



SOUTH AFRICA'S FERRO ALLOYS INDUSTRY - PRESENT STATUS AND FUTURE OUTLOOK

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ABSTRACT

South Africa is a leading player in the international ferro alloys industry. Historical factors that have contributed to this dominant position include an abundance of natural resources and relatively low cost electricity. A number of relatively recent developments are potentially threatening this position. These include new legislation affecting the mining and minerals industry, a shortage of some types of suitable reductants, depletion of surplus electricity generation capacity with resultant threat of real escalation of electricity prices and pressure resulting from the recent strengthening of the South African Rand. The industry is addressing these challenges in a number of ways to ensure long-term viability. Some of these measures include investments in more efficient technologies that have economy of scale benefits and are less dependent on expensive reductants and electricity. Local macro-economic impacts include new legislation regarding ownership of enterprises, mineral rights and royalties on mineral sales, development plans for port and rail infrastructure, as well as initiatives to expand electricity generation and coke production capacity.

The fundamentals for being a successful ferro alloy producer are still largely in place for South African producers. Therefore the South African ferro alloy industry will remain competitive and is well placed for continued growth in line with the international growth in ferro alloy demand. The industry should emerge leaner, more efficient and ready to respond to any future demands of the industry. This paper will cover the present status of the industry, the factors that are impacting thereon and a view on its future outlook.

1. HISTORICAL PERSPECTIVE

The ferro alloy industry in South Africa can i.a. be attributed to the foresight of the late Dr. H. J. van der Bijl who was a pioneer in the exploitation of the mineral wealth of the country by the formation of African Metals Corporation (Amcor) Limited. The company was incorporated on 23 July 1937 and started production of pig iron and high carbon ferromanganese (HCFeMn) in a 10 ft hearth blast furnace in Newcastle, Natal. In 1939 a decision was taken to construct two electric furnaces for the production of ferro alloys in Vereeniging, Transvaal. The first 3 MVA rectangular furnace was commissioned on 15 February 1942 for the production of HCFeMn, followed by a second furnace on 23 April 1942 for ferrosilicon (FeSi) production. Shortly thereafter, two 1,2 MVA tilting refining furnaces for the production of medium and low carbon alloys were commissioned. The plant finally closed down on 29 March 1953. At that time it had produced not only HCFeMn, high carbon ferrochromium (HCFeCr) and FeSi, but also medium and low carbon ferromanganese (M/LCFeMn), medium and low carbon ferrochromium (M/LCFeCr), ferrotungsten (FeW), ferrotitanium (FeTi), lead (Pb), martensitic 13% Cr stainless steel, low carbon 18/8 austenitic stainless steel and mild steel. The plant was relocated to a site near Meyerton, Transvaal where production commenced on 11 April 1951. This plant is still in operation today and is known as Samancor Manganese's Metalloys plant.

Highlights in the history of ferro alloy production in South Africa are summarised below.

- In 1918 Rand Carbide Limited was founded in Germiston, Transvaal for the production of calcium carbide and FeSi. The plant was relocated to Witbank in 1926 and in 1978 Highveld Steel & Vanadium Corporation Limited acquired the total issued share capital.
- In 1957 Assmang established the Cato Ridge Works (formerly Feralloys Limited) for ferromanganese production.
- Vanadium production started in 1957 in South Africa when Minerals Engineering of Colorado started producing vanadium pentoxide near Witbank, Transvaal. Anglo American acquired a majority share in 1959.
- Ferrometals became part of Amcor Ltd on 1 December 1959 when it purchased the entire share capital of Ferrometals Ltd from Wire Industries Steel Products and Engineering Company Ltd. At the time, Ferrometals had two 7 500 kVA furnaces for FeSi production on a 950-acre site near Witbank.
- Transalloys was started in 1960 in Witbank as an integrated HCFeCr/LCFeCr plant, based on the Perrin process. During 1967, the plant was converted from ferrochromium to ferromanganese production. At the time Airco Alloys had a 40% share in the plant, the balance belonging to Anglo American. In 1976, Highveld Steel acquired the 65% stake in Transalloys, previously held by Anglo American.
- The origins of Middelburg Ferrochrome (now part of Samancor Chrome) can be traced back to the RMB Alloys Ferrochrome Pilot Project in 1963.
- Palmiet Chrome Corporation came about through the endeavours of John Hahn. The first furnace for the production of charge chrome (ChCr) was started up on 22 February 1963 at the plant near Krugersdorp. On 28 December 1983 the first DC plasma arc furnace for ferrochromium production was commissioned at Palmiet.
- In 1971 Feralloys Limited erected a ferrochromium smelter at Machadodorp for the production of ChCr and LCFeCr.
- Amcor and S.A. Manganese merged in 1975 to become Samancor Limited.
- The CMI plant of JCI at Lydenburg (now part of Xstrata) came into being during 1975 for the production of ChCr, based on the Showa Denko SRC process.
- Tubatse Ferrochrome was initially built as a three-furnace operation in 1975 as a joint venture between Gencor Ltd and Union Carbide Inc (USA). In the same year, the Union Carbide Inc. shareholding was taken over by Samancor, and in 1989 Samancor acquired the Gencor Ltd shareholding. During the years 1989-1990 the plant was expanded to five furnaces with the sixth furnace being built in 1996. The plant is situated in Steelpoort, Mpumalanga.
- Chromecorp Technology (Pty) Ltd was registered in October 1987 and erected a furnace at Batlhako and later two furnaces for ChCr production in Rustenburg. In April 1995 the name was changed to Chromecorp Holdings Ltd and the company was listed on the Johannesburg Stock Exchange on 23 May 1995. The company was delisted on 2 April 1998 and the full share capital was acquired by Sudelectra South African Holdings (Pty) Ltd. The name Sudelectra SA was changed to Xstrata South Africa (Pty) Ltd on 9 April 1999. Xstrata has become the largest producer of ChCr in the world with plants at Rustenburg, Wonderkop, Boshhoek, Lydenburg and the new plant near Steelpoort, Lion Ferrochrome.
- Hernic Ferrochrome was founded in 1995 for the production of ChCr, as a venture amongst Hernic (Pty) Ltd, ELG Haniel, Nippon Steel Trading and management. In 1996 the company commenced production on two 37MVA furnaces. Presently Mitsubishi Corporation holds the majority share of 53,2%.
- Purity Ferrochrome was started in Rustenburg in 1991 with two furnaces for ChCr production. It was taken over by CMI in 1993 and CMI in turn was taken over by Xstrata in 1998.
- ASA Metals (Pty) Ltd was established in February 1997 near Polokwane and is a 60/40 joint venture between EAMI (Eastern Asia Metals Investment Co. Ltd) and LEE (Limpopo Economic Enterprise). ASA Metals produces ChCr.
- South African Chrome & Alloys Limited ("SA Chrome") was incorporated in South Africa on 24 July 1987 as Southern Witwatersrand Exploration Company Limited and changed its name to SA Chrome in December 1999. The main focus of the business is the ChCr smelter constructed at Boshhoek. Subsequently, SA Chrome entered into a Pooling and Sharing venture with Xstrata in 2004.

Thus, from very humble beginnings in 1918, the South African ferro alloy industry has prospered and grown to become a leading producer of bulk ferro alloys on a global scale. Details of the present ferro alloy industry in South Africa are found in the next section.

2. THE CURRENT STATUS OF THE INDUSTRY

The summarised capacity of South African ferro alloy plants is shown in Table 1. Note that the information in the table is based on best available information and has not been verified by the producers in all cases.

Table 1: Installed Capacities of SA Ferro Alloy Plants

Operating Company	Production Units	Capacity (tpa) (excludes feed to refined products)
Samancor Cr Ferrometals	2x25MVA semi-open AC	Primary ChCr 400 000
	1x48MVA semi-open AC	Recovery ChCr 20 000
	1x63MVA semi-open AC	
	2x63MVA closed AC	
	1x30t CLU converter	MCFeCr 70 000
Samancor Cr Middelburg Ferro-chrome	2x48MVA semi-open AC	Primary ChCr 220 000
	1x63MVA closed DC	Recovery ChCr 10 000
	1x18MVA open arc AC	LCFeCr 40 000
	2x18MVA semi-open AC	
Samancor Cr Tubatse Ferro-chrome	3x30MVA semi-open AC	Primary ChCr 340 000
	3x37MVA semi-open AC	Recovery ChCr 20 000
Mogale Alloys	1x40MVA closed DC	Primary ChCr 120 000
	2x20MVA semi-open AC	Recovery ChCr 5 000
	Alt: 2x20MVA semi-open AC	SiMn 40 000
Samancor Mn Metalloys	2x18MVA semi-open AC	Primary SiMn 120 000
	1x21MVA semi-open AC	Recovery SiMn 5 000
	2x25MVA semi-open AC	
	2x75MVA closed AC	Primary HCFeMn 300 000
	1x81MVA closed AC	Recovery HCFeMn 10 000
	1x30t converter	MCFeMn 60 000
Siyanda Inkwali Resources DMS Powders	1x12MVA open AC	14/16% FeSi 36 000
Xstrata Alloys Lydenburg	3x33MVA closed AC	Primary ChCr 380 000
	1x38MVA semi-open AC	Recovery ChCr 20 000
Xstrata Alloys Lion	2x60MVA closed AC	Primary ChCr 340 000
		Recovery ChCr 20 000
Xstrata Alloys Rustenburg	5x33MVA semi-open AC	Primary ChCr 410 000
	1x45MVA semi-open AC	Recovery ChCr 20 000
Xstrata Alloys Wonderkop	6x45MVA semi-open AC	Primary ChCr 440 000
		Recovery 20 000
Merafe Boshhoek	2x60MVA closed AC	Primary ChCr 230 000

Table 1: Installed Capacities of SA Ferro Alloy Plants (Contd...)

		Recovery ChCr 10 000
Glencore Siltech	1x51MVA semi-open AC	75% FeSi 40 000
	1x40MVA semi-open AC	
Assmang Chrome Machadodorp	1x54MVA closed AC	Primary ChCr 285 000
	2x33MVA semi-open AC	Recovery ChCr 15 000
	1x30MVA semi-open AC	
Assmang Manganese Cato Ridge	1x24MVA semi-open AC	Primary HCFeMn 180 000
	1x24MVA closed AC	Recovered HCFeMn 15 000
	2x22MVA semi-open AC	
	2x12MVA closed AC	
	1x30t converter	MCFeMn 50 000
Hernic Ferrochrome	2x37MVA semi-open AC	Primary ChCr 410 000
	1x54MVA closed AC	Recovery ChCr 20 000
	1x78MVA closed AC	
ASA Metals	1x33MVA semi-open AC	Primary ChCr 115 000
	1x45MVA semi-open AC	Recovery ChCr 10 000
International Ferro Metals	2x66MVA closed AC	Primary ChCr 250 000
		Recovery ChCr 10 000
Highveld Steel Transalloys	2x21MVA open AC	Primary SiMn 150 000
	1x23MVA semi-open AC	Recovered SiMn 10 000
	2x48MVA semi-open AC	
	2x7MVA open arc AC	MCFeMn 50 000
Highveld Steel Rand Carbide	1x20MVA semi-open AC	75% FeSi 60 000
	1x46MVA semi-open AC	
	1x16MVA semi-open AC	
Invensil Silicon Smelters	3x30MVA semi-open AC	Si metal 40 000
Xstrata Alloys Rhovan	1x3,5MVA DC	FeV 5 500
Highveld Steel Vanchem	2x3MVA AC	FeV 7 000 (theoretical)
Stratcor Vametco	Not defined	FeV 2 000 - 6 000 (potential)

The South African ferro alloy industry is experiencing interesting changes in terms of ownership and restructuring. This reflects an increasing interest from non-South African organisations in the investment and strategic potential of the business. This is a far cry from 20 years ago when the ferro alloy industry was basically dominated by Samancor, MS&A and Highveld Steel.

- In 2006 Russian group Evraz acquired the majority share in Highveld Steel and Vanadium Corporation, which includes alloy businesses Transalloys and Rand Carbide, as well as their vanadium business.
- In 2006 final approval was given for the erection of a HCFeCr plant by the Indian steel giant Tata Steel in Richards Bay, South Africa.
- In 2005 Samancor Chrome was acquired by the UK group Kermas, a company with considerable experience in the chrome ore and alloy industry
- In 2002 Japanese group Mitsubishi Corporation became the majority shareholder in Hernic Ferrochrome.
- JISCO, the Chinese steel producer, became a 24% shareholder in International Ferro Metals (IFM), a new ferrochromium producer. IFM is an Australian owned company, listed on London AIM.

- In 1997 ASA Metals, a ChCr producer, was established with Eastern Asia Metals Investment Company as the major joint venture partner.
- A number of organisations have acquired new order mineral rights for manganese ore reserves. Most of these organisations have international shareholding and are presently in various phases of feasibility studies to assess the viability of investing in manganese ore mining and manganese alloy production.

The major growth and activity has recently been in the ferrochromium industry. The manganese initiatives may lead to significant investments in the near future, which would change the South African manganese landscape significantly. Expansion plans for Xstrata's Rhovan vanadium operation have recently been announced[1].

Primarily as a result of the abundance of good quality raw materials (ores, reductants and fluxes), cheap electricity, a well-developed infrastructure and relatively cheap capital, South Africa's ferro alloys industry has burgeoned over the last five decades to become the world leader in ferrochromium production, a major exporter of manganese ore and alloys and a significant producer of vanadium products. In addition, ferrosilicon of different grades as well as silicon metal are produced. South Africa is also a producer and exporter of Söderberg electrode paste.

At the moment, there are seven ferrochromium producers viz. Samancor Chrome, Mogale Alloys (producing ChCr and SiMn in campaigns), Xstrata Alloys/Merafe, Assmang Chrome, Hemic Ferrochrome, ASA Metals and International Ferro Metals. The major producers have plants in more than one location.

- Samancor Chrome has three plants: Ferrometals in Witbank, Middelburg Ferrochrome in Middelburg and Tubatse Ferrochrome in Steelpoort.
- Xstrata Alloys/Merafe has five plants: Boshhoek (formerly SA Chrome), Rustenburg (formerly Chrome Corp Technology and Purity Metals), Wonderkop, Lydenburg (formerly CMI) and Lion Ferrochrome.

By early 2007 the gross installed annual ChCr capacity (including feedstock to refined products and reclaimed alloy from slag dumps) would be in the order of 4,2 million tonnes.

Major ferrochromium expansion projects in South Africa are in the pipeline. Xstrata Alloys/Merafe is well advanced with the construction of a major green field ferrochromium plant, Lion Ferrochrome, at the site of the Vantech plant near Steelpoort, which incorporates two submerged arc electric furnaces, based on the patented Premus technology. Provision has been made to treble this first phase capacity to 1 million tonnes of ferrochromium by 2015[2]. In addition, International Ferro Metals will commission their green field, two-furnace smelter near Brits in the North West Province early in 2007. This plant has a reported capacity of 267 000tpa[3]. Samancor Chrome has announced a planned investment of US\$1,46 billion to double its charge chrome capacity by early in the next decade. Construction of the first phase of 500 000 tpa green field plant is planned to commence in 2007, in addition to 260 000tpa brown field expansions presently underway[4]. Tata Steel's project for a 135 000tpa HCFeCr plant in Richards Bay should be completed towards the end of 2007[5]. They already plan to double this plant's capacity as the next stage[6]. ASA Metals plans to triple its charge chrome output by 2008[7].

In contrast to ferrochromium production, South Africa is a relatively small player in manganese alloy production with only three producers and one swing producer. Of the three, Samancor Manganese is the largest (Metalloys, Meyerton), followed by Assmang Manganese (Cato Ridge) and Highveld Steel (Transalloys, Witbank) with Mogale Alloys (formerly Palmiet Ferrochrome) as the swing producer. As most plants have the possibility to switch between HCFeMn and SiMn, production capacities are flexible. However, the nominal annual capacities, excluding Mogale, are as follows (including feedstock to refined products):

- HCFeMn 635 000 t
- SiMn 300 000 t
- M/LCFeMn 160 000 t

In terms of manganese alloy capacity the most significant development was the announcement by Kumba Resources and Samancor Manganese of their joint feasibility study for a 200 000tpa HCFMn project based on a new process, developed by Kumba Resources's AlloyStream technology. Furthermore, after the recent allocation of manganese ore mineral rights, a number of potential new entrants have embarked on feasibility studies for investment into new manganese ore mining and alloy production facilities.

Ferrosilicon production is small with production mostly for the local market. Rand Carbide (division of Highveld Steel) and Siltech are the only producers of 75% FeSi with a combined estimated annual production capacity of 100 000 tonnes. DMS Powders produces 14/16% FeSi for dense media separation. The only silicon metal producer is Silicon Smelters in Polokwane, part of the Ivensil Group, with an estimated annual capacity of 40 000 tonnes. Apart from low electricity cost, South Africa's competitive benefits to produce silicon alloys are limited.

There are three producers of vanadium based products in South Africa viz. Xstrata Alloys (Rhovan) in Brits, Vanchem (division of Highveld Steel) in Witbank and Vametco, a division of Stratcor, also in Brits. Vametco has the capacity to produce 4 500 t/a Nitrovan®[8], which can be switched to FeV, while the other producers have the capacity and flexibility to produce a range of vanadium products and can vary production between V₂O₅, V₂O₃ and FeV. It is thus difficult to estimate the capacity of FeV. The market was in a state of flux at the time of writing, as it had just been announced that the Russian producer, Evraz would effectively purchase the majority stake in Highveld Steel and Vanadium from Anglo American, having also recently acquired Stratcor, which owns Vametco.

3. RAW MATERIALS

South Africa has vast reserves of chromite, manganese ores and vanadiferous ores. This position makes South Africa unique in the world.

3.1 Chromium

The latest USGS (United States Geological Survey)[9] cites the world resources of chromite as being greater than 12 billion tonnes of shipping-grade chromite, sufficient to meet conceivable demand for centuries. About 95% of the world's chromium resources are geographically concentrated in Kazakhstan and southern Africa. Shipping-grade chromite ore is defined by the USGS as the deposit quantity and grade normalized to 45% Cr₂O₃. The total global chromite reserves (shipping-grade) are estimated by the USGS at ~474 million tonnes.

According to Cramer *et al*[10] South Africa's chromite reserves probably exceed 75% of the world's economic resources. All the chromite in South Africa is located in the BIC (Bushveld Igneous Complex). The economically viable seams are the LG6 (lower group 6) with a Cr/Fe ratio of 1,5-2, the MG1/2 (middle group 1 & 2) with a Cr/Fe ratio of 1,5-1,8 and the UG2 seam (upper group 2). The UG2 with a Cr/Fe ratio of 1,3-1,4 is primarily a source of platinum group metals (PGMs). However, with technological innovations (DC plasma arc smelting, improved chromium yields) UG2 is gaining acceptance as source of chromium for ChCr production. Thus, South Africa's chromite reserves can meet increased demands to meet the rapid escalation of ferrochromium production for an almost indefinite period[11].

It should be noted that the South African *in situ* chromites are generally low grade (<45% Cr₂O₃) and low ratio (Cr/Fe<1,6) and are generally friable. The resultant alloys produced from these ores are ChCr, with Cr content of typically <55%. There is also a general requirement for agglomeration of the ore to render it suitable for efficient charge chrome production. The production of ChCr with lower Cr content also impacts adversely on transport costs per Cr unit.

3.2 Manganese

As with chromite, South Africa has extensive deposits of manganese ore, mostly concentrated in the Kalahari Manganese Fields in the northwestern region of the country. Again, quoting the USGS[9], South Africa has about 80% of the world's identified resources. The table below lists the countries with major reserves.

Table 2: Manganese reserves of the world

Country	Reserves (thousand tonnes)	Reserve base (thousand tonnes)
Australia	68 000	130 000
Brazil	23 000	51 000
China	40 000	100 000
Gabon	20 000	160 000
India	93 000	160 000
Mexico	4 000	9 000
South Africa	32 000	4 000 000
Ukraine	140 000	520 000
Other	Small	Small
Total	430 000	5 200 000

The South African deposits are either of the carbonate type (low grade, high Mn/Fe-ratio) containing about 38 %Mn and 4%Fe or of the siliceous type (high grade, low Mn:Fe-ratio) containing 40–48%Mn and 18–12%Fe. A notable feature of both types of ores is the low impurities (P, S) and the physical competence of the ore. By blending the two types of ores, all commercial grades of ferromanganese can be produced, although high grade, high ratio ores have in the past been imported in small quantities for special campaigns.

The carbonate type ore is amenable to sintering and as a result, Samancor Manganese established an on-strand cooling sintering plant for Mamatwan ore at the mine with a capacity of 500 000 t/a[12]. Recently, the plant capacity was increased to ~1 million tonnes by the addition of a sinter cooler, thereby utilising the full strand for sintering.

Manganese ore is thus not a constraint for South Africa's ferromanganese industry. Furthermore, the Government has recently allocated extensive reserves in the Kalahari Manganese Field to BEE (Black Economic Empowerment) consortia. It is thus likely that ferromanganese production capacity will be increased in the foreseeable future. The logistic constraints that the industry is experiencing are described elsewhere.

3.3 Vanadium

In contrast to ferrochromium and ferromanganese, ferrovanadium can be produced from a number of feed-stock materials, including titaniferous magnetite, vanadiferous pig iron slags, spent catalysts and oil residues. The vanadium content of the host rock is very low compared to chromite or manganese ore – usually in the order of 2%.

The USGS estimates the world resources of vanadium to exceed 63 million tonnes[9]. Because vanadium is usually recovered as a byproduct or co-product, demonstrated world resources of the element are not fully indicative of available supplies. The following table gives the reserves and reserve base for vanadium:

Table 3: Global vanadium reserves and reserve base

Country	Reserves (tonnes contained V)	Reserve base (tonnes contained V)
China	5 000 000	14 000 000
Russia	5 000 000	7 000 000
South Africa	3 000 000	12 000 000
US	45 000	4 000 000
Other	-	1 000 000
Total	13 000 000	38 000 000

The feedstock for vanadium production in South Africa is titaniferous magnetite. In the case of Xstrata, the conventional process is used, viz. magnetite is roasted and the vanadium leached and precipitated from the solution whereas Highveld Steel & Vanadium Corporation uses a combination of slag from the iron plant and magnetite from the Mapochs mine as feedstock. In any event, South Africa has sufficient reserves to support the local industry for the foreseeable future.

3.4 Reductants

South Africa has been self sufficient for many years with respect to reductants for the production of ferro alloys. However, in recent years it has become necessary to import metallurgical coke, mostly from China (mainly for chrome alloys) and Zimbabwe (mainly for manganese alloys). The reasons for this can be ascribed to the rapid increase in ferro alloy production capacity, no growth in coke production capacity in South Africa in recent years and the trend towards closed furnaces (which generally require more coke), mostly for environmental reasons. As an example, the increase in specific coke consumption for ChCr production has increased from 0,31 tonnes to 0,33 tonnes over the last few years. Specific char consumption has also increased by 0,2 tonnes at the expense of coal. This increased consumption of char/gas coke has resulted in a large increase in manufacturing capacity in South Africa over the past decade. Xstrata Alloys has developed a dominant position in this market. There has also been a tendency to increase the usage of anthracite in ferro alloy production. Applications for anthracite have been mainly in DC ChCr furnaces and smaller AC ChCr and manganese alloy furnaces. For economic reasons the usage of metallurgical coal is maximised within the constraints that are experienced with the use of coal on larger, closed furnaces.

Not only is the type of reductant important, but also the properties of the reductants for successful ferro alloy production. This is more so for e.g. ferrochromium production where low phosphorus and sulphur contents are necessary in order to meet the alloy specifications.

The table below gives typical properties of reductants for ferro alloy production.

Table 4: Typical properties of selected carbon reductants used in ferro alloy production

Characteristic	Anthracite	Char/Gas coke	Coal	Chinese ChCr coke	SA ChCr coke
Volatile matter %	6-10	1-2	18-25	<1	<1
Ash %	15	19	11	14	16
Fixed carbon %	80	80	56	85	83
Sulphur %	0,6	0,2	0,8	0,6	0,7
Phosphorus %	0,004	0,009	0,009	0,013	0,009
Reactivity	23,1	56,8	n/a	23,90	45,40

Metallurgical coal is mostly obtained from mining the No. 1, 2 lower and 5 coal seams in the Witbank basin and contains typically less than 0,7% sulphur and 0,012% phosphorus.

The ferro alloy industry is presently facing two challenges: (i) insufficient local coke production capacity, resulting in producers having to import coke and (ii) perceived supply constraints of low phosphorus, low sulphur coals for use as such or for conversion into coke, gas coke and char.

As far as the former is concerned, Mittal Coke & Chemicals announced the installation of a new coke battery situated at the Newcastle Works in Kwazulu Natal with a capacity of 450 000 t/a. The coking coal will be sourced from the Grootegeluk mine and also from Kwazulu Natal. The output of the battery will primarily be for ferrochromium and ferromanganese production in South Africa. The plant is scheduled to come on stream during October 2006. There are also indications of coke production by other major players such as Xstrata and Kumba Resources in South Africa and Moatize in Mozambique.

As far as the latter is concerned, it is likely that with promulgation of the Mineral and Petroleum Resources Development Act (Act 28 of 2002), deposits of metallurgical grade coals previously held but not exploited

by the big mining conglomerates will be allocated to small BEE entrepreneurs who have previously not had access to such resources. These deposits could be mined efficiently on a small scale, thus providing the reductants for ferro alloy production. This will make more metallurgical coal available, much of which presently disappears in steam coal exports and feedstock to power stations.

With the depletion of reserves in the existing coalfields over the next 15 years, the production of coal will shift to the vast coalfields of the Waterberg reserves in the Northern Province. Thus, for the foreseeable future, South Africa should be self-sufficient as far as carbon reductants are concerned.

4. TECHNOLOGY

There are a number of factors driving the development and implementation of technologies in the South African ferro alloy industry, some of which are discussed in more detail elsewhere in this paper. The rising real costs of electrical energy, coke and environmental compliance are the major concerns, but any technical solutions will need to maintain high levels of furnace availability. The economics are very sensitive to furnace availability and careful consideration has to be given to the implementation of new technologies, delivering for example increased unit capacities (annual tonnes installed) or higher intensities (kW/m^2), not to negatively affect furnace availability[13]. The implementation of the Kyoto Protocol by the European Union provides significant opportunities for the ferro alloy industry in South Africa to implement CO_2 reduction technologies which could be traded in terms of the Clean Development Mechanism (CDM), the so called "carbon credits" which are currently valued at $_14/\text{t CO}_2$ equivalent[14]. The installation of an electricity generation facility driven by the CO-rich furnace gas is an obvious means of achieving a CO_2 saving and has been implemented successfully at the Metalloys plant of Samancor Manganese[15].

The technologies for the chromium, manganese, silicon and vanadium sectors will be reviewed in order of the stage of development (currently installed, ready-for-implementation, under-development or conceptual). Details of the different furnaces are shown in Table 1.

4.1 Chromium

The submerged-arc furnace is still the dominant technology for ChCr and ferrosilichromium (FeSiCr) production, although there are two DC open-bath furnaces producing ChCr. The technology variations revolve largely around the upstream ore processes

The friable nature of the South Africa chromites necessitates some form of agglomeration before being charged into large, closed furnaces in particular. The simplest process consists of agglomeration of the ore by pelletising, briquetting or Xstrata's "block" process[16], which uses brick making techniques, followed by cold charging to the submerged-arc furnace together with lumpy reductants and fluxes. Many of these furnaces are still open or semi-closed which obviates energy recovery from the furnace gas and increases the Cr^{6+} content of the furnace dust emissions[13][17]. For this reason approval requirements for newly built open or semi-closed furnaces are extremely stringent.

The patented Outokumpu process[13][18] for pelletising, sintering and preheating is widely used and includes the steps of ore-milling, blending with coke fines and a suitable binder, pelletising, sintering and preheating in a shaft furnace which gravity feeds a submerged arc furnace. The closed furnace allows the capture of the CO-rich furnace gas, which is then used to fuel the pre-heating shaft furnace and the sinter furnace. Presently 9 pelletising and sinter plants and 7 preheaters will have been built on ChCr plants in South Africa by early 2007, with more in the pipeline

The first SRC process (originally patented by Showa Denko) was installed in South Africa in 1977 and utilised a rotary kiln to pre-reduce composite pellets of milled chromite and coke fines to achieve as high as 70% Cr metallization[19] which was then fed hot to a closed submerged arc furnace. The Premus process[16] is an improvement on this technology by Xstrata and is the basis of their major expansion (Project Lion), which is scheduled for commissioning late in 2006.

The DC open-bath furnace has been in use since 1983. It utilises 100% ore fines and requires no coke or char but suffers from higher energy losses through the roof and upper side-walls as well as lower availability due to the time lost to make electrode additions[13]. The raw material feed is dried and then fed through the hollow graphite electrode. The present two DC furnaces are operated at 32 and 40MW respectively, although the latter is in the process of being upgraded to 60MW. A number of feasibility studies are underway for the installation of further DC furnaces. Extensive work has been conducted on the preheating of chromite ore fines in different kiln configurations and the potential exists to achieve significant improvements to the electrical energy consumption of the DC furnace by implementing the preheating step.

The implementation of the Krupp-developed CDR technology by MS&A in the late 1980s, and further developed by Samancor Chrome in the 1990s, was later abandoned before it could be fully developed to its ultimate potential. The technology was based on direct reduction of unagglomerated chromite ore in a rotary kiln and hot fed to a smelting/melting furnace. This is an example of the harsh financial demands of the ferrochromium commodity cycle not allowing a technology development process proceeding to full fruition.

Large-scale test work and detailed engineering have been conducted on a process to pre-heat chromite ore fines in a series of cyclones fired by cleaned furnace gas and then fed to a DC open-bath furnace[20].

Concepts under investigation include Söderberg electrodes for DC furnaces, energy recovery from molten slags, hydrocarbon-based pre-reduction in a fluid-bed and rotary hearth furnace pre-reduction of composite pellets[21].

A plant was installed at Samancor Chrome in 1986 to produce MCFeCr from molten ChCr in a steam/oxygen blown CLU converter[22].

LCFeCr is produced by reacting FeSiCr with a chromite/lime melt in a classic Perrin process at Samancor Chrome's Middelburg Ferrochrome plant[22].

4.2 Manganese

Currently HCFeMn and SiMn alloys are produced in submerged-arc furnaces fed with a cold charge of sintered ore, lumpy ore, fluxes and lumpy coke/coal reductants. The use of closed furnaces has allowed the installation of an in-plant electrical power generation facility fired by the CO-rich furnace off-gases. This makes a substantial improvement in overall process efficiency and lowers the total CO₂ emission per ton of alloy.

Extensive research and development has been conducted to improve on the classic submerged-arc furnace process, but these efforts have not been successful. The low-shaft blast furnace, the DC open-arc furnace and the COREX process were tested at pilot plant scale. The relatively high vapour pressure of manganese at temperatures above 1 450°C has resulted in higher Mn losses to the off-gas system for open-bath smelting processes compared to the submerged-arc furnace.

Another feature of manganese thermodynamics is the chemical stability of MnO which has limited attempts to pre-reduce manganese ores in the solid state to metallic Mn. However recent work[23] utilising methane has shown promising results at laboratory scale, which warrant further investigation. Thermodynamic studies[24] have shown that pre-heating to 600°C or pre-reduction to MnO can achieve savings in electrical energy consumption of ~20% whereas pre-reduction to metallic Mn could more than double this saving. Manganese ores have relatively low melting points, which has led to suggestions that the ore be pre-melted perhaps in a flame cyclone reactor at 1 400°C before being reduced in an open-bath electric furnace.

MCFeMn and LCFeMn are produced at three operations in South Africa. Two of the plants use converter-refining processes, whilst the third utilises the Perrin-type process where silicomanganese and lime-ore melt are reacted to produce MCFeMn. Metalloys has an installed plant for the production of LCFeMn, utilising Japanese technology.

A new process for the production of HCFeMn has recently been announced[25] known as the AlloyStream process which aims at utilising ore fines, reducing coke and electrical energy consumption to achieve a claimed 30% reduction in production costs. The technology has been developed by Kumba Resources and is based on the innovative use of induction heating technology. Kumba Resources and Samancor have undertaken a joint feasibility study for a 200 000tpa HCFeMn project based on this technology, following the successful demonstration of the technology at Kumba's purpose-built pilot plant in 2005.

4.3 Vanadium and Silicon

The submerged-arc furnace remains the technology of choice for both Si metal and FeSi production as a burden of carbon containing material above the smelting zone is essential to avoid large silicon losses via gaseous SiO. Improvements continue to be made in process control resulting in significant savings in energy and raw materials. Advances have also been made in the critical area of electrode performance for silicon production while post-taphole techniques have improved final product quality and yields.

Ferrovandium production has shifted from predominately autothermic processes utilizing V_2O_5 to endothermic processes carried out in electric furnaces from V_2O_3 , thereby achieving savings in aluminium consumption. The plants in South Africa use both AC and DC technology for the production of FeV.

4.4 Concluding Comments on Technology

The technological development of the South African ferro alloy industry over the past few decades and direction for the future can probably summarised by the following trends:

- Increasingly stringent environmental legislation and enforcement have decreased the pollution and particulate emission levels from ferro alloy plants quite dramatically.
- Electricity tariff models, which all incorporate severe price premiums during the winter months, have resulted in producers rescheduling their production profiles to minimise the effect of electricity costs.
- Concerns about possible increases in electricity costs, increased international coke prices and limited available coke and metallurgical coal have forced producers to reconsider their technology options.
 - Since 1998 a total of 7 large, closed ferrochromium furnaces have been equipped with preheaters, utilising furnace gas.
 - A total of 9 pelletising and sinter plants have been installed to agglomerate chromite, which improves energy and metallurgical efficiencies. These plants provide sintered pellets to both new and existing furnaces.
 - A feature of the new Xstrata Lion project for ferrochromium production is its reduced dependence on electricity and coke.
- There has been a gradual move away from furnace technologies with low efficiencies.
 - Almost all new furnaces are closed and utilise agglomerated, primarily sintered and pelletised, ore feed. These include furnaces by Assmang Chrome, Merafe, Herculite Ferrochrome and IFM. Tata Steel opted for agglomeration via the briquetting route.
 - Two DC arc furnaces for ferrochromium production have been commissioned by Samancor Chrome since 1996. Major features of these furnaces are high chromium yields, utilisation of lower grade fine chromite, and also cheaper reductants. More DC furnaces are in different phases of project planning.
- There has been a general movement towards larger furnaces. These furnaces are all closed and linked to agglomerated ore feed and some to preheating.
 - Herculite Ferrochrome has installed a 78MVA closed furnace, producing ChCr from preheated sintered pellets. This furnace currently operates at the highest operating load of all ferrochromium fur-

naces worldwide.

- Several furnaces at Samancor, Merafe, Assmang Chrome and IFM have been newly installed or upgraded to levels of between 54 and 66MVA.
- There have been tentative steps towards testing new technology frontiers. The AlloyStream technology is being exploited in co-operation with Samancor Manganese for the production of HCFeMn. The details of this process are protected by confidentiality and intellectual property arrangements.
- New investments in the manganese and silicon based alloys have been limited and no new furnaces have been built in the last few years. The only exception is a medium-sized SiMn furnace at Samancor Manganese commissioned recently. The AlloyStream project will be the first substantial capacity expansion project, although Assmang Manganese and Siltech are also considering new furnaces.

In summary, technology developments in the ferro alloy industry have mainly been refinements and improvements of conventional submerged-arc technology, the introduction of viable DC furnaces for ferrochromium production, and the announcement of new technology for HCFeMn production. The future will demand further improved efficiencies and economies of scale. It is thus conceivable that large, closed submerged arc furnaces, improved preheating processes and a new generation DC arc furnaces will be the technologies of choice for the foreseeable future.

5. REGULATORY ENVIRONMENT

5.1 *A Brief history of mining law in South Africa*

The Dutch were the first European settlers to come in large numbers to South Africa and with them they brought the Dutch law, which in turn was based on Roman law. The basic rule in Roman law as it applies to land ownership is “*cuius est solum eius est usque ad coelum et usque ad inferos*”, which means in essence that the owner of the land owns everything above and below the land[26].

The discovery of diamonds in the late nineteenth century led to the concept of severance, in which the ownership of the land and the mineral rights could be separated. This was enacted in the Deeds Registry Act No 47 of 1937[26]. The Gold Act No. 1 of 1871 of the Zuid-Afrikaansche Republiek reserved the right to mine precious metals and stones to the State. Rights over the minerals in the Kalahari Manganese fields resided with the State from 1967.

5.2 *The White Paper*

The white paper (Mineral and mining policy for South Africa white paper, October 1998) is a critical policy document written with a backdrop of a gold industry under threat and increasing liberalisation of regulations in other mineral rich countries. It led to a major change in South African mining law. The State clarified here that it has no intention to nationalise the mining sector. However, government stated its intention to enhance equity in ownership and management of mining companies.

Specific recommendations regarding proposed government policy include:

- Lower royalty rates for projects that include beneficiation
- The requirement from business of export parity pricing
- Assurance of government commitment to stability in cost of public services and goods
- Assurance of state support for research in beneficiation techniques
- Effective dissemination of non-confidential, State-held information that could promote beneficiation
- Research and training programs to produce necessary skills
- Review of policies and regulations that constrain downstream development

5.3 The Mineral and Petroleum Resources Development Act (Act No. 28 of 2002)

Firstly the Act recognises the need to expand opportunities for historically disadvantaged peoples. The objectives of the Act allow for State custodianship over all mineral and petroleum resources in South Africa, promotion of economic growth and development of these resources and expanding of opportunities for the historically disadvantaged. The objectives also ensure security of tenure concerning prospecting, exploration, mining and production operations. Finally they ensure that holders of mining and production rights contribute to the socio-economic development of the areas in which they are operating. It allows the Minister to issue rights to prospect, mine and explore and in so doing it nullifies the concept of 'mineral right'. Much of the act deals with the application for and granting of licences for reconnaissance, exploration and mining. Granting of such rights will be on a "first come first served" basis. Quebec brought in a "first come first served" system in the Mining Act of 2000 (www.mrn.gouv.qc.ca, 2003).

Schedule II to the Act provides for certain "Transitional Arrangements" which facilitate the conversion of rights previously held under the Minerals Act of 1991. These are collectively referred to as "old order rights" and consist of three different types of rights, namely:

- An "old order mining right"
- An "old order prospecting right"
- An "unused old order right"

An "old order mining right" continues in force for a period not exceeding five years from the promulgation date. Within this period, the holder of the "old order mining right" must lodge the right for conversion to the new form of mining right. Such an application would need to contain an undertaking as to the manner in which the holder will give effect to the empowerment objectives of the Act. An "unused old order right" continued in force for a period not exceeding one year after the promulgation date during which time the holder of an "unused old order right" had the exclusive right to apply for a prospecting right or a mining right under the Act. These rights have now lapsed as the conversion period expired on 30 March 2005.

5.4 The Mining Charter

The Mining Charter[27] was officially unveiled in October 2002. The process was one of discussion at a forum at which government as well as industry and labour was represented. The Charter is a proactive strategy to foster and encourage transformation of the mining industry through

- Promoting indigenous participation in mining ventures
- Human resource development
- Employment equity/ co-management
- Housing and living conditions
- Mine communities & rural development
- Procurement
- Beneficiation

The Charter commits all stakeholders in the mining industry to transferring 15% of assets to black ownership within a five-year target period and 26% within ten years. In the clarification document issued by the relevant department it was made clear that where the State was the owner of the "old order mineral rights" (the case for the Kalahari manganese field) it would require a 51% BEE participation to be instated during the one year transition period.

5.5 The Mining Charter Scorecard

In addition, government indicated that it would issue a Scorecard against which companies could gauge their BEE credentials. The 3 page Scorecard was unveiled on 18 February 2003. Guidelines for mining companies operating in South Africa on how to measure their progress in meeting the requirements of the Mining Charter

are listed. Each provision of the scorecard must be met, although there is a degree of latitude in the area of ownership transfer and beneficiation – provisions that were negotiated to have scope for interplay.

5.6 New Legislation

On 30 September 2003 the Minister was reported as indicating that beneficiation incentives would be tied to the Charter through the Beneficiation Bill[28]. The Minister said that this would allow companies to offset beneficiation against empowerment ownership commitments over and above the minimum equity target agreed on.

Cabinet approved the release of the Royalty Bill for comment on 20 March 2003. The Bill recognised the State's right to charge royalties on mineral production to compensate the nation for the 'loss' of these resources. The Bill proposed royalties on gross revenue ranging from 1-8%. Royalties are to be paid quarterly once new order mineral rights have been granted. The royalties were to be considered as an operating expense and therefore be tax-deductible. It was proposed that exemptions might be granted where the royalty could cause risk of retrenchments. The Bill was withdrawn and is expected to be released under a new form in mid 2006, and to come into power in 2007.

5.7 Beneficiation of Manganese and Chromium

The Department of Minerals and Energy together with Mintek and Industry have been in discussion for some time in regard to the beneficiation offset against the equity provision of the Mining Charter. Through these discussions the base form for manganese has been set at ferromanganese (except in the case of chemical manufacturing e.g. electrolytic manganese dioxide, or the manufacture of manganese metal), whilst that for chromium has been set at ferrochromium (except in the case of chemical manufacturing). Offset percentages for value addition beyond the base form are still being discussed.

5.8 Environmental Legislation

South Africa has adopted standards for the protection of the environment in line with most First World countries[29]. This has had a significant effect on the requirements for the disposal of the slags and dusts produced by the ferro alloy industry. Provision has also been made to conduct comprehensive Environmental Impact Assessments (EIA) before licensing new plants to ensure that all risks and impacts are subject to public scrutiny. While this inevitably increases the time required to proceed with new plant construction, and also significantly increases the capital and operating costs to be compliant, it positions the country to meet the increasingly demanding international environmental requirements. The ferro alloy industry has responded very positively to these challenges and a number of initiatives have been made to develop environmentally safe products from the dusts and slags such as aggregate, bricks and soil conditioners[29].

5.9 Summarised Conclusions on Regulatory Environment

South Africa has made a major change to the laws regarding mineral rights that has brought it into alignment with other countries in the world and in addition is endeavouring to create opportunities for previously disadvantaged South Africans to benefit more broadly and meaningfully from the exploitation of the country's mineral wealth. This is likely to have the effect of increasing the number of ferro alloy producers, within the constraints of international markets. This has already taken place in the ferrochromium industry and the ferromanganese industry is following suit. The culmination of the additional regulatory requirements on new investors in the ferro alloy industry is, however, often perceived by the investors as cumbersome.

In summary, although the ferro alloy industry is operating in a substantially different regulatory environment, these changes are a result of a robust consultation process, aimed at the ultimate benefit of the industry and all role-players are committed to the equitable growth of the industry

6. INFRASTRUCTURE AND LOGISTICS

6.1 Roads, Railways, Ports

“The freight system in South Africa is fraught with inefficiencies at system and firm levels. There are infrastructure shortfalls and mismatches; the institutional structure of the freight structure is inappropriate, and there is a lack of integrated planning. Information gaps and asymmetries abound; the skills base is deficient, and the regulatory frameworks are incapable of resolving problems in the industry”. This bold and frank statement comes directly from the South African Minister of Transport[30][31]. Despite efforts to improve the efficiency of South Africa's ports and rail utilities, the country's transport infrastructure has been found inadequate of supporting higher export volumes to take advantage of the commodities boom led by China's surging industrial output[32]. Whilst the South African rail and road infrastructure has been effective and sufficient until a decade or two ago, accelerated economic growth and lack of adequate maintenance and upgrading have now rendered the transport system in need of urgent and comprehensive corrective measures. In 2006 South Africa was rated 44th out of 60 countries in Swiss business school IMD's world competitiveness ranking, but its run-down transport infrastructure was only rated 58th[32][33].

The National Freight Logistics Strategy document published by the Department of Transport in September 2005 is a response to the freight system's inadequacies. This document identifies the main cause for this failure an inappropriate institutional and regulatory structure that does not punish inefficiency and reward efficiency[30]. Overall logistics costs in South Africa are at the relatively high level of 15,2% of GDP[34] compared to the USA level at 9,8%[35]. Chronic congestion at ports is frequently experienced[32] and movement away from rail transport to road transport has become common practice[30][34][36][37]. The market share of road transport compared to rail transport increased from 65% in 1990 to 75% in 2004[36], placing strain on the road network in terms of congestion, deteriorating condition of roads and road accidents. In 2004 the total tonnage of road freight in South Africa was 1 037 million tonnes over an average transport distance of 270km, whilst the total tonnage for rail freight was 202 million tonnes over an average distance of 600km. South Africa presently moves 300 billion ton-kilometres. The fact that this number is estimated to increase to 400 in 2010 and 1 000 in 2050[34], emphasises the challenge ahead.

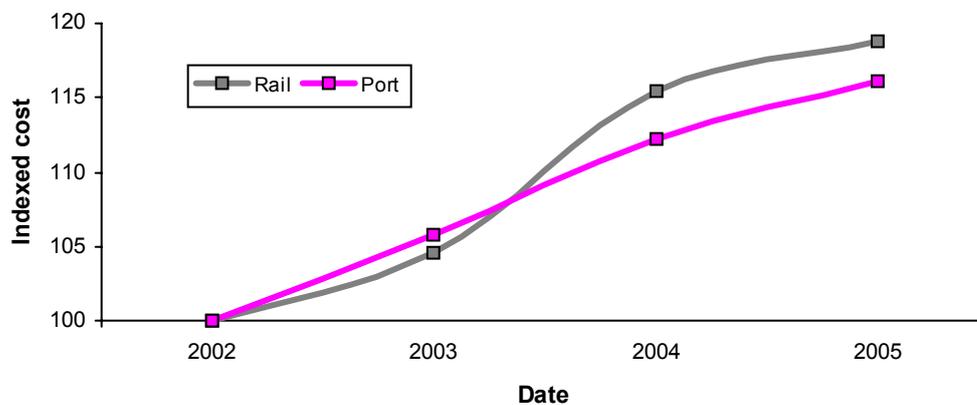


Figure 1: Rising SA Rail and Port Costs 2002-2005

From a ferro alloy perspective, existing producers are experiencing constraints in terms of reliable rail transport for their products to the ports, delays at the ports, and generally increasing logistics costs for the transport leg from the plants to the ports. BHPBilliton indicated recently that capacity limitations within South Africa's railways and port system were a major constraint to the development of its manganese business and called for a South African mining industry initiative to deal with the problem[38]. An indication of the

effect of rising rail and port costs to the ferrochromium industry is shown in Figure 1 below. The graph indicates an increase experienced by alloys producer Xstrata of some 16% in port costs and 18% in rail costs over the period 2002 to 2005[39].

For new entrants to the ferro alloy business the situation is perhaps even more problematic. A topical current situation is prospective investors in the manganese ore and alloy industry. The ore resources are in the Northern Cape Province, which is logistically linked by rail to the Saldanha and Port Elizabeth ports. There is limited rail capacity available on some of the rail sections on these routes and constraints in terms of port infrastructure to handle additional volumes[40]. The South African rail transport operator, Spoornet, is hesitant to invest in additional wagons and locomotives to move additional ore and product to the ports unless it receives the required financial guarantees. The current FOB tariff for manganese products to Port Elizabeth is already high due to the mentioned limitations, but could increase if Spoornet has to spend additional capital to upgrade the railway line[40]. A new port, Ngqura, is under construction near Port Elizabeth to service the Coega Industrial Development Zone. Transnet, the state transport utility, is committed to relocate the present manganese terminal from Port Elizabeth to Ngqura, but the timing thereof has not been finalised[40]. All three present major role-players mining iron and manganese ores in the Northern Cape – Kumba Resources, Assmang and Samancor – have been quoted voicing concerns about the high transport costs and constraints to expansion due to lack of rail capacity[38][41].

What is encouraging is that all role-players have recognised the logistics problem and its effect on the economy and are committed to contributing towards the required restructuring process. The National Freight Logistics Strategy document is very clear in formulating the problem statement as well as committed to the corrective measures identified in its proposed strategy implementation[30]. There are, however, industry concerns about government's apparent reluctance to involve the private sector in the programme, given the existing restrictive legislative and regulatory framework[32]. In the 2006 National Budget approval was given for substantial capital expenditure on infrastructure, which includes the road, rail and port systems. In terms of the latter, the National Ports Authority has embarked on an intensive capital expenditure programme and has brought infrastructure development forward by 10 years. They have again confirmed their commitment to support the economic growth blueprint and to reduce operating costs in real terms. Major approved projects to improve port infrastructure total R1,9 billion in 2005/6, R2,6 billion in 2006/7 and R1,4 billion in 2007/8[42].

There is no short-term solution for the present infrastructural constraints and resulting high costs. It would be unrealistic to expect the cost structure to improve substantially in the near future. In fact, the congestion situation and high costs may worsen before improvements are seen. The Transport Committee of the Ferro Alloy Producers Association (FAPA) is interacting with the relevant authorities on these issues on a regular basis.

In conclusion, although the infrastructure capital investment programme will take time for implementation, all role-players are committed to ensure that the logistics infrastructure in South Africa will support the anticipated continued growth of the ferro alloy industry.

6.2 Electricity Supply

Frequent reports have appeared in the press over the past few years about the perceived problems with electricity supply in South Africa, claiming that electricity demand has caught up with electricity-generating capacity and that Eskom (the state-owned power utility) has no clear plan for the expansion of electricity-generating capacity[43][44][45]. Further reports suggest that major players in the global commodity business have expressed reservations about sufficient electricity-generating capacity being available to support major planned investments in new production facilities[46], and that South Africa's days as a low cost electricity supplier are numbered. All these reports contribute to the impression that South Africa's status as a supplier of sufficiently available, low cost electricity to support the anticipated growth of its substantial ferro alloy industry is also questioned. These perceptions have triggered speculation about more attractive alternative future growth areas elsewhere in the world for ferro alloy production[11]. To put the electricity supply

situation in South Africa into perspective, information has been used from a number of recent publications and interviews covering a realistic perspective on the status of Eskom's electricity supply situation.

Eskom generates 95% of South Africa's power and more than 50% of power consumed on the African continent, is the world's 7th largest electricity supplier in terms of generating capacity and is the world's

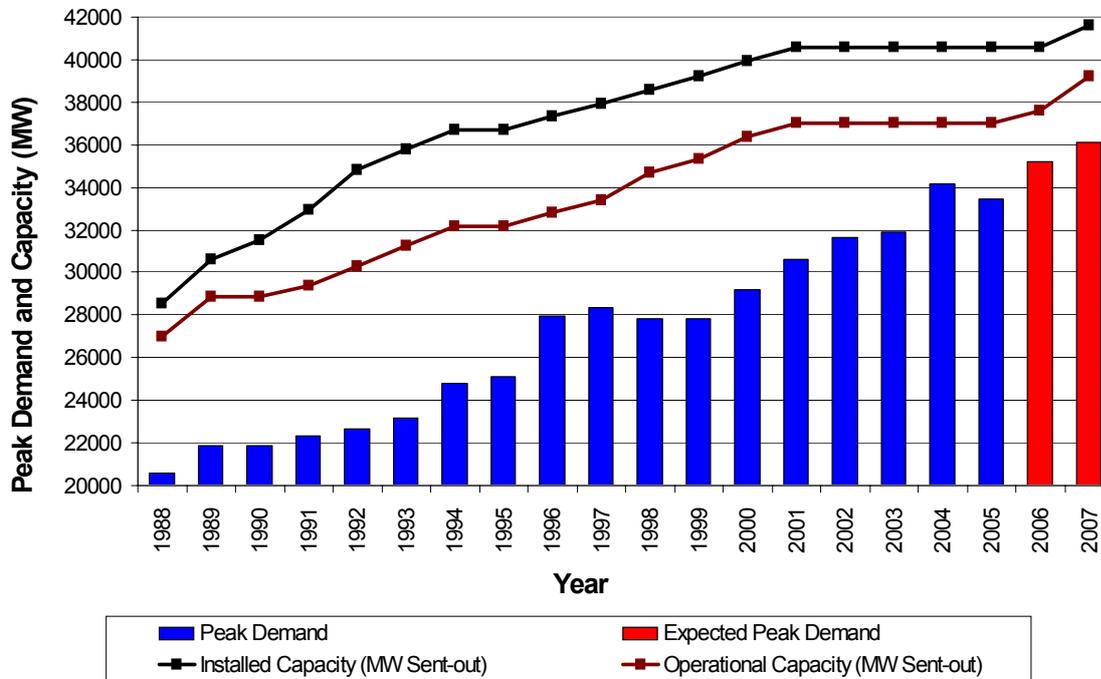


Figure 2: Historic Electricity Demand Overview for South Africa

cheapest industrial supplier by some margin[47][48][49]. Eskom presently operates 24 power stations (of which 13 are coal-fired), employs 30 000 staff and has 3,6 million customers, of which 85% have been connected in the last decade[48][49]. Eskom presently has an installed capacity (total nominal capacity) of about 42 000MW, with a total net maximum capacity (excluding mothballed stations and internally consumed electricity) of just over 36 000MW[49]. In addition, Eskom has Interruptible Supply Agreements for over 1 000MW and Demand Market Participation Agreements for approximately 500MW. In 2005 electricity exports averaged 1500MW and imports averaged 1 000MW[50]. Over the years South Africa has experienced a steady increase in the peak demand for electricity, increasing by approximately 1 000MW per annum over the past several years[50]. The historic demand overview is depicted by the following graph[50]:

From Figure 2 it can be clearly seen that substantial surplus installed generating capacity was available for a long time and for a decade or more no new generating plants have been built. In this period Eskom even made incentives available to industry to increase utilisation of the surplus capacity. Gradually demand began catching up with supply, especially in recent years when the country's GDP has been growing at accelerated rates. In the meantime Eskom was in the midst of a restructuring of the South African electricity industry, during which period it was not clear who would take responsibility for the building of new generating capacity. In October 2004 the Cabinet gave approval that Eskom would lead the current phase (5 year period) of creating new electricity generation capacity and also approved a 5-year investment plan in South Africa's electricity infrastructure. Decisions on the future beyond the 5-year period would be handled on a case-by-case basis. A Capital Expansion Department was created to cater for the new-build programme, as well as a Project Development Department to prepare business cases from the study phases. The investment programme includes investment in new generation (approximately R53billion), which includes the early

stage of a build programme beyond 2010. Approximately half of the expansion programme will be funded from internally generated cash, with the remainder to be funded locally and internationally[51][52].

Eskom has positioned itself to meet the South African Government's 6% GDP growth aspiration[52]. Due to the fact that the activities contemplated to achieve the higher growth trajectory are not particularly electricity intensive, a 6% GDP growth rate will correspond to an approximate 4% in electricity demand growth. This growth rate would require an additional approximately 47 000MW between 2005 and 2025 or roughly 2 400MW per annum[53]. Over the next 5 years Eskom will add over 5 000MW to the grid with a further 1 000MW via the independent power producers. Additional capacity in the next 5 years will come from the return to service of 3 mothballed power stations (Camden, Grootvlei & Komati), a new 2 100MW coal-fired project for the Limpopo province, and the installation of a number of open-cycle gas-turbine

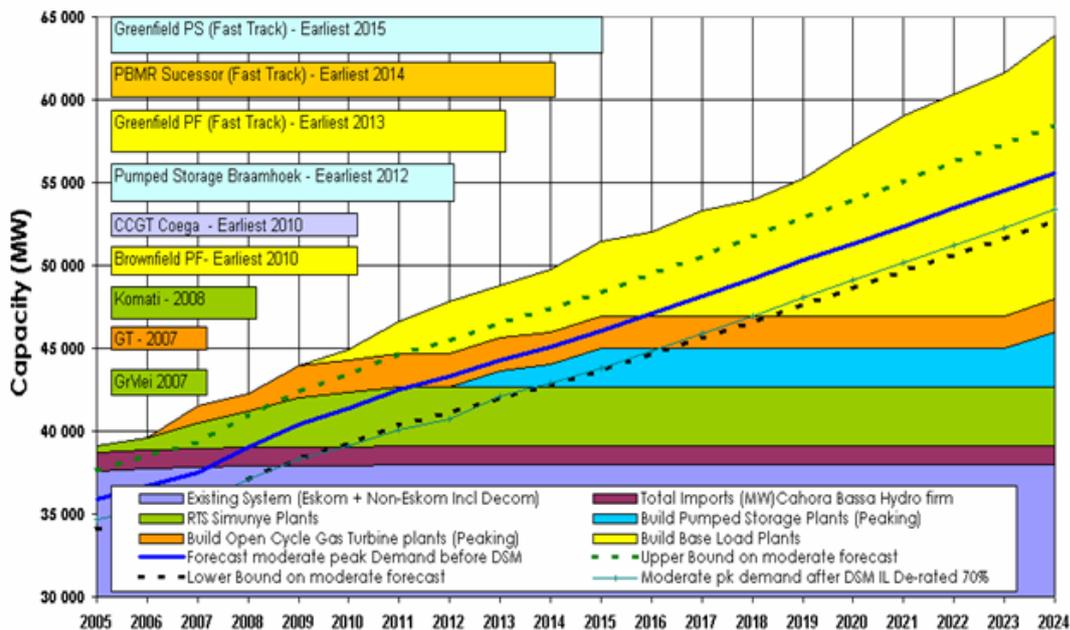


Figure 3: Eskom's long-term capacity outlook 2005-2024

(OCGT) peaking stations and combined-cycle gas-turbine (CCGT) power stations. Investment decisions are underway for two further base-load power stations, which will add another 8 000MW. These could be made up of both coal-fired and nuclear, the first of which would be completed in approximately 2012. In all, projects involving 8 400MW are already proceeding, projects involving 21 000MW are in an advanced stage of planning and projects with the potential to yield over 7 800MW are in a prefeasibility stage of development, including pebble-bed modular reactors (PBMRs), under-ground coal gasification (UCG), regional hydropower options, wind farms and solar installations[51][52].

The resultant long-term capacity outlook based on Eskom's Integrated Strategic Electricity Plan (ISEP) is clearly shown in the following schematic presentation[49][51]:

In conclusion it is clear that both the South African Government and Eskom are fully committed to meet the growing demand for electricity in South Africa. This is clear from Eskom's mission statement: "Together, building the powerbase for sustainable growth and development"[52]. Investment decisions taken up to 2006 will address increased demand well into the next decade, while projects are being brought forward for the period thereafter. There is sufficient flexibility in the investment programme to adjust the actual capacity expansion to fluctuations in demand. The type and mixture of technologies envisaged for the capacity

expansions will ensure that the low electricity generating cost base will be maintained, which would entrench South Africa as one of the lowest cost electricity producers. The investment programme, together with the

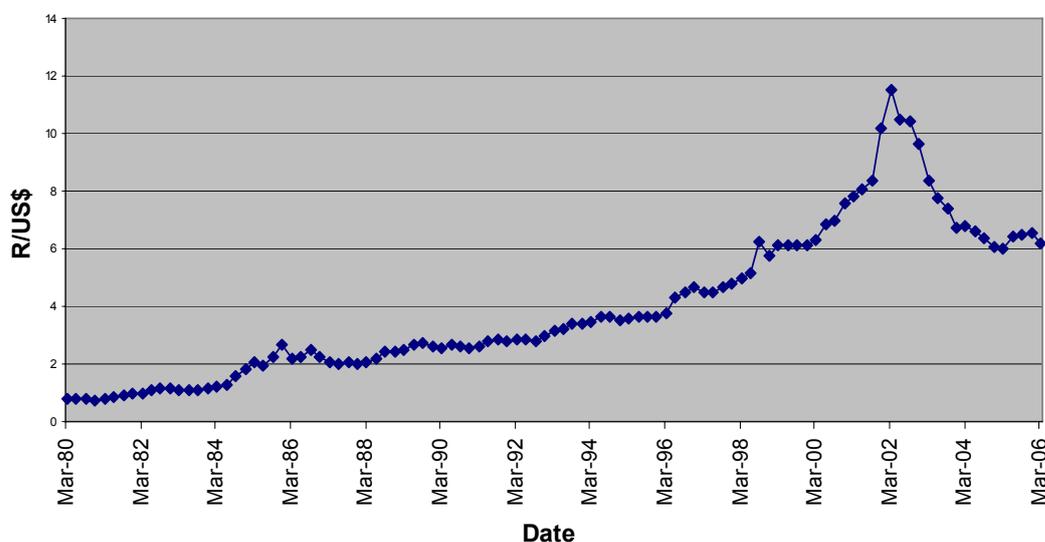


Figure 4: Quarterly R/US\$ movement for the period 1981-2005

remaining rural electrification programme, will not impact substantially on the price structure for electricity, but will result in prices to rise in real terms for the foreseeable future[49]. The National Electricity Regulator of South Africa (NERSA) has already set electricity price increases for 2007 at 5,9% and for 2008 at 6,2%[54].

7. SOUTH AFRICAN CURRENCY

References to the strength of the South African currency have been notable in recent years during price negotiations for particular commodities. This was particularly apparent for ferrochromium where the relative strength of the Rand over the past two years has been a strong positioning factor when setting ferrochromium prices for a particular quarter. The movement of the Rand against the US dollar over the past 25 years can be seen in Figure 4[55]. From this graph it can be seen that the present value of the Rand is not out of line with the long-term trend, but that the 2001-2003 period rather reflects abnormal movements.

There are various methods to forecast the future movements of exchange rates[56]. Exchange rate modelling has been used to analyse historic trends, although it remains risky to use these models for predicting future behaviour. Exchange rate modelling typically forms part of any macro-economic model or decision-making process. Exchange rate behaviour is theoretically influenced by a number of variables such as commodity prices, interest and inflation differentials, growth and trading partners, foreign reserves and the current account balance. Economic theory tends to provide hope and direction, but the reality often seems chaotic. One such forecast by Citadel[56] for the R/US\$ exchange rate forecast for the next ten years assumes 3-4% real global economic growth, US inflation at 2-3%, SA inflation at 4-5%, US interest rates at 4-6%, SA interest rates at 7-9% and commodity prices increasing at 3-4% per annum. The resultant forecast is shown in Figure 5[57], from which it is predicted that the R/US\$ exchange rate would be close to 8 in 2015. The ABSA forecast[58] for the same period indicates an exchange rate of 8,52 in 2015, which would result from a period of continued Rand strength[59]. It should be noted that the risk of short-term volatility remains high[60], which could make any short- and medium term currency forecast inaccurate. A case in point was the sudden weakening of the Rand against the US\$, _ and other major currencies from ~R6.00/US\$1.00 to ~R7.5/US\$1.00 in the space of about two weeks during June 2006.

It can generally be concluded that longer term trends for the R/US\$ will impact on commodity prices, especially in the case of those ferro alloys in which South Africa plays a dominant role. This trend will remain

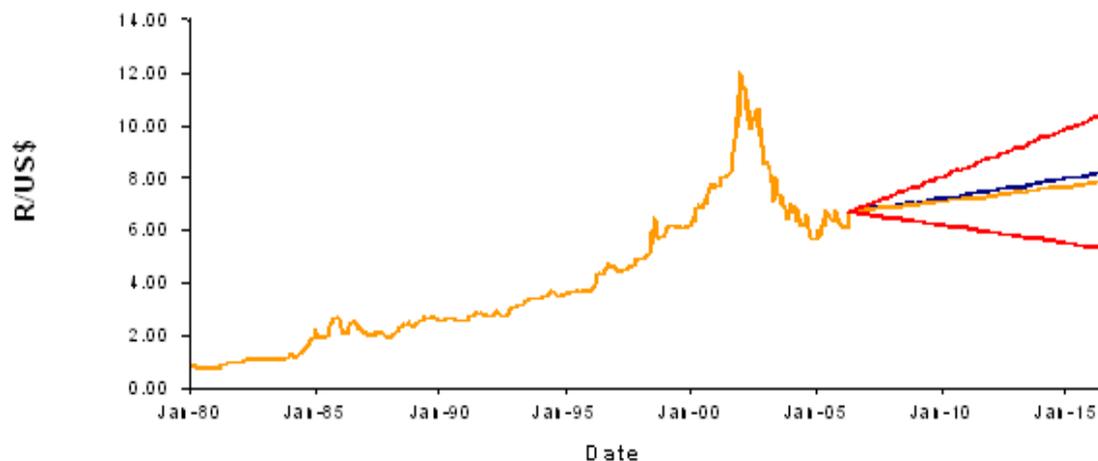


Figure 5: Historic and forecast R/US\$ movement for the period 1981 - 2015

valid in the future. However, due to the relative volatility of the South African currency, short-term movements in the exchange rate will remain disruptive in terms of fluctuations in commodity prices and profitability of South African ferro alloy producers. For ferro alloys in which South Africa is dominant and for which the critical competitive success factors are present, South Africa should remain strong and competitive.

For ferro alloys in which South Africa is not as dominant and competitive success factors are less prominent, normal competitive market forces, together with creative measures to lower the cost basis, will determine South Africa's position in these markets. The majority of ferro alloys presently produced in South Africa fall in the first category and there is no reason to suggest that the South African ferro alloy producers would not be able to further strengthen their competitive positions, taking into account normal expectations for the South African currency movements in the future.

8. CONCLUSIONS

The fundamentals for viable ferro alloy production are access to low cost electricity, low ore input costs and competitive logistics costs. South Africa remains well placed in terms of these fundamentals.

- Electricity costs are at the bottom of the international cost curve and there is no real indication that this position should change, even though prices could increase in real terms for a number of years to fund the electrification and capital investment programmes.
- South Africa's natural resources in terms of ore for ferro alloy production, particularly chrome and manganese ores, are well documented. In terms of manganese ore the reserves are classified as high grade (some high Mn content and others high Mn/Fe) and high quality (low impurities) and the size of these reserves can sustain the industry for centuries. In terms of chrome ore the reserves represent approximately 70-80% of the world's economically mineable reserves and are low in impurities, albeit that these reserves are of relatively low grade (both Cr content and Cr/Fe) and are relatively friable.
- South Africa's logistics costs (as defined by the transport costs from the plants and mines to the ports, the port handling costs and the shipping costs to clients) are presently relatively high. This is related to the

country's geographic position and also to over-extended freight logistics infrastructure. Capital investment programmes have been initiated that would improve the infrastructural constraints in the foreseeable future.

These positive fundamentals are structurally entrenched and should therefore continue to support South Africa as a leading ferro alloy producer in the future. This positive future perspective is reflected in the continued investment of international companies in the South African ferro alloy business. This is particularly evident in the chrome and manganese businesses where major international players in the minerals and metals business are increasingly getting structurally involved through mergers, take-overs and the establishment of new enterprises. Therefore the South African ferro alloy industry is becoming truly internationalised. There is a growing awareness by industry players that survival in the business is primarily determined by their ability to continuously improve their productivity and to stay at the cutting edge of technological innovation. This has to be achieved amidst the challenges of more demanding environmental requirements and a socio-political regulatory framework. The ferro alloy industry is ready to take up this challenge, as all the recent operating developments clearly indicate.

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