the United Nations Framework Convention for Climate Change (UNFCCC), the South African Government sought to draw up a long-term climate policy, informed by the best available information. This resulted in the production of the Long Term Mitigation Scenarios (LTMS) document that motivated for different strategic options for the country's mitigation of greenhouse gas emissions, based on sound scientific analysis. The approach was a balancing act between the need for South Africa to grow and develop in order to reduce poverty, and the re-structuring of its economy in order to reduce its greenhouse gas emissions.

Having ratified the UNFCCC and its Kyoto Protocol, under which carbon constraints, or caps, were placed on industrialised countries only, South Africa has been exempt from taking mandatory action to reduce its high levels of relative emissions. Under the Kyoto Protocol, the principle of equity and “common but differentiated responsibility” was agreed to, by which the developed nations would take the lead in mitigating the greenhouse gases. *“In the first commitment period (2005 to 2012), South Africa, along with other larger developing countries such as Brazil, China and India, may continue to grow without any cap on emissions. However, once the developed nations take the lead with more ambitious emissions reductions, they will expect at least some developing countries to take a fair share of our common (albeit still differentiated) responsibility”* (DEAT, 2007: 7). As total exemption from any mitigation effort was not an option for South Africa, the country had a loose commitment to mitigate, but not a legally binding, quantified target. The LTMS process was, therefore, in preparation for what was to happen after 2012, with agreement expected in 2009. It was therefore important to translate LTMS into policy and negotiation positions.

The South African Government, looking ahead to the 2050 horizon came up with two scenarios. In a scenario that was termed “Growth without Constraints”, the country could choose to develop without any consideration of greenhouse gas emissions, and the economy would be energised purely on least-cost grounds and without internalising external costs. This scenario was considered a reference case, and any other scenarios and strategic options will be assessed against it. “Assumptions about economic growth that underpin this scenario were consistent with the growth targets of the Accelerated and Shared Growth Initiative for SA (ASGISA) ranging between 3% and 6% of GDP growth per year.

These and other assumptions were fed into the model, which selected the least-cost sources of energy to fuel the economy over the period 2003 to 2050” (DEAT, 2007:7). This scenario is likely to see emissions quadrupling, overall fuel consumption growing five-fold, a total of nine new conventional nuclear

plants built, and new coal-fired electricity generating plants using supercritical steam technology or integrated gasification combined cycle (IGCC). But, most importantly “[t]here is no incentive for (and therefore no uptake of) energy efficiency, despite the potential net savings over time, demonstrating the typical market pattern of not taking no-cost strategies... Very few renewables enter the electricity mix in this scenario. No electricity addition is generated from solar, thermal, or wind, with only significant addition being 70 MW of landfill gas” (DEAT, 2007:7).

If the "Growth without Constraints" is pursued, the country will achieve its goals and considered itself successful by 2050, despite its emissions having quadrupled. If this scenario is compared with the existing government policies a new scenario, called "Current Development Plans" emerges. The two most important policies included are the "Energy Efficiency Strategy of 2005 (DME, 2005) which aimed to achieve a final energy demand reduction of 12% by 2015, and a renewable energy target of 10 000 GWH contribution to final energy consumption by 2013, taken from the 2003 White Paper on Renewable Energy. The disturbing conclusion from this comparison is that beyond 2050, the "Current Development Plans" scenario is not radically different from the "Growth without Constraints" scenario - greenhouse gas emissions are still increasing but at a higher rate.

The response to higher greenhouse gas emissions lies in what the South African Government termed the "Required by Science" scenario, where the country has all the resources and technology at its disposal to contribute to the global mitigation effort that is required to stabilise the climate. The Required by Science refers to the emission reductions needed in order to curb global warming and prevent a 2 degree Celsius temperature rise, which is a critical point for climate change impacts. Because of so many unknowns, especially technologies, the Required by Science scenario could not be modelled in the same way as the Growth without Constraints scenario but its components were rather envisaged, as the future would be expected. Therefore, the Required by Science scenario imagines the South African target band of greenhouse gas emissions reduction of between 30% and 40% from 2003 levels by 2050. The

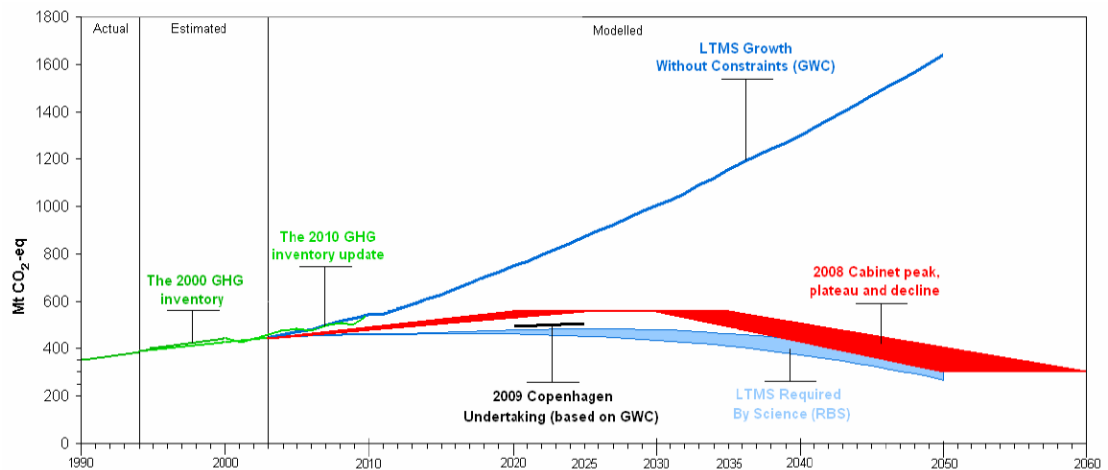
target range could be made even larger but this was not explored. Comparing this scenario to the reference case there is a large gap between the two emission trajectories.

The Required by Science scenario accedes, though, that emissions would still rise at first, and then peak at an appropriate level, to allow the required decline to the target range. For large emission reductions to be achieved, a national coordination mitigation programme with appropriate international assistance is required.

The South Africa in 2050, as imagined by the Required by Science scenario is vastly different from the one we have today. *"New technologies dominate the electricity generation and transport sectors, and the renewable and nuclear technologies encountered in the Global without Constraints scenario are taken up much earlier, and at a much larger scale...New technologies, notably hydrogen-based transport, will by then be the norm, with hydrogen being manufactured through non-carbon means. Although the largest emissions reductions come about through widespread changes in human behaviour patterns that underpin GHG emission, much of this is achieved through awareness, as most citizens will be acutely concerned about emissions and adopting low emission lifestyles"* (DME, 2007:12).

2.5 Strategies for Achieving the Required by Science Objectives

In addition to mapping up the scenarios, LTMS explored groups of mitigation options, called 'wedges'. Considering the emission reduction results and impacts on the economy, they were assembled as packages of actions to inform strategic planning. The energy sector was prioritised as most emissions are found in this sector. These packages of actions resulted in four strategic options as represented and discussed below.

Figure 1. The LTMS Modelling

Source: DEA (2011)

2.6 Implications of the LTMS

The LTMS demonstrates that South Africa can no longer follow economic growth without any constraints such as climate change concerns. The Growth without Constraints route is wrought with looming problems including failure to maintain competitive advantage (cheap energy), climate/political/trade risk and stranded assets; for example, assets that are not used because they are not deemed environmentally friendly by stakeholders. Without the inclusion of the Reaching for the Goal Strategy, the first three strategic options (Start Up, Scale Up and Use the Market) only get South Africa two-thirds of the way to the Required by Science goal. It is only through the implementation of all four strategies together that the Required by Science scenario could be achieved.

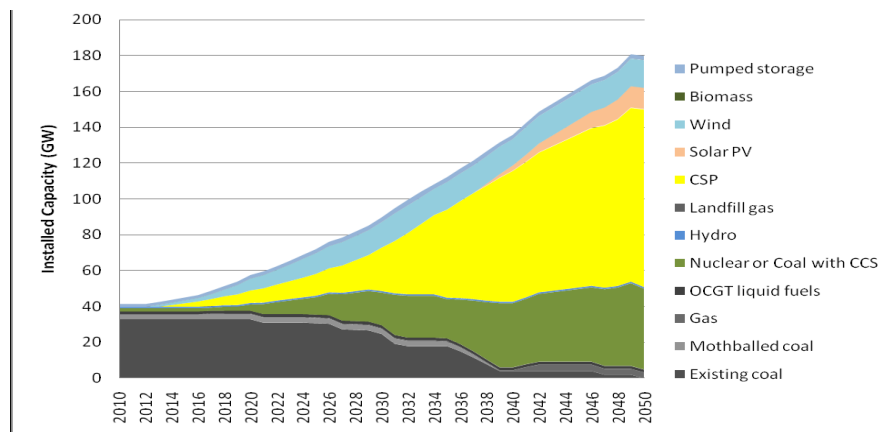
The LTMS (DEAT, 2007) lists a number of steps that are crucial if the Required by Science scenario is to be followed. However, the two most important and achievable are:

- a. Energy Efficiency – This forms a component of all strategic options. “Energy Efficiency can deliver large and smart mitigation. Indeed, all the suggested strategies can be thought of as “Energy Efficiency plus.” Although economically obvious, voluntary agreements only work to a degree. Hence tough motivators will have to be introduced, some of

which have already been suggested in the Energy Efficiency Strategy” (DEAT, 2007: 28); and

- b. Renewable Energy – an investment, equivalent to the amount government committed to finance the now-defunct pebble bed modular reactor (PBMR), which stood at 51% of the capital requirements over three years, is needed in various renewable energy technologies.

Figure 2. Electricity generation capacity projected for South Africa to achieve near carbon-neutral electricity generation by 2050



Source: Winkler (2007)

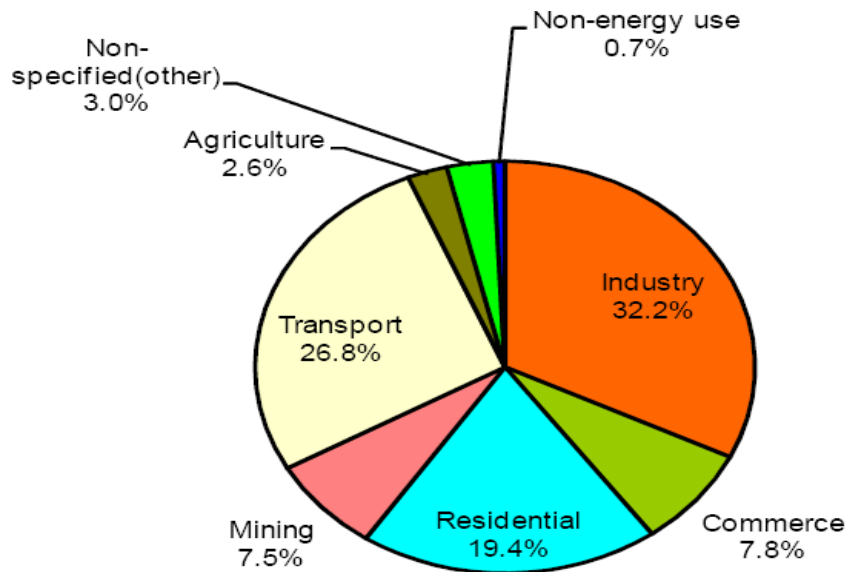
As a conclusion, “...the ‘Start now’ option requires that 27% of electricity is to be generated from nuclear and renewables by 2030. The ‘Scale up’ strategic option is more ambitious, requiring at least 50% of electricity generation (kWh) to come from renewables and the rest from nuclear or coal with carbon capture and sequestration (CCS), thereby almost making the electricity sector carbon-neutral by 2050. According to the LTMS, achieving renewable electricity supply targets of at least 27% by 2030 and 50% by 2050 would require a major rollout of CSP generation capacity” (Winkler, 2007:2).

As a logical step following the LTMS process, a long-term climate policy and the Energy Efficiency Accord for the country, based on the parameters outlined in the document, was developed.

2.7 *The Minerals Energy Complex (MEC)*

South Africa's endowment with natural resources, especially minerals and metals, created a South African form of capitalism. *"The South African economy is dominated by the extraction of minerals from the ground, processing them into metals through the use of electric power and chemicals and selling them to the rest of the world. Most of the assets of the economy are devoted to these activities, which also account for most of the country's exports"* (Mbeki, 2009:76). This captures the essence of what is referred to as the minerals-energy complex (MEC) in South Africa. Winkler (2006: 24) summarises it as follows: *"Historically, energy demand in South Africa has been dominated by heavy industry and mining, which have determined the economic and energy structure of the economy. Much of the manufacturing sector is linked to mining activities through minerals beneficiation and metals production. These industries are all energy intensive, and rely on the availability of inexpensive coal and electricity"*.

In the South African economy, energy has always played a key role. As far back as the early part of the twentieth century, electricity supply was driven by demand from the mining industry. Massive coal power station projects were initiated in the 1960s and the 1970s. The mainly coal-generated electricity resulted in low energy prices that became the country's key competitive advantage, and continues to a large extent to drive new investment in the mining industry. *"The largest proportion of electricity is consumed by the industrial sector (42%). Mining and residential are the next two largest, with these sectors also showing the greatest growth in electricity demand in recent years"* (Winker, 2006:27).

Figure. 3. Sectoral Consumption of Energy in South Africa, 2006

Source: Subramoney (2006)

According to Ben Fine (2013), the history and consequences of the MEC can be traced back to the emergence of mining in the 1870s through to the present day. *“In the inter-war and immediate post-war period, core MEC sectors drove the economy... State corporations in electricity, steel, transport and so on, represented an accommodation across the economic power of the mining conglomerate and political power of the Afrikaners, an easy compromise of evolving fractions of classes and their interests forged through both state and market”* (Fine, 2013: 558). One criticism about the MEC in this era is that, other than preservation of core MEC sectors, it failed to accrue economies of scale and remains an inefficient consumer of goods industry.

In conclusion, the MEC industries, with the mining sector at the epicentre, remain central to the South African economy. It is for this reason that the country’s programmes like renewable energy and energy efficiency initiatives should put more emphasis on these industries.

2.8 Mining Processes and Energy Use

In South Africa, industrialisation began with the discovery of diamonds and gold in the 1870s. Gold became an important driver of the country's economy, so mining has been logically divided into 'gold' and 'other metals and minerals'. Gold production, because of declining ore grades, has been dropping steadily. This has resulted in increased energy required to mine a unit of gold as mines go deeper and have to process more ore for each ton of gold produced. *“Within South Africa, the gold mines are the single greatest users of electricity across all sectors, and the amount of energy used for gold mining is only slightly less than the total energy used in all the other mining sectors combined. Electricity constitutes over 90% of the energy use of the gold mines. Unlike the gold sector, the other mining sectors are growing and have good prospects – these get about 75% of their energy from electricity”* (Winkler, 2006: 104 – 105). Mining companies depend on Eskom coal power stations for their electricity needs and coal for their thermal energy (heat) needs. This means increased CO₂ emissions which contribute to climate change.

It follows, therefore, that in order to transform mining into a low carbon industry, energy use has to decrease and clean energy sources need to be utilised. By only requiring improved management of the status quo, energy efficiency is the simplest and cheapest approach in this regard.

2.8.1. Mining Sector Engagement in Adaptation to Climate Change

The South African economy is private-sector driven and is historically based on the mining sector. The mining industry provides the raw materials for economic growth and at the same time consumes an enormous amount of energy. For this reason, therefore, the South African mining industry is closely aligned with the outlook for the country's economy. In order to deliver more effective climate change adaptation and energy development goals, businesses,

professional and industry organisations, and governments must work together instead of in isolation.

For the mining sector, and indeed government, in addition to greenhouse gas emissions reduction, there are several other reasons for the implementation of energy efficiency and renewable energy strategies. These energy development goals can be classified as follows:

- a) Energy Security – vulnerability to energy shock, like the recent load-shedding experiences, makes energy efficiency and renewable energy initiatives a must, as an insulation from these shocks;
- b) Energy Cost – the likelihood of fossil fuel price increases is always set to increase as fossil fuels are finite. As a result, a wide range of solutions spanning grid-connected and distributed renewable energy technologies, energy efficiency, grid modernisation and alternative transportation, could help reduce fossil fuel use;
- c) International Competitiveness – the mining industry, through internal market development, developed skills and capabilities that could be used in pursuit of external growth opportunities. The presence of an overarching goal of international competitiveness should be shaping energy efficiency and renewable energy innovation initiatives in the mining sector in important ways;
- d) Modernisation – a developing country like South Africa with an articulated ambitious vision for economic growth and industrial modernisation, can expect its energy demand to grow, especially through new commercial and industrial demand. In order to align itself with this modernisation motif, the mining sector will be required to comply with the demand-side policies, including energy efficiency and renewable energy initiatives. (IRENA, 2013)

These energy developmental goals are particularly important in the South African mining sector. According to the Chamber of Mines of South Africa (2012), the mining industry, for over 130 years, has transformed South Africa into the most industrialised country in Africa. The mining sector in South Africa (SA) is a significant contributor to economic development and job

creation. It directly contributes approximately 9% of the GDP and about 500 000 jobs. If the indirect and induced contributions are considered, this can be elevated to a total contribution of approximately 19% of the GDP and 16% of total SA employment (1.3 million jobs). Currently, almost one fifth of the country's economy is attributable back to the mining sector. But most importantly, “[m]ining is the industry that helps provide about 72% of South Africa's primary energy needs, and effectively “fuels” the South African economy” (CM,2012:1). In addition, given its linkages and induced impacts on many parts of the economy, mining is a significant investor in the South African economy. (CM, 2012)

A global United Nations (UN) initiative, called Sustainable Energy for All (2012), asserts that many development goals could be achieved by achieving the three objectives of Sustainable Energy for All:

- a) Energy access – ensuring universal access to modern energy services,
- b) Energy efficiency – doubling the global rate of improvement in energy efficiency, and
- c) Renewables – doubling the share of renewable energy in the global energy mix. (UN Global Compact, 2012). There are a number of actions that companies, including mining companies, can take to advance these objectives. These priority industry actions, although intended to contribute to achieving the three objectives, should “maximize the business benefits so they can be realised by ensuring access to modern energy services, improving energy efficiency, increasing the use of renewable energy, advancing sustainable innovations in products and services, and collaborating across industries through transformative partnerships” (UN Global Compact, 2012: no page)

In implementing these actions, the report notes that many industries will face a variety of challenges and barriers. *“These include country specific policy and regulatory barriers, a lack of appropriate and available financial mechanisms, and inflexible or ineffective business models. For these reasons, no one overarching global solution exists, and industries must partner and collaborate with each other, with governments, and with civil society to*

develop successful frameworks and opportunities for change” (UN Global Compact, 2012: no page).

In the case of the private sector, including the mining sector, all the priority actions will be aligned to one or more of the four business value levers, namely: (i) revenue growth, (ii) cost reduction, (iii) brand enhancement, and (iv) risk management.

a) Revenue Growth

The three objectives of Sustainable Energy for All present the mining industry with a number of opportunities to create new sources of revenue through modern energy services, and the development of energy-efficient products and renewable energy technologies.

b) Cost Reduction

Energy has become a critical commodity for many organisations, especially for energy-intensive industries such as mining. Having been a relatively inexpensive and abundant commodity for years, it has now become a big portion of the overall cost structure of companies. To mitigate energy costs the mining sector can implement enterprise energy management processes to better understand and manage energy use, improve operational efficiency, and reduce costs through actions such as heating, ventilation, and air conditioning retrofits or lighting upgrades.

c) Brand Enhancement

Globally, consumers are more and more aware of how serious the challenge of climate change has become. As a result, more “consumers show a strong preference for renewable sources of energy, not only to power their homes, but also to power the manufacturing of the brands they consume,” (UN Global Compact, 2012: no page). The implication thereof is that, although it is difficult to quantify and directly link to a business bottom line, an intangible asset, like a brand with strong associations to sustainability in the minds of consumers, can provide a competitive advantage. It is for this reason that mining companies should not consider projects such as providing access to

modern energy services, and local capacity building as primarily social and philanthropic, but as enhancing government- and community goodwill. The goodwill will come with benefits such as greater business opportunities, the ability to attract and retain the best talent and a strong brand.

d) Risk Management

In the mining sector, stable and uninterrupted power sources could be provided by combined heat and power (CHP) systems. The CHP, the simultaneous utilisation of heat and power from a single fuel or energy source, represents a series of proven, reliable and cost-effective technologies that are already making an important contribution to meeting global heat and electricity demand. Due to enhanced energy supply efficiency and utilisation of waste heat and low carbon renewable energy sources, CHP, particularly with district heating and cooling (DHC), is an important part of national and regional GHG emission reduction strategies (IEA, 2008).

According to the IEA Report (2008), assuming a pro-CHP policy regime (for example removing barriers to CHP and introducing targeted incentives), SA's CHP share of total electricity generation can reach 7-8% by 2015 and 17-18% by 2030. This corresponds to the CHP capacity of 4 GWe and 15 GWe respectively. These systems can be designed to enable mines to operate independently of the grid for a short period. The risk associated with operational cost increases due to exposure to potential fuel price increases, can also be reduced by energy efficiency. Renewable energy can also be used as a hedge – a financial mechanism that shifts a mining company's energy budget from a variable to a fixed cost. "The hedge protects a company against volatile energy prices and stabilizes a portion of its operations budget. Renewable energy can also act as a regulatory hedge as new carbon restrictions may be proposed over the life of long-term generation assets" (UN Global Compact, 2012).

The mining industry, in addition to driving business value related to energy efficiency and increased use of renewable energy, can be a catalyst for

sustainable development in areas with little or no existing infrastructure, by providing access to modern energy services, e.g. electricity.

According to the report, in spite of the differences between industries, there are five priority actions that are common across industries, and all relate to renewable energy and energy efficiency. They are:

- i. Increasing the energy efficiency of operations;
- ii. Providing for energy efficiency through products and services;
- iii. Increasing the use of renewable energy to power operations;
- iv. Identifying ways to beneficially reuse waste streams; and
- v. Educating stakeholders on how to achieve energy efficiency (UN Global Compact, 2012).

2.9 RE and EE Approaches in the Mining Industry - a global perspective

The international mining industry, as a complex mix of diverse companies, uses several approaches of extracting and processing natural resources. These minerals and fossil fuels are then used to supply both the energy and raw material needs of the modern world. Depending on the stages of a typical mining project and the major activities involved with the overall set-up of the mining operation, energy demand and consumption varies considerably. With ever increasing pressure from governments, customers, and other stakeholders to operate in a sustainable manner, the use of energy efficiency and energy has become critical for the mining industry.

It is, therefore, important for many key industry players in the mining arena to develop energy saving strategies and invest in renewable energy infrastructure. The result is that the international mining industry is now conscious of how it acquires and uses energy, how it responds to increasing energy costs, changing traditional energy sources, and climate change concerns. The sections below demonstrate some of the approaches that organisations, mining companies or governments are following to make use of renewable energy.

2.9.1 Anglo American ECO₂MAN Program

Anglo American, started in 1917 under Sir Ernest Oppenheimer, has become one of the world's largest diversified mining groups, operating in Africa, Europe, South America, North America, Australia and Asia with its headquarters in London, United Kingdom. Anglo American's core commodities are iron ore, manganese, coal (both metallurgical and thermal), copper, nickel, diamonds and platinum group metals (PGMs). In the view of climate change becoming a real challenge of our era, Anglo American recognised the need to take meaningful steps in addressing the causes and protecting their employees, assets, communities and environments linked to their operations, against potential impacts. "In South Africa [their] Kumba Iron Ore, Platinum and Thermal Coal businesses have been installing heat pumps in their mine change houses, to replace conventional boilers and [they] have been exploring the installation of solar water heaters" (Anglo American, 2014).

The installation of heat pumps has been informed by an ambitious programme, which aims to see Anglo American running cost-effective, carbon-neutral mines by 2030. *"In 2011, we issued a new Group technical standard to manage energy and greenhouse gas (GHG) emissions performance at all our operations, and we are in the process of rolling out energy and carbon management programme, ECO₂MAN. The new group technical standard, requires sites to identify their energy and GHG emission-related risks and opportunities, integrate them into operational plans and establish appropriate measurements and reporting processes"* (Anglo American, 2014). The ECO₂MAN, which is just an abbreviation for an **E**nergy and **CO₂** **M**anagement programme, has been implemented at every site across the company after its successful trials at mine operating sites, including the Minas Rio Project in Brazil.

According to Anglo American (2011), their "climate change strategy seeks to address three key business risks *"an increase in the cost of doing business; changes to their market; and the physical impact of a changing climate on operations and surrounding communities"*. Through the ECO₂MAN programme, Anglo American operations are capacitated to manage energy and carbon emissions, as well as identifying

opportunities for innovative energy saving projects. The ECO₂MAN programme introduced both energy and GHG performance targets on all sites.

This new programme for saving energy and GHG, force climate change issues to be considered earlier on at operational planning and budgeting process level,. *"The emphasis in the first phase of our climate change strategy, is on identifying energy-saving and emission-reduction opportunities, setting ambitious emission-reduction targets relating to site level risks and opportunities and developing high level plans for adaptation to regional climate change...As energy use accounts for roughly 75 % of our GHG emissions, we are primarily focussing existing activities on identifying and implementing innovative technologies aimed at using energy more efficiently. These include technology solutions, to optimise processes and machinery at our operations, such as air compressors, fans, pumps, draglines, conveyors and electric motors"*. (Anglo American, 2014)

2.9.2 Australian Government Energy Efficiency Opportunities

The Energy Efficiency Opportunities (EEO) Program, unlike an EEA in South Africa is a mandatory program for corporations which are heavy energy users (more than 0.5 petajoules per year), although medium energy users may participate voluntarily. It is legislated in the EEO Act and EEO Regulations of 2006 and mandates companies to identify, evaluate and publically report on energy efficiency opportunities in their businesses, in order to increase the uptake of cost-effective energy efficiency opportunities. *"In June 2011, the EEO Program completed its first five-year cycle. Over that period, businesses reported they were implementing energy savings of 88.8 petajoules (PJ). This represent savings of over \$800 million a year and 7.5% of Australia's greenhouse gas emissions...[However], in line with the Government's commitment to reduce costs for business and its deregulation agenda, it has announced its intention to repeal the Energy Efficiency Opportunities Act 2006 from 29 June 2014"* (Australian Government, 2014). This is very unfortunate and represents a step backwards. Nevertheless, the following case studies briefly showcase some of the successes of the EEO program in the Mining Sector.

a) Iluka Resources Limited

Iluka participates in the mineral sand sector and has become the world's largest producer of zircon and titanium dioxide products of rutile and synthetic rutile. In order to identify and pursue energy efficiency improvements at Iluka's facility, the company used the EEO assessment framework to understand the facility's energy consumption and key factors that influenced overall energy performance. The Iluka facility used the energy mass balance (EMB) analysis in software provided by the EEO to model and further simulate energy efficiency improvements and other changes to the plant. *“Iluka's South Western operations have implemented eight energy efficiency projects during the course of Iluka's first five-year EEO Assessment cycle, for a combined total saving of 338 TJ per year, or 8.7% of total site energy use. Iluka used the EMB model during opportunities identification and project identification. Projects that made use of the model accounted for 99% of the total energy-reduction achieved to date”* (Australian Government, 2014). The case of Iluka Resources Limited shows that the EEO Program was very effective in understanding energy use, identifying and evaluating energy efficiency opportunities.

b) Analysis of Diesel Uses For Mine Haul and Transport Operations

As used for material transport processes such as the hauling of ore and overburden, diesel has become a significant energy source for the mining industry. Most of the key diesel-using activities involve trucks and trains, although the understanding of the energy efficiency should not be limited to the analysis of their parameters. *“As of 2008–09, 40 reporting EEO companies in the mining sector consumed 308 PJ of energy, of which 52.5 PJ was diesel (17%) for haulage and electricity generation. These EEO mining companies had identified 3 PJ (or 6%) worth of savings directly related to diesel use. These companies adopted 66% of these identified savings in diesel use”* (Australian Government, 2014).

The Fortescue Metals Group Limited (Fortescues), an iron ore company operating in Western Australia identified that doing away with unnecessary haul truck stops, 13 935 GJ of diesel per annum for the Caterpillar 777 fleet and 15 710 GJ of diesel per annum for the Terex 3700 AC fleet for a single stop sign per payload cycle would be

saved. *“Fortescue also found additional savings through a change to the engine control unit of the haul trucks. Modelling showed a 2.3% reduction in fuel consumption, with an increase in cycle times of 1.8 %, resulting in a fleet-wide fuel saving of 232 kL (8,955 GL) of diesel per annum. In rail operations, Fortescue found that the installation of an automatic short-stop system would reduce idle time, with savings estimated at 675 kL (26,055 GL) of diesel per annum. Numerical modelling also found that savings of between 300 kL (11,580 GJ) to 500 kL (19,300 GJ) of diesel could be achieved by reducing the speed of trains to reduce waiting times at crossing points”* (Australian Government, 2014).

c) Thiess’ Mining Business Unit

Thiess’ Australian Mining Business Unit (Thiess) is part of Thiess Pty Ltd, a mining construction and services contractor with diverse operations throughout Australia and selected international markets. Thiess effectively used the EEO Assessment Framework to assess, identify and quantify energy efficiency opportunities on twelve mine sites where they had contracts for large-scale earth moving operations to open-cut mining companies. In order to perform these functions, mobile mining equipment such as dump trucks and excavators are used. Diesel is therefore used.

In their 2007/08 financial year report, Thiess reported that they used 7.63 PJ of energy. The bulk of this energy was used in the form of purchased diesel in mobile equipment. Thiess ran workshops and identified a consolidated list of 46 potential projects based on impact, cost, risk and effort criteria. So far, only four projects – (i) payment management, (ii) automating mobile lighting equipment, (iii) plant idle-time management, and (iv) turbo idle down-time have been implemented. The remaining 42 are still under further investigation. *“Thiess estimates that these projects will deliver energy savings of 150,800 GJ per annum, \$3.9 million litres of diesel fuel equivalent to 10,600t CO₂-e/annum and \$3,7 million. This represents a 1.7% reduction of total energy use with a simple payback period of less than two years”* (Australian Government, 2014).

2.9.3 Renewable Energy for Off-Grid Operations

According to Boyse et al (2014:17) “*many of South Africa’s remote communities and industries, including its off-grid mining sector, have a substantial energy need that is not currently being met by the centralised energy grid, nor is likely to be met in a reliable and affordable manner in the near future by the utility, Eskom. Moreover, mines operating off-grid in remote areas are currently paying much higher prices for their electricity (supplied by diesel generators) than their grid-connected counterparts*”. This status quo makes the adoption of distributed renewable energy systems by private sector actors, especially in the mining sector, favourable. Different business models have been explored in this regard and the following stand out:

- (i) **Self-generation** – In this business model a single industrial enterprise, in this case a mining firm, develops a renewable energy plant in order to reduce its energy costs or secure its energy source. The mining firm can choose to adopt this model in one of two ways: “*Develop, finance and operate the plant on their own land, potentially through a sub-contract with an external renewable energy developer; [or] Leave or otherwise provide land to a independent power producer, who will in turn handle the development and potentially even the financing and operation of the plant*”. (Boyse et al 2014”:18). This model has the advantage of having few players and is hence easy to implement but the disadvantage of initial investment costs may be too high for many companies.
- (ii) **Industrial Pooling** – In this model, several mining firms currently unconnected to the grid and reliant on diesel for energy, form a partnership and develop a renewable energy plant to reduce their energy costs. This model seems to overcome the high initial investments cost for a few players in the self-generation model as it offers the benefit of economies of scale, however it has its own dynamics. “*In particular, mining firms have proven weary of undertaking joint capital projects with their competitors. Given their possibly diverging interests, and the uncertain lifespan of neighbouring mines negotiating such a deal, would be challenging and currently there is a lack of interest in devoting resources to such resources. No streamlined mechanism for structuring such agreements exists in South Africa today*” (Boyse et al, 2014:19).

- (iii) **Net Metering**– A mining firm, currently connected to the grid develops a renewable energy plant to both reduce its energy costs and avoid supply disruptions or price uncertainties associated with the existing grid. The mining firm can choose to adopt this model in exactly the same two ways as in the self-generation model. However, in this model the utility running the grid, Eskom, purchases the excess capacity generated by a renewable plant. This creates an additional revenue stream for the mining firm.
- (iv) **Self-Generation & Powering Townships** – This model follows the self-generation model exactly as explained but there is an additional player: a nearby community that can be connected with the mining firm by means of a mini-grid. *“A nearby community, close enough to be connected with the PV plant, applies for government support to run a transmission line. This model in particular, creates an additional revenue stream for the industrial operation in the form of the energy they sell to the township. Such an approach would also advance national goals of rural electrification. This model is not viewed as feasible for active miners, as it would represent a deviation from the core business of a mining company”* (Boyse et al, 2014:19).

a) Cronimet Renewable Project

Cronimet Chrome SA (Chronimet), a subsidiary of Switzerland-based Cronimet Mining AG began developing Zwartkop chrome mine near Thabazimbi, Limpopo in 2008. The mine is located in a remote area, which made it inaccessible to the power grid. Diesel fuel was, therefore, the single largest operating expense for the mine. However, given (i) the volatility in the price of diesel, (ii) the decreasing price of solar panels, and (iii) the high irradiation in the location, Cronimet explored the feasibility of developing an on-site photovoltaic (PV) facility for the mine. The self-generation model was therefore considered. However, with only regulatory changes, at least in South Africa, both the Net-Metering, Self-Generation and Powering Township models would also be feasible.

Cronimet required \$2.66 million in CAPEX for the construction of the plant in order to erect 4 158 PV panels and decentralise 63 three-phase invertors. *“In November 2012, Cronimet completed their 1 MW PV facility, which will produce about 1.8*

GWh of electricity annually, or about 60% of the mine's annual daytime power needs. This mine will continue to run on a back-up diesel generator to stabilize the captive hybrid mini-grid during the day and will depend fully on diesel for its energy needs at night. Over the year, the PV Plant will replace approximately 24% of the mine's annual diesel consumption; significantly lowering the mine's total operating expenditure" (Boyse et al, 2014:23). Cronimet's use of solar energy confers significant GHG emissions savings. The annual saving of 450 000 litres of diesel is equivalent to approximately a 1 200 tonne annual abatement in CO₂.

In the mining industry sector, one of the serious problems is the existence of abandoned mine lands (AMLs), which pose serious risks to health and the environment. These AMLs comprise land and surrounding watersheds where extraction, beneficiation or processing of ores and minerals has occurred, including areas where mining or processing activity is inactive. The US Environmental Agency (EPA) conducts and supervises investigation and clean-up actions at a variety of mine sites, and pursues opportunities to explore innovative reuse opportunities at mine sites (EPA, 2012). A lot of clean-up is done using renewable energy, as the case studies below will show.

2.9.4 On-Site EE

Energy Manager Today (2013), quoting the 2013 Navigation Report on Renewable Energy in the Mining Sector, forecasts that between 5% and 8% of the world's mining industry power consumption will be supplied by renewable energy technologies by 2022. It further states that, excluding hydropower, less than 0.1% of power consumed in the mining industry is generated from renewable energy. *"Most renewable energy applications within the mining industry are small-scale, pilot installations, according to the report. The most prevalent application of renewable energy within the industry is rooftop solar PV installations used as on-site energy sources at mine camps and administration areas. Wind power has also been deployed on a large scale, in terms of megawatts but in few locations globally"* (Energy Manager Today, 2013: 2).

However, as far as the U.S Environmental Protection Agency is concerned, although a lot of renewable energy projects on operational mine sites are still at feasibility stage,

a few are already in operational. For example, Smuttville Mine in Colorado which released cyanide and acidic, metal-laden mine water into the Alanso River began construction of a micro-hydroelectric power plant in 2010. It began operating in 2011, to supply electricity to help power remedial activities. The plant, consisting of a pipe penstock and turbine, provides up to 32 KW of energy to the treatment system (EPA, 2012).

2.9.5 Low Carbon Opportunities

In addition to the possibilities of energy efficiency and renewable energy meeting the mining sector's energy needs, there are other alternatives that offer low carbon opportunities that enable reduction of greenhouse gas emissions. According to Smith (2013), as many mines in Australia have access to liquefied natural gas (LNG) or pipeline natural gas, combined cycle gas (or liquid fuel) generators have become far more efficient than the traditional diesel generators. Given the consistent oil price increases, the traditional generators are becoming more expensive to run. However, where significant lengths of power line would be required to connect to the main electricity supply, diesel fuel is becoming very competitive.

According to Smith (2013), in order to reduce their exposure to a carbon price, mining companies could buy carbon offset credits, nationally or overseas. Alternatively, coal mining companies could directly capture methane emissions, which can then be used as combustion fuel, or combustion air. A big growth opportunity, however, lies in mining companies contributing to third party reduction in greenhouse gas emissions (buying carbon offset credits). Mining companies can position themselves for growth markets in i) high grade silicon – for the production of solar PV panels; ii) iron and steel used to make wind power systems; and iii) rare earth metals for the production of renewable batteries (Smith, 2013).

2.10 Implementing EE and DSM

In support of the implementation of South Africa's Long-Term Mitigation Scenarios, the World Bank, assisted by the United Nations Development Program and Energy Sector Management Assistance Program (ESMAP) provided an international peer

review and substantial technical assistance on energy efficiency, demand-side management, and power rationing in light of the urgency of these issues for the near term, due to the acute power crisis which struck South Africa in January 2008 (ESMAP, 2011:2). In the end, various options for accelerating, implementing and disbursing South Africa's energy efficiency/demand-side management (EE/DSM) fund based on international experience in implementing a standard offer model, were suggested.

The standard offer approach has been accepted by Eskom, DME, NERSA and other stakeholders as an improved mechanism for substantially increasing the implementation of EE/DSM projects. *“[It] is the mirror image of a feed-in-tariff mechanism used to procure supply side, renewable resources. Under this approach, the Buyer offers pre-determined tariffs for delivery of energy efficiency resources from different technologies. It is different from demand side bidding where demand resources compete on price”* (ESMAP, 2011:3).

2.10.1 The Need for EE and DSM

South Africa has an energy-intensive economy that is driven by large mining and related industries. The economy's reliance on coal has resulted in South Africa being one of the highest emitters of carbon dioxide (CO₂) per capita in the world and has also had a significant adverse environmental impact at local level. In recognition of the importance of EE and DSM as key elements in a strategy to minimise environmental impacts and contribute to sustainable development, the South African Government published the White Paper on Energy Policy in 1998 (DME, 1998), followed by the Energy Efficiency Strategy of the Republic of South Africa in 2005 (DME, 2005). While the White Paper emphasised the goal of providing the nation with wider access to energy services with minimal environmental impacts on energy conversion, the Energy Efficiency Strategy establishes national targets for EE improvement and a timetable for achieving these targets. These targets have social (improve health, create jobs, alleviate energy poverty), environmental (reduce pollution and CO₂ emissions), and economic (industrial competitiveness, energy security, reduction of additional generating capacity) sustainability goals.

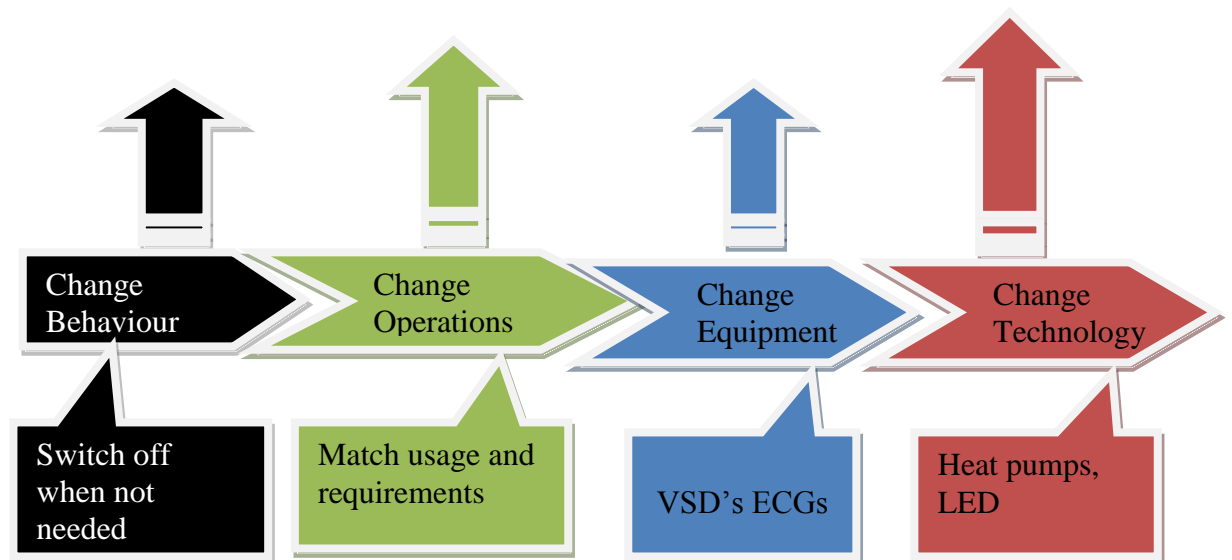
The South African Government mandated the National Electricity Regulator of South Africa (NERSA) with ensuring that there is sufficient installed generation capacity to meet the needs of future electricity demand. With the reserve margins of Eskom's electricity supply capacity getting smaller, NERSA "*determined that to maintain a safe supply-demand situation, provide energy services to customers at the least possible cost, and enforce the government's stated objective of improving the efficiency of the electricity supply sector, there was a need to scale up EE/DSM programs*" (ESMAP, 2011:4). It is for this reason that NERSA promulgated the Regulatory Policy on Energy Efficiency and Demand Side Management for the South African Electricity Industry in 2004. Making EE/DSM planning and implementation one of the license conditions of all major electricity distributors, the policy also defined their responsibilities and obligations. The policy defined the potential roles of Energy Service Companies (ESCOs), in addition to creating an independent Monitoring and Verification (M&V) body that conducted all of the M&V functions related to EE/DSM implementation. Another mandate was for NERSA to establish the EE/DSM Fund administered by Eskom and define the rules and procedures for its implementation. (ESMAP, 2011). The fund is considered consistent with international best practice.

In the EE/DSM Strategy, the ESCOs are extremely important. By conducting an energy audit, project engineering and design, procurement, construction and installation, and project monitoring on a turn-key basis, ESCOs are service providers that help clients to save energy by evaluating their energy use, developing and designing a project to lower the client's energy bills and implementing the project. The ESCOs enter into an Energy Savings Performance Contract (ESPC) with the energy consumer, or "host facility" with a promise of a range of services related to the adoption of energy efficient products, technologies and equipment. "*The services provided may also include the financing of the energy efficiency upgrades, so that the host facility has to put up little or no capital. The host facility pays for the services from the money it saves from reduced energy consumption*" (ESMAP, 2011:6). To verify the MW reduction and/or energy to be saved per EE/DSM project, the independent M&V would be initiated before the implementation of the project.

2.10.2 Towards RE and EE in Mining Sector

The mining industry is a large consumer of electric power in South Africa, using about 15% of Eskom’s annual output. According to Eskom (2012), the gold mining sector is the largest consumer, using 47% of the industry’s electricity, followed by platinum mining at 33% and all other mines together taking the remaining 20%. Energy Efficiency solutions, in order of importance, can be applied in (i) materials handling, (ii) processing, and (iii) compressed air, pumping, fans, industrial and lighting. An in-depth discussion of energy-saving opportunities on these processes can be found in Appendix D of this report.

Figure 4. Energy Efficiency Solutions



VSD = Viable speed Drives; ECG = Electronic Control Gear; LED = Light emitting diode

Source: NBI (2013)

The National Development Plan (NDP) has put some suggestions regarding renewable energy in its chapters dealing with “environmental sustainability and resilience”. It states its vision as a transition to an environmentally sustainable, climate-change resilient, low carbon economy and just society by 2030. According to the plan, an economy-wide carbon price that should drive energy efficiency will be entrenched and at least 20 000 MW of renewable energy contracted by 2030. Even though the plan believes that there is a need to move to climate-resilient and low-carbon economy, it implies that, instead of dealing with all carbon emissions, the focus must be on major emission contributors. In the case of the mining sector the

NDP (2011:201) argues that “[t]he mining sector is a relatively minor contributor to carbon emissions ... responsible for 13.5 percent of carbon emissions. Emissions directly incurred by the industry (Scope 1) account for 3.6 percent of the national total, with the remaining 9.9 percent consisting of Scope 2 emissions, mainly embedded in the purchase of electricity.”

The implication of the above quote is that reducing Scope 2 emissions (purchased coal-based electricity), by reducing the use of coal-based electricity, is key in building a low-carbon economy in the mining sector. This can be achieved by (i) the introduction of more energy-efficient and less carbon-intensive industrial processes, (ii) the increased contribution of renewable energy to electricity generation, and (iii) the carbon-footprint reduction of existing and planned coal-powered power stations through retrofitting, clean coal technologies, and carbon capture and storage (CCS) technologies (NDP 2030, 2011). The plan, therefore, puts more emphasis on the transformation of the electricity sector, and less on increasing energy efficiency in the mining sector. This goes against the spirit of the EELN which emphasises demand-side energy management before supply-side (i.e., energy efficiency before new (renewable) energy supply capacity, and gives mixed signals to the mining sector.

In order to move a step closer to a low-carbon economy, the South African Government published a Carbon Tax Policy Paper in May 2013 (National Treasury, 2013). The policy paper came into being as a response to the 2011 National Climate Change Response White Paper (the White Paper) which suggested a multipronged policy approach of dealing with climate change, comprising market based (e.g. levying environment-related taxes, allocating pollution rights through tradable permit systems, and gravity subsidies for environmental improvements) and regulatory measures, (e.g. emission standards and banning of certain goods and services), information awareness programmes and voluntary initiatives.

The National Climate Change Response White Paper “*supports the implementation of a carbon price through a carbon tax as an instrument to encourage [climate change] mitigation as a complement to regulatory measures*” (National Treasury, 2013:7). The rationale is that a carbon price can drive changes in producer and consumer behaviour, and thereby address climate change. “*Carbon pricing will encourage a*

shift in production patterns towards low-carbon and more energy-efficient technologies by altering the relative prices of goods and services based on their emissions intensity, and by encouraging the uptake of cost-effective, low-carbon alternatives. Second, the carbon-intensive factors of production, products and services are likely to be replaced with low-carbon-emitting alternatives. Third, a carbon price will create dynamic incentives for research, development and technology innovation in low-carbon alternatives. It will help to reduce the price gap between conventional, carbon-intensive technologies and low-carbon alternatives” (National Treasury; 2013: 8-9).

The South African Government could have chosen an Emissions Trading System (ETS) that, just like carbon tax, uses the market to stimulate reduction in GHG emissions. An ETS operates by setting a fixed cap on GHG emissions, at a firm and /or country level while a carbon tax works by pricing emissions directly on an individual or firm. An ETS allows for a cap-and-trade scheme in which entities (firms or countries) are allocated allowances (to be actioned over time) that may be traded with a sufficient number of entities participating in the scheme needed. The oligopolistic nature (currently more of a monopsony) of the energy sector in South Africa makes meeting this requirement difficult because there is no sufficient number of entities participating in the scheme. It is for this reason that the South African Government deems a carbon tax more appropriate than a cap-and-trade scheme.

The White Paper attributes GHG emissions to three sources:

- (i) Scope 1 Sources that are owned and controlled by entities
- (ii) Scope 2 Off-site sources but purchased by the entity resulting from the generation of electricity, heating and cooling, or steam generation
- (iii) Scope 3 Sources related to the entity’s activities (not in Scope 2)

The carbon tax will only be restricted to cover Scope 1 emissions in the tax base, while complementary measures and incentives will be used for other emissions. The carbon tax in South Africa was meant to be introduced on January 1, 2015 but was postponed by another year to 2016, by the Minister of Finance in the 2014 Budget.

There is a growing consensus in South Africa that the creation of a new growth path founded on the restructuring of the country's economy is a pre-requisite for creating decent work, reducing inequality and defeating poverty. It was with this in mind that the New Growth Path (NGP) was prepared in 2010. The NGP (2010:9-10) identifies five job drivers, two of which are “[t]aking advantage of new opportunities in the knowledge and green economies [and] leveraging social capital in the social economy and the public services”. It further prioritises efforts to support employment creation in four key sectors including the mining value chain and the green economy. Although the NGP recognises the role of an effective, developmental state in achieving broad-based employment growth, it still insists on a mixed economy and regards private business as a core driver of jobs and economic growth. This ambivalence results in the state simply being swayed by market forces and vested interests.

As a result of the NGP, the South African Government and other social partners (organised labour comprising COSATU, FEDUSA and NACTU, and community constituents at NEDLAC) signed a Green Economy Accord (GEA) in 2011. According to the GEA (2011:6): “*South Africa has a unique opportunity to create jobs on scale and address the concerns about climate change, through a partnership to promote the green economy and processes to green the economy*”. Energy efficiency jobs can be created through the local manufacture or assembly, and installation of solar water heaters, retrofitting buildings with energy efficient equipment, and replacing incandescent lamps with compact fluorescent lamps (CFLs) or next generation light emitting diodes (LED). The parties agreed upon specific commitments including the rollout of one million solar-water heating systems by 2014/15, the procurement of renewable energy as part of the energy generation plan, the promotion of energy efficiency across the economy, and the promotion of energy efficiency through retrofitting of domestic, industrial and commercial buildings (Economic Development, 2011).

In the foregoing discussion two objectives for a green economy emerge, namely: i) climate change mitigation, and ii) employment creation. It is important, in the South African context, to achieve both.

2.11. Towards a Green Economy

In the document entitled “Towards a green economy”, UNEP (2011), improvements in energy efficiency and greater supply of energy services from renewable sources, are regarded as the necessary requirements to greening the energy sector. The document emphasises the need to limit the concentration of greenhouse gases (GHGs) to below 450 parts per million (ppm) CO₂-eq in order to stay below the 2 degrees Celsius rise of average global temperature, as suggested by the Intergovernmental Panel on Climate Change (IPCC) in 2007 and International Energy Agency (IEA) in 2008. *“This translates to a peak of global emission by 2050, compared with 2005. In 2009, the G8 committed to an 80 per cent cut in their emissions by 2050 in order to contribute to a global 50 per cent cut by 2050, although a precise baseline was not specified”* (UNEP, 2011; 206 – 207).

By committing to an 80 per cent cut, the G8 countries were hoping to be giving developing countries a smaller reduction requirement without compromising the global 50 per cent target. Based on this rationale, South Africa committed to contributing its share by implementing mitigation actions that will collectively result in 34% and 42% reductions in 2020 and 2025 respectively, using its *“business-as-usual”* emissions growth trajectory as its baseline. South Africa’s GHG emissions are expected to peak between 2020 and 2025, plateau for up to ten years after the peak, and then decline in absolute terms thereafter - a peak – plateau – decline (PPD) trajectory (DEAT, 2009). Globally a model adopted for greening the world economy, including greening the energy sector is the one developed by the Millennium Institute (MI) called the global Green Economy Report (T21 – Global).

In the model *“[t]he scenarios modelled for the next few decades up to 2030 and 2050 include: 1) business-as-usual (BAU), which is based on the historical trajectory and assumes no major change in policy and external conditions; 2) allocating 1 or 2 per cent of the global GDP as additional investments to green 10 economic sectors – G1 and G2, respectively. Under G2, the energy sector receives a much larger allocation, bringing the analysis closer to the policy targets of reducing GHG emissions to levels necessary to maintain atmospheric concentrations of CO₂ at 450 ppm”* (UNEP, 2011;210). The BAU scenario implies that the dominant source of energy will

continue to be fossil fuel with a constant share of about 80 per cent until 2050. Under the G2 scenario, designed to achieve the maximum reduction in emissions, the renewable energy subsector is boosted with an additional 0.52 per cent of global GDP, in addition to the current investment and capacity trends in the subsector (UNEP, 2011).

Based on T21-Global, South Africa developed its own Green Economy Model (SAGEM) that seeks to assess the impacts of green economy investments in four sectors, namely, natural resource management, agriculture, transport and energy. *“Four scenarios were defined: BAU, or business-as-usual; BAU 2% representing a 2 per cent investment of gross domestic product in the BAU activities; GE 2% representing an allocation of 2 per cent of gross domestic product in green economy sectors (natural resource management, agriculture, transport and energy); and GETs, which is target-specific scenarios aimed at identifying whether policy-makers can achieve the medium – to long-term targets following green economy interventions in the prioritized sectors”* (UNEP, 2013:14). In essence two types of scenarios, the business-as-usual (BAU) scenario and green economy (GE) scenario, were developed for the SAGEM analysis. The BAU scenario assumes a general continuation of the current investment in the economy, whilst the GE scenario assumes that government will actively intervene in the four sectors in order to create a low carbon, resource-efficient and pro-employment development (UNEP, 2013).

The discussion about energy efficiency and renewable energy in South Africa, is, therefore premised on the two GE scenarios – GE2% and GETS, representing an additional investment of 2 per cent of the total real GDP (GE2%), and a priority-driven investment (GETS) in the selected sectors. *“GETs was developed based on the target expenditure and goals for the different sectors of interest ... for the case of (the) energy sector, the IRP 2010 electricity capacity targets were used...”* (UNEP, 2013:29). The GETs and GE2% scenarios are meant to add to the diversification of the energy mix in the power sector, create jobs and reduce CO₂ emissions.

The IRP (2010) has set the target of 17.8 per cent of newly built generation from renewables by 2030. *“In the GE2%, renewable energy constitutes 16 per cent of total energy generated. On the other hand, BAU and BAU2% scenarios have a lower*

share of renewable energy, which is 8.2 per cent for both scenarios ...Other documents, such as the NDP, have presented a higher target of 33 per cent of new generation from renewables. Such targets would require a more aggressive green economy investment intervention than GETs and GE2%” (UNEP, 2013:34). The GETs scenario would reach 24.4 per cent by 2030.

From the above discussion, it is clear that, even though the GETs and GE2% scenarios are useful, they are not enough for South Africa. In order to achieve the stipulated target of 33 per cent of renewables in the energy supply mix by 2030 in the NDP, more aggressive green investment is needed. As a way of suggestion, in an effort to be more aggressive, maybe as a country we need to go beyond the concentration on the GDP and government can be more interventionist. In the case of the mining sector a GE2% at a facility could be suggested. Making use of a company’s income statement, 2 per cent of the revenue could be dedicated to renewable energy, and energy efficiency initiatives could be encouraged.

In addition to the GE2% and the other GETs scenarios, the company’s 2 per cent of the revenue should reach, if not surpass, the 33 per cent of new generation from renewables. However, in lieu of the published Carbon Tax Policy Paper (2013) and the tax paid to government, many companies will think that they have been double-taxed. There are, however, other sectors of the community who will think that, this is not the case. To introduce GE2% for mining companies, we need to understand the current global economy, and the meaning of “development” to different people.

In order to understand this concept of “development”, Lang and Mokrani (2013) suggest that countries should move from “*Extractivism and Neoextractivism*” to “*Buen Vivir*”. The reason for this transition is necessitated by mainstream thinking that ignores either the planet’s physical limits or the finiteness of natural assets. “*It continues to offer us more expansion, more growth, and increasingly sophisticated technological solutions to natural disasters and energy crises. With the so-called “green economy”, the system has already identified the way to its next modernising leap forward: the commercialization of nature itself and of its conservation, the sale of pollution rights, and investment in renewable energies or harm-mitigation technologies, where all this promises juicy profits for the future markets*” (Lang &

Mokrani, 2013:6). In this way development is just thought of in a very narrow way – investment, exports and growth, which restricts the concept to advance and progress in the economic and social sphere. The most important sphere, ecology and limits of growth, is ignored.

2.11.1 A Move From Extractivism and Neo-extractivism to *Buen Vivir*

Over 500 years ago, with the conquest and colonisation of the Americas, Africa and Asia, a mechanism of colonial and neo-colonial plunder and appropriation was established on a massive scale. This mechanism became a mode of accumulation that could be termed extractivism, and forms the basis of today's world economy - the capitalist system. Extractivism “*refers to those activities which remove large quantities of natural resources that are not processed (or processed only to a limited degree), especially for export...not limited to minerals or oil...[but] present in farming, forestry and even fishing*” (Lang & Mokrani, 2013:62). The main problem with extractivism is how resources are extracted, used and their fruits distributed. Most of the time the rate of extraction is much higher than the rate at which the environment is able to renew the renewable resources, such as forests, and renders them non-renewables. This extractivism mostly benefits transnational enterprises that enjoy a favourable regulatory framework, and can ensure that policies are favourable to them.

The prioritisation of the extraction of the natural wealth for the world market has made all countries that are rich in natural resources, poor. This is because other forms of value creation using human effort other than the exploitation of nature have been ignored. In seeking to overcome this mode of accumulation some progressive governments in South America have created a new type of extractivism, which Langs & Mokrani (2013) call “neoextractivism”. This is a combination of old and new attributes/components of extractivism. “*What this [neoextractivism] natural stance is mainly trying to achieve is greater state access to and control of natural resources and the benefits that their extraction produces. From this point of view, the control of natural resources by transnational corporations is what is criticized, rather than the extraction itself. Some damage to the environment and even serious social impacts are accepted as the price to be paid for the benefits that are obtained for the*

population as a whole” (Lang & Mokrani, 2013:72). In order to socially legitimise extractivism as indispensable for combating poverty and promoting development, some of the revenue is used in financing social programmes.

It could be concluded, therefore, that, based on the above discussions, extractivism could be seen as two sides of the same coin. The world needs to get out of an extractive economy, and promote sustainable activities. This requires “*put[ting] in place new and vigorous state institutions and a new way of organizing the economy... strengthen[ing] the domestic market and the productive apparatus within the country, as well as designing transition strategies for production that will lead to the extractive industries becoming increasingly less important to the economy*” (Lang & Mokrani, 2013:81). This calls for a new type of productive endeavour that ensures that countries are internally sustainable, based on a broad consensus when it comes to different interests. In summary, the recent debates that were ultimately presented as a solution to both extractivism and neo-extractivism”, namely the “Green New Deal” or the “green economy” will not provide the necessary solution.

According to Lang & Mokrani (2013), the solution lies in a shift to a concept termed *Buen Vivir*. “*Buen Vivir, as the principle and goal of public policies and the foundation for both the model of state and the economic model, is inspired by the indigenous ideal of a harmonious relationship between living beings that ensures diversity, life and the equality of redistribution...[It] involves social change: the state is expected to guarantee the basic conditions for the reproduction of the life of its production without jeopardizing the regeneration of the natural biodiversity. It involves exchanging the market system for one that vindicates the right of life (sustenance, reproduction and subsistence) and subjects the economy to social and political criteria*” (Lang & Mokrani, 2013:147). Transitioning to this model of state requires substantial changes to the regulation of capital, and different subsidies that states provide to increase extractivism. It requires a far-reaching reform of the state, which is not just limited to financial aspects, and this calls for effective public policies.

Against this background, the suggestion that companies should provide special GE2% is paving a way for *Buen Vivir*. This position will introduce the price corrections

needed to take into account environmental and social costs associated with extractive companies. In the mining sector, because of the MEC phenomenon, the implications could be huge. Given the inadequacies of both GETs and GE2%, interventions as radical as this one may provide hope in stopping development that is wrought with negative impacts, and bringing in one that enforces co-existence with nature.

Lander (2011) is also very critical of the green economy as espoused by UNEP, because the re-launching of the global economy promotes even higher growth rates than the current model. By investing 2% of the planet's GDP, and introducing incentives based on the market demand, UNEP believes that capital investment will be re-orientated in the direction of green investments and green innovations. All UNEP's policies are meant to defend the sacred right of the free market, despite the evidence of the planet's limitations and crises caused by the current patterns of civilisation. By repeatedly referring to policies and never to politics, the report fails to consider the significance of the existing unequal power relations in today's world. *"The authors of this report... seem to believe (or they would have us believe) that the existing political regimes and the so-called "policy formulators", are able to impose norms and behaviour on the corporations and the financial markets. They seem to assume that finance capital and the transnational corporations that are operating as active agents of the accelerated devastation of the planet, do so not because that is how they seek to maximize their profit margins in the short terms, but because they do not have enough information, or because the signals they receive from the regulatory frameworks within which they operate are not clear enough. These authors opt to ignore the fact that the capacity of existing political systems to establish regulations and restrictions to the free operation of the markets – even when a large majority of the population call for them – is seriously limited by the political and financial power of the corporations"* (Lander, 2011:9).

2.12. Is the EEA Working?

The 2005 National Energy Efficiency Strategy suggested a national overall target of energy demand reduction of 12% but the industry target, including mining, as 15%. The largest companies, mainly in the industrial and industrial mining sectors have, since 2008, been working with government through a voluntary Energy Efficiency Accord to promote and implement energy efficiency. With the National Business Initiative (NBI) playing both the management and secretariat role, an Energy Efficiency Technical Committee (EETC) was formed to convene and co-ordinate the business of the Accord and its link with government activities (DME, 2008). In November of 2008, an assessment study of the Energy Efficiency Accord was done by the NBI on behalf of the Department of Miners and Energy (DME). This study highlighted both successes and weaknesses of the Accord and provided some suggestions for improvements. The two sections below will discuss the weaknesses and ways suggested to address them.

2.12.1 EE and RE Challenges in the Mining Sector

The overall objective of the EE Accord is to reduce energy consumption by using 2000 as the baseline year against which performance would be measured. In the assessment study done (DME, 2008), the report concluded that the year 2000 was not suitable for a large number of the Accord signatories. *“This means that a significant number of the signatories made the Accord commitments without assessing their preparedness to report on their progress”* (DME, 2005:38). The other shortcoming of the Accord was that, even though there was an energy efficiency target of 15% by 2015 against 2000 baseline, no intermediary targets between the years 2000 and 2015 were agreed upon.

The main problem, however, was with regard to how the energy savings were quantified. Some companies just took the difference between their current

consumption and that which they used to consume in the baseline year as their savings. This favoured a few companies whose consumption would have decreased for some reasons other than energy saving, e.g. a company's scale down. For most companies, mainly because of company production growth, there would be an increase in energy consumption, even though efficiency was improved. Using this methodology, there is always an inherent error in the captured energy savings or otherwise of companies. *"The reduction in final energy demand should rather [be] calculated as the difference between what would have been the projected final energy demand without any energy interventions and the current energy consumption attained through application of energy efficiency measures"* (DME, 2008: 39-40). The final energy consumption should be wider than electricity by including coal, diesel, petrol and natural gas. Where applicable, the list should be extended to include illuminating paraffin, jet fuel, heavy fuel oil (HFO), liquefied petroleum gas (LPG), crop husks, wood bark and black liquor (a by-product of the paper-making process).

The fact that a final energy demand reduction can be a result of reduced production that is not necessarily energy-efficient, demonstrates that the EE Accord method of using final energy demand reduction as an indicator for energy efficiency, is flawed. Internationally, a more acceptable measure of energy efficiency is "energy intensity" which indicates the extent to which energy is used in producing a specific output. *"Energy intensity of the production of a product or delivering a service is defined as the amount of the energy consumed in the production or service delivery usually measured in GJ expressed as a ratio to total production for any given year"* (DME, 2008:46). Therefore, energy intensity improvements in the different processes of a facility should be used, rather than an absolute reduction of energy consumption.

The National Energy Regulator of South Africa (NERSA) approved and allocated financial support, the Energy Efficiency and Demand-side Management (EEDSM) fund, for energy efficiency and demand-side management projects that are more financially and environmentally beneficial

to the economy compared with supply-side solutions. The fund, implemented by Eskom, was introduced in order to make EEDSM projects viable. These are projects that have unreasonably long payback periods and are therefore unattractive for investment, due to the historically low price of electricity in the country. The fund was a commitment made by government to the Accord signatories to provide support in terms of financial incentives for energy efficiency projects.

According to the Assessment Report (2008), the EEDSM fund performed dismally because of various reasons, including:

- The long approval lead times, the majority of which were between 18 and 24 months;
- The insignificance of the total amount contributed by the fund – by 2008 the EEDSM fund contribution was just over R565 million, compared with over R9 billion that the Accord signatories have invested themselves in EE projects (DME, 2008); and
- The lack of skills amongst the Energy Service Companies (ESCOs) who are tasked with implementing the projects.

The Accord is voluntary and exclusively concentrates on energy efficiency. However, through another programme, the Power Conservation Programme (PCP), government suggests a mandatory further reduction target of 10% for major consumers not concerning energy efficiency. *“The programme is designed to accelerate the achievement of energy savings through behaviour change and promoting the use of demand-side management (DSM). The reduction in consumption will also provide Eskom with the ‘breathing space’ necessary to address unplanned maintenance and possible slippages in the tight planned timeline for bringing new capacity onto the grid between 2008 and 2013”* (NERSA, 2008:3). Accord signatories, many of whom fall into the major customer category, are likely to investigate other options for reducing energy use such as production cut backs, staff buy-off, and changes in shift and occupancy to avoid the substantial penalties that come with failing to meet new quotas. In addition to having the potential to seriously compromise the

Accord programme, PCP is likely to impact heavily on companies' expansion plans.

The literature review for the EEA showed a serious challenge in estimating, measuring and evaluating the amount of energy savings of many companies. Of critical importance is the establishment of an energy baseline that leads to correct measurement. The Australian Government's Energy Savings Measurement Guide (2013) lists three main methods for establishing an energy baseline:

- a) Regression analysis – determining the relationship between a dependent variable (energy consumption) and an independent variable (variables that affect energy consumption, e.g. production rate, product mix, raw material, occupancy and ambient conditions), by analysing data to develop an equation that describes the relationship (regression line).
- b) Modelling/Simulation – using process data and engineering calculations to model or simulate a process. Completion of an energy-mass balance or equivalent is an effective way to model.
- c) Short-term metering – used for processes that have constant or easily established patterns of energy use that represent fixed energy consumption. Stable energy profile is then metered and used as an energy baseline.

In addition to the main method there are other methods:

- d) Absolute energy use – based on historical data and applicable to a constant process or if required for regulatory purpose (as with the baseline year), but not applicable to processes that are subject to variation.
- e) Specific energy ratio baseline – using a historical average energy intensity figure to estimate future performance.
- f) Multivariate specific energy ratio baseline – using a ratio of energy use to two or more variables.

It is the absolute energy use method that the South African Government and private companies have chosen to use by relying on the use of a baseline year. However, as discussed above, this makes the assumption that processes have constant and easily established patterns of energy use, and hence represent fixed consumption. This assumption, without taking into account issues such as energy price escalations, firm's expansion/contraction, and process improvements, can lead to incorrect energy savings' calculation.

Developing a robust and true baseline enables accurate opportunity evaluation and informed business decisions. *“The majority of energy savings cannot be measured directly, but are calculated from a comparison of pre- and post-implementation energy consumption. The pre-implementation energy use is not the current level of energy use, but a forecast of the energy consumption if the opportunity is not implemented”* (Department of Resources, Energy and Tourism, 2013:29).

The environment in which mining companies operate also presents a challenge all over the world. Mining companies are facing operational complexities and operate in the context of global pressures. The global pressures include current decline in demand and unfavourable commodity prices and mining conditions, regulatory uncertainty following a trend of resource nationalisations, political stability, and investment-friendliness (Deloitte, 2013). In addition to these global pressures, mining companies with South African operations have to face additional complexities in the local environment. Despite having the world's largest reserves of platinum, manganese, chrome, vanadium, and gold, as well as major reserves of coal, iron ore, zirconium and titanium minerals, the *“mining industry[’s] relative contribution to the economy has declined due to the growth in the financial and real estate sectors”* (Deloitte, 2013:5).

For developing countries like South Africa, there are huge expectations from workers, communities and government as to the role mines should play in society. While in developed countries, social needs such as the provision of basic services, education and healthcare are typically addressed by government, the developing countries' governments, although not clearly

defined, expect mining companies to fulfil these social needs. In addition, local communities demand employment opportunities. *“This puts mining companies in a tenuous position, with corporate social responsibility (CSR) today extending well beyond the legal requirements. South African mining companies require a deep understanding of shifting community and government expectations and a commitment to a high level of transparency and operational sustainability to address the demands of relevant stakeholder groups”* (Deloitte, 2013:5).

These demands and expectations are basically rooted in the history of colonialism across Africa. Most mining companies are foreign-owned and are, therefore, viewed by communities as entities with no long-term commitment to the country. They are consequently blamed for generating wealth and repatriating dividends, leaving behind an irreparably damaged environment that impoverishes the local community. This shows how challenging the relationship between mining companies and host countries’ governments can be.

2.13 Conclusions

Despite the difficulties outlined above, significant gains in terms of energy management, energy savings, energy intensity improvements and energy efficiency investments, have been made by the Accord signatories (Assessment Report, 2008). However, a consistent and accurate measurement system must be developed so that energy efficiency gains can be properly acknowledged and aligned with other government policies or initiatives such as LTMS and PCP. In addition, the energy savings should not be exclusively electricity savings, but must cover other energy sources as well. To achieve this, instead of only having long-term goals such as is the case currently, clearer targets need to be set for short- and medium-term goals as well.

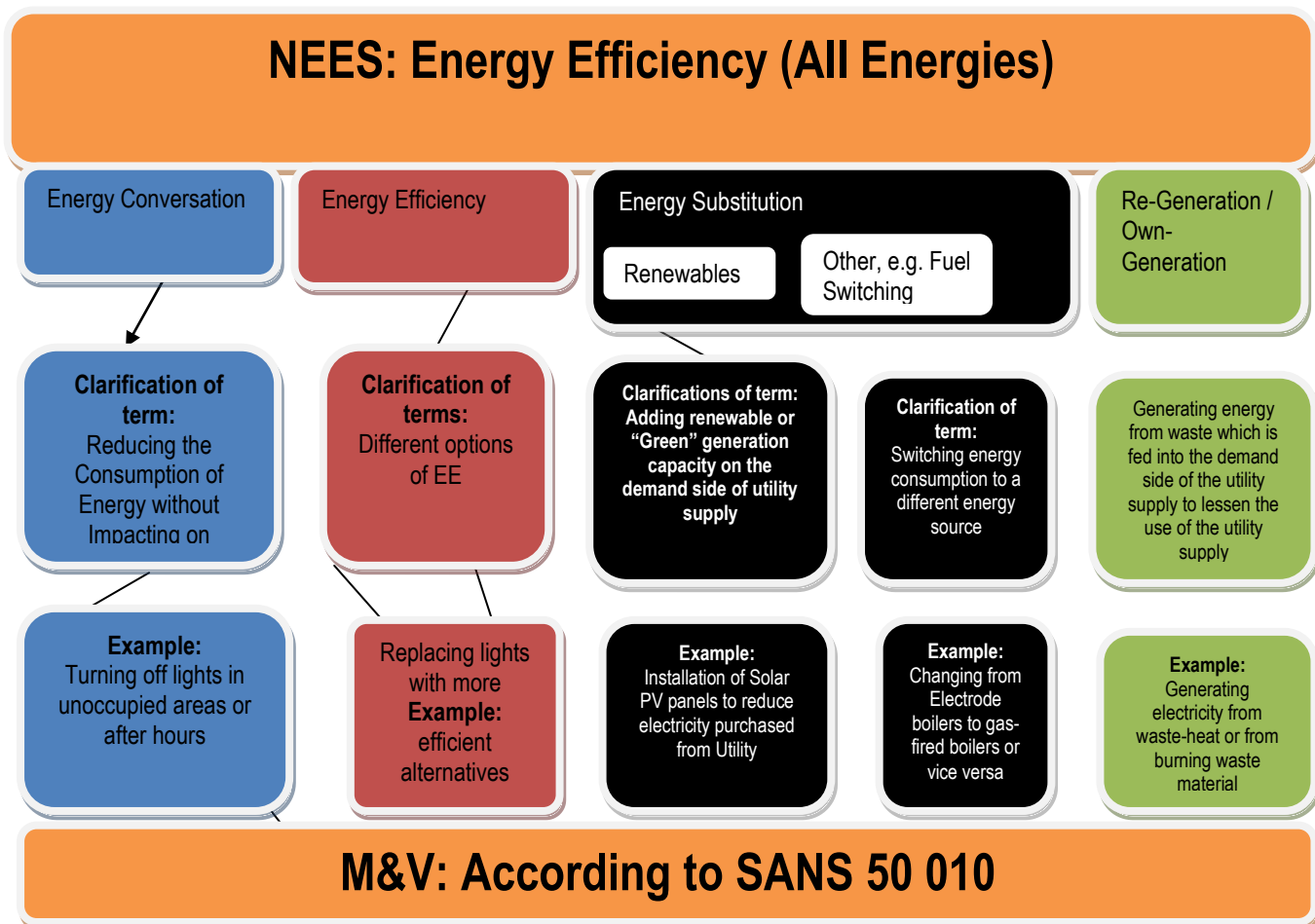
In 2012, a second review of the National Energy Efficiency Strategy (NEES) was published which expanded on the previous versions in accordance with international best practice and in line with the plans for climate change

mitigation. In this strategy, international instruments have been set out in Sector Implementation Plans for deployment by government, businesses and civil society. Private and public enterprises have committed to these plans. *“Whereas the first edition of the NEES was aimed at creating an awareness for the importance of efficient use of energy, the 2012 revision takes a longer view [two decades] at what all sectors in the South African society can make towards creating a sustainable future ...”* (DOE, 2012:ii). However, initial targets set for 2015 in the initial version are still applicable and commitments to targets beyond 2015 are still to be finalised.

The success of NEES will, henceforth, be measured according to the principles set out in the National Standards for Measurement and Verification of Energy Savings (SANS 50010). Amongst a number of different energy management options that contribute to energy efficiency, the following must always be included for reporting purposes as well as for tracking of performance against targets:

- Energy Efficiency
- Energy Conservation
- Energy Substitution by renewable energy sources on the demand side
- Energy Substitution through fuel switching –the switch to a different fuel results in a de facto improvement in energy efficiency
- Re-generation – where energy generated is used to offset purchased energy from the grid. (DoE, 2012).

Figure 5. Energy Efficiency Options to be considered



Source: NBI (2011)

At the end of 2011, the Energy Efficiency Leadership Network (EELN) was launched to supersede the Energy Efficiency Accord. This network is convinced that that largest energy savings and optimal performance can be brought about by the elimination of unnecessary wasteful usage. In the energy efficiency space, therefore, this could be achieved through two different but linked actions, namely: behavioural changes and technology. For this purpose, this network adopted the American Society of Energy Engineers' approach, as shown in fig 4 above, on how to achieve sustainable energy savings (NBI, 2013).

“Given the potential for high energy savings from proven technologies and behavior change, EE has become a key priority for most governments globally, and indeed for many private companies who actively manage their energy usage and consumption costs. To

promote the uptake of EE; incentive programmes, tax breaks, and legislation have been introduced ...” (NBI, 2013:6)

The EE reduction targets set out under the NEES still remain just aspirational and governments will rely on the effective implementation of initiatives such as the EELN for their achievement.

As discussed in the sections above, there are many ways in which energy efficiency can be achieved in the mining sector. There are also many ways in which renewable energy technologies could be implemented. There might also be substantial achievements on these fronts. However, there seem to be uncertainties as to how to measure these achievements. This calls for some accurate indicators for both measurement and verification. With the conversion of the 2008 Energy Efficiency Accord (EEA) to the Energy Efficiency Leadership Network (EELN) in 2011, which emphasises behavioural changes and technology, maybe there is hope that great improvements will be seen. At the end of it all, if the South African Government is serious about energy efficiency and renewable energy, a decision has to be made whether regulation should be preferred over voluntarism, as is the case with the EEA and now EELN.

In the South African context, the challenge in estimating, measuring and evaluating the amount of energy savings for many companies is evident. The first step in solving this challenge is the correct establishment of the energy baseline. In this literature review the researcher has discussed several methods for the establishment of the energy baseline and indicated the route that the South African Government and private companies follow, namely, the absolute energy use method based on the use of a baseline year. Although an easy method to follow, it may not be accurate enough due to a variation in a number of processes over time in mining companies. This assertion is confirmed in both the 2008 and 2013 Energy Efficiency Strategy Reports (DoE, 2012). For both EE and RE initiatives to be successful, four issues appear to be critical, namely: (i) the establishment of an accurate and credible baseline, (ii) the elimination of unnecessary waste, (iii) processes and technology, and (iv) behavioural change.

This research then focused on three categories into which these issues were measured, and excluded the baseline establishment for reasons discussed. These categories under behavioural change for instance, covered factors such as skills development, resistance to change, corporate support, vendors offering solutions, awareness and knowledge. The elimination of unnecessary waste factors (such as cost reduction and revenue growth), and processes and technology opportunities for both EE and RE (in extraction, motor systems, fans, lighting, etc..) were gauged to establish if these issues are addressed by South African mining companies.

South Africa's renewable energy policy to date has largely been driven by a voluntary 10 000 GWh target by 2013 and renewable energy subsidies offered through the Renewable Energy Finance and Subsidy Office (REFSO). REFSO's mandate includes the management of renewable energy subsidies, and offering advice to developers and other stakeholders on renewable energy finance and subsidies. Since the establishment of REFSO, only six projects (3 small-scale hydro, biogas to electricity, wind energy and landfill gas to electricity) with a total installed capacity of 23.9 MW have been subsidised (DoE, 2014). In 2009, the government began feed-in-tariffs (FITs) for renewable energy, but these were later rejected in favour of competitive tenders. The resulting program, now known as the Renewable Energy Independent Power Producer Procurement Program (REIPPPP), has successfully channelled substantial private sector expertise and investment into grid-connected renewable energy in South Africa at competitive prices. To date, a total of 64 projects and private sector investment totalling US\$14 billion, have been committed and are expected to generate 3 922 MW of renewable energy.

Chapter 3 – Research Methodology

3.1 *The Plan*

At this phase of the study, the research carried out a literature review that tried to be exhaustive, fair and topical (Mouton, 2013). The literature review concentrated on opportunities, drivers and barriers for energy efficiency improvements and renewable energy initiatives in the mining sector. The literature review led to the development of a set of broad and specific research questions. These questions are:

- (i) What are the EE and RE targets in South Africa in general, and in the mining sector in particular?
- (ii) What are the policies, plans and strategies in achieving these EE and RE targets?
- (iii) What are some of the EE and RE initiatives that mining companies can be, and are, involved in to try to achieve their EE and RE targets?
- (iv) What are the drivers and barriers for these initiatives?
- (v) What role can the state play in the achievement of these initiatives?

In order to explore these research questions, the researcher prepared a set of interview questions and a detailed questionnaire. The researcher then sent the developed questionnaire to all mines in the sample and conducted a semi-structured interview process with selected managers in the sample. The data collection and method employed, therefore, was interviewing using (a) a structured self-administered questionnaire (b) structured telephone interviewing, and (c) semi-structured focus group interviewing (Mouton, 2013: 105). The researcher also identified both Exxaro and Anglo Gold as relevant case studies on how to undertake EE and RE initiatives in the mining sector.

The collected data were, therefore, both quantitative (survey questionnaire) and qualitative (interviews). The timeframes were as represented by figure 5 below:

Figure 6. Timeframes for Research

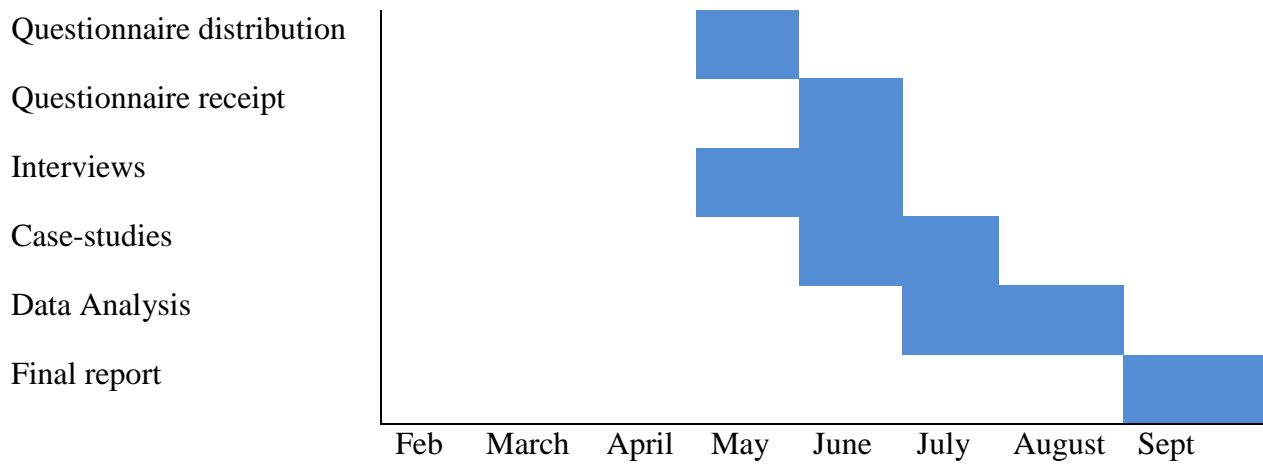
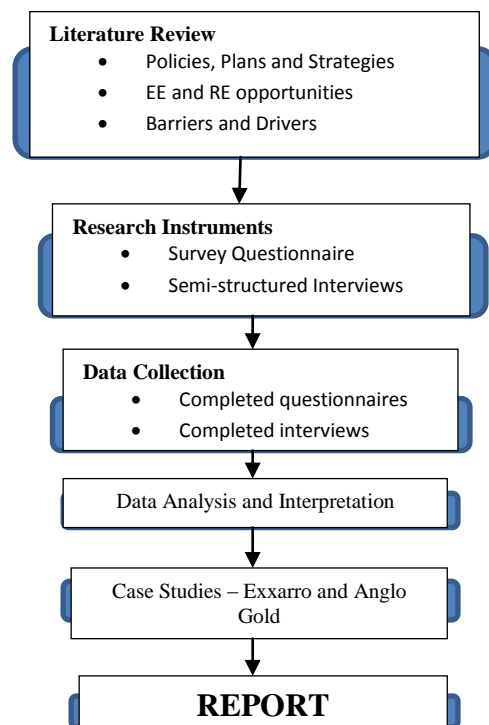


Figure 6 below shows the research methodology used in the thesis:

Figure 7. Research Methodology Flow Scheme



Note: Adapted from Bergh (2012)

In South Africa there are five categories for the mineral mining industry, namely: platinum group minerals (PGM), gold, coal, vanadium and diamonds (Anglo

American, 2014). In this study, the researcher has chosen mining companies that cover all these categories to make my sample more representative. The companies are also members of EELN. In addition to trying to cover the five categories, location was used in choosing specific mines. The idea was that the mine must be as close as possible to Gauteng, where the researcher resides in order to cut costs in the event that specific mines needed to be visited.

Based on these criteria, Anglo American, as one of the world's largest diversified mining groups, became the obvious choice. Anglo American's portfolio of mining spans bulk commodities –iron ore, manganese, metallurgical and thermal coal, base metals and minerals (copper, nickel, niobium and phosphates), and precious metals and minerals (platinum and diamonds, headquartered in the United Kingdom (UK), are listed on the London and Johannesburg stock exchanges). Another global leader, but in the gold mining sector, Gold Fields was chosen. Gold Fields has a primary listing on the JSE Limited, with secondary listings on the New York Stock Exchange, NASDAQ Dubai Limited, Euronext in Brussels and the Swiss Exchange. While Anglo American history dates back to 1917 through Ernest Oppenheimer, Gold Field's history can be traced to Cecil John Rhodes since 1887.

The researcher has therefore randomly chosen the following mines:

Table 1 – Mines Sample

Business Unit	Commodity	Mine
Anglo Gold Ashanti	Gold	Mponeng Tau Tona Moab Kgotsong
Anglo Platinum	Platinum	Bathopele Khomanani
De Beers	Diamond	Venetia
De Beers	Diamond	Voorspoed
Kumba Iron Ore Limited	Iron Ore	Sishen
Exxaro Resources Ltd	Coal	Grootegeeluk Thabametsi Matla
AngloGold HCL	Coal Coal	Anglo Thermal Palesa
Hernic	Ferrochrome	Bokfontein
Chronimet	Chrome	Chronimet
African Rainbow Minerals	Nickel	Nkomati
South Deep	Gold	South Deep

The researcher has decided to discuss two case studies that will demonstrate the EE and RE initiatives in which mines can be involved. The first case study involves Exxaro Resources Limited because of its strategic operations in the Waterberg Coalfield. According to Exxaro Resources' CEO, Siphon Nkosi, quoted in Chamber of Mines, Mining Magazine, (2009:7) "... *the Waterberg ha[s] sufficient coal to host eight power stations and ... Exxaro would be coal-mining there for the next 200 years*". Despite a number of electricity generation alternatives being suggested, Eskom has planned that the Waterberg Coalfield should produce 4 200 MW (i.e. 20% of the country's 20 year new generation plan) with the introduction of its new Medupi Power Station, adjacent to the Grootegeluk Mine owned by Exxaro Resources Limited.

Due to this dynamic, Exxaro prepared its Exxaro Medupi Project with the objective of providing 14.6 million tons per annum (Mtpa) of coal to Medupi. At the same time it is exploring opportunities in the energy market with a focus on cleaner energy initiatives, including plans for five renewable energy projects – two solar and three wind projects. The case study, therefore, showcases Exxaro's attempts to reduce its carbon footprint through the use of renewable energy.

The second case study demonstrates how mines can make a contribution to the National Energy Efficiency Accord. As an example, AngloGold Ashanti introduced a new cooling system at Mponeng Mine in pursuit of improved energy efficiency. Other initiatives include installing a number of peak clipping, demand-side management and energy efficiency projects such as the use of compact fluorescent light (CFL) bulbs and the commissioning of an energy efficient DSM-funded pumping project – a three-chamber pipe feeder system – at its Moab Khotsoeng Mine at Vaal River.

The study, with the information gathered through the survey questionnaire, interviews, and two case studies, should provide valuable insight into EE and RE landscape in the mining sector.

3.2 The Strengths and Limitations

The interviews, although time-consuming and not easy to secure, were considered necessary as, unlike self-completion questionnaires, they allowed the interviewer to explain questions that respondents did not understand and allowed further elaboration of replies. Self-completion questionnaires proved to be cheap, but constrained respondents to fixed categories of responses. Their major advantage though, is their ability to reach people who are dispersed over a wide geographical area. Because of this advantage, the sample size was increased tremendously. With face to face interviews, cost, time, and availability usually limits the size and geographical coverage of the survey (Phellas, et al, 2011).

There is a lot of information that is relied upon and used from the self-completion questionnaires in this thesis. However, there are some disadvantages in relying too much on such information. Although the right people to fill out the questionnaires could be identified, there is no way in which the researcher can ensure that the right person has completed the questionnaires. The researcher, therefore, has no control over who fills out the questionnaires. Secondly, because the questionnaires are emailed, the researcher has no opportunity to probe replies or clarify misunderstandings. Lastly, responses were dependent on the amount of interest in the subject by the recipient, and the low level of response obviously affects the findings and outcomes. The email surveys are, therefore, used with utmost caution to generalise findings to the whole population. However, with the respondents being anonymous, the reliability of responses tends to increase (Phellas et al, 2011). A clearer picture is therefore drawn.

Ordinal variables, that is, variables that involve some notion of order or rank between categories, were used to give the level of measurement. These variables, however, do not give a sense of distance between two adjacent points on a scale. For instance, in the preference scores where 1=completely insignificant and 5=completely significant, the difference between 1 and 3 cannot be quantified.

3.3 The Execution

Two data collection instruments - self-completed questionnaires and interviews - have been used. The interviews have been done face to face, while the questionnaires have been sent and returned via email. A fixed-choice question format, in which respondents were given a number of options from which to pick an answer, was used in the questionnaire. As the last step in the design of the questionnaire and the interview schedule, a test or "run" was done with two participants, prior to the conducting of the actual research. The aim was to reveal some unanticipated problems with instructions, wording of questions, and possible wrong interpretations. This helped both the participants and researcher to have the same understanding of the questions and to avoid many misinterpretations.

The main interview objectives were to establish how decisions regarding energy efficiency and renewable energy are done in mining companies. In addition, the interviews sought to establish the status quo as well as staff and management awareness of the energy efficiency and renewable energy initiatives in which mining companies might be involved. For ease of scheduling, Group Environmental/Energy Managers were chosen as respondents. The researcher managed to have three face-to-face interviews; two Energy Engineers and one Energy Manager.

In the survey Environmental Managers/Engineers, Environmental Superintendents, Heads of Environment, Sustainable Development Engineers and Energy Managers at mine level were conducted. Although a whole range of possible respondents were contacted and requested to complete the survey, the response rate was very low. Out of the 17 questionnaires that were sent, only 7 responses were received; despite many email and phone call reminders that were made. In choosing respondents, a simple random sample technique was used.

The first questionnaire tried to establish which of the listed factors or drivers were considered significant in influencing decisions regarding investing in energy efficiency or renewable energy projects in a mining company. These factors or drivers could broadly be divided into financial (energy cost/cost reduction, energy security/risk management or competitiveness), regulatory/policy (climate change,

carbon tax environmental levy, demand-side management or policy and regulation) or market (brand enhancement, EE or RE technology or staff and management awareness) categories.

The second questionnaire tried to identify processes and systems that offer the greatest opportunities for energy efficiency and renewable energy initiatives in mining companies given the current technology status. The first category refers to the fundamental process and equipment (extraction, materials transport and handling, beneficiation and processing, motor systems, compressed air systems, pumps, fans, lighting, heating using heat pumps and solar, refrigeration). The second category refers to the significance of institutional/organisational and personal behavioural change (corporate support, organisational energy policy, etc).

Chapter 4: Exxaro Case-study

4.1 Introduction

Exxaro Resources Ltd (Exxaro) is a South African majority black-owned resources consortium formed in 2006. It came about as a result of the empowerment process that involved a merger of Kumba Resources and Eyesizwe, and has mining interests in coal, iron ore, industrial minerals, base metals and mineral sands. In producing power station coal, steam and coking coal, about 60 per cent of Exxaro's revenue is as a result of coal mining. Exxaro's power station coal supplies Eskom and municipal power stations. For the next 40 years Exxaro will be supplying Eskom's Medupi Power Station.

Given mining operations' high environmental impact, Exxaro developed a safety and sustainable development policy in an effort to promote sustainable development in its practices as part of its brand. *“To this end, Exxaro observes all environmental legal requirements and all other environmental compliance requirements that are not necessarily statutory, for example the Carbon Disclosure Project; and has internal processes that include the development of innovative policies and programmes aimed at tackling impacts of company operations on the environment and use of natural resources. Among others, some of the specific sustainability initiatives by Exxaro include: biodiversity, air quality management, water conservation, mine rehabilitation, environmental policy compliance and environmental reporting”* (Nhamo, 2014:72). To show further leadership and responsibility, Exxaro became a signatory of the United Nations Global Compact as a voluntary initiative. In dealing with change concerns, Exxaro started adopting the Energy Efficiency Accord in 2006, and thereafter became involved in carbon accounting, climate research funding, fume extraction and development of renewable energy projects. This chapter will discuss some of the

developments of energy projects from renewable sources and cleaner energy technologies implemented at Exxaro.

4.2. Lephhalale eco-housing project

When Eskom announced its plan to construct the Medupi Power Station, Exxaro decided to expand its Grootegeluk Coal Mine to provide for the additional 14.6 million tonnes of coal that will be required by Eskom per annum, (Nhlo, 2014). The two projects changed the growth of Lephhalale (previously Ellisras) from a small rural municipality into a metropolitan area. This growth required the simultaneous expansion of infrastructure. *“Due to the planned expansion, housing had to be provided for approximately 550 new workers, as well as a backlog of approximately 247 units for employees already in service at Grootegeluk but who were staying in rented accommodation in Lephhalale. Projected building costs for the 797 houses were around R590 million. To Exxaro, this was an opportunity to implement corporate social responsibility strategies, including skills development and socio-economic development”* (Nhlo, 2014:82). This was an opportunity for Exxaro to reduce both its GHG emissions and energy demand in its new housing development.

The houses built had to be less reliant on a grid connection for electrical energy, through the incorporation of energy efficiency initiatives and design elements. The main design features of the houses included houses facing north-north-east and located between trees for better temperature regulation and efficient lighting, insulation for improved temperature regulation and hence savings on energy costs, overhanging roofs to capture rain water and also reduce cooling requirements, solar water heating, and installation of evaporative cooling instead of standard air cooling units. By incorporating the energy efficiency goals as set by the Department of Energy (DOE) into the plans for the housing, a 40% saving on municipal accounts due to electricity and water savings was targeted. *“[T]he Lephhalale housing initiative will result in the direct savings of 2334 MWh per annum or the equivalent of 2400*

CO₂e/t. Using a potential carbon tax of R100 per tonne of CO₂e, this will result in a saving of R240 000 per year for Exxaro employees who are the beneficiaries of the housing project, should carbon tax be implemented” (Nhano, 2014: 83-84).

In preparation for the company’s and the provincial housing department’s future housing projects, Exxaro initiated another pilot building project in the nearby town of Marapong. The pilot project involved the construction of five houses through the use of environmentally friendly materials and appliances. These materials and appliances included eco-friendly bricks, zinc-fuel battery systems and electrical appliances, whose cost-effectiveness must be proved. In addition, the pilot was used to impart both civil engineering and entrepreneurial skills to disadvantaged youths of Marapong. Working with Eskom, Sasol, government and local stakeholders, the company initiated the Lephalale Development Forum (LDF). The LDF ensured that, through the pilot project, 24 direct jobs were created, and of the total investment of R25.2 million, 40 per cent was given to local suppliers. In summary, both the Lephalale project and the pilot project in Marapong demonstrated positive impacts with regard to energy savings, environmental awareness, skills development and provisioning of infrastructure.

The construction of the houses was based on social, environmental, and economic aspects of sustainable development as they cater for mixed and affordable housing types, with a reduced requirement for energy and water, and skills training and small enterprise development. *“The environmentally-friendly credentials of the homes include[d] being positioned to face north-east and between trees for improved temperature regulation and efficient lighting; solar powered geyser reduce electricity consumption, as does the installed insulation which regulates indoor temperatures; grey water which is not suitable for human consumption is recycled for use in toilets, gardens and for washing cars”* (Exarro, 2014).

According to Mining Weekly (2011) the 797 houses, required for 1124 current employees and new team members who will operate beneficiation plants

Grootegeeluk 7 and 8, include 81 housing units and 284 flat units in Onverwacht and 292 flat units in Marapong, and cater for different needs and grades. Exxaro undertook this project with a goal to reduce its energy use by 15% by 2015, in line with the Energy Efficiency Accord for industrial and mining sectors.

4.3 Exxaro's Clean and Renewable Energy Initiatives

South Africa, in an effort to embark on a development path based on renewable energy, has decided to attract private sector investment into the renewable energy sector. A new policy framework, the Integrated Resource Plan (IRP 2010), was, consequently formulated in 2010, and set out goals on how South Africa was to diversify its energy mix. The IRP 2010 made a commitment that renewables will make up 42% of additional new capacity of energy by 2030. Based on this commitment, Exxaro and Tata Power decided to develop a pipeline of projects around renewable energy. A market-based Renewable Energy Procurement Program for Independent Power Producers (REIPPP¹) flowed from the IRP 2010 and allowed companies to bid competitively.

In 2012 Exxaro and India's Tata Power entered into a joint venture and established a company named Cennergi (Pty) Ltd., an independent power producer (IPP) that would participate in renewable energy bids opened by the government. Cennergi undertook to have wind, solar, co-generation, gas, coal base load and bio-fuels as its areas of focus. In March 2012, responding to the Department of Energy's (DDE) request for proposals (RFPs) for new generation capacity, Cennergi submitted two solar and three wind energy projects (a total of five). However, only two contracts were awarded under the government scheme to buy 3725 MW of renewable energy from the private sector.

¹ [www.energy.gov.za/files/events_overview % 20 IPP.html](http://www.energy.gov.za/files/events_overview%20IPP.html)

Cennergi was granted preferred bidder status on two of its renewable energy projects that formed part of the second bidding window for the DOE's REIPP. This forms part of Cennergi's goal of achieving 1.6 GW of renewable projects by 2025. The two projects are a 134 MW wind farm, the Amakhala Emoyeni Wind Farm, located near the town of Bedford in the Eastern Cape, and a 95MW wind farm, the Tsitsikamma Community Farm, located on the Mfengu Community land in the Eastern Cape. The two amounting to 229 MW represent 35% of the second window's wind allocation of 650 MW, which Cennergi regards as a huge success.

4.3.1 The Tsitsikamma Community Wind Farm (TCWF)

The story of the Tsitsikamma Community Wind Farm (TCWF) starts with the story of the community of amaMfengu who were forcefully removed from an area rich in vegetation and good for farming, spanning 6000 hectares in Tsitsikamma, to an arid area further north in 1977 (Qobo, 2013). In the confrontations that followed, some members of the community sought refuge in foreign countries. *“One such individual was Mcebisi Msizi, who came from the Tsitsikamma community and resettled in Denmark in the mid – 1970s. While in Denmark, he was inspired by images of the wind turbines that were part of his surroundings. Intuitively, he thought that the weather conditions, especially the wind velocity was not much different from what he had experienced back home in Tsitsikamma. He was captivated by the idea that power could be harvested from wind and bring electricity to many homes on an affordable basis”.* (Qobo, 2013:3-4). Msizi returned to South Africa in the mid – 1990s with a strong conviction that the wind idea must be pursued in Tsitsikamma. To garner support for his idea he consulted various stakeholders in government and the Danish Embassy in South Africa. In addition, he shared his vision with the amaMfengu Tsitsikamma community that, by then, had had its land restored back to their ownership under the Tsitsikamma Development Trust (TDT).

As the community was thinking about creating value with this land to ensure sustainable development, Msizi's vision was supported. *"Msizi found a like-minded partner, Mark Scheepers, and entrepreneur who came from the other side of the racial divide... The two individuals had much in common with respect to the vision of installing wind turbines that would create social benefit for the community in the process. They went ahead and formed a company – Watt Energy – as a basis for the realization of their vision"* (Qobo, 2013:4). Through the support of the Danish Embassy, Watt Energy determined the viability of wind power generation in the land owned by amaMfengu, the Wittekleibosch, in the Tsitsikamma area.

It was by coincidence that, around 2011, the partnership between Exxaro and Tata Power, although still at an incipient stage, was working on developing a pipeline of projects around renewable energy. After the establishment of Cennergi, a partnership was formed between Cennergi and Watt Energy. *"The Tsitsikamma Community Wind Farm (TCWF), a special – purpose vehicle (SPV) that was subsequently formed as a driver of the project, leased, the land from TDT at a commercially agreed cost. Watt Energy and TDT equity stakes were secured against a loan provided by Cennergi. Watt energy would reimburse the entirety of its loan out of future dividend payouts with interest. 2.5% of TDT's loan is free carry and the rest is payable at an agreed interest rate"* (Qobo, 2013:5).

In May 2012, TCWF was successfully chosen as a preferred bidder through the REIPPP. In May 2013, Cennergi management and partners reached an intricate set of conditions for financial closure. The project will have installed capacity of 95 MW at a total project cost of around R2.9 billion (US\$290 million); project construction will start in October 2014 and the commercial operation date is set for April 2016. The sad story of the project is that, one of its pioneers, Mcebisi Msizi died in a road accident in October 2012 before the completion of the project. *"This program sought to address many objectives, including mitigating the effects of climate change, ensuring security of the energy supply at affordable rates and achieving social impact with respect of the job creation and local economic development"* (Qobo, 2013:6). Although

construction had not begun as yet, the project holds promise for local economic development. In terms of ownership of the project, 75% is owned by Cennergi, 16% by Watt Energi and 9% by Tsitsikamma Development Trust, who are also owners of the land.

4.3.2 The Amakhala Emoyeni Wind Farm (AEWF)

The Amakhala Emoyeni Wind Farm (AEWF) project, located on five private farms used for sheep farming and covering 130m², is managed by an SPV, Amakhala Emoyeni RE project (PTY) Ltd, which is owned by Cennergi. Amakhala owns 95% of the Project, with the remaining 5% divided between two separate trusts, the Cookhouse Community and the Bedford Community Trusts, equally, i.e. 2.5% each. The suitability of the project was initially identified by Windlab Developments South Africa (Windlab) on some 270 km² in the Eastern Cape. Windlab completed the Environmental Impact Assessment (EIA) process and received approval to build 350 wind turbines and associated infrastructure, such as access roads, substations, etc.

Subsequent to the above, a bidding process for renewable energy projects by IPPs was initiated by the South African Government under the REIPP programme. *“One of the bidding criteria was that any proposed wind project could only have a capacity of 140 MW. Thus Windlab separated the proposed facility, which covered an area of 270 km² and included 350 turbines, into 4 separate individual phases. In doing so, each phase could then be submitted as a separate project in accordance with the Government’s bidding process for renewable projects. Cennergi acquired the rights for phase 1 of the overall facility as initially considered by Windlab and this phase will generate some 138 MW of power”* (IFC, 2013:1). This case became one of the seven wind projects selected following the second bid window under the REIPP in May 2012, and reached financial close a year later, May 2013.

Although the construction work was expected to commence in early 2014, it only started at the end of July 2014. The project’s operational date is still

anticipated to be September 2016. The overall facility (4 phases) is expected to have 350 turbines and phase 1 alone will have 56 turbines. Standard Bank Group (JSE: SBK) Ltd, Nedbank Group (JSE: NED) Ltd's Nedbank Capital and the International Finance Corporation will provide finance amounting to R7 billion (US\$700million) for the two projects (Tsitsikamma and Amakhala).

Chapter 5: AngloGold Ashanti Case Study

5.1 Introduction

In 2004 AngloGold Corporation that housed the gold mining operations of Anglo American plc and the Ashanti Goldfields Corporation, based in Ghana, merged and formed AngloGold Ashanti Limited (AGA), with headquarters in Johannesburg, but with 21 operations on four continents and listed on the Johannesburg, New York, Accra, London and Australian stock exchanges. AGA has six (previously seven but now two, Savuka and Tauona, have combined) mining operations in South Africa, grouped into the West Wits (near the town of Carletonville, straddling the border of Gauteng and North West Province) and Vaal River (near the towns of Klerksdorp and Orkney on the border of North West Province and the Free State) regions. Two mines Mponeng and Tautona (Savuka and Tautona have been combined to form Tautona), are situated in the West Wits Region, whilst the other four, Great Noligwa, Kopaneng, Moab Khotseng and Tau Lekoa are in the Vaal River Region.

In addition to the four gold plants producing the equivalent of 22% of the group's gold production, at Vaal River operations there is one uranium plant and one sulphuric acid plant. AGA's management is organised under two chief operating officers, namely South Africa and International (Continental Africa, Australasia and Americas). Apart from its mining operations, AGA has a 42% stake in Rand Refinery Ltd, a gold smelting and refining complex in South Africa; a 36% stake in Oro Africa, a South African gold jewellery manufacturing company; and wholly owns and operates the Queiroz Refinery in Brazil (AGA, 2013).

AGA is an energy-intensive sector, mining, which is intractably linked to their GHG emissions and consequently their climate change strategy. In 2013, AGA's total annual energy consumption of 32.68 PJ accounted for 18.7% of their operating costs and an energy intensity of 0.32 GJ per tonne of rock treated.

Based on the ISO 50001 Energy Management System Standard as a foundation, AGA developed the AngloGold Ashanti Energy Management System (EnMs), which among four key principles focuses on improvements in energy efficiency. *"To drive this strategy across operations, [AGA] created and filled a new position of Global Vice President – Energy. This role supports all sites by implementing new technologies and addressing all facets of energy consumption, generation and cost management. This position is supported by Principal Energy Advisors, who focus on the needs of specific regional operations as well as site-level Energy Champions who implement projects, identify opportunities and drive energy performance against related KPI's"* (AGA, 2013:45).

5.2 AGA Energy Efficiency in SA

In 2005 AGA became one of the signatories of the Energy Efficiency Accord and committed to the 12% energy use reduction target by the mining sector. However, through the implementation of 31 energy-efficient projects, AGA reduced the power consumption of its operations by an estimated 94 MW from 2008 to 2012 in the South African region, representing a whopping 18% reduction (AGA, 2012). To achieve this feat, AGA set energy-efficiency improvement projects as short-term goals under Eskom's Integrated Demand Management (IDM) programme and internal funding mechanisms, and new mining methods with advanced technologies as long-term goals.

In order to achieve these goals, a new vehicle, The AngloGold Ashanti Innovation Consortium (ATIC), was formed to reduce dependency on energy and improve kWh per tonne rock processed ratios. However, ATIC was preceded by AGA's Energy Department, formed in 1994, which was tasked with managing energy requirements, but with sustainability and cost control in mind. Working with proven technology providers and research institutions ATIC identifies areas of energy efficiency and renewal energy opportunities and communicates best practices and lessons learnt to various energy forums.

5.2.1 Energy Efficiency Projects

In 2010 AGA initiated a heat pump project over 42 sites in its Vaal River and West Wits Regions as a response to the increasing pressure on the energy supply in the country. A heat pump extracts heat from the ambient air surrounding it, heats and then compresses the refrigerant, which then runs through a heat exchanger in which the water is heated. It, therefore, works like an air conditioning unit in reverse.

The AGA's heat pump project is intended to provide hot water to high-density employee residences. In its review of its energy profiles, AGA discovered that about 80% of the cost in employee residential areas could be attributed to water heating. *“AngloGold Ashanti has achieved savings of around 1, 5 MW, or in actual monthly savings of R150 000 a month, exceeding the expected target of savings of 1.3 MW. Eskom subsidised 50% of the capital cost, while AngloGold Ashanti carried the other 50%. The advantage of this solution is that it replaces normal electric heating, with a vapour compression cycle (heat pump), which produces the same amount of heating using two-thirds less energy , without affecting the service or supply to the end client”* (Eskom, 2012).

The project outlined above was a pilot project and in addition to forming the basis for expansions into other AGA residential projects, it won the AngloGold Ashanti 2012 eta Awards runner-up prize. The follow-up projects duly followed in 2012 and 2013, with 350 and 1 098 heat pump installations respectively. In each installation, a saving of 7 kWh/day/ unit is expected.

In 2013 AGA also received an eta Award for a waste heat recovery project at Moab Khotsong Mine. The project came as a result of heat pump load studies that showed that there exists a greater savings potential, if heat recovery is used rather than a vapour compression system to provide hot water for miners' showers. As part of their underground work, miners use compressed-air driven rock drills. In order to produce compressed air MW-sized centrifugal compressors on surface are used. These centrifugal compressors give off enormous amounts of heat, which require cooling via cooling towers before being dumped into the environment. In

this project, the heat given off by compressors is captured and used to produce hot water for miner change room showers. This waste heat recovery system will be expanded to the metallurgical plants for water heating in the elution circuits. Based on the current mine occupancy, levels of around 6 000 people in three different change houses, the energy reduction target is set at 450 kW with a cost saving of R250 000 per month. Given that the cost for the project is R2.1 million, the payback time works out to nine months (Eskom, 2013).

AGA's Mponeng Mine, at depths of more than 3,8 km beneath the surface, is the world's deepest mine. With this dynamic comes electricity cost viability, as high underground temperatures become unbearable for the workforce to operate in. At depths of more than 3,8km beneath the surface, virgin rock temperatures could reach 55°C and they need to be cooled to a wet bulb temperature of approximately 28°C. In the case of Mponeng Mine, it makes more economic sense to use hard ice for cooling, instead of cooled air, chilled service water and slurry ice. *"Once a mine reaches a depth of 1500m to 2000m, the balance tips in favour of using ice, as the capacity to install more heat-rejection machinery underground becomes limited, and pumping costs associated with service water chillers become very high. Ice-cooling is then more energy efficient than water-based systems, with every 1kg/s of ice providing the equivalent cooling of 5l/s of chilled water, saving approximately 75 % - 80% on pumping costs "* (Van Zyl 2013:2).

In 2009 AGA contracted Howden Projects to design, supply, erect and commission a turnkey hard ice plant project at their Mponeng Mine. It involved making ice on the surface, sending it down the mine into the dam and then circulating the cold melt water through air coolers. *"[It] is more energy efficient than a conventional chilled water refrigeration system, because the latent heat capacity of the kilogram of ice means it can take up far more heat than a kilogram of cold water. This offers significant savings in operational costs. Once the ice melts, the water still has to be pumped back up to the surface, but the quantities are much smaller and pumping costs are reduced to less than a quarter of the costs of a chilled water refrigeration system. In general, the ratio of mass flow rate for hard ice compared to water would be 1:5"* (Van Zyl, 2013:3)

5.2.3 Renewable Energy Projects

There are currently no renewable energy projects, but within the ATIC framework options such as underground hydro power and solar PV power plants are being investigated. If successful, they could generate energy that is sold to Eskom with AGA acting as an independent power producer (IPP) under the REIPPP Programme. In addition, AGA is also investigating the viability of making use of concentrated solar power (CSP) within the process plants in order to reduce the energy requirements of electrode boilers in steam generation in the elution circuit.

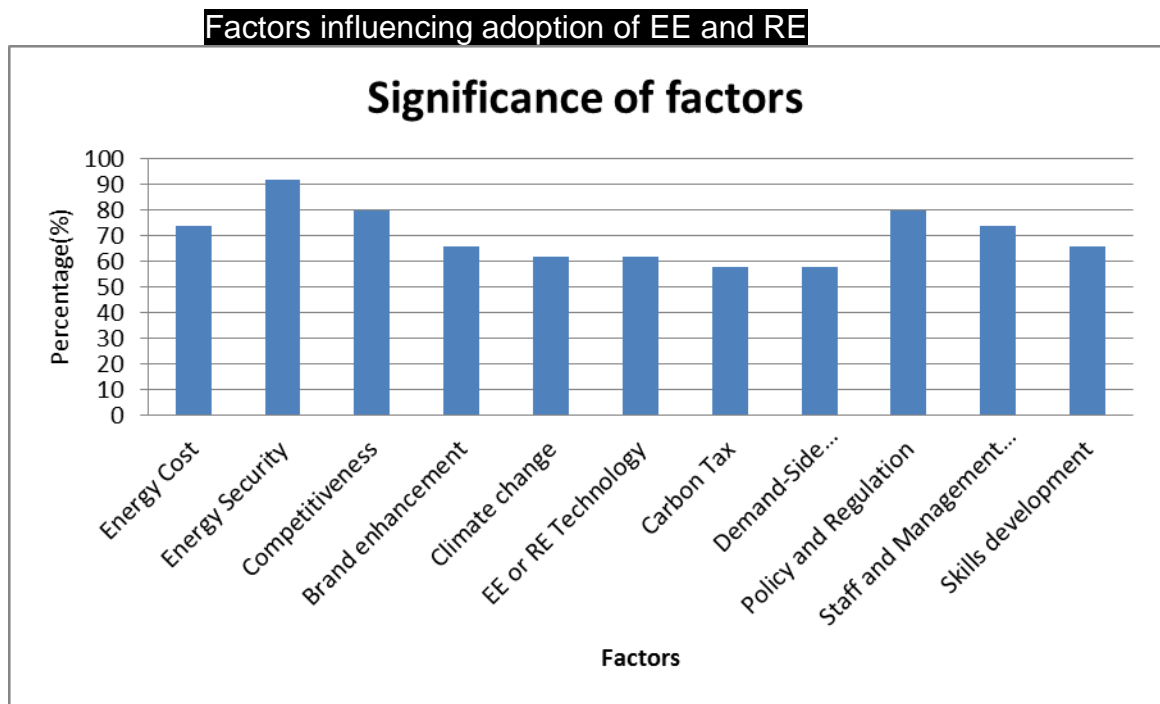
Chapter 6: Results and Discussions

6.1 *Survey Results and Discussion*

Two survey questionnaires were developed, sent to respondents and received back by the researcher. The first questionnaire sought to get a better understanding of what drivers or factors play a significant role in decisions regarding investments in energy efficiency and renewable energy projects in a mining sector. These factors could broadly be divided into financial, regulatory/policy and market aspects.

The financial factors comprise energy cost or financial cost reduction, energy security or risk management, revenue growth, and competitiveness. These factors, according to both the 2008 and 2013 Energy Strategy Reports are geared towards the elimination of unnecessary waste and critical for the success of both EE and RE initiatives. Under regulatory/policy factors, issues related to climate change, carbon tax/environmental levy, demand-side management and policy and regulation are included. The market factors include brand enhancement, EE or RE technology and staff and management awareness. The respondents were requested to rate how significant these factors are in influencing the adoption of EE and RE in different mines. The results are represented in Figure 7 below.

In the three categories (financial, regulatory/policy, and market), the financial category comes out as the most significant (see Figure 7). This is represented by the need to have security in energy, in other words, to have a stable and uninterrupted power supply. This is followed by the need to be competitive and grow revenue, which is as significant as policy and regulation. It is, however, surprising that although policy and regulation as a factor is given a significance rating of 4, climate change/greenhouse gases and carbon tax/environmental levy are given a significance rating of 3. However, as stated in the discussion earlier, the distance between 3 and 4 cannot be quantified.

Figure 8. Factors Influencing adaption of EE and RE

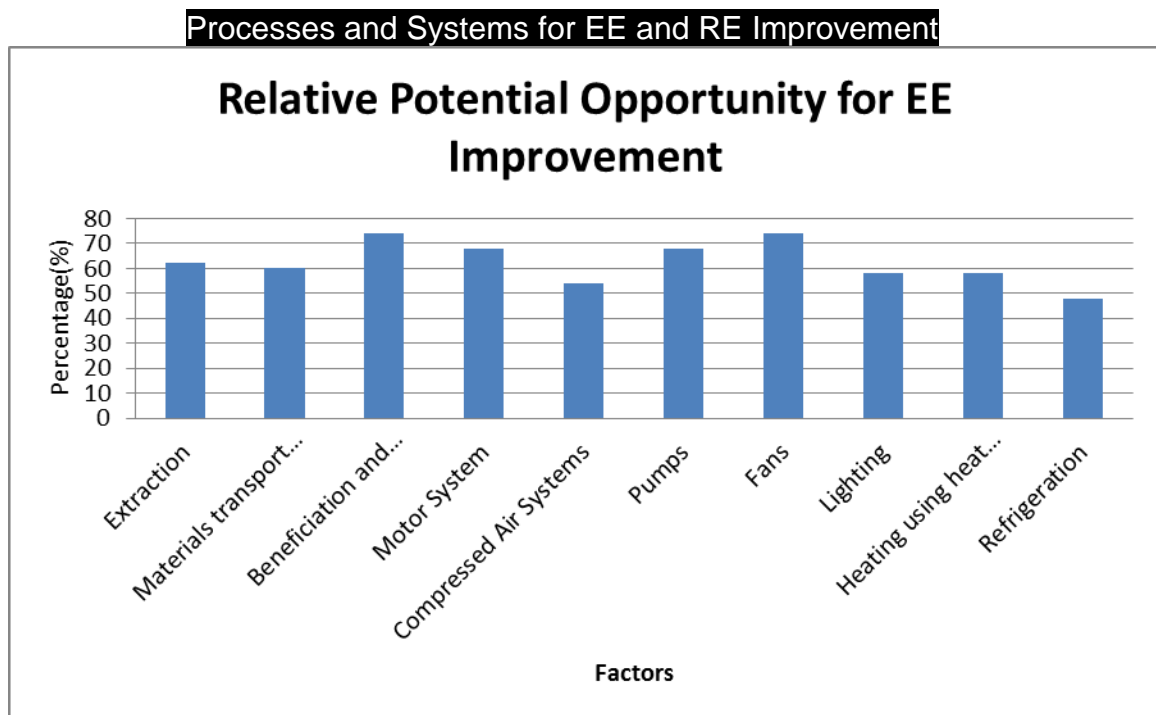
The other factors that rated highly are energy cost reduction and staff and management awareness. According to the survey, factors like demand-side management, EE and RE technology, brand enhancement and skills development are not very significant in influencing decisions about energy efficiency and renewable energy initiatives.

The two case-studies in chapters 4 and 5 also demonstrate the importance of the financial category. In the case of Exxaro, both the Tsitsikamma and Amakhala Wind Farms are solely for the purposes of revenue growth. However, this endeavour assists in the diversification of the energy mix as set out in the Integrated Resource Plan (IRP 2010).

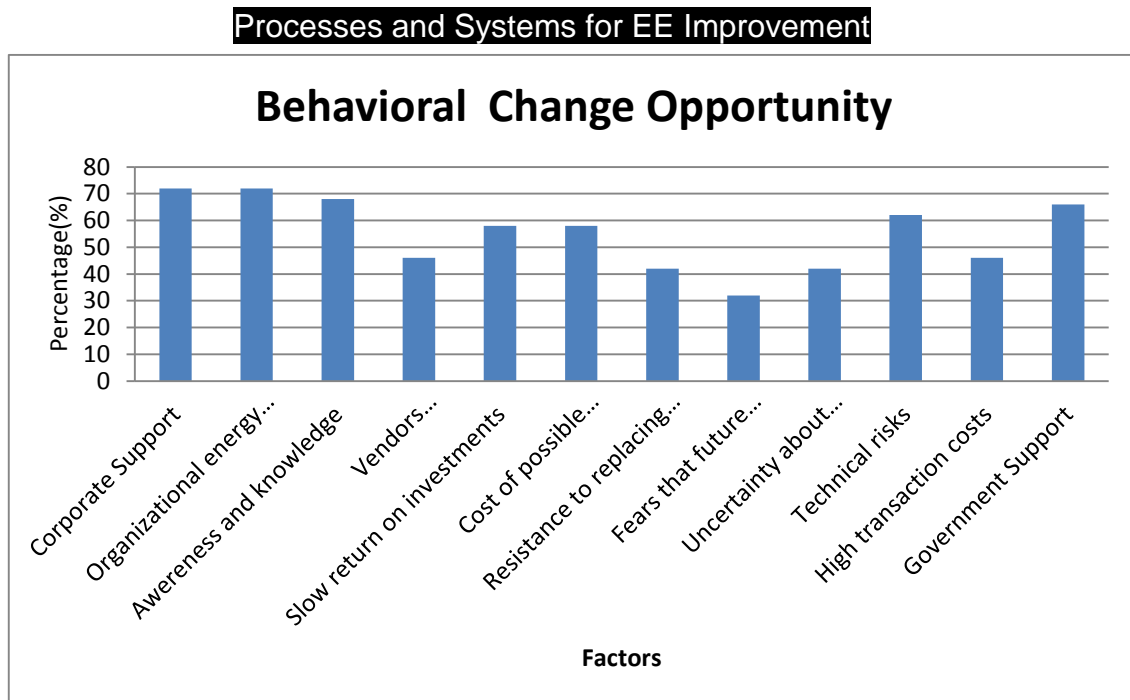
The second questionnaire captured two other issues – processes and technology, and behavioural change – that are critical for both EE and RE initiatives to be successful. The respondents were requested to rate processes and systems, as well as behavioural changes that offer the greatest opportunities for EE and RE initiatives in mining companies given the current technology status. The results are represented in Figures 8a and 9.

In the equipment and fundamental processes category, big opportunities for energy efficiency improvements and renewable energy initiatives lie in beneficiation processing as well as in fans. These are followed by pumps and motor systems. The smallest opportunities are in the compressed air systems.

Figure. 8a. Potential Opportunities for EE and RE improvements



The final category shows that both corporate support and organisational policy or strategy regarding energy is very important in creating opportunities for energy efficiency improvements and renewable energy initiatives. These are followed by awareness and knowledge, and government support.

Figure. 9. Behavioural Change Opportunity

Investment decisions in EE and RE technology are based on budget considerations, and it is, therefore, not surprising that finances are the most significant factor considered in the survey. Policy and regulation are also considered important. This calls on all policy developers to ensure that policies are well communicated and that there are no uncertainties about them. The majority of respondents highlighted corporate support as one of the most important drivers for energy efficiency improvement and renewable energy initiatives. The high level endorsement of energy management is important for the realisation of the energy goals that a company sets itself. This support alone is not enough. It has to be accomplished by organisational policy or strategy, or policy on energy, which make an environment conducive for renewable energy and energy efficiency. According to the survey, all this is possible with government support.

6.2 Interview Results and Discussion

All the respondents indicated that, even though they are responsible for the planning of energy efficiency improvements and renewable energy suggestions, an investment

decision-making process is far too complex to be left to one individual. In each initiative different decision-makers, from different areas of responsibility, are involved. For example, there is a Mine Manager whose role and interest is safety, production and expenditure targets, and a Finance Manager whose sole role is controlling cost. It is therefore the Energy Manager's task to understand all key decision-makers and get them interested in energy efficiency and renewable energy. In order to achieve this, the Energy Manager needs to align his/her business case for energy efficiency or renewable energy with the individual decision-maker's core business objectives. In the case of a Mine Manager and a Financial Manager for instance, the Energy Manager can relate the business case to production, safety and cost reduction targets as well as tax concessions and government funding.

All the respondents indicated that, for the past ten years, there have been energy efficiency initiatives adopted in their companies. However, it was in only one company that there were renewable energy initiatives. It was all respondents' view that in the mining sector, safety, followed by production, are the priorities. These two are then accompanied by a range of other demands, such as cost reduction and legislative compliance requirements. It is, therefore, within this context that energy efficiency and renewable energy initiatives will always be carried out in the mining sector. These initiatives will never be regarded as a priority.

In order to make staff and management aware of the plans, all respondents indicated that they draw up communication plans. In all the respondents' cases, energy management teams that support the process of improvement have been established at many mine sites. In these teams, many functional areas are represented by representatives including Finance Managers, Mine Superintendents, Process Superintendents, Business Improvement Managers, and Environmental Officers, who share the responsibility of getting management support and necessary resources. For Group Energy Managers it is crucial to involve these teams. In the planning phase, according to the respondents, it is also crucial to involve every possible decision-maker early on. In order to be effective, technical language should be avoided as much as possible, and the financial bottom line emphasised. Other important aspects to emphasise when making a business case for energy efficiency and renewable energy, according to respondents, are productivity, safety, compliance and business

improvement. Therefore, feeling the need to comply with legislation or company policy can be used as a big driver for energy efficiency and renewable energy projects in the mining sector.

Chapter 7: Conclusions and Recommendations

From the survey it is difficult to see the impact of climate change policies on mines as many respondents did not identify them as important factors influencing decisions on EE and RE in their companies. The same was true of carbon tax, even though it is still to be implemented in 2016. This might be an indication that our public policies are not as effective as we would like them to be, or that, under the current market framework we are in a “straitjacket”. Maybe Lander (2011)’s argument that by investing 2% of the planet’s GDP in EE and RE initiatives, and introducing incentives based on the market, UNEP believes that capital investment will be re-orientated in the direction of green investments and green innovations, holds true.

All UNEP’s policies, and by extension, South Africa’s, are meant to defend the sacred right of the free market, despite evidence of the planet’s limitations and crises caused by the current patterns of civilisation. By repeatedly referring to policies and never to politics, we fail to consider the significance of the existing unequal power relations in today’s world. Transforming mining, an extractivism enterprise, into a low carbon industry, just requires an improved management of the status quo, the cheapest approach of which is energy efficiency.

This line of thinking is not far from what was gathered from the survey and the case studies. Both show an appetite from mining companies for:

- a) Revenue Growth – New sources of revenue through renewable energy technologies, e.g. Exxaro case-study;
- b) Cost Reduction - To mitigate energy costs, the mining sector can implement enterprise energy management processes to better understand and manage energy use, improve operational efficiency, and reduce costs through actions such as heating, ventilation, and air conditioning retrofits or lighting upgrades; e.g. AGA case-study; and
- c) Risk Management - In the mining sector, stable and uninterrupted power sources which could be provided by combined heat and power systems. These systems can be designed to enable mines to operate independently of the grid for a short period. The risk associated with operational cost increase due to exposure to potential fuel price increases can also be reduced by energy

efficiency. Renewable energy can also be used as a hedge – a financial mechanism that shifts a mining company’s energy budget from a variable to a fixed cost, e.g. the Cronimet case study.

This line of thinking proves that because of our market framework orientation, in the case of the private sector, including the mining sector, all the priority actions will be aligned to one or more of the four business value levers, namely: (i) revenue growth, (ii) cost reduction, (iii) brand enhancement, and (iv) risk management.

The discussion about energy efficiency and renewable energy in South Africa, is, therefore premised on the two GE scenarios – GE2% and GETS, representing an additional investment of 2 per cent of the total real GDP (GE2%), and a priority-driven investment (GETS) in the selected sectors. The GETs and GE2% scenario are meant to add to the diversification of the energy mix in the power sector, create jobs and reduce CO₂ emissions.

The IRP (2010) has set the target of 17.8 per cent of newly built generation from renewables by 2030. The NDP calls for a higher target of 33 per cent of new generation from renewables. For this to be possible we need to come up with investment interventions that are far more aggressive than GETs and GE2%. By way of suggestion, in an effort to be more aggressive, maybe, as a country we need to go beyond concentrating on the GDP and government. In the case of the mining sector a GE2% at a facility level could be suggested. Making use of a company’s income statement, a 2 per cent of the revenue could be dedicated to renewable energy, and energy efficiency initiatives could be encouraged.

In addition to the GE2% and the other GETs scenarios, the company’s 2 per cent of the revenue should reach, if not surpass, the 33 per cent target of new generation from renewables. However, in lieu of the published Carbon Tax Policy Paper (2013) and the tax paid to government, companies might feel like they have been double-taxed. There are, however, other sectors of the community who will think that is not the case. This calls for a shared appreciation of the concept of “development”. It cannot be defined in terms of extractivism and neo-extractivism by some, and *buen vivir* by others. It has to include the most important spheres of ecology and limits of growth,

instead of concentrating on the economic and social sphere, which only emphasises investment, exports and growth.

In South Africa we need to move away from the MEC, and by insisting on the need to fundamentally restructure the economy, the NGP seem to be suggesting this fact. However, insisting that mining will still remain one of our four key sectors for the sake of job creation shows some of the fundamental contradictions of the South African policies. It is as Lang & Mokran (2013:72) said: “*Some damage to the environment and even serious social impacts are accepted as the price to be paid for the benefits that are obtained for the population as a whole*”. In order to socially legitimise extractivism as indispensable for combating poverty and promoting development, some of the revenue is used in financing social programmes. These are daily occurrences in South Africa with the Lephalale case study in this report being a typical example. Therefore, as a country, South Africa needs to come up with a new type of productive endeavour, based on a broad consensus and internally sustainable economy, but leading to less extractive industries. A lot of research needs to be undertaken in this regard.

One country that was brave enough to try to come out of a uneven and unfair playing field of market forces was Australia, by introducing mandatory energy efficiency programs for heavy energy users. In its first five-year cycle the program was so successful that it reported energy savings of over 88 PJ. However, the might of market forces called for deregulation and it was repealed in June 2014. Given the global nature of our economies, this was to be expected – Australia became an “unconventional” economy with an unbearable pressure to be “conventional”. South Africa and many other countries need to be braver than Australia to withstand corporate and global pressures that come with the move towards renewable energy and energy efficiency path.

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Appendices

Appendix A:

Interview Questions (Semi-Structured)

1. Organisational structure / decision process

- What is your role in the company?
- Who is responsible for energy efficiency improvements and renewable energy initiatives of the company?
- Who are the main decision makers of the company for large capital investment?

2. Status Quo Energy efficiency and Renewable Energy (EE & RE)

- Have there been any energy efficiency initiatives that have been adopted by your company in the past ten years?
- Have there been renewable energy initiatives that have been adopted by your company in the last ten years?

3. Opportunities

- Are there any opportunities for EE and RE initiatives in your company?
- Can you list these opportunities?

4. Staff Awareness and Management Information

- Is the information about EE & RE shared with the rest of the company's staff and management?
- If no, what is the reason for not sharing?
- If yes, what is the reason for sharing?
- If yes, how is the sharing done?

Appendix B:

The following survey is in part completion of a Master's Programme (MPhil) in Sustainable Development offered by the University of Stellenbosch. This survey is exploring the impacts of renewable energy and energy efficiency policies on the mining sector. Kindly note that only aggregated scores will be used and no companies' names will be used in the report. However, you could use the letter X if you are not comfortable to write the name of your company.

Company Name:

Questionnaire 1

Please rate the relative importance of the following factors in influencing your company to adopt Energy Efficiency or Renewable Energy (EE or RE) initiatives. Use a scale of 1 to 5, with 1 being "completely insignificant" and 5 being "completely significant".

FACTOR	RATING
Energy Cost/Cost Reduction	
Energy Security/Risk management - stable and uninterrupted power	
Competitiveness/Revenue growth	
Brand enhancement	
Climate Change (Greenhouse gases)	
EE or RE Technology	
Carbon Tax/Environmental Levy	
Demand-Side Management (DSM)	
Policy and Regulation	
Staff and Management Awareness	
Skills Development	

Questionnaire 2

Please rate the relative potential opportunity for energy efficiency improvements in your company's processes and systems. Use a scale of 1 to 5, with 1 being "completely insignificant" and 5 being "completely significant".

Processes and Systems	Rate
Extraction	
Materials transport and handling	
Beneficiation and Processing	
Motor Systems	
Compressed Air Systems	
Pumps	
Fans	
Lighting	
Heating using heat pumps and solar	
Refrigeration	
Corporate Support	

Organisational energy policy/strategic energy objectives	
Awareness and knowledge, e.g. attending conferences, visiting other mines, training, etc.	
Vendors providing/offering solutions	
Slow return on investments	
Cost of possible production disruption	
Resistance to replacing existing machinery	
Fears that future technologies will be cheaper and better	
Uncertainty about economic benefits of EE improvements	
Technical risks	
High transaction costs	
Government support	

Appendix C:

Mining Processes

Three broad stages, each involving several operations, constitute the mining processes. They are:

- Extraction – this stage includes activities such as drilling, blasting, digging, ventilation, and dewatering. In terms of energy, under drilling, electricity, diesel power and to a lesser extent, compressed air, run drills. In the lasting process, the energy consumed is derived from the chemical energy contained in the blasting agents. For the sake of this report I will assume that the mining industry only uses fan systems for ventilation and end-suction pumps (i.e. centrifugal) for dewatering the mine during extraction.
- Materials transport and handling – material handling involves the transportation of ore and waste away from the mine to the mill or disposal area. This involves both diesel powered equipment and electrical equipment such as load haul dump, conveyers and pumps. In materials handling, much of the equipment used, loaders, bulldozers, bulk trucks and rear-dump trucks, is powered by diesel engines. Only small fraction equipment, including load-haul-dump machines, hoists, conveyer belt systems and pipelines for pumping shirriers, is run by electricity.
- Beneficiation and Processing – this stage, happening at the processing plant, recovers the valuable portion of the mined material and produces the final marketable product. Crushing, grinding, and separations (centrifuge and flotation) form the beneficiation operations, while smelting and/or refining complete the processing operations. (BCS, Incorporated, 2007) Energy Band. At this stage, the energy efficiency of both crushing and grinding is influenced by upstream processes in separations, both centrifugal separation for coal mining, and flotation for metals and minerals mining are energy-intensive. The final process, namely roasting, smelting, and refining require relatively less energy.

Each of these stages offers energy-saving opportunities.

Appendix D:

1. Motors and Motor Systems

Electric motors are critical in most mining operations as they are used to convert electrical to mechanical power. The three major consumers of electricity, accounting for some 60% of electricity consumption in the ... industry are those electric motors used to drive pump systems, fans systems and compressed air systems. These provide significant scope for energy savings.

In its EE/DSM strategy, Eskom encourages users, with an offer of a rebate programme subsidising the cost of replacement, to switch from conventional to high efficiency motors. The efficiency of an electric motor is defined as the ratio of usable shaft to electric input power. In the United States, as part of the Energy Policy Act, a set of minimum efficiency levels for electric motors has been set in 1992. Six years later, the European Committee of Manufactures of Electrical Machines and Power systems issued a voluntary agreement of motor manufacturers an efficiency classification – Eff 3 for High Efficiency, Eff2 for Standard Efficiency and Eff for Low Efficiency. These developments are yet to happen in South Africa. By using best practice, the energy efficiency of electric motors can be improved to about 30% with a payback time of less than 3 years. In addition to significant energy and cost savings, improving energy efficiency reduces greenhouse gas emissions that contribute to climate change.

2. Compressed Air Systems

In order to drive a wide range of tools and applications, including the heavy drills, the mining industry, in addition to electrically powered tools, depends on compressed air.

However, compressed air systems are very vulnerable to damage and leaks, which result in wasted energy. To avoid this from happening, a number of activities or initiatives can be implemented, including, but not limited to, the following:

- Use of correctly sized equipment (as opposed to oversized);
- A monitoring system to identify early warnings;
- A modular arrangement that allows for better control of compressed air;
- Continuous identification and fixing of leakages; and

- Looking for value added options, such as recovering heat generated during compression from the cooling material used (Eskom; 2013)

3. Pumps

Virtually every mining operation, from deep-level mining to water for drinking, depends on the use of pumps. To be energy efficient with the use of pumps, the following activities should be carried out:

- Avoid oversizing – correct sizing is imperative for high efficiency;
- During piping. Avoid sharp bends, e.g. 90° elbows and short radius bends – sharp bends cause fluid turbulence that require more power to overcome;
- Install variable speed drives to handle reduced demand;
- Install instrumentation to monitor the key pump parameters, such as the suction and discharge pressures and flow rates – this is to ensure that pumps operate within their best efficiency zones; and
- Because of the nature of the liquids being pumped, preventative or predictive maintenance, rather than time-based maintenance, must be undertaken to ensure that problems are detected early and attended to (Eskom, 2013).

4. Fans

By virtue of their use 24 hours a day, ventilation fans are one of the biggest energy users in underground operations. The control of the energy consumed by fans, used for ventilation of underground mining operations, extraction of flammable gases and provision of fresh air for miners, is very important to the overall efficiency of the system. The efficiency of fans can be improved by correct sizing of fan systems, lubrication of fan components, optimisation of the duct size, correcting leaks, and adapting the air flow to accommodate demand changes.

5. Lighting

Lighting with quality illumination, much of it for 24 hours of the day, is required for every aspect of mining operation. These aspects include residential facilities, administrative offices, and security, processing and extraction activities. Understanding all lighting requirements and analysis of possible inefficiencies in the lighting system help in achieving energy savings. Based on inefficiencies analysis, more energy savings can also be achieved by retrofitting from one lighting system to another. The South African Bureau of Standards (SABS) standards and occupational Health and Safety (OHS) Act specifications on lighting must also be used to choose the correct lux level specification for both interior and exterior lighting.

Other energy saving practices for a lighting system include:

- Switching off of lights in unoccupied areas, and areas where daylight provides adequate lighting levels;
- Regular maintenance of lighting system;

- Properly cleaning light diffusers to improve light output levels and hence efficiency, and
- Replacing redundant lights in modified areas.

6. Heating Using Heat Pumps and Solar

A heat pump system, just like refrigeration equipment, employs an evaporator, a compressor, a condenser, refrigerant gas and an expansion valve within a closed circuit. This system, usually mounted on the outside walls of buildings, under the eaves, or at ground level, is found to be up to three to four times more efficient than a hot water system powered by a normal resistance element like in the case of a geyser.

The initial equipment and installation costs are higher than those of gas or electric geyser systems, but these are offset by lower operating and maintenance costs.

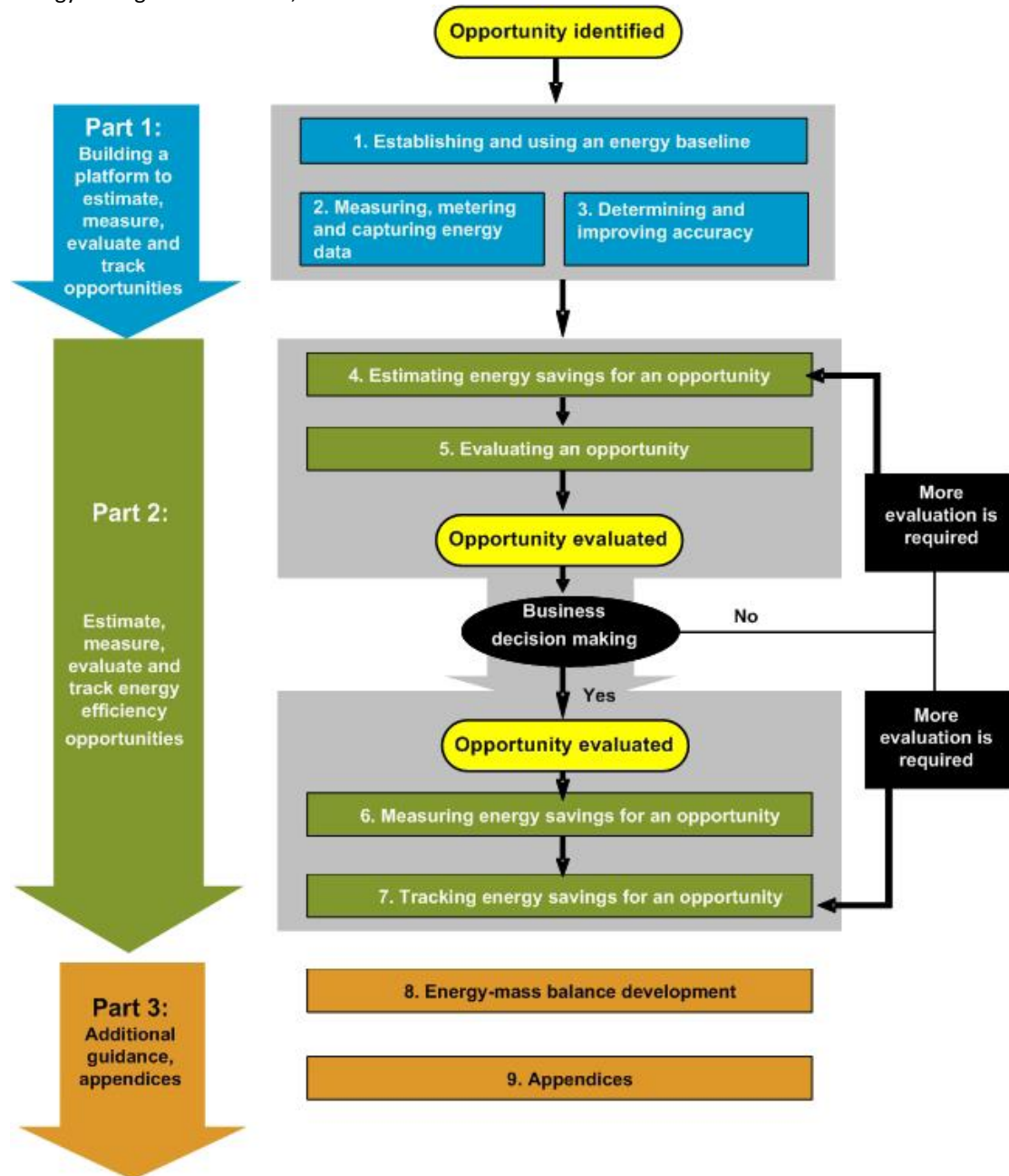
On the other hand, solar water heating as well established technology worldwide, is one of the most cost effective ways to include renewable technology in mining. Using a typical residential solar water heating reduces the need for conventional water heating by about two-thirds (Eskom, 2013). Given that they have very few moving parts, solar water heaters do not have very intensive maintenance requirements.

7. Refrigeration

The energy requirements of a refrigeration or air conditioning system (moving heat from a cooler space to a warmer space) depend on the temperature difference from cold to warm (temperature lift) and the amount of heat the system has to move (the cooling load). Therefore, an effective strategy for minimising the energy cost must involve (i) minimising the temperature lift, (ii) reducing the cooling load, and (iii) regular monitoring. Simple activities to achieve these include cleaning heat exchange surfaces frequently, checking and resetting evaporating and condensing temperatures, insulating the cooled space and refrigeration lines, checking lubricants frequently to prolong the compressor life, and logging the operating parameters such as motor currents to spot abnormalities (Eskom; 2013)

Appendix E:

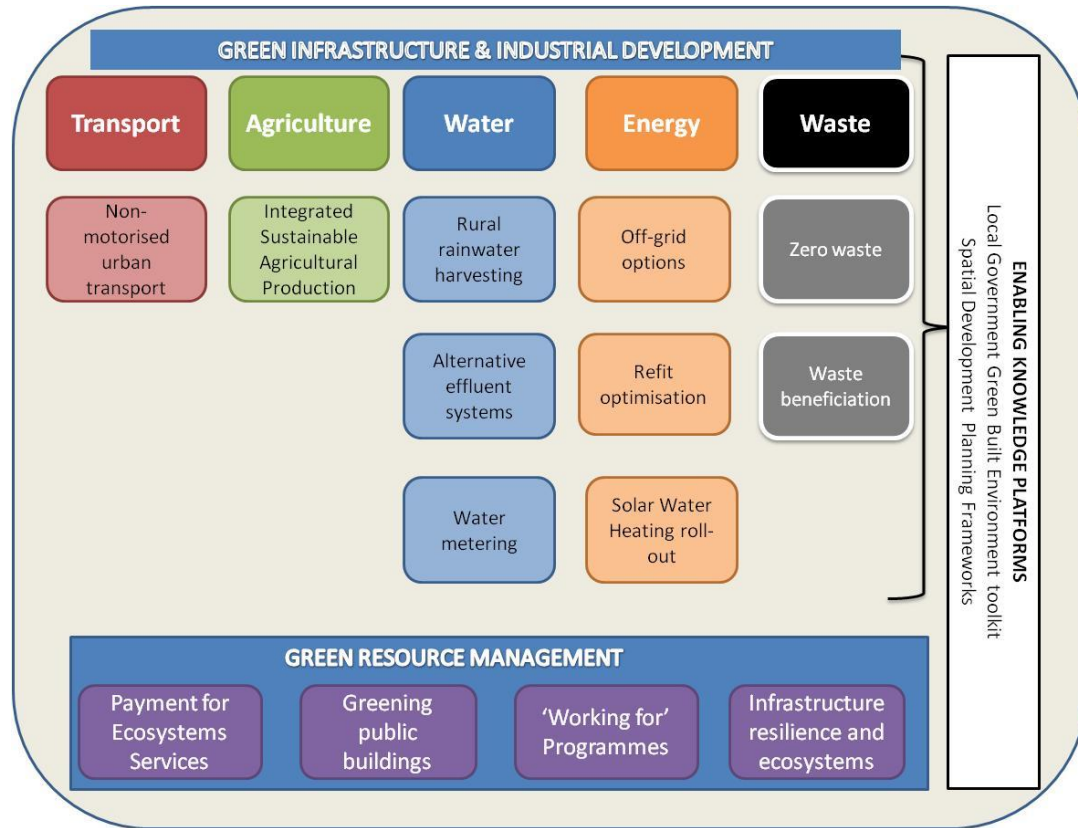
Energy Savings Identification, Measurement and Evaluation



Source: Deloitte (2013)

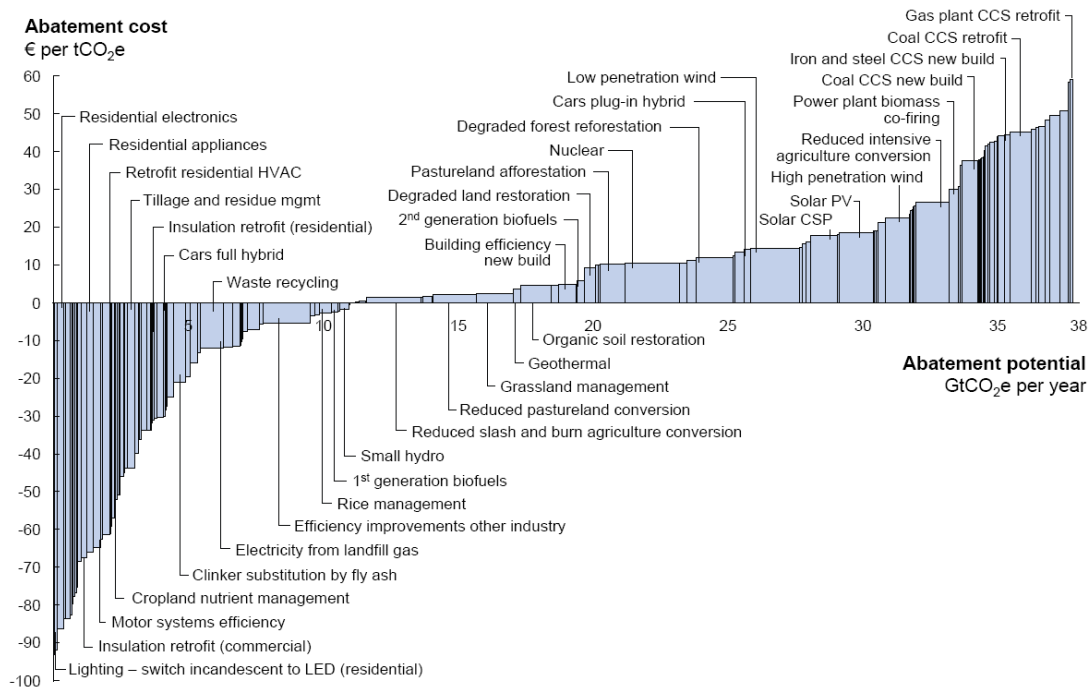
Appendix F:

Summary of Green Economy Programmes and Enabling Programmes.



Source: DBSA (2011)

Appendix H: Global GHG abatement cost curve beyond business-as-usual – 2030

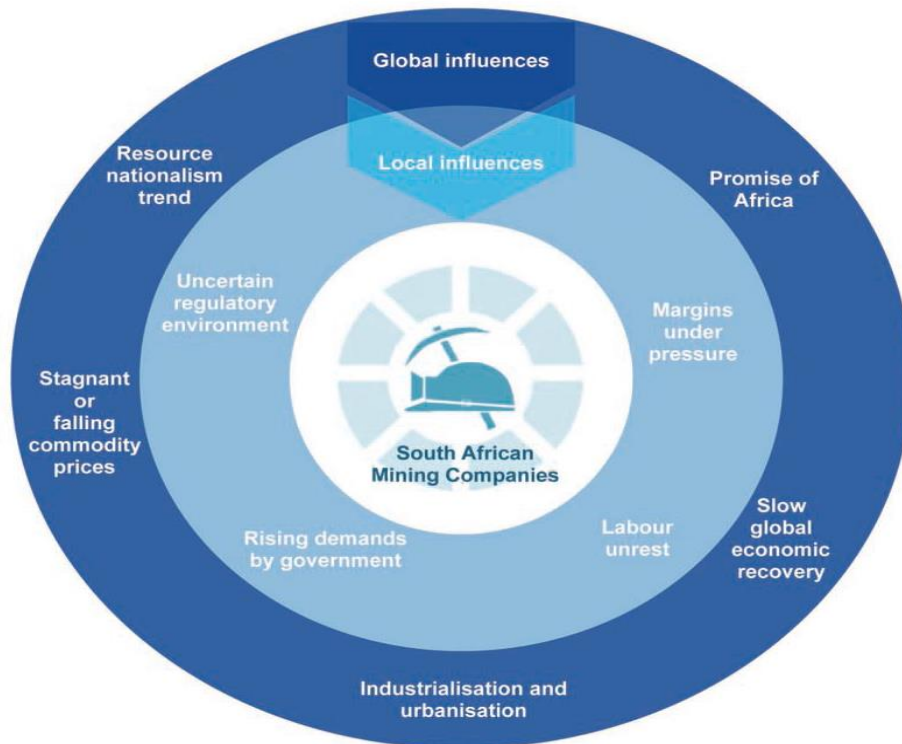


Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €60 per tCO₂e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.
Source: Global GHG Abatement Cost Curve v2.0

McKinsey & Company (2009)

Appendix G:

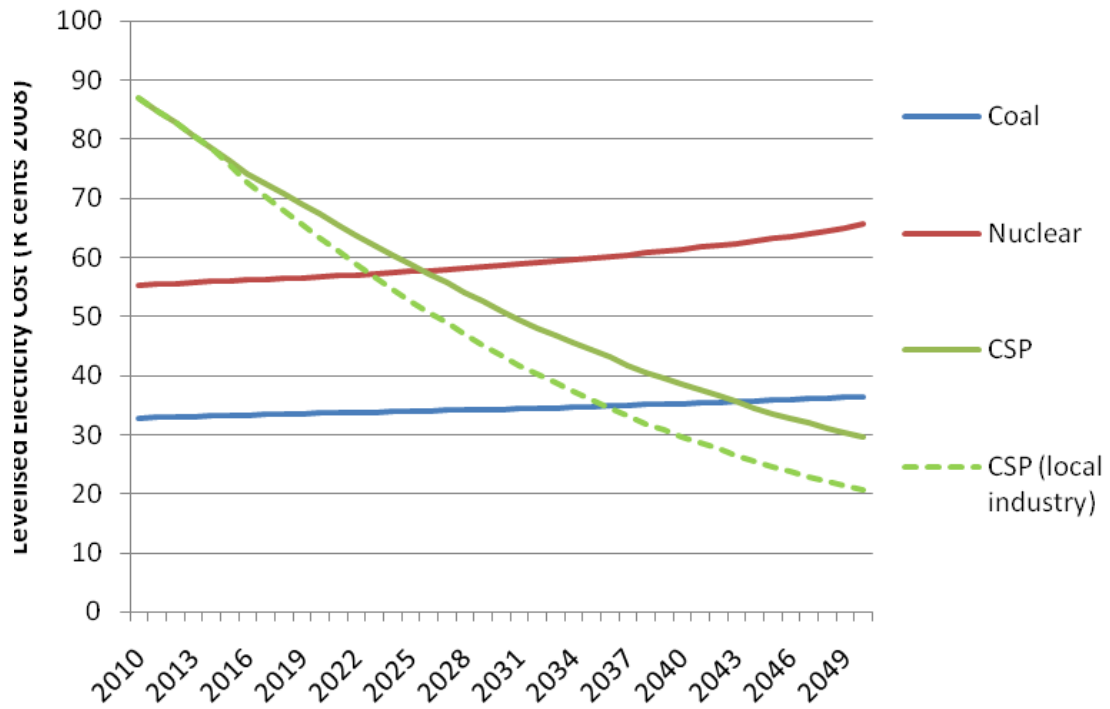
Global and Local Pressures



Source: Deloitte (2013)

Appendix H:

Projections of the levelised costs of electricity from coal, nuclear and CSP in South Africa



Source: Winkler (2007)

Appendix I:

1. Start Now Strategy

This strategy, suggesting mitigation action that is implemented through state action, adds no net cost to the economy against the Growth without Constraints base case and only closes less than (missing text?) of the gap between the Growth without Constraints and the Required by Science scenarios. The Start Now Strategy is made up of all net-negative wedges, i.e. mitigation actions having upfront costs but over time, savings outweigh initial costs. Energy efficiency falls into this category. In each case, the relevant sector would have to act to realise the wedges of emission reduction. Each government department would have to consider policy and other actions needed to drive the emissions reduction actions described in that wedge. Different sectors with their corresponding government departments would have to be involved in implementing efficiency in industry and transport, as well as more renewable and nuclear sources for electricity as the biggest wedges.

According to the LTMS modelling, this strategy would have a relatively small impact on the economy, although buoyed somewhat by the positive effects of increased energy efficiency. Therefore, the Start Now Strategy is not sufficient to reach the Required by Science objectives by 2050. It can only be the first part of an overall mitigation plan.

2. Scale-Up Strategy

The Scale Up Strategy, just like the Start Up, is state-led, but takes the cost of acting into net-positive cost territory. Because of the net-positive cost aspect, a regulatory decision is required. While money was saved with mitigation under Start Up, there is a cost per ton CO₂ resulting from Scale Up. The strategy is characterised by a transition to zero-carbon electricity by mid-century and extension to 50% of electricity generated by 2050 to nuclear power and renewable energy wedges. In addition, the technology of carbon capture and storage matures and is scaled up by a factor of 10, and depending on the limits

of arable land, water, biodiversity and food security, biofuels are extended. In order to further reduce emissions, electric vehicles can provide new transport technology.

Although emission reductions become significantly larger than in Start Up, Scale Up still does not, however result in an overall decline in emissions. Just like the Start Up, this strategy still offers a partial solution. *"As regards national policy, Scale Up requires an ambitious plan for energy. Moving the energy economy, which currently relies on coal for three-quarters of primary energy, to zero-carbon electricity, is a massive undertaking. Under the Scale Up option, energy efficiency cannot be left to voluntary agreements, but must be guided by a policy framework and systems of penalties/incentives"* (DEAT, 2007:18).

3. Use the Market Strategy

Through this strategy, the market will be prompted to work, resulting in the uptake of the accelerated technologies and social behaviour through incentives and taxes. *"The key driver of Use the market is a CO₂ tax - a price change which make the use of fossil fuels much less attractive, and induces an indirect effect of greater investment in low-carbon technologies"*(DEAT, 2007: 19). This strategy argues that an escalating CO₂ tax and incentives for renewables for electricity generation, biofuels and solar water heaters should be the major wedges.

According to this strategy, using economic instruments - both taxes and incentives shifts patterns of domestic investment and results in emissions reductions beyond those seen in Scale Up. In other words, Use the Market reduces emissions the most, but still falls short of the Required by Science goal, and becomes a partial solution.

4. Reaching for the Goal Strategy

In this strategy, because of the unknown future technologies and behavioural changes that will have to mark this scale of emission reductions, exact costs and

economy-wide impacts could not be modelled. However, some of the salient characteristics of this strategy by 2050 could be imagined. These characteristics include:

- a. Investing in technologies for the future. A future is imagined where there is a decentralised grid in which citizens can generate their own electricity and pass any surplus back to the grid.
- b. Searching for lower-carbon resources. Possibilities include importing hydro energy from the Congo or East Africa, and natural gas from the Kalahari or elsewhere.
- c. Incentivising behaviour change. Changes in social behaviour could be driven by policy, education or awareness.
- d. Redefining our competitive advantage. Although energy efficiency and a cleaner fuel mix are significant mitigation actions, maybe in the long run, the solution lies in structurally changing our energy-intensive economy. This means that, instead of our energy-intensive sectors, South Africa should move towards a low-carbon economy (DEAT, 2007: 22-24).