MODELLING THE ECONOMIC IMPACT OF ELECTRICITY TARIFF INCREASES IN THE FERROALLOYS INDUSTRY

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Executive summary

With the rapid and sharp rise in energy prices in South Africa, the cost of energy is becoming a value that cannot be ignored in the industrial sector. However, there are still many practices adopted in industry that do not take energy cost as a prime consideration. These practices focus rather on immediate and direct savings in materials and machinery. In the Metal smelting industry this immediate and direct perspective can result in the incurring of costs that are greatly magnified by the large amount of power consumed. This discrepancy presents an opportunity for significant savings through intelligent scheduling of operations. The development of an analytical model will help to determine when production is profitable, given the market forces at play at any particular instance. Special emphasis is placed on the cost of electrical energy, since it can vary on an hourly basis.

The study is based on the experience and knowledge gained at Mogale Alloys - a Ferroalloy smelting company in Krugersdorp, Gauteng.

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CHAPTER 1: INTRODUCTION

1.1 OVERVIEW

The metal alloying industry is one of South Africa's biggest economic assets. It provides jobs to a countless many; stimulates and supports related industry; improves the country's international trade balance; and helps locally manufactured goods to be more globally competitive.

The vast wealth of metal ores found and mined in the country is the reason why many local and international companies are vying to profit from their extraction and refinement. The United States Geological Survey (USGS 2003) suggests that the bushveld igneous geological complex alone holds an estimated 90% of the world's chromite reserves and roughly 60% of the world's economic chromite, additionally Olsen et al (2007) states that as much as 78% of the world's land-based manganese ore reserves are found in South Africa. These ores are beneficiated into ferroalloys which are primarily used in the production of stainless & specialised steels, and are what gives them resistance to corrosion as well as an attractive reflective finish. The international increase in demand for specialised steels is growing at a healthy rate, boosted significantly by the growth of the Chinese steel industry. As a result of this positive growth trend, local producers are scrambling to increase their production output and gain market share. This is evidenced by the flood of interest from foreign corporations, many of which have made huge investments in the industry in the past decade. However, they face a substantial challenge in the form of a lack of electricity supply capacity from the national power producer Eskom. This shortage has caused a marked increase in electricity tariffs over a relatively short period of time, in order to raise capital for Eskom's new build programme, which involves the construction of a number of new power plants. These new plants will add capacity to the overstretched grid and ease the current electrical shortage.

With electricity as a constraint, in the short term at least, production levels have dropped from previous highs to levels where mining companies are now exporting the raw metal ores, instead of beneficiating them locally, which in turn detracts from the South African economy.

Inspiration for this study came about through exposure to the Ferrochrome industry at an organization, namely Mogale Alloys Pty (Ltd). Mogale alloys Pty (Ltd) is a producer of Ferrochrome, SilicoManagnese and other specialised steel input alloys. They operate a smelting plant consisting of four furnaces in the West Rand of Gauteng. These products are produced by the smelting of various combinations of raw metallic ores, reductants and fluxes in large electric arc furnaces.

Much of the information and insight in this study was collected and gained from their operations.

In light of the information presented above, the most pertinent question now is: how can producers position themselves in the present economic situation, while taking cogniscence of energy considerations, to avoid significant losses in profitability?

1.2 Problem Statement

The process of heating the Ferroalloy ores sufficiently to the point where a carbo-thermic reaction takes place requires a substantial amount of electrical energy, far greater than that of general Industrial applications. The effect this has on metal alloy smelters is that a significant portion of the production cost per unit is comprised of electricity costs. Recently these costs have skyrocketed, and are likely to continue to increase into the future, possibly to levels where profit from ongoing production can become marginal, and losses may even result. This will most likely occur during peak electrical billing periods, such as winter months and peak hours. The billing structure will be covered later in this document.

The metal alloy producers are now met with a complex challenge to manage electricity costs, ensure that production targets are met, all while maintaining profitability in keeping in accordance with plans for future growth.

1.3. Project Aim

The intention of the project is to develop an analytical model for the purposes of determining the operational profitability of a ferroalloy smelting plant. The model should be designed such that it incorporates all the manufacturing costs involved, with special emphasis on the cost component of electrical energy.

The model should be dynamic in a manner that would allow it to accept the ever-changing inputs of market conditions, such as the price of electricity, raw materials, current selling price of finished goods etc.

Additionally, the model will be developed as an easy to use spreadsheet model, which can be used as a decision support system for management in determining when and how to schedule production. The model will be deemed successful if it is able to predict the instantaneous operational profitability of a ferroalloys plant. This will then determine the periods when manufactured product is selling at a loss, and hence management can take steps to cease production until market conditions favour operations at a later stage.

1.4 Project Scope

The project is divided into 3 distinct stages:

- Research into the Ferro Alloys industry
    - General background, history, and current situation
    - Market forces involved
    - Determination of the current operational practices
    - Role of electricity in the industry
- Development of an appropriate analytical model
    - Creating a framework for the model
    - Collection of data relevant to model
    - Finalizing, Verifying and Validating the model
- Delivery and presentation

CHAPTER 2: LITERATURE REVIEW

2.1 OVERVIEW

The literature reviewed to gather information for this study was focused around five major facets:

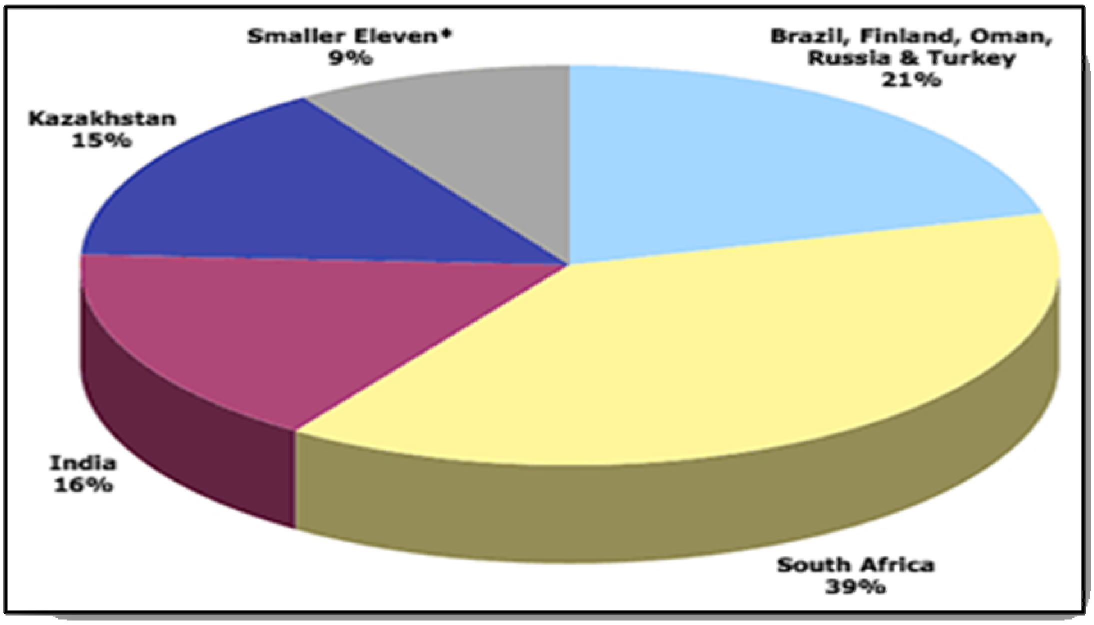
- The Ferroalloy industry in South Africa
- The Ferrochrome process and Electric Arc Furnaces
- Electricity supply in South Africa
- Spreadsheet/Analytical modeling
- Activity/Unit Based Costing

2.2 THE FERROALLOY INDUSTRY IN SOUTH AFRICA

According to Basson (2008), there are four minerals at the heart of the South African Ferro Alloys smelting industry; these are Chromium, Manganese, Silicon and Vanadium.

The first and most important in the South African context is Chromium. Raw ore, known as Chromite (Cr_2O_3), is smelted together with fluxes and reductants to become ferrochromium (FeCr). The reason that ferrochrome is such an important metal is because its geographical distribution is very limited. According to the United States Geological Survey (USGS - 2006) world resources of chromite exceed 11 billion tonnes, of which South Africa and Zimbabwe hold about 90% of the world's chromite reserves and resources. This is illustrated in figure 1 which shows how much chromium ore is mined relative to other producing countries. The natural mineral wealth coupled with a traditionally low cost of electricity has meant that South African Producers have dominated worldwide production.

FIGURE 1: WORLD CHROMITE ORE PRODUCTION IN 2008 (SOURCE: ICDA)



According to the International Chromium Development Association (2004), of the 14.868 million metric tons (Mt) produced in 2003, about 91.2% was produced for the metallurgical industry; 5.2%, chemical industry; 2.8%, foundry industry; and 0.8%, refractory industry in the metallurgical industry, Ferrochrome is used primarily in the manufacture of stainless steels, and is what gives them their resistance to corrosion and their attractive reflective finish.

Ferrochrome production in South Africa has been rising steadily for the last few decades, tracking the expansion of international steel markets. By early 2007 the gross installed annual capacity would be in the order of 4.2 million tons (Basson; 2008). The Economist magazine (ECONOMIST INTELLIGENCE UNIT – 2010) has forecasted an increase of growth in the steel industry of between 5 – 11% per year for the next 3 years, however, local ferrochrome producers have been forced to shelve expansion projects aimed at increasing their production output - compromising their market share- because the local power producer (Eskom) cannot guarantee them a sufficient supply of electricity.

This has put the local industry on the back foot as international competitors aim to fill the growing void. Local mining companies are even resorting to exporting un-beneficiated raw ore to countries such as India, China and the European Union (ICDA; 2004). The cost of electricity has also become central to the profitability of the local manufacturers, as it is a major cost component of production.

Other ferroalloys such as ferromanganese, ferrosilicon and ferrovanadium are also used in the steel making process, each of them having unique physical and chemical properties that enhance steel and improves aspects such as strength, ductility, lustre etc. Although these products are vital ingredients in many steel alloys, and indeed important to the South African ferroalloy producer, the relatively small amounts produced proportionate to ferrochrome, mean that ferrochrome is the prime focus of the industry. Accordingly this paper deals primarily with ferrochrome production.

2.3 The Ferrochrome Process and Electric Arc Furnaces

Ferrochromium is produced by smelting chromite ore in large Electric Arc Furnaces (EAF's). The process involves heating the ore to temperatures ranging from 1550°C - 1900°C, in the presence of reductants and fluxes (Paschkis & Persson; 1960). Reductants are Carbon rich minerals such as coke and various grades and types of coal which facilitate the carbo-thermic reduction of the chromite ore into Chromium metal. Visser (2006) describes that fluxes are materials such as limestone, dolomite and quartz which are added to condition the slag for tapping (pouring). Slag is the term for the layer of metal oxides and other elements which float on top of the primary metal.

Although different variations of the process exist, the heart of any operation is the furnace. There are two types of furnace used in the industry, Submerged Arc Alternating Current Resistance Furnaces, and Direct Current Plasma Arc Furnaces. These furnaces are rated in Megavolt Amperes (MVA). The higher the MVA rating is, the larger the furnace and the greater its production output. Commercial furnaces range from small 3 MVA units to the very large units such as the 78 MVA furnace located at Hernic Ferrochrome near Brits in the Northwest province (Hernic; 2009).

Mogale alloys make use of two 20 MVA submerged arc furnaces, one 40 MVA DC and a smaller 15 MVA DC furnace. These furnaces are of the continuous type, which means they constantly receive an input feed (a process known as charging the furnace) and stay hot in between loads. This is important to note because switching the furnaces off and on again requires a great deal of power before charging can begin again. The furnaces can be run at idle energy by switching the transformer configuration on the AC furnaces from Delta to Star connections, or by directly reducing power by means of a potentiometer on the DC furnaces.

Although there are numerous other supporting activities which require electricity, the vast amount of power is consumed by these furnaces and, as a result, they form the basis of the electrical energy considerations explored in this paper.

2.4 An overview of electricity supply in South Africa

2.4.1 Electricity generation and availability of supply

Traditionally South Africa has had one of the lowest electricity prices in the world. This is largely attributed to the vast resources of coal found in the country. Recent data estimates the coal reserve of the country as being in the order of 33 Billion tons, and consequently 95% of the country's electricity is generated by coal-fired thermal power stations (Jeffrey; 2005).

Basson (2007) states that during the 1970's and 80's, the apartheid government undertook massive public infrastructure projects including the installation of surplus electricity generation capacity. This surplus situation meant that no future expansion plans were created, and linked with the change in government and the uncertainty of the role of Independent power producers (IPP's), the demand gradually caught up with supply. Previously the post-apartheid government adopted a policy of selling power at artificially low rates in order to use up surplus capacity (Eskom; 2008). This has now drastically shifted to a policy of penalising consumers to limit consumption due to a general shortage of power.

At present Eskom's installed generation capacity is approximately 43.2 GigaWatts (GW), while their operational capacity varies at an average of 40 GW, with a predicted peak load of 37.5 GW during the June-July period (Mail & Guardian – 2010). This leaves a reserve margin of less than 10%, well below international standards of 15% or greater. This poses a serious danger of rolling blackouts as was experienced in 2008. The National Energy Regulator (NERSA 2008) suggests that the effects of lost production, damage to electrical distribution systems and manufacturing equipment, cost the South African economy R50 billion in 2008. The electricity crisis also served to dissuade international investors from developing operations in the country costing the economy greatly (Van der Waal; 2009).

As a means of reducing rolling blackouts, the government and Eskom introduced policies which limited the maximum consumption of heavy industry to 90% of their peak demand (NERSA; 2008). This impacted heavily on industry and productivity. Many plans for expansion of local Ferrochrome & Aluminium production have been shelved until Eskom can supply sufficient power.

Eskom's response to the shortage of electricity supply has been in the form of an accelerated new build programme which aims to add 22 GW to the system by 2017. The major contributors will be new base-load coal stations, Medupi and Kusile, which will only come on line in 2012 and 2015 respectively (South African department of Public Enterprises – 2007). This means that electricity supply will remain tight for the next two years, with serious concerns of availability in 2011 and 2012.

2.4.2 Cost of Electricity

As mentioned above, South Africa has long enjoyed low electricity tariffs. As a result of having cheap electricity, a sustained boom developed in the mining and industrial sectors. This was in line with the governmental policy of job creation. Unfortunately the policy was short sighted as the price of electricity was often lower than the cost of producing it. This led to a substantial loss in capital for the power producer Eskom.

As demand for electricity began to near the available supply, Eskom found itself without financial provisions to react to the need for new generation capacity.

As a means of raising capital for the expansion, Eskom has been forced to look abroad for loans as well as to hike electricity costs to previously unthought-of levels, the most recent of which are 24.8,

FIGURE 2: INTERNATIONAL COMPARISONS OF ELECTRICITY COSTS. SOURCE (DPE; 2007)

2007 Rank	2006 Rank	Country	Cost (US¢)/kWh	
			2006	2007
1	1	Denmark	13.41	22.89
2	2	Italy	13.24	15.74
3	7	Germany	10.33	13.16
4	4	Netherlands	11.01	12.62
5	6	Belgium	10.50	11.43
6	3	United Kingdom	11.03	11.16
7	8	Spain	9.30	10.35
8	9	United States	8.82	9.28
9	5	France	10.53	8.54
10	**13**	Australia	5.29	7.11
11	10	Finland	8.09	6.95
12	11	Sweden	6.96	6.60
13	12	Canada	5.87	6.18
14	**14**	South Africa	4.05	3.56

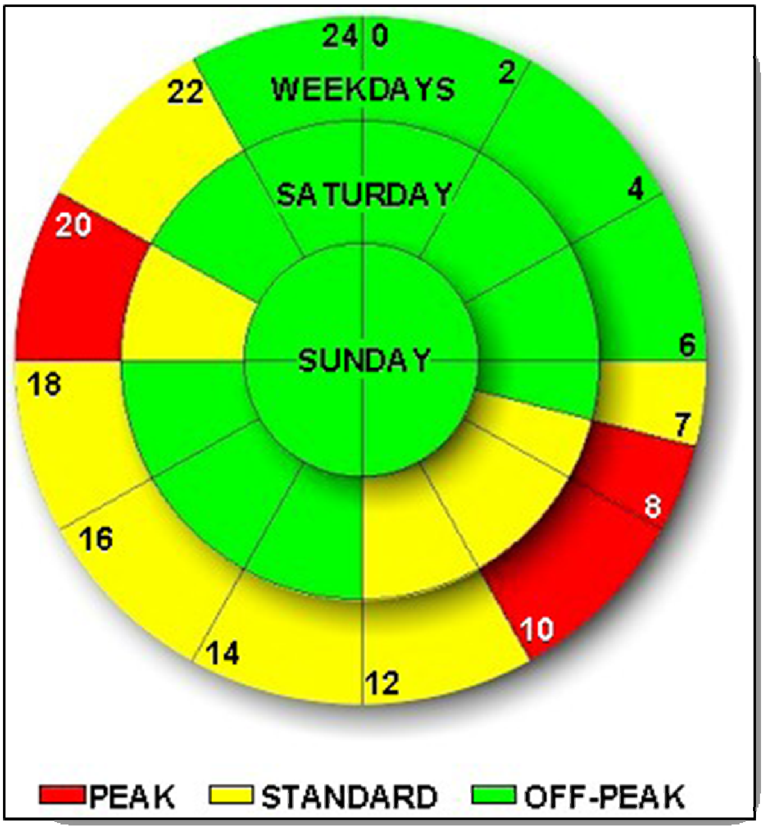
25.8 and 25.9% increases to the tariffs for the years 2010 -2012.

Tetsu Kotaki, CEO of Hernic Ferrochrome, stated that "what the increase means is that in three years, electricity [prices] will double. It's a very difficult time for South African industry. Although it may not lead to a situation of closures [of mining smelters], we will struggle," (In Mail & Guardian; 2010).

The implications of increased tariffs will weigh heavily on the ferrochrome industry since ferrochrome producers are of the heaviest consumers of electricity in the country - of the approximately 63% that the industrial sector contributes to total electricity consumption, this sector contributes approximately 23% (Nedzingahe, L – 2010). Ferrochromium production requires about 3.77 megawatt hours per metric ton (MWh/t) produced (Papp; 2003). Basson (2007) estimates that prior to the major tariff increase the cost component of electricity per ton of ferrochrome produced is 25-35%. This cost has now increased tremendously as will be shown later in this paper.

Most ferrochromium producers are accommodated on Eskom's 'Mega-flex' tariff package. This tariff structure is available to industrial customers who require a maximum demand of 1000kVA or more. The tariff rates are based on time of use billing (TOU), where consumption is monitored in real-time, then allocated to the daily time period: peak, standard and off-peak. The tariffs are further developed into a schedule which encompasses the peak demand as experienced in the weekdays as opposed to the weekend. Additionally the tariff is divided into 2 seasons: High and low demand. The High demand season (June – August) has been designed to coincide with the coldest temperatures across the country when much of the electricity generated is used for heating of homes and business premises (Eskom MegaFlex Customer Information; 2009).

FIGURE 3: COST SCHEDULE BREAKDOWN. SOURCE (ESKOM; 2008)



The vast difference between the Peak, Standard and off-Peak costs are illustrated below. Using the pricing tables (Appendix A), it can be calculated that the 2012 peak cost will be 385% higher than the standard rate cost, and 720% higher than the Off-Peak rate cost.

The exponential upward pricing trend, obvious in the graph below, should be a grave concern to large industry that uses power continually throughout the day.

FIGURE 4: DESCREPANCY BETWEEN TIME PERIODS. SOURCE (AUTHORS OWN)

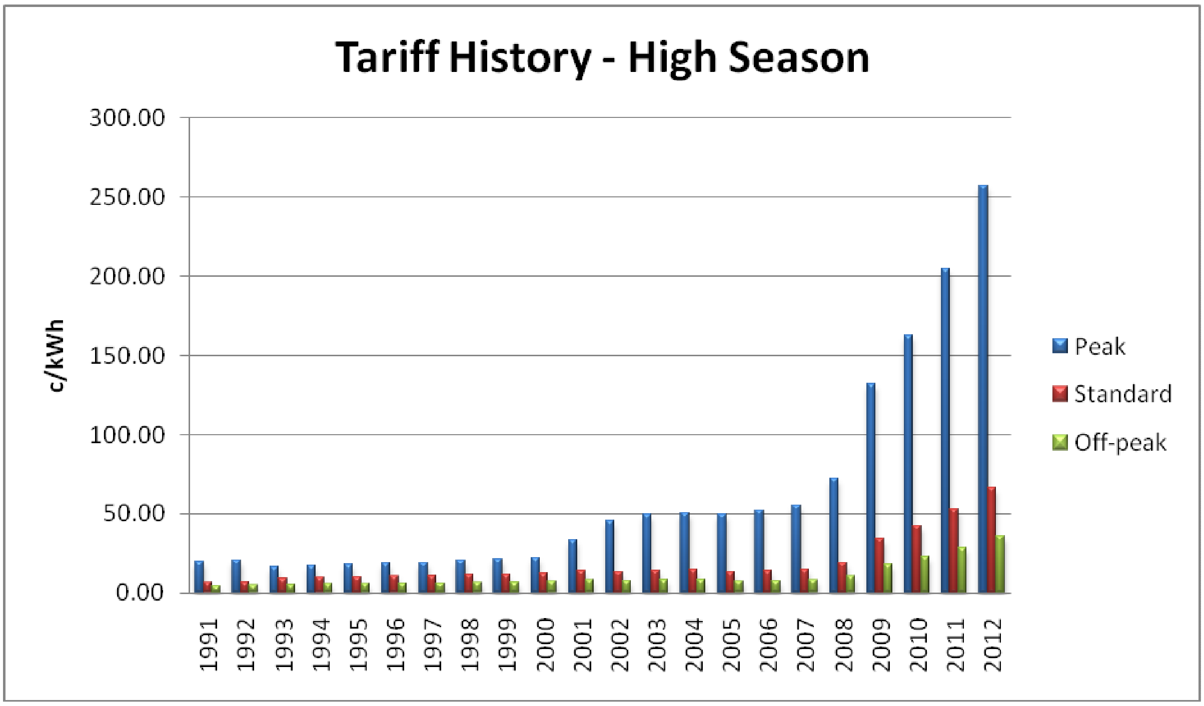
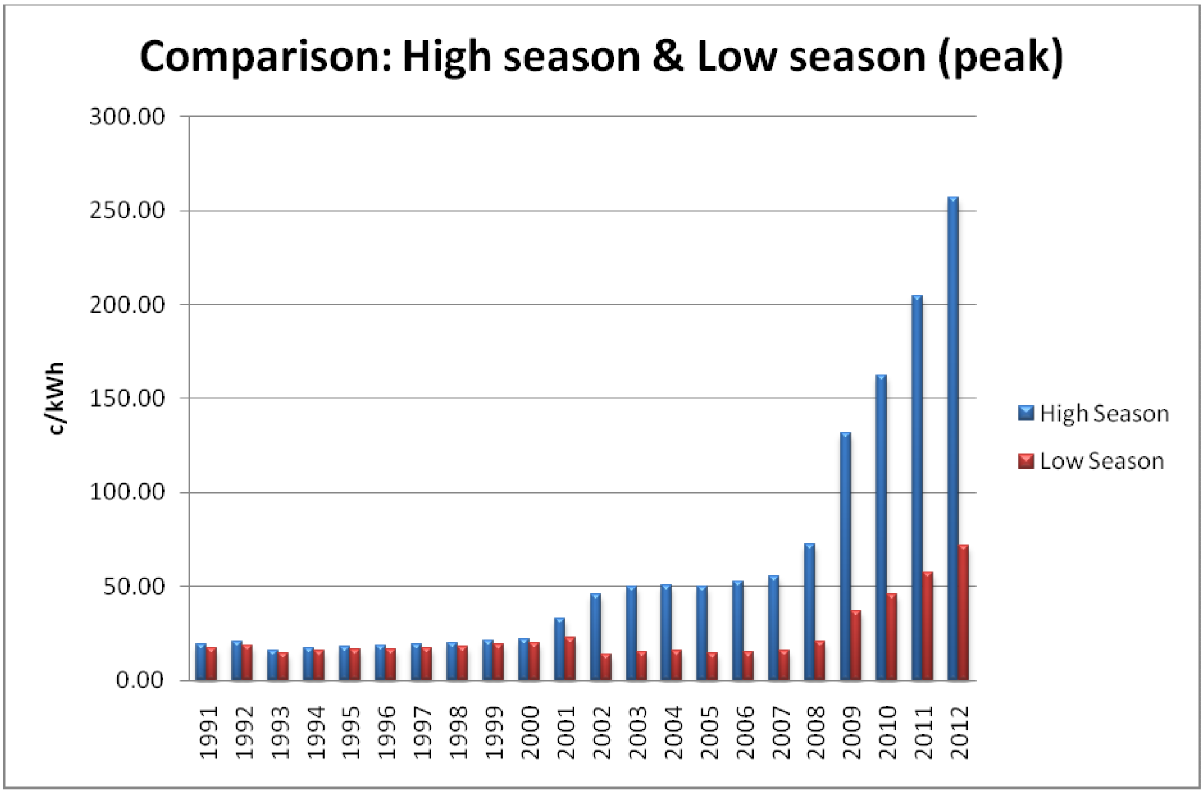


FIGURE 5: SEASONAL PEAK COMPARISON. SOURCE (AUTHORS OWN)



2.5 SPREADSHEET/ANALYTICAL MODELING

Models are tools which are used to represent real life situations, in an environment where one can experiment with the data and the model itself, without the fear of real life consequences (Savage – 2003).

Spreadsheet modeling is one of the most common forms of analytical modeling. It makes use of the enormous power, flexibility and convenience of the computerized spreadsheet. Spreadsheets are most commonly used in business for financial analysis, and are a tool any manager should be conversant with.

An analytical model will be in the form of:

- Output = Function (Input Variables 1,2,3…n)

The benefit of such analytical models over numerical models is the simplicity involved in doing repeat calculations. This way one only needs to update the input variables and not recalculate the whole equation. Savage (2003) states other benefits of model as:

- It is much less costly to make mistakes in a model than in the real world.
- A model can yield unexpected insights into real world problems.
- A model allows you to apply analytical tools not available in the real world.
- Building a model forces you to better understand the relationships being modeled and the data required for analysis.
- A model serves as a means of communication.

It is important to validate analytical models to the highest degree of certainty, since repeat calculations can magnify mistakes.

Spreadsheet modeling really comes into its own when used for sensitivity analysis. Sensitivity analysis is used to determine how "sensitive" a model is to changes in the value of the parameters of the model and to changes in the structure of the model (Breierova & Choudhari – 1996).

This is of vital importance when planning, especially in dynamic models or models where subtle changes in parameter values could cause chaotic reactions in the output.

Sensitivity analysis also helps to build confidence in the model by studying the uncertainties associated with the parameter values.

2.6 Activity/Unit Based Costing – Managerial Accounting

Management Accounting provides the essential data with which decisions are made and organizations are run. The primary concern of management accounting is cost accounting. This form of accounting developed during the 19th century industrial revolution, where it provided essential management information for early large-scale products like textiles, steel and other products.

Seal, Garrison & Noreen (2009) define Activity Based Costing (ABC) as “a costing method based on activities that is designed to provide managers with cost information for strategic decisions”. Where traditional costing does not consider marketing and administrative expenses as a product cost but rather a period cost, ABC takes into account every cost as a portion of a product cost.

The benefit of such a system is that the unit cost of the product will be entirely accounted for, and the margin and sales price can be easily determined. This form of costing is particularly useful where a business produces high volumes of a single product such as is the case in the Ferrochrome industry.

Again Seal, Garrison & Noreen (2009) provide definitions for a few important concepts in managerial accounting:

Fixed costs: A cost that remains constant, in total, regardless of changes in the level of activity.

Variable costs: A cost which varies in direct proportion to the level of activity.

Manufacturing costs (Product costs): The costs directly involved in acquiring or making a product. These are direct materials, direct labour and manufacturing overhead costs.

Non-manufacturing costs (Period costs): All the costs not included in product costs. These are Marketing/Selling costs as well as Administrative costs.

Chapter 3: Solution Approach

3.1 OVERVIEW

This chapter follows the process of developing the means to better understand the electricity problem faced by the ferrochrome industry. This primarily involves the development of an analytical model.

The approach to designing the final model is to develop a physical process model, then to develop a cost accounting model. The model will be developed using Microsoft Excel software.

3.2 MODEL FRAMEWORK

3.2.1 DEVELOPING THE MODEL

When developing the model, it is important to move through a logical sequence of steps to ensure the legitimacy and correctness of the final model. These are demonstrated below:

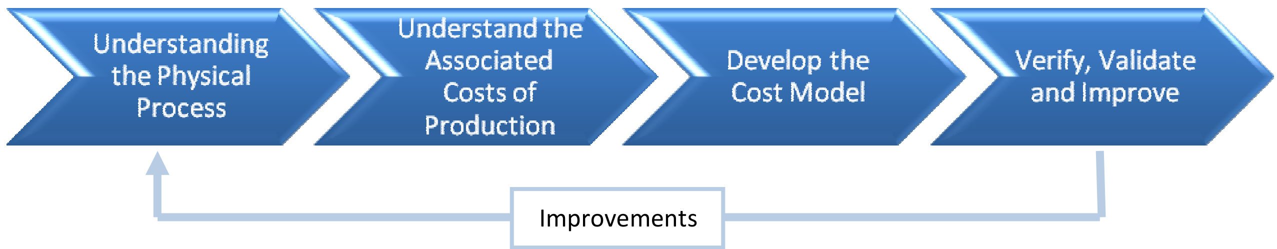


FIGURE 6: THE MODELLING PROCESS. SOURCE: AUTHORS OWN.

The process includes a feedback loop to continually better the model as is shown. This is important as it allows for a more accurate model over time.

3.2.2 THE PHYSICAL MODEL

The first step in developing the model is to understand the physical production process. The following elements of the physical model can be classified as:

- **Inputs**
  - Chromite ore
  - Reductants
  - Fluxes
  - Electricity
  - Human resources

- **Processes**
  - Smelting / Production

- **Outputs**
  - Ferrochromium
  - Slag
  - Off gasses

These elements must now be discussed in detail in order to develope a comprehensive cost model.

3.2.2.1 Inputs

- Chromite Ore
  - This is an ore consisting of the Cr_2O_3 mineral.
  - The amount of chromite within the ore will vary depending on the source of the ore.
  - It is classified according to its size and the amount of chromite it contains.
  - Often this can take the form of recovered chromium and fine metal dusts.
  - The amount of chromite ore required for the production of 1 ton of chromium will depend on the inherent quality of the ore as well as the furnace recipe. This is referred to as the efficiency of the ore. This varies between ± 1.8t – 3.5t of chromite ore required for one ton of ferrochrome.

- Reductants

- These are carbon containing minerals such as coal, coke, anthracite etc. They are required to facilitate the carbo-thermic reduction of the chromite ore into ferrochrome.
- Again these are process dependant, and will vary in the technology and recipe used in the furnace. Often about one ton of reductant is required for each ton of ferrochrome produced.
- Reductant materials are readily available in South Africa. They are classified by the reactivity of the material and influence the product quality, the specific energy consumption and amount of reductant material required. The higher the quality of material used, the greater the price but less is required. This is also understood as the efficiency of the reductant.

- Fluxes
  - Fluxes are materials used to condition the slag for pouring (tapping).
  - Different methods of operation require different types and quantities of flux.
  - Flux materials are usually cheap and readily available.

- Transportation
  - All input materials are gathered from outside sources, and must therefore be transported to the plant.
  - For this model this cost is represented as part of the input material cost.

- Electricity
  - In EAF's the amount of heat produced by the furnace is directly proportional to the amount of power it consumes, which is again directly proportional to the potential rate of production.
  - Since the amount of resistance within a furnace is typically low (± 0.001 Ohm), the amount of current required to maintain its operating power is usually high. This follows the power equations:
    - $P = I.R$
    - $P = V^2/R$
  - Typically the power utility (Eskom) will provide electricity in a high voltage low current form, therefore in order to maintain the operating power required,

they must use transformers to step up the current and step down the voltage. Transformers use a ratio of the number of coils wound around a magnetic medium to perform this function, the input number of coils is known as N_1 and the output N_2.

   - $I_1 N_1 = I_2 N_2$

- The operating power of the furnace - known as the set point- can be decided by selecting the number of turns on one side of the transformer, this is called the "tap position".
- As a rule, a furnace is most efficient at its maximum power rating although this can be altered according to the demands of the process.
- A typical furnace when fully loaded (charged) will operate at 90% of its maximum rating.
- Source: Olsen et al. 2007

- Human Resources
  - The operation of a smelting process involves a complex synthesis between machinery and manpower. Four distinguishable groups of labour and a brief job description are presented below:

1) Furnace operators & controllers: They are directly in charge of the physical process and supervise the control of the furnace. This will also includes the functions of charging and tapping the furnace.

2) Internal plant logistics: The job of moving materials throughout the system, from the RM landing area to the furnace, from the furnace to the shipping yard etc.

3) Maintenance Personnel: Ferroalloy plants requiring continuous production will almost certainly make use of preventative maintenance practices to avoid shutdowns at all costs. Additionally unscheduled maintenance will also be required.

4) Supervisory/Management staff: These employees are tasked with managing the plant from a global perspective, and integrating all departments into one coherent team.

5) Sales and Marketing: These staff members fulfill a wide variety of functions including developing the market, ensuring customer satisfaction, the physical activity of selling product and more.

When considering how to account for these costs, it becomes difficult to place them as either product or period costs. For example the cost of maintenance does not strictly add value to the end product, yet it is essential to ensure continuing production. The principles of activity/unit based costing dictate that the cost should be split up into activity pools, from whence the unit cost can be calculated. The first three categories will be considered as a direct labour cost, while the latter two will be treated as an indirect labour cost.

3.2.2.2 THE PROCESS

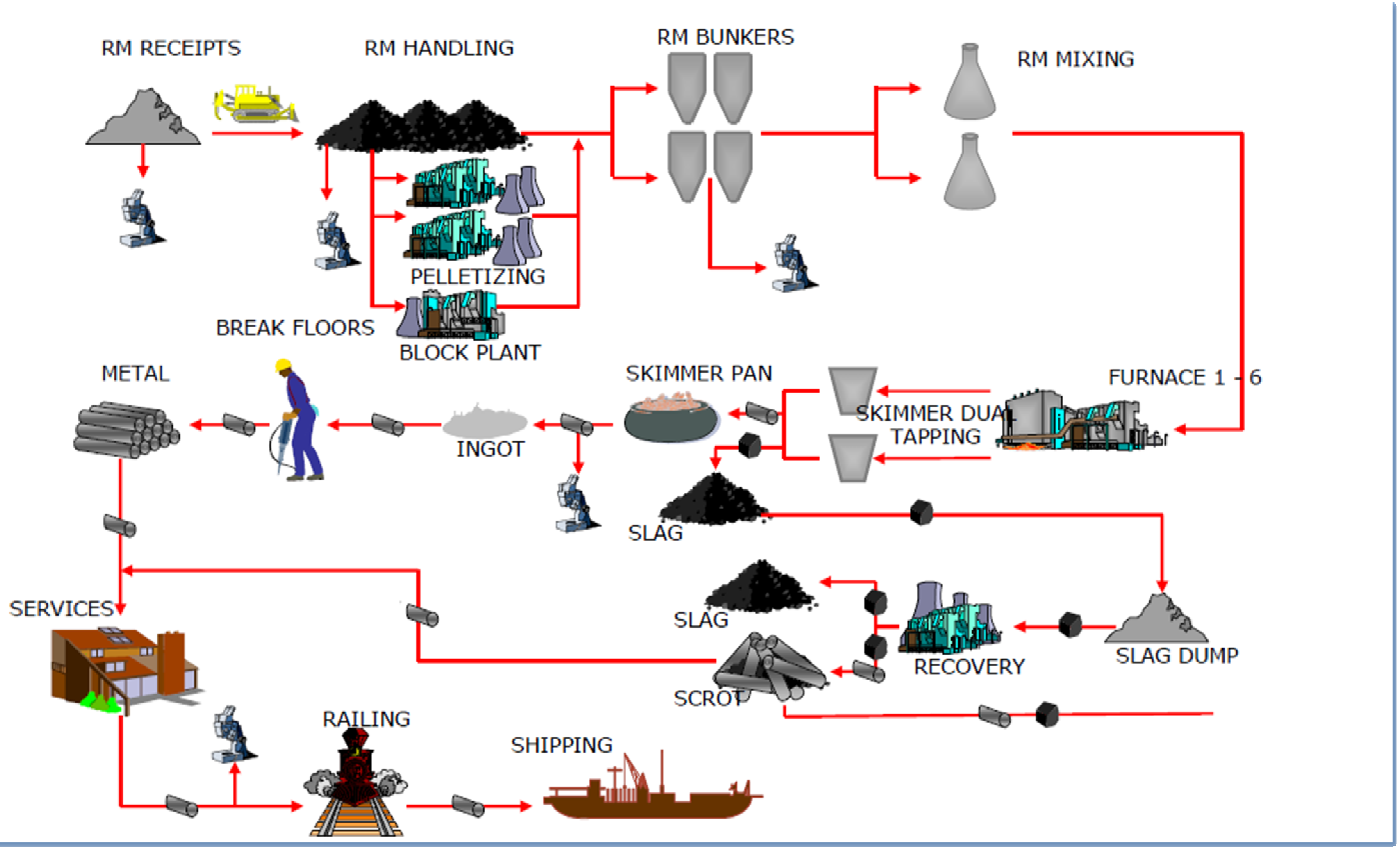
- This is the smelting process where enormous heat is used to smelt the raw materials into the final product.
- The Input materials are batched to the requirements of the furnace recipe.
- These materials are discharged into a specialized vehicle which approaches the furnace, the furnace doors are opened, and the material is dropped in by way of a tipping mechanism on the vehicle (Charging). The doors of the furnace are then closed again.
- The materials are processed forming ferroalloy metal and a slag bath. Since this creates a vast amount of heat the furnace is constantly cooled by water circulating around the furnace hearth. The chemical reaction also creates a carbon monoxide “off gas” which must be extracted using a network of overhead ducts and a system of fans.
- After a prescribed period the furnace tap hole is opened and the final metal flows out. The molten metal is poured through a series of skimmer troughs where the slag layer is separated from the metal.
- The metal now separated from the slag is cast into ingots of a particular size.
- The slag is also cast as it will be reworked at a later stage.
- The ferroalloy ingots are inspected, and then moved to a final shipping yard.

3.2.2.3 OUTPUTS

- The final saleable product being some specification of ferroalloy.
- The slag byproduct which has little more potential, and is dumped in the government prescribed manner.
- Off gasses which are first treated in a back-filter plant are then burnt in a flue chimney.

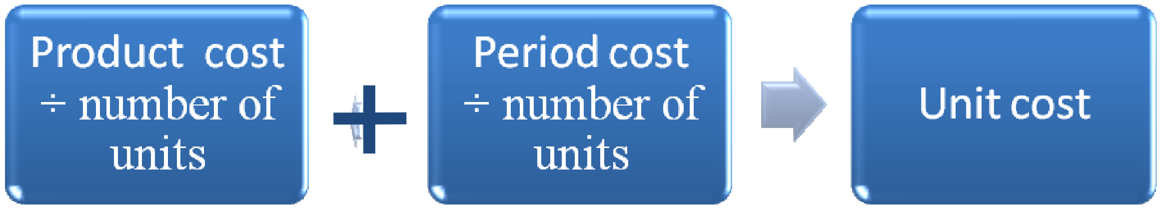
The manufacturing process is well depicted in figure 7 below.

FIGURE 7: THE FERROCHROME PRODUCTION PROCESS. SOURCE (TRANSALLOYS)



3.2.3 The Cost Model

The cost model aims to build upon the physical model by incorporating the product costs with the period costs (also known as variable and fixed costs respectively). These costs now need to be converted to unit costs before being inputted into the model. This will take the form of cost (in Rands) per metric ton of finished goods.



3.2.3.1 Cost breakdown

<u>Variable Costs:</u>

- Cost of Ore/Reductants/Fluxes per ton including transportation to the plant.
- General Operating expense incurred in production.

<u>Energy Costs:</u>

- Direct energy costs
  - Reactive energy charge
  - Environmental levy
  - Electrification and Rural Subsidy

- Indirect Electricity costs and levies including:
  - Service charge
  - Administration charge
  - Network distribution charge

Fixed Costs:

- Water
- Maintenance
- Insurance
- Machinery
- Office costs
- Labour

3.3 Model Data Gathering

3.3.1 Sourcing of data

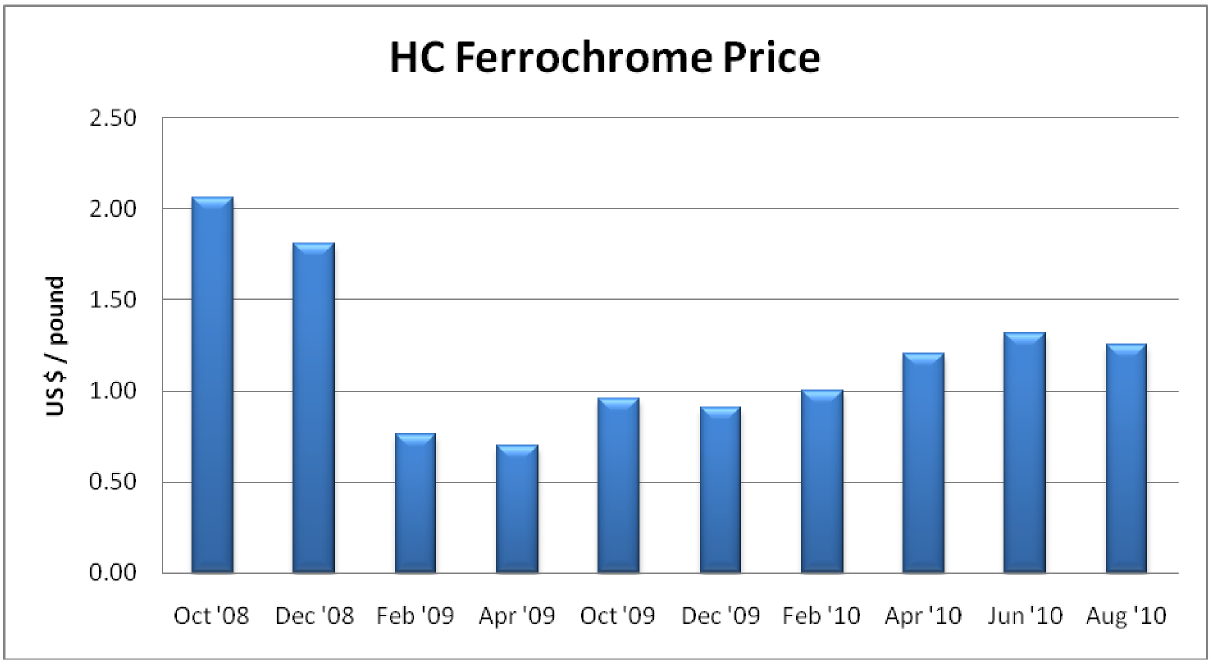
After properly defining the model structure and required inputs, data must be gathered in respect of these. Information presented relating to Cost of Production in this model is developed from general industry data and does not represent the practices of any single manufacturer, therefore the results of the model cannot be interpreted literally, but emphasis should rather be placed on the functional operation of the model.

3.3.2 Market related data

Ferrochrome price:

The price of South African HC (High Carbon) ferrochrome has fluctuated quite dramatically as a result of Eskom's inability to provide adequate power supply. This resulted in widespread panic buying to ensure supplies, which, in turn sparked an increase in price which climbed to a high of USD 2.13 $/lb in Q3 2008. This has subsequently decreased as a result of the global economic downturn and the associated reduction in demand. Today the price stands at a moderate value of 1.36 $/lb. Future trends indicate an increase in price directly linked to the growth and well being of worldwide steel markets.

FIGURE 8: SOUTH AFRICAN FECR PRICES. SOURCE: AUTHORS OWN



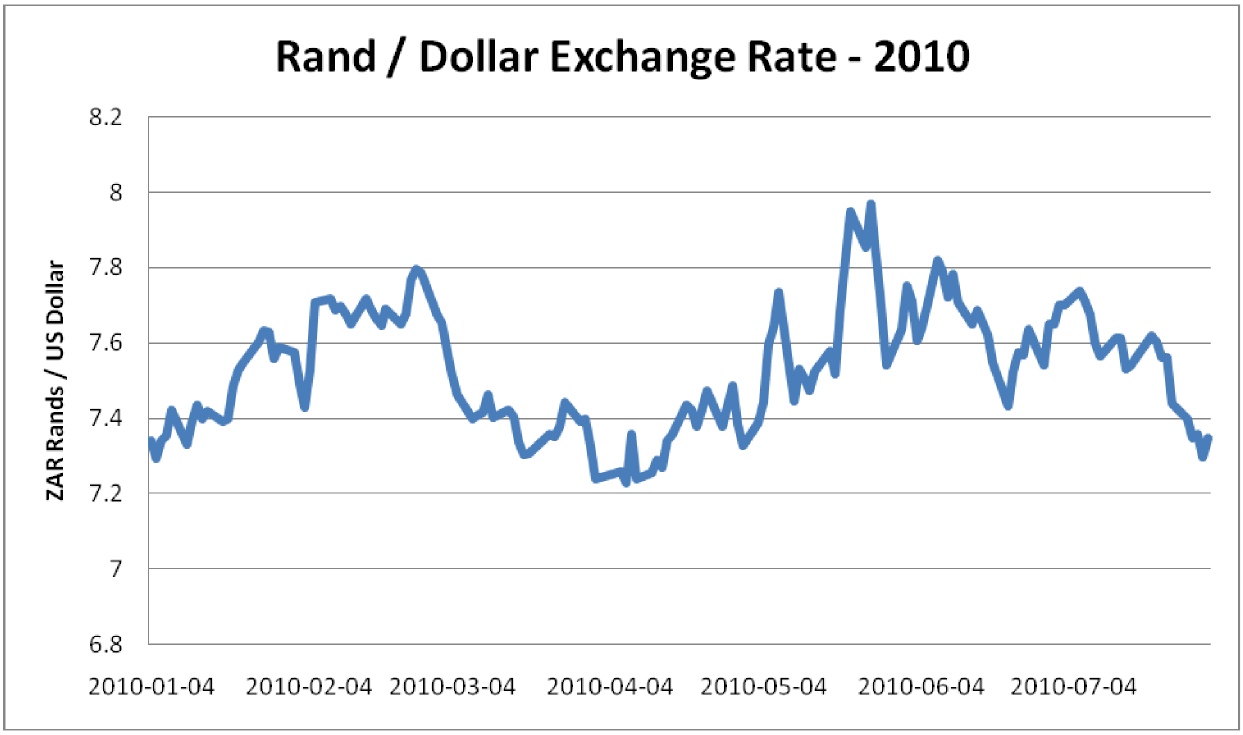
Rand/Dollar Exchange rate:

The state of the Rand / Dollar exchange is crucial to the Profitability of the ferroalloy industry. This is because the US Dollar is the primary means of exchange in the metal markets, where international prices are based on the currency.

The South African Rand has gained notoriety for being one of the least stable currencies in the world, because of how it fluctuates unpredictably and regularly. This creates a challenge for ferroalloy producers – and indeed most South African businesses- to ensure profitable operation in a variety of market conditions. Fortunately for local ferroalloy producers, the raw materials required in the smelting process are sourced locally, and in the local currency. This helps to maintain a degree of stability in the industry.

The role that exchange rates play is crucial in determining the final selling price of finished goods and is hence represented in the model.

FIGURE 9: EXCHANGE RATE HISTORY BEGINNING 2010 - CURRENT



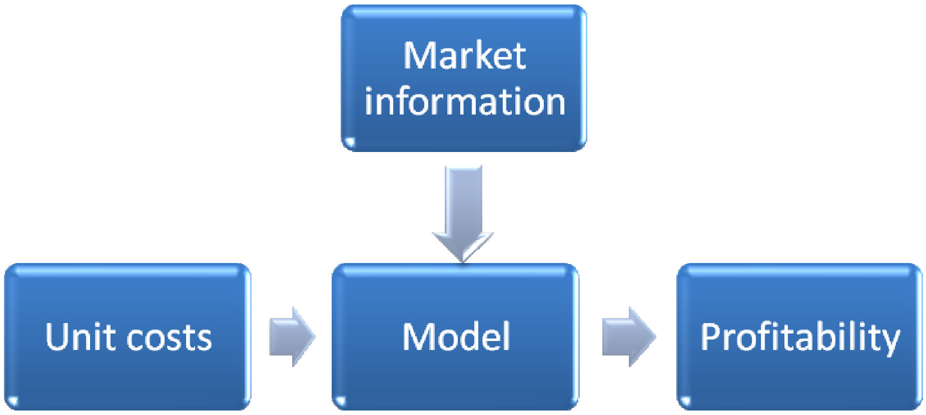
The complete set of inputs together with the general industry data is presented as an example below.

TABLE 2: MODEL INPUT DATA

Model input		
Input	**Unit**	**Value**
Efficiency		
Ore	ton / ton	3.3
Reductants	ton / ton	1
Fluxes	ton / ton	0.8
Operating costs		
Variable operating costs	Rands / ton	1 342 000
Cost of Materials		
Ore	Rands / ton	1300
Reductant	Rands / ton	5100
Fluxes	Rands / ton	600
Electricity		
Energy Efficiency	kWh / ton	3500
Energy Tariff - 2010	Summer	Winter
Peak	41.03	147.08
Standard	25.35	38.2
Off-peak	17.55	20.38
Fixed Costs		
Water	Rands	50 000
Electricity	Rands	40 000
Maintenance	Rands	3 000 000
Insurance	Rands	80 000
Machinery	Rands	2 100 000
Office costs	Rands	80 000
Labour		
Wages & Salaries	Rands	1 233 000
Administration	Rands	420 000
Management	Rands	620 000
Sales/Contract Price		
Current Selling price	USD $ / lb	1.10
Rand / Dollar Exchange Rate		
Current Rate	ZAR / US $	7.41

3.4 The Complete Spreadsheet Model

The complete model makes use of the current market/contract price available for the finished good, to determine whether production, given the chosen conditions, is in fact profitable or whether a loss is being incurred.



Assumptions of the model

- Production is run on a continuous 24 / 7 basis.
- Power availability is not limited by Eskom.
- Market conditions are not overly dynamic, i.e. the selling price remains stable on a day to day basis.
- All raw materials and inputs are constantly available to meet production requirements.
- Fixed costs do not fluctuate month to month. Although in complex, large scale operations this is undoubtedly the case, the assumption needs to be made that fluctuations are small relative to the variable and total manufacturing costs.
- Profit is output as a gross figure not a net figure. Profitability is calculated as Earnings before interest, taxes, depreciation and amortization (EBITDA).

TABLE 3: AN EXAMPLE OF THE COST OF PRODUCTION AND UNIT COSTS OF PRODUCING ONE TON OF FERROCHROME

Cost of production					Monthly Production:	9000
Variable Costs	Description	Efficiency	Units	Cost / unit	Total	Unit Cost
Ore	tons	3.3	29 700	1 300	38 610 000	4290.00
Reductants	tons	1.0	9 000	5 100	45 900 000	5100.00
Fluxes	tons	0.8	6 750	600	4 050 000	450.00
Electricity	kWh	3500.0	31 500 000	0.33	10 395 000	1155.00
General & Operating	Rand				1 682 000	186.89
Total Variable					98 955 000	10995.00
Fixed Costs						
Water	Rand				62 000	6.89
Electricity (Indirect)	Rand				72 000	8.00
Maintenance	Rand				3 000 000	333.33
Insurance	Rand				90 000	10.00
Machinery	Rand				2 100 000	233.33
Office costs	Rand				80 000	8.89
Labour						
Wages & Salaries	Rand				1 633 000	181.44
Administration	Rand				420 000	46.67
Management	Rand				620 000	68.89
Total Fixed					8 077 000	897.44
Combined Total COP					107 032 000	11892.44

Exchange rate conversion		
Rand/Dollar		7.30
Selling Price	USD$ / lb	1.10
Selling Price	ZAR R/ton	17666.00

Energy cost Slider	
0 c	260 c/kWh
Cost R / kWh	0.33

Electricity Tariff Rates (c/kWh)			
	Peak	Standard	Off-peak
Summer	41.03	25.35	17.55
Winter	147.08	38.2	20.38

Profit Calculation (Rands per ton)	
Selling Price	17666.00
Cost of Sales	1400
Cost of Production	11892.44
Profit (EBITDA)	4373.56

3.5 Model verification & validation

When developing any model it is essential to ensure the correct functioning of the model. This is done in two ways, verification and validation.

Verifying a model ensures the model does indeed behave in the manner anticipated by the builder. This includes the basic operation and structure of the model. As pertaining to this model, verification involved checking the formulae of the model to ensure the correctness of the mathematical equations which drive the model. Additionally the input values were tested to check they were correctly inserted into the model.

Validating a model follows verification and is concerned with the numerical accuracy of the model and model data. This compares model performance to real world performance and can be expressed as a percentage ratio of the model output versus the real world figure. The confidential nature of the data available for this study limits the accuracy of the data inputted in the model. The proposed standard for a successfully validated model is a 99% correlation to real world figures.

3.5.1 Changes made to the model

A shortcoming of the model was identified while verifying the application of the model.

When using the model as a decision support system in determining whether production is profitable or not, and indeed in the case when it is not, the model assumes that production can be ceased without direct costs. This is however, not the case. When shutting off power to an EAF, the furnace will lose heat rapidly, freezing the material already in the furnace. The implication of this is a tremendous difficulty in restarting the furnace. This causes a large amount of power to be consumed in a non value-adding process of restarting the furnace.

To avoid this in practice, the model should take into account that the furnace is not shut off but rather throttled back to an appropriate level. This is known as reducing the set in power but maintaining the "colour" of the furnace. In other words the furnace should still glow at this lower temperature. Depending on the technology in use, this can vary from 15 – 30% of the furnace's maximum power rating.

The corrective measure should add the cost of idle running to the cost of production as a direct electrical expense together with the already established electrical expenses.

FIGURE 10: IMPROVED MODEL CONTAINING IDLE TIME AMENDMENT (IN RED)

5	Reductants	tons	1.0	9 000	5 100	45 900 000	5100.00
6	Fluxes	tons	0.8	6 750	600	4 050 000	450.00
7	Electricity	kWh					
8	*Direct Usage*		3500.0	31 500 000	0.69	21 735 000	2415.00
9	*Idle Usage(20%)*		20.0%	72 000	1.47	105 898	11.77
10	General & Operating	Rand				1 682 000	186.89
11	Total Variable					88 560 000	9840.00
12							

Selling Price		ZAR R/ton	17666.00
Furnace Idle time			
Time (Hours)		Hours	12
Idle rate		c/kWh	147.08
Energy cost Slider			
0 c			260 c/kWh

This addition makes use of the property of the furnace, the operating conditions and model output to feedback information into the model to make it more accurate.

The Idle usage calculation is as follows:

Idle cost = (Idling efficiency- example case: 20%) x (Furnace Power Rating) x (1000- Conversion to kWh) x (Idling time – h/month) x (Idle rate – energy cost)

And:

Idle unit cost = Idle cost ÷ Monthly Production

CHAPTER 4: MODEL RESULTS, ANALYSIS AND CONCLUSIONS

4.1 OVERVIEW

After development of the model one now asks the question initially posed in the project title: What is the economic impact of increased electricity prices in the ferroalloy industry?

Is the profitability of the industry suffering during the peak electricity demand season?

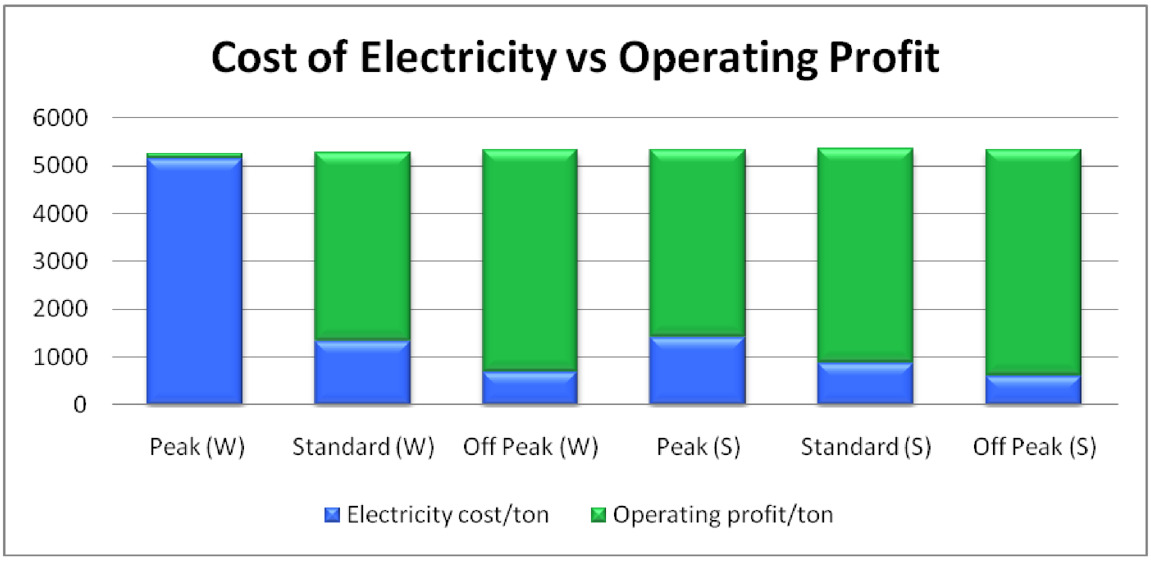
Should production be ceased in order to avoid operating at a loss?

In this chapter these questions will be answered, together with an analysis of the model's sensitivity to change.

4.2 MODEL RESULTS

The relationships between an assortment of electricity tariffs and spot profitability are explored below. Tariffs are based on current 2010/2011 rates.

	Winter			Summer		
	Peak	Standard	Off-peak	Peak	Standard	Off-peak
Electricity Cost / ton (Rands)	5147.8	1337	713.3	1436.05	887.25	614.25
Operating Profit / ton (Rands)	91.67	3941.0	4606.67	3906.67	4466.67	4711.67

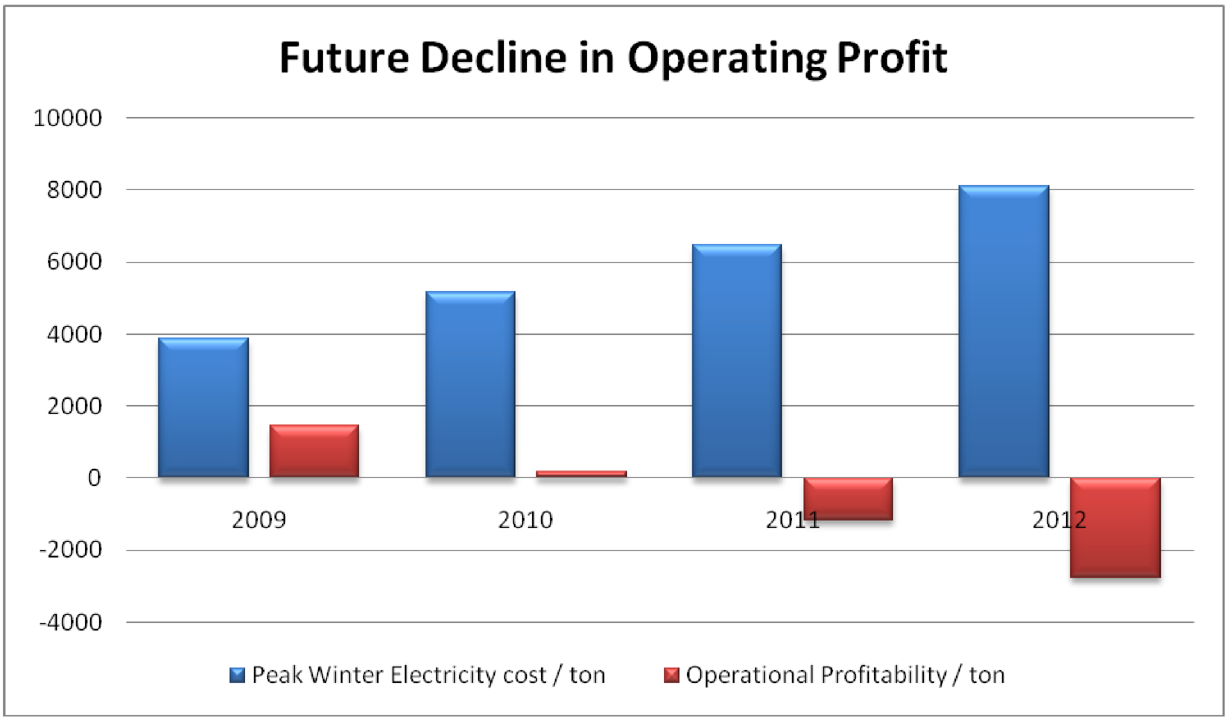

Cost of Electricity vs Operating Profit
6000
5000
4000
3000
2000
1000
0
Peak (W)
Standard (W)
Off Peak (W)
Peak (S)
Standard (S)
Off Peak (S)
Electricity cost/ton
Operating profit/ton

4.2.1 Analysis of results

It can be seen in the above figure that the peak winter cost of electricity (left hand side of graph) is such that almost no profit is realized. Healthy profit is realized during other phases of operation. This leads one to question the future profitability during this period, especially given the proposed tariff increases being imposed in the next two years. The graph below explores the current and future profitability of the industry as determined by the model during peak winter periods.

	2009	2010	2011	2012
Peak Winter Electricity cost / ton	3865.998	5147.8	6481.08	8088.388
Operational Profitability / ton	1444.002	162.2	**-1171.08**	**-2778.39**

FIGURE 11: PREDICTED FUTURE DECLINE IN PROFIT



A predictable yet concerning trend is evident. The operating profit of 2009, 2010, turns into a rather substantial loss in the years after 2010. This alarming trend will mean that producing in winter peak periods will become uneconomical. This is bad news for producers since peak periods make up 14.9% of weekly production time. This totals 25 hours per 7 day week during which furnaces will be forced into an idle state.

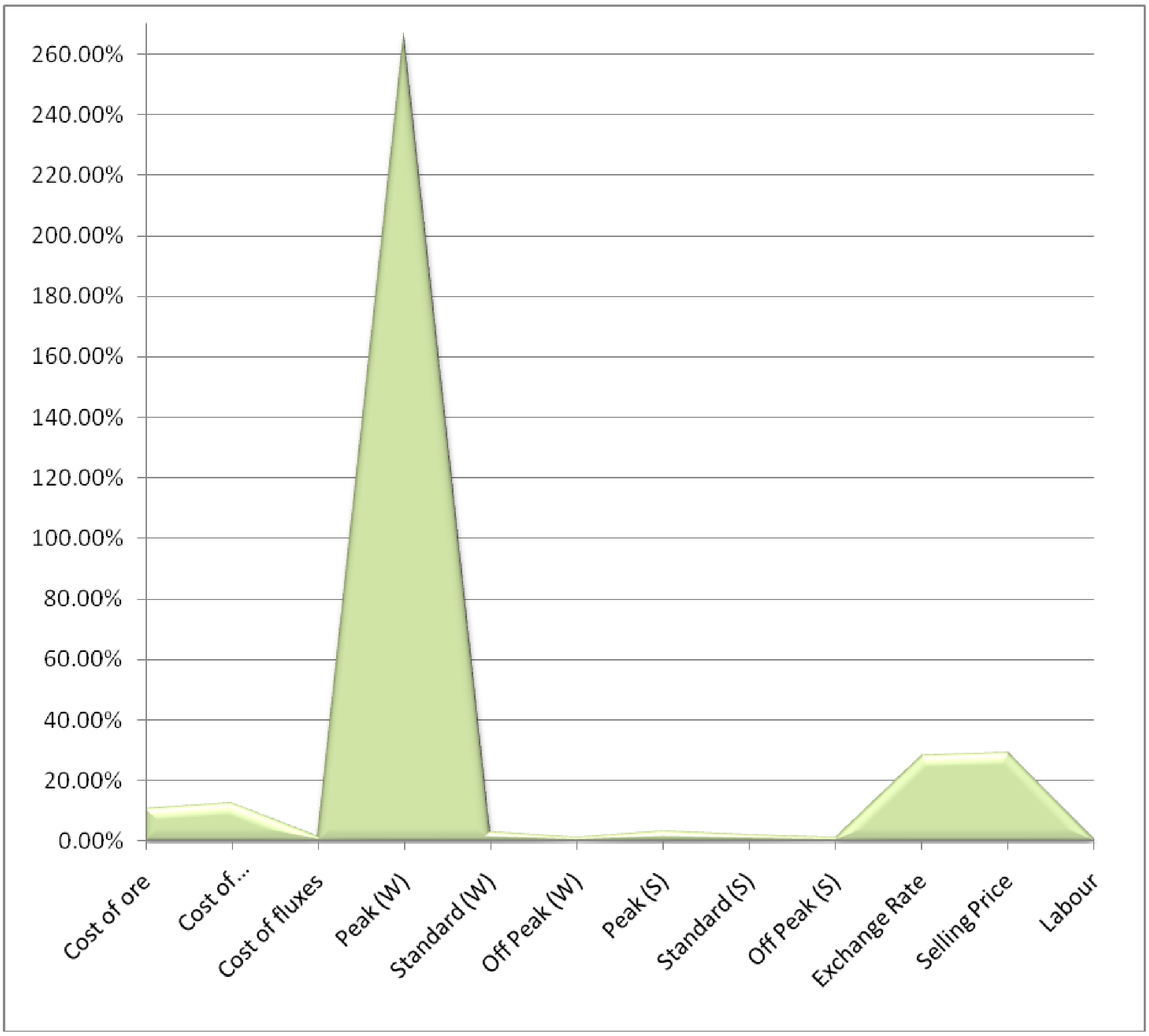
4.3 Sensitivity Analysis

In order to determine which of the Inputs are most susceptible to change, a sensitivity analysis was carried out on the major Inputs. All input values were increased by 10% and the difference in Profitability was noted. If the difference is less than 0-2% then it could be said that the input is barely sensitive to change. As it approaches 10% the input can be said to be linearly related to change. If the difference exceeds 10% it can be classified as sensitive to the model.

Sensitivity Analysis +10%					
Inputs	Original	10%	Original Operating Profit	Recalculated Operating Profit	% Difference
Cost of ore	1300	1430.00	4221.65	3757.75	10.99%
Cost of reductants	5100	5610.00	4221.65	3676.26	12.92%
Cost of fluxes	600	660.00	4221.65	4141.7	1.89%
Cost of Energy (annual ave. 32.4 c/kWh)					
Peak (W)	147.08	161.79	196.67	-328.3	266.93%
Standard (W)	38.2	42.02	4004.67	3871.6	3.32%
Off Peak (W)	20.38	22.42	4641.33	4571.7	1.50%
Peak (S)	41.03	45.13	3906	3766	3.58%
Standard (S)	25.35	27.89	4466.9	4361.12	2.37%
Off Peak (S)	17.55	19.31	4711.3	4641.5	1.48%
Exchange Rate	7.3	8.03	4221.65	5915.1	28.63%
Selling Price	1.1	1.21	4221.65	5988.27	29.50%
Labour	2 673 000.00	2 940 300.00	4221.65	4192	0.71%

The graph below illustrates the relative sensitivity of the input figures.

FIGURE 12: GRAPHIC REPRESENTATION OF SENSITIVITY



As is fairly obvious, the spiking indicated by the winter peak electricity tariff appears to be somewhat of an anomaly. This is known as a leverage point in the data and is not to be confused with extraordinary sensitivity. Points of this type come about when the data fed into the model reaches a point of inflection. In this case it is when the price of electricity swings the output profitability from a positive value to a negative value. This can be understood by considering that the number 4 is twice as large(200%) as the number 2, but add 100 to both and the number 104 is only 2% larger than 102.

When further investigating points like these, one should still treat them as highly sensitive. Calculations show the exponential nature of compounding increases on an already exponential data field can yield anomalies far beyond reasonable figures. Once a greater number of iterations are carried out, the sensitivity falls to 130%, more accurate yet still highly sensitive and should be treated as such.

4.4 CONCLUSION

A model has now been developed which can serve to aid management in optimizing their production scheduling, so as to avoid producing at a loss. The simplicity of the model will enable anybody who has basic Microsoft Excel skills to use it, and once the model is configured for a particular furnace operation, and the variable inputs are set, the model will determine the spot profitability of the operation.

The example model that has been developed in this study clearly shows a trend, which forecasts not only reduced profitability, but net losses in some circumstances. These losses are directly linked to production in peak winter periods when electricity costs are at their highest. In order to avoid these losses, manufacturers need to consider scheduling their production in a manner that will avoid substantial power use in these periods.

The ability to adjust the cost of energy and other market factors quickly and easily, makes the model dynamic, and ensures that the economic impact of energy costs are clearly visible.

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APPENDIX A – MODEL DETAIL AND FORMULA

Cost of production					Monthly Production:	9000
Variable Costs	Description	Efficiency	Units	Cost / unit	Total	Unit Cost
Ore	tons	3.3	29 700	1 300	38 610 000	4290.00
Reductants	tons	1.0	9 000	5 100	45 900 000	5100.00
Fluxes	tons	0.8	6 750	600	4 050 000	450.00
Electricity	kWh					
Direct Usage		3500.0	31 500 000	0.32	10 080 000	1120.00
Idle Usage(20%)		20.0%	0	1.47	0	0.00
General & Operating	Rand				1 682 000	186.89
Total Variable					100 322 000	11146.89
Fixed Costs						
Water	Rand				62 000	6.89
Electricity (Indirect)	Rand				72 000	8.00
Maintenance	Rand				3 000 000	333.33
Insurance	Rand				90 000	10.00
Machinery	Rand				2 100 000	233.33
Office costs	Rand				80 000	8.89
Labour						
Wages & Salaries	Rand				1 633 000	181.44
Administration	Rand				420 000	46.67
Management	Rand				620 000	68.89
Total Fixed					8 344 000	927.11
Combined Total COP					108 666 000	12074.00

Scrollbar Decimal converters	32	0.32	73	7.3

Exchange rate conversion		
Rand/Dollar	7.30	
Selling Price	USD$ / lb	1.10
Selling Price	ZAR R/ton	17666.00

Furnace Idle time			
Time (Hours)		Hours	0
Idle rate		c/kWh	147.08

Energy cost Slider	
0 c	260 c/kWh
Cost R / kWh	0.32

Electricity Tariff Rates (c/kWh)			
	Peak	Standard	Off-peak
Summer	41.03	25.35	17.55
Winter	147.08	38.2	20.38

Profit Calculation (Rands per ton)	
Selling Price	17666.00
Cost of Sales	1400
Cost of Production	12074.00
Profit (EBITDA)	4192.00

Furnace Power Rating		
Maximum rating	MW/MVA	30

Cost of production					Monthly Production:	9000
Variable Costs	Description	Efficiency	Units	Cost / unit	Total	Unit Cost
Ore	tons	3.3	=$G$1*C4	1300	=E4*D4	=F4/$G$1
Reductants	tons	1	=$G$1*C5	5100	=E5*D5	=F5/$G$1
Fluxes	tons	0.75	=$G$1*C6	600	=E6*D6	=F6/$G$1
Electricity	kWh					
Direct Usage		3500	=$G$1*C8	=K14	=E8*D8	=F8/$G$1
Idle Usage(20%)		0.2	=C9*L28*1000*L8	=L9/100	=E9*D9	=F9/$G$1
General & Operating	Rand				1682000	=F10/$G$1
Total Variable					=SUM(F4:F10)	=F11/$G$1
Fixed Costs						
Water	Rand				62000	=F14/$G$1
Electricity (Indirect)	Rand				72000	=F15/$G$1
Maintenance	Rand				3000000	=F16/$G$1
Insurance	Rand				90000	=F17/$G$1
Machinery	Rand				2100000	=F18/$G$1
Office costs	Rand				80000	=F19/$G$1
Labour						
Wages & Salaries	Rand				1633000	=F21/$G$1
Administration	Rand				420000	=F22/$G$1
Management	Rand				620000	=F23/$G$1
Total Fixed					=SUM(F14:F23)+267000	=F24/$G$1
Combined Total COP					=F11+F24	=F26/$G$1

Scrollbar Decimal converters	32	=C28/100	73	=E28/10

Exchange rate conversion			
Rand/Dollar		=F28	
Selling Price		USD$ / lb	1.1
Selling Price		ZAR R/ton	=L4*2.2*K2*1000

Furnace Idle time			
Time (Hours)		Hours	0
Idle rate		c/kWh	147.08

Energy cost Slider			
0 c			260 c/kWh
Cost R / kWh		=D28	

Electricity Tariff Rates (c/kWh)			
	Peak	Standard	Off-peak
Summer	41.03	25.35	17.55
Winter	147.08	38.2	20.38

Profit Calculation (Rands per ton)		
Selling Price		=L5
Cost of Sales		1400
Cost of Production		=G26
Profit (EBITDA)		=K22-K23-K24

Furnace Power Rating		
Maximum rating	MW/MVA	30

APPENDIX B – RELATED GRAPHS AND TABLES

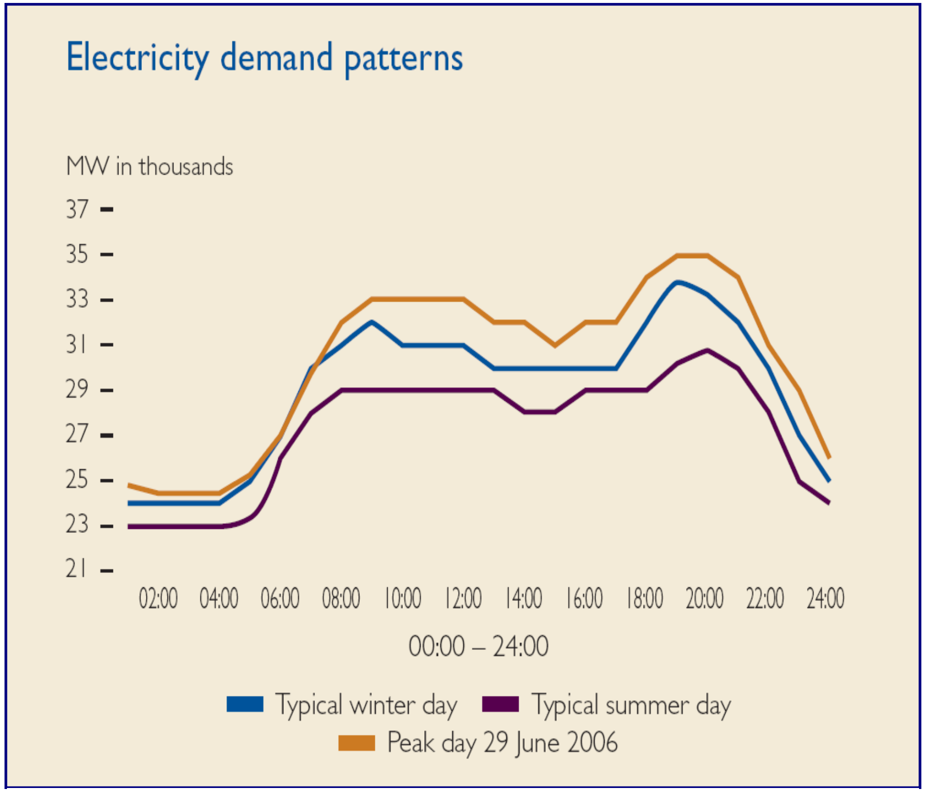


FIGURE 13: THE TYPICAL DAILY ELECTRICITY DEMAND PATTERNS. THE GRAPH HELPS TO DEMONSTRATE THE LARGE VARIATION BETWEEN PEAK, STANDARD AND OFF-PEAK DEMAND.

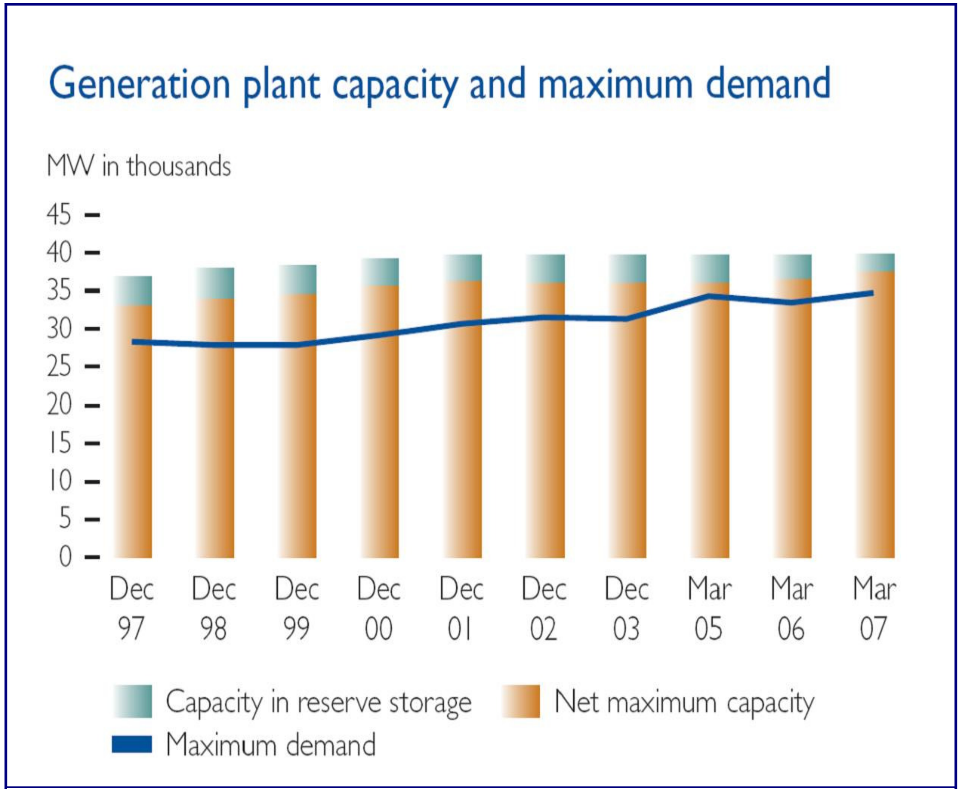


FIGURE 14: AN INDICATION OF THE DWINDLING SUPPLY CAPACITY RELATIVE TO THE GROWING DEMAND

Megaflex *[non local authorities]*

		Active energy charge [c/kWh]												Transmission network charges [R/kVA/m]	
		High demand season [Jun - Aug]						Low demand season [Sep - May]							
Transmission zone	Voltage	Peak		Standard		Off Peak		Peak		Standard		Off Peak			
			VAT incl		*VAT incl*		*VAT incl*		*VAT incl*		*VAT incl*		*VAT incl*		*VAT incl*
≤ 300km	< 500V	**147.08**	*167.67*	**38.20**	*43.55*	**20.38**	*23.23*	**41.03**	*46.77*	**25.12**	*28.64*	**17.55**	*20.01*	**R 3.67**	*R 4.18*
	≥ 500V & < 66kV	**142.38**	*162.31*	**37.01**	*42.19*	**19.77**	*22.54*	**39.75**	*45.32*	**24.35**	*27.76*	**17.03**	*19.41*	**R 3.35**	*R 3.82*
	≥ 66kV & ≤ 132kV	**137.22**	*156.43*	**35.70**	*40.70*	**19.11**	*21.79*	**38.35**	*43.72*	**23.51**	*26.80*	**16.47**	*18.78*	**R 3.26**	*R 3.72*
	> 132kV	**132.45**	*150.99*	**34.51**	*39.34*	**18.48**	*21.07*	**37.04**	*42.23*	**22.74**	*25.92*	**15.94**	*18.17*	**R 4.12**	*R 4.70*
> 300km and ≤ 600km	< 500V	**148.53**	*169.32*	**38.56**	*43.96*	**20.59**	*23.47*	**41.43**	*47.23*	**25.34**	*28.89*	**17.72**	*20.20*	**R 3.69**	*R 4.21*
	≥ 500V & < 66kV	**143.77**	*163.90*	**37.36**	*42.59*	**19.96**	*22.75*	**40.13**	*45.75*	**24.58**	*28.02*	**17.19**	*19.60*	**R 3.38**	*R 3.85*
	≥ 66kV & ≤ 132kV	**138.58**	*157.98*	**36.05**	*41.10*	**19.29**	*21.99*	**38.73**	*44.15*	**23.74**	*27.06*	**16.61**	*18.94*	**R 3.29**	*R 3.75*
	> 132kV	**133.75**	*152.48*	**34.83**	*39.71*	**18.65**	*21.26*	**37.42**	*42.66*	**22.96**	*26.17*	**16.07**	*18.32*	**R 4.17**	*R 4.75*
> 600km and ≤ 900km	< 500V	**150.00**	*171.00*	**38.94**	*44.39*	**20.77**	*23.68*	**41.83**	*47.69*	**25.59**	*29.17*	**17.87**	*20.37*	**R 3.74**	*R 4.26*
	≥ 500V & < 66kV	**145.20**	*165.53*	**37.73**	*43.01*	**20.13**	*22.95*	**40.52**	*46.19*	**24.81**	*28.28*	**17.33**	*19.76*	**R 3.41**	*R 3.89*
	≥ 66kV & ≤ 132kV	**139.95**	*159.54*	**36.38**	*41.47*	**19.45**	*22.17*	**39.09**	*44.56*	**23.95**	*27.30*	**16.75**	*19.10*	**R 3.32**	*R 3.78*
	> 132kV	**135.07**	*153.98*	**35.16**	*40.08*	**18.82**	*21.45*	**37.78**	*43.07*	**23.16**	*26.40*	**16.23**	*18.50*	**R 4.22**	*R 4.81*
> 900km	< 500V	**151.49**	*172.70*	**39.30**	*44.80*	**20.96**	*23.89*	**42.21**	*48.12*	**25.82**	*29.43*	**18.04**	*20.57*	**R 3.75**	*R 4.28*
	≥ 500V & < 66kV	**146.64**	*167.17*	**38.09**	*43.42*	**20.32**	*23.16*	**40.90**	*46.63*	**25.02**	*28.52*	**17.50**	*19.95*	**R 3.45**	*R 3.93*
	≥ 66kV & ≤ 132kV	**141.35**	*161.14*	**36.73**	*41.87*	**19.64**	*22.39*	**39.46**	*44.98*	**24.18**	*27.57*	**16.91**	*19.28*	**R 3.33**	*R 3.80*
	> 132kV	**136.42**	*155.52*	**35.48**	*40.45*	**18.99**	*21.65*	**38.11**	*43.45*	**23.38**	*26.65*	**16.36**	*18.65*	**R 4.25**	*R 4.85*

Electricity Tariff History 1991 - 2012

High Demand

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Peak	19.27	20.62	16.01	17.13	17.82	18.44	18.99	20.02	20.92	22.07	32.98	45.49	49.43	50.44	49.69	52.22	55.30	72.05	131.43	162.31	204.19	256.87
Standard	6.39	6.84	8.97	9.60	9.99	10.34	10.65	11.23	11.74	12.39	13.84	13.11	14.26	14.56	13.14	13.81	14.62	19.04	34.17	42.19	53.08	66.77
Off-peak	4.54	4.86	5.15	5.51	5.73	5.93	6.11	6.44	6.73	7.10	7.93	7.76	8.46	8.63	7.15	7.51	7.95	10.38	18.25	22.54	28.36	35.67

Low Demand

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Peak	17.34	18.55	14.41	15.42	16.03	16.59	17.09	18.02	18.83	19.87	22.20	13.92	15.14	15.45	14.10	14.82	15.69	20.52	36.70	45.32	57.01	71.72
Standard	5.76	6.16	8.07	8.63	8.97	9.28	9.56	10.08	10.53	11.11	12.41	9.21	10.02	10.23	8.75	9.20	9.74	12.77	22.48	27.76	34.92	43.93
Off-peak	4.08	4.37	4.63	4.95	5.15	5.34	5.50	5.80	6.06	6.39	7.14	6.94	7.56	7.72	6.20	6.52	6.90	9.10	15.72	19.41	24.42	30.72

Source: Ramakgopa, B.M. - *Tarrif history* - http://www.eskom.co.za/content/TariffHistory.pdf

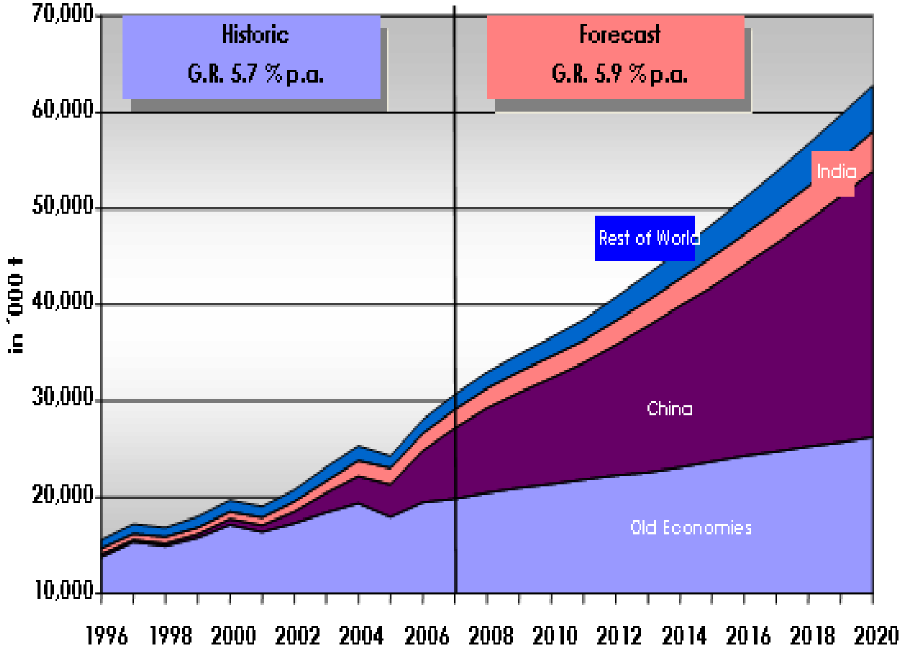
FIGURE 15: INDIRECT COSTS OF ELECTRICAL ENERGY

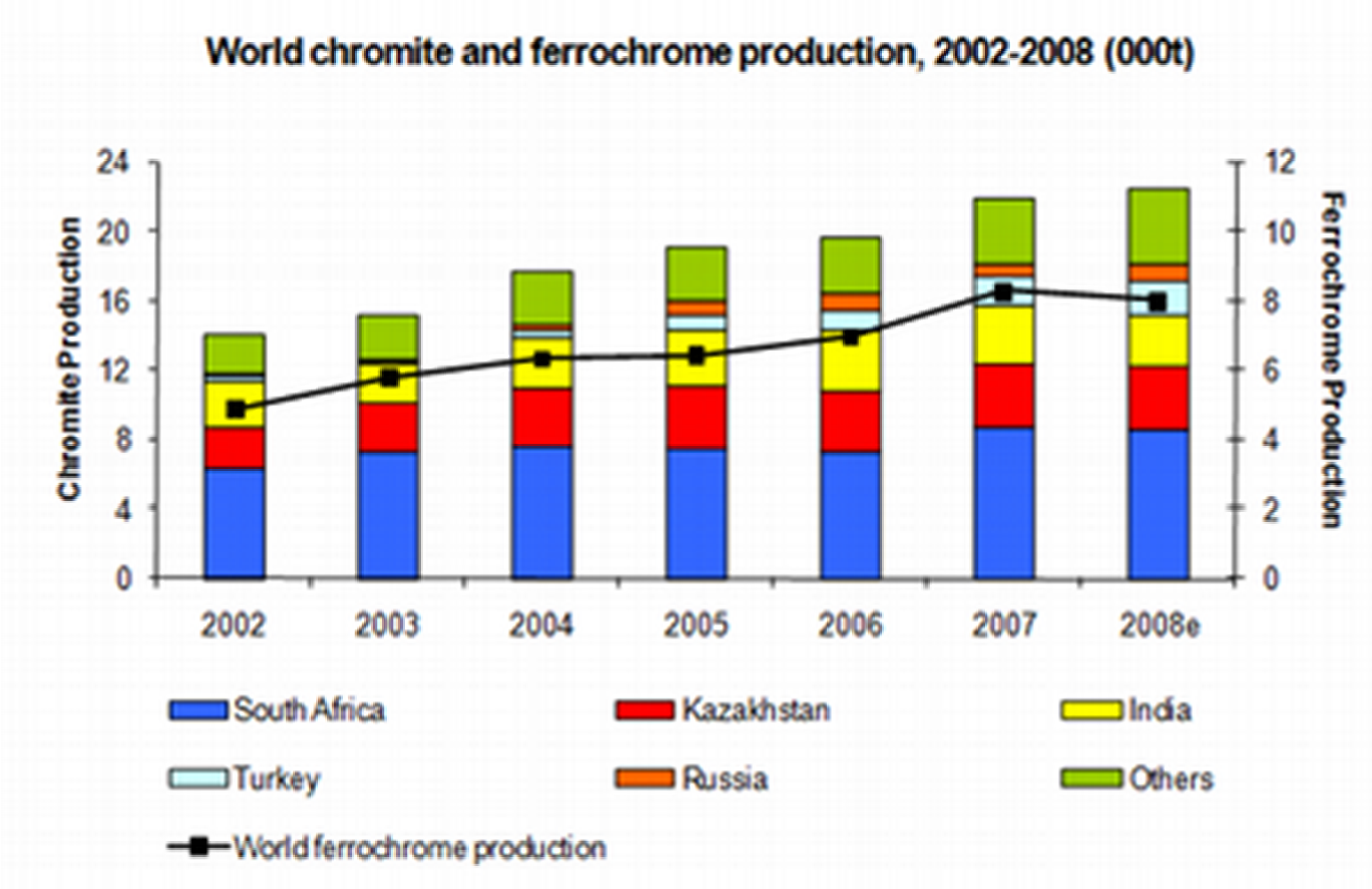
Electrification and rural subsidy [c/kWh]		Environmental levy [c/kWh]		Reactive energy charge [c/kvarh]			
All Seasons		All Seasons		High Season		Low Season	
	VAT incl		*VAT incl*		*VAT incl*		*VAT incl*
3.09	*3.52*	**2.00**	*2.28*	**5.89**	*6.71*	**0.00**	*0.00*

	Service charge [R/Account/day]		Administration charge [R/POD/day]	
Monthly utilised capacity		*VAT incl*		*VAT incl*
> 1 MVA	**R 83.62**	*R 95.33*	**R 37.69**	*R 42.97*
Key customers	**R 1 638.73**	*R 1 868.15*	**R 52.33**	*R 59.66*

Distribution network charges				
Voltage	Network access charge [R/kVA/m]	*VAT incl*	Network demand charge [R/kVA/m]	*VAT incl*
< 500V	**R 7.32**	*R 8.34*	**R 13.88**	*R 15.82*
≥ 500V & < 66kV	**R 6.72**	*R 7.66*	**R 12.73**	*R 14.51*
≥ 66kV & ≤ 132kV	**R 6.50**	*R 7.41*	**R 12.34**	*R 14.07*
> 132kV	**R 0.00**	*R 0.00*	**R 11.12**	*R 12.68*

FIGURE 16: FORECASTED GROWTH OF STAINLESS STEEL. SOURCE: HEINZ PARISER




World chromite and ferrochrome production, 2002-2008 (000t)
Chromite Production
Ferrochrome Production
24
20
16
12
8
4
0
12
10
8
6
4
2
0
2002
2003
2004
2005
2006
2007
2008e
South Africa
Kazakhstan
India
Turkey
Russia
Others
World ferrochrome production