The impact of increased electricity prices on consumer demand

Student name: Ezzard de Lange

Student number: 27526616

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ABSTRACT

The impact on demand resulting from an electricity price increase is unknown, *Dekenah, Heunis, Gaunt and Cheek (2003)*. This study focused on large Eskom customers (industry and mining) and the impact of increased electricity prices (Eskom Megaflex Time-of-Use tariff) on their electricity demand is analysed.

Since, the impact of this can be only be realised in the long-run (> 5 years), this study made use of historical data. In particular, the impact of the revised Megaflex tariff in 2002, which increased high season (winter) peak active charges by approximately 40% against an approximate reduction of 30% in the low season (winter) was analysed.

It was found that the price elasticity of large Eskom customers is inelastic in the short-run (< 2 years) and elastic in the long-run. This is particularly evident in the Manufacturing sector. Furthermore, it was found that price is not the only input cost in the short-run, but economic factors such as commodity prices also influence consumption behaviour. This is particularly evident in the Mining sector. It was also found that alternatives (i.e. mandatory and voluntary load reduction programmes, etc.) impact electricity load profiles.

In conclusion, this study found sufficient evidence in support of the research hypothesis.

DECLARATION

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration at the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination in any other University. I further declare that I have obtained the necessary authorisation and consent to carry out this research.

Student Name: Ezzard de Lange

Signature: ________________________

Date: ____________________________

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This report is not confidential and may be freely used by the Gordon Institute of Business Science.

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I also wish to thank Eskom for allowing me access to key historical customer data, required to conclude this research.

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LIST OF ABBREVIATIONS

The following abbreviations have been used in this report.

IPP – Independent Power Producer

PPA – Power Purchase Agreement

DPE – Department of Public Enterprises of South Africa

NER – National Energy Regulator of South Africa

GDP – Gross Domestic Product

DSM – Demand-Side Management

CAPEX – Capital Expenditure

EPRI – Electric Power Research Institute

RTP – Real-Time Pricing

TOU – Time-of Use

USA – United States of America

C/kWh – Cents (ZAR) per Kilowatt Hour

MW – Mega Watt

ZAR – South African Rand

USD – United States Dollar

DMP – Demand Market Participation

ODS – Operational Data Store

SIC – Sector Industry Class

PPI – Producer Price Inflation

EDI – Electricity Distribution Industry

PCP – Power Conservation Programme

1. CHAPTER 1: INTRODUCTION TO THE RESEARCH PROBLEM

The purpose of this chapter is to present the research problem, to explain the rationale for conducting this research as well as to highlight the purpose and scope of this research.

1.1 RESEARCH PROBLEM

The impact on demand and on revenue resulting from a price increase is unknown, *Dekenah, Heunis, Gaunt and Cheek (2003)*. Reduced consumption and demand could result depending on the basket of consumption and the elasticity of each sector.

South Africa has enjoyed electricity production surplus for years due to overinvestment in electricity generators by Eskom. This eliminated the need to build new electricity generators and through which Eskom achieved the position of being the world's cheapest producer of electricity, *Kohler (2008)*.

However, this situation has now ended and South Africa is in urgent need for additional power capacity. This is evident in the fact that Eskom is struggling to achieve an acceptable reserve margin of between 15% and 20%. Furthermore, Eskom's continuity of supply has deteriorated across all parts of the electricity system, while investment in supply did not follow this trend.

Large South African consumers enjoy among the world's lowest electricity prices *NUS Consulting (2006).* Australia and Denmark are on average 31% and 231% more expensive than South Africa, respectively.

This study therefore focused on the larger Eskom customers (industry and mining) and the impact of increased electricity prices on their electricity demand is analysed.

1.2 BACKGROUND TO THE RESEARCH PROBLEM

This section of this report discusses the structure of the South African electricity generation sector as well as electricity demand and growth in South Africa.

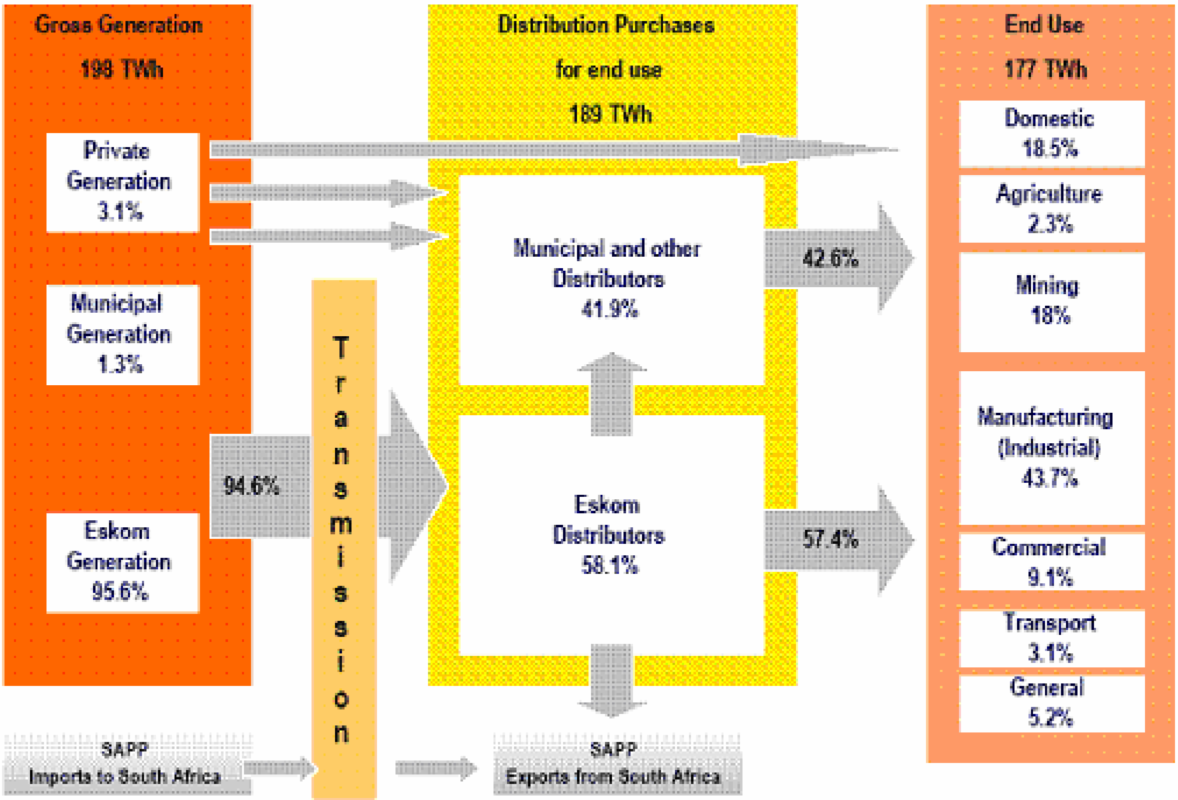
1.2.1 Structure of the South African Electricity Generation Sector

The Electricity Generation Sector in South Africa is dominated by Eskom (State-owned utility), *Kohler (2008)*. Eskom produces approximately 95% of the power consumed in South Africa from 26 power stations (the Eskom generation mix) Creamer, *Naidoo and Tyrer (2006)*:

- Coal (88%)
- Nuclear (5%)
- Gas turbines, hydroelectric plants and hydro-electric storage schemes (2%)

The additional 5% of power is generated within the private sector through independent power producers (IPP's), power purchase agreements (PPA's) and imports (5%), see Figure 1. Eskom is regarded as a monopoly within the South African electricity industry and reports to the Department of Public Enterprises (DPE) Eskom (2007). Eskom is a private company and therefore earns profits, which is regulated by the National Energy Regulator (NER) of South Africa.

Figure 1: South African Electricity Generation and Supply System



Source: National Energy Regulator

1.2.2 Electricity Demand and Growth

South Africa has enjoyed electricity production surplus for years due to overinvestment in electricity generators by Eskom. This eliminated the need to build new electricity generators and through which Eskom achieved the position of being the world's cheapest producer of electricity, *Kohler (2008).*

However, this situation has now ended and South Africa is in urgent need for additional power capacity. Between December 2005 and May 2006 outages were experienced in the Western Cape, in early 2007 outages were experienced across the country and in January 2008 daily load shedding events were experienced. The recent large-scale power outages and load-shedding events have been contributed by a declining reserve margin (see Figure 2). An acceptable reserve margin would be between 15% and 20%.

Various factors contributed to the supply problem *Kohler (2008)* and Eskom Annual Report (2007), which are:

Policy uncertainty, planning confusion and investment delays

This refers to the policy uncertainty and planning confusion (between 1998 and 2004) which resulted in delayed investment in new generation capacity. Furthermore, incorrect assumptions on the planning side contributed as a 10% reserve margin as opposed to a 15% reserve margin were considered.

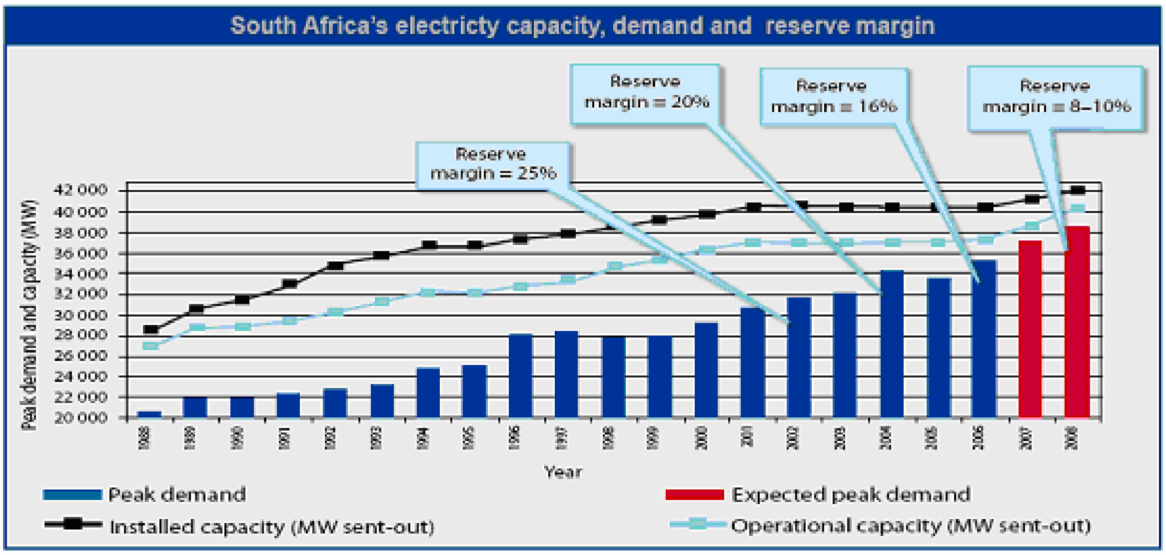
Unexpected plant failures

Traditionally, Eskom conducts planned maintenance during summer when peak demand is lower. However, during this period a significant portion of capacity was unexpectedly out of commission. Factors contributing to this include low coal stockpiles and low quality of coal; ageing plant having to run harder (i.e. boiler-tube leaks), etc.

Demand growth

Since 1980, electricity grew at a compound rate of 3.7% higher than the Gross Domestic Product (GDP) growth rate of 2.1%, while post 1989, electricity and GDP grew at similar rates, *I-net Bridge (2007)*. Eskom's growth assumptions were based on a GDP growth of 4%. This translates to power demand growth of 2.3% *Kohler (2008)*. Actual GDP growth exceeded 4% over this period, while electricity demand grew by 4.9% in 2007, *Kohler (2008)*. Continuity of supply therefore deteriorated across all parts of the electricity system, while investment in supply did not follow this trend.

Figure 2: Electricity Capacity, Demand and Reserve Margin



Source: South African Government: National Response to South Africa's Electricity Shortage

1.3 THE RATIONALE FOR CONDUCTING THIS RESEARCH

Large South African consumers enjoy among the world's lowest electricity prices (see Table 1), *NUS Consulting (2006).* This survey used prices as of April 1, 2006 for the supply of 1000kW for an organisation with a monthly usage of 450 000 kWh. Australia and Denmark are on average 31% and 231% more expensive than South Africa, respectively. Various factors contributed to the low price of electricity in South Africa:

- Power Stations use cheap low-grade coal.
- Eskom's power stations came into service more than 20 years ago when technology was cheaper (debt used to finance power stations is largely repaid).
- Power cost in South Africa has not until recently included environmental taxes.

The era of low price electricity is about to change. This is due to an increased global demand for low-grade coal as well as the increase in the cost of primary fuels. Eskom plans huge investment in Demand-Side Management (DSM) programmes to influence electricity consumption behaviour. The 2008 budget announced a levy on power produced by non-renewable sources (a form of environmental tax). Eskom therefore embarked on a major capacity expansion programme in order to build new electricity capacity.

Table 1: Electricity Price Comparison

2005 Rank	2006 Rank	Country	Cost 2006 (USC / kWh), excl. VAT
2	1	Denmark	13.41
1	2	Italy	13.24
8	3	UK	11.03
5	4	The Netherlands	11.01
9	5	France	10.53
4	6	Belgium	10.50
3	7	Germany	10.33
6	8	Spain	9.30
7	9	US	8.82
10	10	Finland	8.09
13	11	Sweden	6.96
11	12	Canada	5.87
12	13	Australia	5.29
14	14	South Africa	4.05

Source: NUS Consulting (2005-2006) International Electricity Cost Survey

The NER regulates electricity pricing in South Africa. Eskom therefore uses a rate of return methodology to calculate tariffs that enables the organisation to recover its costs and earn a regulated return on its assets. The Capital Expenditure (CAPEX) required by the Eskom Build Programme requires Eskom to increase tariffs in order to fund this programme and to maintain its credit rating. Hence, the current tariffs developed for the diverse customer base (redistributors, residential, commercial, industrial, mining, agricultural) requires revision.

In February 2008, the NER approved an electricity price increase of 14.2% and in June 2008, Eskom received an additional 13.3% against a further 52% increase requested by the company. There is civil interest and a mobilisation of the populace and political pressure to counter this, *Geldenhuys (2008).*

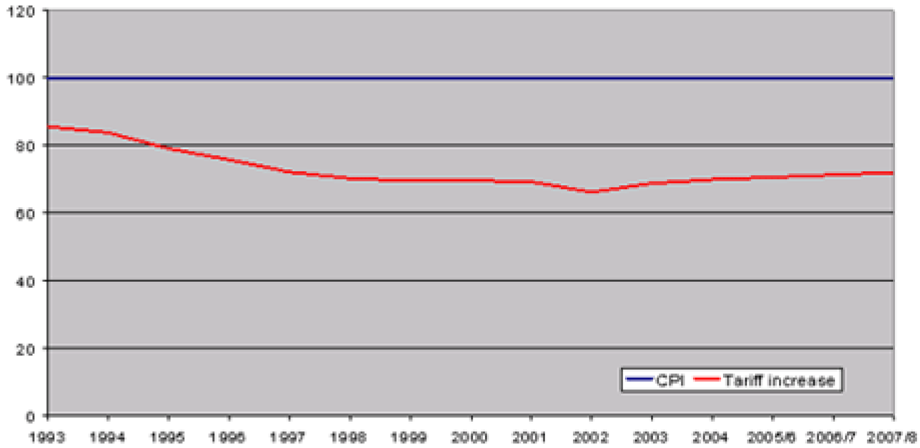
Figure 3.1 and Table 2 provides an overview of Eskom's average electricity price increases since 1993.

Table 2: **Eskom's Average Tariff Adjustment for the Last 15 Years**

Year	Average Price Adjustment	CPI
1 January 1993	8,00%	9,87%
1 January 1994	7,00%	8,82%
1 January 1995	4,00%	8,71%
1 January 1996	4,00%	7,32%
1 January 1997	5,00%	8,62%
1 January 1998	5,00%	6,87%
1 January 1999	4,50%	5,21%
1 January 2000	5,50%	5,37%
1 January 2001	5,20%	5,70%
1 January 2002	6,20%	9,20%
1 January 2003	8,43%	5,80%
1 January 2004	2,50%	1,40%
1 January 2005	4,10%	3,42%
1 April 2006/7	5,10%	(projected) 4,60%
1 April 2007/8	5,90%	(projected) 5,20%

Source: Eskom (2008), http://www.eskom.co.za/live/content.php?Item_ID=937

Figure 3.1: Eskom's Tariff Adjustment as a % of CPI (cumulative graph) – base = 1990



Source: Eskom (2008), http://www.eskom.co.za/live/content.php?Item_ID=937

Ramokgopa B (2008) argue that Eskom's average tariff increases for the past 19 years were below inflation until 2003, but have risen to above inflation levels since 2003 (see Figure 3.2). This places pressure on both the South African Government as well as Eskom to change. The perspectives form both Government and Eskom to address this challenge is as follows, Ramokgopa B (2008):

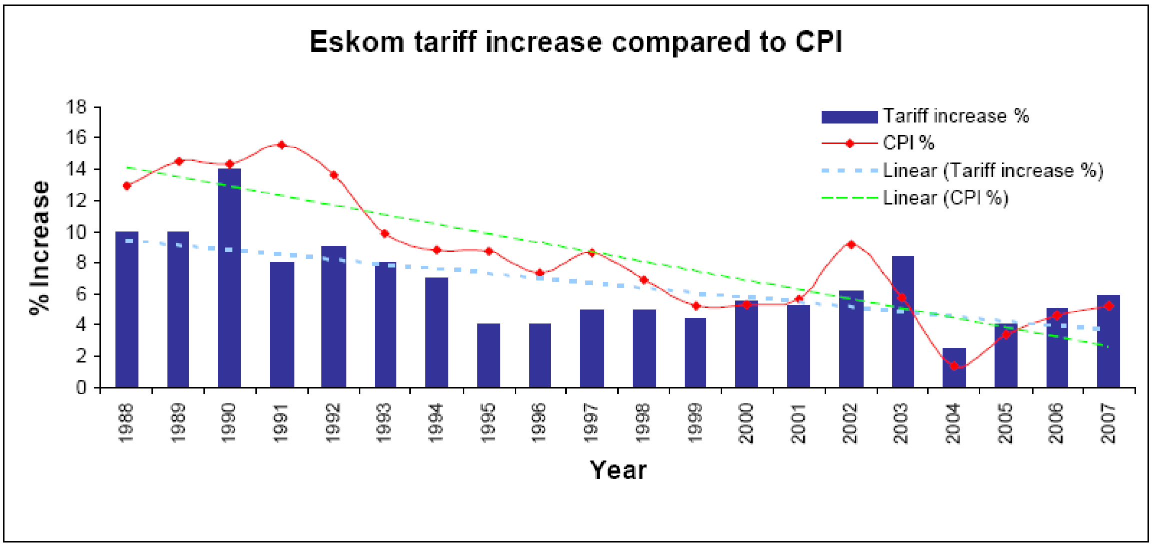
Government:

- Give customers the right to choose their electricity supplier
- Introduce competition in the industry
- Permit open, non-discriminatory access to the transmission network systems
- Encourage private sector participation in the industry

Eskom:

- Gear up for competition
- Retain an interest in the electricity distribution industry (EDI) drive
- Retain focus on electrification
- Generate funding for the business

Figure 3.2: Eskom Tariff Increase Compared to CPI



Source: Eskom (Tariff History 2002 to 2007)

Treasury revenue requirements drive electricity tariffs in Eskom as well as considerations around "affordability". The impact on demand and on revenue resulting from a price increase is unknown, *Dekenah, Heunis, Gaunt and Cheek (2003).* Reduced consumption and demand could result depending on the basket of consumption and the elasticity of each sector.

Revenue impacts need to be quantified, positively or negatively, *Heunis and Dekenah (2005)*. Heunis and Dekenah (2005) argue that most domestic customers are low consumers, relatively recently connected. These consumers are relatively more sensitive to price. These consumers are also partially benefactors of "free units" programmes. On top of this is a layer of higher consumers, longer connected who complicate the picture, and where the sensitivity may in fact be substantially different. The residential market, in particular the recently connected households are price sensitive, Heunis and Dekenah (2005).

This study focused primarily on the larger Eskom customers (industry and mining) and the impact of increased electricity prices on their electricity demand was analysed. This decision was enhanced by reviewing the study on domestic electricity demand elasticities for the Victorian Energy Market, *Langmore M and Dufty G (2004).* Langmore and Dufty (2004) argue that households demand responsiveness to electricity price changes is inelastic in both the short-run and the long-run due to the essential nature of electricity.

1.4 THE PURPOSE AND SCOPE OF THIS RESEARCH

The purpose of this research is to determine the consumer behavior of large industrial customers (mining and industry) in South Africa on increased electricity prices. The research hypothesis is therefore:

- The price elasticity of demand for large customers in South Africa is inelastic in the short-term and elastic in the long term
- Large consumers will change their consumption if electricity prices increase
- High electricity prices will force large customers to consider alternatives

1.5 THE RELEVANCE OF THE TOPIC TO BUSINESS IN SOUTH AFRICA

The electricity industry throughout the world is changing because electricity utilities are being pressured due to globalised markets and governments opening up their countries to foreign investors to help fund power sector expansion and development. South Africa is not exempted from these changes and will therefore have to align itself with these international developments, *Ramokgopa B (2008).* Government's electricity pricing policy is to achieve a balance between equity, economic growth and environmental goals. A balance has to be established between affordable electricity prices for households, low-cost electricity for industrial consumers, prices that provide efficient market signals by accurately reflecting the cost of supply and a general price level that ensures the financial sustainability of electricity utilities, *Ramokgopa B (2008).*

Consumers and business feel strongly about the price of electricity. Evidence in this regard is underscored by Wall Street analysts that strongly favor utilities that successfully compete as low cost providers, Mills and Ramsey (1995). Mills and Ramsey (1995) argue that customers would switch to low cost electricity providers, similar to how people switch to different cellular telephone providers, provided that they can pay lower tariffs. The conclusions drawn by Mills and Ramsey (1995) on the issue of whether price matter is as follows:

- Cheap electricity is preferred and is anti-inflationary
- Electricity is the primary energy input to the economy
- Competitive forces and technology progress drives prices down
- New end-use technologies are biased toward electricity and increase competitiveness

In the light if the above it is critical to comprehend the impact of increased electricity prices on large Eskom customers.

2. CHAPTER 2: THEORY AND LITERATURE REVIEW

The purpose of this chapter is to present a review of an existing body of knowledge of relevance to this research, and pull it all together at the end.

2.1 THEORY ON PRICE ELASTICITIES, Niemeyer (2001)

Numerous studies have estimated overall price elasticities of electricity demand. *Bohi (1981), Bohi and Zimmerman (1984), and an Electricity Power Research Institute (EPRI) report by Laurits R.* Christensen Associates (1988) provide useful summaries of the demand models and statistical techniques used to estimate the elasticities, as well as the values themselves. The reported elasticity values vary widely; though generally fall within expected ranges (see Table 3).

Table 3: Own Price Elasticities of Demand for Electricity

PRIVATE	SHORT-RUN			LONG-RUN		
	Low	Med	High	Low	Med	High
Residential	-0.05	-0.20	-0.40	-0.30	-0.60	-1.20
Commercial	-0.20	-0.30	-0.70	-0.80	-1.10	-1.30
Industrial	-0.10	-0.20	-0.30	-0.90	-1.20	-1.40

Source: Niemeyer (2001)

Own-price elasticity is the ratio of the percentage change in the quantity demanded of a good or service to the percentage change in its price after controlling for all other factors that might affect demand (e.g., weather, and the level of economic activity), *Niemeyer (2001).* This is “Price Elasticity of Demand”. Since consumers tend to reduce consumption as prices rise, own-price elasticities take on negative values. Typical values tend to range in absolute value from zero to one, but can be larger than one (e.g. if a 10% price reduction leads to a 5% increase in electricity consumption, then the implied price elasticity (% _Q / % _P) is – 0.5 [i.e., 5% / (-10%)]), *Niemeyer (2001).*

Another property of own-price elasticity is that it reflects the relationship between the change in the price of a good and the change in consumers' expenditures on that good. At unitary elasticity (i.e., –1), a given percentage price change is offset by an equal change in consumption, leaving expenditures unchanged. If demand is inelastic (i.e., elasticity < 1 in absolute value), a price increase (decrease) will lead to higher (lower) expenditures. Finally, if demand is elastic (i.e., elasticity > 1), a price increase (decrease) will lead to lower (higher) expenditures, *Niemeyer (2001).*

Customers' ability to respond to price changes tends to increase with the length of time that has passed since the price change. In the short run (< 2 years) consumers may only vary the intensity of use of their current stock of equipment. In contrast, in the long-run (> 5 years) consumers have sufficient time to adjust to the change in price level by changing the amount and / or nature of their capital equipment. Thus, long-run price elasticities tend to exceed short-run price elasticities of demand (in absolute value), *Niemeyer (2001).*

Generally, certain factors are likely to affect the degree of consumers' electricity price responsiveness (e.g. the larger, or more important are electricity expenditures as a fraction of income, or total operating costs, the greater is the likely price responsiveness). That is, a small retail sales customer for whom electricity expenditures are relatively unimportant is likely to respond less to price changes than a large manufacturer with electric-intensive processes. In the short run, the manufacturer will make an effort to reduce usage during high-price periods and take advantage of low-price periods. In the long run, it will make plant expansion or relocation decisions in part on the level of electricity prices, *Niemeyer (2001).*

2.2 THE IMPORTANCE OF CHEAP ELECTRICITY IN THE ECONOMY

Consumers and business feel strongly about the price of electricity. Evidence in this regard is underscored by Wall Street analysts that strongly favor utilities that successfully compete as low cost providers, *Mills and Ramsey (1995).* Mills and Ramsey (1995) argue that customers would switch to low cost electricity providers, similar to how people switch to different cellular telephone providers, provided that they can pay lower tariffs. This phenomenon is known as "wheeling". A survey of commercial and industrial customers found that, *Mills and Ramsey (1995):*

- 38% would switch electricity suppliers for a 5% rate reduction
- 53% would switch for a 10% rate reduction

The conclusions drawn by Mills and Ramsey (1995) on the issue of whether price matter is as follows:

- Cheap electricity is preferred and is anti-inflationary
- Electricity is the primary energy input to the economy
- Competitive forces and technology progress drives prices down
- New end-use technologies are biased toward electricity and increase competitiveness

2.3 ELECTRICITY PRICING METHODS

Various types of pricing methods exist in order to facilitate DSM participation programs. This study focuses on the differences between Real Time Pricing (RTP) and Time of Use (TOU) pricing. The fundamental difference between RTP and TOU is that RTP is dynamic and TOU is static (see Table 4), *Abrate (2003).*

RTP is regarded a more efficient pricing method compared to TOU. However, TOU is more widely accepted in part because it is easier and less costly to implement, *Abrate (2003).* RTP pricing implementation requires investment in sophisticated metering technology and efficient communication systems. Technology advancements in metering technology as well as the rapid growing internet may soon overcome the limitations associated with RTP implementation.

Energy does not yield utility in itself, but is rather desired as an input into other processes, *Abrate (2003).* Hence, ignoring the possibilities of substitution between peak and non-peak usage, demand response to higher prices typically involve substitution to other factors of energy. The following are popular characteristics of demand, *Abrate (2003):*

- Energy is undesired in itself; energy demand is driven from demand for more basic products (e.g. light, warm and cold space, motive power, etc.).
- Energy involves usage of durable goods; therefore, it is important to distinguish between short-run and long run demand elasticity.
- While both techniques and results are quite variable, with good approximation, short-run elasticity is measured around -0.2, whereas long-run aggregate elasticity of demand is likely to be in the range of -0.4 to -0.9.
- Energy is virtually applied in all activities, but factor proportions vary widely. This leads to the implication that price elasticity vary widely across users.
- Price elasticities can vary among different regions. This could lead to an overstatement in the estimation of long-run price elasticities in cross-section empirical analysis. Increase in prices of a certain region can involve

migration of industries to another region, reducing energy consumption in the initial location, but without influence on the total energy consumption.

Abrate (2003) argue that the marginal cost of producing electricity varies considerably over time, since demand is highly variable, whereas production is subject to rigid short term capacity constraint. Furthermore, Abrate (2003) states that during off-peak times, there is plenty of capacity and the cost of producing an additional kilowatt-hour only reflects fuel and some operating and maintenance costs, while during peak periods, the capacity constraint will be binding and the incremental cost can increase greatly. As a result Abrate (2003) states that the end-use consumer faces a fixed retail price, which does not give a signal of the actual system load and demand does not play an active role in determining prices.

The measurement of demand responsiveness based on the literature highlighted is the effective price elasticity of demand (i.e. "how much will be willing to change his consumption") *Abrate (2003).* Hence, recently the attention has been dedicated to the possibility of substitution between peak and non-peak usage. The majority of these studies consider a TOU static framework, whereas only a few works concern dynamic pricing Abrate (2003). Earlier work according to Abrate (2003) focused on energy demand (empirical work published in 1975).

Demand-side participation programs are therefore becoming popular. Table 4 describes various types of demand-side participation programs available, *Abrate (2003).*

Table 4: Demand-side participation programs

	Definition	Signal of the actual supply/demand balance
Real-Time Pricing (RTP)	Retail electricity prices that fluctuate with the real time wholesale prices	***Accurate***, depending on the lag time between the price announcement and the price implementation
Time-of-Use Pricing (TOU)	Retail electricity prices varying in a preset way within a certain block of time	***Approximate***, since prices do not capture the price variation within a price block. Moreover, they are based on the average wholesale market variation and adjusted infrequently
Demand Charges	Instrument that allows a portion of the consumer's bill to be calculated on the basis of the consumer's maximum capacity usage	***Approximate***, since the charge is based on the individual peak and not on the system peak
Critical Peak Pricing (CPP)	System that usually starts with a TOU rate structure, and adds one more rate that applies to critical peak hours, which the system operator can call on short notice	***Good***, but less accurate than RTP for two reasons: first, the level of prices for the peak hours are preset; second, the number of peak hours that can be called in a year is limited.
Interruptible Demand Programs	System with a basic constant rate structure, with the option for the system operator to cut off supply to some customers.	Since the customers are not actually physically interrupted, but they retain an option to continue to consume at a greatly increased price, these programs can be viewed just as a crude form of CPP.
Real Time Demand-Reduction Programs (DRP)	System where certain customers are eligible to be paid to reduce their consumption at certain times.	Similar to interruptible demand programs

Source: Abrate (2003), p7

Demand response programs provide incentives for retail customers to reduce demand for electricity during peak hours. The benefits are related to a more efficient use of resources, because customers can partially shift consumption to non-peak hours, thus reducing the excess capacity that should be built. Customers are able to respond to price signals, but the extent of such a response varies widely across users. This can raise equity issues and can imply the necessity to apply a different rate structure among different groups. Large industrial users are the ones more likely to have benefits above costs from the implementation of a RTP tariff, *Abrate (2003).*

2.4 DEMAND RESPONSIVENESS IN ELECTRICITY MARKETS

Lafferty, Hunger, Ballard, Mahrenholz, Mead and Bandera (2001) argue that economic theory provides two expectations about price elasticity. Firstly, a higher price should reduce the quantity demanded and the price elasticity should be negative. Secondly, since more substitution can take place when more time is given, price elasticity for a given product which allow little time for substitution (short-run) will be more inelastic then when more time is allowed for substitution and the development of substitution technologies (long-run). Numerous studies on price elasticity in the electric industry have been published, with the most recent involving that of (TOU) pricing, *Lafferty, Hunger, Ballard, Mahrenholz, Mead and Bandera (2001).*

2.4.1 Non-TOU Price Elasticity

A number of the price elasticity studies from before 1980 are captured in one of four survey articles according to Lafferty, Hunger, Ballard, Mahrenholz, Mead and Bandera (2001). Eighteen elasticity studies, incorporated in two surveys by Taylor, led to the summary conclusions that the short-run price elasticity for aggregate electricity demand is -0.2 and the long run elasticity is between -0.7 and -0.9. Bohi (1984) found that the few existing studies for commercial demand indicated that long-run demand is elastic, while studies of industrial demand, which Bohi criticises severely and have a consensus estimate of price elasticity of 1.3. Bohi (1984) conclude that the wide variance of the elasticity estimates from available studies make it difficult to report the price elasticity for either the commercial or industrial sector.

2.4.2 TOU Price Elasticity Literature

Most recent studies of electricity price elasticity have included the analysis of TOU pricing. The sample evaluated in a number these studies; see Table 5 (the range of price elasticities estimated in each of these studies), *Lafferty, Hunger, Ballard, Mahrenholz, Mead and Bandera (2001).*

Table 5: TOU Price Elasticities

STUDY	BUSINESS			
	PEAK		OFF - PEAK	
	Most Elastic	Least Elastic	Most Elastic	Least Elastic
Woo	-0.04	-0.03	-0.05	-0.03
Tishler	-0.09	-0.04	-0.06	-0.02
Tishler	-0.47	-0.01	-0.38	-0.02

Source: Lafferty, Hunger, Ballard, Mahrenholz, Mead and Bandera (2001)

2.5 CUSTOMER RESPONSE TO ELECTRICITY PRICES

According to EPRI, numerous studies have been conducted on the price responsiveness of consumers demand for electricity during the "energy crisis" period in the United States of America (USA) (1970 to 1980), *Niemeyer (2001).* These studies summarised the estimates of consumers own-price elasticity's which can be defined as the ratio of the percentage change in the quantity demanded of a good or service to the percentage change in it's price, assuming ceteris Para bus *Niemeyer (2001).* Typical values reported in the literature of this study for residential, commercial and industrial customers range between -0.2 to -0.3 in the short term (e.g. 1 to 3 years) and -0.6 to -0.12 in the long term (e.g. 5yrs and above). This study furthermore reported separate average elasticity values for different industrial business types.

Niemeyer (2001) found that industrial consumers whose expenditures on electricity comprise a relatively large portion of their overall costs tend to be more sensitive to changes in electricity prices. In contrast, consumers in industries where electricity costs are a minor component of their overall costs are relatively unresponsive to electricity price changes. The average values by group (see Table 6) provide evidence to support this hypothesis. The average price elasticity for the six most electricity intensive industries is more than twice that for the least intensive industries and two of the moderately intensive industries are among the most price responsive.

Table 6: Industry Long-Run Price Elasticities

INDUSTRY & (code)	OWN PRICE ELASTICITY
Food and Kindred Products (20)	-0.48
Textile Mill Products (22)	-0.69
Apparel, Other Textile Products (23)	-0.49
Lumber and Wood Products	-0.25
Furniture and Fixtures (25)	-0.90
Paper and Allied Products (26)	-0.45
Printing and Publishing (27)	-0.31
Chemicals, Allied Products (28)	-1.54
Petroleum and Coal Products (29)	-1.18
Rubber, Miscellaneous Plastic Products (30)	-0.44
Leather and Leather Products (31)	-0.34
Stone, Clay and Glass Products (32)	-0.46
Primary Metal Industries (33)	-1.72
Fabricated Metal Products (34)	-1.46
Machinery, Except Electrical (35)	-1.29
Electrical Equipment and Supplies (36)	-0.53
Transportation and Equipment (37)	-0.47
Instruments and Related Products (38)	-0.23
Miscellaneous Manufacturing Industries (39)	-0.37
INDUSTRY	**AVERAGE PRICE ELASTICITY**
Electric Intensive (22, 26, 28, 29, 32, 33)	-1.01
Moderately Intensive (20, 30, 34 - 37)	-0.78
Non-Electric Intensive (21, 23 – 25, 27, 31, 38, 39)	-0.41

Source: EPRI (2001)

A study conducted by Sheen, Chen and Wang (1995) to determine the response of large industrial customers to electricity pricing by voluntary TOU in Taiwan, found that electricity pricing by TOU was highly responsive to price changes. It was found that TOU customers decrease peak electricity consumption and increase off-peak electricity consumption where TOU tariffs are implemented *Sheen, Chen and Wang (1995).*

Eskom and Enerweb have been active to understand the impact of TOU electricity tariffs on large Eskom customers, *Bipath, Nortje and Heunis (2004).* This research is particularly relevant considering the major pricing changes introduced to both the Megaflex and Nightsave tariffs since 2002. This study considered the impact of the tariff changes on different customer segments and furthermore considered the seasonal impacts (i.e. winter peak demand and summer demand).

The motivation for this research was supported considering the impact and nature of customer response on Eskom's planning assumptions and pricing strategy. It was found that industry drivers play a significant role in the customers' price sensitivity. This is most pronounced in the ferro metals industries and, to a lesser extent, in the mining industry *Bipath, Nortje and Heunis (2004).*

The Nightsave customers do not appear to react significantly to the time differentiated tariff. This could be explained by considering the effective price signal by the Nightsave tariff. Using the actual consumption of consumers, the price per unit (Peak to Off-Peak) differentiation is 26 c/kWh to 10 c/kWh, compared to Megaflex which is 57.5 c/kWh to 8.8 c/kWh. Nightsave customers only represent approximately 3 500MW of total system demand and, with approximately 2000MW of this demand being Municipal (proven not responsive). The remaining 1500MW (max demand) appears to react (i.e. the ferro metals and mining groups). This impact cannot, however, be measured with statistical certainty due to the relatively small sample size available. From observation it appears to be less than 50MW to 100 MW.

The Nightsave tariff had a small impact on the load profiles of the Ferro Metals customers and Gold Mining customers *Bipath, Nortje and Heunis (2004).* This impact is, however, within the sample uncertainty band and is, therefore, not statistically significant. By estimating the effective price differential the customers are exposed to, this could be explained (i.e. not enough incentive exists for load shifting in the case of Nightsave customers).

Hence, the focus of this study will be to consider the impact of the MegaFlex tariff on large Eskom customers (industrial and mining).

3. CHAPTER 3: RESEARCH HYPOTHESES

This study investigates the impact of increased electricity prices on the consumption behavior of large South African industrial consumers in the short-term and in the long-term.

3.1 RESEARCH HYPOTHESIS 1

The price elasticity of demand for large electricity customers in South Africa is inelastic in the short-term and elastic in the long-term.

3.2 RESEARCH HYPOTHESIS 2

Large electricity customers will change their consumption behavior if electricity prices increase.

3.3 RESEARCH HYPOTHESIS 3

Increased electricity prices will make large electricity customers to consider alternatives.

4. CHAPTER 4: RESEARCH METHODOLOGY

This study aims to explore the impact of increased electricity prices on consumer demand of large electricity customers in South Africa. This section of this report summarises the research methodology followed in conducting this research.

4.1 RESEARCH DESIGN AND DATA USED FOR THE STUDY

A two-pronged research methodology was followed, which includes both qualitative as well as quantitative research.

The qualitative research (aim is to obtain secondary data) was conducted based on exploratory research in the form of literature reviews that considered both local as well as international reviews related to this research.

The quantitative research (aimed to obtain primary data) was based on historical data obtained by Eskom on load research to determine consumption patterns of large electricity consumers. Statistical inferences were made on the achieved results.

The research methodology can be summarised as follows:

- A literature review (considering local and international data) was conducted
- Historical consumption data of large electricity consumers (on the Eskom Megaflex tariff), in particular mining and industrial customers was used during this analysis to analyse consumption behaviour
- This data was used to calculate demand elasticities of these large customers during peak and off-peak periods

4.1.1 Hourly Customer Load Data

Historical data of Eskom Megaflex customers since 2003 are used in this study. Load data from the same accounts are used until 2007 and beginning of 2008. The same customer data is used for each year in order to assess the effects of industry drivers.

A total of 80 accounts were tracked since 2003 and were scaled using sample design theory in order to estimate the total Megaflex load profile. Some filtering was applied and discussed in section 4.2 of this report.

4.1.2 Description of Customers used in this Study

Cordaptix (Eskom Enerweb Database) was used to extract customer descriptions, the Economic Sector, the Standard Industry Classification (SIC) code as well as the customer's applicable tariff. These accounts were combined in order to ensure information consistency. This was achieved through:

- Removing all accounts that were on more than one tariff
- Removing all accounts that had more than one economic sector description

This process ensured that customers used in this study are not on more than one tariff. Furthermore, it ensures that the customers used in this study does not fall within more than one economic sector and are not subject to a mix of price signals (both from the tariffs and industry drivers).

4.1.3 Industry Drivers

Table 7 highlights the industry drivers considered in this study.

Table 7: Industry Drivers

Description	Unit	Time basis	Start date	End date
Gold price (JSS-GOLD)	USD	Daily	19850327	20071231
Platinum price	USD	Daily		20071231
Ferro chrome price	USD	Weekly	20000109	20071231
Ferro manganese price	USD	Weekly	20010101	20071231
Ferro silicon price	USD	Weekly	20010101	20071231
USD/ZAR exchange rate ($-Rand)	-	Daily	19850902	20071231
Consumer Price Index (CPI)	-	Monthly	19600101	20071231
Producer Price Index (PPI)	-	Monthly	19600101	20071231

Source: ShareNet and Eskom Treasury

All data was converted to South African Rand (ZAR) using an applicable exchange rate that was aggregated to a weekly level.

4.1.4 Demand Market Participation (DMP) Data

During 2007, the Eskom DMP programme (is used during under-frequency load conditions and forms part of the energy supply planning process) had three different contract types (Instantaneous, Supplemental and Emergency) as part of the load shedding process.

Instantaneous

Is used during under-frequency conditions and has a maximum duration of 10 minutes. However, due to the relatively short shed durations, the instantaneous events were not considered in the impact analysis.

Supplemental

The average shed duration is significantly longer (between 1 hour and 2 hours).

Emergency

The load shedding duration is similar to supplemental. However, the customers are not scheduled on stand-by and only respond when dispatched during emergency situations. This category of DMP has been discontinued.

A total of nine Instantaneous customers took part in this programme during 2007 with a total certified capacity 322MW. A total of eight Supplemental DMP customers took part with a total certified capacity of 441MW. A total of 26 Emergency DMP customers took part with a total certified capacity of 1,159MW.

Both supplemental and emergency DMP customers were included in the impact analysis. All event data since 2005 were obtained from the DMP programme and loaded into an Operational Data Store (ODS). A cross-reference between the DMP contracts and the relevant accounts were obtained.

4.1.5 Key Industrial Customers and Municipal Customers

During February 2008 and March 2008, key Eskom industrial customers were requested to reduce their load by 10%. Eskom annually define the key industrial customers and for the 2007/08 period, 154 customers qualified.

The load profiles for these 154 customers were extracted from the Eskom Enerweb's SPOT database between April 2007 and March 2008. No additional filtering was applied.

During March 2008, Municipal customers participated in the voluntary load reduction and the aggregate municipal load profile was extracted from the MV90 upload process using Cordaptix customer metadata (tariff and Standard Industry Classification).

4.1.6 Load Shedding Data

Between October 2007 and March 2008 mandatory load shedding occurred. An event list was sourced from Eskom Transmission with an indication of the amount of Megawatts (MWs) that were instructed to be daily load shedded.

4.1.7 Power Alert

Power alert information as broadcasted daily by the South African Broadcasting Commission (SABC) on the status of the Eskom electricity supply system, was consolidated in order to obtain a maximum daily level. This information was loaded into an ODS. This was used to assess the applicability of Power Alert as a component of DSM, in particular as an alternative to save electricity.

4.1.8 Planned and Unplanned Outages

Planned and unplanned outages from all Generation stations on a monthly basis were obtained and loaded into the ODS.

4.2 POPULATION AND SAMPLING

The population includes the large Eskom customers (mining and industrial) that are on the Eskom Megaflex TOU tariff.

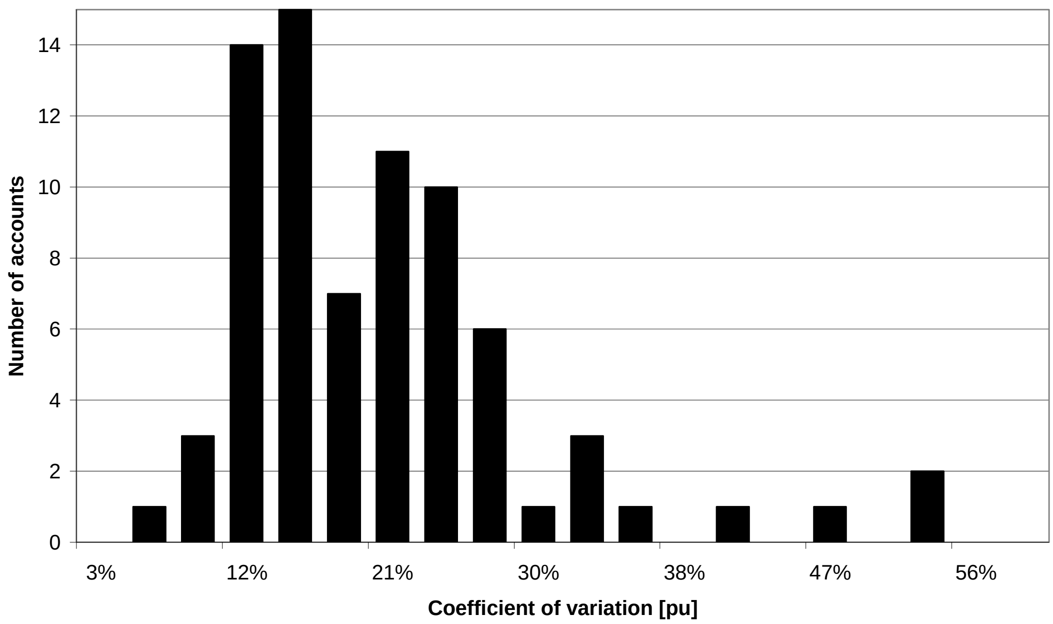
The sample of major Eskom customers included in the population can be categorised into a particular Sector Industry Class (SIC) consisting of the Industrial Sector and Mining Sector within South Africa. Much of the sample data was discussed in section 4.1 of this report. The strata was categorised according to strategic bins that will classify users in terms of high, medium and low consumers within a particular SIC category.

The TOU Tariff (Megaflex) was considered and the impact of pricing changes associated with this tariff on the selected sample was analysed. This was done based on an assumption that this will give a good reflection of behavioral changes impacted by increased electricity prices.

4.2.1 Sample Filtering on Hourly Customer Load Data

The hourly load data were extracted from the Eskom Enerweb Cordaptix Upload process and filtered to remove significant level changes in the data. The purpose was to eliminate the effect of plant expansion or reduction. A histogram on the filtered data is presented in Figure 4, which illustrates the coefficient of variation of monthly electricity consumption patterns for different accounts. A level of 33% for Megaflex was chosen as a good play-off between variability and data available.

Figure 4: Coefficient of Variation Histogram for Different Megaflex Accounts from October 2002 to August 2008



The number of accounts available post the filtering process is presented in Table 8, which were reduced to 71 from 76.

Table 8: Number of Megaflex Accounts Available After Filtering

Tariff	Total Number of Accounts	Number of accounts after filtering
Megaflex	76	71

4.3 RESEARCH LIMITATIONS

A number of limitations impacted the results of this research. These include:

- The availability and accuracy of historical load research data on customer consumption patterns
- The availability of recent literature relevant to the research topic being addressed
- Accuracy of data obtained through structured interviews with large industrial customers (customers may be sensitive to share information, interviewer bias, time constraints, the structure of the questionnaire, incorrect statistical inferences, etc.)

4.3.1 Sample Design

Sample design techniques were applied as only a portion of the load profiles were available for this analysis. This was done in order to obtain an estimate of the population response.

Specifically a model-based sample design strategy was followed. The model that was used is as follows:

- $L_{i,j} = a_{i,j}\overline{L} + b_{i,j} + \varepsilon_{i,j}$
-

Where:

- $L_{i,j}$ - is the load of group i at time j
- $a_{i,j}$ - is the slope of a linear regression
- $b_{i,j}$ - is the intercept of a linear regression
- $\varepsilon_{i,j}$ - is a random variable with mean=0 and standard deviation = f(E[L])

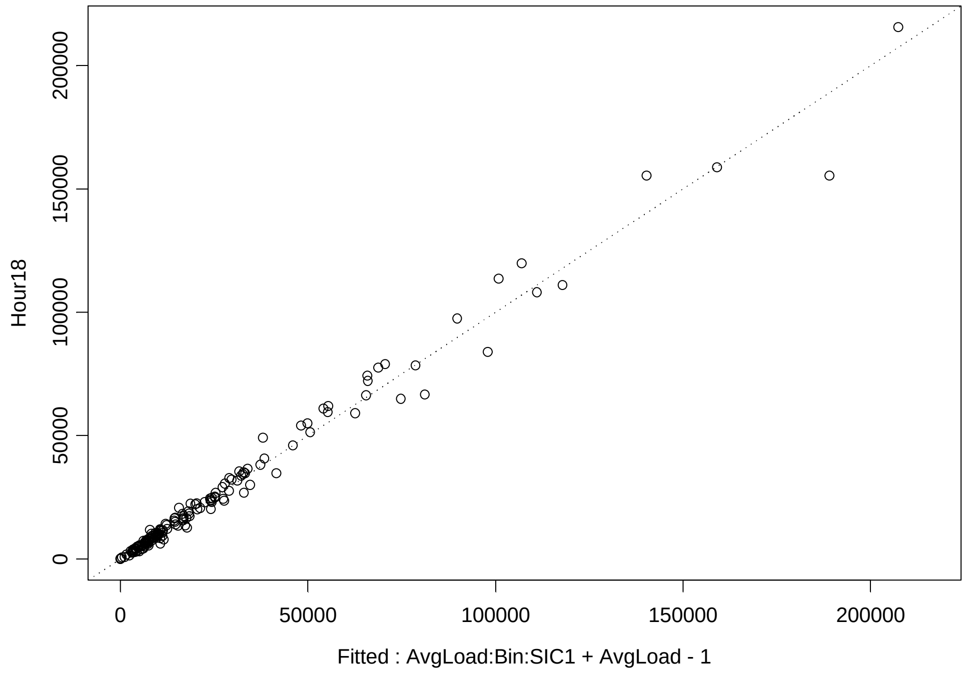
Table 9 presents the groups or strata that were defined per SIC class for Megaflex.

Table 9: Strata per SIC Class for Megaflex

Major Group	Bin	Number of accounts	Number in Sample	Minimum Consumption	Maximum Consumption
Mining (SIC 1)	0	24	16	0	4 781 320
	1	24	20	5 077 580	12 128 800
	2	24	11	12 164 200	161 982 000
Industrial (SIC 2)	0	22	5	20 407	6 139 010
	1	22	16	6 584 750	22 751 700
	2	22	13	23 677 200	512 428 000

The model was fitted using S-Plus 4.5 for Megaflex customers. The results are presented in Figure 5.

Figure 5: Fit of a Model Relating the load at hour 18 and the Average Load (a stratification of Bin and SIC class is used for Megaflex)



This model explains 99% of the variance in the source data. Using this model it is possible to obtain an estimate of the accuracy of this approach. The following equation gives an estimate of the error:

- $$Error_j = \sqrt{\sum_{i=1}^{N}\left(\frac{N_i}{N}\right)^2 \frac{\sigma_{ij}{}^2}{n_i}\frac{(N_i - n_i)}{N_i - 1}}$$

Where:

- $Error_j$ - is the error for hour j
- N - is the total number of profiles in the population
- N_{i} - is the total number of profiles in the population that falls in strata i
- σ_{ij}^2 - is the variance of the profiles at time j for strata i
- n_i - is the number of profiles in strata i in the sample

Since the model explains a very significant portion of the variance, σ_{ij}^2, according to model-based sample design theory it can be adjusted to $(1-\rho^2)\sigma_{ij}^2$, where ρ^2 is the variance explained by the model.

In the analysis, the difference between two 18:00 in consecutive years is sought, therefore:

- $$DiffError_j = \sqrt{2Error_j^2 - 2\rho Error_j^2}$$

Where:

- ρ is the correlation between the load in year 1 and year 2
- $Error_j$ is the error in time j
- $DiffError_j$ is the error in the difference between the load at 18:00 in year 1 and year 2.

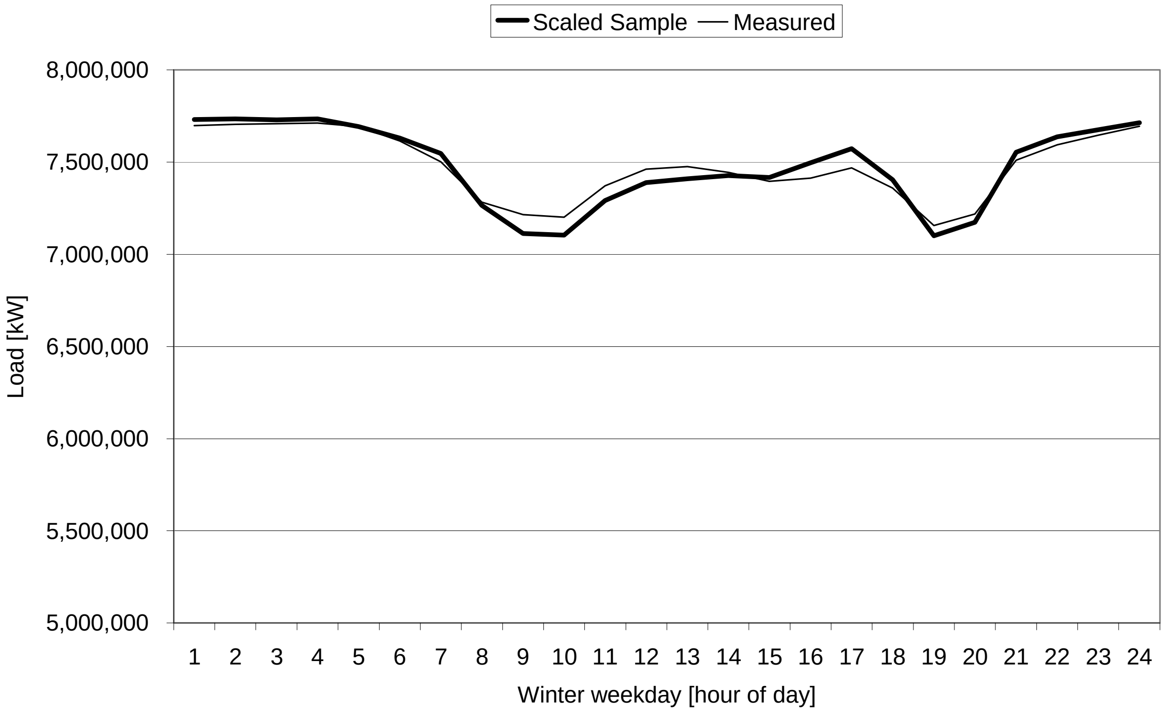
Table 10 summarises the results for the Megaflex customers.

Table 10: Results Obtained for Megaflex Customers

Variable	Megaflex
Variance explained by model [pu]	0.99
Error [pu]	0.15
Adjusted for Model [pu]	0.015
Year on Year Correlation [unitless]	0.85
Diff Error [pu]	0.0082
Estimated Error [MW]	41 MW

The model was ***verified*** by comparing the scaled sample to actual measurements of load during the High season of 2007. Figure 6 presents a comparison between the scaled sample and the measured sample.

Figure 6: Scaled and Measured Sample as well as the Measured Profiles for the 2007 High Season



It should be noted that the measured data cannot be used directly since sufficient historical data does not exist. The scaled sample does appear to represent the population and the measured error is within the level predicted by this model.

5. CHAPTER 5: RESEARCH RESULTS

This chapter presents the finding of this research. In particular, it presents the findings of the total TOU tariff (Megaflex) impact, the energy demand per sector, the results achieved through mandatory and voluntary load reduction as well as the results from the power alert exercise. Furthermore, the calculated price elasticities for the mining and industrial sectors are presented.

5.1 TOTAL TOU TARIFF IMPACT (MEGAFLEX)

This section of this report presents the results achieved within the High Season (June to August), the Low Season (September to May) as well as the DMP corrected results for both High Season and Low Season.

5.1.1 High Season

Figure 7 presents the average winter week day profiles for the Eskom Megaflex customers (Mining and Industrial) for the High Season (June – August) from the year 2003 through 2007.

5.1.2 Low Season

Figure 8 presents the average week day profiles for the Eskom Megaflex customers (Mining and Industrial) for the Low Season (September – May) from the year 2003 through 2007.

Figure 7: Eskom Megaflex Customer (Mining and Industrial) Average Weekday Profiles for the High Seasons (2003 to 2007)

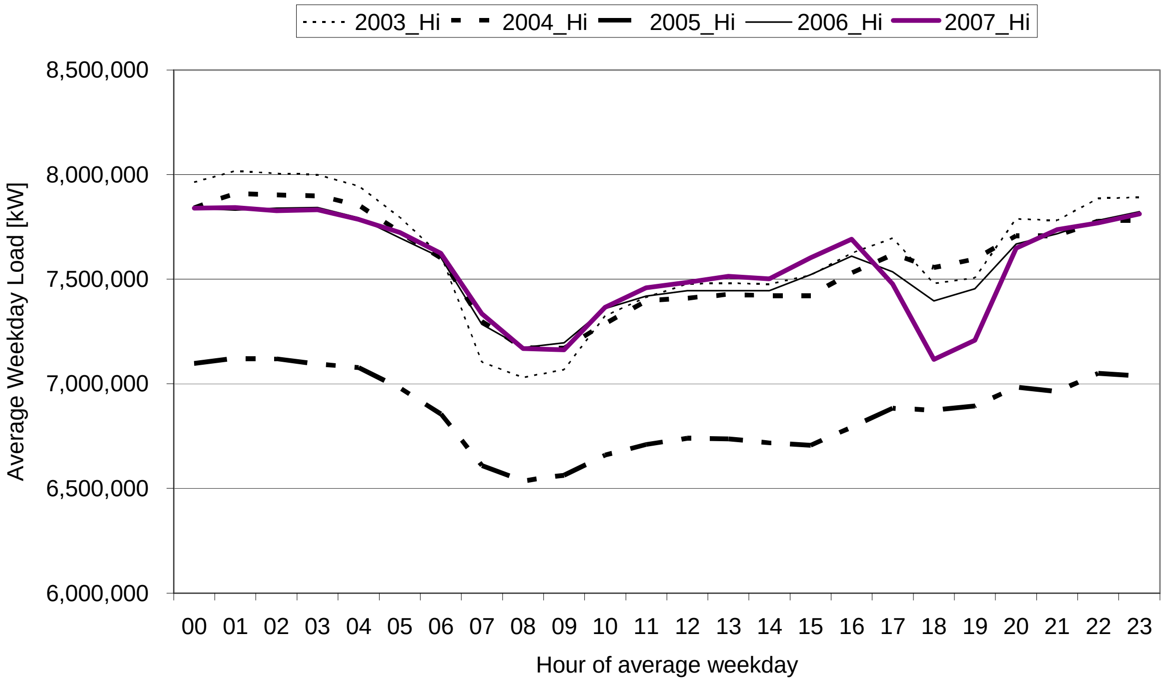
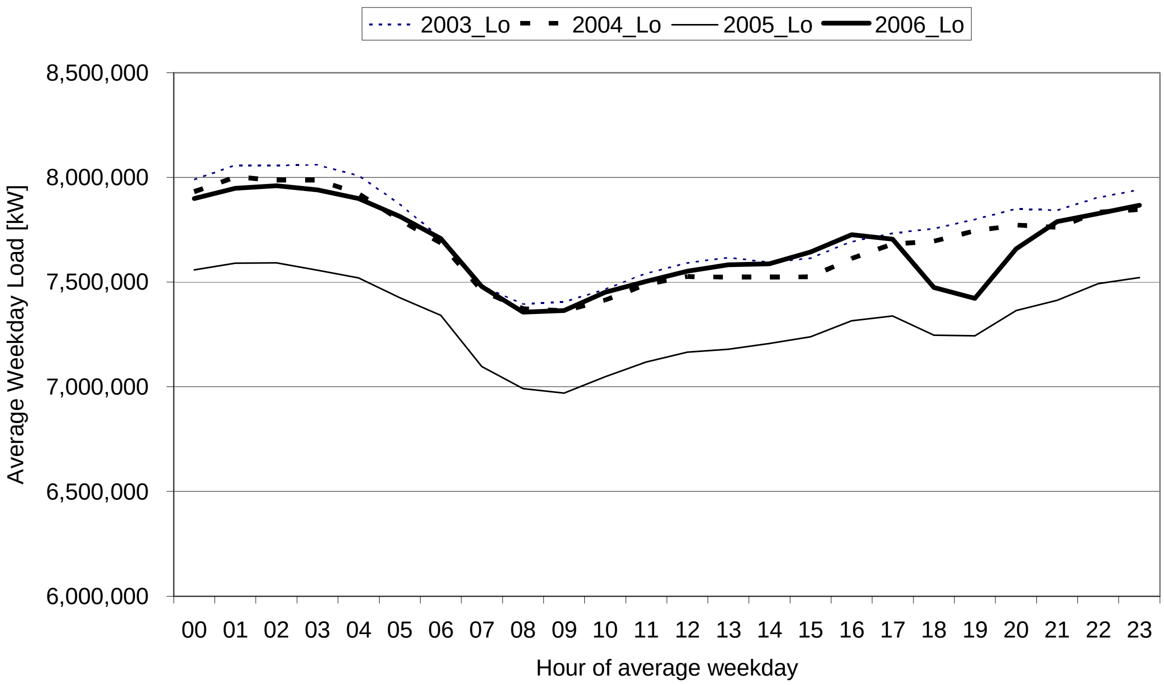


Figure 8: Eskom Megaflex Customers (Mining and Industrial) Average Weekday Profiles for the Low Seasons (2003 to 2007)



5.1.3 High Season and Low Season Corrected for DMP

The high season and low season profiles corrected for DMP are presented in figures 9 and 10, respectively.

Figure 9: Eskom Megaflex Customers (Mining and Industrial) DMP Corrected Average Weekday Profiles for the High Seasons (2003 to 2007)

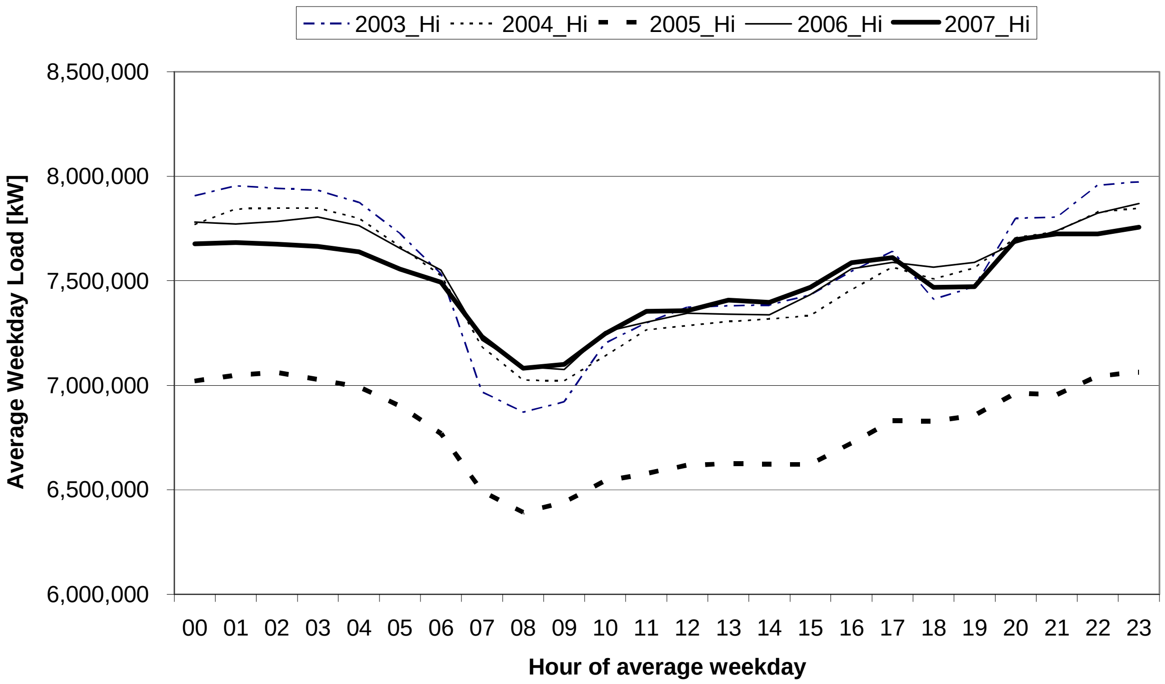
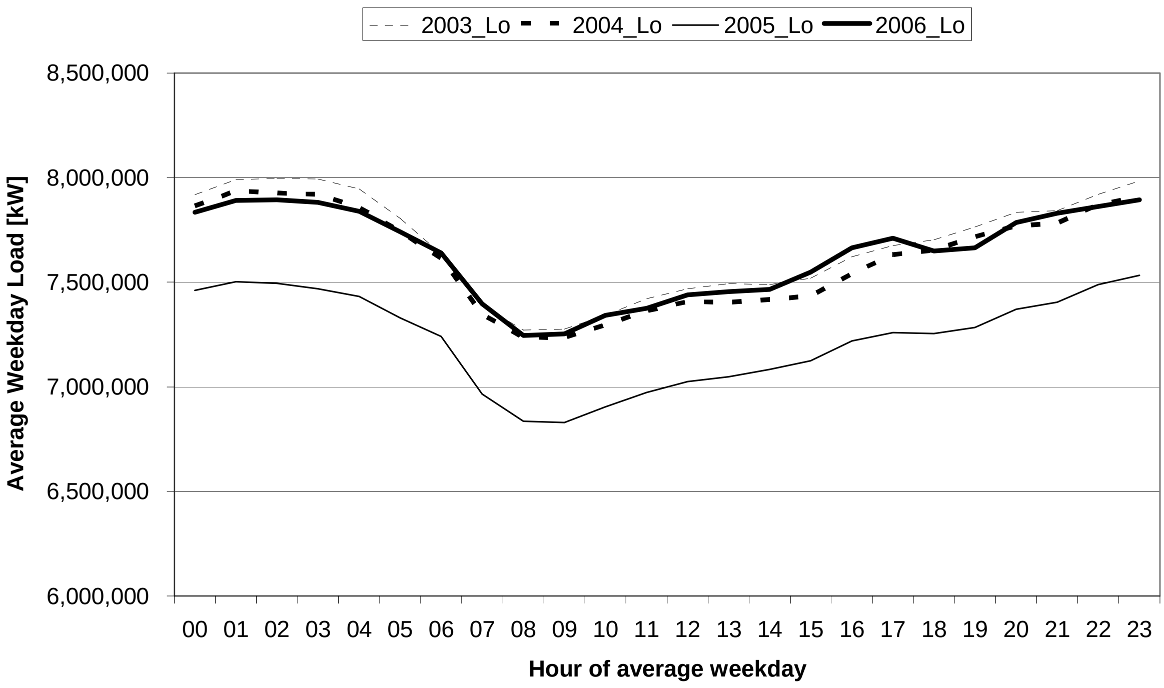


Figure 10: Eskom Megaflex Customers (Mining and Industrial) DMP Corrected Average Weekday Profiles for the Low Seasons (2003 to 2007)



5.2 ENERGY DEMAND PER SECTOR

This section of this report presents the findings of the analysis conducted regarding the energy demand per major sector (i.e. the Ferroy Alloys, Gold Mining and other industries).

5.2.1 Ferro Alloys

The Ferro metals group of Eskom Megaflex customers comprises of Ferro Chrome, Ferro Manganese and Ferro Silicon. Figure 11 presents the DMP corrected average winter weekday profiles for the High Season (June-August) from 2003 to 2007. The Inflation Corrected Ferro Alloy Price per Month (2003 to 2007) is presented in Figure 12.

Figure 11: DMP Corrected Average Weekday Profiles for the High Seasons (2003 to 2007) for Ferro Metals Megaflex Customers

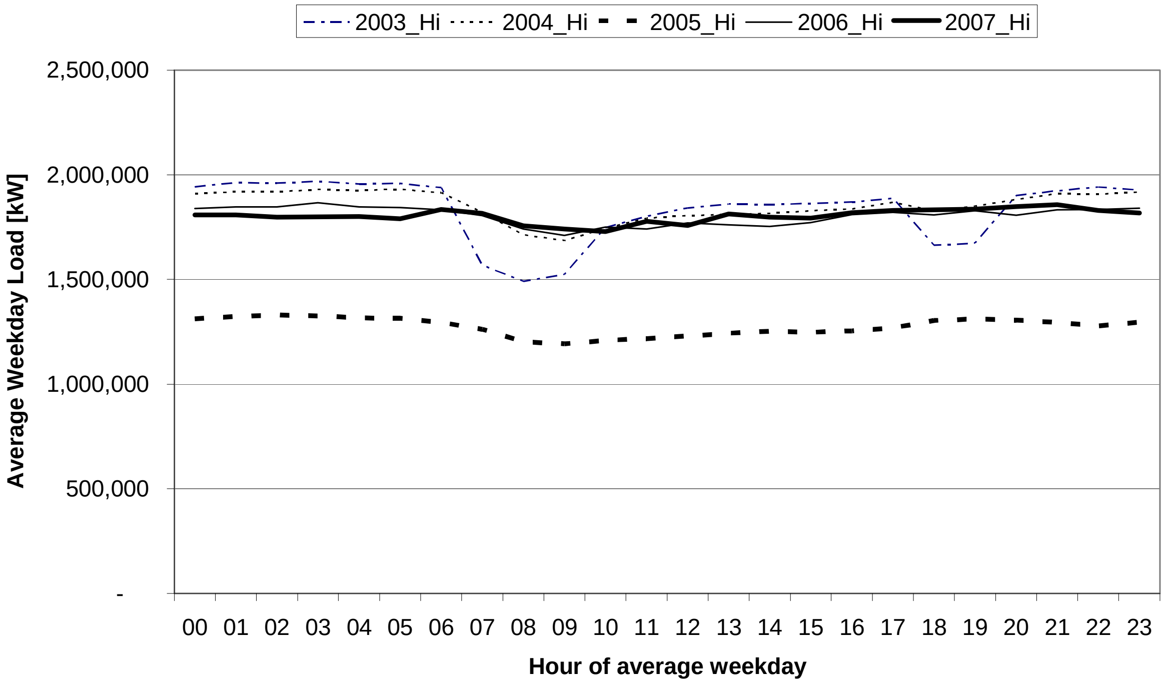
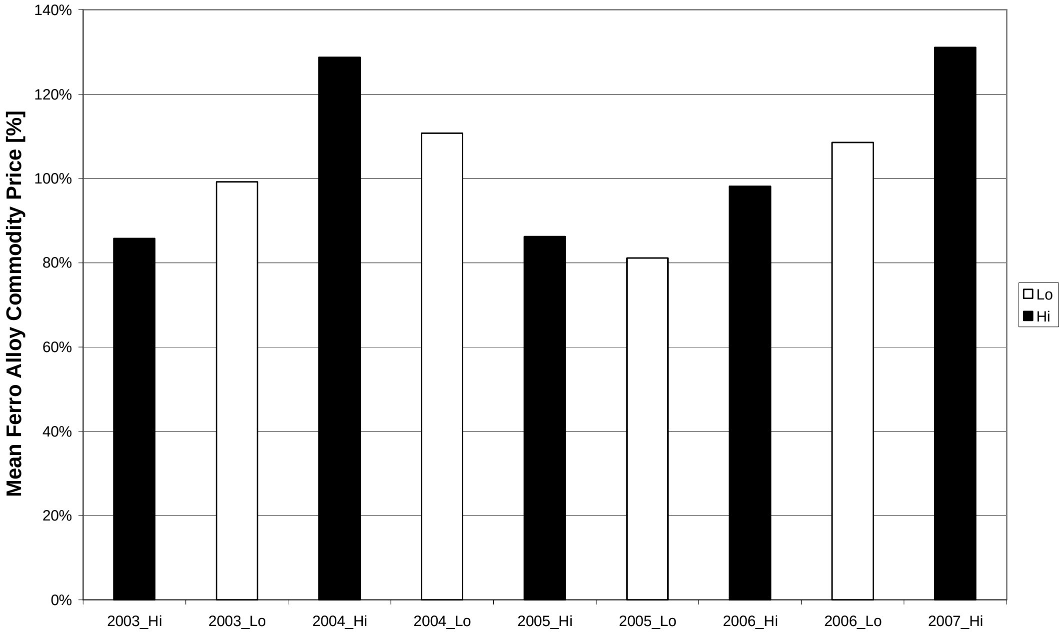


Figure 12: Inflation Corrected Ferro Alloy Price per Month (2003 to 2007)



5.2.2 Gold Mining

Figure 13 presents the DMP corrected average winter weekday profiles for the High Season (June-August) from 2003 to 2007 for the Gold Mining Group of Eskom Megaflex customers.

Figure 13: Average Weekday Profiles for the High Season (2003 to 2007) for Gold Mining Customers on Megaflex

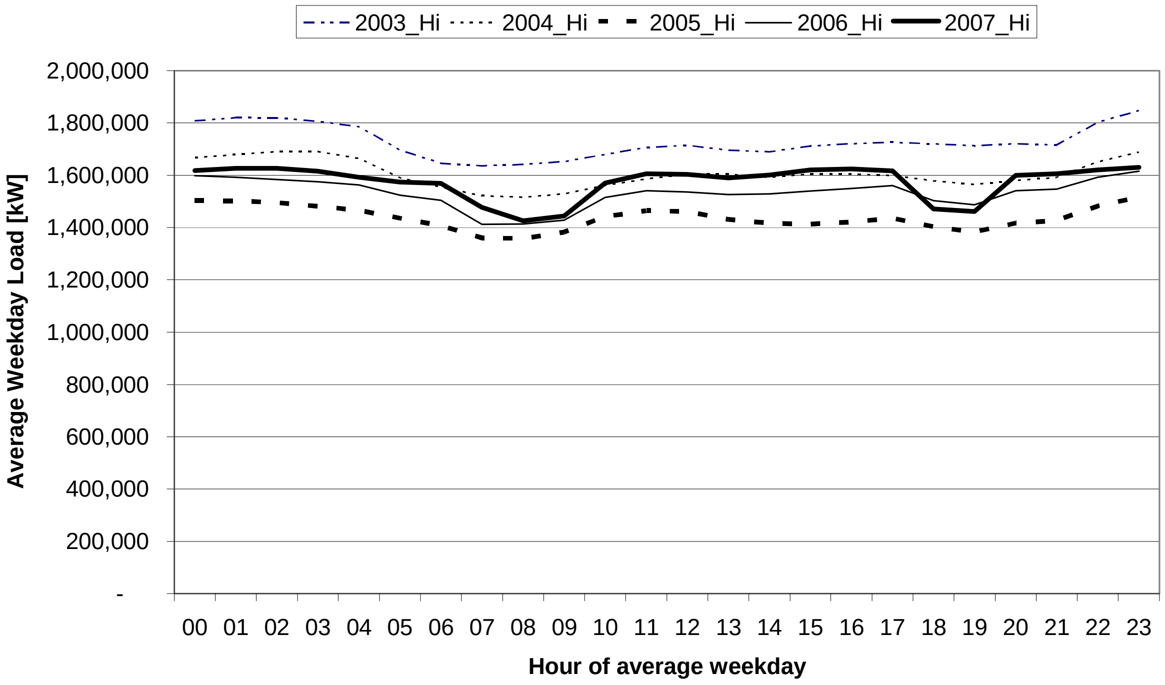


Figure 14 presents the inflation corrected Gold price for the study period. Figure 15 presents the changes in the shape of the Gold Mine Sector (Megaflex only) since 2005. Figure 16 presents the average weekday profiles for the High Seasons (2002 to 2007) for other Eskom Megaflex Customers (Not Gold Mining or Ferro Metals)

Figure 14: Average Gold Price and USD / ZAR Exchange Rate (2001 to 2006). The Gold price was normalised to ZAR and adjusted using PPI.

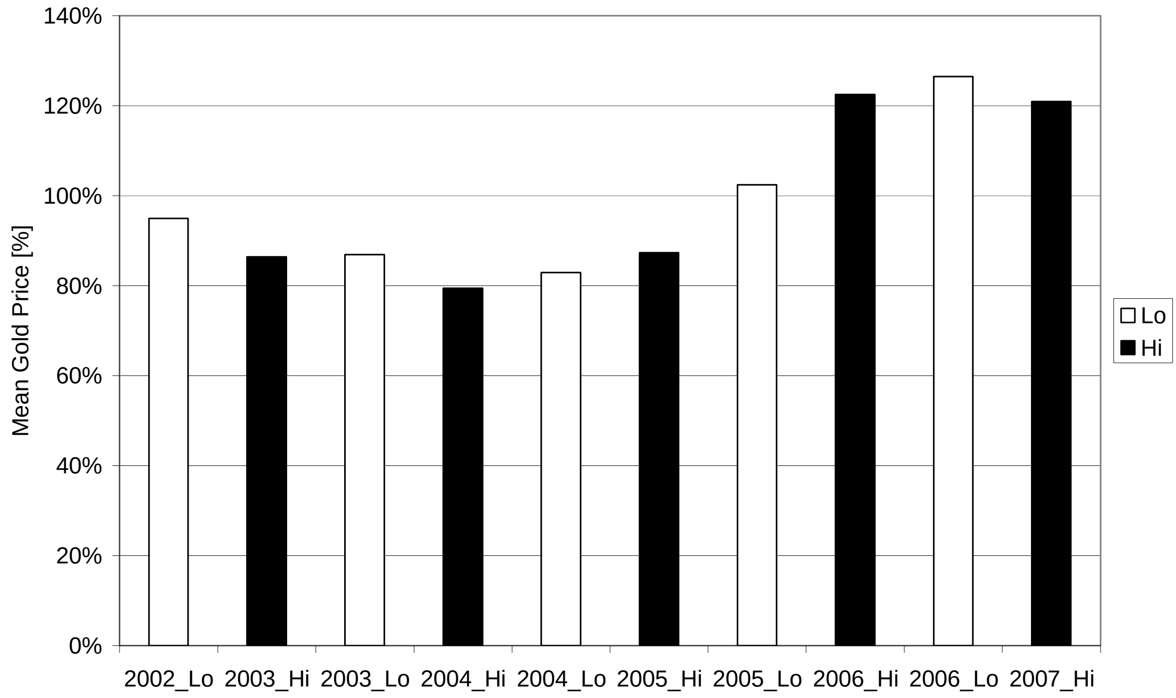


Figure 15: Changes in the Shape of the Gold Mine Sector (Megaflex only) since 2005

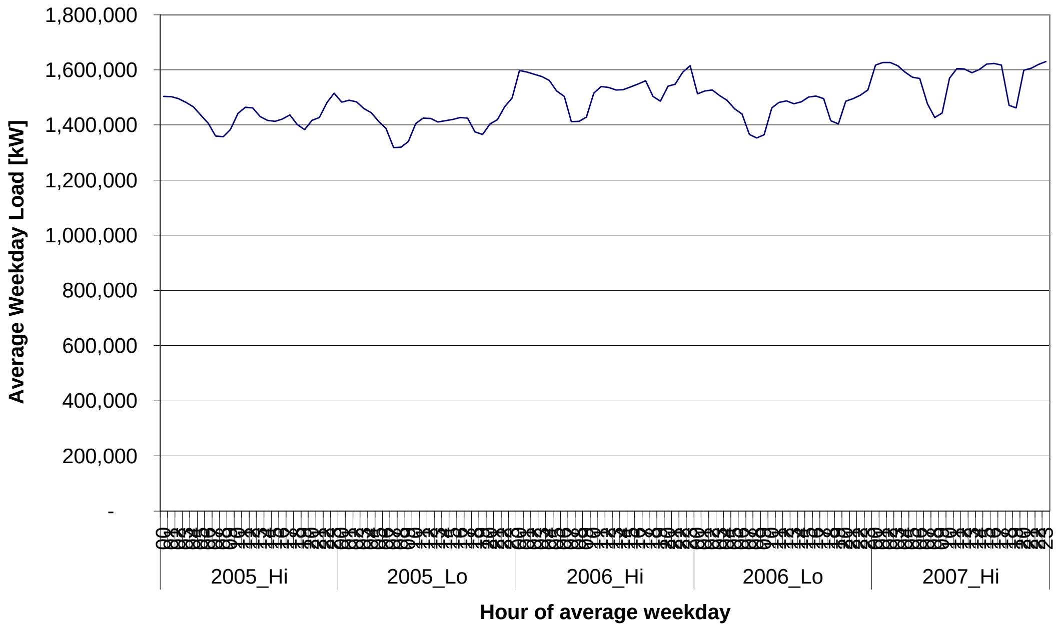
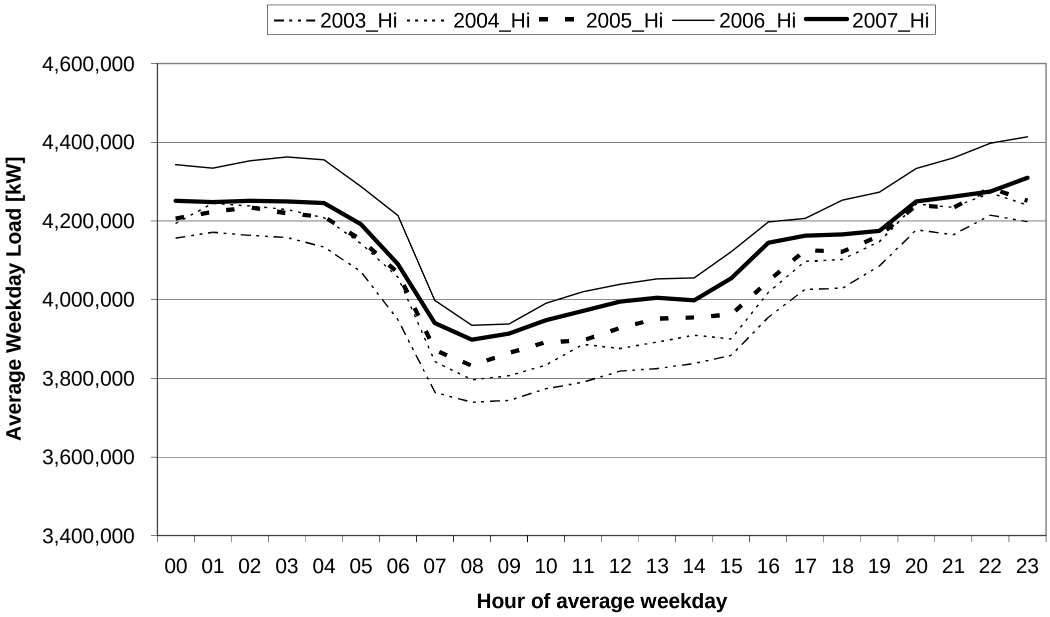


Figure 16: Average Weekday Profile for the High Seasons (2002 to 2007) for other Eskom Megaflex Customers (Not Gold Mining or Ferro Metals)



5.2.3 Other Industries

Table 11 presents the other industries that were available in the sample.

Table 11: Other Industries Available in the Sample

Major group	SIC	Description	Total
Mining	21000	MINING OF COAL & LIGNITE	13
	24100	Mining of Iron Ore	3
	24220	Copper	2
	24230	Manganese	2
	24290	Other metal ore mining, except	5
	25120	Limestone & lime works	2
	25200	MINING OF DIAMONDS	5
	25399	Other minerals & materials	3
Mining Total			**35**
Industrial	31219	Manufacturer of textiles	3
	31290	Manufacturer of other textiles	1
	32310	Manufacturer of pulp & paper	2
	33210	Petrol, fuel, oils, lubricating oils	2
	33410	Manufacturer of basic chemicals	1
	33800	MANUFACTURER OF PLASTICS	2
	34240	Manufacturer of cement, lime	5
	35110	Stainless steel	1
	35111	Conventional iron & steel	3
	35201	Refining of precious metals	1
	35224	Titanium	1
	35225	Zinc	1
	35227	Silicon metals	1
	35228	Other primary non-ferrous	1
	35310	Casting of iron & steel	2
	38309	Manufacturer of other motor vehicles	1
Industrial Total			**28**

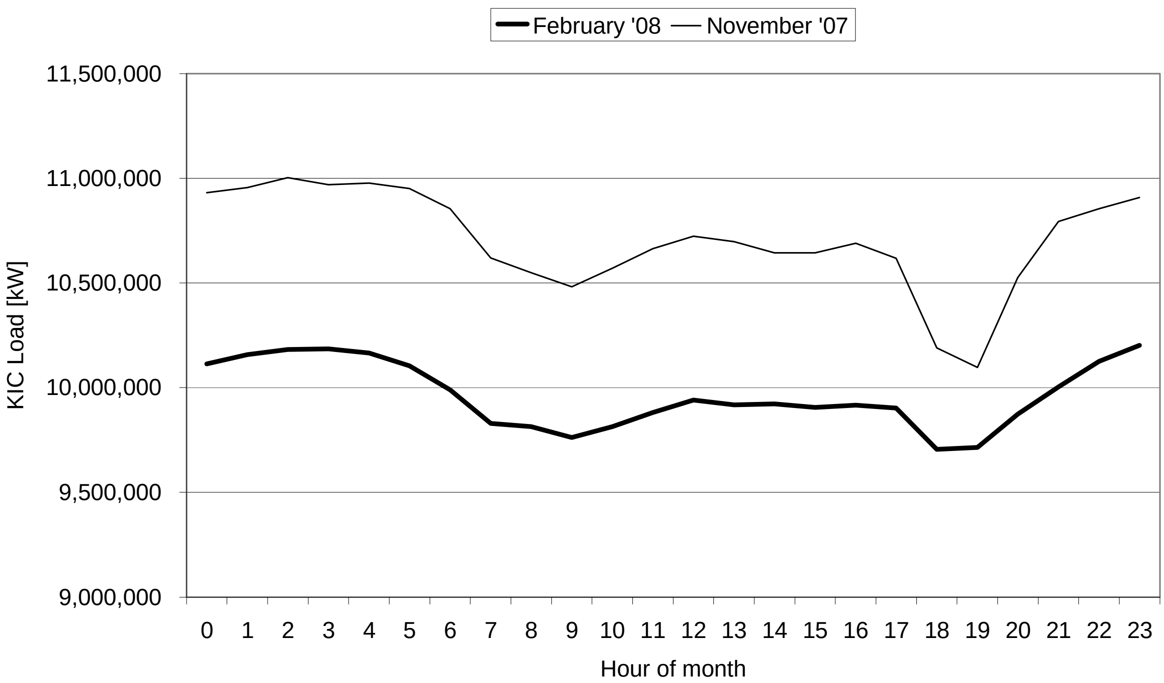
5.3 MANDATORY AND VOLUNTARY LOAD REDUCTION

This section of this report presents the findings achieved through mandatory and voluntary load reduction for key industrial customers and municipal customers on the Eskom Megaflex tariff.

5.3.1 Key Industrial Customers

Figure 17 presents a comparison between the average weekday profiles of the Key Industrial Customers (measured in November 2007 and February 2008). At the beginning of February 2008, these customers were requested to reduce their load by 10% in a voluntary load reduction initiative. The Power Conservation Programme (PCP), which is part of the Energy Conservation Scheme, aims to use legislation to reduce customer load below a customer energy-based baseline and the effect of this are presented in Figure 17.

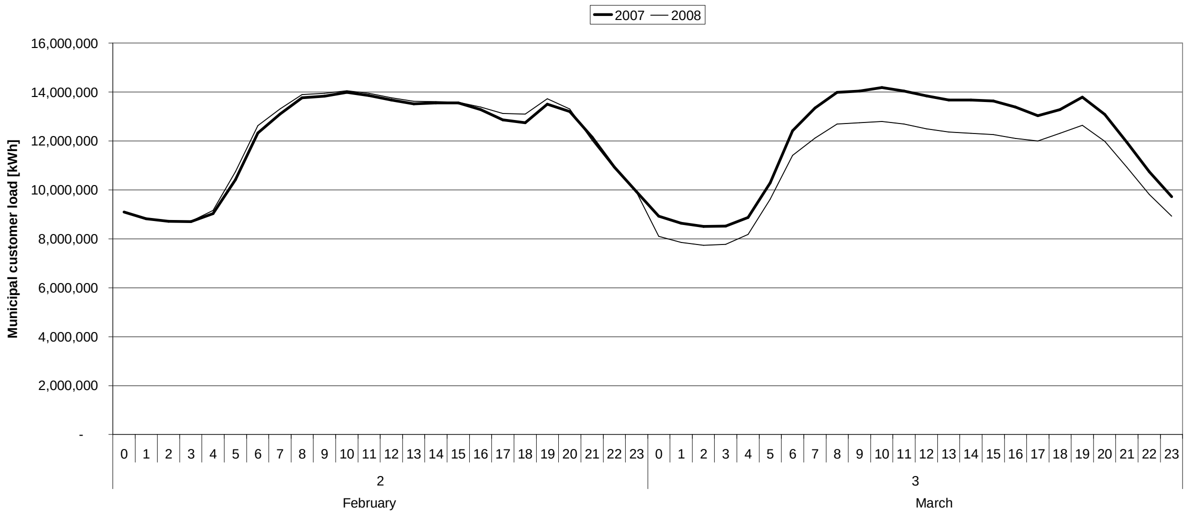
Figure 17: Comparison between the average weekday profile of the Key Industrial Customer as measured in February and November



5.3.2 Municipal Load Reduction

Figure 18 presents a comparison between the average weekday profiles of the Municipal customers as measured in February 2007 and 2008 and March 2007 and 2008. The load reduction in March 2008 was part of a voluntary load reduction initiative which aimed to reduce the load by 10%.

Figure 18: Average Weekday Profiles of Municipal Customers Measured in February 2007 and 2008 as well as March 2007 and 2008.



5.4 POWER ALERT AS DISPATCHABLE LOAD REDUCTION

To assess the usage of Power Alert as a dispatchable load mechanism, the following procedure was followed:

- Obtain total Municipal load – the municipal load contains in terms of load the majority of residential consumers.
- Extract October 2007 and November 2007. The reason October 2007 and November 2007 was chosen is two fold:
  - No public holidays or temperature to compensate for,
  - During this time the public awareness around power conservation was elevated due to load shedding

- Obtain Power Alert information for the various SABC channels and normalise to obtain an indication per day about the communicated alert level (i.e. Green, Orange, Red or Brown)
- Only Monday to Thursday was considered, since the load profile on these days are very similar, especially around the evening peak. Friday, Saturday and Sunday was not considered

Figure 19 presents the average weekday (Monday – Thursday) profiles for days where the Power Alert Level was Green, compared with a profile for the same day where the level was Orange or worse.

Figure 19: Average Weekday (Monday – Thursday) Municipal Load Profile for Days where the Power Alert Level was Green, compared with a Profile where the Level was Orange or Worse

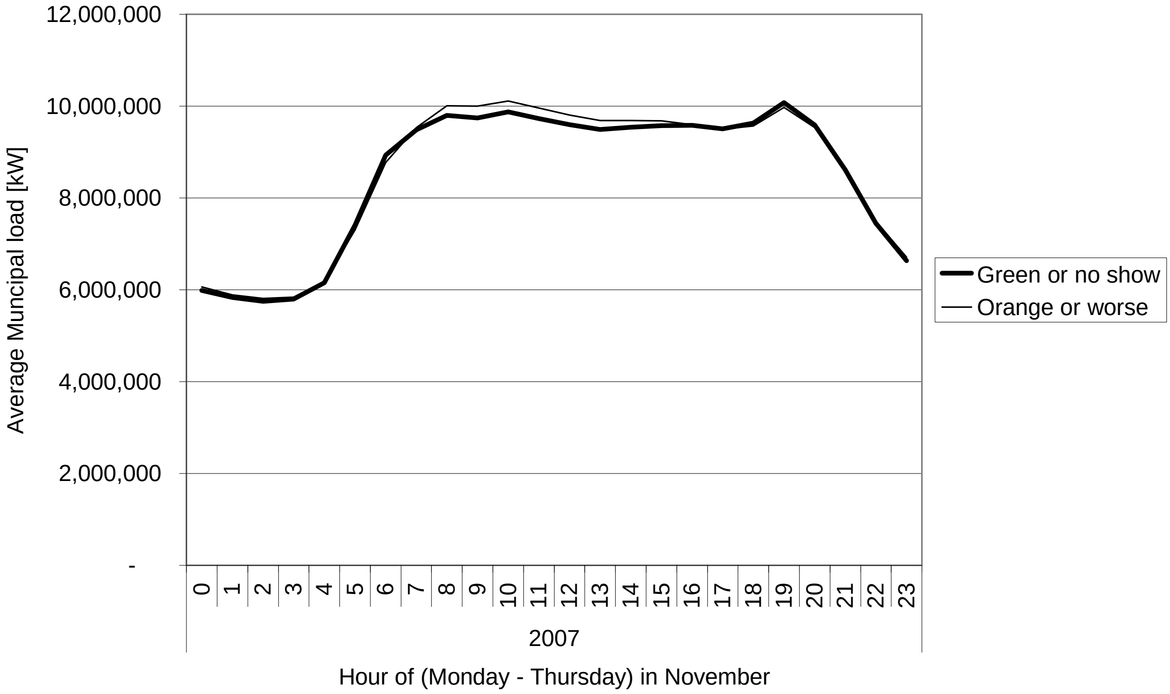
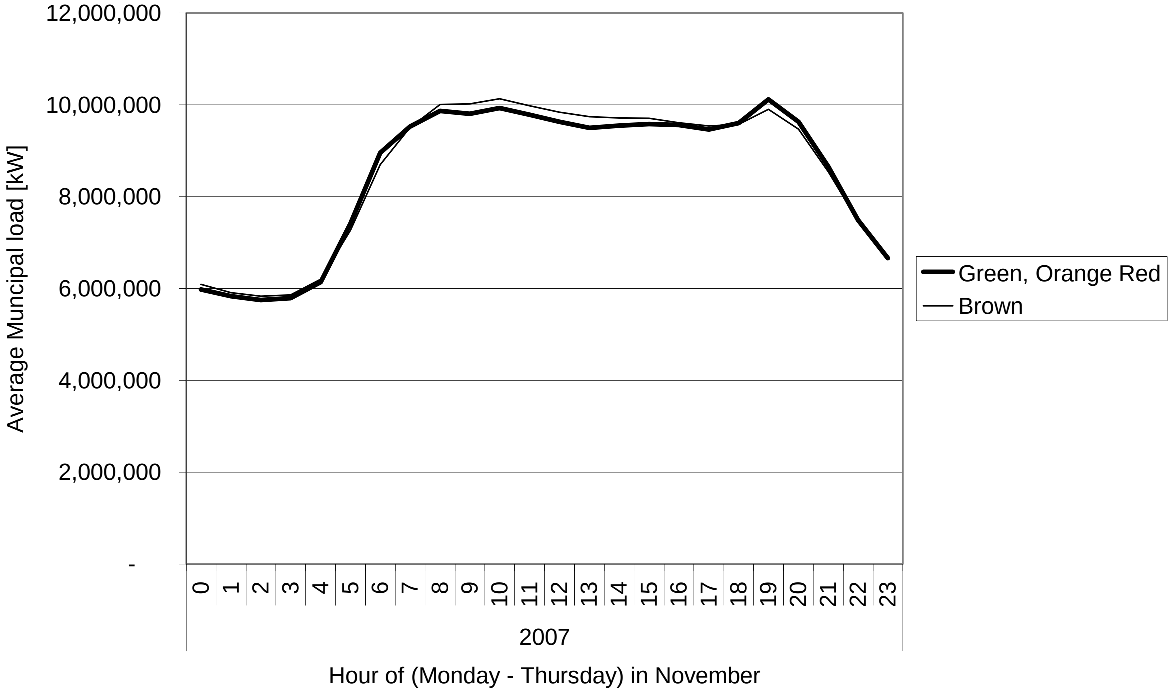


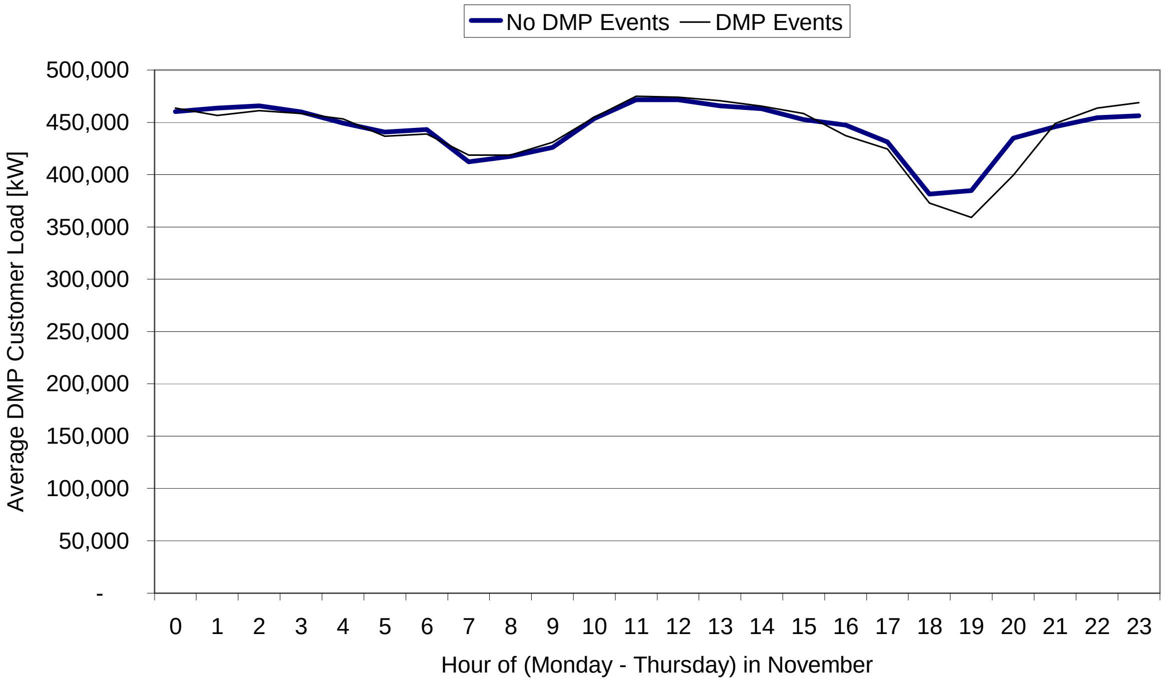
Figure 20 compares the profile for Green days compared with Red/Brown days.

Figure 20: Average Weekday (Monday – Thursday) Municipal Load Profile for Days where the Power Alert Level was Green, Orange, Compared to a Profile where the Level was Brown



As a reference the load shape change that occurs with DMP was compared. Figure 21 presents the load profile of one selected DMP customer for days (Monday – Thursday) in November with DMP events and those without.

Figure 21: Average Weekday (Monday – Thursday) Load Profile for Days with DMP Events, Compared with a Profile where no Events Occurred.



5.5 TOU PRICE ELASTICITIES

This section of this report presents the price elasticities calculated (see Table 12). The formula used to calculate the elasticities (see Section 2.1 of this report) is (% _Q / % _P), *Niemeyer (2001).*

The average price increases of the Eskom Megaflex tariff (2002 to 2007) was used as the applicable price, however only the active charge component for the different TOU (Peak, Standard and Off-Peak) rates were used. Also note that the prices were not adjusted for inflation.

The price elasticities for the Manufacturing and Mining Sectors were calculated. This was done as these sectors are the largest end-users of electricity in South Africa and accounts for 43.7% and 18%, respectively (see Figure 1). The Ferro Alloys were excluded due to erratic consumption patterns primarily driven by commodity prices.

Table 12: TOU Price Elasticities for the Manufacturing and Mining Sectors

		Manufacturing Elasticity	Mining Elasticity	Total Elasticity
2003_Lo	Off Peak	0.66	0.16	0.34
	Peak	-0.19	-0.03	-0.09
	Standard	-0.27	-0.06	-0.13
2003_Lo Total		-12.49	-2.60	-6.20
2004_Hi	Off Peak	0.60	-1.92	-0.99
	Peak	0.51	-1.81	-0.96
	Standard	0.62	-1.62	-0.79
2004_Hi Total		0.59	-1.76	-0.89
2004_Lo	Off Peak	0.81	-2.06	-0.99
	Peak	1.02	-2.03	-0.88
	Standard	0.91	-2.03	-0.93
2004_Lo Total		23.32	-52.88	-24.49
2005_Hi	Off Peak	0.20	0.19	0.19
	Peak	0.26	0.46	0.38
	Standard	0.21	0.29	0.26
2005_Hi Total		0.27	0.34	0.32
2005_Lo	Off Peak	0.03	0.24	0.16
	Peak	0.04	0.65	0.41
	Standard	0.02	0.30	0.19
2005_Lo Total		2.68	29.63	19.20
2006_Hi	Off Peak	1.20	0.55	0.80
	Peak	0.58	0.15	0.31
	Standard	1.09	0.60	0.79
2006_Hi Total		0.61	0.27	0.40
2006_Lo	Off Peak	0.20	0.64	0.46
	Peak	0.37	0.64	0.53
	Standard	0.33	0.85	0.64
2006_Lo Total		12.63	31.37	23.91
2007_Hi	Off Peak	-0.65	0.10	-0.19
	Peak	-0.60	0.01	-0.23
	Standard	-0.64	0.38	-0.01
2007_Hi Total		-0.63	0.21	-0.12
2007_Lo	Off Peak	-0.14	0.97	0.54
	Peak	-0.11	0.86	0.47
	Standard	-0.19	1.06	0.57
2007_Lo Total		-6.60	41.44	22.59

Figure 22 presents the average Megaflex tariff price increases (1994 to 2008). Figures 23 and 24, respectively presents the average Gold and Platinum price increases.

Figure 22: Megaflex Price Increases for High Seasons and Low Seasons

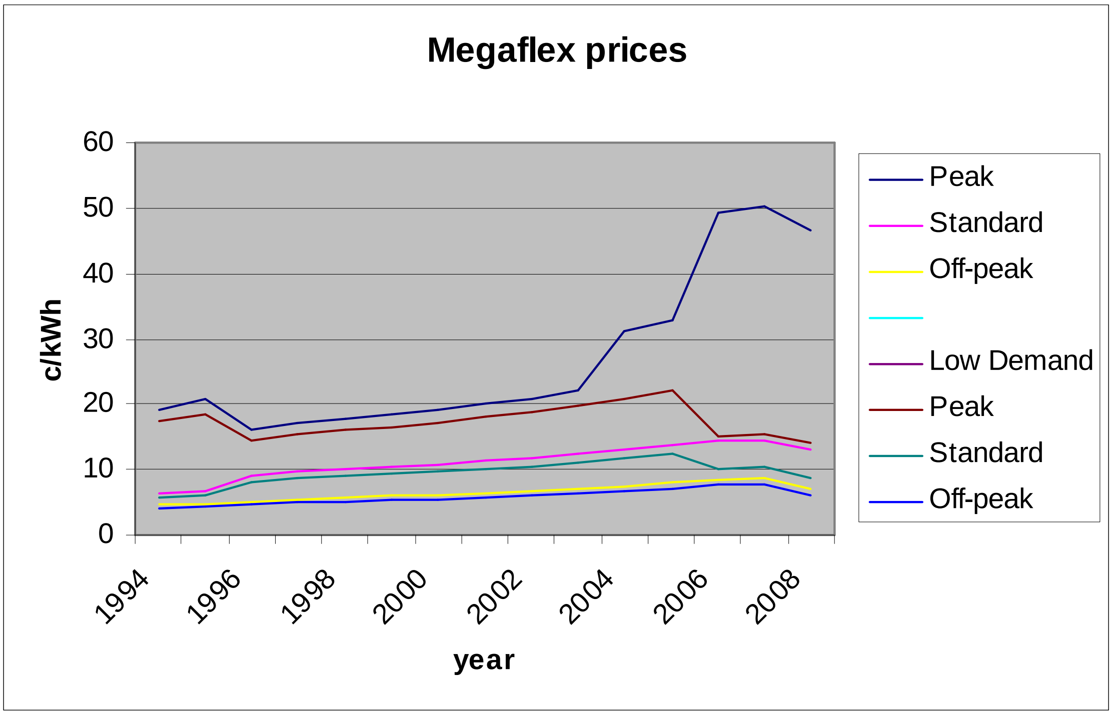
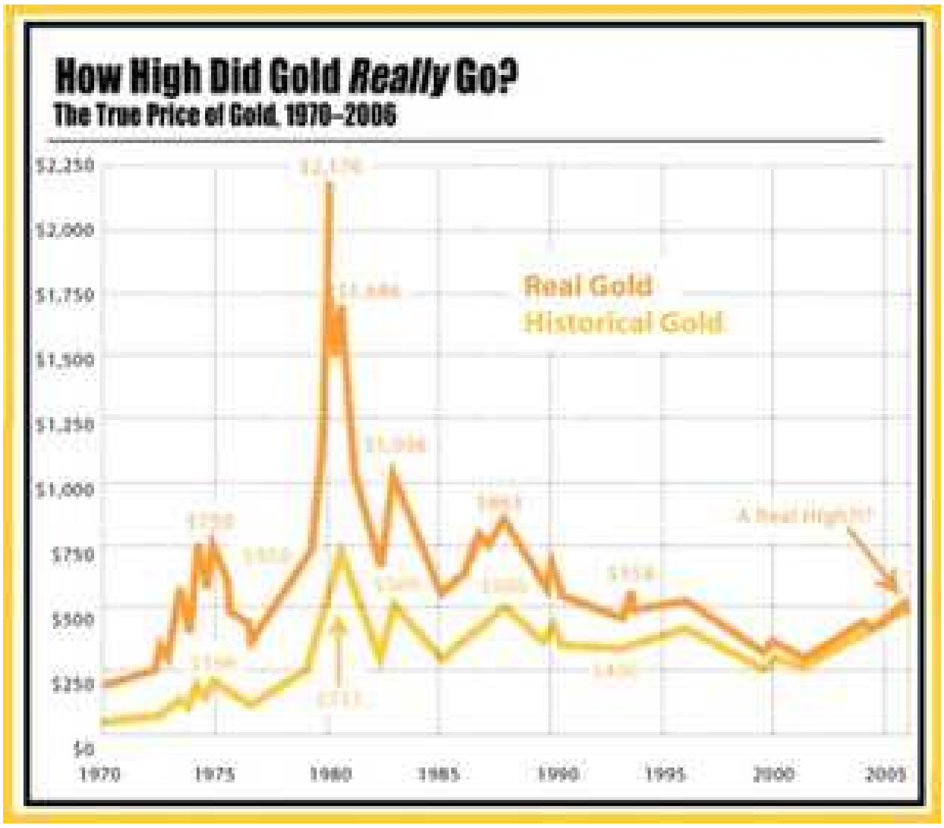
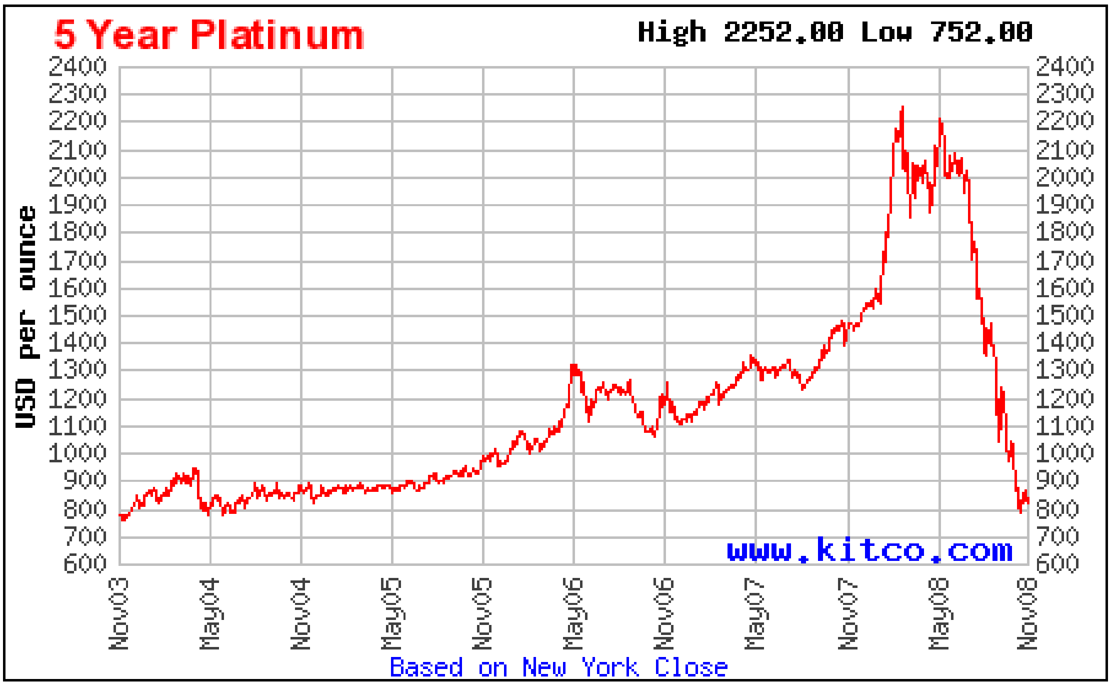


Figure 23: Gold Price History (1970 to 2005)



Source: http://goldprice.org/inflation-adjusted-gold-price.html

Figure 24: Platinum Price History (2003 to 2008)



Source: http://platinumprice.org/platinum-price-history.html

6. CHAPTER 6: DISCUSSION OF RESULTS

This section of this report discusses the impact of the Megaflex TOU tariff (High and Low Seasons, respectively), the energy demand per sector (Ferro Alloys, Gold Mining and other Industries), the impact of mandatory and voluntary load reduction on key Eskom customers (including the Power Conservation Programme) as well as the impact of the Power Alert Programme. Furthermore, the price elasticities calculated are being discussed.

6.1 TOU TARIFF (MEGAFLEX) IMPACT - DISCUSSION

The Low season profiles for 2002-2004 (see Figure 8) are almost identical in shape and size, but the High Season profiles (see Figure 9) are significantly different. The 2005 High and Low season profiles are significantly reduced and only recovered to the normal levels during 2006.

This reduction is attributed to the reduction in Ferro-Alloy production during 2005 and specifically the high season of 2005. The reduction in production can be attributed to weaker demand in this sector which led to a combination of supply and price reductions.

The 2006 Low Season (see Figure 8) and 2007 (see Figure 9) high season profiles, respectively presents a significant intra-day load shift. This change is mostly due to customers taking part in the Demand Market Participation (DMP) programme.

6.1.1 DMP Corrected Average Weekday Profiles

After correcting for DMP, the 2007 profile (see Figure 9) still exhibits a significant intraday shift. This is due to aggressive cost saving initiatives at some of the gold mines, *Financial Mail (2004)*. Also refer to section 5.2.2 of this report, in particular the Gold sector profile.

The correction is achieved by excluding load data for days on which DMP events occurred. A DMP contract to account mapping were used to perform this exclusion on a per account basis.

6.2 ENERGY DEMAND PER SECTOR - DISCUSSION

This section of this report discusses the impact on energy demand for the Ferro Alloy customers, the Gold Mining Customers as well as other customers that are not within the Ferro Alloy or Gold Mining industries, respectively.

6.2.1 Ferro Alloys

An important observation is that the intra-day load shift observed in 2003 virtually disappeared in 2004 (see Figure 11). The level of consumption for 2005 has significantly decreased with very little intra-day movement (see Figure 11). In 2006 the level of consumption had recovered to that of previous years and has remained stable into 2007 (see Figure 11). The difference in the seasons can be explained by considering Figure 12 (Inflation Corrected Mean Ferro Alloy Price).

6.2.1.1 Inflation Corrected Ferro Alloy Price

The energy demand in the Ferro-Alloy sector is related to the volume of product produced. Electrical energy forms about 30% of the total input cost in this sector. This volume is in turn related to the demand for this product in the manufacture of steel. In low product demand periods, the producers can either reduce their price or reduce their demand Business Report (2005). Both of these occurred and this led to a reduction in the energy demand as measured in 2005. The strong upward trend, which has been described as a super-cycle, is driven by demand from China as well as speculative fund activity, *Business Report (2005).*

It is evident that the Ferro-alloy sector is running at full capacity (in terms of electricity consumption) since virtually no difference between the 2006 and 2007 is present (see Figure 11). This is despite the 20% difference in commodity price.

6.2.2 Gold Mining

From 2003 to 2005 the energy demand in the Gold sector has been decreasing as part of a long term reduction in production in the Gold sector in South Africa. However, the increase in gold prices during the last two years clearly had an impact on the energy demand (see Figures 15 and 16, respectively).

A shape change is visible in 2007 and to a lesser extent in 2006. This is due to DSM projects related to the management of pumping activities at the gold mines Financial Mail (2004). Figure 15 illustrates how these programmes assisted in changing the shape of the mining sector profile since 2005.

6.2.3 Eskom Megaflex Customers, not Mining and Ferro Metals

No significant intra-day movement is visible and the 2007 high profile seems to be slightly depressed (see Figure 16). This reduction can in most part be attributed to a reduction in the consumption of stainless steel manufacturers.

6.3 MANDATORY AND VOLUNTARY LOAD REDUCTION

This section of this report discusses the impact of mandatory and voluntary load reduction on key Eskom industrial customers as well as the impact of the Power Conservation Programme (PCP).

6.3.1 Impact on Key Industrial Customers

The reduction in terms of energy was about 7% in February 2008 compared to November 2007 (see Figure 17). The mechanism for reduction varied and the following patterns were observed:

- Consistent reduction (i.e. in every hour)
- Reduction only during certain parts of the month (e.g. the last couple of days)

The latter mechanism is not ideal since it does not address the capacity constraint on the system, but only the energy constraint. However, not all customers are in a position to reduce their load in a consistent manner. This is due to the type of processes being used.

6.3.1.1 Power Conservation Programme

The voluntary load reduction by the Key Industrial Customers also caused a change in the shape of the average weekday profile for these customers as presented in Figure 17.

The change in shape of the average profile between November 2007 and February 2008 is due to DMP not being in use during February. This highlights a need for coordination that will be required, if both DMP and the planned Power Conservation Programme are in effect. Part of this coordination would be the communication of planned and actual DMP load reduction.

6.3.2 Impact on Municipal Customers

The actual load reduction was very close to this target at about 9.5% and occurred in all hours (see Figure 18).

This load reduction was achieved through a coordinated effort within each municipality by means of published load shedding schedules that were communicated to affected business and residential users.

It is evident that the load reduction even in January was not required in all hours and varied through the day in terms of level. It also varied on a daily basis, between a couple of hundred MW and peaked at 3000 MW.

6.4 POWER ALERT IMPACT

This section of this report discusses the impact of the Power Alert Programme on consumption behaviour.

6.4.1 Green or no Show vs. Orange or Worse

It is clear that there is no significant difference between the two profiles, especially over the evening peak (see Figure 19).

6.4.2 Green, Orange Red vs Brown

A slight reduction was evident (i.e. +/- 25 MW), see Figure 20. However, the standard deviation of the load profile at 18:00 is about 150MW which makes it statistically insignificant.

6.4.3 No DMP Events vs. DMP Events

The dispatched load was about 10% of the total customer load (see Figure 21).

6.5 PRICE ELASTICITIES DISCUSSION

The consulted literature reports that elasticity values vary widely, (see Table 3) *Niemeyer (2001).* However, there is sufficient evidence that customers reduce consumption as prices rise ("Price Elasticity of Demand"), *Niemeyer (2001).* Hence, Niemeyer (2001) argue that customer's ability to respond to price changes tends to increase with the length of time since the increase. Short-run Price elasticities (< 2 years) include input costs that one does not have control over (e.g. fuel costs and commodity prices), but long-run (> 5 years) consumers have sufficient time to adjust to the change in pricing level, *Niemeyer (2001).*

Eighteen elasticity studies, incorporated into two surveys by Taylor, led to a conclusion that the short-run price elasticity for aggregate electricity demand is -0.2 and the long-run elasticity is between -0.7 and -0.9, *Lafferty, Hunger, Ballard, Mahrenholz, Mead and Bandera (2001).* This is related to the elasticities presented by Niemeyer (2001), see Table 3, but also different.

Bohi (1984) conclude that the wide variance of the elasticity estimates from available studies makes it difficult to report the price elasticity for either commercial or industrial sectors. Bohi (1984) found that the few existing studies for commercial demand are elastic in the long-run, while studies of industrial demand have a consensus estimate price elasticity of 1.3.

Other elasticity values are presented in Tables 3, 5 and 6.

Consider Table 12 (TOU Price Elasticities for the Manufacturing and Mining Sectors), the achieved results in this study. It is clear that the Manufacturing Sector elasticities are different to the Mining Sector. This section of this report discusses the elasticities for the Manufacturing and Mining Sectors, respectively.

6.5.1 Manufacturing Sector

In the short-run the elasticities is in line with the consulted literature, in particular the 2003 Low Season as the peak and standard values range from -0.19 to -0.27.

The Eskom Megaflex tariff provided a clear price increase signal in 2003. The high demand peak price increased by approximately 40%, while the peak price for the low demand reduced by approximately 30%. The impact of this price increase is only evident on the consumption behaviour of the Manufacturing Sector in the 2007 High Season. Price elasticities of approximately -0.60 to -0.64 is evident across the peak, standard and off-peak periods. Literature indicated that in the long-run, price elasticities of between -0.7 and -0.9 can be achieved. Since 2007 is only four years into the long-run period; it cannot be technically regarded as long-run as it is one year short. However, it can be assumed that within a year or two, the expected elasticity values can be achieved as per the consulted literature.

It is therefore safe to conclude that the Manufacturing sector is inelastic in the short-run and elastic in the long-run.

6.5.2 Mining Sector

In the short-run, the Mining sector takes on negative price elasticity values, which imply that an increase in price leads to a reduction in electricity demand. Typical values achieved are -0.09 and -0.13. However, these values are not particularly in line with the values stated in the literature for the short-run, which states -0.2.

The interesting phenomenon is evident in the long-run as the 2007 High Season takes on positive values ranging from 0.01 for the peak period to 0.38 for the standard period. Although the elasticity values are positive, the peak period is still most elastic. The positive values imply that consumption increases as price increases.

Considering, Figures 23 and 24 (historical Gold and Platinum prices), respectively. It is evident that there is steady increase in both Gold and Platinum prices. It is therefore assumed that the short-run increase in input costs (in particular electricity) is negligible considering that the mines can capitalise on the stronger price for their respective commodities.

6.6 HYPOTHESIS

This section of this report discusses the results with respect to the Hypothesis.

6.6.1 Hypothesis 1

"*The price elasticity of demand for large electricity customers in South Africa is inelastic in the short-term and elastic in the long-term*".

The results discussed in Section 6.5 of this report, is sufficient evidence in support of this hypothesis more especially the results obtained in the Manufacturing Sector. However, it is recommended that this work be continued considering the fact that the Megaflex tariffs, in particular that of the High Season is rapidly increasing (see Figure 22). It is also evident in Figure 22 that the greatest price increase is in the Peak period and therefore, the impact of this price signal should influence consumption behaviour (increased price elasticity) in the long-run (post 2007).

The mining sector at this stage does not provide conclusive evidence in support of this hypothesis. It is therefore recommended that further work be conducted to obtain a greater understanding around the economic factors that are contributing to this observation.

6.6.2 Hypothesis 2

"*Large electricity customers will change their consumption behavior if electricity prices increase*".

Again, the results presented in Section 6.5 of this report provide evidence in support of this hypothesis (see Section 6.7.1). Furthermore, the results discussed in Section 6.1 through Section 6.4 of this report provide some evidence in support of this hypothesis. This statement is supported by considering the impact of the DMP Programme (see Figure 10) that encourages gold mines to embark on aggressive electricity cost savings.

6.6.3 Hypothesis 3

"Increased electricity prices will make large electricity customers to consider alternatives".

The results from the customer survey were a significant component in terms of providing evidence in support of or against this hypothesis. However, due to confidentiality and sensitivity around strategic information, customers were not willing to participate. This was based on fears around disclosing sales and productivity information. The biggest fear was to disclose information related to competitiveness.

In the light of the above, it is therefore recommended that an independent study be conducted or alternatives be sought on how to obtain reliable information that can be used to make statistical inferences around alternatives that may be considered by the key Eskom Customers. This process however, will prove to be costly and time-consuming.

However, sufficient evidence exists in this report that alternatives can make a difference. This is evident in the Gold Mining Sector that embarked on aggressive electricity cost saving initiatives through considering efficient pumping technologies. Furthermore, some customers took part in the DMP Programme that resulted in a reduced electricity consumption profile.

Various customers also participated in mandatory and voluntary load reduction programmes and the impact of this are evident in Figure 17. Since November 2007 and February 2008, a load reduction of approximately 7% was achieved which forms part of the PCP strategy.

Furthermore, municipal customers also participated in the PCP process and achieved a saving of approximately 9% between February 2007 and March 2008. However, the Power Alert Programme showed disappointing results as no significant consumption reduction was evident as a result of this process.

7. CHAPTER 7: CONCLUSION

The change in the Eskom Megaflex TOU tariff in 2002, that saw the high season peak prices increase by 40%, sent a clear signal to the Eskom key customers (in particular the mining and manufacturing sectors). The need to increase tariffs was an attempt by the utility to meet long-run marginal costs.

Hence, the customers' response to this pricing signal was found to be positive since price elasticities within the manufacturing sector took on a value of – 0.19 in 2003 within the low season. Furthermore, in the long-run the manufacturing sector experienced a price elasticity value of – 0.60. This implies that electricity demand is inelastic in the short-run and elastic in the long-run.

Furthermore, it became clear that the electricity consumption behaviour of key customers is not only driven by electricity prices, but also by economic factors (e.g. commodity prices). This was evident in the increase in consumption in the mining sector, despite increased electricity prices where both the price of Gold and Platinum increased. This phenomenon is also evident in the Ferro-Chrome industry, whereby operations stopped during the high season of 2005 due to weak demand, low commodity prices and high electricity prices.

DSM related initiatives as an alternative to investment in new capacity by the utility also proves effective. Meanwhile, the DMP initiatives attracted key customers and reduced load profiles. This is so, since the DMP Programme in itself provides a more dynamic option to customers with flexible production. Furthermore, mandatory load reduction programmes also lead to reduced consumption.

It has therefore become evident that customers take initiative in an attempt to reduce energy demand, for example, the Gold Mining sector introduced improved pump management technology during the 2006 to 2007 period thus the load profile experienced a significant intra-day shift.

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