

EXAMINING ELECTRICITY CONSUMPTION PATTERNS BY THE MINING SECTOR

IN NAMIBIA BETWEEN 2003 -2013

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## ABSTRACT

Energy is an essential component of a developing economy such as that of Namibia. The affordability, availability and security of energy supply are indispensable to economic development on many facets. This study focused on electricity consumption patterns by the mining sector in Namibia by examining variations of annual production output, electricity consumption, electricity per unit output of production, and electricity tariffs of Gold, Uranium and SHG (Special High Grade) Zinc in Namibia between 2003 and 2013. The research also aimed to examine relationships between mining production output, electricity consumption, and electricity tariffs of Gold, Uranium and SHG Zinc.

Main findings indicate that: Gold mining scatter plots of electricity consumption against production output revealed a negative correlation; Uranium mining scatter plots of electricity consumption against production output revealed a positive correlation; and lastly SHG Zinc scatter plots of electricity consumption against production output revealed a positive correlation. It could thus be recommended that onsite energy audits be conducted as a means of assessing the underlying causes of the observed trends particularly the increase in electricity consumption accompanied by a decrease in overall production for gold mining. It could also be advisable for Uranium and SHG mining to visit the option of energy audits within their operations as a means to possibly curb possible excess electricity consumption.

Electricity tariffs for mines in Namibia have increased with 700% between 2003 and 2013. It could thus be recommended to the ECB to revisit their tariff design for the mining sector in particular so as to not harm this industry. The study has also revealed that there has been a positive correlation between electricity tariffs and electricity consumption of gold, uranium and SHG Zinc mining in Namibia between 2003 and 2013 due to the fact that, "electricity demand in Namibia is price inelastic but income elastic" (Ziramba & Kavezeri, 2012, p.6).

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## ACRONYMS

ECB	Electricity Control Board of Namibia
EDM	Electricidade de Mozambique
ESKOM	Electricity Supply Commission of South Africa
GDP	Gross Domestic Product
GWh	Giga Watt hour
kWh	Kilo Watt hour
MW	Mega Watt
Nampower	Namibia Power Corporation
ppm	Parts per million
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SHG	Special High Grade
SWAVEK	South West Africa Water and Electricity Corporation
TWh	Tera Watt hour
USD	United States of America Dollar
ZESA	Zimbabwe Electricity Supply Authority
ZESCO	Zambia Electricity Supply Company

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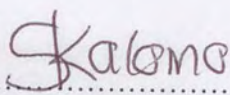
Last but not least, I thank my partner Di-anne Harases, my mother Olga Kalomo as well as my close relatives and friends for their love and support and for always being by my side, I shall remain forever grateful.

## DECLARATION

I, Shapua Kalomo, declare hereby that this study is a true reflection of my own research, and that this work, or part thereof has not been submitted for a degree in any other institution of higher education.

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Date: 28 November 2014

[Shapua Kalomo]

## **1. Chapter 1: Introduction**

The following chapter will introduce and discuss the milieu of the research under the following themes: orientation of the study, problem statement, objectives, significance of study and lastly, limitations of study.

### **1.1 Orientation of the study**

The mining industry in Namibia accounts for a large portion of the country's GDP (gross domestic product) and contributes significantly towards state revenues (Chamber of Mines of Namibia Annual Review, 2012, p.95). Some of Namibia's key mineral resources include Diamonds, Lead, SHG (Special High Grade) Zinc, Gold and Uranium.

Namibia is currently unable to solely provide for its own electricity needs domestically, hence imports more than half of its electricity from neighbouring countries. During 2012 Namibia's electricity supply mix consisted of; regional imports of 55.55% from ZESA (Zimbabwe Electricity Supply Authority), ZESCO (Zambia Electricity Supply Company) and ESKOM (Electricity Supply Commission of South Africa): and domestic production from Ruacana (43.5%), Anixas (0.38%), Paratus (0.04%) and Van Eck (0.59%) power stations (Namibia Power Corporation [NamPower], 2012, p.24).

It has been established that mining and mineral industries worldwide use between 4-7% of global energy (Rebago, Lovins, & Feiler, 2002, p.4). Mining industries have generally been known to use large amounts of electricity for their operations, especially metal and oxide ores (Rebago, et. al, 2002, p.6). A Namibian example of this is that in 2010, Namibia's total electricity consumption stood at 3.91 TWh, of which 0.69 TWh was spent by the Scorpion

Zinc Mine alone, this represents 17.65% of the national total electricity consumption (VO Consulting, 2012, p. 30).

Through the Electricity Act 4 of 2007, price regulation of electricity in Namibia was introduced through the establishment of the Electricity Control Board (ECB) in the year 2003. Since then, all electricity supply and distribution institutions that provide electricity to end users needed to receive approval on their proposed tariffs by the ECB every year (Schmidt, 2009, p.8). According VO Consulting (2012, p.12), "Rapidly rising electricity prices will negatively affect enterprises that use electrical energy for productive purposes. This is set to lead to a negative impact on the commercial, mining, industrial and manufacturing sectors." Furthermore, Namibia is said to have among the highest electricity prices in SADC (Southern African Development Community) (Sherebourne, p.162, 2009).

In order to reduce negative impacts and safe guard the overall economic contribution and foreign exchange earnings of the mining sector of Namibia, a steady-secure and reasonably priced supply of electricity is essential to the functioning of the sector. It thus becomes substantially important to understand the dynamics at play between production, electricity consumption & tariffs of the mining sector.

This comes at a time when Namibia relies heavily on questionable regional electricity imports while mines require larger amounts of electricity and three new large mines are to become operational by 2015 (Tschudi (Copper), Oshikoto (Gold), Husab (Uranium)). Namibia's largest regional electricity supplier, ESKOM, cannot be relied upon due to the evident difficulties that institution faces with meeting the needs of South Africa as severe blackouts have been experienced in that country, negatively affecting both domestic and industrial users (Iglesii, 2010, p.1).

## 1.2 Statement of the problem

Mining industries require large amounts of electricity for production (Rebago, et. al, 2002, p.6). In Namibia, electricity tariffs have been on the increase over recent years, double-digit increases in most instances (VO Consulting, 2012, p.16). Of great concern is the current status and condition of the Electricity Supply Industry of Namibia. Regional imports make up a large percentage of the total electricity consumption in Namibia, particularly imports from the vulnerable South African power utility, ESKOM. High electricity price increases in combination with a vulnerable national electricity supply could negatively affect the Namibian mining industry that contributes significantly towards the economy as well as foreign exchange revenue earnings of Namibia amongst others (De Vita, Endersen, & Hunt, 2006, p.4). Thus, there is a need for an investigation into the dynamics of the variations and possible relationships between mining production output, electricity tariffs, and electricity consumption within the Namibian mining sector. Such information could be used in the proactive management of the Electricity Supply Industry of Namibia, for the mining sector and other large industries in particular. Sherebourne (2009, p.222) mentions that, “most official [Namibian] government documents such as the Energy White Paper and National Development Plans steered clear of electricity self-sufficiency as an explicit policy goal”, thus research of this kind could act as a motivation to policy makers to urgently address Namibia’s energy self-sufficiency short-comings.

### **1.3 Objectives of the study**

The objectives of the proposed research study were to examine the following:

- Variations of: annual mining production output, electricity consumption, electricity consumption per unit output production, and electricity tariffs, of Gold, Uranium and SHG (Special High Grade) Zinc in Namibia between 2003 and 2013.
- Relationships between mining production output, electricity consumption, and electricity tariffs of Gold, Uranium and SHG Zinc in Namibia between 2003 and 2013.

### **1.4 Significance of the study**

The study is of great significance because; reduced costs of electricity to mines can help improve productivity and profitability of these mines. Increased profitability could further enhance the contributions of these mines towards the economy of Namibia and boost investor confidence. The security of electricity supply in Namibia is vulnerable due the fact that Namibia imports more electricity than it produces, and these imports originate from countries that face challenges in meeting their own electricity needs as possibilities of load shedding and black-outs remain eminent and these countries may want to shy away from long-term electricity supply agreements with Namibia in future, for example ESKOM of South Africa (Inglesi, 2010).

Namibia will have three large mines opening in 2015 and this study could serve as a motivation for a more proactive management approaches as well as a strong motivation for Namibia to secure more domestic electricity supply for its growing industries and population.

Mining companies and host countries view mining differently in this stance: the mining company would want to invest in the harvesting of mineral resources in countries with a good secure supply of affordable electricity in order to generate maximum profits, the host country on the other hand would like to see more gains for the society it serves in terms of employment, taxes and royalties from their finite mineral resources. According to the Chamber of Mines of Namibia (2012, p.56), the mining industry contributed the following to the Namibian economy in 2012: 11.5% towards the GDP of the country: N\$ 18. 52 billion in total revenue generated; 7 898 total permanent employees; more than N\$ 2.93 billion in salaries, and lastly N\$ 2.65 billion was paid to the Namibian government in taxes.

### **1.5 Limitations of the study**

A limitation attributed with the study is the amount of time that was made available towards its completion, for this reason, the study could not accommodate all the mineral commodities in Namibia and thus only focused on: Gold, Uranium (excluding Langer Heinrich) and SHG Zinc. However, this limitation could serve as a platform for further study and research by others. Langer Heinrich Mine has been excluded because attempts to retrieve the necessary information proved fruitless.

## **2. Chapter 2: Literature Review**

The following chapter shall deal with background information regarding the Namibian mining and electricity supply sectors, relevant applicable national policies and legislature, institutional role players as well as existing gaps in knowledge.

### **2.1 The Mining Sector in Namibia**

#### **2.1.1 Background Information on the Namibian mining industry**

According to the World Bank (2009, p.8) the Namibian economy relies heavily on the extraction and processing of mineral resources. However, the GDP contribution of the mining sector in Namibia has almost halved since the country gained independence in 1990 from 18% to 9.3% in 2013. Even though a substantial decline in GDP contribution has been observed over more than two decades, the mining sector firmly remains the highest foreign exchange earner for Namibia as well as a significant contributor to GDP (World Bank, 2009, p.8).

Since the 1920's, over 50 mines have closed in Namibia, due to various reasons such as mineral exhaustion and lack of profitability (Mendhelson et. al., 2002). According to the Chamber of Mines Annual Review (2013, p.3), in the year 2013, 9 large mines were in production (excluding the complexes of smaller mines at Namdeb as well as other smaller mines with lesser GDP contribution), with 3 others under construction and nearing completion for the most part, namely: Husab Mine (Uranium), Otjikoto (Gold), Tschundi (Copper).

Due to the electricity intensive nature of mining operations of mineral resources extracted from oxide ores, the following study primarily focused on variations and relationships, as set out in the objectives of this research, on only three mineral commodities in Namibia, namely: Gold, Uranium and SHG Zinc (Rebago, et. al, 2002, p.6) (Jochens, 1980). It would have been ideal, and it would have been logical to also include Copper into this research study; however, current available data on copper mining in Namibia is very fragmented, unreliable and incomplete as Copper mining has been plagued by such mines constantly closing, re-opening and changing ownership several times due to poor as well as fluctuating commodity prices and economic conditions in recent times.

### **2.1.2 Namibian Mining Policies and Legislature**

The mining sector in Namibia is mainly regulated and governed by three key pieces of legislature, namely; the Minerals (Prospecting & Mining) Act of 1992, which took effect on 4 April 1994, the Minerals Policy of 2003 approved in March 2003, and lastly the Diamond Act of 1999.

The Minerals (Prospecting & Mining) Act of 1992 was established in order “To provide for the reconnaissance, prospecting, mining for and disposal of, and the exercise of control over, minerals in Namibia; and to provide for matters incidental thereto”.

The vision of the Minerals policy of Namibia is “to achieve a high level of responsible development of natural resources in which Namibia becomes a significant producer of mineral products while ensuring maximum sustainable contribution to the socio-economic development of the country”. The Minerals Policy further affirms the Namibian government’s aims to attract investment, and create an enabling environment for the private

sector within mineral exploration, extraction, beneficiation and the marketing of Namibian mineral resources.

The significant contribution of the gem quality diamonds to the Namibian economy necessitated the need for much greater control over the diamond sector by the state. The Diamond Act of 1999 was thus established to “provide for the establishment of a board to be known as a Diamond Board of Namibia; To define the objects and the powers, duties and functions of the said board; to provide for the establishment of a fund to be known as the Diamond Valuation Fund; To provide for the management and control of the said funds; to provide for control measures in respect of the possession, the purchase, sale, processing, import, export of diamonds..”

The Ministry of Mines and Energy is the custodian of Namibia’s endowment of mineral resources as well as the executing body of the above mentioned Minerals (Prospecting & Mining) Act of 1992, Minerals Policy of 2003, and Diamond Act of 1999.

### **2.1.3 Gold Mining in Namibia**

The Navachab gold mine started production in 1989. The Mine is located in the Erongo Region approximately 170 km north-west of the capital of Namibia, Windhoek (Anglogold Ashanti Namibia, 2012). Navachab has been the only gold mine in Namibia for more than two decades until the ground breaking ceremony of the construction of the Otjikoto Gold Mine in early 2013. The Otjikoto gold mine will be located between the towns of Otavi and Otjiwarongo in the northern regions of Namibia. Once complete, Otjikoto would be the country’s second gold mine and is anticipated to resume production by 2014 (Chamber of Mines Annual Review, 2013, p.75). “Once production of the Otjikoto Mine is ramped up, Namibia is set to more than double current annual gold output” (Chamber of Mines Annual

Review, 2013, p.75). One unanswered question could stem of this; will the current electricity consumption figures of gold mining in Namibia also double with the anticipated increased annual national output of gold? Further study from this research could delve into that.

The Navachab gold mine operates a 120 00 metric t/month processing plant which consists of typical metallurgical processes such as; crushing, milling, carbon-in-pulp as well as electro-wining (Chamber of Mines Annual Review, 2005, p.49) .

By the end of 2013, Navachab mine produced 1795 kg of gold, and employed 847 people (permanent, temporary, expatriates as well as contractors) (Chamber of Mines of Annual Review, 2013, p.43). The Otjikoto mine construction however, employed a total of 712 employees by the end of 2013 (permanent, temporary, expatriates as well as contractors) (Chamber of Mines Annual review, 2013, p.2).

According to latest mine life estimates, Namibia could remain a gold producer until 2028 once the Otjikoto gold mine commences production in the first quarter of 2015 (Chamber of Mines Annual Review, 2013, p.2).

The two gold mines are at variance much in terms of the grades of their ore bodies, the Otjikoto mine is anticipated to have a grade of about 3.2 grams/t while the Navachab mine has grades much lower than 3 grams/t (Chamber of Mines Annual Review, 2013, p.35).

#### **2.1.4 Uranium Mining in Namibia**

The Namibian uranium mining industry is best appreciated by figure 3 bellow, as all of the discovered uranium deposits in Namibia that have been extensively prospected are found in the Erongo region of the central Namib desert.

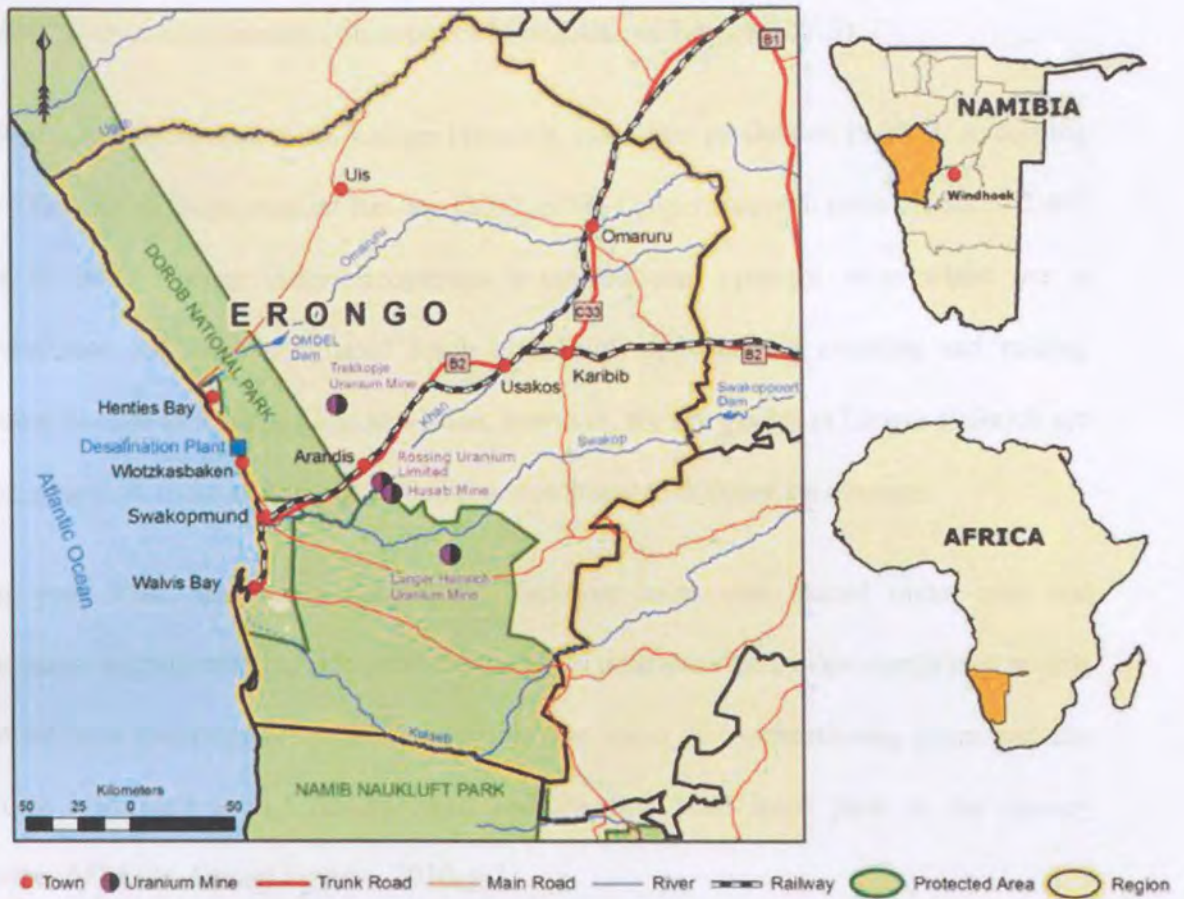


Figure 1: Illustration of the locations of various uranium mines in Namibia (Chamber of Mines Annual Review, 2014).

Uranium in Namibia was first discovered in 1928 in the central Namib Desert (Mendhelson, 2002). By the year 2007, Namibia was in the midst of a Uranium rush due to favourable Uranium spot prices, this was however short-lived due to the Fukushima Nuclear Reactor Meltdown in Japan 2011, as well as a decision by the Namibian government to impose a moratorium on Uranium exploration amidst environmental concerns (Chamber of Mines Annual Review, 2012).

Namibia's first uranium mine, Rössing, only commenced production in 1966 (Chamber of Mines Annual Review, 2005). Rössing is an open pit mine found 12 km outside the town of Arandis and 72 km from the coastal town of Swakopmund. By the year 2013, Rössing mine

had produced 125 862 tonnes of uranium in all of its years of existence, and had been in operation for over four decades (Chamber of Mines Annual Review, 2013).

Namibia's second uranium mine, Langer Heinrich, came into production in 2008. According to the Chamber of Mines Annual Review (2013, p.28) Langer Heinrich mine produced 2 469 tonnes in 2013. Langer Heinrich operates a conventional open-pit mine where ore is recovered and fed into an agitated leach plant with conventional crushing and milling processes, similar to Rossing Uranium Mine, however, the ore grades at Langer Heinrich are much higher than those at Rossing, 800ppm as compared to 300ppm on average.

In the year 2012, the newly constructed Trekopje mine was placed under care and maintenance without entering into production due to unfavourable market conditions, mostly due to the poor spot price of Uranium. Trekopje was under its commissioning phase and was set to be Namibia's third Uranium Mine and the first heap leach plant in the country (Chamber of Mines Annual Review, 2010, p.3).

Currently under construction is the Husab Mine owned by Swakop Uranium. Exploration test work on the Husab deposit has been extensive since 2008. Once operational, the Husab mine is anticipated to be the second largest uranium mine in the world, and is set to double the current annual uranium production output of Namibia (Chamber of Mines Annual Review, 2013, p.65). As similarly noted under 2.1.2 of this literature review, an interesting question to ponder for further research is whether the electricity consumption of Uranium mining in Namibia would double with the expected doubling of annual production output too.

#### **2.1.5 SHG Zinc Mining in Namibia**

Namibia currently has two Zinc mines; Scorpion Zinc mine and Rosh Pinah. Both mines are located in the town of Rosh Pinah in southern Namibia.

Scorpion Zinc is an open pit mine and commenced production in the year 2003. Scorpion Zinc Mine produces Special High Grade (SHG) Zinc of an exceptional quality for export to world markets. In the year 2013, the Scorpion Zinc mine had an output production of 124 924 tonnes (Chamber of Mines Annual Review, 2013, p. 55). The Scorpion Zinc Mine uses electro-winning within its refinery process, a procedure that is normally characterised by high electricity consumption (Jochens, 1980).

Unlike Scorpion Zinc mine, the Rosh Pinah mine is an underground mine and produces not only Zinc, but Lead as well. Rosh Pinah exports its Lead and Zinc in concentrates. The Rosh Pinah Lead and Zinc mine has been in production since 1969 (Chamber of Mines Annual Review, 2013, p. 55). Due to the dual nature of Rosh Pinah's output production, as well as the fact that their product is not pure, this study will only take the Scorpion Zinc Mine into consideration and shall exclude Rosh Pinah.

## **2.2 The Namibian Electricity Supply Industry**

### **2.2.1 Legislature Regarding Electricity in Namibia**

The electricity sector in Namibia is mainly governed by two key pieces of legislature, namely: the Electricity Act 4 of 2007 and the Energy Policy of 1998, the custodian of both of these is the Ministry of Mines and Energy of the Republic of Namibia.

The Energy Policy of 1998 has within it several goals discussed in six broad themes that include: effective governance, security of supply, social upliftment, investment and growth, economic competitiveness, efficiency, and lastly, sustainability. Despite the evident need, the Energy policy does not explicitly state electricity self-sufficiency as goal (Sherebourne, 2009, p.222).

The Electricity Act 4 of 2007 on the other hand was established in order “to establish the Electricity Control Board and provide for its powers and functions; to provide for the requirements and conditions for obtaining licences for the provision of electricity; to provide for the powers and obligations of licensees; and to provide for incidental matters.”

### 2.2.2 Structure of Namibian Electricity Supply industry

The electricity supply industry of Namibia is best appreciated in the figure below:

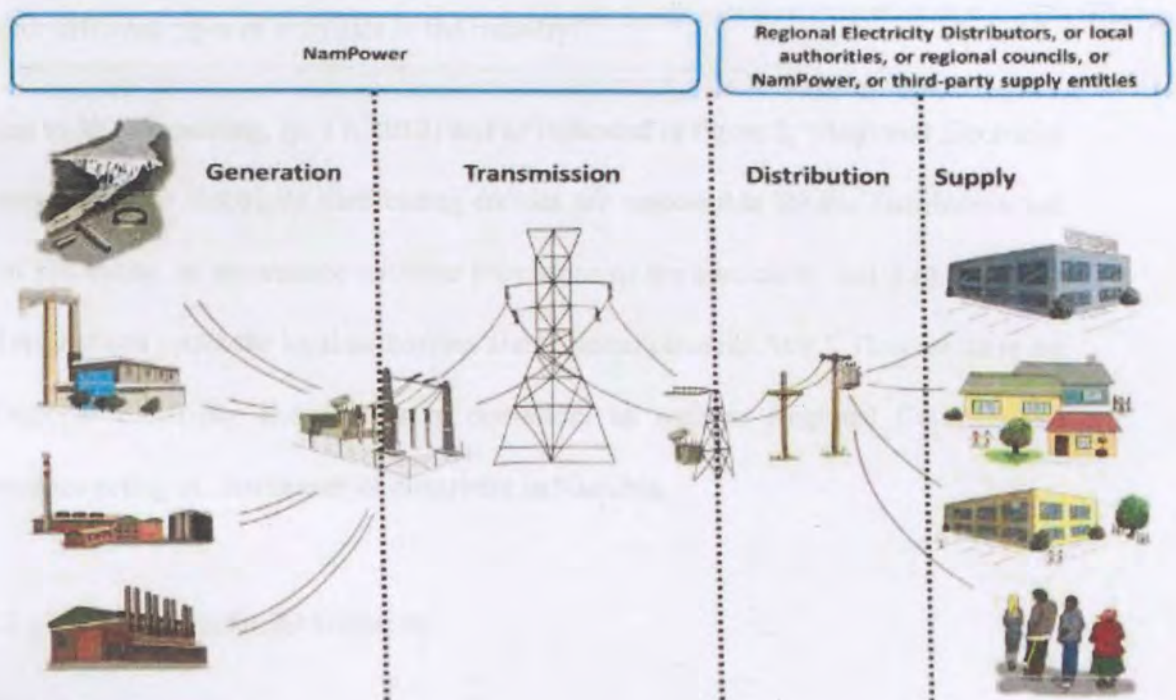


Figure 2; Illustration outlining the main role players within the Electricity Supply Industry of the Republic of Namibia. (VO Consulting, p.14, 2012)

Namibia gained independence from South Africa in 1990, after which NamPower was formed six years later in 1996 from the previous South West Africa Water and Electricity Corporation (SWAVEK). NamPower has ever since been the Namibian national power utility. Although NamPower is a registered company and operates under the Companies Act.,

it remains a wholly state owned parastatal accountable to Ministry of Mines and Energy of the Republic of Namibia (NamPower, 2013). The main purpose of NamPower is for the provision of electricity throughout Namibia, while being regulated by the Electricity Control Board of Namibia (ECB) as per the Electricity Act 4 of 2007. According to Ziramba & Kavezeri (p.203, 2010) the ECB is “a statutory regulatory body mandated to restructure the ESI in collaboration with the Ministry of Mines and Energy of the Republic of Namibia and other stakeholders in the industry. The responsibilities of the ECB include: inter alia, setting up the regulatory authority internally, implementing tariff methodologies and the issuing of licenses for different types of activities in the industry.”

According to VO Consulting, (p. 17, 2012) and as indicated in figure 2, “Regional Electricity distributors and other electricity distributing entities are responsible for the distribution and supply of electricity, in accordance with the provisions of the Electricity Act 4 of 2007 and residual regulations under the local authorities and regional councils Acts.” Thus far there are three Regional Electricity Distributors in operation, as well as Regional Councils and Municipalities acting as distributors of electricity in Namibia.

### **2.2.3 Installed Electricity Capacity**

Namibia’s domestic electricity supply originates predominantly from four power stations that feed into the grid. These Power stations include: Ruacana, Van Eck, Paratus and Anixas, as illustrated in Figure 1. Ruacana power plant is the largest power plant in Namibia with an installed capacity of 332 MW (Elombo et al. 2010). Ruacana power plant is hydroelectric and is built on the Ruacana waterfall in the far north eastern part of Namibia in the Kunene Region. Van Eck power plant is located on the outskirts of the capital of Namibia, Windhoek and is a coal-fired power plant. The Van Eck plant is the oldest power station in all of Namibia and has an installed capacity of 120 MW (Elombo, 2009). Anixas and Paratus

Power stations both use heavy fuel-oil and are both located in the harbour town of Walvis Bay, these stations have installed capacities of 22.5 MW and 24 MW respectively (VO, Consulting, p. 14-15, 2012).

#### 2.2.4 Regional Imports

Namibia imports a good majority of its total electricity demand from other Southern African countries through the Southern African Power Pool (SAPP), through the following utilities: ZESCO (Zambia), ZESA (Zimbabwe), ESKOM (South Africa) and lastly EDM (Electricidade de Mozambique) (Ziramba & Kavezeri, 2010, p.1).

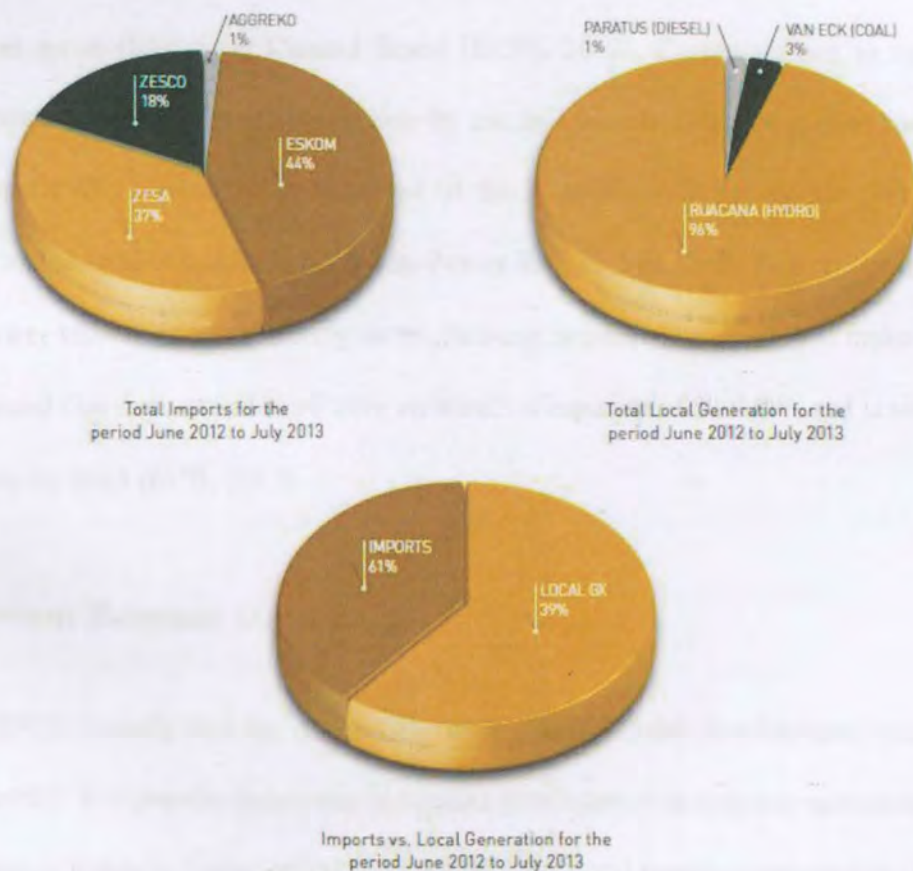


Figure 3: Pie Charts indicating: composition of total imports, local generation and import versus local generation of electricity in Namibia for the period June 2012 to 2013 (Namibia Power Corporation [NamPower], 2014, p.24).

As seen in figure 3 above, ESKOM is the largest supplier of imported electricity to Namibia, and has recently signed an extension supplemental agreement with NamPower that would take effect in March 2015, however, under this new agreement ESKOM reserves the right to terminate in the event that NamPower exceeds the allowable amount of import electricity and load shedding (NamPower, p.30, 2013). Furthermore, should South Africa meet load shedding, the new agreement would allow ESKOM to cut exports to Namibia (NamPower, p.30, 2013).

### **2.2.5 Future of the Namibian Electricity Supply Industry**

Namibia's annual electricity demand is estimated at 534 MW and believed to be growing at a rate of 4% per annum (Electricity Control Board [ECB], 2013). Current efforts to meet the growing demand for electricity will rely heavily on the establishment of a new base-load power station, for this reason the government of the Republic of Namibia has pledged its commitment to the establishment of the Kudu Power station. The Kudu Power Station is an envisaged power station that is currently in its planning phases. The plant will make use of the Kudu Natural Gas deposit and shall have an installed capacity of 800MW, and is expected to come online by 2018 (ECB, 2013).

## **2.3 Previous Relevant Studies.**

Rosenburg (1998) investigated the role of electricity in industrial development within the American context. It is popular belief that industrial development is certainly associated with increasing energy intensity (measured as the ratio between total energy consumption to GNP, Gross National Product). However, this has not been the case for America as energy intensity rose between 1880 and 1920, but has been on the decline there after. On the other hand, Inglesi (2009) conducted research on the aggregate electricity demand in South Africa and

conditional forecasts to 2030. Results indicated that there is a long run relationship between electricity consumption, price and economic growth (Inglesi, 2009).

In the Namibian experience, a study conducted by De Vita et. al. (2006) on the empirical analysis of energy demands in Namibia, it was discovered that energy consumption responds positively to changes in GDP and negatively to changes in energy price and air temperature. To bring these changes down to figures, Ziramba & Kavezeri (2012, p.6) found that a 10% increase in GDP will increase electricity consumption by about 11.2%, they also discovered that in Namibia electricity demand is price inelastic but income inelastic. A detailed assessment of the regulation within the electricity supply industry of Namibia by Eberhard & Kapika (2010) discovered that prices were yet to gradually transition towards cost reflectivity and thus the sustainability of the arrangements in the distribution of electricity in the country were found to be of an unsustainable nature on the long run.

When one considers the cost of electricity, in most instances the cost of providing the electricity comes to light as most electricity pricing regimes are geared towards cost reflectivity as mentioned above in the case of Namibia. In the African context, a study by Vennemo & Rosnes (2012) aimed at estimating the cost of providing electricity to the continent through a model that links several attributes of electricity, namely; demand, supply, generation, distribution and transmission between countries. It was discovered that the total net demand within the SAPP is expected to grow with more than a hundred TWh from 259 TWh in 2005 to 383 TWh in 2015 (Venemo & Rosnes, 2012). Furthermore, the study revealed that the SAPP would require an investment of 73.3 billion USD to improve electricity generation, transmission and distribution in the region (Venemo & Rosnes, 2012).

Estache et. al. (2008) conducted a study to examine the efficiency of African electricity companies by sampling the 12 operators in the 12 countries of the Southern African Power

Pool (SAPP) (which includes Namibia). The study revealed that these electricity companies have not made significant improvements in using capital and human resources between 1998 and 2005, but they have however improved in using better technologies and commercial practices, over the same period. Pollitt & Stern (2002) on the other hand found strong evidence that there are “significant human resource constraints which limit the scale and, hence the scope and potential effectiveness of electricity energy regulatory agencies in developing countries”.

Research on energy supply, consumption and access dynamics in Botswana by Essah & Ofetotse (2014) realised that the best approach to recuperating electricity accessibility and security is to increase the supply. However, increased installed capacity does not necessarily translated to increased electricity supply. According to Oseni (2011), “rapid economic growth and sustainable development depends largely on the level of infrastructural development of a nation”. In a study of Nigeria’s electricity sector performance it was found that the installed capacity in Nigeria stands at 6000MW (approximately 15 times more than Namibia’s domestic installed electricity capacity), however only about 40 % of this is installed capacity is produced annually, and thus limits employment and industrialisation opportunities in Nigeria (Oseni, 2011).

Jochens (1980) points out that the price of energy has a direct effect on the competitiveness of metals on international markets, and that it represents a significant proportion of the selling price of copper and other metals recovered from oxide ores. This is very significant if one considers that for example in the experience of the United States that “the metallurgical sector was for many years the largest the single industrial user of energy and later became the largest single user of electricity” (Rosenburg, 1998).

## **Chapter 3: Methodology**

### **3.1 Research Design**

The research study was of a quantitative nature. The study predominantly made use of secondary time-series data of electricity tariffs, electricity consumption as well as annual production data of Gold, SHG Zinc and Uranium (excluding Langer Heinrich Uranium) mines in Namibia between 2003 and 2013.

One of the reasons why the study considered the 2003 – 2013 decade is because the Electricity Control Board initiated the allocation of electricity tariffs to mines in the year 2003 and the most energy intensive mine in Namibia (Scorpion Zinc) commenced production in the same year. Another reason for choosing the 2003 – 2013 time period is the fact that data relating to the study, most importantly; Individual consumption of mines, is hard to come by as one goes further back into time, this is especially the case with smaller/fragmented mines such as those that mine small, low grade deposits.

### **3.2 Population**

The Population of the research included all the mines that are members of the Chamber of mines of Namibia, because most mines in Namibia are members of the Chamber, and all major mines that are energy intensive (large power users) are definite members.

By the end of 2013, there were 14 mines that were part of the Chamber of Mines of Namibia (Chamber of Mines of Namibia, 2013, p.2). Even though the population was defined from an “individual mine point of view” the data was treated on a commodity level, as shall be further.

### **3.3 Sample**

From the above mentioned population, the sample from which statistical inferences were made includes all of the mines that produce Uranium Oxide, Special High Grade Zinc, and Gold. These were 4 mines in total, for the mentioned 2003 – 2013 period. These three mineral commodities were primarily chosen because of their complete and un-fragmented available time-series data. However, Langer Heinrich Uranium mine was excluded from the study because data regarding their electricity consumption and production output could not be obtained.

### **3.4 Research Instruments**

From the secondary data that was gathered during the research study, data on the electricity consumption (energy) (kWh), electricity tariffs (energy) (N\$/kWh) of the mines was collected from the mines themselves and the Electricity Control Board of Namibia respectively. Both the mines and the ECB were contacted telephonically and provided the data via email.

Data regarding the annual production figures of the sampled mines was gathered from the Economic division of The Chamber of Mines of Namibia. The units of the production data of the sampled mines was expressed in tonnes (t) for all three commodities. A major instrument for data analysis of the study was Microsoft Office Excell 2013.

### **3.5 Data analysis**

The collected secondary data of the electricity tariffs and electricity consumption of the sampled mines was then tabulated on Microsoft Excel. Electricity data of certain mines was

received in units other than kWh and GWh, but was then converted to such prior to tabulation.

Graphs were then plotted to illustrate the variations in output production, electricity consumption, electricity consumption per unit of production and electricity tariffs for each of the sampled mines according to the commodity they produce (Gold, SHG Zinc and Uranium) between 2003 and 2013.

The annual production data of the mines together with the annual electricity consumption was used to calculate the average quantity of electricity required by a particular mine to produce its final product between 2003 and 2013. For example, SHG Zinc, the annual production data (in tonnes) of the mine together with the annual electricity consumption (kWh) will be used to calculate how many tonnes was produced in a particular year for each kWh of electricity consumed in that year, this shall then be expressed as t/kWh.

After which, scatter plots of the electricity tariffs, electricity consumption and output production of the individual commodities (SHG Zinc, Uranium & Gold) from the sampled mines between 2003 and 2013 to examine patterns and possible relationships.

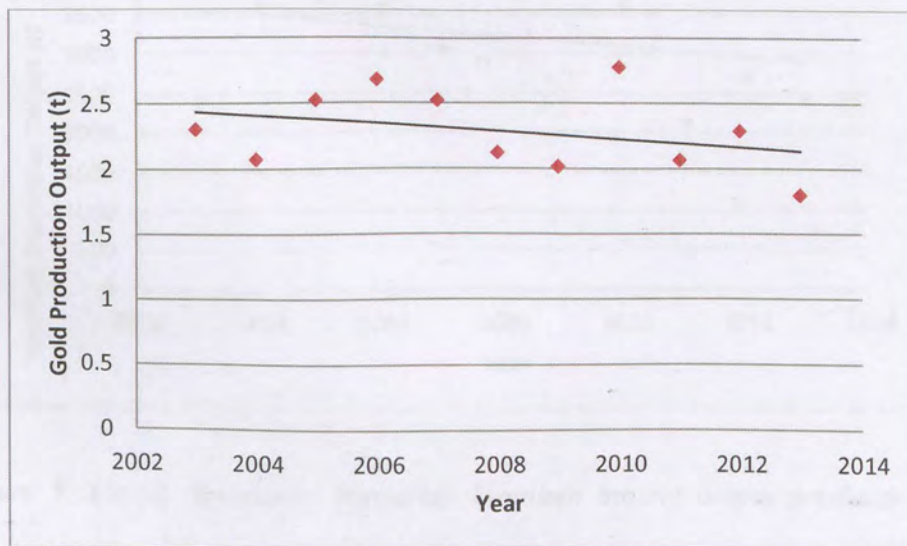
## Chapter 4: Results

The following section will highlight the variations and relationships of and between mining production output, mining electricity consumption, electricity consumption per unit of mining output production, and lastly mining electricity tariffs. The analysis is based on Gold, Uranium (Excluding Langer Heinrich Mine) and SHG Zinc mining in Namibia.

### 4.1 Variations of annual mining production output between 2003 -2013.

#### *Gold Mining Production Output in Namibia (2003 - 2013).*

Gold mining in Namibia over the past decade has predominantly been the provocative of the Navachab Gold mine found in the Erongo Region of Namibia. The following variations are based on the Navachab Mine as there has been no other gold mine in the country for the period between 2003 and 2013.

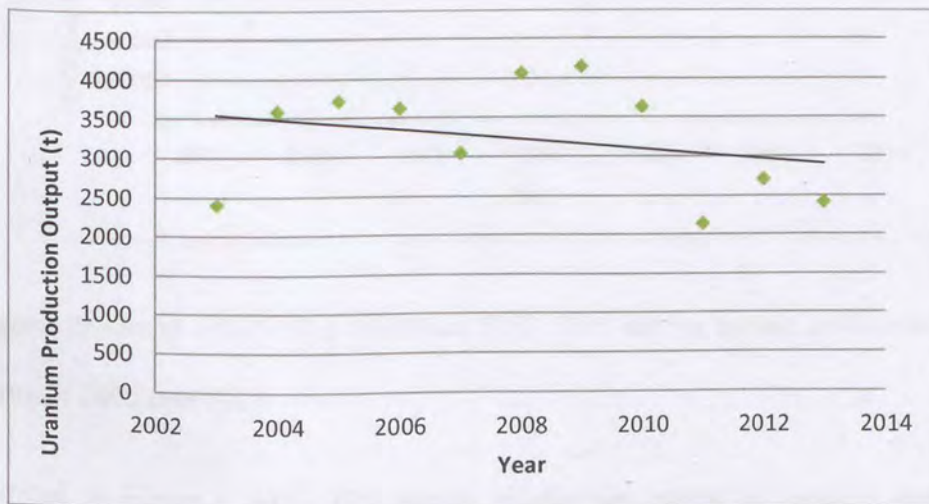


*Figure 4: Graph illustrating Namibian gold mining output production (tonnes) between 2003 and 2013.*

Gold mining in Namibia has shown a decline over the 2003 – 2013 decade. During the period, the highest annual production output was 2.773 t and it was experienced in the year 2010, and the lowest annual production was 1.795 t in 2013. On average, Namibia had an annual gold production output of 2.284 during the 2003 – 2013 decade.

***Uranium Mining Production Output in Namibia (2003 - 2013).***

Namibia currently has 2 uranium mines in production. The Rössing Uranium Mine has been the only mine that has been in production for the entire 2003 – 2013 decade. The other smaller Uranium mine, Langer Heinrich, commenced production only in 2008 and data regarding the mines electricity consumption could not be obtained, thus the study has excluded Langer Heinrich Mine entirely in order to avoid biased or misleading results and comparisons.



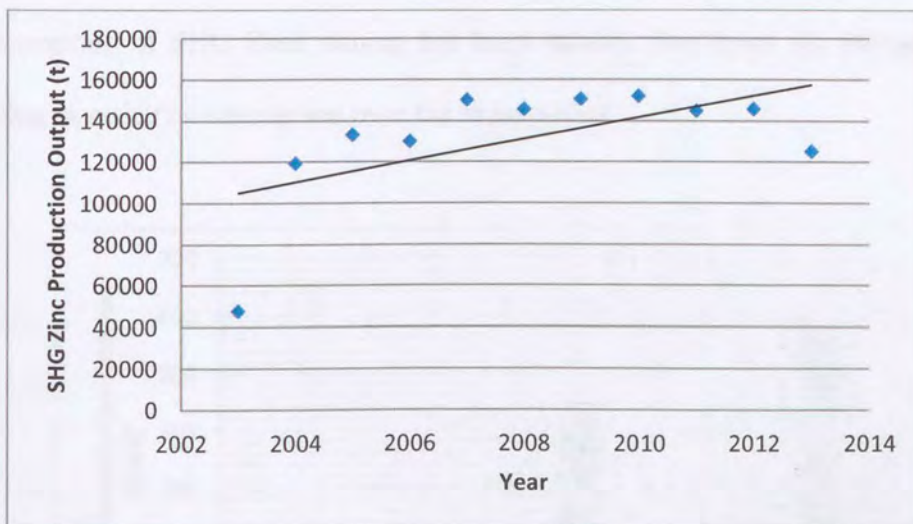
*Figure 5: Graph illustrating Namibian Uranium mining output production (tonnes) between 2003 and 2013.*

Uranium Mining in Namibia has shown a general decline in production over the last decade. The highest annual production was experienced in 2009, where 4150 t of Uranium was

produced. The poorest year of production in the last decade has been 2011 with an output of 2137 t. On average, the Uranium mining industry has produced 3222.5 t per annum over the last decade.

### ***SHG Zinc Mining Production Output in Namibia***

Namibia currently has one SHG Zinc mine and refinery plant in operation, the Scorpion Zinc Mine. The mine produces zinc of an exceptional quality and is located in the South of Namibia.



*Figure 6: Graph illustrating Namibian SHG Zinc mining output production (tonnes) between 2003 and 2013.*

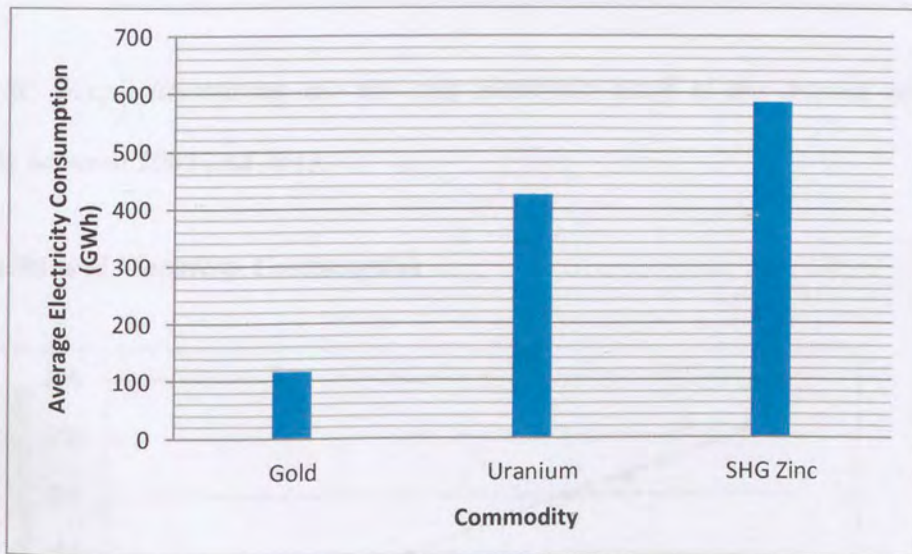
As illustrated in Figure 6, SHG Zinc mining production output in Namibia has shown a general increasing trend over the past decade. Namibia's highest annual SHG Zinc production was 151 688 t experienced in 2010, and the lowest was 47 436 t in 2003. On average, Namibia has produced 131 085 t of SHG Zinc over the past decade.

## 4.2 Variations of annual mining electricity consumption and tariffs

*Average electricity consumption and Tariffs of the Namibian mining sector between 2003 and 2013.*

In ascending order; over the past decade Gold mining has consumed 116 GWh, Uranium Mining 423 GWh and lastly, SHG Zinc mining has consumed 584 GWh on average between 2003 and 2013.

An interesting observation from the figures above is that the average electricity consumption of SHG Zinc mining has been exactly five times the average of gold mining electricity consumption over the same period.



*Figure 7: Chart illustrating average annual electricity consumption, for gold, uranium and SHG Zinc mining in Namibia between 2003 and 2013.*

The mines sampled for this study are all classified as Large Power Users (LPU) according to NamPower's various user categories for distribution sales. Tariffs in this LPU category are

predominantly charged per unit of electricity consumed (c/KWh) amongst other charges. The figure below illustrates the changes of this discussed tariff over the past decade, between 2003 and 2013. This tariff has increased from 11.5 c/KWh in 2003 to 81.0 c/KWh, representing an increase of about 700%.

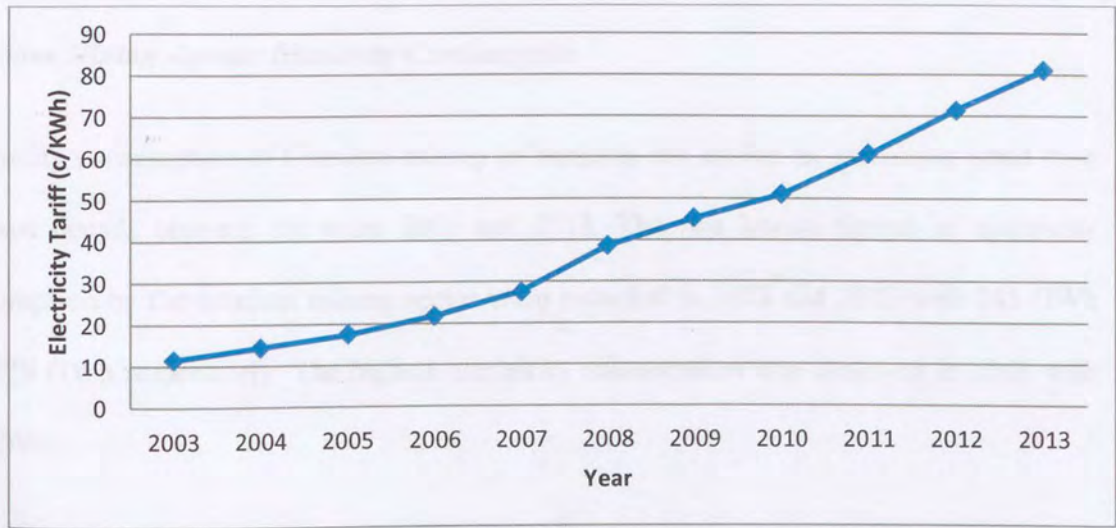


Figure 8: Graph illustrating the per unit electricity tariff of the mining sector in Namibia between 2003 and 2013.

**Gold Mining Annual Electricity Consumption**

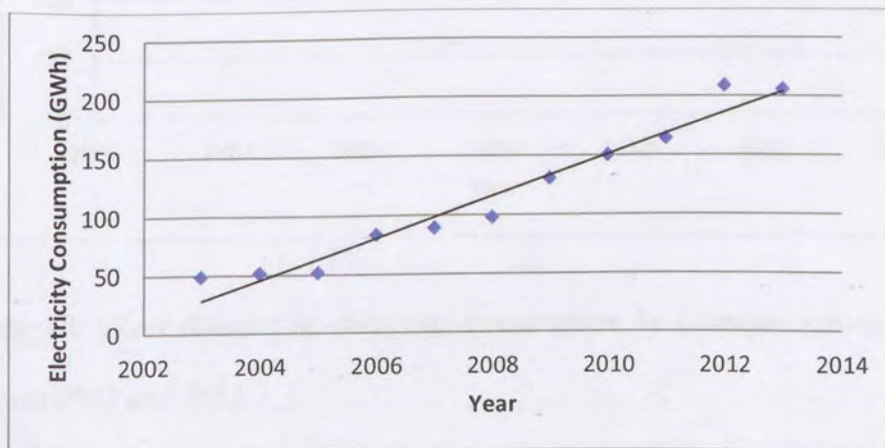
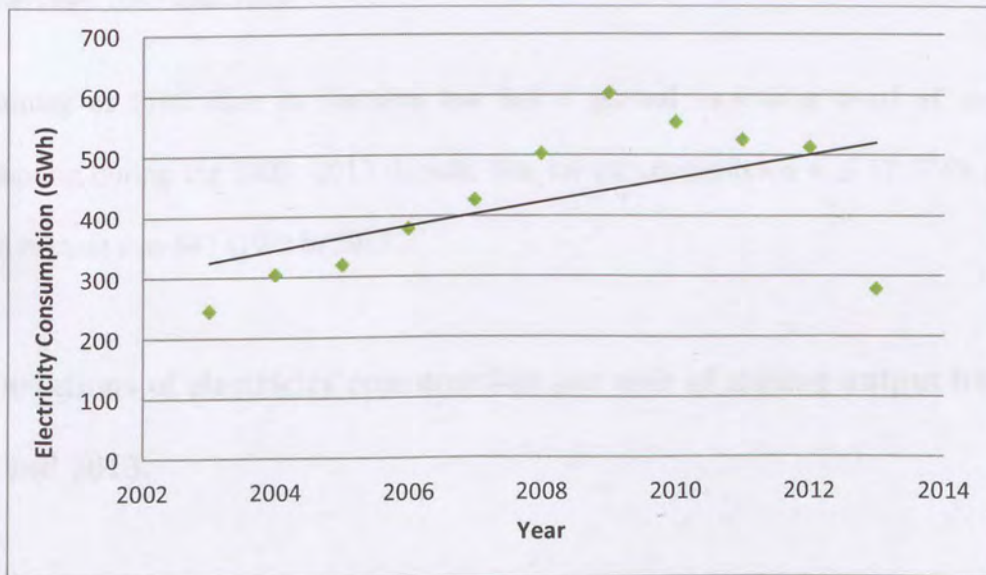


Figure 9: Chart illustrating electricity consumption by Gold mining in Namibia between 2003 and 2013.

As seen in Figure 8 above, the electricity consumption of gold mining in Namibia has been on the increase over the past decade. The lowest electricity consumption by the gold mining sector in Namibia was recorded in the year 2003 with 48 GWh, the highest however, was in 2013 with 205 GWh.

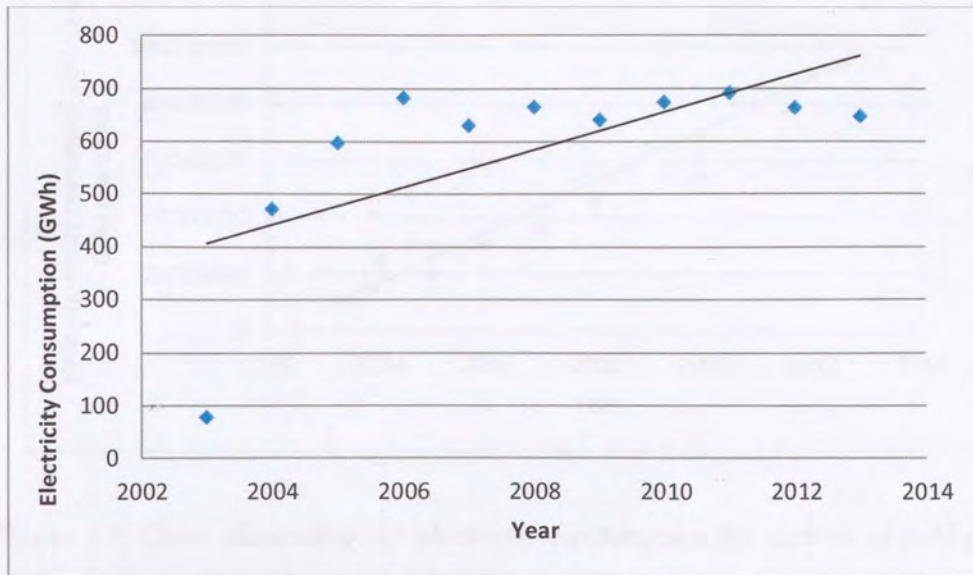
### ***Uranium Mining Annual Electricity Consumption***

Electricity consumption of Uranium mining in Namibia has shown an increasing trend over the past decade between the years 2003 and 2013. The two lowest figures of electricity consumption by the uranium mining sector were recorded in 2003 and 2013 with 245 GWh and 279 GWh respectively. The highest electricity consumption was observed in 2009 with 602 GWh.



*Figure 10: Chart illustrating electricity consumption by Uranium mining in Namibia between 2003 and 2013.*

### *SHG Zinc Mining Annual Electricity Consumption*



*Figure 11: Chart illustrating electricity consumption by SHG Zinc mining in Namibia between 2003 and 2013.*

The mining of SHG Zinc in Namibia has had a general increasing trend of electricity consumption during the 2003 -2013 decade. The lowest consumption was 47 GWh in 2003 and the highest was 647 GWh in 2013.

### **4.3 Variations of electricity consumption per unit of mining output between 2003 and 2013.**

#### ***Gold***

On average, it took the Namibian mining industry about 52.9 GWh to produce 1 t of gold. Figure 12 bellow indicates the general increasing trend of the electricity intensive nature of gold mining between 2003 and 2013.

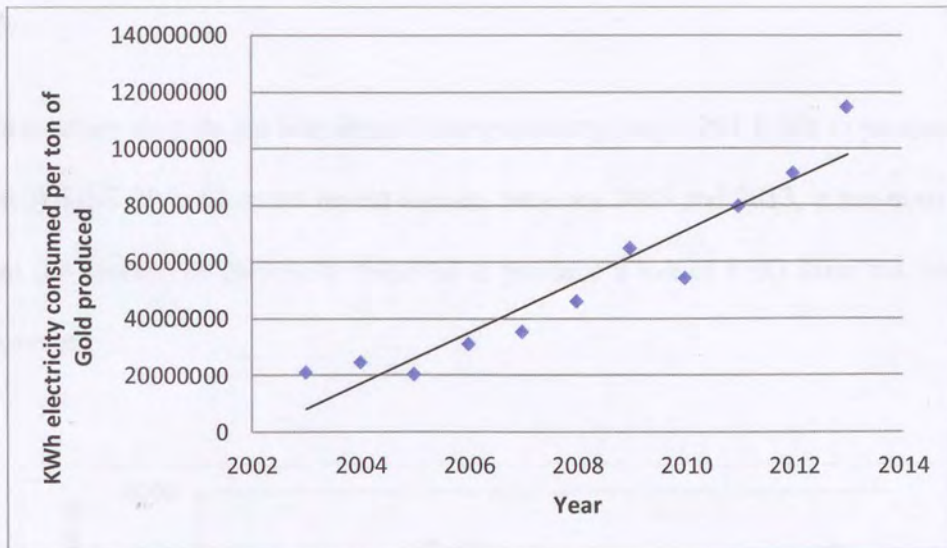


Figure 12: Chart illustrating the electricity consumption for each ton of gold produced in Namibia between 2003 and 2013.

### Uranium

Calculations reveal that on average, the Namibian Uranium mining sector consumed 135644.5 KWh or 0.136 GWh of electricity for each ton of Uranium produced between 2003 and 2013, as illustrated in figure 13 below.

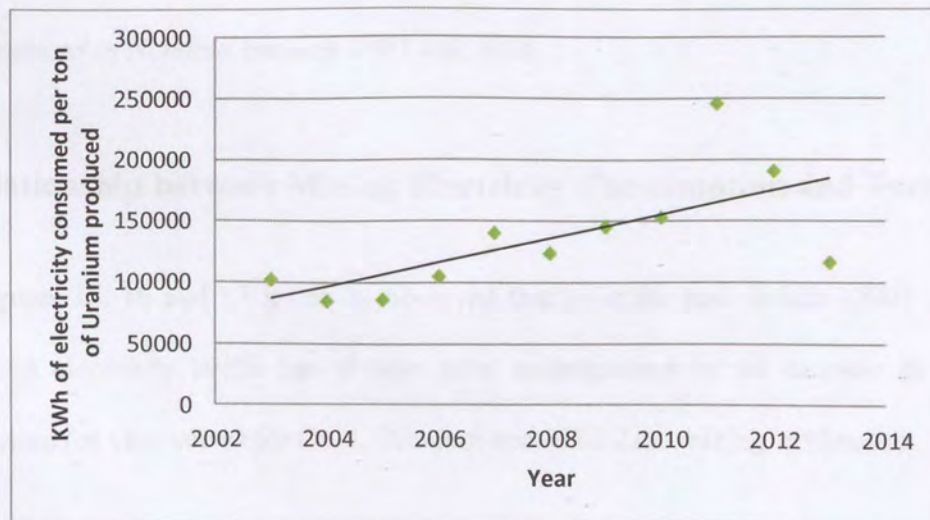


Figure 13: Chart illustrating the electricity consumption for each ton of Uranium produced in Namibia between 2003 and 2013.

## SHG Zinc

On average, it costs the Namibian Mining industry only 4293 KWh to produce a single ton of SHG Zinc. Over the recent decade, between 2003 and 2013, it has been observed that the amount of electricity required to produce a ton of SHG Zinc has been on the increase.

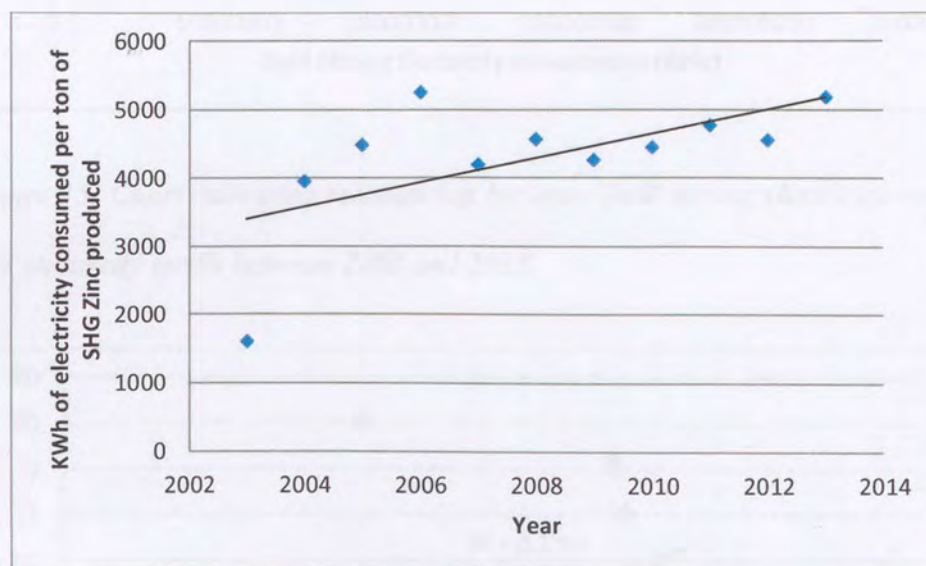


Figure 14: Chart illustrating the electricity consumption for each ton of SHG Zinc produced in Namibia between 2003 and 2013.

### 4.4 Relationship between Mining Electricity Consumption and Tariffs.

From figures 15, 16 and 17 it can be observed that over the past decade (2003 - 2013) an increase in electricity tariffs has always been accompanied by an increase in electricity consumption (or vice-versa) for Gold, Uranium and SHG Zinc mining in Namibia.

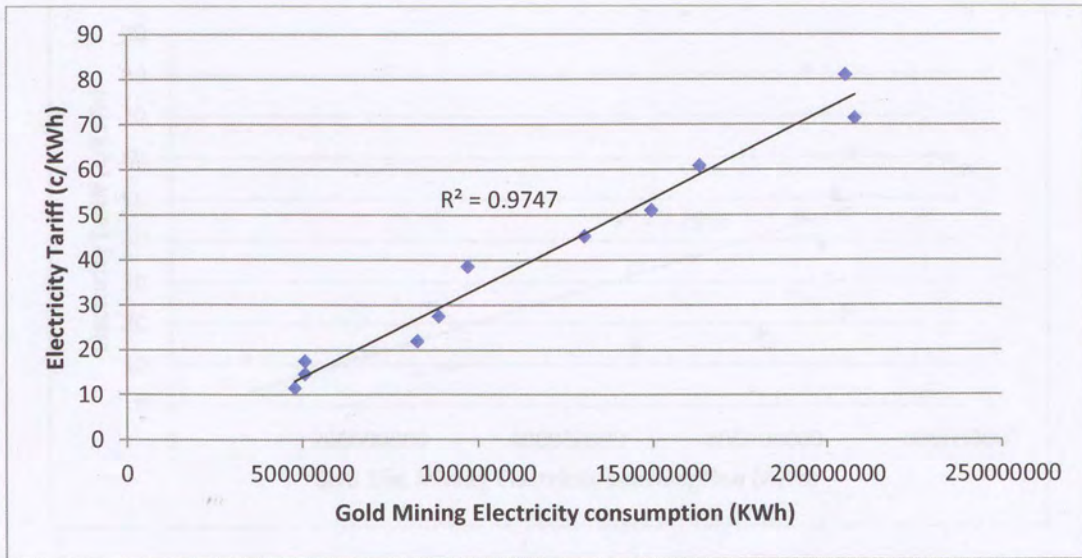


Figure 15: Chart indicating relationship between Gold mining electricity consumption and electricity tariffs between 2003 and 2013.

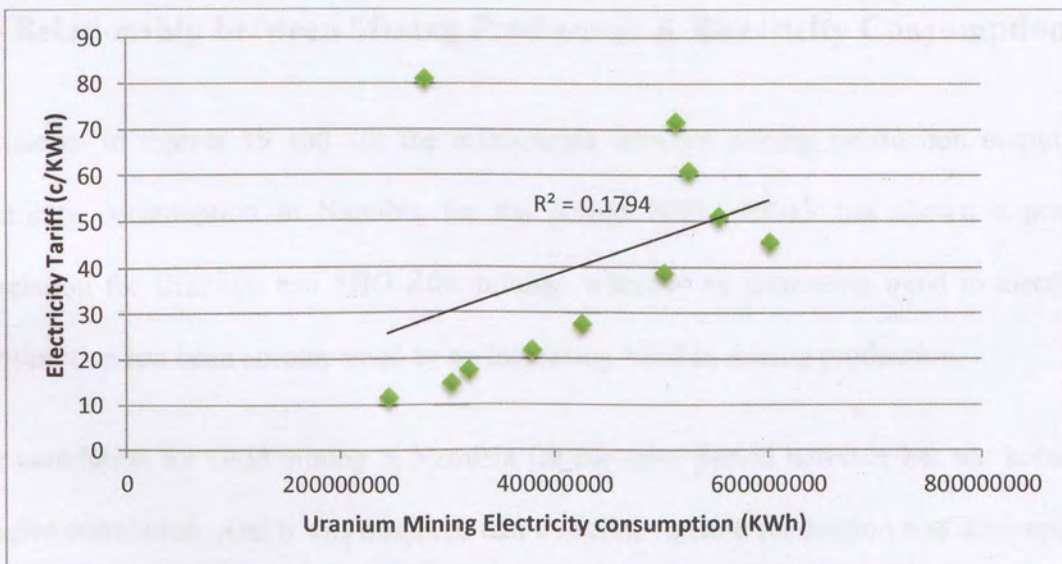


Figure 16: Chart indicating relationship between Uranium mining electricity consumption and electricity tariffs between 2003 and 2013.

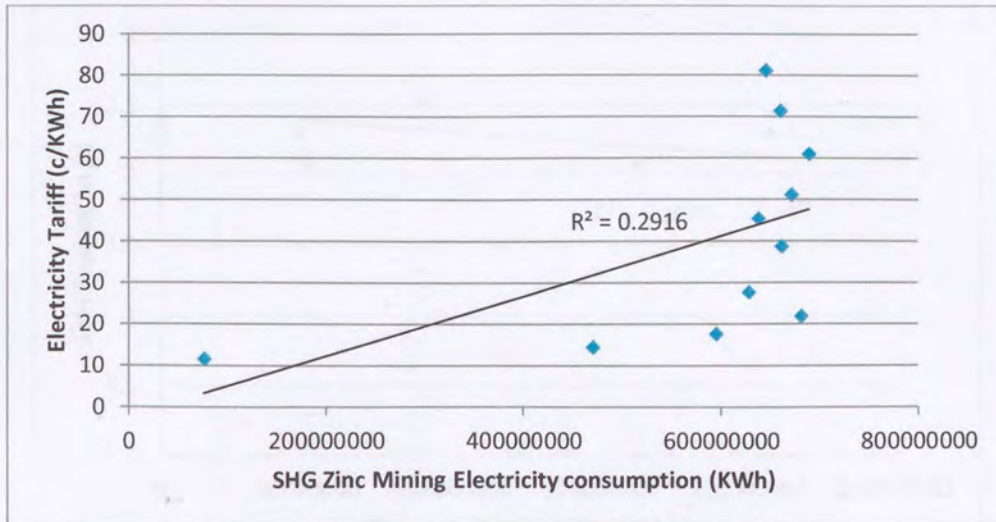


Figure 17: Chart indicating relationship between SHG Zinc mining electricity consumption and electricity tariffs between 2003 and 2013.

#### 4.5 Relationship between Mining Production & Electricity Consumption.

As shown in figures 19 and 20, the relationship between mining production output and electricity consumption in Namibia for the period 2003 - 2013 has shown a positive correlation for Uranium and SHG Zinc mining, whereby an increasing trend in electricity consumption has been accompanied by an increasing trend in mining production.

The correlation for Gold mining in Namibia for the same period however has not been of a positive correlation. And it was observed that a decline in Gold production was accompanied by an increase in electricity consumption as illustrated in figure 18.

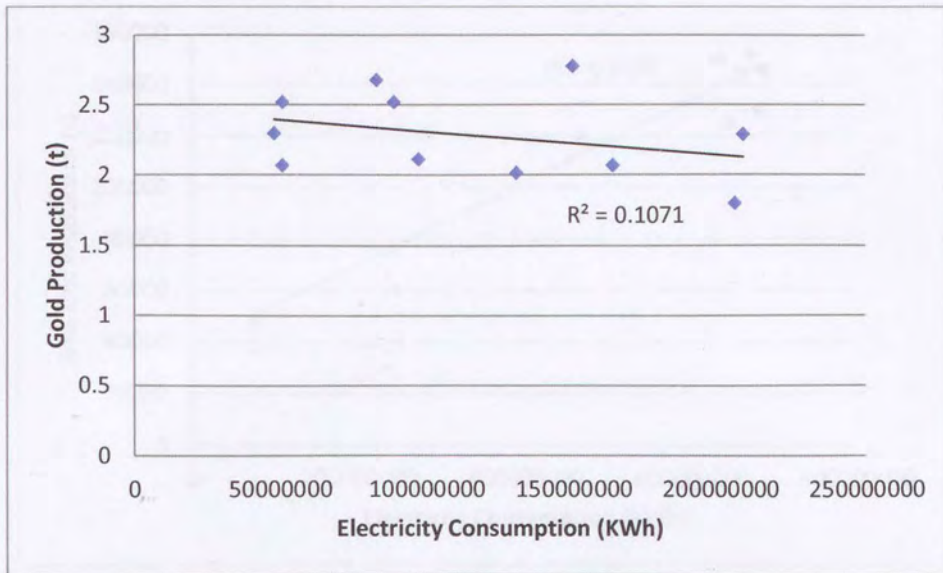


Figure 18: Chart illustrating the relationship between Namibian Gold production and electricity consumption between 2003 and 2013.

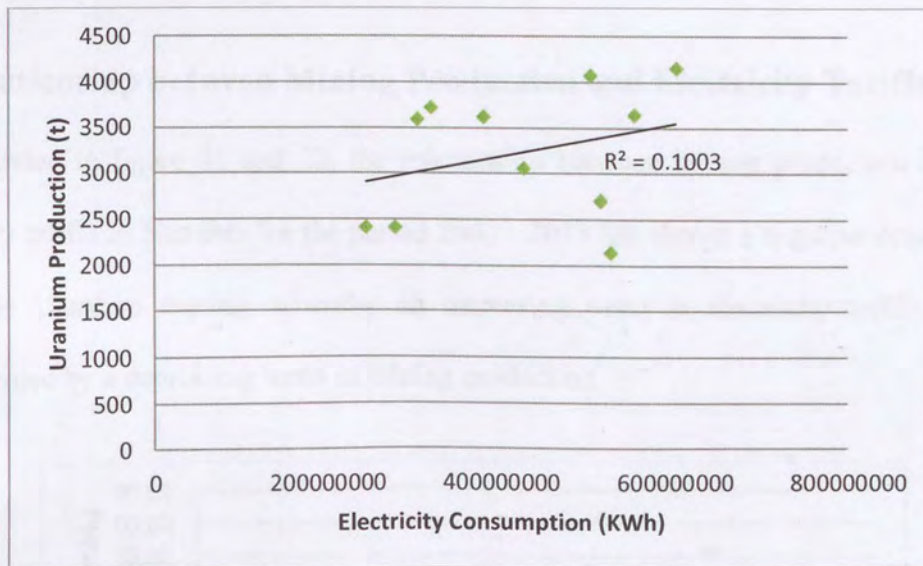


Figure 19: Chart illustrating the relationship between Namibian Uranium production and electricity consumption between 2003 and 2013.

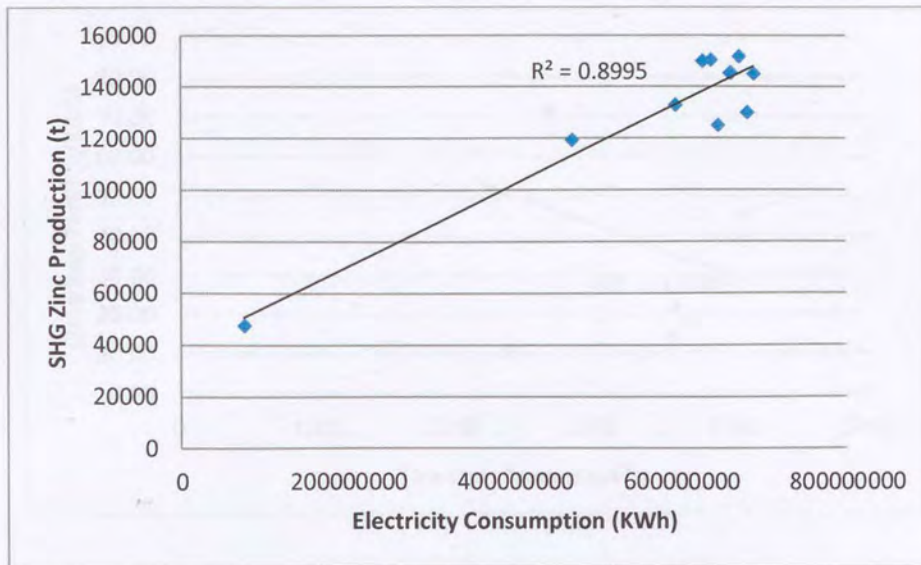


Figure 20: Chart illustrating the relationship between Namibian Gold production and electricity consumption between 2003 and 2013.

#### 4.6 Relationship between Mining Production and Electricity Tariffs.

As illustrated in figure 21 and 22, the relationship between mining production output and electricity tariffs in Namibia for the period 2003 - 2013 has shown a negative correlation for Gold and Uranium mining, whereby an increasing trend in electricity tariffs has been accompanied by a decreasing trend in mining production.

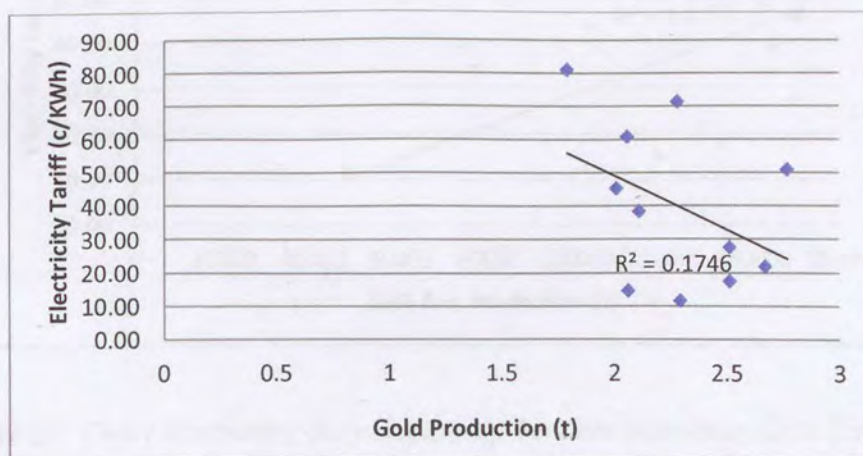


Figure 21: Chart illustrating the relationship between Namibian Gold production and electricity tariffs between 2003 and 2013.

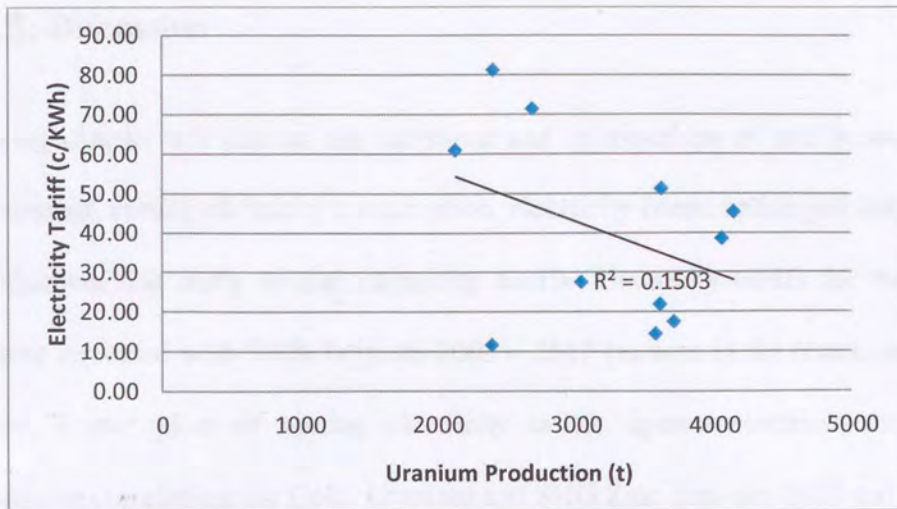


Figure 22: Chart illustrating the relationship between Namibian Uranium production and electricity tariffs between 2003 and 2013.

On the other hand, the relationship between SHG Zinc Mining in Namibia and electricity tariffs has been of a positive nature whereby increased electricity tariffs were accompanied by increased SHG Zinc output production between 2003 and 2013 as shown in figure 23.

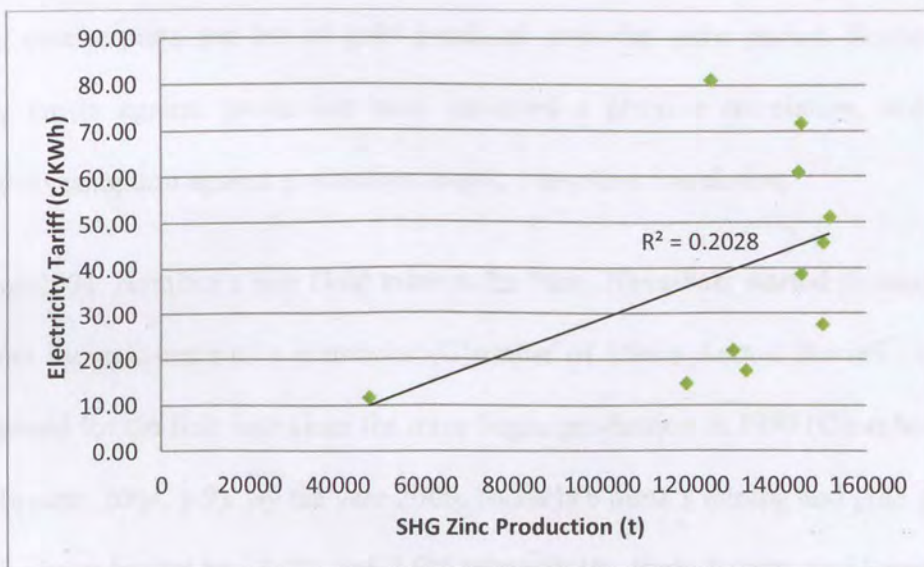


Figure 23: Chart illustrating the relationship between Namibian SHG Zinc production and electricity tariffs between 2003 and 2013.

## **Chapter 5: Discussion**

The following chapter will discuss the variations and relationships of and between mining production output, mining electricity consumption, electricity consumption per unit of mining output production, and lastly mining electricity tariffs. Electricity tariffs for the mines in Namibia have increased with 700% between 2003 – 2013 (as seen in the results section 4.2). Furthermore, scatter plots of mining electricity tariffs against electricity consumption revealed positive correlations for Gold, Uranium and SHG Zinc between 2003 and 2013.

### **5.1 Mining production and electricity consumption.**

#### ***Gold Mining***

Gold mining in Namibia over the past decade (2003-2013) has experienced a steady decline in gold production accompanied by an increase in electricity consumption, as well as electricity consumption per ton of gold produced over the same period. Scatter plots of electricity tariffs against production have indicated a positive correlation, and those of electricity consumption against production output, a negative correlation.

In the year 2004, Namibia's sole Gold mine at the time, Navachab, started to mine and haul ore without the assistance of a contractor (Chamber of Mines Annual Review, 2004, p.9). This happened for the first time since the mine began production in 1989 (Chamber of Mines Annual Review, 2004, p.9). By the year 2006, Navachab mine's mining and gold production were both above budget by 11.8% and 3.9% respectively, these figures could point out that contractor mining was delivering more ore to the plant for processing and thus increasing the electricity consumption at the same time, however, further study could delve into the

variations in ore grade for the mentioned period for a much detailed comparison (Chamber of Mines Annual Review, 2006, p.17).

During 2008, Gold production had dropped from figures of the previous year mainly due to poor performance by the drilling, thus effecting good quality ore delivery to the processing section, this thus creates a situation whereby much electricity is spent on processing poor grade ore, causing reduced production output and increased electricity consumption and electricity consumption per ton of gold produced, hence a possible reason for the observed negative correlation between electricity consumption and production output (Chamber of Mines Annual Review 2008, P.17).

Navachab Mine replaced its mill trammel screen with a vibrating screen in 2009 in order to improve operations, detailed specifications of the new screen are not well known and the information could not be sourced, however there is a possibility that the replacement of the screen may have had electricity consumption implications, electricity consumption per ton of gold produced as well as production to the mine as a whole (Chamber of Mines Annual Review 2009, P.17).

During 2012 and 2013, Gold mining production fell due to several factors such as: technical complications of mining a new ore body, low grades and overall recovery from mined tonnes (Chamber of Mines Annual Review, 2013 p.36). However, during the same year, Navachab Mine had experienced its second highest electricity consumption (205 GWh) over the 2003 – 2013 period a possible reason for the observed negative correlation between electricity consumption and production output.

## *Uranium Mining*

Uranium mining in Namibia over the past decade (2003-2013) has experienced a steady decline production accompanied by an increase in electricity consumption, as well as electricity consumption per ton of uranium produced over the same period. Scatter plots of electricity tariffs against production have indicated a negative correlation and those of electricity consumption against production output a positive correlation.

Between 2003 and 2004 Namibia produced 7.7% of the world's uranium. An increase in uranium production was observed and was mainly attributed to favourable ore grades and improvements in recovery techniques (Chamber of Mines Annual Review, 2004, P.33).

Over the 2003-2013 decade, uranium production has decreased and its electricity consumption has increased in general according to the trends in the results section. Most notably during the 2009 production year: Rossing Mine produced its highest amount of Uranium since 1988 with a record breaking 4 150 tonnes (Chamber of Mines Annual Review, 2009, P.43). Further examination revealed that within the time period on which the study focused, 2009 was also the year that Uranium mining in Namibia consumed the most electricity, 602 GWh. However, in 2010, production fell due to lower ore grade delivery. Interestingly, electricity consumption also decreased. In March 2011, a Tsunami occurred in Japan, and its consequent effects on the Fukushima Nuclear Plant/Reactor were so detrimental that the government of Japan shut down 52 nuclear power plants due to fears of future possible melt-downs, which sent the Uranium price plummeting due to reduced demand. Uranium prices have been on a downward spiral ever-since, with detrimental consequences to the Namibian mining sector, such as job cuts at Rossing mine, resulting in reduced production and ultimately decreased electricity consumption by the uranium mining sector (Chamber of Mines Annual Review, 2012, P.3). All of these trends are supportive of

the results observed for the uranium mining sector, most notably: the steady decline production accompanied by an increase in electricity consumption, as well as electricity consumption per ton of uranium produced over the same period; and lastly, scatter plots of electricity tariffs against production have indicated a negative correlation, but those of electricity consumption against production output have indicated a positive correlation.

### ***SHG Zinc Mining***

SHG Zinc mining in Namibia over the past decade (2003-2013) has experienced a steady increase in production as well as an increase in electricity consumption, as well as electricity consumption per ton of SHG Zinc produced over the same period. Scatter plots of electricity tariffs against production have indicated a positive correlation as well as those of electricity consumption against production output.

The SHG Zinc mining industry of Namibia holds a unique position within the entire mining sector of Namibia and the electricity consumption of the country as a collective. This is due to the fact that the Scorpion Zinc mine, which is Namibia's sole SHG Zinc mine, accounts for about 18% of the annual electricity consumption of Namibia as a whole. According the Chamber of Mines (p.54, 2005) "Skorpion zinc mine is a pioneering operation which mines a zinc oxide deposit and uses a new and sophisticated Zinc Solvent Extraction Electrowinning (SXEW) process to produce zinc of 99.995% purity".

First production of SHG Zinc in Namibia took place in 2003; however 2004 was the first full year of production. The ramp up program experienced some difficulties in 2003 as evident in that year's production due to operational challenges (Chamber of Mines Annual Review , 2005, P.32). The spike in electricity consumption for 2003 to 2004 in response to production

is evident in figure 6 and figure 11. This is also supported by the notion that the correlation between electricity consumption and production of SHG Zinc is positive as results indicate.

Between 2007 and 2008, a 4.4 decrease in production output was experienced and was reportedly directly linked to load shedding and major mechanical breakdowns (Chamber of Mines Annual Review, 2008, p.52). In addition to this, between 2008 and 2009, a 1.5 decrease in production output was experienced and was also directly linked to load shedding amongst other reasons (Chamber of Mines Annual Review, 2009, p.52). This demonstrates the vulnerability of SHG Zinc mining to national electricity supply and further necessitates research of this kind.

## **5.2 Mining electricity tariffs**

The study has revealed that Electricity tariffs for mines in Namibia have increased with 700% between 2003 – 2013. An explanation for large increase could be the argument by Eberhard & Kapika (2010, p.1) that prices are yet to gradually transition towards cost reflectivity and thus the sustainability of the arrangements in the distribution of electricity in the country are unsustainable on the long run.

The study has revealed that there has been a positive correlation between electricity tariffs and electricity consumption of gold, uranium and SHG Zinc mining in Namibia between 2003 and 2013. Previous discussions indicate that this correlation does not necessarily mean that mines use more electricity due to the cost of electricity, as several other factors also come into play such as drilling, mining, ore grade delivery etc. However, as established by Ziramba & Kavezeri (2012, p.6), “electricity demand in Namibia is price inelastic but income elastic”. This implies that the mining companies use as much electricity as they can afford.

The study has also revealed that electricity tariffs have had a negative correlation with Namibian Uranium and Gold production, but a positive correlation with SHG Zinc production. No literature could be obtained to explain this finding, however, such information could serve as a platform for pro-active management within electricity pricing regimes for the mining sector so as to balance policy and legislature aims with the operation of the mining and electricity supply sector.

According to a demand side management study by the ECB, it may be of mandatory necessity to undertake tariff reforms as part of the ongoing ECB mandated (ECB, 2006, p.4). Furthermore, tariff designs need to be guided from a macro-economic point of view by taking into account: actual generation costs, imports, blackouts, and most importantly socio-economic impacts on individual consumers and industries alike.

## **Chapter 6: Conclusion**

This research was aimed at examining the variations of annual production output, electricity consumption, electricity per unit output of production, and electricity tariffs of Gold, Uranium and SHG Zinc in Namibia between 2003 and 2013. The research also aimed to examine relationships between mining production output, electricity consumption, and electricity tariffs of Gold, Uranium and SHG Zinc.

For Gold mining in Namibia between 2003 and 2013, scatter plots of electricity consumption against production output revealed a negative correlation. Several production factors come at play when production is gauged against electricity tariffs and consumption such as: ore delivery, drilling performance, mined tonnage etc. It could thus be recommended that energy audits on site be conducted as a means of assessing the underlying causes of the observed trends particularly the increase in electricity consumption accompanied by a decrease in overall production.

For Uranium mining in Namibia between 2003 and 2013, scatter plots of electricity consumption against production output revealed a positive correlation. As with Gold mining, several production factors come at play when production is gauged against electricity tariffs and consumption. In addition to these mentioned production factors, the Uranium mining sector of Namibia has had economic challenges such as weak uranium prices and various downsizing of operations. It could also be advisable for Uranium mining to visit the option of energy audits within their operations as a means to possibly curb possible excess electricity consumption.

For SHG Zinc mining in Namibia between 2003 and 2013, scatter plots of electricity consumption against production output revealed a positive correlation. The SHG Zinc mining

sector has seen increased production output and electricity consumption between 2003 and 2013. It is thus recommended that SHG Zinc mining also visit the option of energy audits as a possible means of curbing some possible excess electricity consumption.

The study has also revealed that Electricity tariffs for mines in Namibia have increased with 700% between 2003 and 2013. An explanation for large increase could be the argument by Eberhard & Kapika (2010, p.1) that prices are yet to gradually transition towards cost reflectivity and thus the sustainability of the arrangements in the distribution of electricity in the country are unsustainable on the long run. It could thus be recommended to the ECB to revisit their tariff design for the mining sector in particular so as to not harm this industry.

The study has revealed that there has been a positive correlation between electricity tariffs and electricity consumption of gold, uranium and SHG Zinc mining in Namibia between 2003 and 2013. And as established by Ziramba & Kavezeri (2012, p.6), "electricity demand in Namibia is price inelastic but income elastic". Further study involving mining revenues is recommended to further establish trends in mining electricity consumption and income from mining.

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