

# **Improving Power Infrastructure in Sub-Saharan Africa**

An Integrated Role for the Mining Industry?

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Dei gloriam*

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## **Abstract**

Sub-Saharan Africa suffers from a severe infrastructure deficit, particularly in the power sector and this is broadly recognised as a barrier to poverty alleviation, economic growth and sustainable development in the region. At the same time, the region is rich in natural resources and the mining sector, which already makes a significant contribution to national economies is currently expanding and this growth is expected to continue. Given the importance of electricity to development, there are a number of organisations and a large body of literature devoted to improving power infrastructure in the region. However, to date, the role of large, politically powerful end-users such as the mining industry is largely unconsidered and this thesis argues that this should change. The mining industry is dependent on a reliable supply of electricity and is likely to take steps to secure this. For this reason, a Resource Dependency Theory conceptual framework was developed from the organisational behaviour literature and used to identify and classify the strategies the mining industry in Zambia and South Africa is adopting to manage its dependence on the electricity sector. Both of these countries are large-scale mineral producers and have a recent history of power supply unreliability. This thesis shows that their mining sectors are actively engaged in power sector development. The mining industry is represented on many of the boards and committees relevant to power, actively lobbies for regulatory change, is influential in sector planning, and often makes a direct contribution to national infrastructure stocks. Internally, Demand Side Management measures within the sector have a significant impact on grid stability. Many of the steps the mining industry is taking are congruent with solutions touted by the power development community, such as regulatory reform, the enhancement of institutional basics within utilities and the encouragement of regional trade in power. It is therefore recommended that the power development community take the mining industry into consideration as it seeks to improve the electricity sector in the region. Possible avenues to do this include taking into account the growth of the mining industry during power sector planning, using the political influence of mining to promote positive change and to enhance DSM measures in the economy.

**Keywords:** Mining, electricity, sustainable development, demand side management, resource dependency

## Executive Summary

### Scope, Background and Knowledge Gap

This thesis is directed at the mainland states of Sub-Saharan Africa and the large-scale minerals extraction industry that exists in several of the countries in the region. It therefore excludes the island states, small-scale and artisanal mining and the oil and gas industry.

Sub-Saharan Africa suffers from a severe infrastructure deficit, which is broadly recognised as an impediment to poverty alleviation efforts, economic growth and sustainable development (CFA, 2005; Foster & Briceño-Garmendia, 2009). The biggest challenge lies in the power sector and 32 of the 48 countries in the region face current or imminent supply shortfalls. Although the region has abundant renewable and non-renewable energy resources, nearly three quarters of the population lack access to electricity and the supplies are erratic and expensive (Eberhard *et al.*, 2009; Legros *et al.*, 2009).

At the same time, Sub-Saharan Africa contains considerable mineral wealth and the region is a world leader in terms of both the production and reserves of several mineral commodities (Sinkala, 2009; AU, 2009). The mining industry is currently undergoing a period of rapid global expansion and much of this is expected to occur in Africa. This could present a window of opportunity for resource rich countries to internally generate wealth to spend on sustainable development efforts (Peck, 2011; UN, 2010a). Indeed, although large-scale minerals extraction has often not translated into meaningful development, national governments expect that it will do so in the future (AU, 2009) and hence the growth of the mining industry is likely to be encouraged in the region.

There is a broad consensus within the mainstream development community that access to high quality energy sources is an important step towards sustainable development (e.g. UNDP, 2011, AGECC, 2010; UNECA, 2007). Hence, significant resources are devoted towards improving the power sector in the region and there is a growing body of literature on the subject. However, the role of large-end users such as the mining industry is largely not considered in the development of the power sector and this is the point of departure for this thesis. Large-scale mining activity is not possible in the absence of a reliable power supply and hence mining organisations are dependent on this being available. This thesis uses a Resource Dependency Theory (RDT) conceptual framework drawn from the organisational behaviour literature to determine whether the mining industry has a significant influence on power sector development in order to address this knowledge gap.

### Aims and Research Question

The aim of this thesis is to contribute towards the growing body of literature on power sector development in Sub-Saharan Africa, specifically by considering the role of the large, politically powerful mining sector. The research question to address this aim is:

- How does the mining sector influence the development of the power sector in Sub-Saharan Africa?

Once the research question is addressed, it can be determined whether the role of the mining industry is significant and discuss the implications of this finding.



## Methodology

This research was conducted via literature review, expert interviews and database searches. These methods were chosen as they allowed for the greatest amount of relevant information to be analysed within the given time period. The initial research stages focused on Demand Side Management (DSM) measures within the sector, however as the broader role of the mining industry was recognised, a conceptual framework based on Resource Dependency Theory (RDT) was developed from the organisational behaviour literature. The following objectives were formulated to address the research question:

1. Set the context of the importance of electricity to economic growth and development.
2. Establish reasons and delineate solutions for the regional electricity problems.
3. Set the context of the importance of mining to development.
4. Establish the dependence of the mining industry on electricity.
5. Establish the steps that mining companies are taking to manage their dependency on electricity.
6. Discuss how those organisations and institutions seeking to improve power infrastructure in Sub-Saharan Africa should consider the role that the mining industry has to play in power sector development.

A number of relevant informant groups were identified in the course of this research. Regarding the power sector, in order to assess the current state of power infrastructure in the region; the specific issues the sector faces; why a poor power sector is a problem; and the regional and national solutions to power sector issues, information was sought from development organisations; national utilities and power pools; governments; academia, and electricity databases.

For the mining sector, in order to assess the current and expected future state of mining in the region; its potential contribution to the national income and meaningful development; the dependence of the industry on a reliable supply of electricity; and the measures it adopts to secure its power supply, the following sources were utilised: mining engineers and managers; mining related organisations and initiatives; development organisations; governments; academia; and economic and development databases.

The interviews served to corroborate literature sources, expand on certain topics and to identify new avenues for research. These were either conducted in person during a visit to South Africa in January 2011, over the phone or on Skype.

## Findings

Chapter 3 provides a synopsis of the state of power infrastructure in the region where several countries have power systems prone to supply shocks. Additionally, the costs of producing power are high due to the prevalence of small, inefficient generation plants; tariffs largely do not reflect the full costs of production; revenue collection rates are low; sector planning is poor; maintenance is often deferred; and only a quarter of the population have access to the grid. The current power supply situation has been identified as a significant barrier to sustainable development by organisations such as UNDP (2011), AGECC (2010) and the World Bank (2008). In particular, low access rates limit poverty alleviation efforts and unreliable supplies are a significant constraint to economic growth and the development of the value-adding industries typical of a modern economy.

If sustainable development in the region is to occur then:

- Electricity access needs to be expanded to 100% of the population; and

- supply reliability needs to be improved so that it no longer constrains the growth of a value-adding manufacturing industry with associated service sectors.

Improving power systems is one of the most significant development challenges facing the region. Unfortunately, this cannot currently be achieved using purely technical fixes. It requires politically difficult institutional reforms, massive capital investments as well as socially and economically difficult tariff increases (e.g. Eberhard *et al.*, 2008). Some of the required outlays of public funds can be reduced via efficiency and private sector spending. The necessary solutions drawn from the literature are:

- the rehabilitation run-down infrastructure and the subsequent implementation of regular preventative maintenance regimes;
- the addition of 7 000 MW a year of new capacity, particularly large-scale projects which have low marginal production costs, to ensure that full cost recovery tariffs will be affordable;
- the enhancement of regional integration and cross-border trade to connect countries with energy resources to the major centres of demand and so that countries with demands too small to justify large-scale generation projects can pool their demands and take advantage of scale economies in production;
- the elimination of utility inefficiencies such as low collection rates, underpriced power, overemployment and transmission losses;
- the alteration of regulatory frameworks to promote private participation, which reduces the funding burden on the public sector; and
- the use of demand side management measures to get the maximum benefit out of existing infrastructure.

In chapter 4, the mining industry and its current and expected future rapid expansion is discussed. Mining provides an important source of export earnings and the income tax and royalty payments from the industry often fund a significant portion of national socio-economic activity (e.g. CIA, 2011; Sinkala, 2009). If sustainable development means meeting the needs of today without compromising the ability of future generations to meet their own needs, then the current exploitation of non-renewable mineral reserves needs to catalyse the development of a value-adding manufacturing base and an associated services industry. This will enable future generations to meet their needs when reserves are depleted or when prices fall. While the current high cycle of mineral prices represents a window of opportunity for resource rich countries to internally generate wealth to spend on SD efforts historically, mineral wealth has usually not translated into meaningful development in the region. In recognition of this, a number of initiatives have been developed to ensure that a vibrant minerals sector contributes towards broad-based growth. The Africa Mining Vision (AU, 2009) is arguably the most relevant regional initiative and signals the intention of governments to include natural resource exploitation in national development strategies. According to the Vision, mining should contribute towards meaningful development by creating up-, down- and side- stream linkages to beneficiating industries such as services and manufacturing, contributing towards infrastructure and enhancing the local capacity base.

The heavy dependence of the mining industry on a reliable electricity supply is also established in chapter 4. Power cuts damage equipment, cause shafts to flood and trap workers underground. Unreliable power also presents a significant constraint to the growth of the industry in a time of rising metal prices.

In chapter 5, the role that the mining industry plays in power sector development was documented in South Africa and Zambia. Both of these countries are large-scale minerals producers with a recent history of power supply unreliability. The strategies distinguished in

the literature and during interviews that the mining industry adopts to manage its dependency on power were identified according to RDT categories. These revealed that the mining industry plays a significant role in power sector development in the following ways:

- via direct infrastructure contributions;
- by providing a secure base load that acts as a catalyst for capacity addition;
- by actively influencing regulatory reforms for example, to improve utility financial performance and institutional capacity, promote independent power production and strengthen sector planning;
- by partnering with utilities to reduce national peak demand;
- by improving efficiency to maximise the use of existing capacity and defer the need for new generation sources;
- by promoting efficiency in other sectors to further reduce the national demand;
- via active participation in relevant power sector bodies; and
- by promoting regional trade in power.

## Implications and Recommendations

Given that the mining industry plays a significant role in the development of the power sector and actively lobbies for many of the solutions proposed by the development community, it is reasonable to conclude that the role of mining should be considered in power sector development. The implications of this conclusion and how the mining industry could be considered are discussed in chapter 6. A number of avenues where the role of the mining industry could be incorporated and enhanced were identified. These were:

- Incorporating the growth of the sector into national planning bodies so that its direct contributions can be optimised and the base demand it creates taken into account;
- enhancing the negotiating capacity of national authorities responsible for mining so that a fair infrastructure contribution from the mining sector can be realised for example by bolstering the Africa Mining Vision;
- including the mining industry as part of the target audience so it can be used as an influential ally for sector reform;
- approaching the mining sector regarding the business viability of some proposed infrastructure projects;
- transferring the DSM potential of the mining sector to other industries; and
- encouraging cooperation between end-users and utilities

Idealism will of course, need to be balanced with commercial realities. The mining industry is not a silver bullet for improving the power sector. On the one hand, the mining industry has the potential to contribute towards development on the other, if unreasonable expectations are put on it, then new mining investments will not occur and the opportunity offered by the current high prices missed. The power development community should therefore assist in increasing the capacity of authorities to negotiate the win-win situation for all stakeholders that is theoretically possible.



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## **Abbreviations**

AGECC	United Nations Secretary-General's Advisory Group on Energy and Climate Change
AICD	Africa Infrastructure Country Diagnostic
ASK	Africa Support Kiosk
CDM	Clean Development Mechanism
CEC	Copperbelt Energy Corporation (Zambian private utility)
CFA	Commission for Africa
CFI	Consortium for African Infrastructure
CMSA	Chamber of Mines of South Africa
CMZ	Chamber of Mines of Zambia
CSD	United Nations Commission for Sustainable Development
ESKOM	Electricity Supply Commission (South African utility)
GFC	Global Financial Crisis
GMI	Global Mining Initiative
ICMM	International Council of Mining and Metals
IEA	International Energy Agency
IMF	International Monetary Fund
IPP	Independent Power Producer
JPOI	Johannesburg Plan of Implementation
K	Kwacha (currency of Zambia)
KNBC	Kariba North Bank Company (Zambian State-owned Utility)
MDGs	Millennium Development Goals
MMSD	Mining, Minerals and Sustainable Development
NEPAD	New Partnership for Africa's Development
PGMs	Platinum Group Metals
PPP	purchasing power parity
SAPP	Southern African Power Pool
SD	Sustainable Development
SNEL	Societe Nationale d'Electricite (DR Congo utility)

UNDESA	United Nations Department of Economic and Social Affairs
UNECO	United Nations Economic Commission for Africa
ZACCI	Zambia Association of Chambers of Commerce and Industry
ZESCO	Zambia Electricity Supply Corporation (Zambian State-owned Utility)

# 1 Introduction

## 1.1 Background

Sub-Saharan Africa has some 791 million inhabitants in 48 different countries. This thesis is directed at the 42 mainland states shown in Figure 1. Many of these are small, with populations of fewer than 5 million and gross domestic products of less than US\$ 5 billion at purchasing power parity (PPP). Additionally, only 36% of the population lives in rural areas. This means that economies of scale and of agglomeration are difficult to achieve in the delivery of infrastructure services, which contributes to their relatively high cost. It is the poorest region in the world with 72% of the population living on less than 2 US dollars a day (at PPP). Average annual GDP per capita is 2 100 US dollars (at PPP). This falls to 1 500 dollars if South Africa and Nigeria, the two biggest economies are excluded (World Bank, 2010; Foster & Briceño-Garmendia, 2009a).

The region suffers from an acute infrastructure deficit, which was brought to global attention by the Commission for Africa's (CFA's) inaugural report *Our Common Interest* (CFA, 2005). Sub-Saharan Africa lags far behind other developing regions in terms of access to basic infrastructure services such as all season roads, electricity, water and sanitation (Yepes *et al.*, 2008). At the same time, the cost of using infrastructure services is high which creates demand-side barriers in a poor region (Foster and Briceño-Garmendia, 2009b). However, many in the development community, including the Commission for Africa, the World Bank, the Consortium for African Infrastructure as well as several national governments hold that for most countries, the biggest challenge lies in the power sector, which is struggling to cope with rising demand (World Bank, 2008; Eberhard *et al.*, 2008; CFA, 2010). 32 countries in the region have systems vulnerable to supply shocks and power cuts and load shedding are common (Eberhard *et al.* 2008; Eberhard *et al.* 2009).

Infrastructure services are an essential component of modern day life and it is difficult to imagine any economic activity without them. At the most basic level, roads provide access to markets, electricity pumps water in fields, hospitals increase wellbeing, telecommunications decrease the cost of doing business and so on. The lack of and poor quality of available infrastructure is therefore an impediment to long-term, meaningful development and poverty alleviation in the region (CFA, 2005; 2010). More critically, expanding electricity access is crucial in the short term if the internationally acclaimed Millennium Development Goals (MDGs) are to be achieved by 2015 (IEA, 2010; GNESD, 2010).

At the same time, the region is exceedingly well endowed with mineral resources. Revenue from mining funds a large proportion of socio-economic activity in the region and the industry is perceived to be a possible vehicle for long-term development. Development in some of the region's most successful economies such as South Africa and Botswana has been underpinned by minerals extraction and other countries with natural resource wealth wish to replicate this success. The mining industry is also a large end-user of electricity and cannot operate without a reliable supply (Sinkala 2009; AU, 2009, CMSA, 2009).

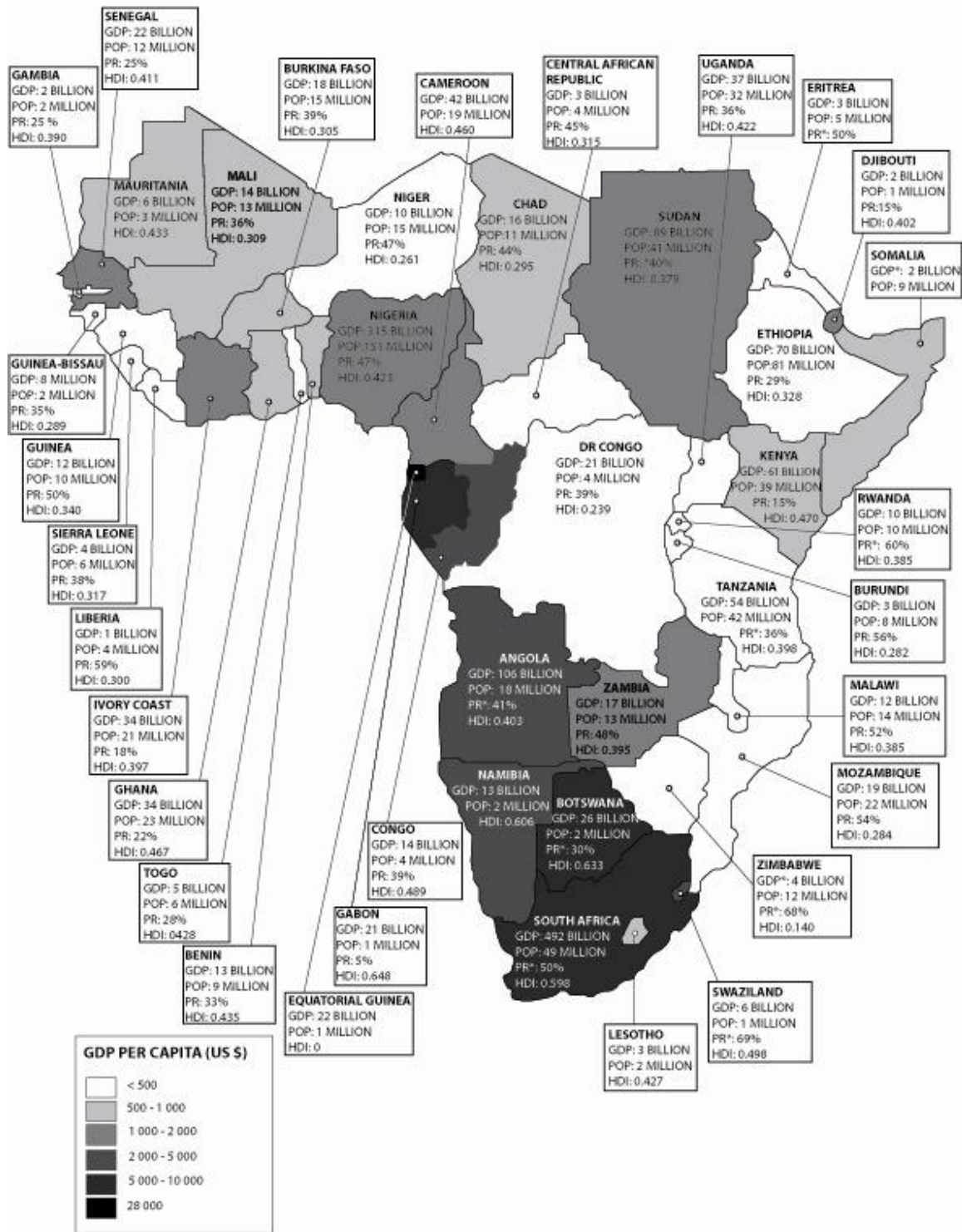


Figure 1. The states of mainland Sub-Saharan Africa. GDP is in US dollars at Purchasing Power Parity. GDP per capita is in current US dollars. Pop = population; PR = Poverty Rate (%); HDI = Human Development Index. GDP and PR Data for 2008 and from World Bank (2010), except when marked with a \* in which case they are from CIA (2011). HDI data are from UNDP (2010).

## 1.2 Aim of research

Sub-Saharan Africa has a large infrastructure deficit, which is broadly recognised as a major impediment to development and the most significant infrastructure challenge lies in improving the power sector. The broad aim of this work is to contribute to the growing body of knowledge that focuses on improving the power sector in the region. At the same time, the

region has significant mineral resources and the expectation of many stakeholders is that the exploitation of these can contribute to meaningful development. Given Africa's large mineral reserves and the current high commodity cycle and mining boom, it is likely that the mining industry in the region will grow significantly in the future. The specific aim of this work is to explore the role of the large, politically powerful mining industry in power sector development.

### 1.3 Meaningful Development

The term meaningful development appears often in this work and in the development literature as the ultimate aim of a program or a society. Unfortunately it is also a term that while conceptually useful as a goal, lacks a clear and uncontroversial definition. Sustainable Development (SD), which is the stated goal of most literature sources, development organisations and governments, was defined by the Brundtland Commission as "Development that meets the needs of today without compromising the ability of future generations to meet their own needs" (WCSD, 1987, p.24). The context of SD differs in countries that are already materially developed and those that have yet to develop economically. Countries that are already developed need to undergo a paradigm shift onto a more sustainable path and countries yet to develop need to do so in way that they do not lock themselves onto a path of unsustainable consumption.

In this thesis, the term meaningful development is used in the context of minerals based development. Mineral resources are finite hence it not possible to mine them sustainably, however as will be established in chapter 4, there is a general consensus that mining can contribute towards sustainable development. For the purpose of this thesis, the definition of meaningful, resource driven development is drawn from the Africa Mining Vision (AU, 2009; see section 4.6). According to the vision, for countries exploiting natural resource wealth, meaningful development occurs when the mining sector catalyses broad-based growth via up, down and side-stream linkages to other sectors of the economy, that adds to the infrastructure and skills base of a country and pays a fair natural resource rent while at the same time undertaking its operations in the most environmentally benign manner. In other words, countries reliant on mineral wealth today should become less reliant on their natural resources as time progresses, their economies diversify and they build up a value adding manufacturing base with associated service sectors. If this occurs, then when mineral reserves are inevitably depleted or prices drop, future generations will have alternative means to satisfy their needs.

### 1.4 Problem Statement

Sub-Saharan Africa suffers from a severe infrastructure deficit, most notably in the power sector. 32 of the 48 countries in the region have electricity systems vulnerable to supply shocks and frequent disruptions (World Bank, 2008; Eberhard *et al.*, 2009). The region is also richly endowed with mineral resources and the mining sector, which already forms a large portion of electricity demand, is expected to grow (UN, 2010a).

A stable electricity supply is both vital to economies and important for poverty alleviation efforts and sustainable development (World Bank, 2008; UN, 2010b). Supply unreliability constrains firm productivity (Escribano *et al.*, 2008), slows economic growth and manufacturing output (Calderón, 2008), damages and increases the maintenance costs of infrastructure and investments, impedes manufacturing and agricultural output and limits the developmental benefits of electrification (World Bank 2008; Eberhard *et al.*, 2008). More specifically relevant to countries pursuing minerals based development, a stable electricity supply is critical to mining operations and to downstream value-adding processes (e.g. CMSA, 2011; Africa Review Monitor, 2008; OECD, 2008).

Given the importance of electricity to development there are a growing number of organisations and initiatives and a large body of literature devoted to increasing access and supply reliability (e.g. Foster & Briceño-Garmendia, 2009a; IEA, 2010, Legros *et al.*, 2009; AGECC, 2010). While these identify rising demand as one of the major problems that needs to be overcome if supply is to be made reliable and electrification expanded, they do not consider the influence that large, politically powerful end-users have on the sector and hence their potential role in its development. Mining is a major industry in Sub-Saharan Africa and historically has catalysed the development of power and other infrastructure in much of the region (e.g. ZESCO, 2011a; ESKOM, 2011a) and, as such, its role in the development of the electricity sector is worth considering.

## 1.5 Rationale and Knowledge Gap

This author is Zimbabwean and wished to make a contribution, however humble to the long-term, meaningful development of Sub-Saharan Africa. According to the mainstream development community, the lack of access to electricity and the unreliability of the existing supply is a large impediment to this (World Bank, 2008). At the same time, the mining industry, which is also of major developmental importance, has boomed in recent years and it is likely that it will continue to do so (Ericsson, 2010; Peck, 2011; Sinkala, 2009). Mining has great potential to drive economic growth and catalyse the development of value-adding manufacturing and services industries, which should ultimately replace it as the major contributors to GDP (e.g. AU, 2009; UN, 2010a; IIED, 2002). However, rising demand from mining is increasing the pressure on already overstretched supply systems. This in turn, constrains growth in other sectors of the economy (World Bank, 2008). Unreliable power reduces growth by ca. 2 percentage points and is a major constraint to productivity particularly in the informal sector (Calderón, 2008; Escribano *et al.*, 2008). Disruptions in domestic consumption also limit the developmental and poverty alleviation benefits of electrification (World Bank, 2008; IEA, 2010).

Given its benefits, electrification and improving system reliability are high on the development agenda. Mainstream development organisations such as UNDP, the World Bank and the Commission for Africa all devote resources to power sector development (e.g. UNDP, 2011; World Bank, 2008; CFA, 2010). Similarly, the repercussions of system unreliability are well documented in the literature, as are solutions to the power crisis (e.g. Eberhard *et al.*, 2008; UNECA, 2007). While most sources identify meeting rising demand as one of the key challenges that needs to be overcome in order to be able to deliver a reliable supply across national grids, the role of large end-users and their influence on power sector development is largely not considered and this is the point of departure for this thesis.

Mining also requires a reliable, guaranteed, constant power supply and both the current operations and the future growth of the industry are impeded when this is not available (e.g. CMSA, 2009). In this regard, the interests of the mining industry and wider society are aligned, both would like a reliable power supply at the lowest possible cost (in this case lowest possible cost can include a premium for reliability). The mining industry also has considerable political influence in the countries where it operates and manages to convince governments to invest in roads, railways and ports, change labour laws and business regulations and alter taxation regimes. Given their dependence on the electricity supply, it is likely that the industry is also active in power sector development. This thesis contributes to the knowledge by documenting how the mining industry is influencing the power sector in Zambia and South Africa.

## **1.6 Research Question**

This thesis aims to address the power supply crisis in Sub-Saharan Africa by considering the role of the large and growing, politically powerful mining industry that exists there. The research question to be addressed is:

How does the mining industry influence the development of the power sector in Sub-Saharan Africa?

## **1.7 Target Audiences**

This work is primarily directed at those individuals or organisations involved in development in Sub-Saharan Africa. In particular the mainstream, multilateral organisations that push electricity for development such as the World Bank Group, the Africa Infrastructure Country Diagnostic UNEP, UNDP, UNECA and the Commission for Africa. It is feasible that they might behave differently if they begin to consider that the mining industry is a significant player in electricity development and could begin to include it in their portfolios and enhance its role. Similarly, power sector supporters and financiers may take a different view of project viability and funding if they consider new infrastructure development in the context of a rapidly expanding mining base.

This work would also be of interest to the mining industry as it seeks to enhance its social licence to operate in the region. Mining companies could consider enhancing their infrastructure roles within their corporate social responsibility portfolios in order to augment their reputations and increase their chances of being awarded further natural resource rights. This thesis also presents a number of proposed solutions to improve overstretched power systems, including regional integration. Mining industry players might opt to promote some of these solutions as they exert their influence on the development of the power sector.

## 2 Research methodology

This section introduces the conceptual framework, which was used in the latter stages of the research to assist in the identification and classification of the strategies and behaviours that the mining industry adopts towards the power sector. The research objectives draw from the conceptual framework and hence these are presented afterwards. In the last section, the research methods used, sources identified and types of information sought for as well as relevant limitations are documented and defended.

### 2.1 Conceptual Framework

This thesis discusses mining companies (organisations) and electricity systems (part of the environment that mining companies operate in). As large-scale mining cannot take place without reliable electricity, mining companies are to an extent dependent on their power supplies. A relevant body of theory pertaining to organisations and their external environments is Resource Dependency Theory (RDT) (Scott, 2003). The following three paragraphs describing RDT are sourced from Pfeffer and Salancik (1978; 2003) who are the early delineators of the theory as it is widely used today.

The basis of RDT is as follows:

1. The survival of an organisation rests on its ability to acquire and maintain resources.
2. No organisation has full control of all its resources, some need to be sourced from the external environment.
3. Hence, organisations are to a certain degree, reliant on their environments to survive.

This reliance on the environment would not be a problem if stable supplies were assured, however the environment is often unpredictable and undependable. It changes, new organisations constantly emerge and existing ones leave and so on. Acquiring certain resources can therefore be problematic. Organisations prefer to operate in an environment without constraints and, according to RDT will endeavour to increase their power over and hence reduce their dependency on critical resources. They can do this by:

1. Acquiring as much control over critical resources as possible
2. Acquiring control over resources that make other organisations reliant on them

In the organisational behaviour literature, a number of different strategies and behaviours adopted by firms have been identified as in accordance with RDT. The theory has also been conceptually useful in a broad range of industries for a broad range of external resources. For example, Singh (2007) looked the hiring of ethnic minorities on the boards of FTSE 100 companies in the US and concluded that they gave those companies access to new pools of resources such as links to public bodies and community influence. Hirsh (1975) compared the pharmaceutical and music industries, which both rely on patent law to survive. He concluded that the pharmaceutical industry was the more profitable as it was better equipped to modify its legal environment to its own advantage. McCarthy-Byrne and Mentzer (2011) looked across eight different industries and concluded that firms may integrate their supply chains to assist in resource access and create additional value. A common thread in all the examples found was that organisations can either adapt to or try and influence their external environments. The various strategies they can adopt in order to do this are shown in Table 1 below, which forms the framework for this research. In the literature review and interviews similar strategies were looked for in the mining industry.



*Table 1. Examples of strategies adopted by organisations in the Resource Dependency Theory literature. Congruent strategies adopted by the mining industry towards the power sector were sought after in the course of this research.*

Strategy	Description	Literature
Outcompete other organisations	An organisation will seek to secure access to its own resources by becoming more competitive	Pfeffer and Salancik (1978)
Modify the environment	An organisation will try and influence the regulatory environment to its own advantage	Hirsch (1975); Pfeffer and Salancik (2003)
Access new pools of resources	An organisation will adapt to the environment by taking steps to access new or existing pools of resources	Singh (2007)
Interorganisational alliances	Organisation will form an alliance to increase its power and control over the providers of scarce resources	Barringer and Harrison (2000); Ireland <i>et al.</i> (2002); Bretherton and Chaston (2005)
Exchange alliance	Partner organisations cooperate in achieving their distinct objectives by offering a resource in exchange for another resource.	Chen and Chen (2003)
Integration alliance	Resources are pooled for a common purpose and integrated into an organisation designed by partners	Chen and Chen (2003)
Negotiated Environments	Organisations enter into inter-organisational arrangements between buyers and sellers to decrease uncertainty	Buvik and Grønhaug (2000)
Supply-chain value integration	Organisations form collaborative supply chain relationships. Integrated efforts create joint value that would not be possible in the absence of the relationship	McCarthy-Byrne and Mentzer (2011)

## 2.2 Objectives

The research question raises a number of objectives. The thesis is set in the context of the importance of electricity and development which needs to be established. An overview of the electricity situation is also required. Therefore the first part of the thesis which is devoted to outlining the problem and setting the context has the following objectives:

7. Set the context of the importance of electricity to economic growth and development.
8. Establish reasons and delineate solutions for the regional electricity problems.
9. Set the context of the importance of mining to development.

The second part of the research is where the role of large mining companies is considered. As a Resource Dependency Theory framework is used, it is necessary to determine that the mining industry is dependent on the electricity situation. This is the fourth objective:

10. Establish the dependence of the mining industry on electricity.

Once this is established than the behaviours and strategies the mining industry is adopting towards the power situation can be explored. Hence the fifth research objective:

11. Establish the steps that mining companies are taking to manage their dependency on electricity.

Once the fifth objective has been realised, then it will be possible to answer the research question and determine how the mining industry affects the development of the power sector. If it is concluded that the influence of the mining industry is significant, then this has some implications for the knowledge gap that this thesis identified. Hence the final research objective:

12. Discuss how those organisations and institutions seeking to improve power infrastructure in Sub-Saharan Africa should consider the role that the mining industry has to play in power sector development.

## 2.3 Methodology

### 2.3.1 Timing and the Development of the Research Topic

This work has its origins in the Applied Research in Preventative Environmental Approaches (ARPEA) course taught in semester three of the MESPOM program at Lund University and progressed in four main stages.

Stage 1 involved preparing the mini research project required for the ARPEA course. This was designed to be a test for a thesis topic on the potential of Demand Side Management (DSM) in mining in Sub-Saharan Africa in stabilising the power systems there.

The ARPEA work identified that DSM was one avenue to improve power sector performance in the region and that there was significant potential for it in the large mining industry. Stage 2 involved analysing the ARPEA data and findings and preparing to continue with DSM in mining as a thesis topic.

Stage 3 involved a visit to South Africa (and one site in Zimbabwe) to interview mining sector representatives about power management and the potential for demand shifting and efficiency measures in the sector. The initial focus of these interviews was on DSM, however, it soon became apparent that the mining industry had a wider role to play as interviewees expressed the other solutions that the industry was facilitating externally as well as internally.

In stage 4, the results of the literature review, database searches and interviews in South Africa were analysed and it became apparent that the role of the mining industry was potentially more wide ranging than just DSM. It was decided that the external influences of the mining sector were potentially also important in power sector development and as such, should be included in the scope of the project. This involved a realignment of research objectives and focus from DSM to the RDT framework described above.

Once the new research objectives and RDT framework had been developed they were retroactively applied to past interviews, literature review and database results. Ongoing research, including follow up interviews in South Africa and the Zambian series of interviews then had the specific aim of identifying behavioural strategies adopted by the mining sector to manage its dependency on power. These were then compared to the range of solutions to the regional power problem prescribed in the development literature in order to determine whether or not mining has a significant role in improving the power sector.

Table 2. Research timetable from December 2010 till May 2011.

		Task	Dec	Jan	Feb	Mar	Apr	May
DSM Focus	Identifying the research problem and knowledge gap	Preliminary research (ARPEA)						
		First round of Interviews (in South Africa and Zimbabwe)						
		Literature review and database searches						
		Ongoing analysis feeding back into research process						
<b>Broadening of scope, realignment of objectives and shift in focus to RDT</b>								
RDT Focus	Ongoing data collection, processing and analysis	Development of RDT Framework						
		Apply RDT to past research on DSM						
		Ongoing literature review and database searches with RDT focus						
		Second round of interviews						
		Writing first draft						
		Final draft						
			Dec	Jan	Feb	Mar	Apr	May

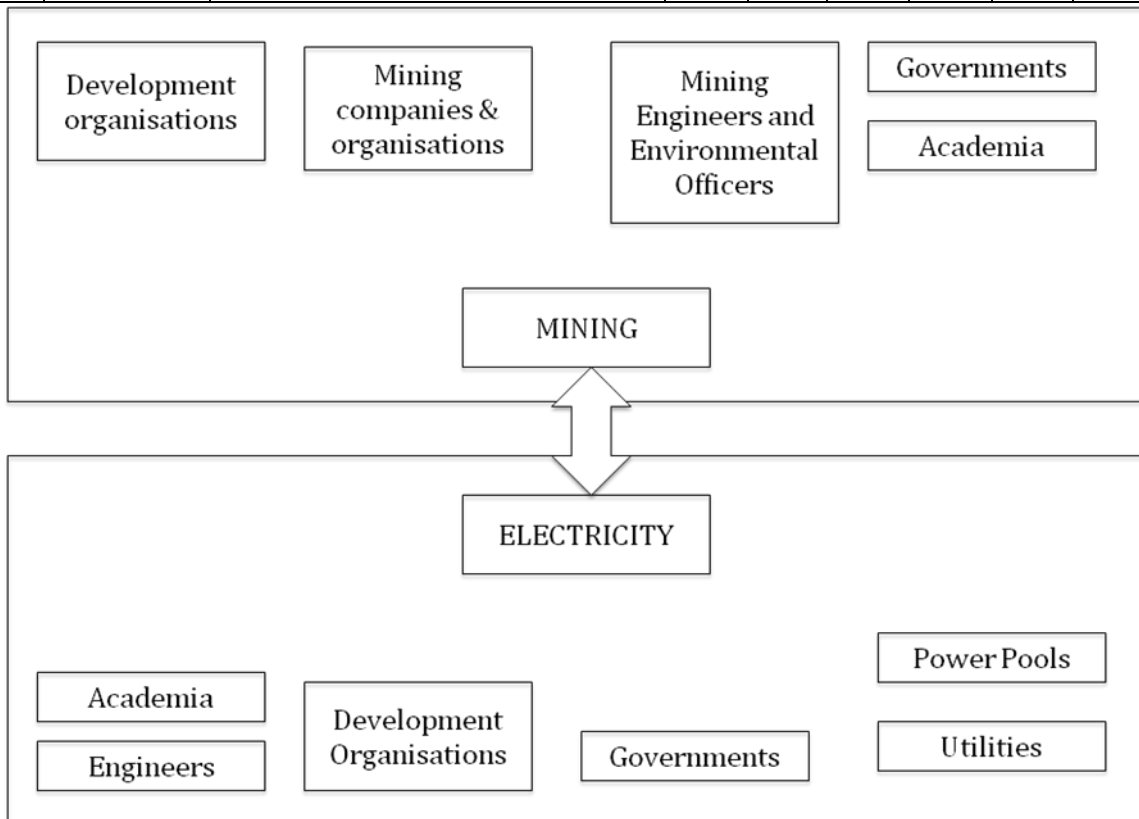


Figure 2. Stakeholder groups identified during the research process. The interaction between the mining and electricity sectors was the focus of research.

### 2.3.2 Stakeholder Selection

An effort was made to identify a broad range of sources from multiple fields in order to gain a multi-angle, integral view of the research topic. The broad range of sources identified is shown in Figure 2. Further details as to which sources were used for which information and why is provided in section 2.3.3 below and illustrated in Figure 4.

### 2.3.3 Research Methods

This thesis was conducted via literature review, backed up by database searches and expert interviews. A site visit in Zimbabwe was also conducted, however its usefulness was limited due to a power failure at the time. Major stakeholders in the mining and electricity fields were identified with aim of obtaining a multi-angle, integral view of these sectors. These methods were chosen as they allowed for the greatest amount of relevant information to be analysed within the given time period than with for example surveys or questionnaires directed at certain stakeholders.

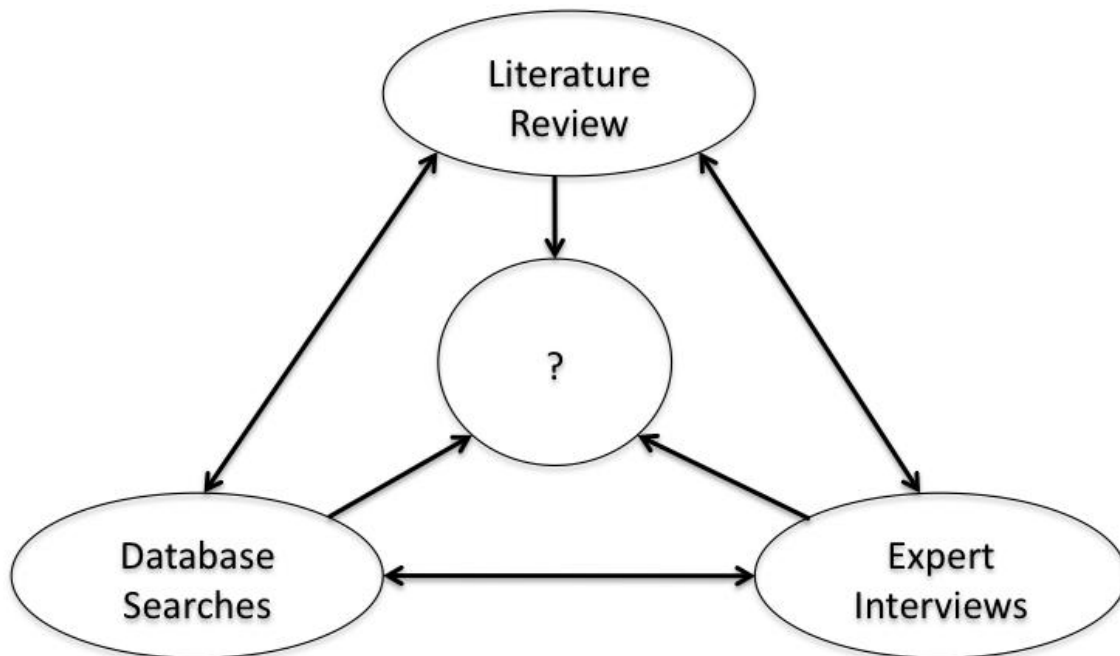


Figure 3. Methods used to approach the research question.

In order to meet the research objectives a number of information types were specifically sought after during the course of this work, which initially considers the power and mining sectors separately and then together. The following paragraphs outline what kind of information was sought for during the research process and the reasons why.

Regarding the power sector, it was necessary to establish the current state of infrastructure in the region, whether it is sufficient and how it is developing. At the same time the view of the mainstream development community as to why reliable power is important and how regional power systems should be improved was sought after. It was necessary to identify what the specific issues faced by the sector are, and how the power sector and development community are rectifying these or how they should be rectified. This was done in chapter 3.

The knowledge gap identified in this thesis is that the role of the mining sector is largely unconsidered in the development of the power sector. A perfectly feasible explanation for this is that the mining sector does not have a significant role to play. This work aims to establish that the opposite is the case. This was done in two steps. The first step in chapter 4 involved

establishing via mining sector sources, mining related organisations (e.g. Raw Materials Institute and US Geological Survey), development organisations (e.g. UNEP) that mining is a large industry in the region, makes a significant economic contribution, has considerable political influence and is expected to grow. The second step in chapter 5 outlined the steps that the mining industry was taking to manage its dependency on a reliable power supply. These steps were compared to the list of solutions to power sector issues in the region generated in chapter 3 in order to argue that the mining industry has a significant role to play and therefore should not be overlooked.

The fact that the mining industry has a significant role to play in power sector development raises the question of how should the industry be considered. This and other implications of the research finding are discussed in chapter 6. An outline of the sub-questions asked during the research process, the types of information sought after and why is shown in Figure 4.

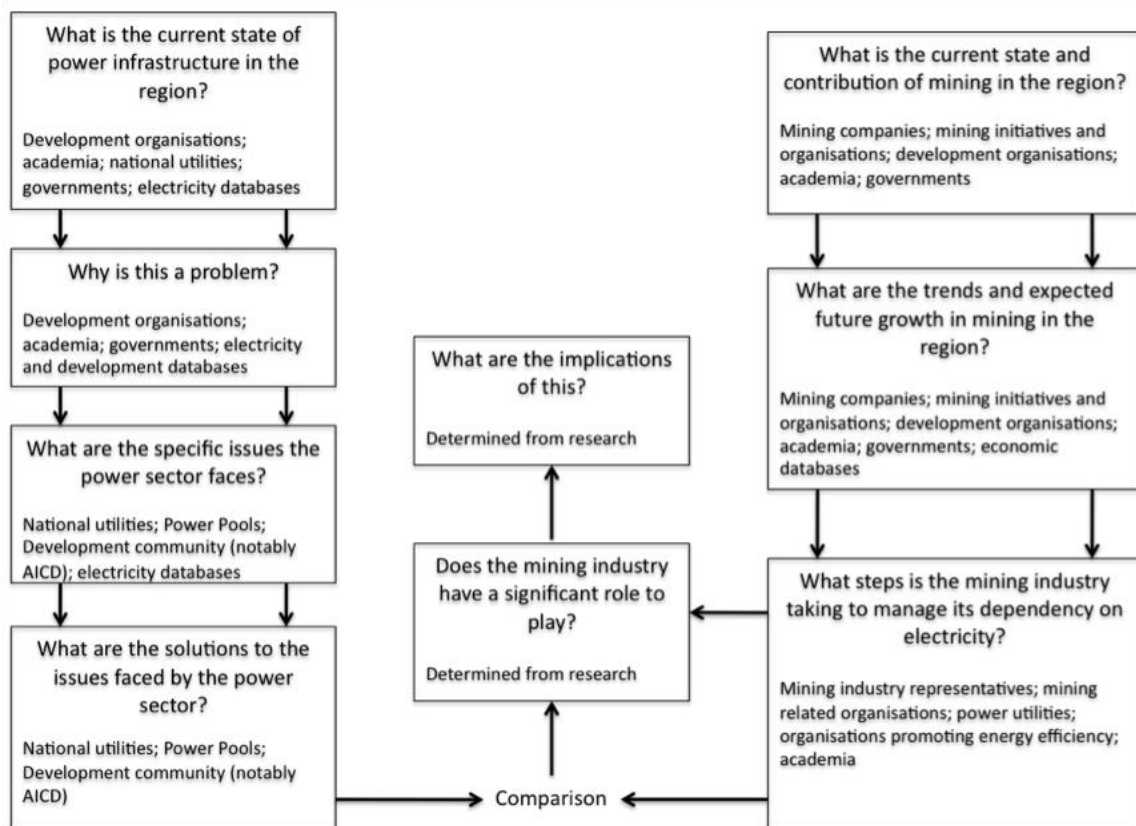


Figure 4. The reasoning behind each section of the research and the sources used in each step.

### 2.3.3.1 Literature Review

A detailed literature review was performed to establish the state of the electricity and mining sectors on mainland Sub-Saharan Africa. Sources identified for this are shown in Figure 2. Literature was found via general internet searches; perusal of relevant organisational websites, searches of the Lund University Library catalogue as well as searches of the literature databases subscribed to by Lund University. Reverse searches for documents citing AICD documents were performed as well in an effort to find criticisms of this heavily relied upon source (see section 2.4 for limitations). The literature review forms the backbone of the thesis and important in meeting all research objectives.

### 2.3.3.2 Database Searches

Wherever possible, database searches were done to verify or back-up claims made in the literature. However in some instances, the literature source used the same data. For example ACID sources draw on the AICD database, which is arguably the most reliable and up to date one pertaining to the power sector. In those cases, data were used to illustrate rather than corroborate findings. The reader is able to use the reference system to identify when data are corroboratory or illustrative. The databases searched were:

- The World Bank Electricity Database for power issues;
- International Energy Agency database for power issues;
- World Bank Africa Development Indicators database for power issues as well as regional economic and developmental data;
- United Nations Statistical Division database for regional economic and developmental data;
- CIA world factbook for regional economic and developmental data;

### 2.3.3.3 Expert Interviews

Experts from as many stakeholder groups as possible were interviewed on the subject. The broad aims of the interviews were to corroborate findings in the literature, obtain personal insights and to establish areas for further research. Important informant groups identified during the literature review process were mining companies; mining related organisations; electricity utilities and power pools and electricity development organisations. A summary of informant groups contacted is given in Table 3 below and a full list of all interviewees is shown in Appendix 1. Interviews were either conducted in person, over the phone or via Skype.

*Table 3. Number and sector affiliation of experts contacted from each informant group.*

Informant Group	Interviewees
Mining companies	Directors (1) Engineers (2) Managers (2) Consultants (2)
Mining organisations	Chamber of Mines Representatives (2) School of Mines Academics (2)
Electricity utilities and power pools	Southern African Power Pool Chief Engineer (1) Copperbelt Energy Corporation Manager (1)
Electricity organisations	Energy Efficiency Company (1)

As described in section 2.3.1, the theme of the interviews changed as the research progressed. This is because during the initial interviews that focused on DSM in the mining sector, interviewees voluntarily broadened the topic to wider power sector issues (it should be noted that one of the aims of the interviews described in the preceding paragraphs was to establish areas for additional research). As this became apparent the scope of the interviews was also broadened to include how the mining sector is involved in any power sector issues. After the RDT conceptual framework had been formulated, roughly halfway through the interview process, resource dependency behaviours became a specific theme in the interviews. Where

RDT behaviours could not be retroactively inferred from prior interview notes, follow-up interviews were conducted.

Contacts were initially established via personal connections with people involved in the mining sector and via emailing the authors of important sources. Additionally, contacts suggested by interviewees were an important source.

The interviews were informal with a loose framework in which each participant was sent a brief description of the research problem in an email sent well beforehand and then asked for their point of view. Given the wide variety of stakeholders a consistent set of interview questions was not possible however each participant was asked how they thought the mining industry affected power demand and its interest and role in rectifying the problem.

In chapters 3 and 4 of this document the role of interviewees was secondary to the literature review and was used to back up and/or as an additional source of information. However, the relative importance of the interviews increased in the latter part of the research, which focuses on the strategies adopted by the mining sector in response to its dependence on the electricity supply.

#### **2.3.3.4 Site Visit**

A site visit was undertaken to Turk Mine, which is a small-scale gold operation just outside Bulawayo in Zimbabwe. In Zimbabwe the monthly electricity tariff for commercial consumers is set based on their peak demand for that month and the purpose of the visit was to view the computerised electricity and peak load management system in operation and gain an idea of electricity management in mining. Unfortunately (and perhaps relevant to this thesis), power to the mine had been cut on the day of the site visit, so it was not possible to do this. An interview with the Chief Engineer was the most that could be salvaged from the day. Nonetheless, a site visit was undertaken.

## **2.4 Scope and Limitations**

This work is delimited to the mainland states of Sub-Saharan Africa and to large-scale mineral extraction. As such, the region's six island states, artisanal mining and oil and gas extraction are not considered.

Regional integration is touted one of the solutions for the power sector and for this reason, this work is applicable to and aimed at the mainland where power trade is possible. However, the region does include island states whose infrastructure and mining data are included by most sources and hence obtaining averages pertaining solely to the mainland was not possible. Similarly other useful sources such as the Commission for Africa consider the whole continent in their analysis and do not distinguish between subregions. In these cases it was made clear that the figures pertained to Africa and not Sub-Saharan Africa. Generally, island states and North Africa have better power infrastructure than mainland Sub-Saharan Africa so their effect on the regional average is positive. As much country level data as possible were presented alongside regional averages to minimise this constraint.

Given that it was created specifically to address the large information gaps on the state of infrastructure in Sub-Saharan Africa, it is not surprising that the Africa Infrastructure Country Diagnostic was relied upon to a large (but not complete) degree as a source of information. In particular, two papers specifically relating to the power sector Eberhard *et al.* (2008) and Eberhard *et al.* (2009) were drawn upon heavily. An attempt was made to obtain a more balanced view by conducting reverse database searches, with the aid of the Lund librarian for authors who cite AICD papers. Unfortunately, these only yielded documents that had used AICD as a source of information and did not either elaborate on or contradict AICD's

views. Hence a major assumption in this work is the reliability of AICD data. This is not an unreasonable assumption given the scope, organisations, researchers and funding behind the AICD project (see section 3.3). Although the AICD documents are recently published, there has been sufficient time for criticisms and shortcomings to appear in the literature. The fact that the reverse searches only revealed documents that use AICD as a source of information indicates that the electricity development community is comfortable with the reliability of AICD. Nevertheless, in recognition of this limitation, AICD claims were backed up by data from other sources wherever possible.

Although contact was made with AICD, it was not possible to secure an interview with one of their representatives. This was unfortunate as an interview is likely to have contributed to this work and some useful insights such as further details as to how AICD calculate their future demand projections and whether or not these take into account DSM initiatives and the imminent expansion of the mining industry were not obtained. As far as this author is aware, AICD do not give a timeline for their recommended spending on infrastructure and without an interview, this could not be clarified.

An effort was made to get the most recent data possible. However a time lag between the publication of this thesis and the collection of the data was sometimes unavoidable. For some data such as installed generation capacity, which are robust and slow to change, this is not an issue. However other datasets such as installed emergency generation or unelectrified households living within 10 km of the national grid are potentially more dynamic. Hence, giving the reader a view of the actual current situation is not possible. The year data are taken from is always given in captions or the text. Database searches were used to either corroborate or illustrate the findings of literature sources. These draw from a variety of sources and their researchers then select and display what in their opinion is the most correct figure. Back of the envelope calculations were performed to ensure that data presented were not unrealistic, however apart from this check, for the purpose of this work, these data were assumed to be sound.

Whether or not countries in Sub-Saharan Africa should exploit their mineral wealth as part of their national development plans and whether or not this will lead to meaningful development in the long-term are two important debates that are outside the scope of this thesis. Rather, this work has the point of departure that the exploitation of mineral wealth is going to occur and is set in that context. This view is shared by governments in the region and reflected in the Africa Mining Vision as well as by a number of key players in the development community including UNDP, UNEP, UNECA, NEPAD and the World Bank.

Hydropower is touted as the 'future of Africa' and could in theory generate most of the power supply according to sources such as AICD and AFREPREN. Examples of these include the proposed Inga Megadam project in DR Congo, which will generate an impressive 43.5 GW and the Grand Millennium Dam in Ethiopia that will generate 5.25 GW. The construction of large hydropower projects raises environmental and social concerns as well as other issues such as water resource conflicts in transnational river basins, debt-burdens and so on. These are also outside the scope of this document. It is hoped that environmental planning and multilateral treaties will be included in the development of the hydropower sector. Given the large amounts of finance required for such projects and the size of the national economies of the countries where they are to be built, it is likely that external sources of funding will be required. Large, concessionary infrastructure loans from the World Bank and IMF require approval from the World Council on Dams so it is likely that environmental planning will take place before most projects are developed.

Finally, it should be noted that the limited scope above was selected in recognition of the project period and available resources



## **3 The Power Sector in Sub-Saharan Africa**

### **3.1 Introduction**

This section gives the reader a general overview of the state of infrastructure in the region and afterwards takes a more in-depth look at the electricity situation. The main aim of this chapter is to fulfil the first two research objectives listed in Section 2.2, namely:

1. Set the context of the importance of electricity to economic growth and development.
2. Establish reasons and delineate solutions for the regional electricity problems

Thus this section establishes why low access rates and unreliable supplies are an issue and the solutions established according to the second objective aim not only to ensure a reliable supply to commercial customers, but also to allow electrification of the population to proceed. The focus is at the regional level with some specific country examples.

### **3.2 Infrastructure in Sub-Saharan Africa**

In its inaugural report *Our Common Interest* in 2005 (CFA, 2005), The Commission for Africa (CFA) documented for public attention, the developmental challenges that Africa faced in its commitment to the Millennium Development Goals. (MDGs) According to the Commission:

“Infrastructure is a key component of the investment climate, reducing the costs of doing business and enabling people to access markets; is crucial to advances in agriculture; is a key enabler of trade and integration, important for offsetting the impact of geographical dislocation and sovereign fragmentation, and critical for enabling Africa to break into world markets; and is fundamental to human development, including the delivery of health and education services to poor people. Infrastructure investments also represent an enormous untapped potential for the creation of productive employment.” (CFA, 2005, p.232)

It is not possible to deliver basic services to a population, nor will a people’s ability to generate wealth be enhanced in the absence of infrastructure services. Sub-Saharan Africa suffers from a severe infrastructure deficit. Most of the region’s 791 million people lack access to basic infrastructure services such as all-season roads, electricity, water and sanitation. Paradoxically, not only does the region lag behind the rest of the developing world in terms of infrastructure services (see Figure 5), but the cost of these services are high by global standards (see Table 4) (CFA, 2005; Foster & Briceño-Garmendia, 2009a).

The lack of infrastructure constrains GDP growth by ca. 2.3 percentage points (Calderón, 2008). This is significant given that regional GDP growth is currently 4% and needs to be increased to 7% in order to meet the MDGs on poverty alleviation (Foster & Briceño-Garmendia, 2009c). An analysis by Escribano *et al.* (2008) also showed that inadequate infrastructure services are the single biggest constraint to firm productivity (30 – 60% of the adverse effect in countries analysed). Importantly, this study identified that infrastructure presents a larger problem to most firms than other regional issues such as bureaucratic red tape and corruption. It should also be noted that power accounted for 40 – 80% of the infrastructure effect in half of the countries analysed.

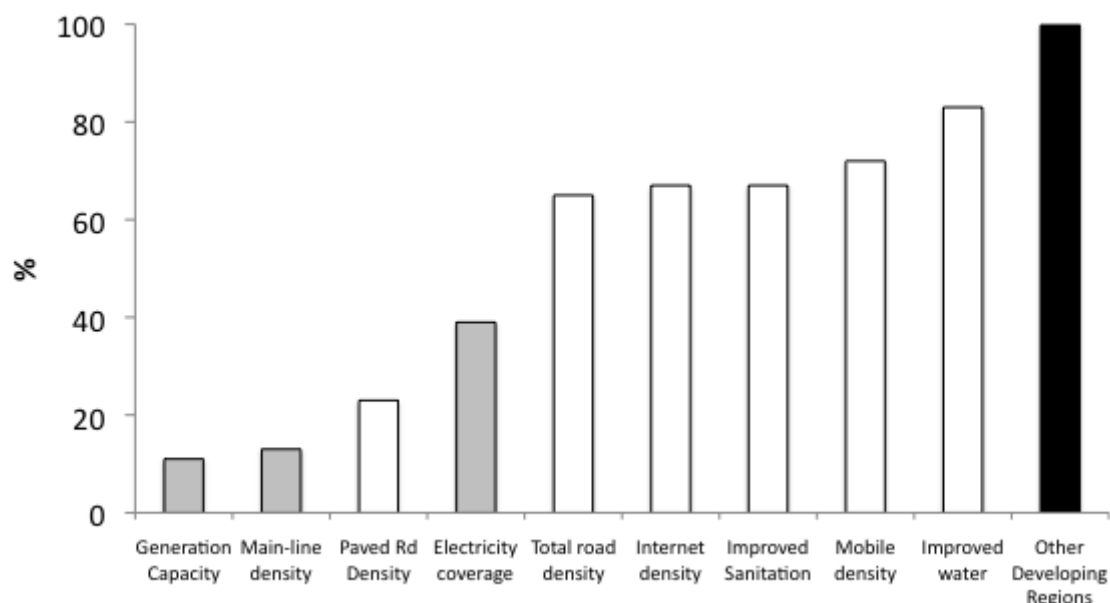


Figure 5. Sub-Saharan Africa’s infrastructure deficit: percentage infrastructure access in the low-income countries of Sub-Saharan Africa compared to other developing regions (100%). Power sector indicators shown with grey bars. Data taken from Yepes, Pierce and Foster (2008). Units compared are MW per million population for generation capacity; km per 100 km<sup>2</sup> arable land for road density; connections per 1 000 population for telephone, internet and mobile density and percentage population for electricity, water and sanitation.

Table 4. A comparison of the cost of infrastructure services between Africa and other developing regions. Ranges reflect prices in different countries and different consumption levels. Note that data for telephony and internet represent all developing regions including Africa.

Sector	Units	Africa	Other developing regions
Power tariffs	US\$/kWh	0.20 – 0.46	0.05 – 0.10
Water tariffs	US\$/m <sup>3</sup>	0.86 – 6.56	0.03 – 0.6
Road freight tariffs	US\$/tonnekm	0.04 – 0.14	0.01 – 0.04
Mobile phones	(US\$/basket/month)	2.60 – 21.0	9.90
Internet dial-up service	US\$/month	6.70 – 148.00	11.00
International telecommunications	(US\$/3 minute call to the United States)	0.44 – 12.50	2.00

Source: Foster and Briceño-Garmendia (2009b)

### 3.3 The Africa Infrastructure Country Diagnostic

After the CFA published its inaugural report in 2005, a political commitment was made at the G8 summit at Gleneagles to increase funding for African infrastructure. This commitment gave rise to the creation of the Consortium for African Infrastructure (CFI), a multi-stakeholder body with the responsibility of closing the infrastructure gap. It soon became apparent that there was a large lack of reliable data and analyses on even elementary items such as quantity and quality of infrastructure stocks, access to services, prices and costs, efficiency parameters, historic spending and future investment needs. This was identified as a serious impediment to understanding the region’s infrastructure and developing efficient solutions. In view of this, the consortium created the Africa Infrastructure Country Diagnostic (AICD) to improve the knowledge base of African infrastructure by collecting data and

analysing past successes and failures. The AICD steering committee is chaired by the African Union and includes representatives from the African Development Bank, the New Partnership for Africa's Development (NEPAD) and the regional economic communities namely, the Common Market for Eastern and Southern Africa (COMESA), the Economic Community of West African States (ECOWAS), Economic Community of Central African States (ECCAS), East African Community (EAC) and Southern African Development Community (SADC) (Foster and Briceño-Garmendia, 2009c).

Although the AICD project is not yet complete, it has collated the most up-to-date data on infrastructure in Sub-Saharan Africa and, alongside reports from CFA, utilities and the Southern African Power Pool (SAPP) is the source most heavily relied upon in this chapter hence its detailed introduction in this document. The first stage of the project focused on primary data collection from 24 Sub-Saharan African countries. This is half of the regional total and care was taken during selection to ensure that this large subset was representative of the entire region. This stage gave rise to the most up-to-date data on infrastructure services in the region. The second stage was devoted to analysis of the data and gave rise to the production of the background papers, which are important sources in this thesis. The third stage involved outreach and stakeholder consultation on findings and culminated in the production of the Flagship Report *Africa's infrastructure: A time for transformation*, of which some of the chapters are also important sources for this thesis. Subsequent tasks for AICD include data collection from the remaining Sub-Saharan African countries and the inclusion of North Africa.

AICD estimate that 93 billion US Dollars a year or 15% of regional GDP is needed to close Sub-Saharan Africa's infrastructure gap. This is more than double the Commission for Africa's 2005 estimate of 39 billion and an unachievable burden to most economies. Around 17 billion dollars of this could be raised simply by using existing infrastructure more efficiently (Briceño-Garmendia, Smits and Foster, 2008).

*Table 5. The annual efficiency and funding gaps in African Infrastructure. ICT = information and communication technology; WSS = water supply and sanitation. Figures are in billions of US Dollars a year*

Item		Electricity	ICT	Irrigation	Transport	WSS	Cross-sectoral gain	Total
Total spending needs		(40.8)	(9.0)	(3.4)	(18.2)	(21.9)	n.a.	<b>(93.3)</b>
Existing spending		11.6	9.0	0.9	16.2	7.6	n.a.	<b>45.3</b>
Efficiency Gap	Gain from raising capital execution	0.2	0.0	0.1	1.3	0.2	n.a.	<b>1.9</b>
	Gain from eliminating operational efficiencies	3.4	1.2	–	1.9	1.0	n.a.	<b>7.5</b>
	Gain from tariff cost recovery	2.3	–	–	0.6	1.8	n.a.	<b>4.7</b>
	Potential for reallocation	n.a.	n.a.	n.a.	n.a.	n.a.	3.3	<b>3.3</b>
	Total	6.0	1.3	0.1	3.8	2.9	3.3	<b>17.4</b>
Funding gap		(23.2)	1.3	(2.4)	1.9	(11.4)	3.3	<b>(30.6)</b>

*Source: Foster and Briceño-Garmendia (2009a)*

### 3.4 Power infrastructure in Sub-Saharan Africa

Sub-Saharan Africa's biggest infrastructure challenge is its power supply. The 48 countries in the region have a collective generating capacity of 70.5 GW, 40 GW of which are generated in South Africa. It has been estimated that as much as 25% of total generation capacity is unavailable due to inadequate maintenance and aging plants (Eberhard *et al.*, 2009). Compared to other regions, energy infrastructure is lacking in quality and quantity, electricity services are costly and unreliable and access rates are low (Eberhard *et al.*, 2008; World Bank, 2008). AICD estimate that a total of 41 billion dollars a year is required to reinvigorate this sector, nearly half of the infrastructure total. Of this, 6 billion dollars could be raised via using existing power infrastructure more efficiently (Foster and Briceño-Garmendia, 2009a). One of the key challenges the region faces is to make energy access universal, with an electricity supply that is both reliable and sustainable in the long-term.

### 3.5 Energy and Development

Energy affects all aspects of human life. The contribution of energy access to development is well summed up by the United Nations Development Program (UNDP) in the energy section of their website:

**“Energy is central to sustainable development and poverty reduction efforts. It affects all aspects of development -- social, economic, and environmental -- including livelihoods, access to water, agricultural productivity, health, population levels, education, and gender-related issues. None of the Millennium Development Goals (MDGs) can be met without major improvement in the quality and quantity of energy services in developing countries” (UNDP, 2011)**

Similar descriptions can be found on the websites or in the publications of other organisations including UNECA (2007), IEA (2010) and AGECC (2010). It is now widely accepted that energy access is an essential prerequisite for sustainable development.

The most high profile development initiative today is arguably the internationally agreed upon Millennium Development Goals which are eight specific targets for basic human rights and needs to be achieved by 2015 (UN, 2010b). Given the importance of energy in achieving these goals, it is perhaps surprising that there is not a goal for energy access. Nevertheless, improving access to both energy and fossil fuels is high on the development agenda and the United Nations Advisory Group on Energy and Climate Change has called for universal access to modern energy by 2030 to be adopted as a goal (IEA, 2010). Most governments have a policy of increasing access and 35 countries in Sub-Saharan Africa have set specific targets (IEA, 2010). Some countries, such as South Africa and Botswana have been remarkably successful in adding new connections (Bekker *et al.*, 2008; Eberhard *et al.*, 2009), others, such as Zambia have experienced more difficulties (Haanyika, 2008).

## 3.6 The State of the Power Sector in Sub-Saharan Africa

### 3.6.1 Electricity Access in Sub-Saharan Africa

Today, most of Sub-Saharan Africa's 791 million people rely on traditional biomass as their primary source of energy. 587 million people or 74% of the population lack access to electricity (See Figure 6) and 653 million people do not have clean cooking facilities (IEA, 2010). If electricity access is to be considered a basic human right, then this is a colossal failure and a significant obstacle to development and poverty alleviation. The long-term sustainability of meeting energy requirements via traditional biomass is also questionable.

There is also a large disparity between rural and urban electrification and electrification levels between income groups. While the overall access rate is 26%, it is 71% in urban areas and 12% in rural areas. At the same time, more than 50% of those in the upper half of the income distribution have access compared to less than 20% in the lower half (Eberhard *et al.*, 2009).

AICD also note that while the other developing regions of the world (East Asia, Latin America and the Middle East) have added at least 20 percentage points to their electrification rates in recent decades, electrification in Sub-Saharan Africa has fallen as population growth and household formation outstrip the rate of new connections. Under the current scenario less than 40% of countries in the region will achieve universal access by 2050 (Eberhard *et al.*, 2009).

Increasing electrification in rural areas will be a significant challenge. According to the AICD, electrification of a household can be achieved at low cost if it is within 10 km of a substation or 5 km of a medium voltage line. Only 15% of the rural population (which accounts for two thirds of the total) meet these criteria and 41% of the rural population lives in areas considered remote from the grid. In the medium term, such remote areas will only be electrified by off-grid technologies such as photovoltaic panels, which have an output costing 50 – 75 USc/kWh (Eberhard *et al.*, 2009).

### 3.6.2 Electricity Consumption in Sub-Saharan Africa

Per capita electricity consumption is low, and falling. If South Africa is excluded it is 124 kWh/person/year, which is roughly 10% and 1% of consumption in other developing countries and in the OECD respectively (Eberhard *et al.*, 2009). This is just enough for each person to use a single, 60 W lightbulb for five and a half hours each day. Couple this with the facts that the majority do not have access to power and the unreliable supplies to industry and commerce and it becomes obvious that the current supply is not enough to facilitate poverty alleviation efforts and the development of modern economies with a value-adding manufacturing base and service sectors.

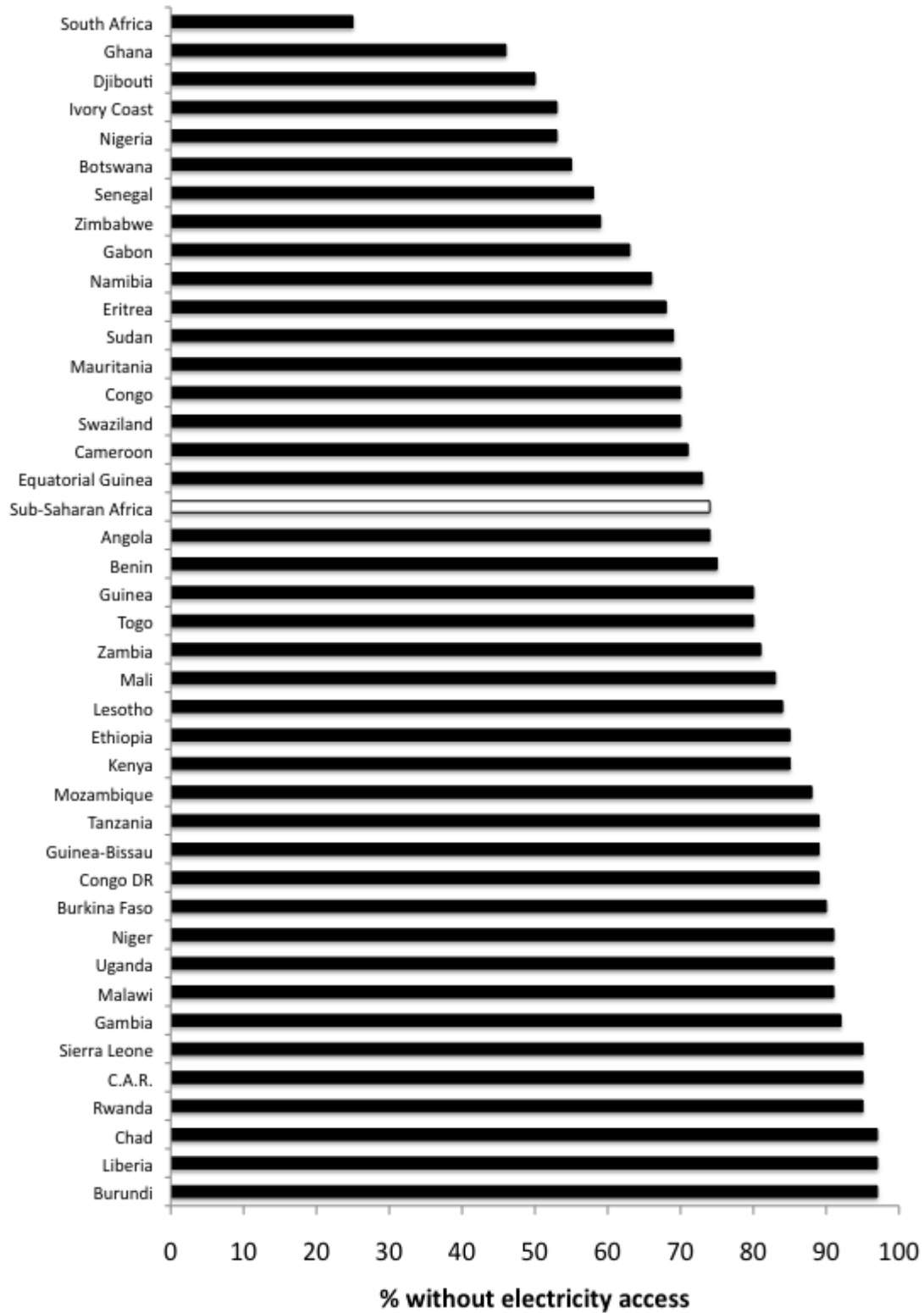


Figure 6. Percentage of the population without access to electricity in the mainland states of Sub-Saharan Africa. Data are from Legros et al. (2009). Note that the average access rate for Sub-Saharan Africa (white bar) includes the island states, which tend to have higher access rates.

### 3.6.3 Supply Reliability in Sub-Saharan Africa

Grid instability is caused when the demand for electricity exceeds the amount being generated. When demand exceeds supply a blackout will follow and it may take a significant period of time to restore supply. Utilities will typically run a reserve margin to ensure that the grid remains stable if power demand were to suddenly peak. The internationally accepted margin is around 15% (Eberhard *et al.*, 2008). The Southern African Power Pool, which is affected by a supply shortfall, aims for 10.2% (SAPP, 2009). If the reserve margin is compromised, then utilities will typically resort to load shedding, which is the selective turning off of sections of the grid in order to maintain overall stability. According to the World Bank and to AICD, 32 of the countries in the region have electricity systems that can be described as highly vulnerable to supply shocks (See Figure 7 and Figure 8) (World Bank, 2008; Eberhard *et al.*, 2008).

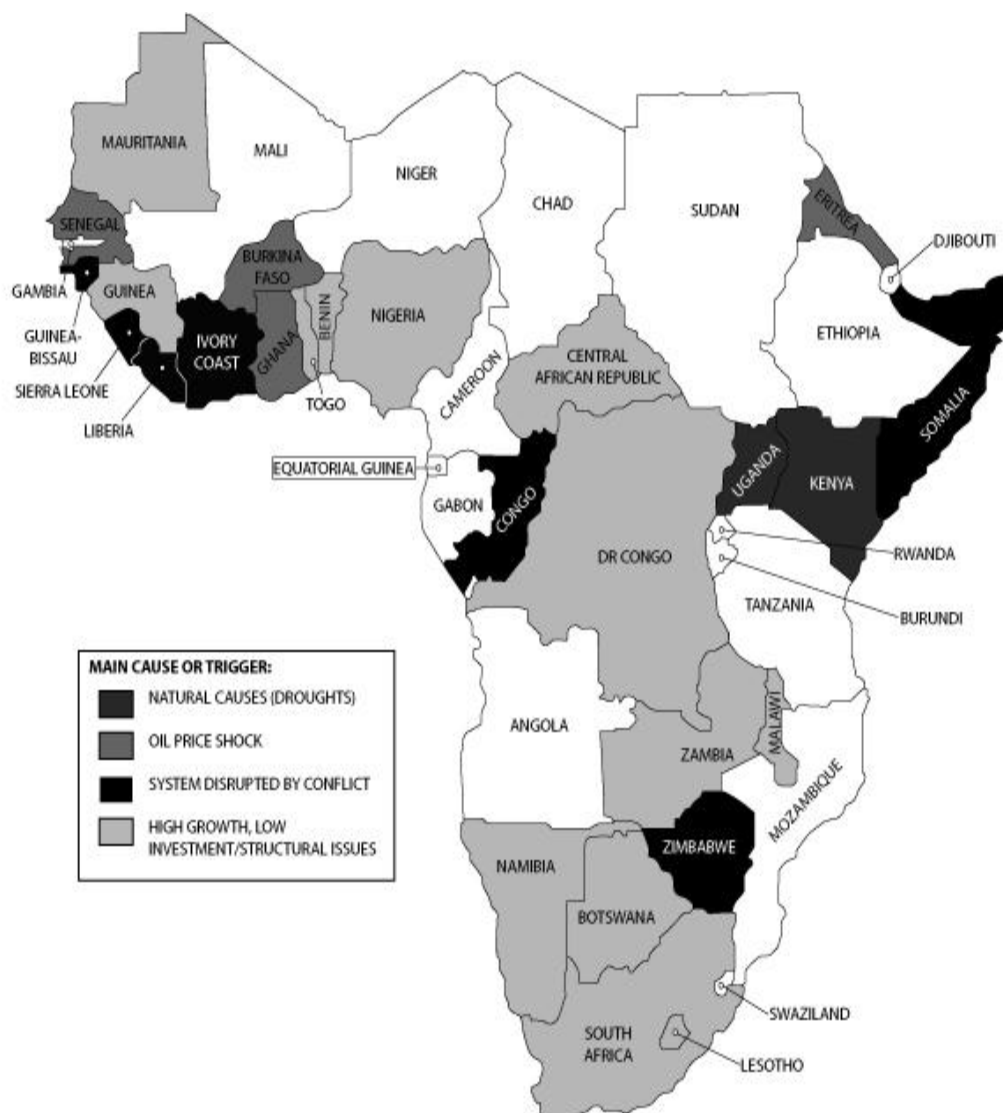


Figure 7. Countries with current or imminent electricity shortfalls and the reasons why. This map shows the extent of the electricity crisis and identifies increasing demand as the most common cause. Source: Eberhard *et al.* (2008).

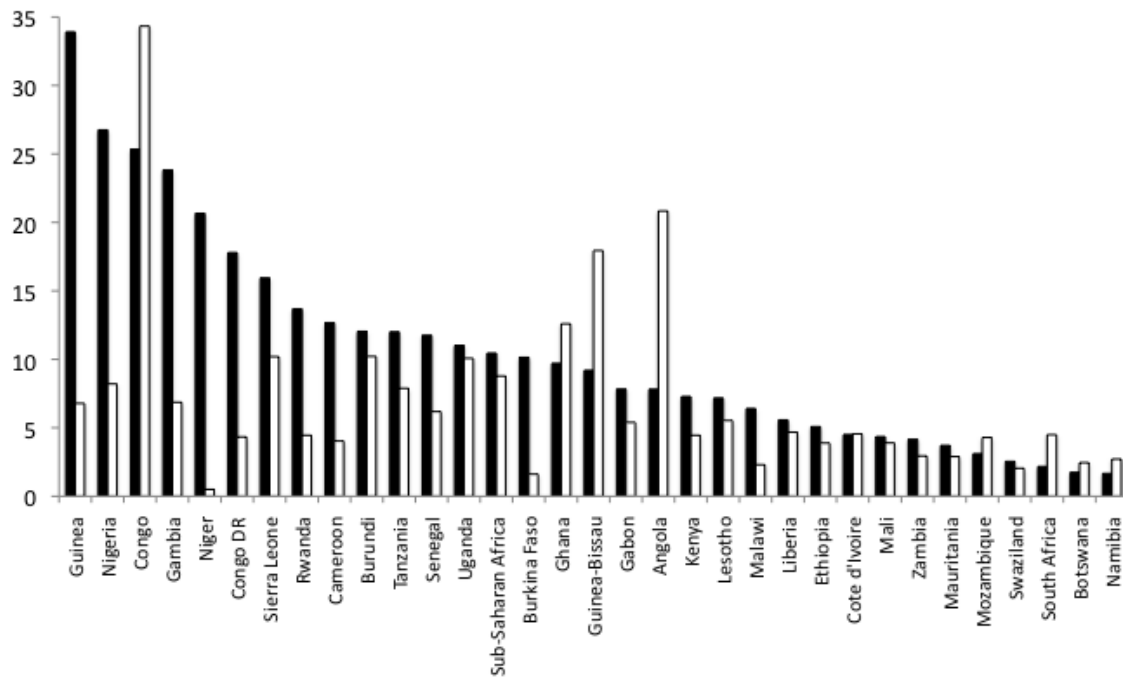


Figure 8. Number of power outages (black bars) and average duration of outages in hours (white-bars) for a selection of Sub-Saharan African countries. High average durations are due to abnormally long power outages (several days) distorting the mean. Data taken from the Africa Development Indicators database (World Bank, 2010) and are from the latest year between 2006 and 2009.

### 3.6.4 The Cost of Using Electricity in Sub-Saharan Africa

There is considerable variation in tariffs within the region, which range from remarkably cheap (0.01 USc/kWh) to very expensive (25USc/kWh). However the average tariff is 14 USc/kWh, which is nearly double that in other developing regions and almost on par with the OECD (World Bank, 2008; Eberhard *et al.*, 2009). This reflects the generally high cost of power in Sub-Saharan Africa.

There are numerous examples of households that are connected to the grid, but have switched off their supply. Additionally, households close to the grid, which should be relatively cheap and easy to electrify often fail to connect up. This indicates that demand as well as supply-side barriers exist to universal access. Sometimes, even if a household could afford the tariffs for using electricity, up-front capital costs in the form of connection charges prevent it from doing so (Eberhard *et al.*, 2009; Banerjee *et al.*, 2009).



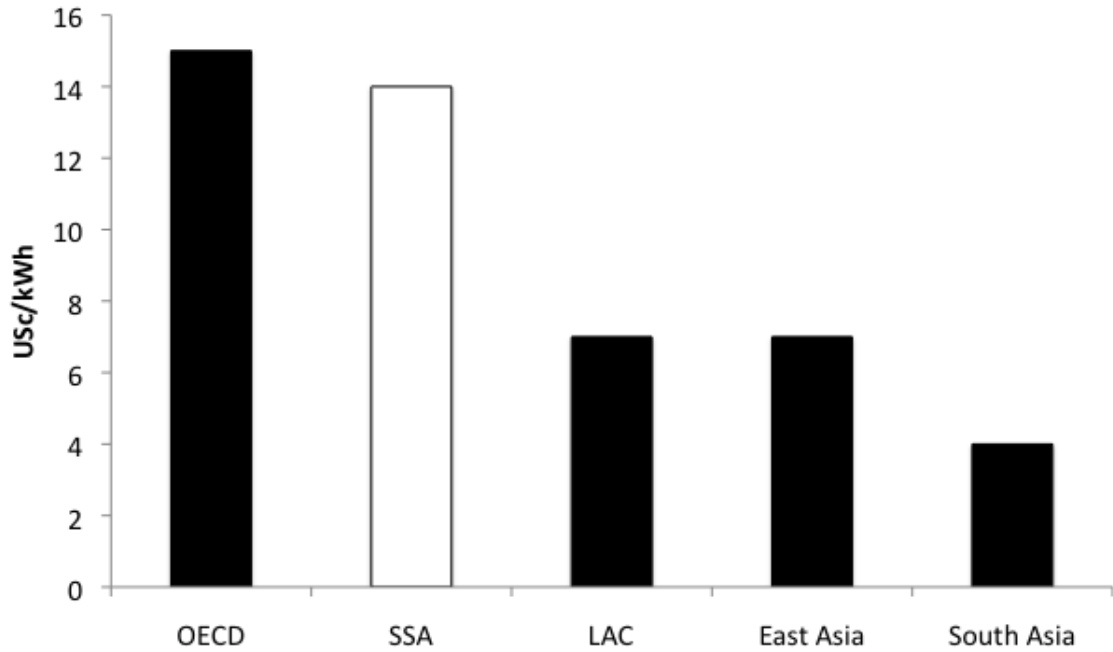


Figure 9. A comparison of average electricity tariffs in the developing regions of the world and the OECD countries. The average tariff in Sub-Saharan Africa is around double that of other developing regions. OECD = Organisation for Economic Cooperation and Development, SSA = Sub-Saharan Africa, LAC = Latin America and the Caribbean. Data for SSA, East Asia and South Asia are from Eberhard et al. (2009). Figures for OECD and LAC are inferred from World Bank (2008).

Affordability issues are exacerbated by expensive power. AICD note that as a general rule, a utility bill should cost no more than 5% of household income to be considered affordable. However, at the same time, a monthly income of 260 US dollars would place a household in the wealthiest 20% in the low-income countries in the region (Eberhard *et al.*, 2009). Therefore, it can be inferred that the monthly electricity bill needs to be less than 13 US dollars to be affordable to richer households. Hence, for a subsistence consumption of 50 – 100 kWh/household, tariffs need to be between 13 and 26 USc/kWh. If access is to be expanded to the wider population, they need to be significantly lower. Cheap electricity also improves the competitiveness of manufacturing and industry and has positive effects on an economy. Historically, this view has been one of the main justifications for subsidising the cost of electricity. A pertinent question today is whether households can afford to pay for services and if not, whether governments can afford to subsidise them. (Banerjee *et al.*, 2009).

Access itself does not automatically alleviate poverty. Rather a certain threshold needs to be reached for a household to be able to afford electricity before its benefits can be realised and household income further increased. It should be noted that the initial, pre-access increase in income required for household access may often be energy related such as the provision of mechanical power to a village decreasing milling costs to farmers or an electric borehole reducing the time spent collecting water (IEA, 2010).

### 3.7 Consequences of Low-Access Rates and Supply Unreliability

Not only do unreliable power systems negate the developmental benefits of electrification, but they affect industry, manufacturing and the private sector. In this light, Eberhard reports that while a factory in the United States can expect a single day's disruption every 10 years, enterprises in Sub-Saharan Africa experience, on average, 56 outages every year (Eberhard *et*

*al.*, 2008). The losses caused by power outages in the form of lost sales and damage to equipment amount to 5 – 6% of turnover for the formal sector and as much as 16% of turnover in the informal sector which typically lacks backup generation (World Bank, 2008; see Figure 10).

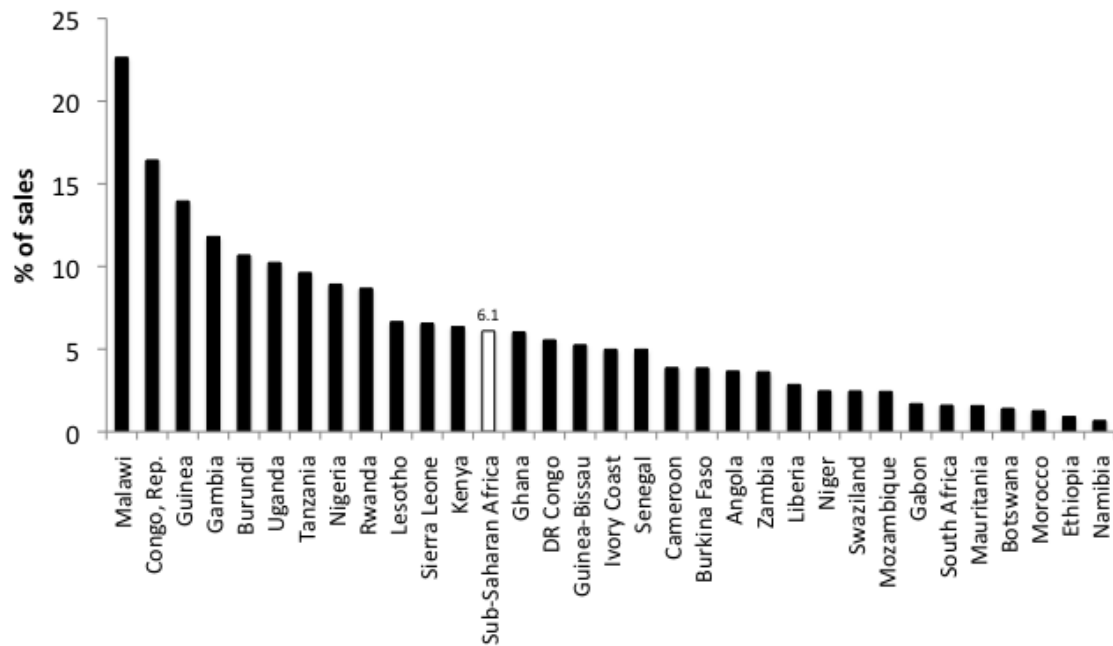


Figure 10. Value lost due to power outages as a percentage of sales in Sub-Saharan African states. The regional average is represented with a white bar. Data are from the World Bank Africa Development Indicators database (World Bank, 2010) and are for the latest year available between 2006 and 2009.

Unreliable power is a significant drain on national economies, slows economic growth and constrains manufacturing output (Calderón, 2008). The latter is important as the establishment of a manufacturing base that enhances the amount of value-addition within an economy is an important step towards long-term development. As already mentioned in section 3.2, firms in Sub-Saharan Africa identified infrastructure as the biggest impediment to their productivity with power accounting for most of the infrastructure effect in more than half of the countries (Escribano *et al.*, 2008). The World Bank Enterprise Surveys also collect data on the investment climate in Africa and a high percentage of firms consistently identify unreliable power as a major impediment to doing business in annual surveys (See Figure 11).

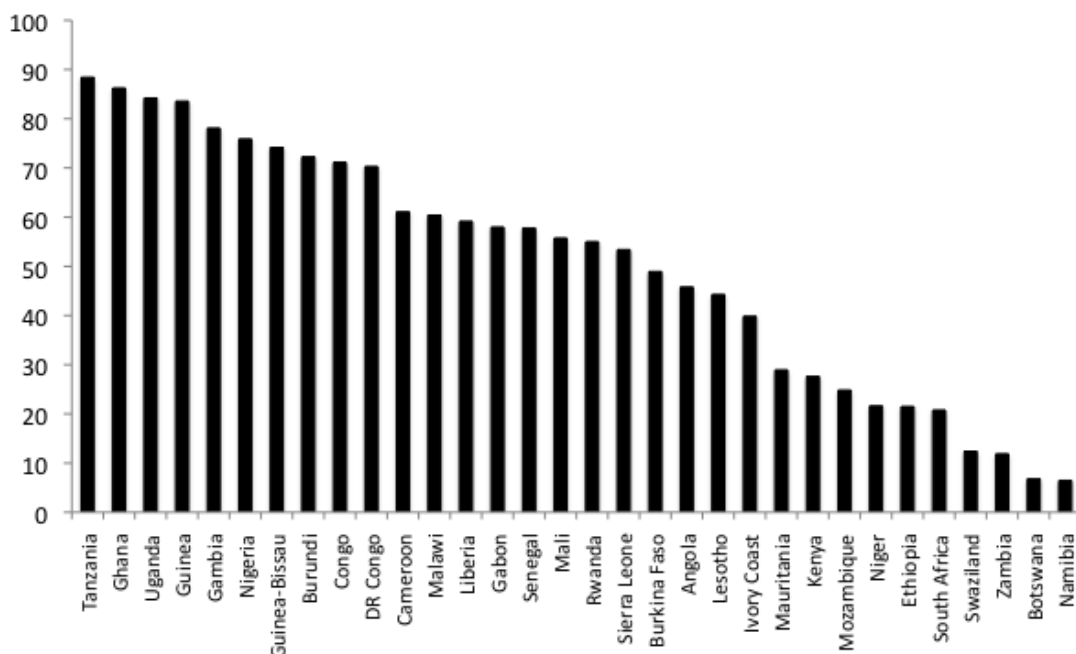


Figure 11. Percentage of firms identifying the electricity supply as a major constraint to doing business. Data are from the World Bank Africa Development Indicators database (World Bank, 2010) and are for the latest year available between 2006 and 2009.

### 3.8 The Underlying Causes of Supply Shocks

The biggest cause of system unreliability is that the growing demand for electricity now exceeds the installed generation capacity. Sub-Saharan Africa’s developing economies are skewed towards industry and manufacturing rather than services and as such, it is important that new capacity is added at the same rate as GDP growth (World Bank, 2008). In recent decades, regional GDP has grown at an average of 5%, while generation capacity has grown at 2.9% (World Bank, 2008), which slowed to a 1.2% between 2001 and 2005 (Eberhard *et al.*, 2009). This situation will inevitably give rise to supply shortfalls during periods of peak demand.

Supply shocks have also exacerbated the situation. For example, the increasing frequency of drought in East Africa affects the hydropower dominated power systems there. This was compounded by a rising oil price, which raised the production costs of alternative generation means. West Africa in particular is heavily reliant on oil-based generation and some countries there have recently struggled to afford the diesel imports for their power systems. Conflicts and/or economic collapse have also destroyed power infrastructure in fragile states such as Zimbabwe, Somalia and Ivory Coast (Eberhard *et al.*, 2009; Karekezi *et al.*, 2009).

A lack of maintenance on aging plants and transmission infrastructure also affects power systems. In underperforming utilities, managers may often face a choice between buying spare parts, importing fuel or paying salaries and as much as 25% of installed capacity is not currently in operating order (World Bank, 2008; Eberhard *et al.*, 2009). Whether it is a lack of capital investment or a lack of maintenance, the underlying reasons for the underperforming power systems have similar roots and are explored under the sub-headings below.

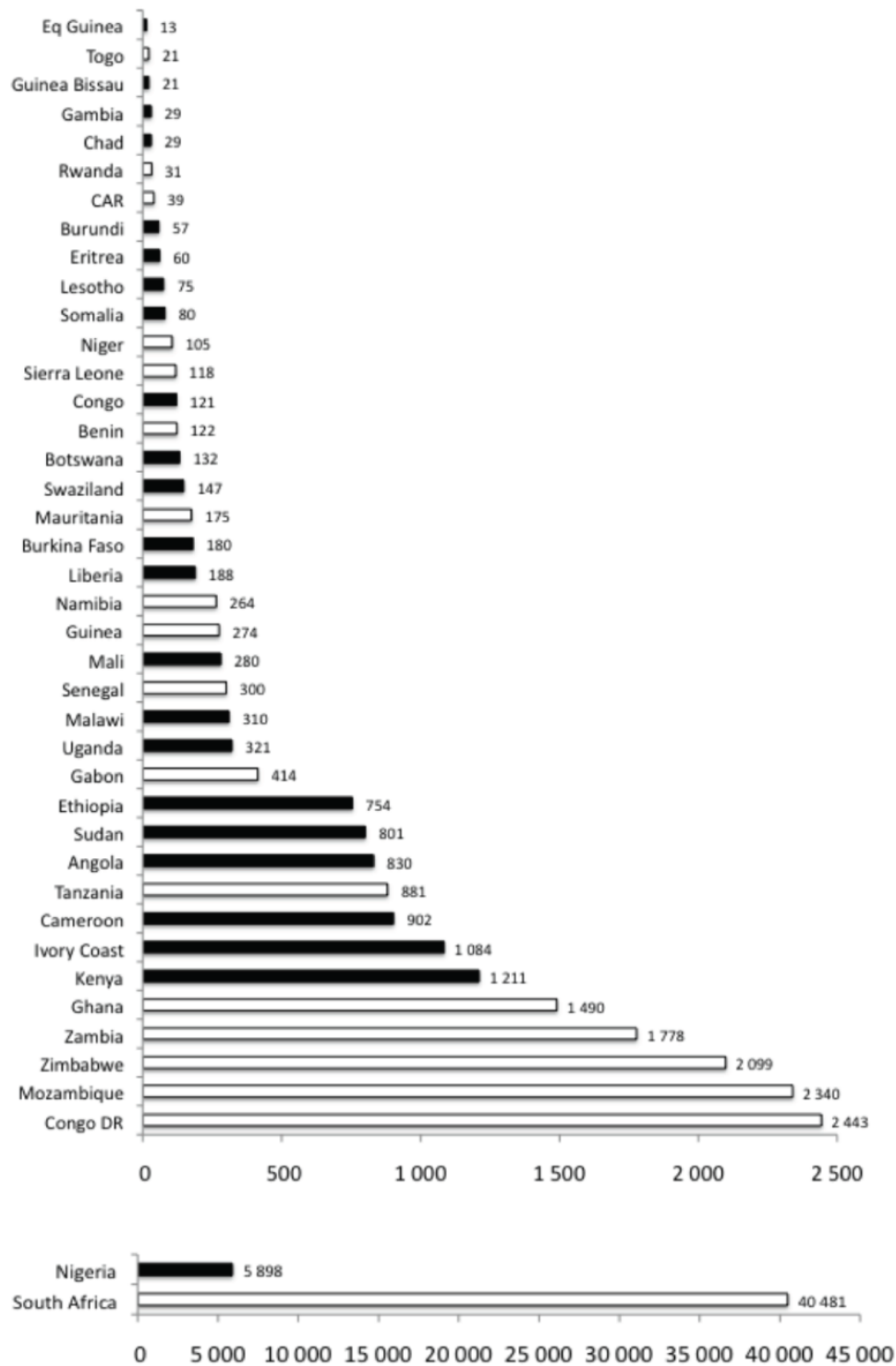


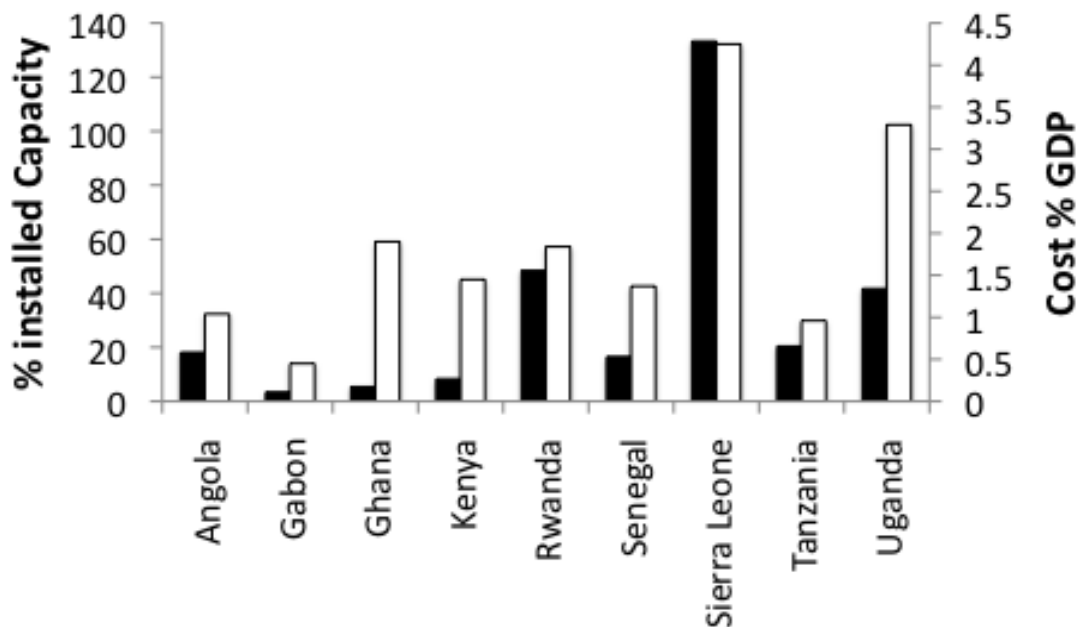
Figure 12. Installed generation capacity in Sub-Saharan African countries. X-axis units are MW. Black bars are countries with a mineral as one of the top three exports according to Sinkala (2009). White bars are countries without a mineral in the top three exports. Installed capacity data include capacity that is not currently available and are from the Africa Support Kiosk Electricity Database (ASK, 2011).

### 3.8.1 High Production Costs

Electricity tariffs are high because production costs are high. This is due to the fact that demand is often too small to take advantage of the economies of scale associated with large-scale production, which begin at around 400 – 500 MW (World Bank, 2008; Eberhard *et al.*, 2009). Only 14 countries in the entire region exceed this threshold (See Figure 12). Although

power pools have been created and are being strengthened, there is still little cross-border trade (Coulibaly *et al.*, 2009). The end-result is small, inefficient and more expensive forms of generation. According to AICD, a country with less than 200 MW capacity could face a cost-penalty as high as 30 USc/kWh compared to a country with over 500 MW capacity (Eberhard *et al.*, 2008). The widespread reliance on expensive, oil-based systems, particularly in West Africa further compounds the problem. Oil price spikes and the cost of importing for land-locked countries, far from ports add to production costs (Eberhard *et al.*, 2009).

A common response to supply shortages is to rent emergency generators. These are expensive to operate, with the marginal cost of their electricity being around 35 – 40 USc/kWh (Eberhard *et al.*, 2009). Costs amount to 0.5% of GDP in Gabon and 4.3% in Sierra Leone (See Figure 13). They are usually rented on a short term basis with typical contracts lasting from one to two years, but they add significantly to the cost of generation. According to AICD a conservative estimate of emergency generation operating in the region in 2009 was 750 MW (Eberhard *et al.*, 2009).



*Figure 13. Reliance on emergency generation as a percentage of total permanent installed capacity (black bars) and the cost as a percentage of GDP (white bars) for selected Sub-Saharan African states. Note that as the contracts are short term they do not show the precise present day situation. Data are from World Bank (2008).*

### **3.8.2 Maintenance Intensive Equipment**

Two-thirds of Sub-Saharan Africa is in the tropics where the combination of heat and moisture results in heavy wear on equipment and means that rigorous maintenance is required. A lot of the infrastructure is poorly maintained due to a lack of funds (see below section on low collection rates), a lack of skilled personnel or mismanagement. This is compounded by the fact that a lot of the power infrastructure is old. The end result is startling, of the 70.5 GW installed capacity, 44.3 GW need to be refurbished and an estimated 18 GW are unavailable (Eberhard *et al.*, 2009). In a region suffering from a shortfall, this is hugely significant. It is also unfortunate as a dollar spent on preventative maintenance probably saves more dollars in refurbishment and in the long run would free up more money for capital investment.

Temporary shutdowns for maintenance are also more problematic when grids are small. This is because a single plant will represent a significant portion or possibly all of the total installed capacity. The drop in supply has to be made up by imports, expensive backup generation or by shedding demand. For example, Zambia has an installed capacity of 1 778 MW (ASK, 2011). When the Zambian utility, ZESCO needed to perform routine maintenance on its Kafue Gorge hydrostation, 330 MW was removed from the national grid for two days. This represents 18% of total capacity and ZESCO had to load-shed (ZACCI, 2010).

### 3.8.3 Inefficient Use of Existing Infrastructure

AICD estimate that inefficiencies cost the power sector a total of 6 billion US dollars a year (See Table 5; Foster and Briceño-Garmendia, 2009a). Nearly all (5.7 billion) of this falls into two categories, operational inefficiencies (3.4 billion) and tariff cost recovery (2.3 billion). These inefficiencies lead to power utilities that are neither cost-effective nor creditworthy and in such institutions deferring maintenance expenditure is often necessary to meet operational costs. Given the high costs of rehabilitation, this is the most expensive means of financing current operations (Eberhard *et al.*, 2009).

#### 3.8.3.1 Tariff Cost Recovery

Although the tariffs charged are relatively high, they usually do not reflect the full cost of the production of power. In fact, underpriced power is common in Sub-Saharan Africa. If full cost recovery tariffs were to be implemented, this would save the sector 2.3 billion US dollars per year (See Table 5). According to AICD, the worst cases are Malawi and Tanzania, which capture less than half of the revenues they need and cost the economy over 2% of GDP (Eberhard *et al.*, 2009).

AICD speculate that cost-recovery figures are probably understated as the supply to large end-users such as mining and industry are typically negotiated in bilateral contracts and hence not reflected in the tariff structure. Examples of historical subsidies are the aluminium smelting sectors in Cameroon and Ghana and the mining sector in Zambia. These subsidies were originally justified on the basis of securing a baseload demand for the construction of generation projects that would otherwise have far exceeded demand at the time. However, given that these countries now face shortfalls this justification is worth reviewing as competing demands can probably absorb capacity (Eberhard *et al.*, 2009).

#### 3.8.3.2 Operational Inefficiencies

Operational inefficiencies cost 3.4 billion dollars a year and fall into two main categories: transmission losses and revenue collection. Transmission losses in the region average 23.3% compared to the international norm of 10%. The US dollar value of these losses is 1.3 billion. At the same time, collection ratios average 88.3% compared to the international norm of 100% (Eberhard *et al.*, 2009).

These two inefficiencies have a telling effect on power systems. The pace of electrification is faster in countries with utilities that have above average efficiencies in these two categories (1.4% compared to 0.8%). The supply shortfall in countries with below average efficiency is also less than half that of countries with above average efficiency (unmet power demand is 13% compared to 6%) (Eberhard *et al.*, 2009).

Another large inefficiency is overemployment. The developing country benchmark is 413 connections per employee. Based on this, utilities in the region are overstaffed by 88% and this costs between 0.07 to 0.6% of regional GDP (Eberhard *et al.*, 2009).

### **3.8.4 Historic Lack of Investment**

Paradoxically, although power expenditure in Sub-Saharan Africa is relatively high (around 2.7% of GDP, with a significant number of countries spending 4%), the amount of capital expenditure is low. This is due to the high operating costs, subsidies and low revenue recovery described above which absorb 75% of spending. As a result only 0.7% of GDP is spent on infrastructure investment, which is not enough to keep pace with rising demand (World Bank, 2008). When the electricity utility cannot raise enough money for capital investment, foreign direct investment is the only avenue for infrastructure to be improved (IEA, 2010). However, an artificially low price and other regulatory barriers deter investors (Eberhard *et al.*, 2009; various interviewees).

The historic lack of investment is particularly stark when electricity (and other infrastructure) is compared with other regions. In 1970, Sub-Saharan Africa had nearly three times the per capita generating capacity as South Asia. Today, it has less than half and South Asia is a region with similar per capital incomes. Since the 1970s, donor funding for infrastructure services decreased substantially. In hindsight, this was a mistake, because the ability to deliver basic services was ignored. Sub-Saharan Africa's starting infrastructure stocks were comparable or better than other developing regions. However, four lost decades in infrastructure investment have left the region far behind the rest of the developing world (CFA, 2005; Foster and Briceño-Garmendia, 2009c).

AICD estimate that the power sector faces a funding gap of 23 billion US dollars a year after all possible efficiency gains have been made. If no efficiency gains are made this increases to 29 billion (see Table 5) (Foster and Briceño-Garmendia, 2009a). Current expenditure is estimated to be around 11.6 billion dollars a year, just over a quarter of the amount required to close the power infrastructure gap (Foster and Briceño-Garmendia, 2009b).

## **3.9 Solutions**

Ideally, Sub-Saharan Africa should aim to have a power supply that is reliable, affordable and capable of delivering access to the entire population. In the long term, supply sustainability also needs to be increased which means decreasing the heavy reliance on coal and fossil fuel generation, improving the efficiency of plants and enhancing the share of renewables. The necessary measures are outlined under the sub-headings below.

### **3.9.1 Invest in Additional Capacity**

Systems are already struggling to meet present day demand, which is continually growing. AICD estimates that an additional 7 000 MW a year needs to be added (Eberhard *et al.*, 2009). As the region is poor, low-cost power supply systems are preferable. Therefore large-scale projects that utilise economies of scale should be commissioned. In particular the hydropower potential of the region has yet to be fully tapped. Similarly, if new thermal power projects are commissioned, these should also be large, efficient generation plants. The use of oil-based generation, particularly prevalent in West Africa, should be reconsidered. The trend over time should see the small-scale units generating power today being decommissioned and replaced with larger, efficient generation sources (World Bank, 2008; Eberhard *et al.*, 2009).

Stumbling blocks to large-scale generation projects include that countries endowed with energy resources may be fragile states, such as the DR Congo, which contains more than half of the region's hydropower potential. The up-front capital costs required to construct such projects is beyond the financial capabilities of most countries; and large generation projects require a secure base demand, which is lacking in most of the region. These are significant, but not insurmountable challenges. Capital can be provided from external sources including concessionary loans from the World Bank, the IMF or interested neighbours. In particular,

enhancing regional trade can connect large-projects to demand centres justifying their viability. These measures will require rethinking of the regulatory frameworks in place today (Eberhard *et al.*, 2008). All these are discussed under the following subheadings.

### 3.9.2 Open the Markets and Invest in Transmission Infrastructure

Cross-border trade in power should be increased for two main reasons:

1. While one single country may not have the demand to take advantage of the economies of scale of large-scale production, the combined demand of several countries will. Therefore the inefficiencies in power production could be tackled by increasing cross-border trade (World Bank, 2008; Coulibaly *et al.*, 2009).
2. While the region does have abundant renewable and non-renewable resources, these tend to be concentrated far from the major centres of demand and in countries lacking the means to raise the large amounts of capital required for constructing large-scale generation projects. For example 61% of the region's hydropower potential lies in just two countries DR Congo and Ethiopia. Without access to major demand centres or beneficiary countries to contribute towards capital costs most large-scale generation projects will not be economically viable (World Bank, 2008; Coulibaly *et al.*, 2009).

Until recently, power was traded via bilateral agreements between states. Various power pools have since been created to streamline cross-border trade, however according to the World Bank (2008), none of these arrangements is fully economically competitive and trade could still be enhanced. Only 16% of the region's power consumption is from cross-border sources and almost all of it (90%) takes place within the Southern African Power Pool (SAPP). Furthermore, within SAPP the majority of trade is essentially bilateral between South Africa and its immediate neighbours. If appropriate transmission infrastructure was to be built and all regulatory barriers removed, 40% of consumption could be met via regional trade (Coulibaly *et al.*, 2009). According to AICD, this would reduce the projected future costs of producing power in the region by 2.2 billion US dollars a year (Eberhard *et al.*, 2009).

In the long-term, regional trade means that power can be produced at lower costs (savings would range from 1 – 7 USc/kWh), which means that utilities in most instances will be able to pursue a policy of full-cost recovery while maintaining affordability to the majority of their populations (Coulibaly *et al.*, 2009; Eberhard *et al.*, 2009). It would also require investing in cross-border transmission infrastructure. AICD maintain that given the production cost savings, most of these investments would pay back in a single year (Eberhard *et al.*, 2009; Coulibaly *et al.*, 2009). However there are some significant difficulties in realising the full potential of regional power trade. These are:

- Regional trade really means that most countries would be net importers and a handful of countries would be large exporters. In fact, under a maximum trade scenario, roughly one third of countries would import more than half of their power needs. Energy security is also a major political issue that may carry just as much or more weight in a national development plan than cheap power (Eberhard *et al.*, 2009).
- If the full potential of regional trade is met, DR Congo, Ethiopia and Guinea would account for 74% of power exports and most of the remaining 26% would come from Sudan, Cameroon and Mozambique (Countries listed in descending order of export potential). Firstly, with the exception of Mozambique, these are all fragile states (FFP, 2011), which may heighten energy security concerns. Secondly, although the returns would be high (an estimated 2 – 6% of GDP for the top three exporters), the scale of the generation projects that would have to be built are far too large for the host economies (an estimated 8% of GDP per year over 10 years) (Coulibaly *et al.*, 2009; Eberhard *et al.*, 2009).



It is important to remember that these are long-term plans for the region. States that are fragile today might not be fragile in 20 years time (and indeed, regional integration is one way to improve regional stability). Cross border agreements generally evolve from small to large as states build mutual trust. The AICD scenario is also built based on the region's hydropower potential being realised. However, the region also has significant non-renewable resources. Large thermal projects also require cross-border trade and while they are less desirable, they are still better than the inefficient, small, fossil-based generation systems that would remain in place if regional trade is not pursued.

An example of a country that has benefited from regional trade is Botswana, which has an installed capacity of 132 MW and a peak demand of 400 MW. Botswana opted to meet rising demand via imports from South Africa rather than constructing additional small-scale capacity because these imports cost less than internal production. Cheap imported power was undoubtedly a factor in its rise from a poor to a middle income country and in the rapid rate in which it has increased electricity access to its population (22% in 2006; 70% in 2009; 100% projected in 2016) (Krishnaswamy & Stuggins, 2007; Eberhard *et al.*, 2009). Botswana is also set to benefit from exporting power into SAPP. It is endowed with coal resources and is constructing a 1 200 MW thermal station near its border with South Africa (BPC, 2011). Its decision was probably influenced by power cuts in South Africa, which subsequently rationed exports, but resisted calls by prominent politicians to end them completely. However, even if motivated by energy security concerns, a project this size is not justified by a 400 MW peak demand, but by the presence of a regional power pool with a demand an order of magnitude higher.

According to AICD, regional trade would also mean that the share of hydropower would increase to 48% of total generation and would displace 20 GW of thermal capacity. This would save 70 million tonnes a year of CO<sub>2</sub> emissions, which is 8% of the Sub-Saharan African total. Integrating the power grids would also assist in balancing the load which will increase the penetration potential of other renewable sources with variable, destabilising outputs such as concentrated solar or wind (Coulibaly *et al.*, 2009).

### **3.9.3 Improve Utility Performance**

A detailed overview of each utility in the region is far beyond the scope of this document. However, while each country will have its unique set of circumstances, a number of broad policy aims can be identified. These reforms are not mutually exclusive and an integrated approach needs to be taken.

AICD list the key policy challenges in their various position papers. According to Eberhard *et al.* (2009) these can be condensed down to:

- Strengthen sector planning;
- accelerate electrification;
- reform state owned enterprises and close the financing gap; and
- promote regional trade.

### 3.9.3.1 Strengthening Sector Planning

The prevalence of expensive emergency generation highlights the shortcomings in power sector planning. Fixed generation facilities take years to construct and failure to predict increases in demand results in supply gaps. Furthermore, when countries are reliant on emergency generation, their eagerness to get off it often reduces the transparency of the bidding process. Policy makers should aim to create and strengthen an integrated planning process (Eberhard *et al.*, 2009).

### 3.9.3.2 Accelerate Electrification

For social, environmental and economic reasons, access to electricity needs to be expanded. From a policy point of view, this requires that demand-side barriers such as connection charges are rethought and that a system of systematic planning is instituted so that electrification can proceed in an efficient, egalitarian manner (IEA, 2010; Eberhard *et al.*, 2009).

### 3.9.3.3 Reform State-owned Enterprises and Close the Financing Gap

Reforms in the power sector are often politically hard to implement, especially if a large number are required and each brings marginal results. As a general guide, AICD recommend that the initial focus should be on institutional basics (improving corporate governance, cost recovery, transparency and so on) rather than purely technical fixes (Vagliasindi&Nellis 2009).

For most utilities in the region, revenues do not cover costs and it is a recognised priority that this be addressed if new capacity and electrification programmes are to be financed and if cross-border trade is to be viable. Institutional changes required to close the financing gap are to improve collection rates, move toward full-cost recovery tariffs and reduce over-employment. The ability of government to meddle in utility operations should also be constrained. Technical fixes involve reducing the high technical and non-technical (theft) transmission losses (Eberhard *et al.*, 2009).

There is a strong economic argument for full cost recovery. Allowing utilities to continue running at a loss is effectively a subsidy and this is costing economies significant amounts of money. Given that only a small proportion of the population has access to electricity, the long-term affordability of these subsidies is questionable if electrification rates are to be increased. As it is typically the more affluent that have access to power, the subsidies are also highly regressive and therefore questionable. In fact, according to AICD, random allocation would give greater benefits to the poor than most of the subsidy arrangements in place today (Eberhard *et al.*, 2009). In a review of power sector reform in Africa, Karekezi and Kimani (2002) point out that in countries with low access rates such as Uganda, the majority of the poor are not connected and hence the removal of a subsidy will not affect them directly. However in countries with high access rates such as South Africa, a change in subsidisation policy will directly affect the poor.

Full cost recovery would be affordable in countries with large-scale hydro or coal generation, but not in countries with small oil based plants (See Figure 14). Therefore cross-border trade to bring production costs down is required to make full cost recovery tariffs affordable in much of the region. However, even with regional trade affordability will be hard to achieve in West Africa which is heavily reliant on diesel generation (Eberhard *et al.*, 2009).

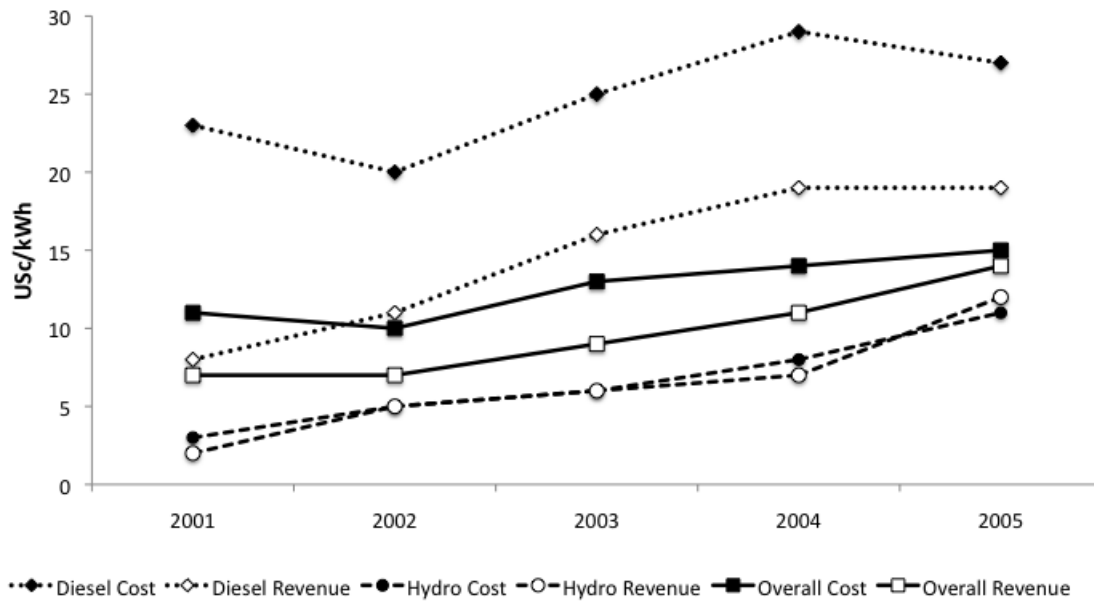


Figure 14. Average operating costs (black markers) and revenue collected (white markers) for overall, predominantly diesel-fired and predominantly hydro systems in Sub-Saharan Africa. Full cost recovery is possible with hydro systems. Cost recovery data are for actual revenue collected, not tariff charged per kilowatt-hour. Adapted from Eberhard et al. (2008).

The argument is not to eliminate subsidies entirely, but rather to ensure that they are well targeted and benefit the poor. In particular, historical agreements and block tariffs that result in large amounts of subsidised power going to commercial users should be renegotiated (Eberhard *et al.*, 2009). Power subsidies are highest in countries with emergency generation. The prevalence of private generation in the commercial sector reflects a willingness to pay that is even higher than the cost of emergency generation. Utilities in such countries should consider charging the commercial sector the full marginal cost of generation (Eberhard *et al.*, 2009).

Once utilities are creditworthy, they will be able to raise their own finance, for example by issuing bonds or listing on the stock market. This will alleviate the funding burden on governments and free up money to be spent on other socio-economic activity. Private sector participation also saves public finances. Independent Power Producers (IPPs) could fund much of the new capacity needed, however changes in the regulatory frameworks are required for this to be viable, notably in eliminating the monopolies enjoyed by state-owned utilities and creating a fair and transparent set of rules for wheeling<sup>1</sup> on national grids (Eberhard *et al.*, 2009).

It is far easier to write these recommendations in a thesis, than to implement them. Raising tariffs towards cost recovery will meet considerable political resistance, and governments are unlikely to be willing to grant utilities more independence. Reforming the regulatory frameworks to eliminate state monopolies is also no small matter. The reforms also have implications beyond the long-term viability of the power sector. For example, tariff increases in South Africa are expected to cost 250 000 jobs, increase inflation, cut household consumption and reduce the competitiveness of industry (Kohler, 2010). Although a cost-benefit analysis would probably conclude that in the long-term reliable power would result in

<sup>1</sup> Wheeling refers to the transport of power produced by one entity via transmission infrastructure owned by another entity.

more jobs, lower inflation, higher household consumption and more competitive industry, it does not mean that power sector reform does not involve difficult, complex trade-offs.

### 3.9.4 Demand Side Management

Demand Side Management (DSM) involves increasing production efficiency to reduce the electricity required per unit of output and conducting energy intensive operations when overall demand is low to flatten the demand curve and prevent peak demand from exceeding the installed capacity. New capacity takes time to add and demand side management has the potential to manage the supply deficit while it is being added in the short-term and reduce the rate that it needs to be added in the long-term. For example the Southern African Power Pool expect to free up 3 000 MW of capacity by 2011 by promoting efficient lighting. This is twice the amount of new capacity that they commissioned in 2008 (SAPP, 2009). Demand side management has the advantage in that it can save instead of cost money and would be of particular importance to countries that rely on emergency generation (which has a high marginal cost) to meet peak demand. If peak demand could be reduced, even slightly this would reduce the need for emergency generators and therefore lower the cost of electricity.

Given the potential to free up demand, it is perhaps surprising that AICD and other sources barely mention DSM in their analyses of the power sector. Reducing peak demand probably then represents an additional efficiency saving to be made in the power sector. Most utilities and the Southern African Power Pool (SAPP) tout DSM as a solution to supply shortfalls (e.g. SAPP, 2009; ESKOM, 2011b). However, a number of utility websites were consulted and at present, with the exception of the South African utility ESKOM, DSM appears to be limited to encouraging the use of energy saving CFL lightbulbs. Where DSM plans exist, they acknowledge the potential demand reduction but often lack a clear implementation strategy so it is uncertain that potential gains will be realised. On the other hand, it should be noted that a specific plan for DSM from the utility is not required for consumers to implement DSM measures. Rather this can (and is as utilities move toward full cost recovery) be incentivised via rising prices overall and during periods of peak demand.

South Africa, the region's largest economy currently faces a tight demand-supply balance and views DSM as a large part of the solution, particularly as significant new capacity will not start to come online until 2016. The country has a comprehensive, cross-sectoral DSM program including, among other things, measures to encourage solar heaters, move towards decentralised solar powered street and traffic lights and changing the building policy to ensure that stoves and electric water heaters may not be switched on at the same time in new households (ESKOM, 2011b). SAPP is also expanding its DSM program to include solar water heaters and remote controlled relay switches in electric water heaters that will allow utilities to temporarily reduce demand. (Alison Chikova, personal communication, 15 April, 2011). This is further discussed in chapter 5.

### 3.9.5 Off-grid and Mini-grid Technologies

Although countries that have approached electrification in a centralised manner have had much greater success in increasing access (e.g. Botswana and South Africa), a significant portion of people live in remote areas where grid expansion is not economically feasible. In these areas, off-grid and distributed generation sources are the only solutions in the medium term. Although these generation sources are typically more expensive and cannot deliver the unlimited power required by manufacturing or mining industries, some modern renewable technologies such as mini-hydro and solar photovoltaics are cheaper than private diesel generators and their use should be encouraged as a best-fit solution in some circumstances (Eberhard *et al.*, 2009; Karekezi *et al.*, 2009; ESMAP, 2007).

In a position paper for the Energy, Environment and Development Network for Africa (AFREPREN), Karekezi *et al.* (2009) take the position that the costs of the drought induced 50 MW shortfall could have been averted in Kenya, had the country invested in other small-scale renewable options. Particularly attractive are geothermal and co-generation options that produce steady outputs. Other technologies including wind energy and small-scale hydro are also worth considering due to abundant resources. Although Karekezi *et al.* do not consider the price of such technologies in their report, these should be considered where appropriate. Other sources including the World Bank (2008) note the geothermal potential of the Great Rift Valley in East Africa.

In order not to leave the rural population behind, a rural electrification policy with quotas for remote areas is recommended because dollar for dollar more people can be electrified closer to urban areas than further away from them. Each nation state will have to balance economic efficiency with equality and should consider electrification in the context of a long-term development plan that should include rural growth points. In such instances, the use of diesel generation should be considered as a last resort.

### 3.10 Conclusions

This chapter begins by showing that infrastructure services in Sub-Saharan Africa are lacking in both quality and quantity when compared to other regions of the world and that this is an impediment to sustainable development. It also establishes that the greatest infrastructure challenge lies in the power sector. Supplies in the region are often unreliable, power is usually (but not always) expensive and the majority of the population lack access to it.

The first research objective was to set the context of the importance of electricity to economic growth and development. The developmental and poverty alleviation benefits of electricity access are numerous and this was demonstrated by the importance of increasing supply to achieving the internationally acclaimed Millennium Development Goals. According to the mainstream development institutions such as UNDP and UNECA, sustainable development is not possible without electricity. The current electricity situation also has negative effects on economic growth, firm productivity and the development of a value-adding industry base. As such the current situation is a major developmental constraint that needs to be overcome. In order to pursue a course of sustainable development:

- electricity access should be made universal;
- power supplies should be made reliable; and
- power should be affordable to the extent that it does not affect reliability.

These three criteria were used when addressing the second research objective, namely to establish reasons and from these delineate solutions for the regional electricity problem. The major reasons for supply shocks include:

- high growth in demand outpacing new investments in supply;
- disruptions due to natural or market forces e.g. drought or oil price shocks; and
- disruptions due to conflict.

There are a number of causes behind the reasons above that are important in gaining a fuller understanding of power sector issues. These are:

- inefficiencies in utilities such as low collection rates, non-cost recovery tariffs

- transmission losses and over-employment leading to fiscal insolvency
- lack of maintenance due to a lack of finance and/or skilled personnel
- poor sector planning resulting in failures to keep pace with demand
- the prevalence of small, inefficient and expensive forms of generation which have high production costs.

A number of reforms need to be undertaken in the power sector to improve reliability and, in many instances bring down the costs of production. These are:

- the rehabilitation run-down infrastructure and the subsequent implementation of regular preventative maintenance regimes;
- the addition of 7 000 MW a year of new capacity, particularly large-scale projects which have low marginal production costs, to ensure that full cost recovery tariffs will be affordable;
- the enhancement of regional integration and cross-border trade to connect countries with energy resources to the major centres of demand and so that countries with demands too small to justify large-scale generation projects can pool their demands and take advantage of scale economies during production;
- the elimination of utility inefficiencies such as low collection rates, underpriced power, overemployment and transmission losses;
- the alteration of regulatory frameworks to promote private participation, which reduces the funding burden on the public sector; and
- the use of demand side management measures to get the maximum benefit out of existing infrastructure.

A point stressed by AICD is that institutional basics should be favoured over technical fixes. For example, the governance of a utility should be improved before technology to reduce transmission losses (which are often high) is installed. This means that institutional reforms and capacity building are essential to solving the crisis. This reality adds a layer of complexity to improving power systems. Many reforms may be politically difficult to pass and may involve trade-offs. For example, while there are clear economic benefits to maximising power trade, it does mean that some countries will need to sacrifice their energy security. Expensive power may be seen as a worthwhile premium by many governments. Similarly, while fiscally sound utilities are required if new generation projects are to be commissioned and access rates improved, there are political barriers to full-cost recovery tariffs. These include the short-term loss of competitiveness, job losses and inflationary pressures. A power subsidy to avoid these might well make economic sense to some governments. It needs to be accepted that power systems are a politically sensitive, complex issue and that reform will be a slow and difficult process.

## **4 The Mining Sector in Sub-Saharan Africa**

### **4.1 Introduction**

The aim of this chapter is to give the reader an overview of the minerals extraction industry in Sub-Saharan Africa. As such, the following sections describe the current and projected future states of the mining industry in the region, the heavy economic reliance on the minerals sector and the expectation of governments that mining will contribute to future meaningful development. The political power of the mining industry is also highlighted as this shows the negotiating power of the industry and its ability to alter the business environment. As discussed in the limitations section, this chapter does not consider whether mining and minerals processing activity in the region should be enhanced or discouraged, but rather aims to establish what the future of mining is anticipated to be. Thus, this section of the thesis addresses the third research objective, which was to set the context of the importance of mining to development.

The ultimate goal of this thesis is to discuss the role of the mining industry in the development of Sub-Saharan Africa's power sector. This was addressed using a Resource Dependency Theory (RDT) conceptual framework. In order to ensure that the research is applicable to RDT theory, the fourth research object was to establish (perhaps somewhat obviously) the dependence of the mining industry on electricity. This is addressed at the end of this chapter.

### **4.2 Mining and Metals**

Minerals are an essential ingredient to modern day life and wellbeing. Without them, several basic needs could not be met. Steel is required to build bridges, stone from quarries is necessary to construct roads, and metals are found in most appliances in a modern society. The mining sector provides these minerals, which serve as raw materials for the world economy. There is a broad consensus that social and economic development has not taken place in the absence of minerals (UN 2010b; Ericsson, 2010; Sinkala, 2009).

### **4.3 Mining in Sub-Saharan Africa**

Africa contains vast resource wealth and is a world leader in terms of production and reserves for several mineral commodities (Sinkala, 2009; See Figure 15). According to the United States Geological Survey (USGS), the continent is ranked either first or second in terms of reserves of bauxite, chromite, cobalt, hafnium, industrial diamond, manganese, phosphate rock, platinum-group metals (PGMs), soda ash, vermiculite, and zirconium (Yager *et al.*, 2010).

Furthermore, the region is relatively unexplored and it is expected that future exploration will reveal a more extensive resource base (Sinkala, 2009; AU, 2009; Yager *et al.*, 2010).

Approximately 1.9 billion US dollars were spent on exploration in 2008, roughly 15% of the world total (Yager *et al.*, 2010). As the world recovers from the global financial crisis it is likely that exploration activity will increase.

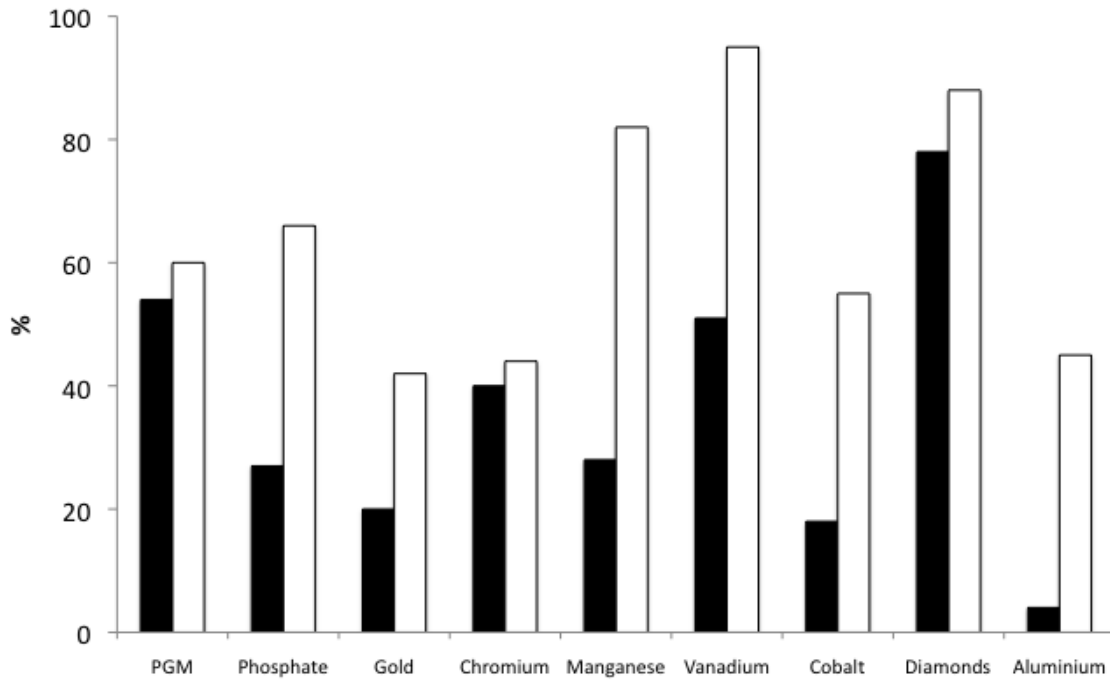


Figure 15. African percentage of world production (black bars) and of world reserves (white bars) for selected minerals. PGM = platinum group metals. Data from the *Africa Mining Vision* (AU 2009).

#### 4.4 Economic Contribution of Mining

Mineral wealth can play an important role in the national development plan of an economy. Many countries in the region rely on the foreign exchange and income generated by mining to fund their socio-economic activities. Thompson Sinkala, a recently retired professor from the Zambian School of Mines illustrated this reliance in a report for UNEP in 2009 by compiling export data for all countries in the region from a variety of sources (Sinkala, 2009). He showed that of the 42 countries that comprise mainland Sub-Saharan Africa, 26 engage in large-scale minerals extraction and of these, 18 have at least one mineral as one of their top three export commodities. He also showed that commodities from small-scale and artisanal mining processes could sometimes form a major export in smaller economies. Sinkala's data are corroborated by export profiles from the CIA World Factbook (CIA, 2011). According to this database, 23 countries have mineral commodities listed as significant exports and, of these 21 have a mineral commodity as one of the top three exports. The map in Figure 16 shows the contribution of mining to the region.



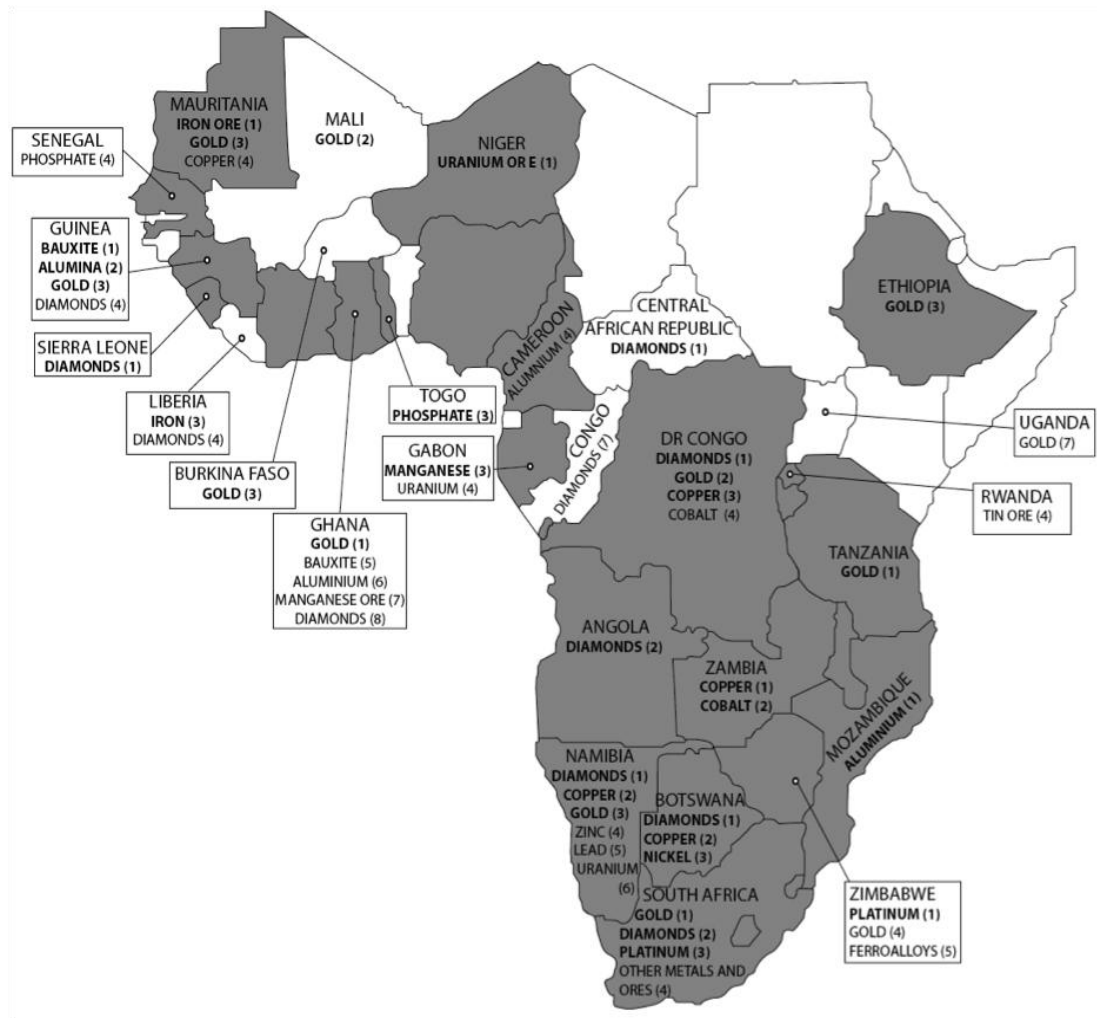


Figure 16. The economic contribution of mining to mainland Sub-Saharan Africa. Countries shaded grey are those with large-scale mining operations according to Sinkala (2009). The export rankings of mineral commodities are also shown and these are taken from the CIA World Factbook country profiles (CIA, 2011). Note that export data include small-scale and artisanal mining, which can be significant, particularly in smaller economies.

Mining is particularly important to countries that lack alternative means to generate wealth and develop and that would otherwise be unappealing to foreign investors (IIED, 2002; UN, 2010a). Sub-Saharan Africa is a poor region, and in theory exploitation of its natural resource wealth could be an engine for sustained growth and meaningful development. However, despite having been a significant minerals exporter for over a century, this has usually not been the case and the resource driven development seen in Western Australia, Canada or the United States is rare (Sinkala, 2009). In particular, sudden wealth has often been detrimental to countries leading to corruption and authoritarian regimes and in extreme cases, human rights abuses and armed conflict (IIED, 2002). However countries such as Botswana and South Africa are two notable examples of places where meaningful development has taken place on the back of the exploitation of mineral reserves (IIED, 2002; Sinkala, 2009).

#### 4.5 Mining and Development in Sub-Saharan Africa

The mining industry has often attracted severe criticism for environmental degradation; a lack of concern for the local communities it disrupts and the fact that mineral wealth has not always translated into meaningful development. In recent years there has been a growing consensus within the global mining sector that simply meeting the demand for minerals is not

the only performance measure. Today, the large mining companies all agree (in public at least) that their long-term survival depends on a social licence to operate (IIED, 2002; Sinkala, 2009).

Major industry players including Rio Tinto, Anglo American, BHP Billiton, Freeport McMoRan, Newmont and WMC formed the Global Mining Initiative (GMI) in 1998. All these companies have questionable environmental and social records and the idea behind the GMI was to explore ways for the industry to improve its image. The GMI gave rise to the Mining, Minerals and Sustainable Development (MMSD) project. This two-year project identified the various stakeholder expectations from the mining industry and explored how the industry could and should contribute to sustainable development. The International Council of Mining and Metals (ICMM) was formed after the project and is the body that guides the industry on sustainability issues and corporate social responsibility (Whitmore, 2006; IIED, 2002).

In the international arena, the potential role of mining in sustainable development has also been recognised. Notably, the Johannesburg Plan of Implementation (JPOI), which followed the World Council on Sustainable Development meeting in 2002, called for the contribution of mining to sustainable development to be enhanced. Included in the mandate for The United Nations Commission for Sustainable Development (CSD) is “to elaborate policy guidance and options for future activities to follow up the Johannesburg Plan of Implementation and achieve sustainable development”. Since then, mining has been one of the thematic areas covered by the CSD. This culminated in the call for the Global Initiative on Mining and Sustainability (GIMS) at the eighteenth CSD session in New York in 2010 (Peck, 2011). More relevant to the region under discussion, The Africa Mining Vision 2050 (See section 4.6 below) aims to ensure that the mining industry would contribute to meaningful development and broad-based, long term sustainable economic growth (AU, 2009).

It is also worth noting that the World Bank Group seriously reconsidered withdrawing support from mining and announced a review of all its mineral activities in 2000. However in 2004 the *Extractive Industries Review* did not recommend a withdrawal of support, but rather a focus on strengthening the development potential of the sector (World Bank, 2004).

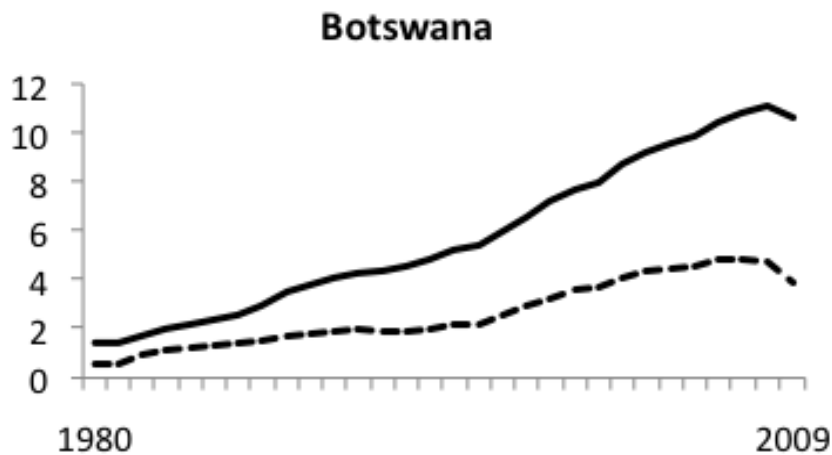
## 4.6 The Africa Mining Vision

Today, most minerals exports from Africa are in the form of ores, concentrates or primary metals and significant value addition is rare (AU, 2009). This is a considerable lost opportunity for development as mining can contribute significantly to value addition in a country’s economy (UN, 2010a). This is illustrated in Figure 17, which shows value addition in Botswana’s economy. The Africa Mining Vision 2050 was created in October 2008 with the aim of ensuring that the mining industry would contribute to meaningful development and broad-based, long-term, sustainable economic growth (AU, 2009). Of all the recent mining initiatives created in recent years it is singled out for analysis in this thesis as it was created under the auspices of the African Union by African mining ministers and its text draws on other regional and sub-regional mining initiatives. It therefore signals the intentions of African governments towards mining. Its aims are however not significantly different from international initiatives such as the MMSD project (IIED, 2002), CSD (CSD, 2011), UNDESA (UN, 2010a) and UNEP (Sinkala, 2009). According to the vision, mining should contribute towards and be integrated into a single African market through:

1. Down-stream linkages into mineral beneficiation and manufacturing;
2. Up-stream linkages into mining capital goods, consumables & services industries;

3. Side-stream linkages into infrastructure (power, logistics; communications, water) and skills & technology development (HRD and R&D);
4. Mutually beneficial partnerships between the state, the private sector, civil society, local communities and other stakeholders; and
5. A comprehensive knowledge of its mineral endowment.

Sustainable mining is at best a tricky term and at worst greenwash as minerals are finite resources that will eventually run out (e.g. Whitmore, 2006). However, mining has the potential to drive sustainable development if it stimulates other sectors of the economy via the vertical and horizontal linkages described above and if it enhances the local knowledge and skills base. In addition to employment and the hard currency raised from exports, taxes and royalties, revenues from mining should also contribute to the development of infrastructure such as roads, schools and hospitals. For countries dependant on mining today, the long-term outcome should be that reliance on the resources sector diminishes as manufacturing and commerce begin to dominate the economy (AU, 2009). It goes without saying that unreliable electricity makes the achievement of this vision more problematic.



*Figure 17. Total value added (solid) and value added in the minerals sector (dashed) between 1980 and 2009 in Botswana. Y-axis units are in millions of 2005 US Dollars. Since 1980, the amount of value added activity in the diamond mining industry has increased while at the same time the total-value added has increased at a higher rate as other sectors have expanded. Data taken from UNSD (2010).*

Like the other recent mining initiatives, the Africa Mining Vision was born out of the acknowledgment that the mining industry, with a few notable exceptions has not lived up to its development potential. However, instead of withdrawing support for minerals extraction, the Vision identifies reasons for both successes and failures and designs a framework for modernisation and sustainable development driven by mineral resources. This forward looking view is supported by other initiatives developed by foreign governments and the mainstream development community which also seek to ensure that mining makes a net positive contribution to society. The Vision establishes that minerals extraction is supported by the polity and will be included in national development plans. It should be noted here that the ongoing debate over whether or not or to what degree Sub-Saharan African countries should exploit their mineral wealth, while important is outside the scope of this work which does not aim to contribute towards it at all. Rather, given that minerals extraction is going to occur, the purpose of this work is to consider how the mining industry could assist in reinvigorating the power sector.

## **4.7 Growth and Trends in the Mining Sector**

The 20<sup>th</sup> century saw a 27-fold increase in industrial minerals extraction (UN, 2010a). However, the industry is cyclical and the demand for metals both declined and increased during this period (Ericsson, 2010). Notable intervals of declining or stagnant metal prices were the first 30 years of the 20<sup>th</sup> century and between 1970 and 2000. War demand and post war reconstruction between 1930 and 1970 gave rise to high global demand for minerals (Ericsson, 2010).

After 2000, demand from emerging economies, notably China soared and the mining industry experienced an unprecedented boom. In 2008, the global trade in metals and diamonds was worth 465 billion US dollars. The demand and hence also the price of metals fell in 2009 during the Global Financial Crisis (GFC) but this has since been reversed (Ericsson, 2010). In their annual review of the mining industry in 2010 (PWC, 2010), PriceWaterhouseCoopers announced a positive outlook for the industry and according to UNDESA (UN, 2010a), global minerals extraction is set to double by 2020.

Dr. Philip Peck at the International Institute for Industrial Environmental Economics (IIIIEE) in Lund, Sweden is an extractive industries specialist. He points out that if the size of Africa's current production and extensive reserves are compared, it becomes apparent that there is considerable opportunity for expansion of the minerals sector in the region (Peck, 2011). Dr. Peck agrees with other Sources, including UNDESA (UN, 2010a) and Dr. Magnus Ericsson at the Raw Materials institute in Stockholm (Ericsson, 2010) in that much of the predicted expansion in mining will take place in Africa. At the same time, the Oil, Gas and Mining Unit at the World Bank tells of a business environment fast becoming increasingly friendly to foreign investment in most countries in the region (World Bank, 2011). The consensus is that minerals extraction in Africa is set to boom. Given that many of the new ore bodies to be exploited are in remote areas, further significant infrastructure contributions from the mining industry can be expected.

The World Bank Oil, Gas and Mining Unit also point out that roughly half of Sub-Saharan Africa's population live in countries that are either rich in mineral resources or in oil and gas. These countries account for around 70% of regional GDP and the bulk of foreign investment (World Bank, 2011). According to Dr. Peck, the current high commodity prices both present a window of opportunity for these countries to internally generate wealth to spend on sustainable development efforts and raise some legitimate environmental and social concerns (Peck, 2011). If development is to be realised and mining is to bring a net benefit to stakeholders, than these will need to be considered and addressed in the planning process. A concern relevant to this work is the effect of a rapidly expanding minerals sector on the region's already overstretched power infrastructure.

## **4.8 The Political Influence of the Mining Sector**

The political power of any industry body will largely depend on its economic importance relative to other sectors. In those countries where mining makes a large contribution, the sector will have a powerful influence on that country's government and economy. The mining sector has an influence in areas such as taxation regimes, labour laws, business regulations and areas for future government investment. The sector can also influence developments in the electricity sector and has managed to attract power subsidies in the past (e.g. World Bank, 2008). For examples of the economic contribution and political power of the mining sector in some countries, the reader is referred to section 5.2 where the case study countries, Zambia and South Africa are introduced.

## 4.9 Electricity and the Mining Sector

Mining is an energy intensive activity and a large end-user of electricity. Much of the available power in Sub-Saharan Africa goes to the mining and minerals processing industry (Sinkala, 2009).

Specific data on the actual consumption and total demand by the mining industry within Sub-Saharan Africa are hard to come by. This is because most energy related sources do not make the distinction between the mining sector and the rest of a country's industrial sector. Nevertheless, a perusal of the International Energy Agency's database (IEA, 2011) does reveal that industry is large consumer of power in the region and given the importance of mining and the size of the industry in the region, it is not unreasonable to assume that the industry accounts for a large portion of demand and consumption. This assumption is backed up by numerous sources (e.g. Merven *et al.*, 2010; Eberhard *et al.*, 2008; World Bank, 2008; Sinkala, 2009; Haanyika, 2008) that state that the mines are a large end-user and have a significant impact on the demand-supply balance. Separate data were found for South Africa (ESKOM, nd), Botswana (Krishnaswamy & Stuggins, 2007), and Zambia (Sooka, 2007) where mines account for 18%, 45.5% and 68% of end-consumption respectively. Only the South African source (ESKOM, nd) cited mining's contribution to maximum demand. It is 14%. An interviewee from the Copperbelt Energy Corporation (CEC) which supplies most (but not all) mining operations in Zambia revealed that the total demand from CEC's customers was just under 500 MW and that before the Global Financial Crisis it was approaching 700 MW (Emmanuel Katepa, personal communication, April 19, 2011). These figures are 30% and 40% of installed capacity respectively.

While total consumption is indicative of demand (as a large consumer is likely to have a large demand), demand is the more important figure for analysing grid stability. Figures for the demand from the mining industry can however be inferred. For example, Turk Mine, just outside Bulawayo in Zimbabwe is a small-scale gold operation extracting and processing around 1 000 tonnes per month. According to Thomas Armstrong, their chief engineer (personal communication, January 14, 2011), its electricity demand is 2 MW. This is not large, but is significant if total installed capacity is small. For example it is 0.5% of 400 MW, a capacity threshold that only 14 countries in the region exceed. This shows that even small-scale mining operations can have a significant impact on demand in most Sub-Saharan African countries.

The demand from large-scale operations is significantly higher. According to Rex Zorab (personal communication, January 17, 2011), an engineer for Rand Uranium in South Africa the demand from a single shaft of a large gold operation could easily be in excess of 100 MW. An engineer for another large mining operation in South Africa (personal communication, 18 January 2011), who asked that neither he nor his employer be named when he handed over the figures for that company's demand-side management plan had identified 100 MW of demand savings. That particular company consumed over 4 000 GWh of electricity in 2010. This is approximately 2% of total consumption in South Africa according to ESKOM (nd). If the mine operated for 8 500 hours in 2010 (This would leave 260 hours for maintenance), this translates into an average demand of 470 MW. Thus the operations of a single large mining company exceed the total installed capacity of many countries.

## 4.10 Mining and the Electricity Sector

For countries with small national grids, the development of a large-scale minerals industry will have a significant and a possibly destabilising effect on the power system. Furthermore, as the global demand for metals continues to drive up prices, deeper, more remote and lower grade ores become economically viable and will be exploited. These are typically extracted at lower

efficiencies and increase the amount of electricity required to extract and process a given amount of mineral or metal (Norgate & Haque, 2010).

However it needs to be noted that historically, the large-scale exploitation of mineral reserves has been one of the driving forces behind the construction of power infrastructure in the region. For example the first power station in Zambia at Victoria Falls was built with the purpose of supplying mines in South Africa 1 000 km away. When this turned out to be unviable, power plants were built in South Africa instead, again with the sole purpose of supplying the gold mines in Johannesburg (ESKOM, 2011a). Zambia also continued to develop its power industry around its copper mines (ZESCO, 2011a). In fact, ZESCO historically sold subsidised power to copper mines in order to secure a base load for generation capacity that would not otherwise have been feasible (Eberhard *et al.*, 2008). Figure 12 shows the size of the installed capacity in each mainland Sub-Saharan African state and the degree to which mining contributes to exports. Of the nine countries with installed capacities of above 1 000 MW, seven have a mineral as one of their top three exports and a possible reason for their large generation capacities is because they have large mining industries. Indeed the infrastructure contribution of mining is not limited to Africa and goes far beyond the electricity supply. The development of a minerals industry is credited with transforming previously rural, agrarian societies into urbanised, modern economies in for example South Africa, the United States and Western Australia (CMSA, 2009; Sinkala, 2009).

AICD recommend that the bulk of new capacity to be added in the future should be generated in large-scale plants as these have lower production costs. They also point out that such projects require a large demand that is often absent, which is why they recommend that regional trade should be pursued. However, the development of a minerals extraction industry can also create sufficient demand, has historically justified the building of new generation capacity and could still do so today. As an added efficiency, the mining company might contribute towards it, relieving public funding pressures. Other, traditional operating efficiencies such as low collection rates and high transmission losses are less of an issue if large mining customers buy a large portion of power. This is because the number of end-users to invoice is orders of magnitude less and per kWh sold, there is far less transmission infrastructure and connectors between the generation plant and a mine, than say the generation plant and households (Emmanuel Katepa, personal communication, April 19, 2011).

#### 4.11 The Electricity Dependency of Large-Scale Mining

Large-scale mining activity cannot take place without electricity and the high demand of the industry points to a rather obvious reliance. Operations continue 24 hours a day. If the hoists stop working, employees are trapped underground and may be in serious danger if supply to ventilation fans and cooling systems is also cut. Water needs to be pumped out or mines flood, which damages machinery and also presents a hazard to employees. Machines, such as the large air compressors are also damaged if they are suddenly turned off. It is taken as a given in the literature that power is essential and every single interviewee stressed that large-scale mining was not possible without electricity.

When power systems become overstretched, existing mines can often find ways to manage this. However power shortages are a significant constraint to the future growth of the sector. This will be discussed in more depth in the following chapter, however to strengthen the resource dependency perspective, all interviewees in South Africa, where power supplies are rationed complained that their ability to expand was severely reduced. This was best summed up by Roger Baxter, Chief Economist at the South African Chamber of Mines who lamented, “South Africa has the largest mineral endowment of any country in the world, bigger even than the United States and Russia, yet during a resources boom, we are the only country in the

world where minerals extraction is decreasing. This is because we do not have the electricity to mine.” (Personal communication, January 21, 2011).

## **4.12 Conclusions**

Sub-Saharan Africa contains vast natural resource wealth. This chapter has established the historical, current and future significance of mineral resources to several countries in the region and sets the context of the importance of mining to development, which was the third research objective. Mining makes a significant contribution to many economies, catalyses infrastructure development, is a significant employer, can strengthen up and downstream businesses and funds other national socio-economic activities via income tax and royalty payments. Although mining has often not lived up to its development potential, international, regional and national stakeholders still see it as an opportunity for development. Hence, instead of abandoning minerals development, they are taking steps to reduce the chances of past failures being repeated. The Africa Mining Vision signals both the expectations of national governments that natural resources should contribute towards development and their intention to exploit them.

The mining industry is currently undergoing a boom period and is expanding rapidly. The global demand for metals is not expected to stagnate in the near future and high natural resource prices could present a development opportunity to the region. Globally, the mining industry is expected to double in size by 2020 and due to its extensive mineral reserves and increasingly friendly investment climate, much of this expansion is expected to take place in Sub-Saharan Africa.

Mining is an energy intensive industry and often accounts for a significant portion of national demand. The expansion of the industry could place additional pressures on already overstretched infrastructure as well as drive the development of new generation and transmission capacity. This balance will be explored and discussed in the following chapters. In accordance with the fourth research objective, the dependency of the industry on a reliable electricity supply was established. Hence the use of RDT as a conceptual framework is applicable.

## **5 The Mining Industry in Power Sector Development**

### **5.1 Introduction**

The aim of this chapter is to document how and where the mining industry is active or plays a relevant role in power sector development. This is in accordance with the fifth research objective:

- Establish the steps that mining companies are taking to manage their dependency on electricity.

South Africa and Zambia were selected as case study countries due to their significant mining industries and recent histories of power supply unreliability. The chapter begins with an introduction of these two Southern African states. After this, the ways in which the mining industry attempts to influence or plays a direct role in the development of the electricity sector were identified, mainly via expert interviews, but also from relevant literature sources. This was done according to the RDT conceptual framework given in Section 2.1, which was used as a guide to identify possible dependency strategies and afterwards to classify them. Note, that while no interviewee requested complete anonymity, some did ask not to be directly quoted on some items and the text has been written to respect that wish.

### **5.2 Case Study Countries**

Relevant case study countries are those that have both a large mining sector and power supply issues. In Sub-Saharan Africa, this leaves a large pool to select from. South Africa and Zambia were selected for a number of reasons. South Africa has the continent's biggest and most technologically advanced economy and is regarded as the regional leader in many respects. Its mining industry is also by far the largest in the region and it does not lack the skills or capacity to implement high tech solutions. Its deep-level gold and platinum mines are among the most sophisticated in the world. The major mining companies have their headquarters in Johannesburg and the proximity of this city to Zimbabwe enabled the author to travel there and conduct personal interviews which although not the primary driver also influenced selection.

Zambia was selected partly because the author spent five years there and thus has a better understanding than he does of other countries, but also because the economy is heavily reliant on its large copper mines (see below) which account for nearly 70% of consumed electricity (See Sections 4.9 and 5.2.1.3). The supply problems in Zambia are due to the rapid expansion of copper mining and this makes for an interesting interaction between the electricity and mining sector.

#### **5.2.1 Zambia**

##### **5.2.1.1 Introduction**

The Republic Zambia is a landlocked, low-income central African country with large copper reserves. The economy is small and GDP at Purchasing Power Parity (PPP) was 20 billion US dollars in 2010 (CIA, 2011). The population is 13 million, 48% of which live on less than 2 US dollars per day at PPP (World Bank, 2010) and 14% of the work force are unemployed (CIA, 2011). The country was ranked almost at the bottom of the Human Development Index in 2010 (150 out of 169) and is one of the poorest in the region (UNDP, 2010).



### 5.2.1.2 Mining

Zambia is Africa's largest copper producer and according to the US Geological Survey the large mines in its Copperbelt region supplied 4% of world demand for copper and cobalt in 2009. This amounted to 3.3 billion US dollars and 74% of exports (by value) that year. Zambia is also a producer of gem quality emeralds, uranium and coal (Mobbs, 2010; Edelstein, 2009).

Additional information regarding the contribution of mining to Zambia's economy was found in a presentation to the Zambian Economic Forum by Fred Bantubonse, the general manager of the Chamber of Mines of Zambia (Bantubonse, 2009). In 2006, the mines contributed the following to Zambia:

- 54% of Pay as You Earn tax (PAYE)
- 45% of Value Added Tax (VAT)
- 91% of exports
- 55% of new jobs

These figures show a heavy reliance on mining and in particular the copper industry, which is also noted by other sources such as the CIA World Factbook (CIA, 2011) and the OECD (OECD, 2008). This implies that the political power of the mining sector is large. The figures above show that when Mr Bantubonse sits down with the government he is representing almost the entire export income of the country, the biggest source of employment and the better part of the tax base.

Zambian copper production has increased rapidly since 2000. This was briefly reversed during the Global Financial Crisis (GFC) in 2008/9 when the copper price plummeted and some operations were closed down. However, the price and copper production rapidly recovered (Mobbs, 2010; See Figure 18).

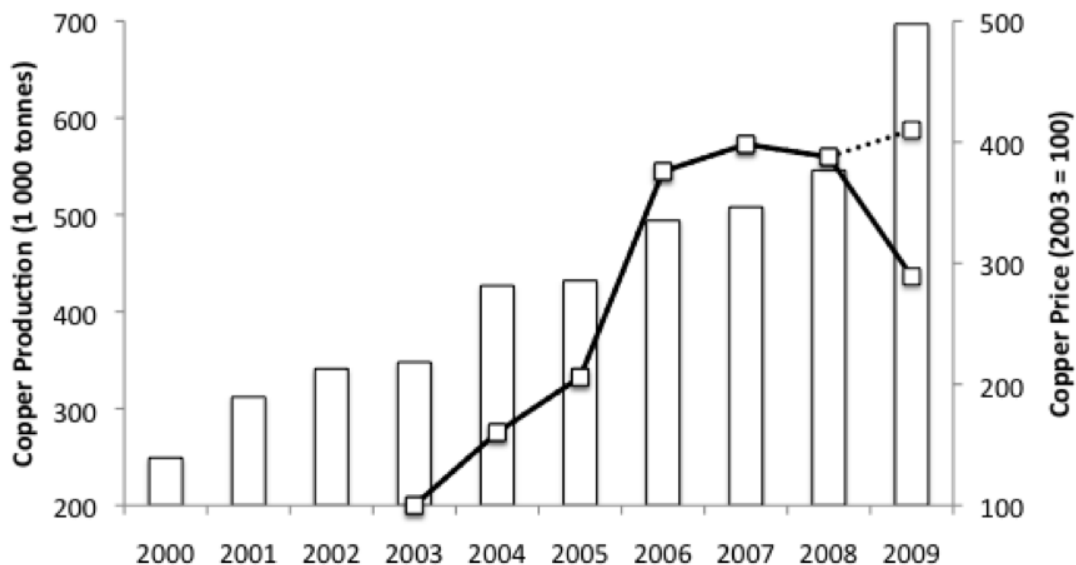


Figure 18. The copper boom in Zambia. Total mine production (bars) and the trends in the average annual price since 2003 (lines). The dotted line shows the closing price in 2009, which is significantly above the average for that year. Price data are from PWC (2010). Mine production figures are from the US Geological Survey (Mobbs, 2004; 2010).

The Chamber of Mines of Zambia (CMZ) is the industrial body that represents mining interests in the country. It was recently established and before then the mines lobbied individually or through the Zambia Association of Chambers of Commerce and Industry (ZACCI). To the author's knowledge, CMZ does not have a website or issue an annual report.

### **5.2.1.3 Power**

Zambia has an installed capacity of 1 778 MW (ASK, 2011) and is a member of the Southern African Power Pool (SAPP). At present there are three significant power companies in the country:

- the state-owned Kariba North Bank Company (KNBC) which owns and operates the 600 MW hydro facility at Kariba Dam on the Zimbabwe border. KNBC sells all of its power to ZESCO (ZESCO, 2011b);
- the state-owned Zambia Electricity Supply Corporation Limited (ZESCO) which owns and operates the majority of the remaining generation capacity, buys all of KNBC's power and sells power to CEC (ZESCO, 2011b; CEC, 2011); and
- the Copperbelt Energy Corporation PLC (CEC), which was formally the power division of the parastatal that owned all the mines before privatisation. CEC buys 99.8% of its power from ZESCO, supplies almost all the mines on the Copperbelt and has no non-mining customers. It owns and operates an 80 MW emergency gas turbine generation plant and also owns the cross-border interconnector with DR Congo. It listed on the Lusaka Stock Exchange in 2008. (CEC, 2011; Emmanuel Katepa, personal communication, April 19, 2011). As its only customers are mines, CEC can be viewed as having similar interests to and being an extension of the mining sector.

In addition to the above there are some independent power producers, which make a minor contribution to total installed capacity. However a number of large projects run by independent producers have recently been approved and private sector involvement will increase in the coming decades. These include the 750 MW Kafue Gorge Lower hydro project, which has been awarded to a Chinese company and will come online in 2017. CEC has also been given approval for a 40 MW project at Kapombo Gorge and an Indian company is set to construct a 600 MW thermal station by 2020. ZESCO and KNBC are also adding new capacity of their own including adding an additional 360 MW to the Kariba and 120 MW to the Iteshi Teshi hydro stations (Emmanuel Katepa, personal communication, April 19, 2011; Tristan Pascal, personal communication, April 13, 2011).

According one highly-placed interviewee, the regulatory environment in Zambia has only recently become conducive to private investment. While the necessary changes were legislated by the regulator in the 1990s and private sector participation made theoretically possible since then, all major power infrastructure contracts were given to ZESCO. A large change in attitudes was required and this occurred during the shortages in 2007 and 2008 when it became apparent that ZESCO did not have the capacity to meet growing demand on its own. Although the private sector involvement listed above is indicative of an investor friendly environment, according to Emmanuel Katepa at CEC (personal communication, April 19, 2011), the regulatory framework is still being improved. An important current development is a review of the transmission code for accessing the grid, which should result in a clearer set of rules for all participants. Currently everything is handled through ZESCO.

According to the ZESCO website, Zambia's internally generated electricity mix is 99.9% from hydro sources with the remaining 0.1% coming from ten diesel generators at various locations around the country. These generators cost 870 K/kWh (20 US\$/kWh) to run compared to an

average tariff of 80 K/kWh (2 USc/kWh). This amounts to a monthly subsidy of 1.42 billion kwacha (300 000 US dollars) (ZESCO, 2011b).

Due to the fact that it imports power from SAPP, Zambia does consume some electricity from thermal sources. According to Francis Yamba (personal communication, April 8, 2011), this enabled his organisation, the Centre for Energy, Environment and Engineering, Zambia (CEEZ) to get the Zambian electricity mix certified with a carbon baseline for CDM projects. These could enhance the payback period for efficiency investments. Zambia is currently seeking to enhance its trade within SAPP and CEC is currently adding an additional 500 MW connector with DR Congo in addition to the 280 MW one in place (CEC, 2011). ZESCO is also building interconnectors with Tanzania and Namibia (ZESCO, 2011c).

Mines consume around 70% of all power produced in the country (Sooka, 2007; Francis Yamba, personal communication, April 8, 2011). The total demand from CEC's mining customers is currently around 500 MW and was approaching 700 MW in 2007 (Emmanuel Katepa, personal communication, April 19, 2011). These figures are 30 and 40% of total installed capacity and do not include demand from mining operations supplied directly by ZESCO.

Zambia experienced supply shocks in 2007 and 2008, which were attributed to increasing demand from its rapidly expanding copper sector. However the situation was alleviated by the decline in copper production in the aftermath of the GFC. Even when the grid is unstable, the power supply to mines is guaranteed. If a supply shortfall is expected, ZESCO will relay a request to the mines via CEC to undertake voluntary reductions. However, contracts stipulate that even when this request is given, mining operations are not obliged to reduce their outputs. This means that when load shedding is required, it affects other parts of the economy first and mining last. Occasionally, mining operations are affected by disruptions. However these are now due to non-technical reasons (vandalism and theft) or other factors such as faults in the DR Congo resulting in supply being cut off (e.g. Mfula, 2010a; GOZ, 2010). Zambian interviewees were all satisfied that new capacity was being added at a sufficient rate by ZESCO and other players to meet projected growth in demand and expansion in the mining sector. This confidence was reflected by the rarity of significant backup generation.

## **5.2.2 South Africa**

### **5.2.2.1 Introduction**

South Africa has the continent's largest economy and is widely regarded as the regional leader in many respects. GDP at PPP was 528 billion US dollars in 2010 which is 10 700 US dollars for each of its 49 million inhabitants. However, half of the population still live under the national poverty line and 23% of the workforce is unemployed. A significant manufacturing industry exists and the biggest contributor to GDP is the services industry indicating a more modern economy (CIA, 2011).

### **5.2.2.2 Mining**

South Africa is a one of the largest mineral producing countries in the world (Yager, 2010) and has by value the single biggest natural resource endowment of any country. This is valued at 2.5 trillion US dollars, well ahead of second placed Russia with 1.7 trillion (CMSA, 2011). Table 6 shows the global importance of South Africa in terms of production and reserves of several mineral commodities.

Table 6. Mineral commodities for which South Africa was ranked in the top ten in terms of global production and minable reserves in 2009. Note this is not an exhaustive list of its mining production.

World Ranking	Production	Reserves
1	Alumino-silicates (55%) Chrome (49%) PGMs (58%) Vanadium (35%) Vermiculite (39%)	PGMs (88%) Manganese (80%) Chrome (72%) Gold (30%)
2	Titanium (19%) Manganese (14.2%) Zirconium (30%)	Vermiculite (40%) Vanadium (32%) Zirconium (18%) Fluorospars (17%) Titanium (16%)
3	Antimony (2%) Gold (9%)	
4	Fluorospars (6%) Diamonds (by value) (10%)	Uranium (10%) Phosphate Rock (5%)
5		Nickel (8%)
6 – 10	Coal; Iron Ore; Silicon Metal	Antimony; Iron Ore; Coal; Lead; Zinc

Sources: CMSA (2010b); CMSA (2010a) for diamonds and chrome

The Chamber of Mines of South Africa is the industrial body that represents mining interests in the country. According to the Chamber’s most recent annual report (CMSA, 2011), in 2009 the minerals sector contributed the following to the economy:

- about 19% of GDP (8.8% directly);
- over 50% of merchandise exports (including secondary beneficiated mineral exports);
- about one million jobs (about 500 000 indirectly);
- about 18% of gross investment (10% directly);
- approximately 30% of capital inflows into the economy;
- about a third of the market capitalisation of the Johannesburg Stock Exchange;
- 93% of the country’s electricity generating capacity (via the supply of coal to ESKOM);
- about 30% of the country’s liquid fuel supply (via coal to oil conversion); and
- 10.5 billion Rand (1.5 billion US dollars) of direct corporate tax receipts.

The Chamber therefore has a large say in domestic politics and due to the global importance of South Africa in meeting the global demand for metals, also has some influence internationally. For example, the Chamber was influential in persuading the Swiss and UK governments to prevent reserve banks from selling their gold reserves in 1999. It also lobbied against the Extractive Industries Review by the World Bank (See section 4.5) that was initially

commissioned to consider whether the group should cease financial support for mining projects. The Chamber also lobbied against the European Union's Registration, Evaluation and Authorisation of Chemicals (REACH) policy arguing that while it endorsed its objectives, the inclusion of ores and concentrates had significant negative impacts on Sub-Saharan African countries that export these to Europe (CMSA, 2011).

In spite of its large reserves, South Africa's mining output is actually decreasing. While globally, the mining industry grew by 5% a year from 2001 till 2008, in South Africa it declined by 1% per annum. In its latest annual report, CMSA identified infrastructure, particularly power and railways as major operational constraints. According to the Chamber, had the industry grown at the global average of 5%, an additional 45 000 jobs and 8 billion US dollars of value would have been created in South Africa (CMSA, 2011).

### **5.2.2.3 Power**

At 40 GW, South Africa's installed generation capacity is significantly more than half of the regional total (ASK, 2011). The state-owned utility ESKOM is responsible for generation and transmission and input from private producers is insignificant.

Historically, the country has had an excess of generation capacity due to the priority the apartheid government gave to energy security. After 1994, power plants were mothballed as they were not required in spite of a booming economy. The government then instructed ESKOM to not to commission any new power plants, but to let the private sector add new capacity, as it was required. However, regulatory barriers effectively prohibited private investment and none was added. Additionally the power sector began to face additional impediments such as poorer quality coal being delivered to thermal plants and perverse incentives leading to a reduction in preventative maintenance. This resulted in a reduction of output in the running power plants. At the same time, the economy was booming and a rapid electrification program was in place with the ambitious goal of power for all by 2012. In 2008, demand exceeded supply and the economy experienced rolling blackouts (World Bank, 2008; CMSA, 2009; anonymous interviewees).

Eskom's immediate response was to cut off large end-users to stabilise the grid. Mining operations were sometimes given minutes to close. At the height of the crisis ESKOM rationed the mining sector to 50% of 2007 power usage and could not guarantee a constant supply (CMSA, 2009; anonymous interviewees). This forced many mines to close for safety and financial reasons. Mine production was effectively halted for over a week. The blackouts cost the South African Economy an estimated 8.3 million US dollars per day, were blamed for a 3.8% drop in the JALSH (Johannesburg All-Share Index) (Africa Review Monitor, 2008) and caused the global price of gold to spike (World Bank, 2008).

In the aftermath of the crisis, mines were rationed to 90% of their 2007 use. There was some subsequent negotiating so that expanding operations got more and those that were scaling down got less. Existing operations were able to meet this via efficiency measures, however all interviewees in South Africa said that their ability to expand was severely reduced (See section 4.11) and identified power as a major reason for the paradoxical decline in mining output in the world's most resource rich country.

In response to the crisis, ESKOM put in place a number of measures. Supplies of good quality coal were restored to running plants, mothballed plants were recommissioned and existing plants were run at maximum capacity (which shortens their overall life). The moratorium on new capacity was also lifted and a new build program was started with the goal of adding a further 20 GW by 2020 (World Bank, 2008). New capacity takes time to construct and nothing significant is due to come online before 2017. Therefore ESKOM implemented a

comprehensive DSM program that encourages efficiency in all sectors (this is discussed in section 3.9.4 where the underuse of DSM is highlighted)

### 5.2.3 The Southern African Power Pool

Both South Africa and Zambia are members of the Southern African Power Pool, which connects 12 countries in the region and accounts for roughly 90% of the total traded power in Sub-Saharan Africa (SAPP, 2009; Eberhard *et al.*, 2009). Power is traded via a day-ahead market system and SAPP also serves as a forum for the development of regional solutions to electricity problems. The collective generation capacity of the 12 member countries was 49 089 MW in 2009 and peak demand in the power pool was 43 267 (SAPP, 2009). According to the acting regional coordination centre manager and chief engineer, Alison Chikova (personal communication, April 15, 2011) large end users can now join SAPP as full members and buy power directly from the pool instead of from their national utility.

## 5.3 Mining and Electricity

In this section the areas where the mining industries are involved in the power sector are identified and classified into RDT categories (see section 2.1). It should be noted that many of the strategies adopted are not exclusive to a single RDT category. Additionally, some aspects of the mining – electricity interaction, while relevant to RDT in some respects also make sound business sense and this as well as dependency management is probably a driving force behind them. A summary of strategies adopted is shown in Table 7 below.

Table 7. How the mining industry interacts with power sector development in order to secure its power supply.

RDT Category	Behavioural Strategy
Direct reduction in dependency by increasing supply security	Self-generation Back-up generation Direct infrastructure contribution Demand-side management
Interorganisational alliances	Chambers of mines between mining companies With power providers to reduce demand and participate in sector planning With government planning bodies to ensure that enough capacity is added to supply their needs
Create negotiated environments	Secure a position as a key customer with a guaranteed supply Negotiate a favourable price often in exchange for infrastructure
Alter business environment	Influence sector planning to ensure supply security Encourage changes in regulatory frameworks that facilitate trade and independent power production Encourage long term price signalling Push for DSM incentives in other sectors
Access new pools of resources	Install new generation Cross border trade Join SAPP as full members

### **5.3.1 Direct Infrastructure Contributions**

Mining projects often make a significant infrastructure contribution to the host country in Sub-Saharan Africa and the rest of the world. From an RDT viewpoint, they would do this in order to secure their access to an essential resource such as electricity but also for example, transport or water. By adding their own infrastructure, mining companies also reduce their dependency on an external actor (the government) that serves a much broader constituency. An operation in an unelectrified part of a country still requires electricity and the mine will often agree to build the necessary infrastructure because it may be able to do it faster or it may view this as less risky. Additionally a mining company might choose to contribute capital towards a generation plant in order to ensure that sufficient capacity is available for it to conduct its operations.

The historic development of the power systems around the mining industries in Zambia and South Africa has already been documented in section 4.10. While it is rare for a mining company to build, run and maintain a generation plant, which is outside of its normal core competence, they are responsible for building a lot of transmission infrastructure and catalyse the electrification of the communities where they operate. Infrastructure development is expensive and benefits a much broader section of the community than the mining operation itself. Hence the state will usually agree to pay some of the costs, either directly or via subsidies. As the state would otherwise be responsible for the full cost of infrastructure development a win-win situation for all stakeholders can theoretically be negotiated. In Zambia, mining operations in remote areas are allowed to negotiate a benefits package from the government depending on their direct infrastructure contribution. A common benefit is subsidised power in exchange for infrastructure (Thomson Sinkala, personal communication, March 11, 2011; Ted Grobicki, personal communication, April 7, 2011; Roger Baxter, personal communication, January 21, 2011; Fred Bantubonse, personal communication, April 14, 2011).

The Chamber of mines in South Africa, in its effort to reverse the decline in the industry there has now partnered with the government and the labour union in an initiative to identify current impediments and encourage broad based growth and beneficiation. One of the 13 joint commitments was to establish a long-term infrastructure planning mechanism (CMSA, 2011). It should be noted that one of AICD's recommended solutions to the regional power crisis was to improve sector planning (See section 3.9.3.1).

### **5.3.2 Provision of a Secure Base Load**

In chapter 3, it was established that reducing the production costs of power is an important step towards cost effective utilities. Cost-effectiveness is, in turn a vital step towards expanding access to the entire population. AICD note that this requires large generation plants that can take advantage of economies of scale. As many countries in the region currently do not have the demand to make the construction of these viable, regional trade is recommended to pool a large base demand. However, as was established in chapter 4, the development of mining industries in South Africa and Zambia created the base demand to justify the construction of large generation projects. In Zambia, the dynamics of resource dependency and exchange relationships apparently worked in the opposite direction and the utility was initially dependent on the secure base demand that the mines provided. This dependency was managed by selling the mines subsidised power to secure the base load (Eberhard *et al.*, 2009).

In Zambia, there was a consensus among interviewees that power infrastructure was still being built around the mining industry. Given that the mines consume 70% of production, this is not surprising. New capacity is required due to growth in the mining sector. There is also no reason why this could not be repeated. 27 countries have current installed capacities under the nominal 400 MW scale economies threshold (ASK, 2011). Given the expected increase in

mining in the region (see section 4.7), it is likely that the mining industry as well as trade will justify the construction of large projects in some instances.

### **5.3.3 Self and Back-up Generation**

Investments in self-generation capacity internalise the production of an externally sourced resource and hence eliminate a number of areas of dependency on external actors. In general, when located adjacent to a grid, a mining operation would not be expected to generate its own power as it is outside of its normal core competence and usually more expensive than power from the grid. Additionally, a self-generation path may result in more constraints as, in normal circumstances, as much power as required can be bought from a grid whereas the installed internal capacity can never be exceeded. However, in remote areas, the infrastructure investment of connecting to the central grid may be more expensive than self-generation. If a mining company divorces itself from the grid, this could entail a significant reduction in national demand. However, it should be noted that baseload customers are important in maintaining grid operations and stability. Therefore whether or not this is an efficient outcome for national supplies needs to be considered on a case by case basis.

For most mines, back-up generation would appear to be a more economically viable way of reducing dependency. In this manner, more affordable power can be purchased from the utility and when this supply is unreliable, back-up generation can be used. It appears that mines will typically not install enough to run their operations, but enough to be able to evacuate workers and prevent flooding of the shafts. The gas turbine plant operated by CEC is an example of this. CEC only use this plant, which can be turned on almost immediately in times of emergency and its 80 MW capacity is far below the 500 MW aggregate demand of its customers.

An example of complete self-generation could not be found in either Zambia or South Africa. Interviews also revealed that back-up generation was rare, however in South Africa it was becoming more common. It should also be noted that small-scale self-generation is prevalent in most operations. For example, when cooling water is piped down a shaft, it will often be run through a turbine at the bottom. While this only results in marginal savings, such investments usually have short payback periods and form an important part of the demand management and efficiency programs in place as well as assist in cost reduction and meeting voluntary climate goals.

Mining and, in particular downstream processing and smelting operations generate a lot of waste heat. Interviewees in both countries identified this as a commercially viable self-generation resource. However, regulatory barriers currently prevent its implementation, particularly in South Africa where the mining sector is involved in regulatory reform.

### **5.3.4 Demand-Side Management**

Demand side management consists of reducing the total need for power without affecting output via efficiency and the shifting of load to non-peak periods to enhance grid stability. On the face of it, it is hard to see how it reduces dependency on electricity. For example, even if total usage is reduced by 10%, an operation is still just as dependent on a reliable power supply from the utility as it was before. In this case efficiency is the product of sound business sense and is becoming increasingly viable as prices continue to rise. However when power is scarce, or as in South Africa, rationed, efficiency is an essential step towards managing dependency. Additionally, when mines shift load to assist in reducing peak demand, this assists in stabilising the grid, thereby ensuring that a reliable supply is maintained to the operation. Examples of this were found in both South Africa and Zambia.



### **5.3.4.1 Efficiency**

As with any industry, there are always opportunities to increase the efficiency of operations the viability of which increases as the price of power rises. The driving force behind efficiency would normally be expected to be higher prices. All interviewees from mining companies identified this as a major driver and pointed out that the portion of operational costs spent on electricity has increased from around 5% to 10 - 20% in recent years. However in South Africa, when power was rationed to 90% of 2007 use, increasing efficiency was essential to maintaining operations.

In the deep level gold and platinum mines in South Africa, around 80% of electricity consumed is used to maintain a working environment in the shafts. This involves running ventilation, compressed air and cooling systems and pumping water out of shafts. This usage is considered base load and is constant regardless of the level of production. The remaining 20% is used for actual mining (Running the hoists and drills and so on). In such operations the sudden reduction to 90% of normal use was an immense challenge. The 10% reduction cannot come off the base load, so has to come off production. This means that a 10% reduction in power usage translates into a 50% reduction in production and hence revenues (CMSA, 2009).

However, as cost control is vital to the success of a mining operation, mining companies managed to meet this challenge with relative ease (Ted Grobicki, personal communication, January 5, 2011). Existing cost accounting systems designed to identify to a low level of organisation, the profitability of each section of a shaft were also able to identify the electricity efficiency of each part of each shaft. Less efficient production areas were shut down and more efficient areas were scaled up. It should be noted that there is a social trade-off to this. The shutting or scaling down operations resulted in job losses, though an effort was made to minimise these (CMSA, 2009). One interviewee revealed that the best option for his company would have been to close down entire mines. However, the unemployment this would have created would have been unacceptable. An analysis of social costs is outside the scope of this document, however the reader should be aware that this was not a simple solution. Further rationing is also not likely to be possible, there was a general consensus amongst interviewees that additional reductions would be significantly harder to achieve. Additionally, while current operations can adapt to rationing, expansion of the industry is severely constrained by it. In a country where unemployment is over 20% (CIA, 2011), this is not ideal.

The rationing was disruptive because it was sudden. Over a longer time period, South African mining operations were able to improve the efficiency of their infrastructure. According to engineering interviewees, the major uses of power in each mine are compressed air, cooling, ventilation, pumping and the hoists. Savings of around 20% can be made for each. One mining operation had identified 100 MW worth of savings, all with reasonable payback periods. ESKOM also pays for efficiency and these rebates roughly halve the payback period of each investment. Engineers and executives alike expressed interest in using the Clean Development Mechanism (CDM) to further increase the viability of investments in efficiency.

Although improving mining infrastructure is significant, a number of interviewees agreed that the biggest efficiency gains were behavioural. An example from one engineer was avoiding parking ore trains in front of ventilation fans, which increases the resistance to air flow. This costs nothing and saves a lot. However, managers identified the lack of efficiency culture as a barrier. There is evidence that this is slowly changing as it is well communicated down organisations from top management.

The absence of efficiency culture was also identified at other levels of the organisation and was blamed on the historic low costs of power. The following hypothetical example was given

by Ian Langridge, an engineer and the efficiency manager for Anglo American (personal communication, January 20, 2011) and relates to procurement: A process engineer when designing a new project will use a motor that is 10 – 20% larger than actually required. The mechanical engineer will then view the process engineer's design and commonly add another 10 – 20%. The final figure for the project will be 11 MW and when the project is passed on to procurement. Procurement may only be able to source a 10 or a 14 MW motor, so will pick the 14 MW one. This is an historic inefficiency that is now avoided via better review of all projects. According to Ian Langridge, mining also lags behind other industries in terms of automation, which should be embraced. He pointed out that at one extreme the Finns are currently designing unmanned, underground mines and that while this may not be feasible in South Africa, some areas could be automated to increase efficiency.

Mining interviewees all pointed out that the expensive nature and long life of mining investments limited the uptake of best available technologies. A common example cited was switching from compressed air to hydraulics and electric motors. Although the latter are significantly more efficient, existing operations are not likely to completely retrofit their shafts. This is because the required new mining infrastructure is a significant investment that would render the existing, expensive compressed air infrastructure investment redundant. The greatest efficiency opportunities therefore lie in designing new mines for efficiency. In such cases the most appropriate technology can be installed from the beginning and efficiency can be taken into account in the design stages.

Unfortunately, not enough responses were obtained from mining operations in Zambia to be able to determine whether efficiency is pursued to the same degree there. However given that many operations are subsidiaries of multinational companies with climate and energy efficiency targets it is reasonable to assume that it is pursued to some degree. Tristan Pascal from Kanshanshi Mining PLC (a subsidiary of First Quantum Minerals) which runs Zambia's largest copper operation, confirmed that that cost accounting systems in place in South Africa were also running in Zambia and that as power was a significant cost, its use was constantly monitored (personal communication, April 13, 2011). Other interviewees, outside the mining sector indicated that Zambia was behind South Africa on efficiency, but this can partly be interpreted as a comparison of ESKOM's DSM initiative to ZESCO's.

#### **5.3.4.2 Load Shifting**

Mining operations are able to shift some of their demand to off peak periods to assist in reducing peak demand. For example, dewatering reservoirs can be emptied during periods of low demand so that pumps can be turned off when demand is high. Intensive operations such as electrotwinning can also be performed at night to reduce pressure on the power system. Again, while this is partly driven by business sense as utilities increase the price of power during peak periods, it also reduces the likelihood of a blackout or the need to loadshed thereby increasing supply security. According to Roger Baxter, the mines in South Africa cooperate closely with ESKOM and have managed to reduce national peak demand by 450 MW (Personal communication, January 20, 2011). This is larger than the total installed capacity of many countries in the region.

In Zambia where the mines are not obliged to reduce, even during periods of instability, significant reductions in demand can be achieved via voluntary reductions. According to Emmanuel Katepa at CEC (personal communication, April 19, 2011), reductions of 100 MW or 20% of CEC's total demand can be achieved for as long as four to five hours. This is nearly 6% of national installed capacity. Importantly, this is not achieved by compromising output, however provided that sufficient advance notice is given mines can reduce their demand by shifting their operations accordingly. At present Zambian operations are only asked to reduce once or twice a year, typically when ZESCO is shutting down generation units for routine

maintenance. However in 2007, this request was issued almost daily and undoubtedly assisted in managing the tight demand-supply balance that existed then.

### **5.3.5 Negotiated Environments**

According to Resource Dependency Theory, organisations will endeavour to create negotiated environments with suppliers to minimise constraints on their operations. It is important here to note that as much of the power infrastructure in both countries has been built around mining development and due to the current and historical socio-economic importance of the sector, mining has negotiated itself into a relatively strong position regarding power.

For example, although Zambia is affected by load shedding, the mines there have negotiated power contracts that stipulate that they do not have to compromise their output. Even during times of emergency, mining operations are given priority and are not expected to reduce their output. This effectively means that the industry is only affected during periods of severe instability and other commercial consumers such as manufacturing and agriculture as well as domestic demand bear the brunt of load shedding. It is likely that the mines can retain this situation because of their importance to the Zambian economy. It is also true that power cuts are more disruptive to mining operations than they are to other industries. The argument that what is good for copper mines is good for Zambia would strengthen the case before the regulator and the government. However, this increases the constraints of unreliable power to other sectors of the economy. This needs to be dealt with if the development of downstream, value-adding manufacturing industries according to the Africa Mining Vision is to occur. However the solution is to increase supply reliability, not to make the mines share in load shedding.

The situation is different in South Africa where the mines are under contract to assist in demand management in times of severe grid instability. This can best be understood from the point of view of the utility. It is far easier to bring down current demand by switching off a few mines than by randomly turning off sections of the grid, cutting off multiple users and bringing a far less predictable result. During the height of the crisis, mines were sometimes given minutes notice and often chose to close for safety reasons when Eskom could not guarantee their supply. However, there is evidence that the mines are adopting behaviour to try and change this situation and renegotiate their environment. Management level interviewees and Roger Baxter from the Chamber of Mines argued that switching off a mine has a large economic and social affect on the whole of South Africa, and hence it should be a political decision that someone at a power utility should not have the authority to make.

In Zambia, mining operations that create an infrastructure contribution to remote areas are able to negotiate a benefits package with the government (Thomson Sinkala, personal communication, March 11, 2011). One of the benefits that can be arranged is subsidised electricity (if they are ZESCO customers). This raises concerns as to moving towards full cost recovery tariffs. The mining industry is not unique in that it will try and secure a favourable price for its inputs and recent tariff increases have been met with some opposition. According to one article in a Zambian newspaper, some of the older mines with less efficient equipment would be unable to cope with these and would have to close. In order to prevent this, the article called for the current system of a blanket tariff for all customers to be removed, with older operations given concessions (Mfula, 2010b). From an efficiency point of view, this is rewarding the worst industry players and disincentivises a positive outcome. However, this does need to be balanced with the view that the mines are a significant employer and produce an economically important commodity.

Mining sector interviewees claimed to be aware of commercial realities when it comes to pricing. The fact that ZESCO was funding additional generation projects with loans whose

lenders would demand a commercially realistic tariff was recognised. However exactly what constitutes a cost reflective tariff will depend on the balance sheet value of assets. According to one interviewee ZESCO's are old and therefore depreciation costs on capital should be negligible. However, given that these are unlikely to be decommissioned anytime soon, ZESCO could well argue that these should be revalued to effective life and depreciation recognised in tariff structure.

Although ZESCO could not be reached, Alison Chikova, the acting coordination centre manager of SAPP stated that tariffs in Zambia are currently almost cost effective to cost effective (personal communication, April 15, 2011). Emmanuel Katepa at CEC also took the position that ZESCO charges CEC the full cost of its power (personal communication, April 19, 2011). According to Mr. Katepa, the mines were the only customer capable of paying full cost recovery tariffs in the medium term and hence would finance most of the new capacity being added by ZESCO and CEC. There was a recent outcry in Zambia when it became public knowledge that the mines were receiving a lower per kilowatt-hour tariff than other commercial and domestic consumers. However, the cost of providing power to large end-users at high voltage is cheaper than to smaller consumers. This is because transmission losses are less and less transmission infrastructure is required per kWh sold to larger consumers. Eberhard *et al.* (2009) at AICD agree with this principle.

In South Africa where the supply demand balance is tighter than in Zambia, the mines are prepared to pay a premium for power. Some interviewees put this as high as 30 – 40%. In its 2009 annual report (CMSA, 2010), CMSA actually called for tariffs that reflect the full costs of production to be implemented. However, they took the position that the tariff increases were being announced with little warning and that this was just as disruptive as an unreliable supply. Mining operations have a long lifetime with many years between the planning phases and the start of extraction. CMSA stated that it was working with the regulator to improve the price signalling system. Emmanuel Katepa at CEC stated that the price signalling from ZESCO was sufficient and that the current tariff plan was set 15 years in advance with the expected effects of new generation projects on tariffs and so on.

### **5.3.6 Interorganisational Alliances**

While mining operations will continue to be dependent on their power supply to operate, this dependence can be managed by forming alliances with other organisations in the operating environment. Some examples of this were found in the research.

The formation of Chambers of Mines in each country can be viewed as an alliance of mining companies. In each case, the Chambers of Mines serve to present the collective interests of the industry to the government and to other stakeholders such as trade unions and the general public. This was not driven by the power shortage, however as companies seek to create a negotiated environment, such alliances are useful as negotiating power is obviously improved when companies present their interests collectively.

Some of the associations between mining companies and electricity utilities and regulators can be viewed as interorganisational alliances. The Copperbelt Energy Company, which only has mining customers, can be viewed as an alliance. In this case, it is important to note that dependency can be mutual. While mining companies rely on CEC for power, CEC relies on its customers to buy it. Hence there is an incentive for the two parties to work closely together. The infrastructure contributions as well as peak load reductions undertaken by the industry in both countries discussed in the section 5.3.4 can also be viewed as an alliance between the power and mining sectors, with both working together to serve mutual interests.

### **5.3.7 Alter the Regulatory Environment**

As they are large end-users and therefore important customers, mining industry representatives sit on relevant power sector boards and committees and are consulted on power sector developments. However, according to interviewees in both countries, the mining industry is not merely consulted by the power sector. It is very active on power issues and exerts an influence on the sector in a number of ways.

Every industry will try to alter the regulatory environment within which it operates to its own advantage. The mining industry is not unique in this, however it does have a larger influence than most other industries in the region. Given its size and importance to the economies of South Africa and Zambia, it is also able to present the argument that what is good for mining is good for the whole country and therefore in the national interest.

Mining industry representatives are present on influential electricity committees in South Africa. These include the National Stakeholder Advisory Council on Electricity; the National Electricity Response Team; and the expert group advising the Department of Energy on its Integrated Resource Plan 2 (CMSA, 2011). It is also working with the government and labour unions on the long-term Integrated Infrastructure Planning Mechanism (CMSA, 2011). Given its presence on all these boards, it is reasonable to conclude that the industry plays a significant role in the national debate on power.

The Chamber has raised a number of issues with ESKOM and the Government of South Africa in recent years. It maintains a watching brief on the power sector and raised supply concerns with ESKOM in 2001 (Roger Baxter, personal communication, January 20, 2011), (well before the country was struck by power cuts in 2008) and issued a strong warning in 2007 (CMSA, 2009). Annual reports show that the Chamber has continually raised concerns about the regulatory environment in South Africa. These include the failure to unbundle utilities according to the 1998 White Paper on Electricity which would have among other things given the mines a choice of supplier (CMSA, 2005); lobbying against additional licensing when mines supply communities with electricity (CMSA, 2005); and arguing for full cost-recovery tariffs albeit with a strong price signalling mechanism (CMSA, 2010).

Although ESKOM's tariffs are still to an extent subsidised, an industry representative identified the regulatory environment and not price as the major barrier to reliable power in South Africa. In particular the need for a clear set of rules for wheeling on the grid and the introduction of marginal cost pricing were identified as major obstacles to the private sector participation that the country was relying upon to add capacity before the power cuts.

CMSA is also active in some areas, which may be considered outside of a normal customer-supplier relationship. This is not surprising given the tight demand-supply situation in the country and the fact that no significant new generation is due to come online before 2017. Hence, it is important to the mining sector that as much use is made from current capacity as possible. CMSA is pushing for efficiency measures in other sectors to help control maximum demand. For example, Roger Baxter, Chief Economist at the South African Chamber of Mines argued for the government to introduce a rebate for solar heaters, which it eventually did. The reasoning behind this is sound. There are 4 million taxpayers in South Africa, and if 1 million solar heaters could be introduced this would remove 1.5 – 2 GW of from the grid. The new Medupi, 4.8 GW thermal power station, due to start coming online in 2018 will cost around 124 billion Rand to build. A 10 000 Rand Solar panel rebate, saving 1.5 GW would cost 10 billion Rand or 6.7 Billion Rand per GW. A new power station costs nearly 29 billion Rand per GW and the benefits of solar heaters would potentially be realised far sooner (Roger Baxter, personal communication, January 21, 2011).

According to its general manager, Fred Bantubonse (personal communication, April 14, 2011), CMZ was not active on power issues with the government or the regulator. The reason given was that the Chamber was satisfied that enough capacity was being added in the long term to meet the industry's needs. Therefore, a watching brief was maintained, but the Chamber was not active on an issue that in normal situations would be outside of its core competence. During the period of unreliable power however, the Chamber did raise the issue with the government.

CEC however, is very active on power issues and in this regard seems to have occupied the role of the recently created CMZ. According to, Emmanuel Katepa, CEC and individual mining companies have been very active in shaping the regulatory environment in Zambia and are present on several committees relevant to power. The evolution of an environment friendly to Independent Power Producers is in part attributable to lobbying from the mines as well as an emerging consensus that ZESCO did not have the resources to add capacity at the required rate without private sector assistance. Zambia is currently reviewing its grid transmission code with the aim of establishing clear rules for participation. According to Mr. Katepa, the mines have been active on this issue as well.

### **5.3.8 Access New Pools of Resources**

Another way of reducing dependence on the supplier of a critical resource is to begin to source it from other suppliers. This is difficult to achieve in the current market, as currently ZESCO and ESKOM are the only significant power generators in each country. However, examples of mines looking for new sources of power were found. They accomplish this by boosting regional trade between utilities and by encouraging utilities to add capacity.

In Zambia, moves by CEC to boost trade and add to its own capacity are examples of mining companies accessing new resources. CEC currently buys 99% of its power from ZESCO, however it is beginning to invest in its own generation capacity. It already has a gas turbine plant and has been given permission to build the 40 MW Kapombo Gorge hydroplant. CEC is also very active in sourcing power from neighbouring DR Congo. It owns the grid interconnector between DR Congo and Zambia and is currently constructing a second one to both increase the amount that can be imported and to improve the reliability of supply (in the past disruptions have been caused by the failure of the interconnector). Some individual mining companies have also been involved in sourcing power from DR Congo and have been encouraging the rehabilitation of the Inga Dams (Tristan Pascal, personal communication, April 13, 2011; Emmanuel Katepa, personal communication, April 19, 2011).

SAPP has also recently announced that it will allow large end-users to join as fully-fledged members. The implication of this is that it is no longer only utilities that are able to buy from SAPP. Instead a large mining company in South Africa could buy directly from the power pool (with a wheeling fee to ESKOM included in the tariff) if it decided that the supply from SAPP was more reliable. It is too early to see how this development will affect the mining sector.

## **5.4 Conclusions**

The snapshots of the power sectors in each case study country at the beginning of this chapter revealed that the power sector and regulatory environment in both countries are undergoing constant reform. The examples found are all in accordance with the regional recommendations from AICD that aim to resolve power sector issues. For example:

- new capacity is being added and sector planning strengthened;
- regional trade is being promoted with several cross border connectors being added;

- financial governance is being improved and tariffs are moving towards full-cost recovery; and
- a number of regulatory reforms are taking place which both promote better institutional governance in the sector as well as private investment.

The second half of the chapter focuses on the involvement of the mining sector in accordance with the fifth research objective. It was revealed that the mining sector is actively engaged in the power supply in a number of areas including:

- direct infrastructure contributions and the historical catalysis of electricity development;
- active influencing of regulatory reform with the aim of improving utility financial performance and institutional governance as well as promoting private sector involvement and strengthening sector planning and the timely addition of new capacity;
- working with respective utilities to reduce national peak demand to assist in grid stabilisation;
- improving internal efficiency to assist in maximising the use of the current installed capacity;
- promoting efficiency measures in other sectors to further reduce peak demand
- Active participation in relevant power sector management and planning committees; and
- promoting regional trade.

Thus, it is reasonable to conclude that the mining industry has historically and currently played a significant role in the development of the power sector. Its ultimate goal of managing its dependency is in line with that of the power development community. Both actors are striving for a reliable supply. It is also clear that in order to achieve this goal it is actively promoting the same solutions recommended by the development community. The above list essentially answers the research question (see section 1.6). The implications of the mining industry's significance of power sector development are discussed in the final chapter where reasons why its role should be considered in power sector development are identified.

## 6 Enhancing the Role of the Mining Industry

### 6.1 Introduction

In chapter 5, it was established that the mining industry plays a very active and often significant role in the development of the power sector. This finding essentially answered the research question and established *why* the industry's role should be considered. However, in order to address the knowledge gap the implications of the significant involvement of the mining industry need to be discussed in order to determine *how* its role should be considered in power sector development. This is in accordance with the last research objective:

- Discuss how those organisations and institutions seeking to improve power infrastructure in Sub-Saharan Africa should consider the role that the mining industry has to play in power sector development.

There are a number of areas where the mining industry is contributing towards the solutions to power sector issues prescribed by the development community and this section proposes how this could be enhanced. Additionally there are a number of areas where the power development community would benefit from increasing its interaction with the mining industry. These are discussed under the subheadings below, which are mutually reinforcing and should be considered together. A number of areas for further research are identified which will need to be addressed if the role of mining is to be optimised.

### 6.2 Infrastructure Planning

In chapter 3, sound infrastructure planning was identified as a key factor in improving the power sector in the region. In chapter 5, it was established that mining makes a significant contribution to power infrastructure, though it was not possible to put an exact figure on this. The biggest contribution by the sector is transmission infrastructure, however mining also indirectly justifies the construction of new capacity. As tariffs become cost-effective in the region, a growing mining industry may induce private investors to add to national capacities. While the private sector is recognised in the power development literature as a potential major contributor, this appears to refer to the more traditional situation where an investor will construct something and then continue to own and run it for a profit. Mining's infrastructure contributions are often public goods, partially or fully paid for by the private sector, but owned by the government or utility and hence do not appear to have been taken into consideration.

Given the potential of mining to add to national infrastructure stocks, its role should be considered by the development community with the broad expectation that it should be enhanced. This is particularly important if the rapid growth in mining expected in the near to medium future is to benefit a broader section of society in accordance with the Africa Mining Vision. Perhaps the best way to enhance the role of mining would be to take the industry into account during the planning process. The development community should therefore seek to assist national planning bodies in identifying those areas where mining could directly contribute and where the industry is expected to grow and create the base demand to justify new capacity. It should be noted that this is different to the role that the mining industry currently plays in sector planning. The mining industry seeks to ensure that poor power sector planning will not result in a supply shortfall. What is proposed here is that the role of the mining industry in contributing towards infrastructure stocks and providing a stabilising steady base load is also considered by the planning body as it seeks to ensure a reliable supply to the national grid.



There are some challenges associated with incorporating the mining industry into long-term infrastructure planning. Firstly, it is likely that there will be an information gap similar to the one faced by CFI that led to the creation of AICD. It is unlikely that an exact figure could currently be put onto past mining contributions, nor could a reliable estimate be made of possible ones. Similarly, while there are likely to be large funding savings if some of the costs of new infrastructure could be passed on to the mining industry, exactly how much is unknown. This lack of information and numbers will impede the planning process and will need to be addressed as reliable information would assist governments in negotiating a fair infrastructure contribution from or subsidy package to mining operations in order to gain a mutually beneficial outcome. Therefore organisations such as AICD should consider including the mining industry in their infrastructure assessments. A set of indicators and success factors should also be developed by comparing success stories such as Botswana and South Africa to failures such as Sierra Leone and DR Congo.

The relatively unexplored nature of the region also presents a further difficulty to planning bodies as they will be unable to predict where the next big mining project may be. However, significant exploration is occurring and in order to minimise this limitation, planning bodies should keep themselves abreast of this activity and set priorities according to those areas with and without mineral wealth.

The time lag between deciding to mine an area and the start of production is longer than in other industries and the lag between finding an ore body and mining is even longer. At the extreme, if mining is relied upon completely to provide infrastructure in resource rich areas, there is the possibility that this will result in those areas being left behind in terms of infrastructure services. The cyclical nature of the industry increases this risk. When prices drop as they did in 2008, projects get shelved and development halted. Therefore a note of caution needs to be added. Even a booming mining industry is not a silver bullet for development and long-term uncertainty needs to be built into the planning process. Depending on the risks associated with the long-term viability of some mining projects, the state might well still opt to use public funding for new power infrastructure. In such cases, it is important that mining operations still indirectly fund power infrastructure development via a full cost recovery tariff.

### **6.3 Mining and Utility Financial Performance**

There is a general consensus that financially sound utilities are a prerequisite to delivering access to the entire population and being able to afford the maintenance and capacity addition to deliver a reliable supply to industry (See Section 3.8). Current subsidies present a large economic burden in the region and if access is increased from the current 26% to 100%, they will be unaffordable. It was also noted in section 3.8 that most current subsidies are regressive and bypass the poor. For this reason, AICD and others in the development community recommend that power subsidies be reviewed and that utilities begin to charge commercially realistic tariffs. It was expected that the mining industry would oppose this issue in order to manage its production costs. However, in both South Africa and Zambia there was a willingness to pay a premium for a reliable supply. The South African Chamber of mines even recommended increases and a Zambian interviewee expressed the view that the mines were the only users capable of paying a cost reflective tariff in the medium term and hence were cross-subsidising other users.

When a mining operation receives subsidised power in exchange for an infrastructure contribution, or (as some miners in Zambia were arguing for, but did not get) if an historical subsidy is kept in place so that an older, inefficient mines can be kept open, this raises questions as to the long-term financial performance of utilities. However there are socio-economic trade-offs involved in each decision. The mining industry should not and indeed, simply could not be required to fund every infrastructure and development project in a

country. If a government puts this expectation on it, then the growth of the sector will be significantly constrained and the development opportunity offered by the current high prices missed. On the other hand, if there is no contribution made by a burgeoning mining sector, then when prices drop or reserves run out, the development opportunity is also missed. In the latter example of the old inefficient mine, a power subsidy will maintain jobs and possibly pay for itself via taxes and royalties.

There are trade-offs involved in all subsidy schemes and whether or not they are in the national interest will depend on the current development priorities of the polity at the time. If the government decides that a subsidy is in the national interest than the shortfall in production costs should actually be transferred from the national infrastructure or other relevant fund to the utility. In this way it is the government and not the utility that is meeting the cost of the subsidy and as such the utility will still have the cash flows to run its operations, perform regular maintenance and expand its customer base. In this case, assistance in setting up an appropriate funding mechanism is recommended.

Many subsidies are currently in place to maintain affordability to domestic and sometimes commercial consumers. In a region where only 26% have access, these are automatically regressive. In this case, the tariff paid by other users is a cross subsidy to these sectors. In such instances, the mining industry would be a useful ally in convincing governments to perform a subsidy review. The political influence of mining and its potential to drive reform is further discussed in section 6.5.

## **6.4 The Africa Mining Vision**

Sections 6.2 and 6.3 above, which consider the infrastructure contributions and subsidy eligibility of the mining sector are likely to raise considerable debate. On the one hand, the mining industry can and should make a meaningful contribution to development, on the other, if it is expected to contribute too much, then no new mining projects will be commissioned. It is taken as a given that it is the national government that has the authority to make demands of or give concessions to the industry and negotiate the win-win situation for all stakeholders that is theoretically possible. The key point here is that the win-win situation rests on the negotiating capacity of the government body responsible for mining.

The implication for the infrastructure development community is that mining initiatives such as the Africa Mining Vision that aim to ensure that the minerals sector contributes towards meaningful development are an important part of closing the infrastructure gap. When power infrastructure is considered, a robust regulatory environment is not only important in the power sector, but potentially also in the mining sector. The strengthening of mining frameworks with clear guidelines as to societal expectations, transparency initiatives and skills and negotiating capacity enhancement is therefore conducive to improving Sub-Saharan African infrastructure. If the potential infrastructure contribution of the sector is to be optimised then the polity needs to have the capacity to recognise both what might be an unreasonable burden or what would be an unjustified incentive for the mining sector.

## **6.5 Mining and Power Sector Reform**

The mining industry has a vested interest in reliable power. A common theme found in the course of this research was that a number of reforms are required to improve the performance of the power sector. The mining industry is active on power issues including many of the regulatory issues identified and solutions proposed by industry representatives in both case study countries were similar to problems identified and solutions proposed by AICD and other organisations. The mining industry also plays a role beyond what is considered a normal customer-supplier relationship most notably by actively promoting DSM measures in other

sectors of the economy. In so doing, it is taking on the role of the development community and is involving itself in the national solution to the electricity issue. In lieu of this, it is recommended that the infrastructure development community could further their cause by including the mining industry as part of their target audience as well as using it as an information source. Many reforms will be politically difficult to implement and this can be partly alleviated with the assistance of the influential mining sector.

### **6.5.1 Mining as a Target Audience**

For those individuals or any organisations seeking to improve the power sector in Sub-Saharan Africa, including the mining industry as a target audience is a potential boost to the development cause. This is particularly important when politically or socially difficult reforms are required. An example would be persuading a state owned monopoly to allow private sector competition. In this case, the development community would benefit by presenting its arguments to the mining industry in addition to its normal target audience. For example, Chambers of Mines in resource rich countries represent a significant portion of the national economy and thus have the ear of government. If the mining industry can be convinced of the benefits of some of the development community's proposed solutions, then it is a potentially useful ally in convincing the government to implement reforms.

It was noted during the course of this research that most of the reforms recommended by AICD and other organizations were also recommended by mining industry representatives. Therefore on most issues, the industry already is an important influence for what is generally seen to be positive change. However, this does not mean that the role of mining could not be enhanced if the industry was approached more directly. Notably, when regional integration is believed to be the optimum solution, then it becomes more important to take an active approach towards mining. This is because the infrastructure development community starts its research from a regional perspective, while the mining industry, although it does sometimes promote cross-border trade, is primarily concerned with stable national supplies.

This situation is illustrated in South Africa. The Chamber of Mines there warned ESKOM that demand was growing faster than supply as early as 2001 and began to lobby for excess capacity to be added by ESKOM and for regulatory changes to encourage the private sector to invest in generation in South Africa. Today, South Africa is engaged in an extensive new build program. New capacity in South Africa means coal, while new capacity in SAPP will be mainly hydro, with some coal. Had ESKOM taken the regional perspective recommended by AICD and met rising demand via SAPP, the result would have been a decrease in the carbon intensity of South Africa's electricity mix.

In this case a very strong argument would need to have been presented to both the South African Government and the mines that this was in the national benefit. The mines might well take the position that the supply from a dam in Mozambique or DR Congo is unreliable, simply because if there is a fault, someone in another country has to fix it. Similarly, if the government has to finance the new capacity, it would far rather it was on South African soil than elsewhere, not only for energy security reasons, but also so that the employment and growth benefits associated with large engineering projects such as new power plants could be enjoyed internally. Additionally, as South Africa has a large enough base demand to make use of large and efficient and therefore cheap thermal generation plants, it would appear to have little to gain and much to lose by depending on foreign generation to meet its growing power demand. In this case the debate over whether regional trade is the optimum solution is not relevant. The point is that those promoting regional trade would benefit from targeting the mining industry.

For countries that cannot generate cheap power internally like South Africa, the argument for regional integration is much stronger. This because it will allow countries to meet their demand from cheaper production sources. In this case, if the mining industry can be convinced that this is the best way to keep tariffs affordable, it may decide to lobby the government to promote trade in electricity. Although such countries would be sacrificing their energy security, the economic growth and social benefits of cheaper, reliable power could be perceived as a net gain and hence sovereignty bargain.

In South Africa, where the mining industry was pushing for efficiency measures in other sectors of the economy, the development community would also further their cause by directly approaching the mining industry. While in theory any proposal that is more cost effective than adding new capacity should be taken up by a national government or regulator, there are difficulties associated with persuading them to implement it. In such cases, the mining industry, which has a vested interest in improving the power supply could be an influential partner. As an example, if the climate lobby is pushing for higher efficiency standards to be incorporated into a commercial building policy, the mining industry, which in South Africa is constrained by power rationing might choose to include it in their list of suggestions to the utility.

## **6.5.2 Mining as an Information Source**

Where industry has been approached over electricity issues, it is more to do with finding out the detrimental effects of unreliability rather than working towards a positive solution. Given the level to which the mining industry involves itself in power sector development, it is likely to have a clear idea of the optimum way forward for the power sector. As such, it is worthwhile to consult them.

A common theme in this document is that the mining industry and the development community have a common interest in improving the power sector. While this work holds that this true and relevant, it should be noted that the aims of stakeholder are likely to be a little different. The development community wants reliable power and for access to be increased to 100% and for a higher portion of renewable generation and so on. All the mining industry wants is reliable power and this should be taken into account when they are consulted.

Where the developmental literature could benefit is from gaining the perspective of a large, private sector industry on the viability of some solutions. An example of this in DR Congo came out during the course of this research. The two dams at Inga in North-western Congo generate power that is exported into SAPP and is important in supplying the Zambian copper mines. Another two dams at Inga could generate an impressive 43.5 GW of power, or nearly two thirds of current regional installed capacity. While some of the difficulties associated with the construction of such projects are recognised in the literature, the Inga megadam project is frequently cited as a premier example of the potential benefits of regional trade, probably due to its vast generation potential and relatively small reservoir size.

On the other hand, every single interviewee that was asked about the Inga project voiced serious doubts. These included the 80 billion US dollars in funding required for its construction; the level of business risk involved as DR Congo is not a stable state; and the capacity of the Congolese utility SNEL to maintain a reliable supply. The response of one interviewee was that if the dams were ever built, it would be so far into the future that it should not even be considered now. Another, who had done some work in DR Congo with SNEL, described the project as a “pipe dream”.

The potential of large projects also depends on their business viability. The multinational companies in the mining sector have a reasonable understanding of the levels of governance; institutional capacities and risk profiles of most of the countries in the region, because they operate in most countries in the region. In this case, approaching the mining industry with the question, “would you like to get more power from DR Congo?” would assist in differentiating the theoretical and realistic optima in the regional trade scenario.

## **6.6 Mining and Demand Side Management**

In the short to medium term, Demand Side Management is important in maximising the use of the current generation system before new capacity comes online and in the medium to long-term as it reduces the required rate at which new capacity needs to be added and hence the funding burden. However, although utilities have recently begun to implement basic DSM programs, its potential is still largely unconsidered in the regional power development literature. The gains made in the mining industry, particularly in peak load reduction illustrate the potential of DSM when utilities and end-users cooperate. It would appear that there are large gains to be made if other industries and the residential sector follow suit. In order to realise these such relationships should be enhanced and encouraged with other end users.

The potential for efficiency in mining has been recognised within the sector, but not within the development community. They should take note of the large gains that the mining industry has been making. Other countries should also consider copying ESKOM’s model of paying for demand reductions to shorten the payback period for efficiency investments. If these are well planned, they may free as much capacity as a new power plant and cost less money. South Africa has a greater capacity to implement technical solutions than other countries in the region. However, not all of ESKOM’s DSM program is technical. The power development community should identify relevant DSM measures that have worked in South Africa and that could work elsewhere and encourage their roll out in the rest of the region

The interest that the mining sector appears to be taking in using the CDM to assist in paying for efficiency is also noteworthy. The CDM has largely bypassed the region and the mining industry could catalyse a significant roll out of CDM projects.

## **6.7 Applicability to Other Industries and Infrastructure**

The gap in the knowledge that this research attempted to address was the lack of attention given to the role of large industries when considering Sub-Saharan Africa’s power sector. The mining industry was selected to address this gap, as it is the most significant industry for many countries in the region. However there is no reason why similar research on other infrastructure challenges and other industries would not produce a similar conclusion. It is likely that chambers of commerce and commercial farmers unions are also active on power issues, though possibly to a lesser degree. The mining industry is also involved in other infrastructure areas. For example in South Africa and Zambia it engages in improving railway systems and implementing transport efficiencies such as one-stop border posts.

## **6.8 Conclusions**

This thesis addressed a knowledge gap enfolded the potential role of large end users in the development of the power sector. The previous chapter established that the mining sector, which is a large end-user influences electricity development in a number of ways. The implication of this is that the role of the mining industry should be considered and enhanced. Hence a number of recommendations were made as to how this could be achieved. These are shown in Table 8 below.

Table 8. A summary of the findings and recommendations of this research.

Finding	Recommendations
<p>Mining makes a significant direct infrastructure contribution to the region</p> <p>Mining indirectly catalyses the development of power infrastructure</p>	<p>Enhance this contribution by incorporating the mining sector into power infrastructure development plans</p> <p>To ease this infrastructure development bodies should be kept abreast of exploration and mine planning activities to reduce information gaps in sector planning.</p>
<p>Mining operations will sometimes receive subsidised power in exchange for infrastructure contributions</p>	<p>Existing subsidy systems should be reviewed.</p> <p>Any subsidy should be paid by the government, not the utility.</p>
<p>A win-win situation is theoretically possible from mining and development</p>	<p>The negotiating capacity of the authority responsible for mining needs to be enhanced. Power infrastructure development includes assisting the implementation of the Africa Mining Vision and similar initiatives.</p>
<p>The mining sector has significant political influence and it uses this to promote power sector reform</p>	<p>Where appropriate approach the mining industry as an ally as its influence could speed up the reform process.</p> <p>Power sector developers should include mining as part of their target audience as they develop solutions, particularly when they focus on the regional and not the national level.</p> <p>The mining sector should be used as an additional information source, in particular when assessing the commercial viability of projects.</p>
<p>Demand Side Management</p>	<p>Encourage additional incentives for DSM in mining and other sectors.</p> <p>Transfer successful DSM programs to other countries in the region.</p> <p>Enhance the interaction between utilities and large end users particularly in peak demand reduction.</p>

This thesis takes a positive, forward-looking view on future developments in Sub-Saharan Africa. A vibrant mining sector and a reliable power supply are both important in tackling the various developmental problems the region faces. This thesis has argued that these two sectors should not always be considered separately. If a vibrant mining sector is required to internally generate wealth, then this requires a reliable power supply. At the same time, a vibrant mining sector can contribute towards improving supply reliability. This is something that should be noted by the infrastructure development community, which should enhance the already significant role of mining in improving regional power systems.

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## Appendix A – Interviewees

Name	Position	Date and type of interview
Ted Grobicki	Executive Director Harmony Gold	Telephone interview, January 5, 2011 Personal interview, January 19, 2011 Email communication, April 7, 2011 Telephone interview, April 15, 2011
Thomas Armstrong	Chief Engineer, Turk Mine, Bulawayo Zimbabwe	Personal interview, January 14, 2011
Zob Smythe	Health & Safety Officer, Anglo American, South Africa	Personal interview, January 16, 2011
Ian Langridge	Energy Efficiency Manager, Anglo American, South Africa	Personal interview, January 20, 2011
Louis Botha	Mining Engineer, Harmony Gold, South Africa	Personal interview, January 18, 2011
Rex Zorab	Consultant, Rand Uranium, South Africa	Personal interview, January 17, 2011
Roger Baxter	Chief Economist, Chamber of Mines of South Africa	Telephone interview, January 21, 2011
Tristan Pascal	New Business Manager, First Quantum Minerals, Zambia	Telephone interview, April 13, 2011
Fred Bantubonse	General Manager, Chamber of Mines of Zambia	Telephone interview, April 14, 2011
Francis Yamba	Founder and Director, Centre for Energy, Environment and Engineering, Zambia (CEEZ)	Telephone interview, April 8, 2011
Emmanuel Katepa	Copperbelt Energy Corporation, renewables division, Zambia	Telephone interview, April 19, 2011
Alison Chikova	Chief Engineer and acting Coordination Centre Manager, Southern African Power Pool (SAPP), Zimbabwe	Telephone interview April 15, 2011 Telephone interview, April 20, 2011
Thompson Sinkala	Retired professor, Zambia School of Mines. Author of “Mining and Environment in Africa” review for UNEP	Telephone interview, March 11, 2011
Chozi Lungu	Zambia School of Mines	Telephone interview, April 18, 2011