

Chapter 1 : Introduction

1.1 Electricity demand in South Africa

The South African electricity market is constantly changing whilst the supply provided remains unstable. Approximately 95% of the electricity consumed in the country is supplied by Eskom, being the largest South African electricity utility. Eskom has rolled out several initiatives and key plans to ensure constant supply after a significant supply shortage experienced in 2008. The supply shortage resulted in Eskom forcefully restricting supply to certain areas at certain periods, otherwise known as load shedding.

During 2012, Eskom was again facing scenarios where the demand could exceed the supply and there have been predictions that load shedding may take place again at regular intervals due to necessary but unplanned maintenance [1]. While the internationally accepted electricity reserve margin is 15% [2], in 2013 little or no capacity was available during evening peak periods, as illustrated in the reserve margin report in Appendix A.

To reduce the energy gap, Eskom started with the building of two major power stations (Medupi and Kusile) whilst recommissioning old inoperative power stations. Eskom will have spent more than R340-billion on this additional electricity generation capacity [3]. The predicted completion date for Medupi is 2015 whilst the completion date for Kusile is 2017. Both coal power stations will each add an additional 4800 MW to the grid. However, there have been project delays on both power plants, thus reducing the projected reserve margin even further with the continual growing demand [4]. The additional capacity that is to be added compared to the increasing yearly capacity gap (difference between supply and demand) is illustrated in Figure 1.1.

To help Eskom during winter months when the electrical demand is higher, large customers were partaking in voluntary load shedding. In 2012, Xstrata stated that they would help Eskom by shutting off five furnaces, while Eskom in return paid an incentive to Xstrata for the reduced electrical load. Running the Xstrata furnaces could have forced the electricity supply grid into problems, resulting in production losses at other Xstrata plants [5]. From the top 140 electricity consumers that consumes more than 40% of South Africa's supplied electricity, the smelters consume more than 40% [6].

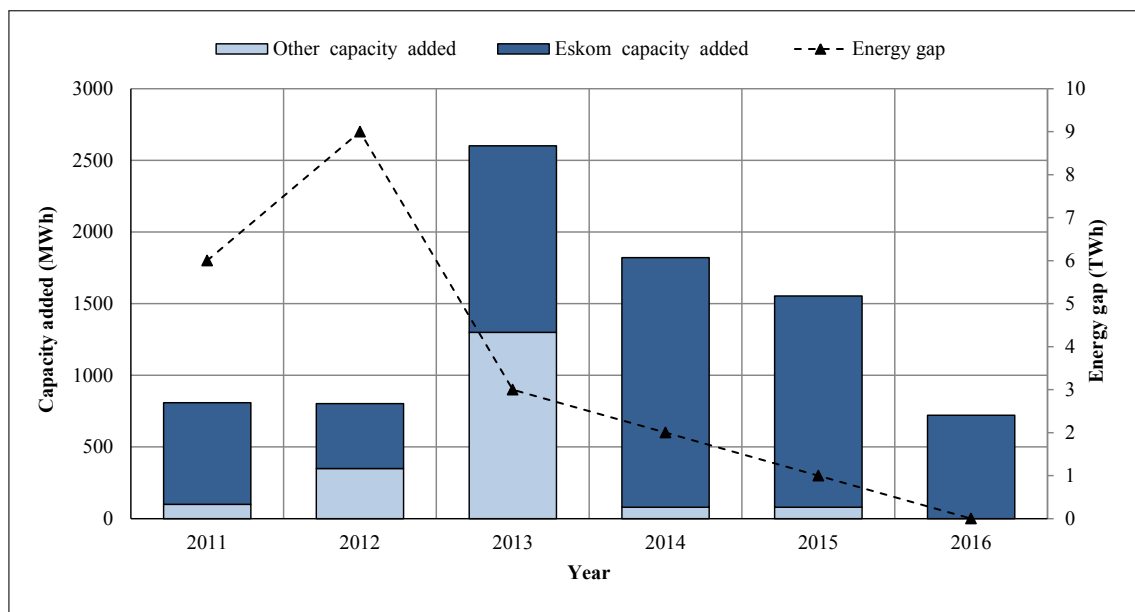


Figure 1.1: Eskom capacity added and projected energy gap [7].

In 2012 Eskom projected a 17 GW additional electricity-generating capacity that would be added to the national grid by 2018/19 [7]. From Figure 1.1 it can be noted that there is a large supply shortage and that strict management or mitigation strategies should be in place to ensure that all the industrial consumers and general public can receive electricity during the winter months.

In the period during which additional power stations are being built, the country's constant supply of electricity is dependent on large consumers not ramping up their production or Eskom having unplanned maintenance [7]. The projected end date of all buy backs or agreements with large customers was 31 May 2012 resulting in an uncertain supply future for large electricity consuming industries.

In 2013 Eskom has performed a great task in allocating resources and ensuring that forced national load shedding did not happen. However, because of these uncertainties of future supply and tariff charges, large electricity consumers must have a strategic plan in place for possible supply changes in the future.

1.2 Mitigation strategies

Eskom has two main strategies, firstly providing additional power to the grid by building new power stations and recommissioning old power stations. Secondly, reducing the demand by controlling the electrical load of the consumer according to the supply capability.

To mitigate generational or supply problems, Eskom established the Integrated Demand Management (IDM) programme. The main objective defined by Eskom for IDM is to improve efficiency. This can be done by reducing the average costs of generating electricity and better utilisation of current resources. IDM consists of a series of Demand Side Management (DSM) programmes which include Energy Efficient DSM (EEDSM), Demand Response (DR) and the Energy Conservation Scheme (ECS). IDM has reduced the peak demand by 3000 MW in 2011/12 as illustrated in Figure 1.2 [7].

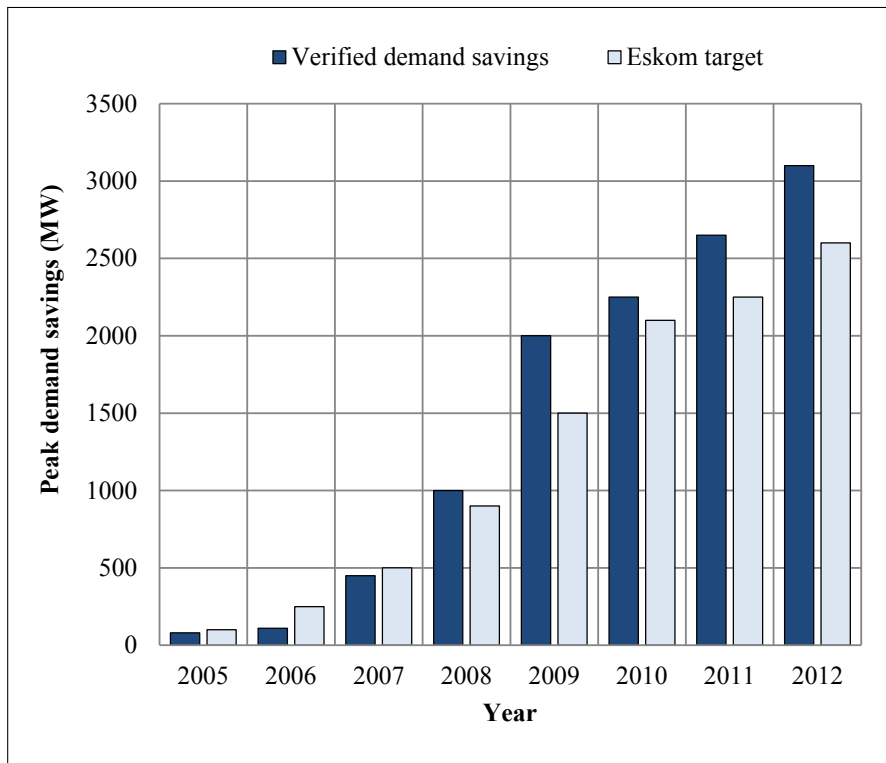


Figure 1.2: Verified accumulated savings and annual targets [7].

Examples of EEDSM include load management and electricity efficiency projects. The DR programme entails customers partaking in voluntarily load reduction when requested from the system operator. Customers who participate are remunerated according to the load which was reduced and the load reduction period.

The Energy Conservation Scheme (ECS), if passed into law, will set a 10% electricity reduction target for the country's 500 largest electricity users, with penalty charges imposed for non-compliance. Eskom has already implemented a voluntary ECS and is engaging with the South African local government and municipalities to help their customers implement energy conservation measures [7].

It is crucial that DSM funds be made available by the National Energy Regulator of South Africa (NERSA) for future DSM projects [8]. DSM funding will not only enable the implementation of energy efficient projects, it will also fund electricity-generating projects.

1.3 Electricity cost risks

Electricity costs for South African industries have increased by 178% from 2007 until 2012. In 2013 Eskom requested a yearly 15% price increase until 2017 to fund the new generational capacity and network upgrades, but only 8% was awarded. Electricity costs in South Africa are fairly low when compared internationally and so consumers could face larger price increases in the future [3]. It was also noted that price increases are preferable to electricity rationing, assuming that if the price for electricity increases, the demand will decrease. It was shown that a price increase of 72% may induce an unrationed 10% reduction [9].

It is uncertain how the electricity price increases will be absorbed by consumers and what the economic impact will be. For the manufacturing industry, the customer is faced with two choices: either increasing the cost of the product or investing in the energy efficiency projects to continue production with optimal electrical consumption.

One study performed when the predicted price hikes were announced concluded that the price of electricity was not the only influence in consumption behaviour but commodity prices also had a major influence, especially for the mining industry [10]. Evidence was also presented that the mandatory and voluntary load reductions impacted the load profiles of the analysed mining sectors or mines. It has been proven that large consumers such as the mining industry will change their consumption behaviour if the electricity price increases [10].

The electricity price increase of the past 15 years and potential next four years is illustrated in Figure 1.3. From Figure 1.3 it is clear that the future above-inflation price increases poses a financial risk for large electricity consumers providing motivation for investment in mitigation strategies.

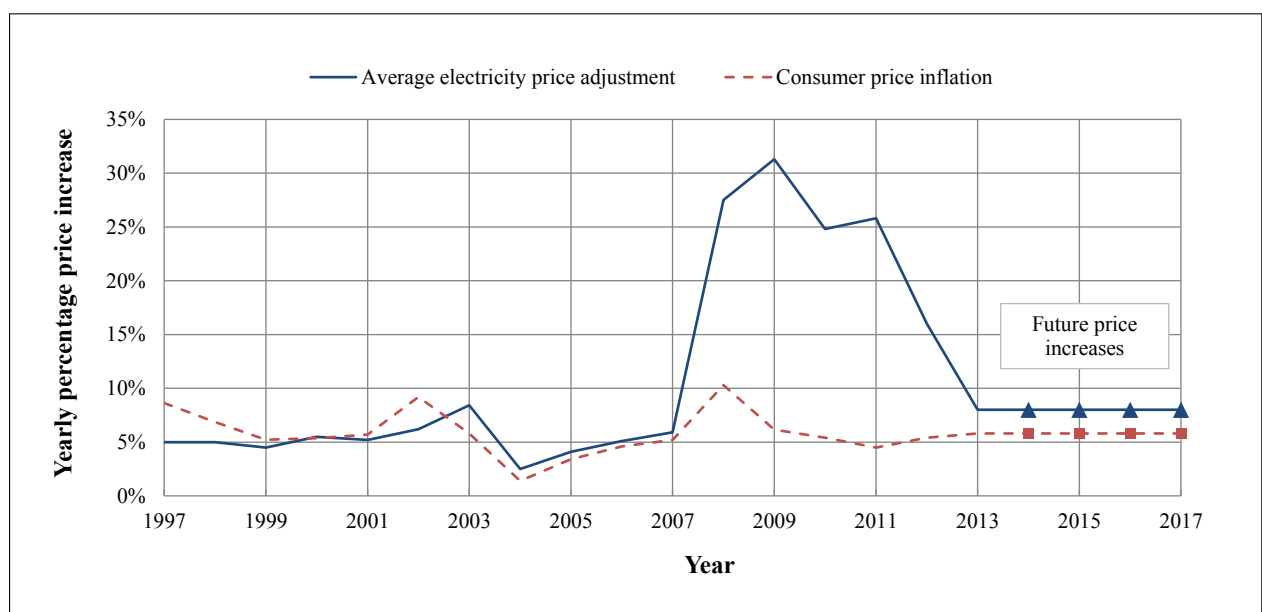


Figure 1.3: The average tariff increase for the past fifteen years with predicted increases for the next four years [11].

Climate change is a global concern and it requires that every contributing sector should invest in efforts to reduce greenhouse gases (GHG). South Africa is ranked as one of the top 20 non-Annex I developing countries according to the Kyoto Protocol [12]. There is an overwhelming amount of evidence linking human-induced atmospheric concentrations of GHG emissions and the rising global temperatures [13].

South Africa announced in 2009 at the Copenhagen climate change negotiations that it would reduce domestic GHG emissions by 34% by 2020 and 42% by 2025. It has been recommended that market-based instruments such as carbon tax be used to induce behavioural changes that result in lower GHG emissions, with feasibility proven in Europe [14], [15]. Countries such as Finland, Sweden, Denmark and the Netherlands as well as the United Kingdom have reviewed existing energy taxes to focus on carbon content.

In July 2009 South Africa also took a step in the green direction by introducing an electricity levy of 2 c/kWh on electricity generated from non-renewable sources. The carbon tax White Paper draft was released in May 2013 for public comment. The latest update was a proposed carbon tax of R120 per tonne carbon dioxide (CO₂) equivalent. This could result in a estimated additional price increase of 6%.

The ECS should be activated during a time of crisis and it would act as a safety net, enforcing high electricity cost rates with a 10% mandatory load reduction against a 2007 baseline [16] [17]. From the present situation with the low reserve margin, the possibility of applying the ECS during a supply or emergency incident remains high. About 140 of Eskom's top 500 electricity customers have signed up for a voluntary load reduction and have achieved a load reduction of 5% against their baseline.

However, the top 250 customers have only achieved a 1% load reduction from a defined 2007 baseline. Unplanned power cuts are damaging due to the related uncertainty and impacts on production targets [9]. The ECS has not yet been activated but remains a great concern due to the present load restrictions.

The abovementioned electricity cost risks with the available mitigating strategies or funding mechanisms will be discussed in Chapter 2.

1.4 Implications faced by the gold mining industry

It becomes evident that all industries are facing a future that could entail many electricity cost risks. The gold mining industry is one of South Africa's crucial contributors to the economy. South Africa was the top gold producing country in the world in 2006 and fifth in 2012 [18]. The mining industry is one of the largest electricity consuming sectors in South Africa, consuming an estimated 14% as illustrated in Figure 1.4 [7].

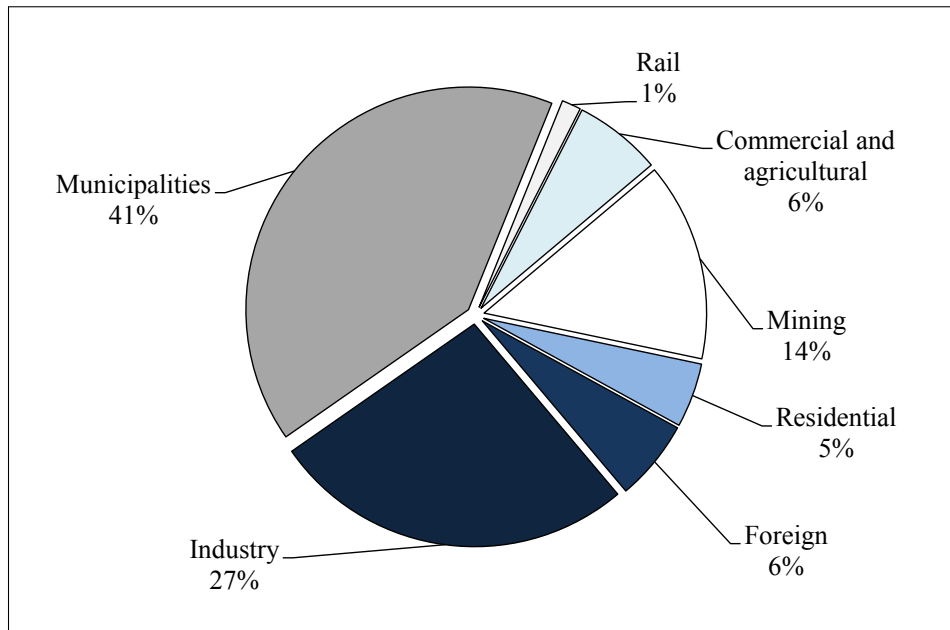


Figure 1.4: Breakdown of annual electricity purchases for the large electricity consumers at Eskom 2012 [7].

In the past, electricity costs were not a major concern for the mines, as Eskom was at a stage the world's cheapest producer of electricity [19]. Compared to other countries such as Canada, Australia and United States, South African gold mines have the highest production costs in terms of energy [20]. The predicted price increases and the proposed carbon tax will increase the operational costs even more. Other risks faced by the gold mining industry include labour, safety factors and the highly volatile nature of the gold price.

The Harmony gold mining group stated that the electricity cost risks are affecting future electricity-intensive gold projects and making investing into other countries more attractive [21]. The electricity price increases is one of the main reasons for operating costs increasing [21]. The electricity costs related with direct operating costs for a South African gold mining company (Sibanye) is illustrated in Figure 1.5. The calculations indicated that the initial price increase of 16% would have resulted in the electricity cost as part of the total mining cost, to increase by 8% from 2012 to 2017.

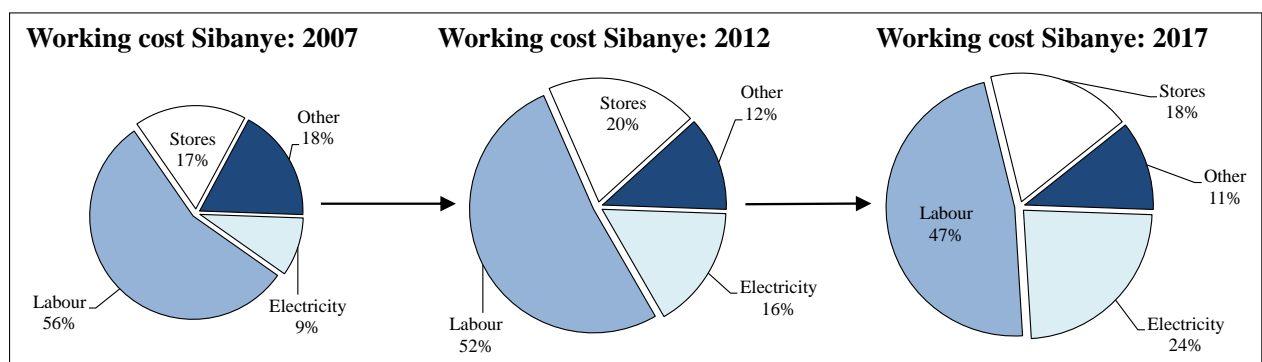


Figure 1.5: Mining cost increase for the South African mining company Sibanye [22].

Concerns have been raised by the Chamber of Mines that the mining industry would be further damaged if they would not be excluded from carbon tax. The increased cost will result in other countries such as Columbia being more attractive to investment due to mining taxes not being imposed there [23]. The South African mines were designed for low electricity costs. An example is the usage of mining equipment such as compressed air rock drills, which are practically very sufficient but also energy inefficient. Replacing this equipment will result in massive capital costs that could have been used for development.

Mines located at the upper end of the cost curve will be forced to close or to restructure with negative employment and production [24]. Electricity is vital for underground activities and services, such as those provided by high electrical consuming equipment such as ventilation and refrigeration, to provide a sustainable and safe environment.

Electricity costs comprised a significant 11% of cash operating costs and this will double in three years to 20% [24]. All of these unwanted costs will limit possible development and growth if electricity is not well managed.

1.5 Research objectives

From the abovementioned sections it is evident that the South African gold mining industry is faced with electricity cost risks related to Eskom's third proposed Multi Year Price Determination (MYPD3), carbon tax and the ECS. The combined effect of these three risks poses a threat to the financial well-being of the gold mining industry and could be the final motivation for closing down low-profit mines.

The first goal of this study is to determine the cost risk or price increase for each proposed electricity charge. The second is determining the potential to mitigate the identified risks. This would provide insight in electricity usage and the potential for future gold mining development in South Africa.

To quantify the possible electricity cost implication faced by the South African gold mining industry, the production and electricity usage of a selected gold mining company in South Africa was analysed to determine the possible impact.

A simplified approach must be derived in order for mine personnel to quantify the cost risk with possible mitigation in relation to the expected annual price increases. Benchmarking will be used to identify possible opportunities and to quantify the possible reduction of electricity with available technologies.

The results of the study could be used by other gold mines in South Africa, providing guidelines and simplified methods in quantifying the possible outcomes of the reviewed cost risks and mitigation strategies.

1.6 Contributions of this study

Simplified cost risk quantification model

The Regulator and Eskom have published rules for the related electricity prices of the identified schemes and tariffs. These rules are, however, circumstantial resulting in a complicated approach to calculate the resultant price increase. Risk modelling has been performed on South African gold mines but they only included production, grade, capital and operational cost [25]. Bolt provided insight in funding mechanisms that could be used to mitigate electricity costs and the impact of the proposed carbon tax [13], [26]. The study only focused on CDM and DSM funding mechanisms to fund new projects, the impact of other electricity cost risks were not quantified.

Pelzer and Kleingeld investigated potential costs related to the proposed ECS but did not investigate ECS-specific mitigation or strategies [27]. No study was found providing a simplified combined electricity cost risk and mitigation strategy for the South African gold mining industry. The contributions in relation to cost risk quantification can therefore be summarised by the following:

- A simplified quantification model was derived for the expected price increases of the ECS, carbon tax and predicted tariff increases. Related mitigation strategies for these cost risks were reviewed and developed for a selected South African gold mining company.
- The combined cost risk that could be expected by the selected gold mining company was quantified and illustrated with risk scenarios.
- Available DSM funding mechanisms were compared providing the selected mining company insight into future electricity savings investments.
- The developed risk model quantifying potential cost increases can be used by any other large electricity consuming industries.
- The study of cost risks significantly increases the industrial awareness of the modelling benefits presented.

Analysis of benchmarked power usage for main services of a gold mining company

Benchmarking provides a starting point to identify possible mitigation. Previous work on benchmarking has been performed on several industries, providing standardised measurement and promoting energy efficiency [28]. However, with the benchmarking no mitigation strategies are provided for the listed benchmarked industries.

Tshisekedi performed benchmarking on other South African mines but was limited to one year's production and electricity consumption comparisons to identify abnormal consumption [29]. Also no derived mitigation strategy was determined to reduce identified abnormal consumption. The contributions in relation to benchmarked analysis can be summarised by the following:

- The developed benchmarked items can be used by the selected mining company to manage and implement the identified DSM projects. The benchmarked results can be used for further studies on other South African gold mines.
- Benchmarking was used to provide useful insight in the main electricity consuming services and can also be used to provide standards for mining practices in the future.
- To ensure correct identification of possible improvement, eight selected mines were uniquely categorised according to their electricity influencing characteristics.
- This study illustrated that annual production and electricity benchmarking can be used to identify potential DSM projects. Monthly benchmarking was incorporated for this study and provided a higher resolution and insight into predicting performance improvement and managing electricity.
- The benchmarking approach is unique in categorising the mines according to the risks and electricity influencing factors resulting in the identification of mines with potential electricity reduction.

Simplified main services electricity reduction methodology

Some electricity savings initiatives only focus on a single mine or component, where additional benefits can be obtained by managing electricity usage for a group of mines or a company. Studies on successful individual electricity savings strategies on selected services or mines have been performed. These studies include mitigation strategies on mine services such as pumping [30–32], compressed air [33–35] and refrigeration [36–38]. These studies provide insight in available technologies or strategies and not the impact or the improvement of the other large services.

No studies have been found on the combined mitigation effect of the selected services on a gold mine that were verified with proven case studies. There is also not a clear guide as to what service of a mine to focus on and on which mine to first implement the strategies if managing the electricity usage of a group of mines. The contributions in relation to main services electricity reduction, can be summarised by the following:

- Proposed mitigation strategies were derived for the main electricity consuming services to minimise the penalties associated with possible future imposed risks.
- The derived methodologies can be used by personnel on the mine to quantify and identify possible electricity cost savings projects.
- Unique models were developed to assess the potential efficiency improvement of the main electricity consuming services related to production.
- Individual DSM components were integrated for the gold mining company's installed capacity and electricity usage. Case studies of the applied methodology on selected mines of the gold mining company were reviewed.

Development of a reporting and risk management system

Energy Management Systems (EMS) have been implemented on several industries [39]. A study has been presented with savings of 25% resulting from an implemented energy management system [40]. The case study was for the manufacturing industry with the presented specific consumption reduction strategies not being applicable to the mining industry. There is also very limited information regarding the implementation of a EMS on a South African gold mining company.

There are studies available which provide guidelines for the development of an EMS specifically for industries [41–43]. However, the information provided is general and acts as a guideline; no specific modelling equations are provided to quantify electricity reduction for certain electricity consuming loads or services on a gold mine.

The available commercial packages require instrumentation and specialised software [44] [45]. Presently no EMS provides the functionality of reporting on electricity cost risk for South African industries. No study was found on the development of an EMS or methodology for the gold mining industry in South Africa. The contributions in relation to the development of a reporting and risk management system can be summarised by the following:

- With easily accessible data, the electricity consumption in South African gold mines can now be prioritised according to efficiencies. Now that electricity costs have increased, guidelines and best practices are needed that could identify system inefficiencies.

- Electricity management systems are commercially available but do not provide the capability of managing multiple mines or sites to mitigate the combined cost risks. By using the developed risk model, reporting method and management strategy, savings can be identified and generated, without the need of additional infrastructure.
- The reporting structure, developed risk mitigation and benchmarking analysis was incorporated into the development of an ISO 50001 EMS. The derived reporting and EMS can be applied to other mining practices such as platinum mining to quantify and reduce electricity cost risks.
- The derived electricity cost risk management and reporting system was implemented on a selected gold mining company in South Africa. The reporting system was uniquely developed to provide specific reports to individuals depending on their area of work and responsibility.
- The developed methodology can be incorporated without any additional software and conveys the key fundamental mitigation strategy and focus areas.

1.7 Brief overview of this thesis

The research approach and sequence of the study is illustrated in Figure 1.6, which indicates the process phases in the development of the quantified risks and findings.

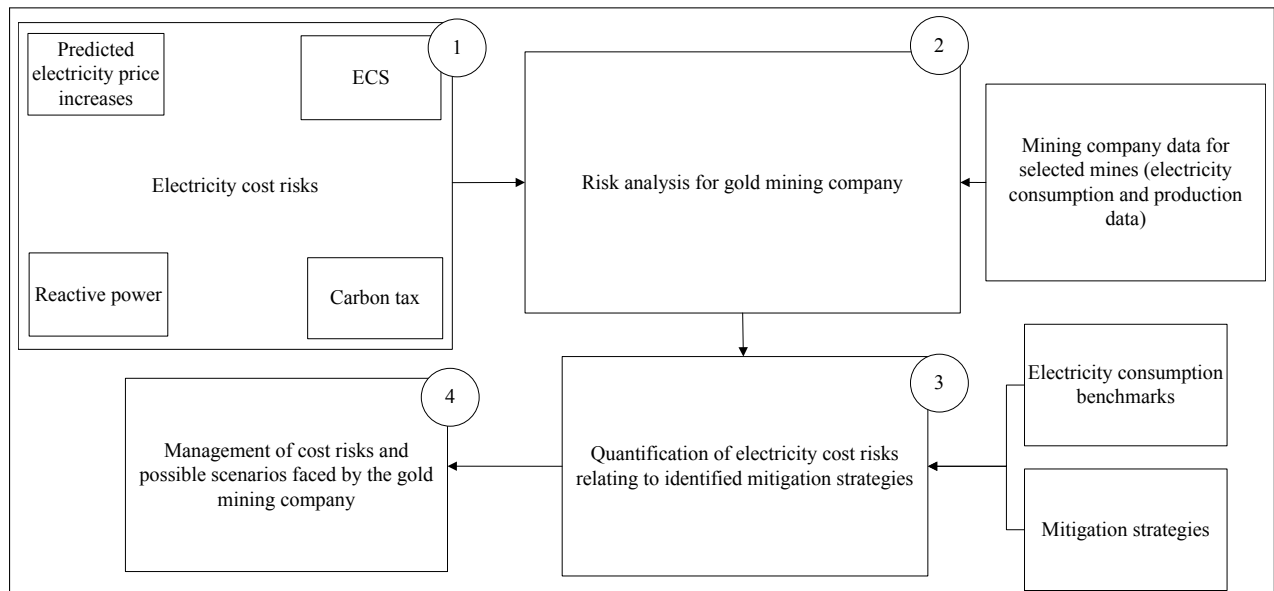


Figure 1.6: The analysis of electricity cost risks for the South African gold mining industry.

Chapter 1 provides a short overview of potential electricity risks for the gold mining industry accompanied with the problem statement and research objectives.

Chapter 2 provides a detailed discussion about the possible cost risks and the related available mitigation strategies. Each risk is quantified in terms of the possible annual price increase.

Chapter 3 provides a benchmark methodology which was used to quantify and identify possible mitigation strategies. Three major electricity consuming services with the applicable mitigation strategies will be discussed, providing case studies with a simplified quantification and mitigation methodology.

Chapter 4 reviews the implemented system to communicate and review quantified risks. Actual production data and reports for the mining company were reviewed.

Chapter 5 gives the findings and recommendations for future work.

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