ENERGY USE IN THE NSW IRON AND STEEL INDUSTRY

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DISCLAIMER

The following report on the NSW iron & steel industry was written for the Department of Minerals and Energy (DME) by McLennan Magasanik Associates Pty Ltd (MMA)

Whilst the report is, in part, based on information supplied by BHP, the views on future steel demand and operating and energy practices are MMA's assessment of the situation, and are not necessarily those of the Department or BHP

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EXECUTIVE SUMMARY

This study examines the likely future operations of the New South Wales iron and steel industry, which is comprised mainly of BHP's steelworks at Port Kembla and Newcastle. The time frame of the study is 1988-2003. The study's principal results are projections of the industry's energy needs. Energy consumption projections are presented for three scenarios.

The key findings are:

- in 1987, the Australian finished steel market was 4.6 mtpa and was worth A$3.4 billion. This required 5.1 mtpa of crude steel

- that, on an international level, the current boom in steel demand and prices is due to a short term resurgence in construction activities and a reluctance by existing producers to reactivate high-cost mothballed facilities (Chapter 2)

- that, in the longer term, the overhang in capacity will persist into the mid 1990's, as world steel consumption returns to its long run growth rate of 1.1% pa, and as developing countries continue to expand their (State owned and subsidized) steelmaking industries

- notwithstanding the overall slow growth in world steel demand, it is estimated that demand in Australia will grow on average by 1.4 to 2.8% pa (or ~1% slower than GDP) over the forecast period. Demand in South East Asia will grow at 3-5%pa.(Chapters 2 & 3)

- based on the Department of Energy's economic forecasts, we estimate that Australian crude steel demand will, under the base case scenario, grow from 5.1 mtpa in 1987 to 6.9 mtpa by 2003. Under the low growth scenario, demand will only grow to 6.3 mtpa, whereas under the high growth scenario it will reach 7.7 mtpa (Chapter 3)

- the building and construction sector will continue to consume most of the steel made in Australia. Because construction levels are affected by investor confidence and economic activity, we estimate that year-to-year swings of up to +/-10% in steel demand could occur in the future

- an audit of major existing process equipment indicates that a total of 5.7 mtpa of crude steelmaking capacity is available in NSW. This is made up of 3.8 mtpa at Port Kembla and 1.9 mtpa at Newcastle

- Following the expenditure of A$1.6 billion over the last 5 years on upgrading equipment, NSW steelworks have largely caught up with overseas producers in terms of quality, costs and productivity. Although more profitable than most other international steel companies, BHP's NSW steelworks are 15-25% more expensive to operate than those in Korea or China (which have lower cost labour). The higher profit margins are due to the company's dominance of the Australian market. Consequently, whilst BHP is able to defend the domestic market, it does not have a cost advantage in the export market (Chapter 4)

- MMP estimates that, under the base case scenario, NSW's steelworks will operate at near full capacity over the forecast period

- several new steelmaking technologies have been identified which could enhance NSW's productivity and cost position. These include direct iron reduction, direct steelmaking, mini-mills and thin strip casting. In many cases these technologies also lead to a reduction in unit energy consumption (Chapters 5 & 7)

- based on discussions with BHP it appears that, over the next decade, the company will not change its current processing route at Port Kembla or Newcastle. However, the company is committed to build a 0.25 mtpa mini-mill in Sydney by 1991. Furthermore, it is possible that thin strip caster may be installed at Port Kembla in the mid to late 1990's

- BHP's long term plans for the industry include expanding overseas and "going up-market" to produce higher value/higher quality steel for the domestic and export market. This will overcome the threat of lower cost (but lower quality) imports. To this end, operations at Newcastle and Port Kembla steelworks will change. The skelp mill at Newcastle will close down in 1992, and its reinforcing bar operations will be transferred to the Sydney mini-mill. More of Port Kembla's output will in higher quality feed for coated sheet products. Also, following the commissioning of the new coke ovens in 1987, Port Kembla will increase coke exports by 0.7 mtpa over the next few years (Chapters 6 & 7)

- under the high growth scenario, it is projected that both steelworks will upgrade their blast furnaces. An extra 0.45 and 0.40 mtpa from Nos.4 & 5 furnaces at Port Kembla in 1993 and 1997, respectively, will be produced. The No.3 furnace at Newcastle is also likely to be upgraded by 0.20 mtpa in 1996 (Chapter 8)

- in addition to the above new facilities, incremental energy saving technologies (such as better process controls and more efficient heating equipment) will be installed at NSW steelworks. This will improve unit energy consumption by 0.5-1.0 % pa (Chapters 7 & 8).

- In Australia, energy costs make up only 10-13% of the total cost of making steel. This is less than half that for overseas producers. Given the reduced economic incentive to save energy, it is not surprising that the Australian steel industry uses 20-30% more fuel per tonne than steelmakers in Japan and Europe. Unless local energy prices increase, this situation will continue in the future (Chapters 7 & 8).

- computer modelling studies[(1)] of the current and likely future energy/material flows within the Port Kembla and Newcastle steelworks indicate that, under the base case scenario, total

(1) Details of the computer model can be found in MMP report titled "Analysis of future energy use in the NSW iron & steel industry : Volume II - computer model of the Newcastle and Port Kembla steelworks" November 1988.

energy needs in the NSW iron and steel industry will level out at 125-135 PJ pa over the forecast period. By comparison demand peaked at 217 PJ in 1978. The 45% fall in energy needs was due to a combined drop of 20% in steel production and a 25% improvement in unit energy usage over the last decade (Chapter 8).

- estimates of the likely coal, coke, natural gas and electricity purchases for the NSW iron and steel industry are shown in Figures I-III. A detailed breakdown of the likely fuel needs of BHP's Sydney mini-mill, Port Kembla and Newcastle steelworks is given in Tables A1-A14 in Appendix A attached.

- under the base case scenario, coking coal demand is projected to remain static at 4.3 mtpa over the forecast period (Figure II). The temporary drop in 1992 is due to the supply disruptions associated with Newcastle replacing its coke ovens

- with respect to natural gas purchases, it is estimated that under the base case scenario, demand will rise by 5 PJ pa over the next 5 years, before levelling out at 14-15 PJ pa

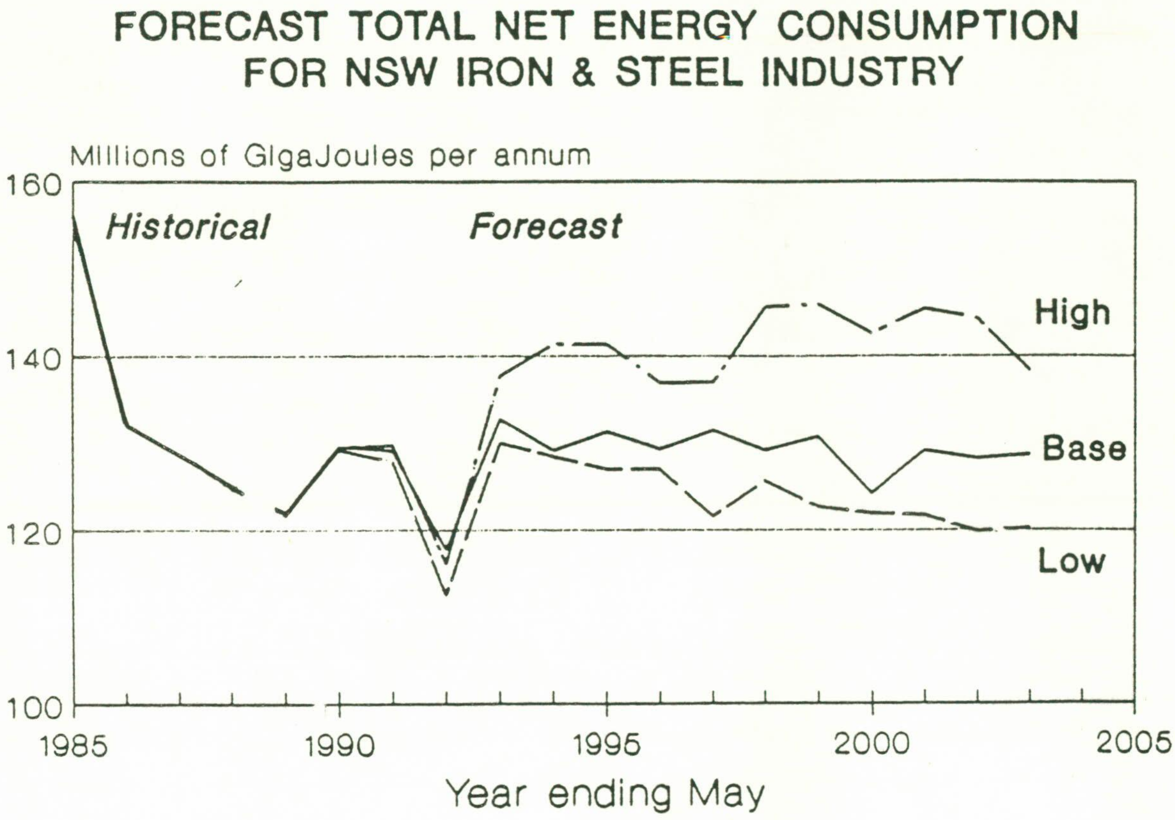
- finally, net electricity purchases, under the base case scenario are projected to rise from 1 100 GWh pa in 1987 to 1 500-1 600 GWh pa by the mid-1990's. This is due to the startup of the electric furnace mini-mill in 1991-92, the installation of a 10 MW BOS ladle furnace at Newcastle in 1992 and a general increase in steel production at Newcastle and Port Kembla steelworks

<u>*Postscript*</u>

Following the completion of the energy study, BHP has announced that it will recommission the No.2 blast furnace at Port Kembla at a cost of $40 million. This will increase the steelworks capacity by 0.50 mtpa, and should be operational by June 1989. Whilst not directly modelled, the general effect of this on NSW's energy needs will correspond to that estimated in the study's high growth scenario - where Port Kembla is expanded by 0.5 mtpa in 1993.

The impact of this, and other possible changes within NSW's steelworks can be readily determined using the computer model developed by MMP.

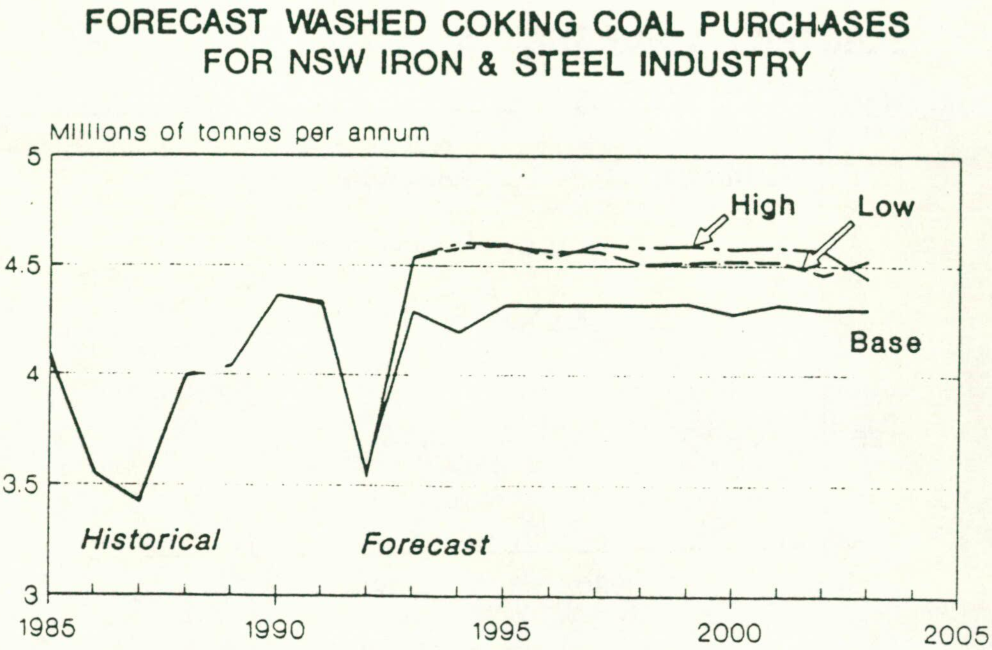
Figure I: Forecast net energy consumption by the NSW iron & steel industry under the base case, high and low growth scenarios : 1985-2003 (PetaJoules per annum)

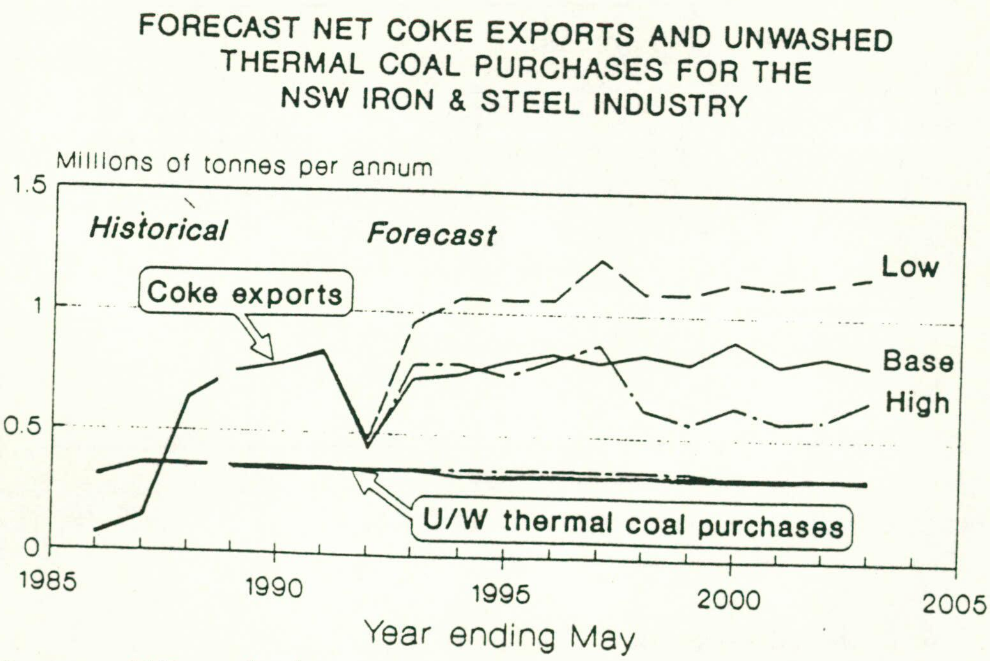


note: Figures cover the Newcastle and Port Kembla steelworks and the proposed Sydney mini-mill. They are also net of sales/purchases of coke and coke oven by-products

Source: MMP

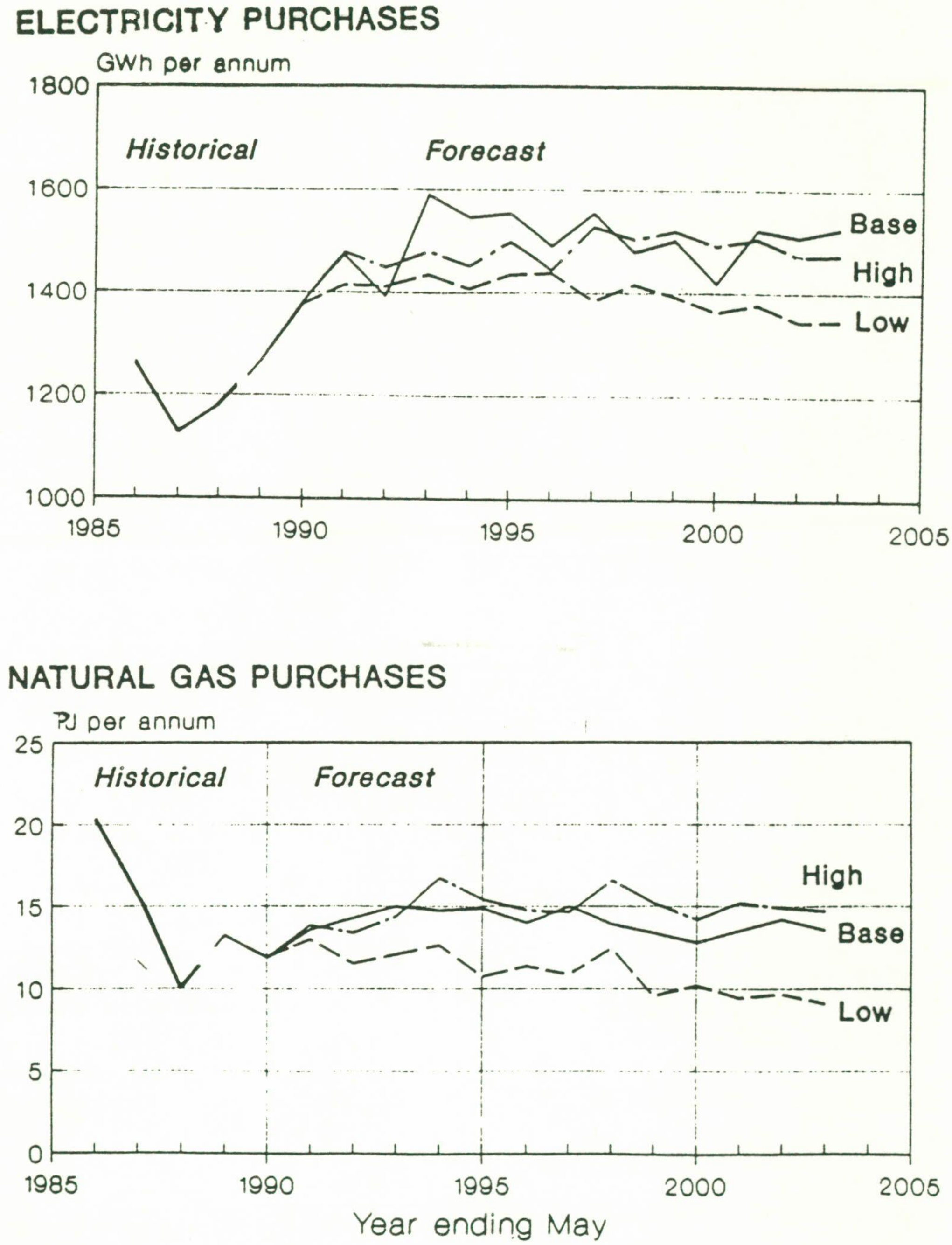
Figure II: Forecast purchases of lumpy coke, washed coking coal and unwashed thermal coal by the NSW iron & steel industry under the base case, high and low growth scenarios : 1985-2003 (millions of tonnes per annum)





Source: MMP analysis

Figure III: Forecast purchases of electricity and natural gas by the NSW iron & steel industry under the base case, high and low growth scenarios : 1985-2003 (GWh and TeraJoules per annum)



note: 1 PetaJoule = 1000 TeraJoules = 1 million GigaJoules

Source: MMP

1 INTRODUCTION

1.1 Study objective

The New South Wales Department of Energy is currently undertaking a major review of the future energy needs of the State. The objective is to place the Government in the best possible position to formulate and implement policies relating to energy resource development and provide adequate supporting infrastructure to enhance the viability of local industries.

The Department commissioned McLennan Magasanik Pearce (MMP) Pty Ltd to carry out the study. MMP has extensive experience in evaluating the strategic and economic impacts of new technology on industry.

This study concentrates on the future energy needs of the New South Wales iron and steel industry - principally BHP's steelworks at Port Kembla and Newcastle out to the year 2003.

1.2 Background

The iron and steel industry is a key part of the New South Wales economy and a major consumer of energy. It is estimated that BHP's steelworks at Port Kembla and Newcastle consume one-fifth of all energy used in the State. An assessment of the future direction(s) of the industry is, therefore, required to develop forward estimates of the overall energy needs of the State.

Energy demand and the types of fuels used at BHP's steelworks can vary markedly from year to year and is dependent on:

- steel output: Aggregate energy consumption increases with increasing steel production
- operating levels: Because of process inefficiencies, unit energy usage is higher at low operating levels. Changes in operating levels may also lead to imbalances in fuel requirements, with (say) surplus blast furnace gas being used for in-house electricity generation and/or backing out natural gas requirements
- type and age of equipment available: Newer equipment tends to be more energy efficient

advances in technology: Changes in technology and process control affect the amount and types of fuel required

- plant layout: The current move to consolidate facilities in one or two sites reduces the need to reheat material - thereby saving energy

- operating strategies: Energy consumption depends on the steelworks' production strategy - ie. whether it is aiming to maximise output rather than minimise operating costs or energy consumption

- relative energy costs: In the past, increases in fuel oil costs have led to the introduction of energy conservation measures and inter-fuel substitution. Similar actions will occur if natural gas and/or electricity costs rise - thereby leading towards increased coal utilization

- raw material quality: Using higher quality raw materials improves product yields and lowers unit energy requirements

- scrap usage: Externally purchased scrap can be used to replace hot metal, thereby lowering the steelwork's energy usage needs

- product mix: Products which require more finishing steps invariably use more energy in their manufacture. For example, a shift from semi-finished products to cold rolled goods will increase energy usage at the steelworks.

Over the last decade, aggregate energy consumption at BHP's Port Kembla and Newcastle steelworks declined by one-third. This was due to improved energy efficiency ,closed older less efficient areas of plants, decreased throughput and changes in product mix.

An appreciation of the world's steel industry is essential in assessing the future operating levels and long term viability of NSW's steelworks - as the Australian industry is fully trade exposed.

Forecasting the industry's energy requirements for 15 years is a complex exercise requiring a thorough appreciation of the available equipment and the likely future demand for locally produced steel. These matters are covered in the following Sections of the report.

1.3 SIMPLIFYING ASSUMPTIONS

The forecast period covers the next 15 years out to the year 2003.

The study focuses on the current and likely future energy flows in BHP's Port Kembla and Newcastle steelworks, as these two facilities account for the bulk of the industry's energy usage. Energy usage in associated down-stream manufacturing operations and in transporting goods to the end user has not been covered. Unless otherwise specified, also excluded were the energy requirements for local foundries and the proposed mini-mill in Sydney, as well as the various operations which supply inputs to the steelworks. The coal and limestone mining operations, refractory manufacturing facilities and local engineering/fabrication workshops are excluded(1).

With respect to future changes in process equipment and operating practices, MMP assumes that BHP only installs equipment which has been commercialized elsewhere.

1.4 METHODOLOGY

The study is largely based on confidential information supplied by BHP plus reports from the International Iron & Steel Institute (IISI), Wharton Econometric Forecasting Associates (WEFA), PaineWebber and the Steel Industry Authority (SIA), as well as information published in the Metal Bulletin and other technical journals.

1.4.1 Steel demand forecast

Econometric modelling of trends in Australian steel demand was attempted. As this effort was unsuccessful it was decided to use a *rule of thumb* formula, in which long-term steel demand grows at 0.5 percentage points slower than GNP. The reasonableness of this formula and associated general trends were reviewed with key industry personnel and was found to be consistent with their views.

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(1) It is recommended that the energy patterns of these related businesses be analysed at a later date with priority given to Lysaght's coated products and stainless steel operations and BHP's proposed new mini-mill in Sydney.

The likely product mix and the level of local production was projected by MMA.

1.4.2 Audit of available equipment

With assistance from local steelworks personnel a quick audit was made of the current throughput and energy intensity of existing process equipment. This was backed up by a review of published information on similar equipment overseas.

Further to identifying current operating practices and equipment, discussions were held with BHP's strategic planners, on the company's long term plans for the industry - particularly with respect to possible investment in new (energy saving) process equipment.

1.4.3 Computer model

In addition to using BHP's forecasts of its future energy requirements a computer model was developed to simulate the energy and material flows through the Port Kembla and Newcastle steelworks. The program models the key energy and material inputs/outputs for each major processing step. These were then linked together to create an integrated energy-flow model of the entire steelworks.

A detailed description of the model and sample printouts can be found in Volume II of the study [(1)].

1.4.4 Scenario studies

Based on economic projections supplied by the NSW Department of Energy, estimates were made of the likely future demand for steel products in Australian out to the year 2003. After allowing for imports/exports the likely level of local production was estimated. This information was fed into the computer model to give a first-pass estimate of the steelworks energy requirements broken down in terms of the aggregate demand for coal, gas and electricity.

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(1) Report by MMA titled "Analysis of future energy use in the NSW iron & steel industry: Volume II - computer model of the Newcastle and Port Kembla steelworks" November 1988.

2 STRATEGIC ANALYSIS OF THE WORLD STEEL INDUSTRY

2.1 OVERVIEW

The key factors driving the world steel industry are:

- the changing demand for steel products, namely a decline in demand in Western countries with the only growing markets being in developing nations. Also a shift in demand is occurring in the type of steel used - ie. away from heavy structural steels to lighter/higher value materials

- a continuation of increasing substitution from competing materials such as aluminium and plastics

- the continued overhang in capacity. Relatively modest progress has been made towards reducing/rationalising excess capacity in the industry

- the historically poor returns which have hindered the producers' ability/enthusiasm to invest in more efficient production technologies

- the role of Governments in owning and protecting local steel producers and reducing trade barriers to steel imports

- new low cost producers. South Korea, Taiwan and China now have the lowest cost integrated steel plants in the world

- the introduction of new technologies such as direct reduced iron, direct steel smelting, mini mills and thin-strip casting. These reduce the minimum economic scale of operation and influence siting issues

The likely impact of these and other factors over the next 15 years are discussed in the following Sections which provide the basis for evaluating the future possible directions and operating practices for the Australian steelworks (see Chapter 6).

2.2 TRENDS IN STEEL DEMAND

Steel is the main material used to manufacture most capital and many consumer goods. This is due to its relatively low cost and its excellent strength and formability.

World crude steel demand totalled 713 million tonnes in 1985. Most of this was in the form of low-carbon steel which (in its hot rolled form) is used in large structural components and (in its cold rolled form) sheet applications such as car body panels.

Table 2.1 summarizes the steel usage patterns in the US. It is broadly similar in other industrialised countries.

Table 2.1: Steel consumption in the United States in 1983 (Percentage of total tonnage)

		%	
Steel type			
	Carbon steel	90.4	
	Alloy steel	7.9	
	Stainless steel	1.7	
			100%
End use			
(Hot rolled)	Ingots, blooms etc	2.1	
	Structural shapes and plates	11.9	
	Rails and accessories	1.3	
	Bars and tool steel	15.0	
	Pipe and tubing	7.2	
	Wire and wire rods	7.4	
			44.9%
(Cold rolled)	Sheet and strip	49.4	
	Tin mill products	5.7	
			55.1%
Total			100.0%

Source: American Iron & Steel Institute 1983 Annual Statistical Report

Figure 2.1 shows the general level of steel demand for various regions. Detailed statistics are given in Table 2.2. As can be seen the western advanced industrialised countries (AIC's) have traditionally been the largest consumers of steel, however it is projected that the centrally planned economies (made up of USSR, Eastern Europe, China and North Korea) will take the lead from the mid-1990s onwards.

It is significant to note that since the first oil crisis in 1973, steel demand in western industrialized countries has declined - especially in the US. This has in part been made up by growth in the centrally planned[(1)] and developing countries.

2.2.1 Product life cycle for steel

The large divergence in growth rates is due to the different level of economic development in the respective regions. Industry analysts have long noted a strong correlation between (per capita) steel demand and the level of economic development.

As shown in Figure 2.2, steel demand goes through four distinct phases - namely introduction, growth, maturity and decline. Under-developed countries such as many in Africa are at an early stage of economic development and so have a very low per capita steel demand. Their economies are still at a subsistence level and are focused on activities which are not steel intensive (such as food production). However as an economy industrializes, such as is occurring in Asia and South America, demand for steel grows rapidly as a larger fraction of the GDP growth becomes concentrated on building steel-intensive infrastructure and capital goods. As a result, steel consumption grows faster than GDP.

As an economy becomes more fully industrialized the per capita demand for steel matures. Australia is at this stage of the life cycle.

(1) Principally the Peoples Republic of China and North Korea, which collectively grew by 46 mtpa in the ten years to 1985, and is projected to grow by another 40 mtpa over the next decade.

Table 2.2: Apparent steel consumption (millions of tonnes pa and percentage annual change on a crude steel basis)

	mtpa			% pa	
	1975	1985	1995	1975-85	1985-95
USA	117	105	89	-1.0	-1.5
Americas (excl. USA)	41	40	52	-0.2	2.7
Western Europe	130	119	122	-0.8	0.2
Africa	15	16	20	0.6	2.3
Japan	68	73	63	0.7	-1.4
Asia (excl. Japan)	19	47	88	9.5	6.5
Oceania	7	7	8	0.0	1.4
Advncd industrialised countries	343	323	296	- 0.6	-0.8
Developing countries	69	104	159	3.9	5.0
Total western world	412	427	455	0.3	1.0
Eastern Europe & USSR	195	212	208	1.1	-0.2
PRC and North Korea	32	78	118	14.4	5.1
Total CPE	227	290	326	2.8	1.2
Total world	639	717	781	1.1	1.1

Source: WEFA December 1987

Finally, in post-industrial countries, such as the USA and those of Western Europe, economic growth tends to be more concentrated on services rather than capital and consumer goods - as the latter are already in place. Consequently the per capita demand for steel tends to decline. Wherever populations and economies grow relatively slowly, steel demand may actually fall in absolute terms.

From the above it is clear that most industrialized western countries are in the mature stage of the product life cycle with aggregate steel demand projected to decline in the longer term. However, in the Asian region, several countries are entering a high steel demand growth phase. This presents a good export opportunity for Australia.

2.2.2 Other factors affecting steel demand

Per capita demand is also influenced by technological change and replacement from substitute materials. For example, the drive to better fuel efficiency has led to the replacement of steel by lightweight plastics and the use of high strength steels in cars. Such trends will continue.

Computer-aided design has also affected the demand for steel as it enables more efficient/lighter weight forms and structures to be built. These savings can be applied across a wide range of goods and are available to all countries irrespective of their economic development.

The diffusion of materials-related technology and improved design skills means that an on-going ratcheting down of the steel demand life cycle curve will occur. In other words, while countries will continue to move through the introduction, growth, maturity and decline phases these changes will be occurring at progressively lower levels of per capita steel consumption. Indeed, WEFA estimates that, in advanced industrialized countries, unless GDP grows faster than 3% pa, aggregate demand for steel will actually decline.

The estimated GDP growth rate for each stage of economic development required to sustain a certain level of growth in steel demand is given in Table 2.3.

Table 2.3: Economic growth rate required to sustain a given level of steel demand (GDP % pa)

	------------- Life-cycle stage	--------------------		
steel demand growth rate	Introduction (undeveloped)	Growth (developing)	Maturity (indstzed)	Decline (post-indstzd)
+10%	+6	+5	+7	+8
5 to 10%	3 to 6	2 to 5	4 to 7	5 to 8
0 to 5%	1 to 3	1 to 2	2 to 4	3 to 5
-5 to 0%	-2 to 1	-4 to 1	-1 to 2	0 to 3
-5%	-2	-4	-1	1

Source: WEFA

2.2.3 World economic scenarios and forecast steel demand

The stock market crash of October 1987 has introduced a measure of instability, not pre sent earlier, into the world's economy. Nevertheless WEFA anticipates that in the longer term the OECD will continue to grow at 2-3% pa. WEFA believes that steel demand has peaked in 12 of 25 of the world's regions with further growth anticipated in 12 others. All-up, non-socialist steel demand is expected to grow on average by 1.6% pa between 1987 and 2000. Forty per cent or 45 mtpa of the growth in total world demand will come from PRC.

PaineWebber puts forward five post-crash economic scenarios (see Table 2.4). The impact on western world steel production and prices is summarised in Table 2.5. PaineWebber's base-line forecast is scenario II, which gives similar growth projections as WEFA's - with aggregate western world steel production rising by 55-65 mtpa between 1987 and 1995.

Table 2.4: Possible world economic scenarios: 1988-1995

Scenario	Probability of occurrence	Details
I - High Growth	5%	Will get tight supply for number of years through to mid 1990s. Western world production to grow at 3.5% with operating levels near 90%
II - Low Growth	45%	Get an average growth rate in production of 2% pa over the period. However, could initially get high operating levels if low growth begins from current demand levels
III - Disinflation	30%	Have a return to the economic conditions prevailing between 1980-86 where had intermittent growth. A sharp reversal in production will occur by the first quarter of 1989 as demand falls off and users quickly liquidate inventories. Action by third-world producers will depress steel prices
IV - Inflation	10%	The expectation of higher prices causes a boom in steel purchases and inventory levels. This will be followed by a market collapse in 1989 or 1990
V - Deflation	10%	World economic activity stagnates. Get reduced demand for steel with declining prices being offered. There will be a sharp reversal of current industry conditions by March 1989 as demand fails to be sustained and users liquidate inventories. Prices will fall by 1989 and show little recovery as cost cutting becomes rampant

Source: PaineWebber December 1987

Table 2.5: **Forecast western world steel demand, production and prices (millions of tonnes of crude steel and US$ per tonne)**

Scenario/Year	1985	1986	1987	1988	1989	1990	1991	1995	2000
<u>WEFA</u>									
Base-line scenario									
- demand (mt)	423	416	415	418	422	426	433	465	507
- production (mt)	447	429	422	425	429	435	442	476	524
<u>PaineWebber</u>									
I : High growth scenario									
- production (mt)*	450	432	441	480	500	520	510	575	
- price ($/t)#	301	334	368	500	600	625	600	650	
II : Low growth scenario									
- production (mt)	-	-	-	460	480	450	480	505	
- price ($/t)	-	-	-	465	550	375	425	450	
III : Disinflation scenario									
- production (mt)	-	-	-	430	430	420	420	470	
- price ($/t)	-	-	-	350	350	340	340	350	
IV : Inflation scenario									
- production (mt)	-	-	-	470	460	430	400	430	
- price ($/t)	-	-	-	500	425	420	380	460	
V : Deflation scenario									
- production (mt)	-	-	-	410	370	380	370	390	
- price ($/t)	-	-	-	330	300	325	300	300	

* Note: Price refers to spot price for export billets FOB Brussels.

Note: Difference between production and demand due to changes in inventory levels plus net exports to CPE countries. Differences between PaineWebber and WEFA historical figures due to different classifications of countries.

Sources: WEFA and PaineWebber, December 1987.

Table 2.6: Steel production (millions of tonnes pa on a crude steel basis)

	mtpa			% pa	
	1975	1985	1995 est	1975-85	1985-95
USA	106	80	66	-2.5	-1.8
Americas (excl USA)	31	50	69	4.4	3.6
Western Europe	154	157	158	0.2	0.0
Africa	8	11	15	3.8	3.6
Japan	102	105	81	0.3	-2.4
Asia (excl Japan)	13	37	70	11.0	6.6
Oceania	8	7	8	-0.8	1.4
Advncd industrialised countries	390	372	337	-0.5	-1.0
Developing countries	32	75	130	8.9	5.7
Total western world	422	447	467	0.6	0.4
Eastern Europe & USSR	193	214	221	1.1	0.3
PRC and North Korea	27	55	94	7.4	5.5
Total CPE	219	269	315	2.1	1.6
Total world	642	717	782	1.2	0.9

Source: WEFA December 1987

2.3 Trends in supply

World steelmaking capacity peaked at 980 mtpa in 1982 and has since then declined to around 935 mtpa in 1987. Crude steel production was only 645 mtpa and 725 mtpa respectively.

As shown in Figure 2.3 the decline in capacity has been exclusively in the OECD - where a net loss of over 100 mtpa occurred between 1980-87. By contrast, over the same period 74 mtpa of new capacity came on-line in the developing and CPE countries.

The massive decline was caused by a sustained reduction in the demand for steel in OECD countires plus an associated fall in steel prices.

Even after allowing for bottlenecks and mothballed facilities etc, in the early 1980s western steelplants were operating at only 60-80% of their maximum effective capacity (Figure 2.4). Because of the inherently high fixed costs associated with running an integrated steel plant many producers attempted to maintain production by using marginal costing principles. This led to a substantial fall in steel prices and large scale dumping on the international market. The end result was the wholesale closure of high-cost steel plants.

In aggregate terms, the largest decline in capacity occurred in the US and Western Europe.

WEFA projects that the over-capacity situation will persist through the mid-1990s. Approximately 80 mtpa of plant will be closed down in the industrialised western countries between 1985 and 1995. However, this will be counterbalanced by a corresponding expansion in CPE and developing countries (see Table 2.7).

Table 2.7: Net change in steelmaking capacity (mtpa of crude steel)

	1980-87	1988-90	1991-95
Developing countries	41.4	17.7	15.7
Advanced industrialised countries	(100.2)	(34.2)	(5.1)
Total Western World[1]	(58.8)	(16.5)	10.6
Eastern Europe & USSR	18.7	9.6	11.4
PRC and North Korea	13.9	11.0	19.6
Total CPE	32.6	20.6	31.0
Change in Total World capacity	(26.2)	4.1	41.6
Change in steel demand	*(4)*	*16*	*46*

(1) Includes Japan

Source: PaineWebber

2.3.1 United States

Since 1977, a total of 60 mtpa of old crude steel production and hot rolled finishing facilities closed down in the US. Nevertheless, over the same period 10 mtpa of new mini-mill capacity was built - giving a total available capacity of about 112 mtpa in 1987. WEFA projects that this will fall to 95mtpa within the next five years and may be as low as 79 mtpa in the year 2000 as operating margins and local steel demand continue falling.

2.3.2 Western Europe

European capacity only began to be scaled down from 1980 onwards as the EEC Steel Commission negotiated the orderly closure of 32 mtpa of crude steel making and hot rolled finishing capacity. Despite this the EEC steel industry was still only operating at two-thirds capacity in 1986, and WEFA projects that an additional 30 mtpa of plant will need to be closed down in the next three to five years

2.3.3 Japan

In Japan, the steel industry is undergoing rapid rationalisation. This has been spurred on by the recent maturation of the overall economy and a loss of export-oriented markets due to the surging value of the Yen. In fiscal year 1988, the five major steel producers are expected to post a combined loss of 390 billion Yen which equals A$4.0 billion or A$50/tonne of steel produced. PaineWebber projects that gross capacity will fall from 148 mtpa in 1987 to 134 mtpa by 1990 and will remain at this level at least until 1995.

Current restructuring efforts have been focused on moving to higher value-added products. This involves diversifying into new materials and sale of steelmaking technology to overseas competitors, lowering production costs through automation and continuous processing and closing older/higher cost production facilities.

In addition, the Japanese have been buying up interests in steel plants in the US and South America.

Fortunately part of the pain of restructuring will be cushioned by a temporary pick-up in domestic demand as Japan spends its way out of its current-account surplus.

2.3.4 Developing countries

In recent years virtually all of the increase in iron-making capacity[1] has been in developing countries. This has been driven by the Governments' desire to reduce imports of steel goods and boost their countries' level of industrialization. In many instances steelmaking viability is enhanced by access to low cost energy (namely natural gas for the DRI process), cheap labour and high product prices (due to tariff barriers and/or good access to expanding local markets).

Installation of new capacity in developing countries will continue (see Table 2.7). According to PaineWebber, over the next 8 years half the expected growth in capacity in developing countries will be at new green-field sites - principally in Brazil, Algeria and the Middle East.

In addition, a major construction program is underway in the People's Republic of China. Over the next ten years two-thirds of the CPE's and 40% of the world's growth in capacity will occur in Communist China. China is planning to increase capacity from 53 mtpa in 1987 to 76.5 mtpa by 1995. By comparison gross capacity and steel production was only 43 and 37 mtpa respectively in 1980. The consequences of this rapid growth for world steel trade are discussed in the next Section.

(1) As opposed to mini-mills which use scrap steel and direct reduced iron.

2.4 SUPPLY/DEMAND BALANCE

Figure 2.5 compares steel production and consumption in various regions around the world. As can be seen the industrialized west (including Japan) has traditionally been a net exporter of steel, to the developing countries. The CPE countries, as a group, have generally kept their supply/demand in balance. Figure 2.4 shows that the CPE and developing countries generally operate their plants at near full load, whereas the industrialized countries have excess capacity.

Table 2.8 shows that about 20% of all the world's steel production is sold across national boundaries. Most of this trade is within the industrialised western countries with export sales also going to developing countries and communist China.

2.4.1 Short-term situation

Due to reductions in capacity plus a modest spurt in demand, the market for steel has become tight in the last six months. As a result, spot prices for many steel products have risen by 30-40%.

The shortages have been exacerbated by the fact that both China and USSR continue to be heavy importers in 1988 and that most customers are building up inventories in expectation of higher prices/increased demand. Furthermore, many western steel producers are reluctant to put on new workers or de-mothball capacity because of the high cost and long lead times involved.

Most industry experts believe that this situation is temporary and, under most scenarios, prices will flatten out as the world's economy slows down and inventory-building stops,.

PaineWebber's medium and long-term steel price projections under various economic scenarios are given in Table 2.5.

Table 2.8: World supply/demand balance and international steel trade (millions of tonnes of crude steel)

	1975	1980	1985	1990	1995	2000
Industrialised west[1]						
- production	383	405	372	341	337	338
- consumption	343	357	323	304	296	296
Net exports/(Imports)	40	48	49	37	41	42
Developing countries						
- production	32	57	75	97	130	174
- consumption	69	99	104	125	159	199
Net exports/(imports)	(37)	(42)	(29)	(28)	(29)	(25)
USSR & Eastern Europe						
- production	193	209	214	226	219	214
- consumption	195	209	212	211	208	205
Net exports/(imports)	(2)	0	2	15	11	9
PRC and North Korea						
- production	27	43	55	73	92	125
- consumption	32	49	78	94	118	151
Net exports/(imports)	(5)	(6)	(23)	(21)	(26)	(26)
World trade	123	153	177	174	192	208

(1) Including Japan

Note: Due to inventory changes net export figures may not add up.

Source: WEFA

2.4.2 Long-term situation

As discussed before, 50-100 mtpa of integrated steel-making capacity will be decommissioned over the next decade in industrialised countries. However this will be partly off-set by incremental expansions at other plants plus continued growth in the mini-mill sector. Furthermore several large green-field steel plants will be built in the developing nations. The net effect will be to maintain total non-socialist capacity at around current levels. On this basis the industry will continue to be in excess supply.

Figure 2.5 highlights that steel is becoming an internationally traded commodity. WEFA estimates that in the last 15 years developed world trade rose from 30% to 38% of all production and that it will level out at 40% by the mid-1990s.

2.5 EMERGING TRENDS AFFECTING THE INDUSTRY

General trends affecting the world steel industry include:

- trends in technology which do not favour existing integrated plants. Developments in continuous casting of thin slabs will enable mini-mill facilities to compete against larger traditional facilities. Other developments include DR iron which operates on a smaller scale than conventional blast furnaces (for more details see Chapter 5)

- a slow-down in demand in industrialized countries. This encourages the development of smaller plants which better match the lower growth in demand

- the industry will become more international. As demand in developing countries continues to outstrip local supply and as trade barriers continue to fall within Europe, the level of international trade in steel will rise. Hand in hand with this will be increasing co-operation between producers in different countries via joint ventures and other ownership arrangements.

Also, rolling facilities in the US will increasingly source billets from other countries (such as Brazil and Mexico). In the longer term, developing countries will move towards the semi-finished end, selling hot and cold rolled strip directly into the US and Europe

- pricing will remain competitive. In the past steel prices were set by informal cartels between major Japanese, European and US producers, however this has been eroded by the emergence of smaller and independent mini-mills, low priced exports from developing countries and a reduction in the competitiveness of the traditional suppliers. As product quality improves in the developing countries, steel billets and hot rolled coils will be increasingly traded internationally

- steel is becoming a commodity. Steelmakers are beginning to recognize that a large part of their market is driven by prices rather than service or quality (presuming a certain minimum level is exceeded) and as a result steel is becoming a commodity. We speculate that steel billets and coils will be traded on the futures market in the same way as aluminium and copper is now. This will increase the volatility of steel prices and break down the barriers for international trade

- steel production will become more disaggregated. In the past integrated steel mills made a wide range of products with varying degrees of profitability. Lower steel prices, falling demand and increased competition from mini-mills are now forcing steel companies to close down unprofitable lines and narrow their product range. In addition, different casting technologies (ie billet and slab casters) for different end products have reinforced the disaggregation of primary process routes. Therefore a move to single product sites is inevitable. One consequence of this will be a reduction in corporate staffing levels as the production co-ordination task will be very much reduced. As a result disaggregated companies will operate on slimmer profit margins and be more dependent on single customer groupings (such as car manufacturers or building products companies)

- the market has now matured. In industrialized countries customers are well informed as to how/where to use steel. There is very little that steel companies can do to increase overall demand by enhanced product development. Indeed technical change is working against steel as plastics and other materials eat into steel's traditional markets.

2.6 COMPETITIVE RESPONSES TO CHANGES IN MARKET CONDITIONS

Due to differing market and cost factors the competitive situation varies widely between differing regions. Consequently, steelmakers appear to be adopting a diverse set of business strategies.

2.6.1 US producers

Major integrated producers continue to face severe long term threats:

- increased 'free' flow of steel imports. Particularly from the developing nations

- continued increase in the strength of mini-mills especially if/when thin slab casting is developed

- problems with high raw material costs. Many producers are locked into expensive contracts for coal and iron ore which are way above world 'spot' prices

- realization of pension liabilities. Closing down a plant often requires large pay-outs to workers - over and above the monies available from the existing pension funds. This acts as a strong barrier to unprofitable companies closing down, resulting in continued excess capacity

- the lack of investment funds has meant that many steel plants are now becoming dated/obsolete - resulting in reduced profitability

- unit labour costs are the highest in the world and, in part due to the lack of investment in new equipment, management is finding it hard to improve productivity levels

One of the most pressing issues for integrated producers is maintaining financial viability. Likely strategies include taking a stronger market focus with attention being given to reducing the number of products made at a given plant as a means of lowering costs. Other options include filing for bankruptcy and selling the assets to a new company. This breaks the high cost raw materials contracts and allows companies to escape much of their pension funding obligations. Another strategy is to increase the level of customer service, thereby reducing the pressure on steel prices.

2.6.2 European producers

As a generalization, European mills are continuing to undergo further rationalisation. This is influenced by:

- cuts in Government aid. The EEC banned explicit state aid in 1986 though some indirect measures having the same effect still exist

- the production quota system is ending in 1989. This will mean that the regional marketplace will become more competitive

- European markets are becoming 'freer'. In 1992 internal trade barriers will be removed within the EEC. Therefore intra-regional trade will increase, putting pressure on less competitive producers

- little growth in local demand. Out to the year 2000 regional demand is expected to be flat

- the continued strength of local currencies. The export market for surplus production will be unattractive if regional currencies remain strong

The European steel industry will continue to be strongly affected by governmental intervention. The EEC Steel Commission aims to close an additional 30 mtpa of capacity over the next five years. These closures will be funded by a levy on those producers which exceed specified quota levels. Possible strategies for regional producers include narrowing the product range and focusing on particular market niches, as the mini-mills have done already. Large producers will start to break up their operations, closing down the more unprofitable facilities and possibly selling off other activities not central to their specific product focus. The disaggregation of facilities removes the need for heavy corporate management structures and therefore companies will be able to survive on thinner operating margins.

2.6.3 Japanese producers

The Japanese steel industry has a mixed outlook at best. The main factors influencing Japanese producers are:

- they have the best facilities in the world. This enables them to produce high quality material

- labour costs are very high. Although the equipment is modern and productivity is high, the strong Yen means that unit labour costs are comparable to the US and are US$60-80/tonne more expensive than South Korea or Brazil

- steel production costs are now highest in the world. Because of the high value of the Yen, the Japanese producers are now the highest cost exporters in the world

- increasing competition from other regional producers. Plants in South Korea, Taiwan, Brazil and China now produce steel of similar quality at much lower prices. This is severely affecting Japan's ability to sell excess production on the export market

- in the long term steel demand is expected to decline. The Japanese economy is undergoing major change, moving away from steel-intensive industries

- steel demand is currently reasonably strong. In response to outside pressure the Japanese government has embarked on a major capital spending program. This has boosted demand for steel reinforcing bar and other structural sections, with the main beneficiaries being domestic mini-mills

- recent plant closures have affected employee attitudes. The belief in life-time employment has been shattered by the retrenchments by the major steel producers. Top university graduates are now unlikely to pursue jobs in the steel industry. This will affect the quality of management in the longer term.

Under the guidance of MITI the Japanese steel industry is undergoing a major restructuring program. Efforts are being directed mainly towards producing higher value products (including diversifying into new materials), lowering steelmaking costs and closing down excess production facilities. Steelmakers recently increased their efforts to improve product quality, upgrade product lines and promote new product applications as a means of reducing the liability of high production costs. A major trend is towards cost reduction through the introduction of fully-automated and continuous production facilities.

WEFA believes it is inevitable that there will be consolidation between various producers as production facilities are rationalized and investments focused on areas with the greatest return. One radical suggestion being considered in Japan is a move towards a market sharing arrangement with selected producers making products on behalf of other companies. In any case the industry acknowledges that the export market will diminish and that corporate growth can only be achieved by diversifying into other business activities and by going off-shore by buying up steel plants in other countries, such as the US and Brazil.

2.6.4 Developing country producers

Due to their low cost position and political factors non-socialist developing countries will continue their expansion of steel capacity. This is because:

- the plants have access to the latest technologies. It is now possible to import the latest Japanese and European technologies, thereby achieving minimum possible production costs

- have weak currencies. Many developing countries deliberately undervalue their currencies. This helps competitiveness in export and import-replacing industries

- protective government policies. Encouraging domestic steel production through tax breaks and tariff barriers has often been viewed as a means of building the industrial base of many developing countries

- access to low cost materials. For those countries lacking local raw materials it is possible to import iron ore and coal at a modest cost. Other countries, such as Malaysia and Libya, have access to cheap natural gas which can be used for making direct reduced iron

- rapidly rising domestic demand. WEFA projects that domestic demand in non-socialist developing countries will rise by 1.1% pa or 72 mtpa from 1985 to year 2000. In many countries the increased local demand will soon match the minimum economic size for a steel plant

In summary it is clear that many developing countries will soon be large enough to support a local steel industry - and that access to the latest technology, low cost raw materials and low labour rates as well as government protection, will mean that these facilities will be economically viable. Initially, the main focus will be towards meeting domestic demand, with any excess production being sold on the export market at very competitive prices. Recent trends in Brazil and Mexico suggest that, whilst developing countries currently export low value billets, pig iron and DRI feed, ultimately, downstream hot rolling facilities will be installed and these countries will begin to compete in the semi-finished end.

2.6.5 Chinese producers

Steel production in Communist China will rapidly rise over the next decade with local producers becoming an influential force on the world market in the longer term. This is because of:

- rapidly growing domestic demand. Steel demand is expected to grow by 7% pa over the next decade

- construction of major new capacity. To meet the rapid growth in demand a major expansion of the steel industry will occur. PaineWebber projects that 23 mtpa of new capacity will be built between 1985-95. Most of these plants will be located near the coast with good access to shipping

- demand will continue to outstrip supply. Even with the rapid expansion in capacity demand will continue to outstrip supply by 15-20 mtpa

- low cost new facilities. The recently opened 3 mtpa Baoshan steel works (which is to be doubled in the next five years) is one of the lowest cost plants in the world and boasts some of the latest technology from Japan. Other new plants will have similar cost structures

- access to low cost materials. Much of China's steelmaking expansion is occurring on the coast at plants which have access to low cost/high quality materials from overseas suppliers

The main strategy appears to be concentrated on developing a large/low cost modern steel making industry to meet basic steel needs. This will be helped by the willingness of the Japanese and European steel companies to supply the latest production technologies. High quality/special steel grades will continue to be imported.

If the Chinese economy slows down and/or the Government becomes more concerned about earning foreign exchange, imports would be curtailed and much of the increased local production be diverted onto the export market. As a result, the international supply/demand situation could experience a rapid swing of 20-30 mtpa. This would have a profound effect on world steel prices and production in other countries - especially those in the Pacific basin[1].

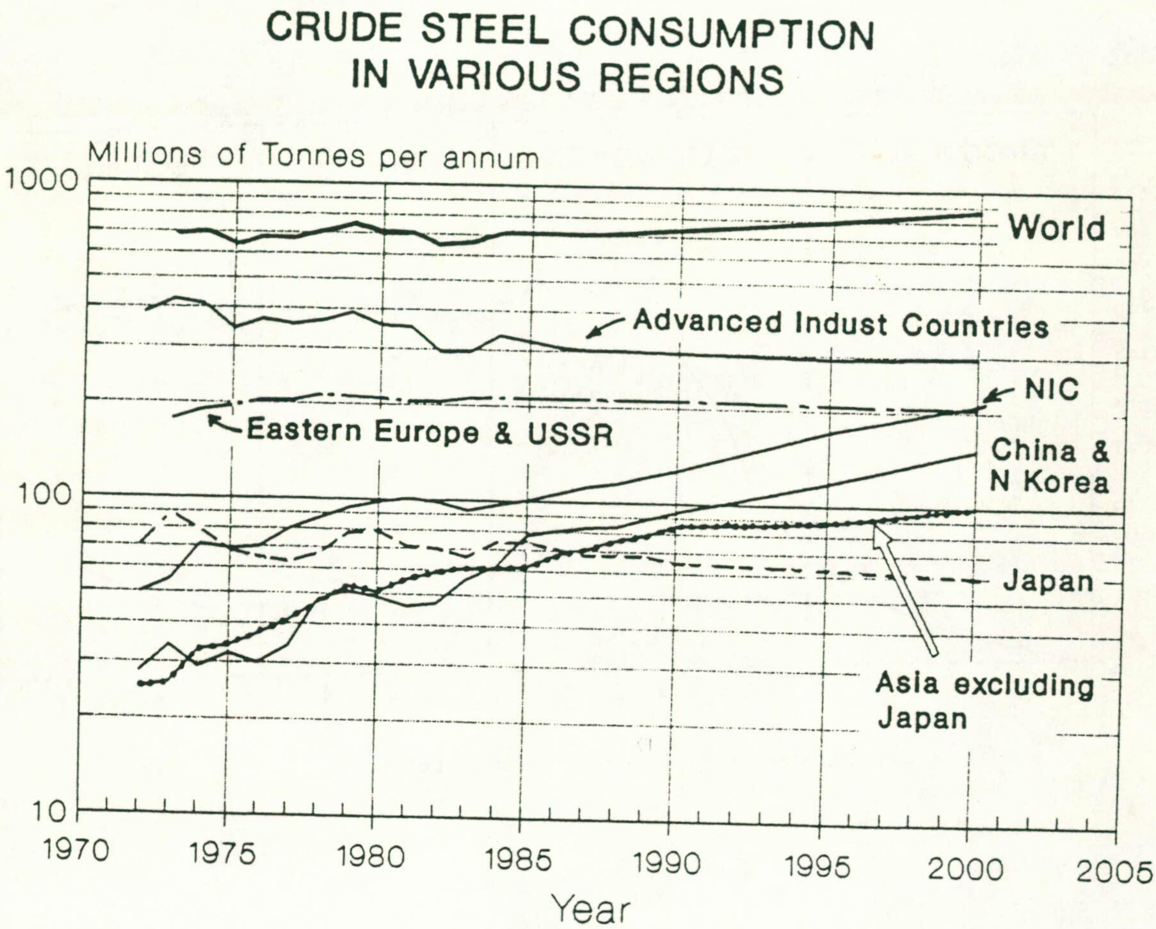
2.6.6 USSR and Eastern European producers

Production in Centrally Planned Economies (Cpe's) will continue to be closely controlled by Government agencies. For foreign exchange reasons these countries will not become large importers except to meet (unexpected) short-term shortages. High cost structures and lack of transportation infrastructure will hinder the development of any major export market.

The major focus will be on improving the efficiency of existing steel operations. Two areas of high priority are mini-mills for specialist products and continuous casters. USSR plans to increase its continuous-casting rate from 11% at present to 40% within ten years. The improved yields will reduce the need to install additional crude steel making capacity.

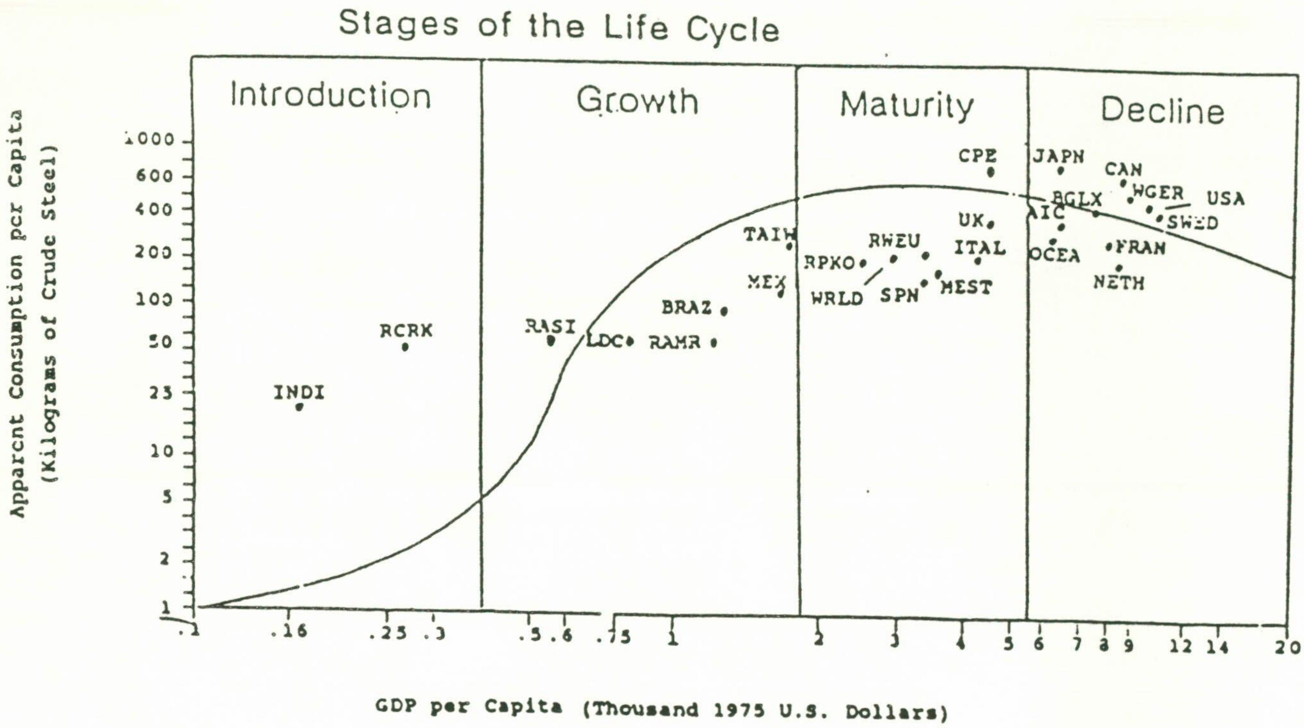
(1) The Peoples Republic of China is BHP's largest overseas customer

Figure 2.1: World steel demand 1972-2003 (millions of tonnes pa on a crude steel basis)



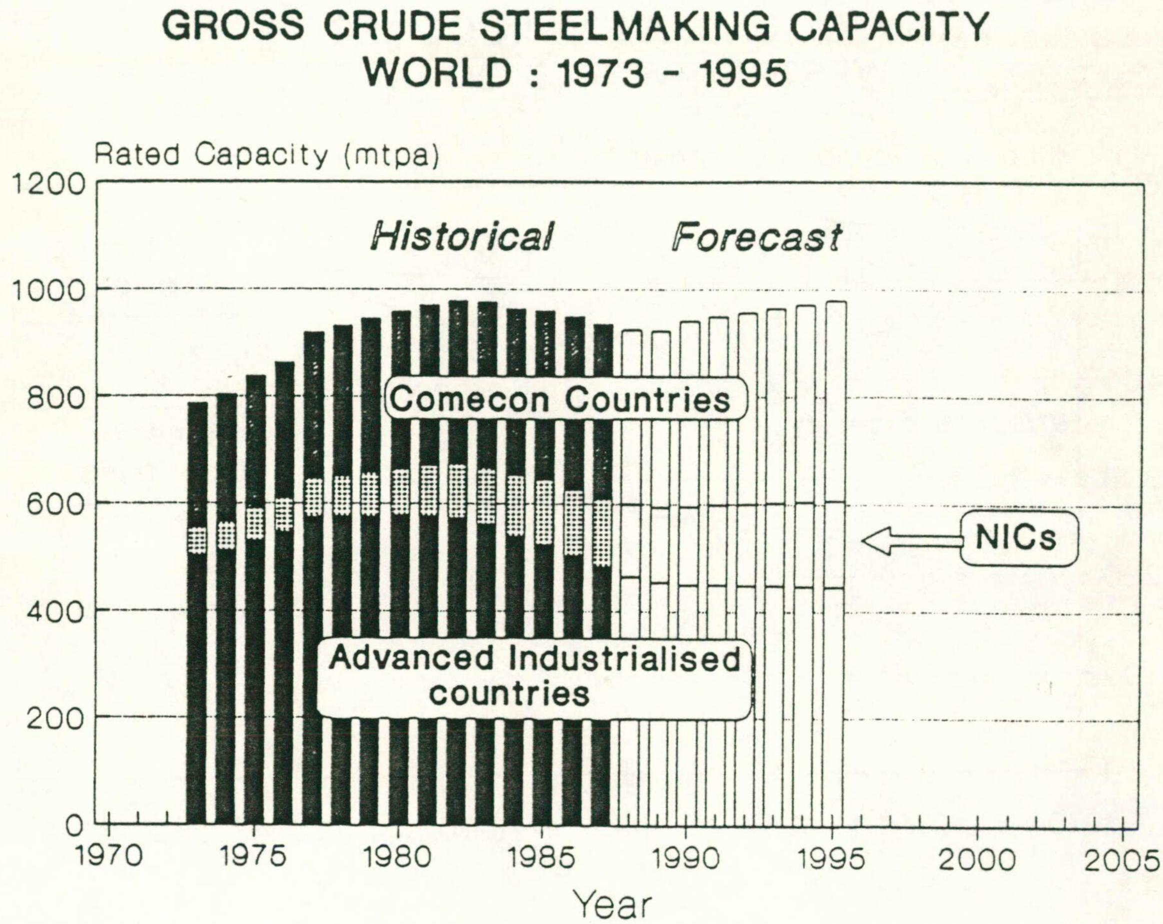
Source: WEFA December 1987

Figure 2.2: Product life cycle: steel consumption versus economic activity in 1985 and 2000 (kg of steel per capita versus GDP measured in 1975 US$ per capita)



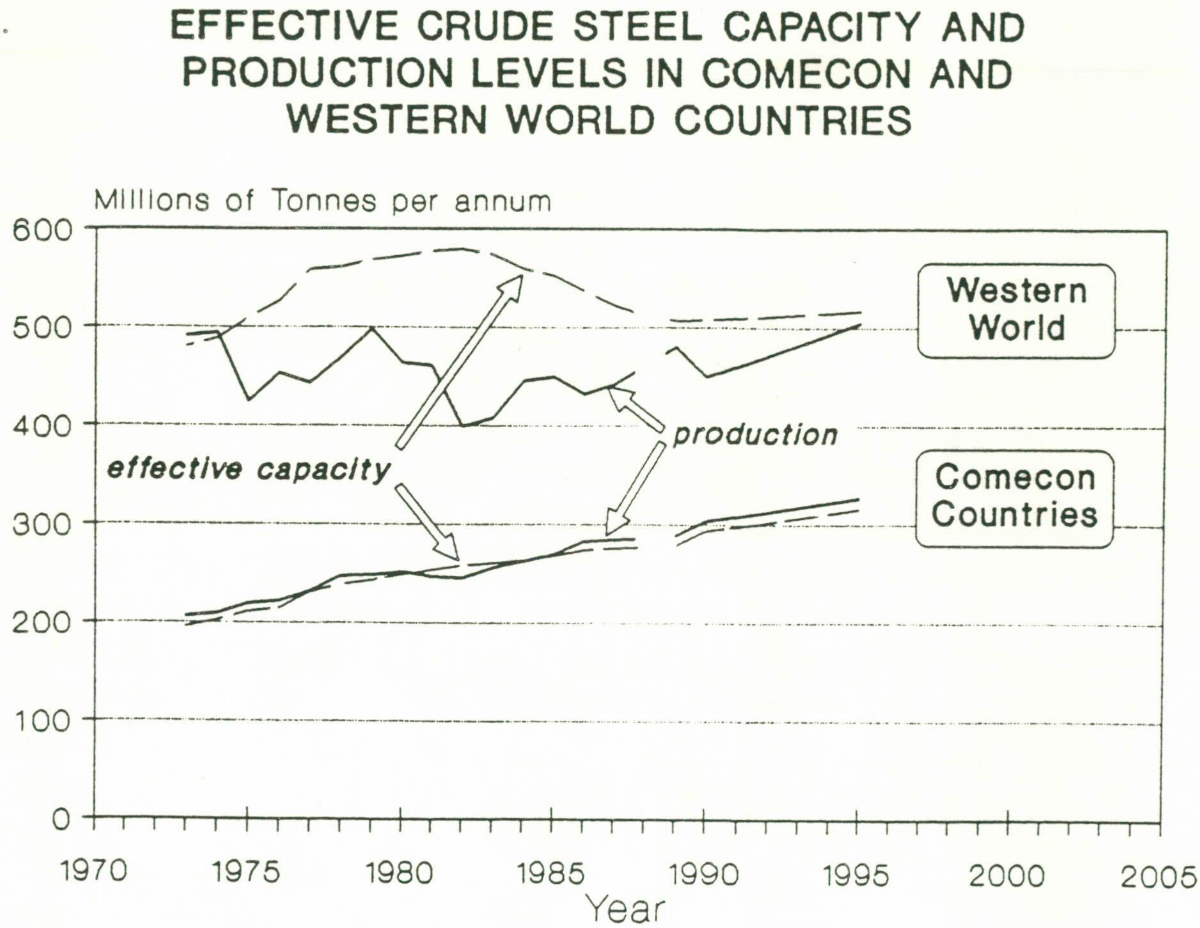
Source: WEFA

Figure 2.3: Gross world steel capacity (millions of tonnes of crude steel pa)



Source: PaineWebber

Figure 2.4: Effective operating levels for steel plant in various regions (ratio of production and effective annual steel capacity)



Source: PaineWebber

3.1 Demand

Domestic demand for finished steel in Australia is estimated to be 4.6 mt in 1987, with the total market worth around A$3.4 billion. A breakdown of the major market sectors is given in Table 3.1.

The New Zealand market for steel is currently estimated to be 0.70-0.80 million tonnes per annum.

Because of yield losses during rolling and finishing the total amount of molten crude steel required is approximately 25% greater than finished steel. In other words the Australian requirements for crude steel (produced at the steelworks), therefore, was 6.1 mt in 1987.

As shown in Table 3.1 the building and engineering construction industries absorb over two-thirds of all steel consumed in Australia - with much of this in the form of slab & plates, structural beams and reinforcing rod. Coated products are generally used in the automotive and whitegoods sectors (as steel sheet pressings), and as roofing material (namely Lysaght's *Colorbond* material) in domestic buildings.

Thus most steel ends up in durable goods. Indeed, the only significant non-durable application for steel is as tinplate for packaging. For this reason, overall demand for steel is very sensitive to changes in economic activity - particularly investment in (steel-intensive) buildings and capital goods. The extent of this sensitivity can be seen in Figure 3.1, which shows that steel demand fell by 20% during the 1975 and 1983 recessions as businesses stopped investing in new plant & equipment. Conversely, the recent boom in housing and office construction and the recovery of the manufacturing sector has led to a substantial increase in steel demand. Recent reports are that steel demand is currently running at 12% above that in 1987.

Table 3.1: Estimated end-use markets for steel in Australia in 1987 (finished-tonne basis)

	Size (mtpa)	Value ($m)
Product type		
- Slab & plate	1.2	620
- Long products	0.7	300
- Rod & bar	0.8	330
- Wire	0.5	400
- Coated products	1.2	1 250
- Stainless & alloy	0.2	500
	4.6	3 400
Customer Sector		
- Structural construction	2.0	1 200
- Engineering construction	1.2	700
- Vehicles & machinery	0.4	500
- Whitegoods	0.2	300
- Packaging	0.2	200
- Primary industry	0.3	200
- Resources	0.2	100
- Other	0.1	200
	4.6	3 400

Note: Excludes intermediate products used internally within BHP, such as slabs which are later rolled into sheet and strip (coated products).
Source: MMP estimates

Gross Domestic Product (GDP) against steel consumption is plotted in Figure 3.3. It is significant that steel demand generally appears to be growing more slowly than GDP. Based on discussions with BHP it is understood that , as a rule of thumb, domestic demand for steel is growing up to one 1 percentage point slower than GDP. This is not surprising given the structural changes in our economy towards less steel-intensive activities and technical/design improvements in the way steel is used - and is in line with the life-cycle concept as outlined earlier in Sections 2.2.1 and Table 2.3.

3.1.1 Future demand for steel in Australia

Based on trends in steel demand over the last 15 years and allowing for structural changes in the various end-use sectors MMP estimates that, in the longer term, domestic steel demand will grow at around 0.5 percentage points slower than GDP(1).

Using the DoE's *Base Case* and *Low Growth* economic scenarios (whereby GDP grows on average by 2.5% and 1.8% pa over the next 15 years) MMP estimates that the corresponding the forecast growth in domestic steel demand will be around 2.0% and 1.4% pa.

A third scenario was developed by MMP, where GDP is projected to grow by 3.3% pa over the forecast period. Under this High Growth scenario steel demand is estimated to likely grow at 2.8% pa.

The *Base Case* and *Low Growth* steel demand forecasts can be seen in Figure 3.4. Also included is WEFA's forecast (which is derived from their forecast of growth in the Oceania region)

Although not plotted, WEFA's forecast falls between MMP's *Base Case* and *High Growth* scenarios.

The WEFA demand forecast is primarily based on a product life-cycle model - with steel demand in the Oceania region (principally Australia) projected to grow on average by 2.4% pa over the next twelve years. This compares favourably with an average growth of only 0.9% pa for all industrialised western countries.

MMP's *Base Case* and *Low-Growth* forecasts closely match those of BHP - which essentially assume that demand will grow by 1.5-2.0% pa over the next decade.

(1) More sophisticated econometric modelling studies (using multiple-linear regression techniques) were carried out by MMP. However these gave a poor fit and so were not used. However given the short-term volatility of steel demand and its impact on energy consumption in the iron & steel industry, it is recommended that more rigourous modelling studies be carried out.

It is understood that the BHP forecast is based on a combination of detailed estimates of end-use requirements and econometric modelling. Its economists have traditionally taken a cautious view of economic growth in Australia and as a result MMP believes that the given steel forecast (of 1.5-2.0% pa growth over the next decade) is conservative. Nevertheless, some of the company's senior management feel that even these figures may be too high!

Not included in Figure 3.4 is a recent forecast published by the Institute of Applied Economic & Social Research (IAESR) in March 1988. Using the *ORANI* model IAESR estimated that between December 1986 and June 1992, GDP will grow by 2.9% pa and steel production by 4.5%.

It should be noted that all of the above forecasts are based on a stable economy. As indicated before, short-term steel demand is extremely sensitive to changes in the economy - with year-to-year swings of +/- 20% not unknown. Therefore, any assessment of the future operating levels (and energy requirements) of the NSW iron & steel industry should take into account the short-term fluctuations.

Consequently, For purposes of projecting the future operating levels and hence energy needs of BHP's steelworks, we have assumed that long term demand will grow by 2.0% pa (matching MMP's Base Case forecast) with short-term swings of +/- 10% occurring around this trend-line.

3.2 SUPPLY SITUATION

Apart from specialised and highly alloyed products, sufficient steelmaking capacity is in-place to meet most domestic needs. In 1987 6.3 mt of crude steel was produced in Australia. After yield losses this equalled 5.1 mt of marketable steel products - of this 4.1 mt was consumed domestically and 1.0 mt exported.

The Australian steel industry is dominated by BHP which produces over 90% of the country's steel.

As indicated in Table 3.2, BHP owns three integrated steelmaking plants - with the two largest being at Port Kembla and Newcastle in New South Wales. The third integrated plant is at Whyalla in South Australia. In addition, BHP operates several major steel finishing plants around the country and has a "mothballed" blast furnace at Kwinana which in fact, has deteriorated badly.

During the early 1980s BHP reorganised its steel plants such that each site now specialises in a given product range. Consequently the Newcastle steelworks is dedicated mainly to producing rod and bar products, with Port Kembla making slab and plate, and Whyalla concentrating on long products (such as steel railway lines and structural beams). This strategy improves manufacturing efficiencies by reducing the range of products made at each site. However this is partly off-set by higher transportation costs to the advantage of the Smorgon mini-mill in Victoria.

The remaining 10% of Australia's steel production comes from the Smorgon Consolidated Industries mini-mill at Laverton and Commonwealth Steel's special-steel plant in Newcastle. The Smorgon mini-mill was commissioned in 1983 and uses an 80 tonne electric furnace to remelt steel scrap to produce reinforcing bar and light steel sections for sale in Victoria and other parts of south-eastern Australia. The Commonwealth Steel plant has a 50 tonne electric furnace for melting stainless and alloy steels. The hot metal is refined in the ladle prior to charging into a two-strand continuous billet caster.

On a crude steel basis, 7.3 mt of effective capacity is currently installed in Australia. This is down from a high of 9.0 mt in 1981 (see Figure 3.2). As shown in Figure 3.5, three-quarters of this steel is made in NSW at the Port Kembla and Newcastle steelworks.

3.2.1 Steel capacity in New Zealand

Any analysis of the Australian steel supply situation should also include steel capacity in New Zealand because the recent signing of the Closer Economic Relations (CER) treaty allows unrestricted trade between the two countries. As indicated in Table 3.1, the New Zealand steel industry differs from Australia in that the principal company, New Zealand Steel Ltd (NZS), makes its iron via direct reduction rather than the blast furnace route. The DR feed is melted and converted to steel in a modified basic oxygen furnace.

NZS was set up by the New Zealand government in 1966 - with a small direct reduction kiln and electric steelmaking plant being built in 1970 at Glenbrook, 60 km south of Auckland. In 1987 NZS expanded their iron & steelmaking operations from 150 000 tpa to 750 000 tpa. Construction has also started on a hot and cold rolling mill for processing 550 000 tpa of continuously cast slab into a variety of finished products. Due to the small size of the domestic market, half of the plant's output is exported to Australia and the United States.

A small electric furnace is also operated in New Zealand, at Otehuhu, by Pacific Steel Ltd. This plant manufactures wire rod, reinforcing bar and simple channel sections for the construction industry.

NZS chose the direct reduction process because of its smaller economic scale of operations and the unusual characteristics of the local iron ore (consisting of a fine beach sand rich in titanium and vanadium) and the available coal (which is high in volatiles and not suitable for making coke). Notwithstanding these limitations the steel produced is of reasonable quality and is cost competitive with BHP's products.

Table 3.2: Australian & New Zealand Steelworks: Capacity and production in 1987 (millions of tonnes of crude steel)

Location		Plant Type(1)	Capacity (mtpa)	Output (mtpa)
NSW	- Port Kembla (BHP)	BF/BOF/CC	3.8	3.2
	- Newcastle (BHP)	BF/BOF/CC	1.9	1.7
	- Newcastle (ComSteel)	EF/CC	0.07	0.03
South Australia	- Whyalla (BHP)	BF/BOF/IC	1.1	1.1
Western Australia	- Kwinana (BHP)	BF	0.75	0.0 (MOTHBALLED)
Victoria	- Laverton (Smorgon)	EF/CC	0.40	0.3
Total Australia			8.05	6.3
New Zealand	- Glenbrook (NZS)	DR/BOF/CC	0.6	0.5
	"	EF/CC	0.2	0.1
	- Otehuhu (PSC)	EF/CC	0.1	0.1
Total Oceania			9.0	7.1

Source: MMP analysis.

(1) Process routes are :

BF = Blast furnace
EF = Electric furnace
DR = Direct reduction
BOF = Basic oxygen furnace
CC = Continuous caster
BM = Bloom cast

3.3 Supply/demand balance

In 1983 the steel industry faced a major crisis. The economy was heading towards a deep recession and domestic demand was declining. The strong Australian dollar coupled with BHP's old plant and inefficient labour practices made the steelworks uncompetitive against overseas producers. The company found it found it very difficult to sell into the export market. At the same time a flood of cheap imports reduced domestic steel prices and affected the company's profitability.

BHP appealed to the Government and the unions for assistance. This led to the *Steel Industry Plan* which resulted in a major restructuring of the industry to improve its competitiveness. An agreement was reached whereby BHP closed down its unprofitable operations, unions agreed to improve labour productivity and the Government provided extra protection against dumped imports. In return, BHP committed itself to A$1 billion capital investment program over 5 years. All up $1.6 billion was spent - primarily on improving labour/energy/material efficiency and product quality, rather than extra capacity. The end result was a 25-30% real reduction in operating costs between 1982 and 1988. This, coupled with the drop in the Australian dollar and a pick-up in international steel demand and prices, has restored BHP's international competitiveness. However, unless the company continues to upgrade its operations a question mark still hangs over the industry's long-term future.

Putting aside the delays associated with commissioning the equipment and minor industrial relations issues, most critics agree that the *Plan* has generally been a success.

Under its terms of reference the *Steel Industry Plan* will finish at the end of 1988. It is rumoured that the *Plan* will not be extended - the Government's Steel Industry Authority, which has overseen the *Plan*, will probably be abolished. In its place BHP will fix a series of direct productivity-sharing agreements with the unions. The company's objective is to improve its return on investment to 15% by 1990 from only 4.1% in 1987.

3.3.1 Short-term situation

Due to the combined effect of recent reductions in capacity plus an unexpected spurt in demand, the domestic market for steel has become very tight in the last year. Consequently the order-times for many steel products have doubled - leading to customer dissatisfaction and growth in imports.

The shortages have been exacerbated as BHP is currently upgrading its steelmaking operations and shake-down problems with the new plant have led to lost production. As a result BHP had to import 0.4 mt of steel in 1987 to fill customers' orders.

As stated before in Section 2.4, most industry experts believe that the tight international supply situation/high steel prices is temporary and that, under most scenarios, prices will flatten out as the world's economy slows down and inventory-building stops. The current boom in office construction is likely to keep the Australian market buoyant at least out to 1991.

In-spite of the very tight market, list prices for BHP steel products have only kept pace with inflation(1). By comparison, in US dollar terms, overseas spot prices have risen by 30-40% in the last year. Inevitably domestic prices will catch up with international rates. For political reasons it is unlikely that BHP will force up prices too quickly. Nevertheless we speculate that, after adjusting for changes in discount levels, domestic prices could increase in real terms by 5-7% over the next 3 years.

On this basis MMP believes that BHP will continue to remain competitive with overseas producers. Assuming that the company can get its facilities running smoothly, the lower domestic prices (coupled with anti-dumping surveillance) should enable BHP to edge out imports. Indeed, if spare capacity is available the company has an excellent opportunity to make profitable sales in the export market. This is contingent on the Australian dollar remaining low.(2)

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(1) However it is understood that the level of discounting offered has fallen in recent years - whereby leading to an effective increase in steel prices.

(2) At the time of writing the Australian dollar was worth US$0.70-0.75 with the Trade Weighted Index at 60-62.

3.4 EMERGING TRENDS AFFECTING THE INDUSTRY

General issues affecting the Australian steel industry include:

- erratic growth in local demand. Over the last two decades major swings in demand of up to +/- 15% have occurred and will continue to take place. This places extreme pressure on the industry's human and capital resources and profitability - as steelmaking has a high level of fixed costs capacity that cannot be increased quickly

- major changes in international competitiveness. Prior to 1983 the domestic steel industry was generally uncompetitive against imports. In addition to the effect of the major cost savings of 25-30% achieved under the Steel Industry Plan, BHP's profitability was significantly enhanced by the collapse of the Australian dollar in 1985. The company now profitably competes on the export market. The risk is that these gains could be lost if the currency strengthens and/or inflation picks-up

- increased competition from overseas producers. In recent years the local steel industry has been faced by the twin threats of lower cost imports from South Korea and Taiwan as well as ever-higher quality material from Japan

- emergence of domestic competitors. In 1983 Smorgon Consolidated Industries started up a mini-mill in Victoria. For the first time in 50 years BHP had a direct competitor. Smorgon currently compete in the reinforcing rod and bar markets, taking sales away from BHP's Newcastle steelworks. Another private company (Quest Ltd) proposed a similar mini-mill in Queensland - though this project was abandoned in 1986 in the face of falling prices and the announcement by BHP that it was to build a re-rolling facility in Brisbane. As domestic demand continues to grow the threat of further new entrants will arise again in the future. For example China Steel Corporation (of Taiwan) has expressed an interest to build an export oriented steel plant in Australia

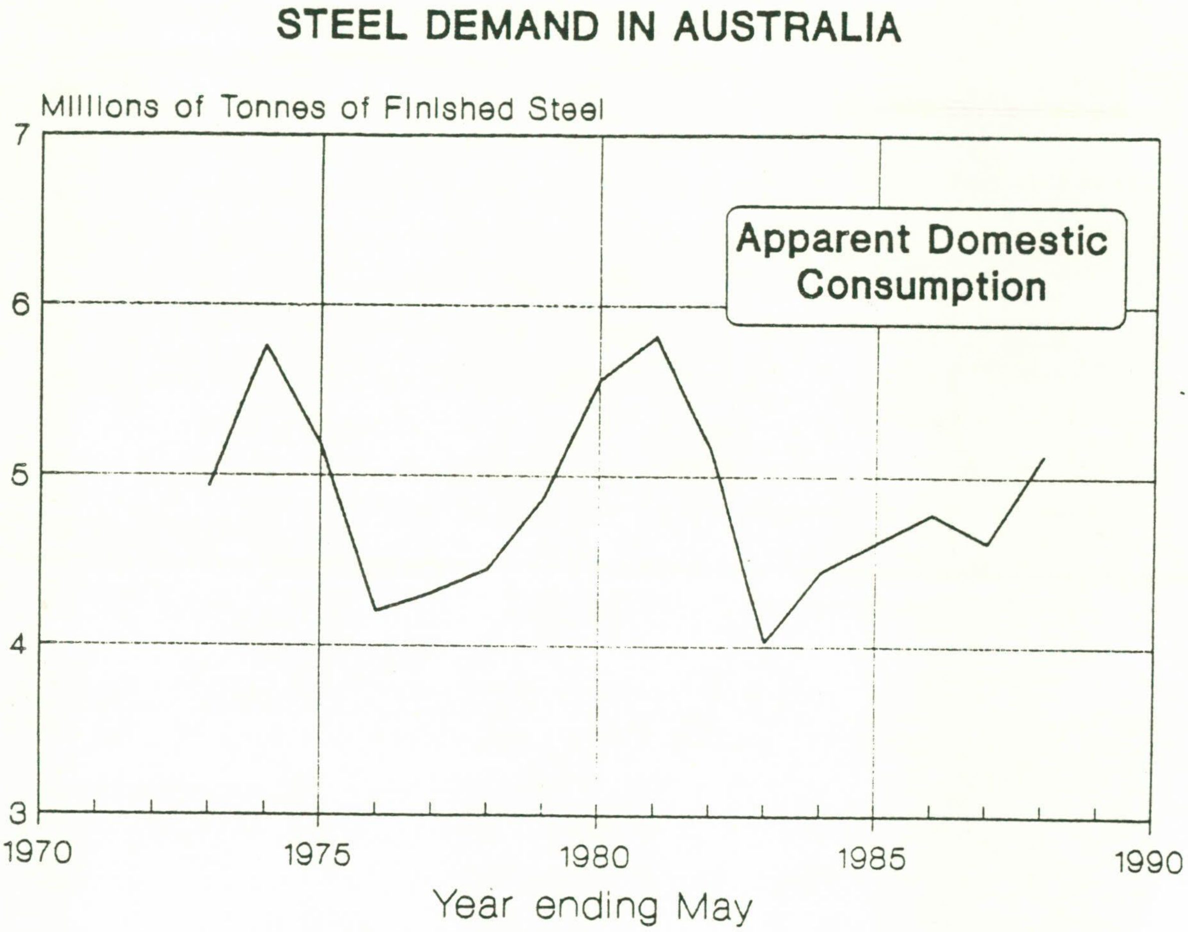
- thin strip casting at Smorgon. It is rumoured that Smorgon intend to install one of the world's first commercial thin strip casters to flat products (see Section 5.2.3 for technical details). If successful this may spur on the construction of new mini-mills. Clearly, this will take sales from BHP's Port Kembla steelworks.

- the creation of a direct reduced iron industry. At present several companies are evaluating the potential of building DRI and direct steel smelting plants in Australia to take advantage of the country's low cost fuel and high quality iron ore reserves. Although the economics of such plants will be based on exports, some of the material will end up being used locally. For example, Smorgon would welcome an independent source of iron so as to reduce its vulnerability in the steel scrap market (the price of which can be influenced by BHP). Furthermore it is logical that once a DRI plant were built the owners would be attracted into going down-stream to add more value and reduce their dependence on international demand

With respect to the last point, the main companies identified include CRA (which is contemplating a coal-fired direct smelting process), Pact Resources NL (a small Perth based company trying to develop a natural gas-fired facility in Western Australia for making iron-carbide which will compete against DR iron), Korf (an Austrian company planning to use brown coal char from Victoria) and Lurgi (which is apparently considering building a gas-fired DRI plant in the West or Queensland).

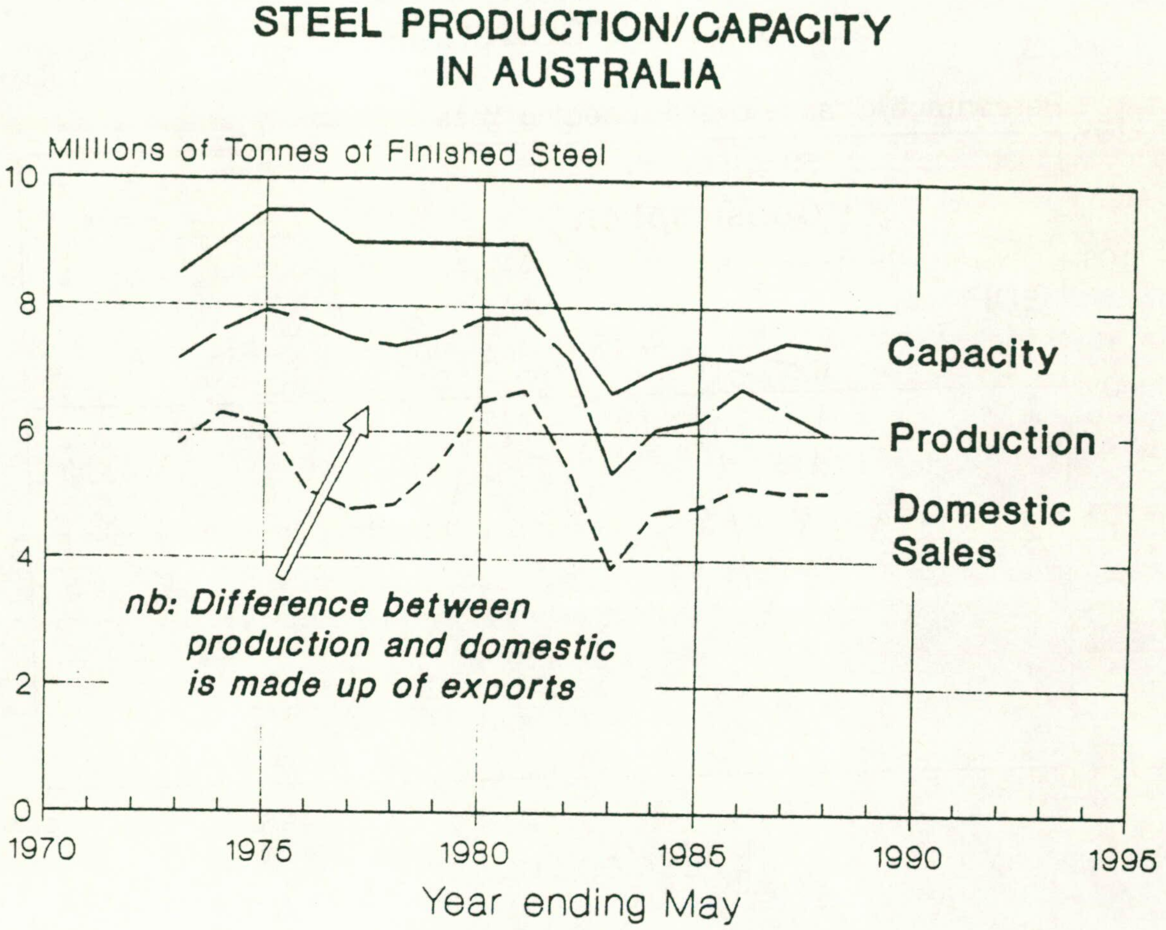
China Steel Corporation may be interested in forming a joint venture arrangement with one of these companies.

Figure 3.1: Steel demand in Australia (finished-tonne basis))



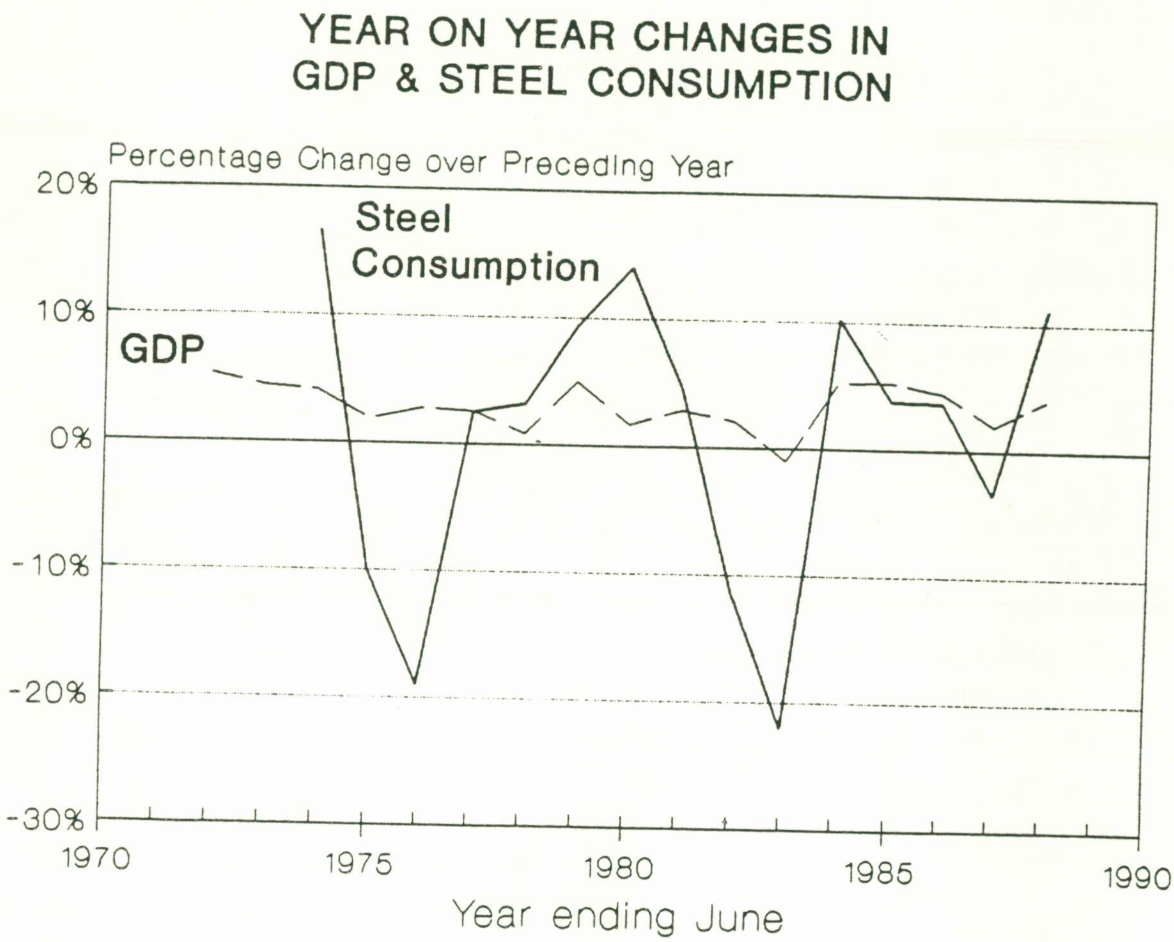
Source: MMP

Figure 3.2: Steel production in Australia (on a crude steel basis)



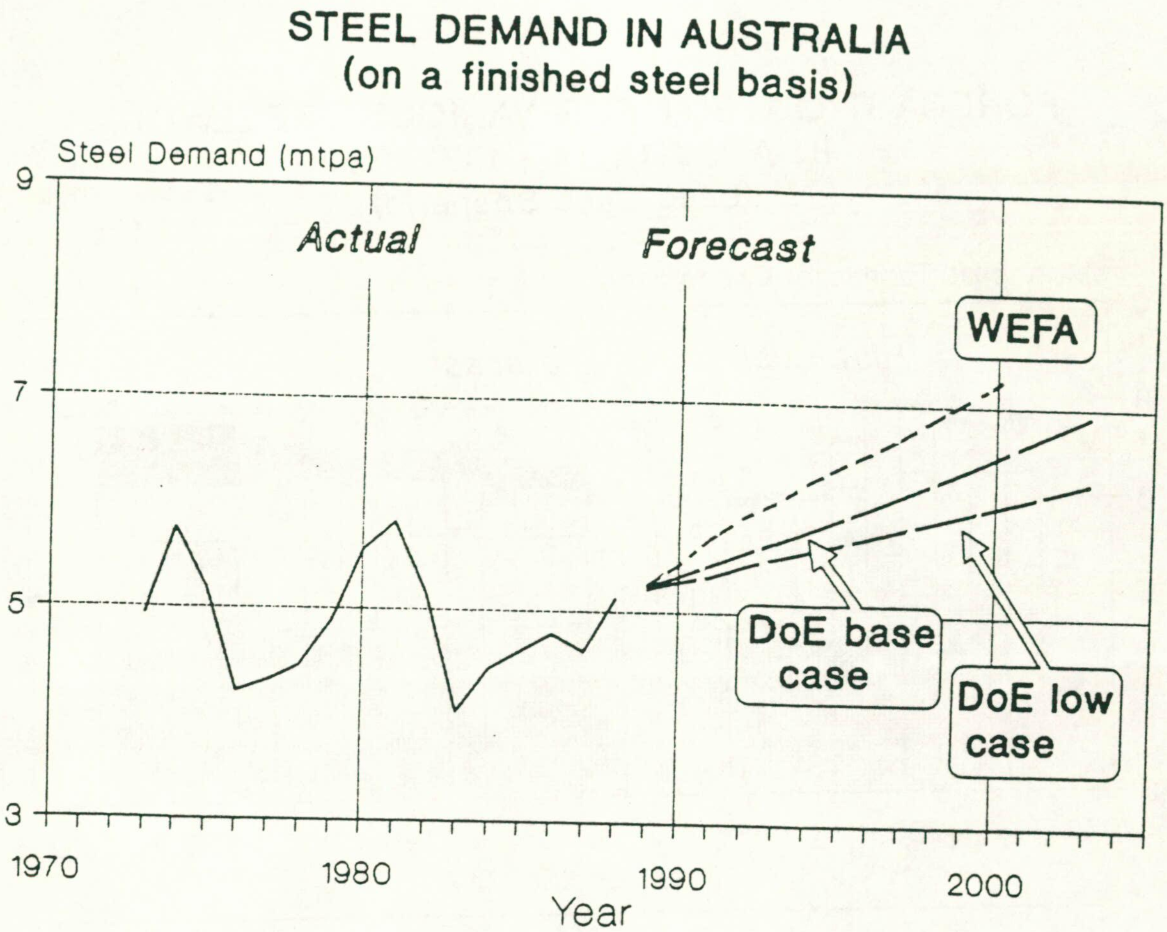
Source: MMP

Figure 3.3: Annual changes in GDP and (estimated) steel consumption in Australia : 1973-1988



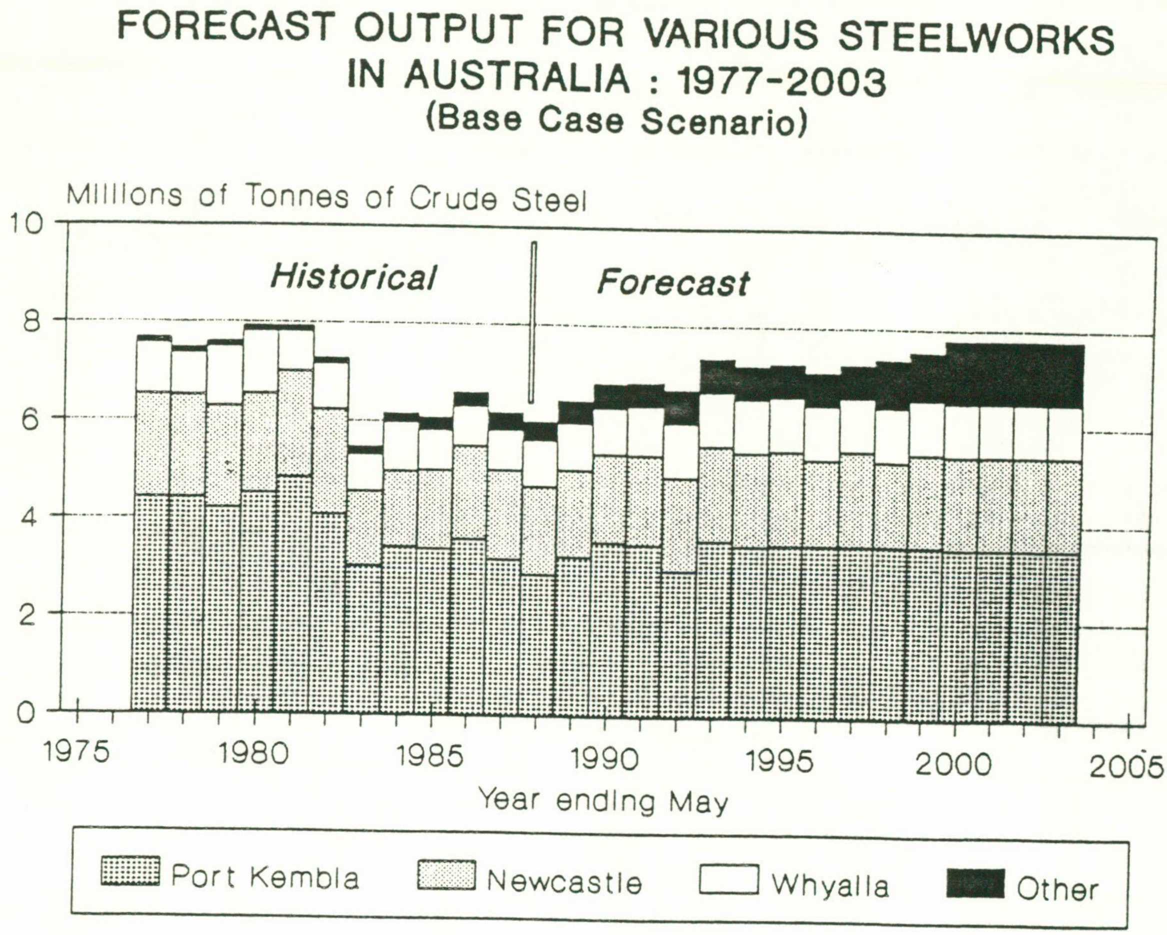
Source: MMP and ABS statistics

Figure 3.4: Estimated demand for steel in Australia : 1970-2003 (millions of tonnes of crude steel)



Sources: MMP analysis, BHP (August 1988) and WEFA (December 1987)

Figure 3.5: Steel production in Australia by site (on a crude steel basis)



Source: BHP and MMP

4 OVERVIEW OF THE NSW IRON & STEEL INDUSTRY

As outlined in Chapter 3 most of Australia's steelmaking capacity is in NSW, consisting of a 1.9 mtpa integrated steelworks at Newcastle and a 3.5 mtpa facility at Port Kembla. Both plants are owned by BHP.

4.1 Facilities

4.1.1 Port Kembla steelworks

Port Kembla is BHP's largest steelworks and is a fully integrated plant producing coke, iron and steel on-site. The plant covers over 800 hectares of land on a tidewater site at Wollongong. Coke-making capacity exceeds 2.7 mtpa - of which 0.5 mtpa is currently being utilized for exports to South America and elsewhere.

Iron-making first commenced on the site in 1928, and over the years five blast furnaces have been built. At present only two of these are operating (Nos 4 and 5) with a combined capacity of 2.9 mtpa. The hot metal is refined in three BOS furnaces (total capacity of 4.1 mtpa) before being continuously cast into slabs for later rerolling.

The main marketable products are:

- slabs which are fed into the company's hot strip mill on-site and to BHP's mill in Westernport
- hot rolled coils, which provide the feedstock for cold-rolled sheet products made at the company's Coated Products Division nearby at Kembla Grange. Some of this material is also rolled on-site for use in the work's tinplate mill
- hot rolled slit strip and plate. This material is sold directly to the end-user in the automotive, engineering, pipe and tube industries
- tinplate coils and sheets for sale to the container industry
- plate products which are used in pipelines and construction as well as general engineering applications, and
- merchant bar and reinforcing rods (*Tempcore*) for sale to the construction industry.

Table 4.1: Inventory of Major Equipment at Port Kembla Steelworks

Equipment	Rated Capacity (mtpa)	Year Installed	Comments
Coal Washery			
Coke Ovens	2.700 (7A battery lit in 1987)		Made up of 5 batteries
No.1 Sinter Machine	2.000		Not running
No.2 Sinter Machine	4.000		
No.1 Blast Furnace		1928	Not running
No.2 Blast Furnace		1938	Not running
No.3 Blast Furnace			Not running
No.4 Blast Furnace	1.0		
No.5 Blast Furnace	1.9		
No.1 BOS	1.37 est	1972	Total capacity of 4.1 mtpa
No.2 BOS	1.37 est	1972	
No.3 BOS	1.37 est	1983	
AOD Vessel	0.040		Vessel used for stainless steels
Electric Arc Furnace	0.040		Used for making stainless steel
Oxygen Plant	0.380 O2		Two units
Slab Casters	4.100	1978/86	Made up of 1 twin strand and 2 single strand machines
Billet Mill	0.900		
Merchant Mill	0.240	1931?	Combination rod, bar & strip mill
Slab Mill	3.700	1954?	
Plate Mill	0.800	1963	
Hot Strip Mill	2.200	1955	
Tin Mill	0.500	1957/62	(See Note 1)
Foundry	0.120		There are 3 foundries

(1) Consists of a cold reduction mill, annealing line and 2 electrolytic tinning lines

Source: BHP

An inventory of the major plant & equipment at Port Kembla is given in Table 4.1. The steelworks is fairly modern and is of world scale. From 1986 onwards 100% of the plant's output has been continuously cast. This has lowered operating costs and improved raw steel product yields by 8-10 percent.

Recent capital investments (under the *Steel Industry Plan*) include:

- upgrading the plate mill ($38 million)
- a $150 m redevelopment of the hot strip mill
- $146 m for a new continuous slab caster, and
- construction of the 7A coke battery ($84 m)

In addition, BHP has just announced that it will upgrade No.4 blast furnace, increasing capacity by 0.4 mtpa (to be ready by 1990). This will bring the iron-making capacity in-line with the available BOS steelmaking capacity and reduce the amount of coke that needs to be sold onto the export market.

Over the period 1983-88 capital expenditure at Port Kembla totalled $800 million.

4.1.2 Newcastle steelworks

Newcastle is Australia's and BHP's first major integrated steelworks. Iron-making first commenced on the site in 1915, producing 0.15 mtpa of steel rail sections. The site presently covers 290 hectares of land ajoining the Hunter River, offering good port facilities.

The main marketable products made are:

- merchant bar in the form of small shapes and sections. Much of this is in the form of low alloy special steels sold to the engineering and automotive industries
- reinforcing bar for use in the concrete construction industry
- rod feed for making wire at AWI in Newcastle and BHP's mill at Geelong
- blooms
- billets for later rolling at BHP's merchant mills at Kwinana, Brisbane and Geelong
- skelp and narrow hot rolled strip feed for making pipe and tubes
- narrow cold rolled strip for making steel strapping on-site

Following a major rationalisation program in the early 1980's coke-making capacity was cut back to 0.80 mtpa, resulting in the need to import additional coke when the steelworks is running at full load[(1)]. The plant's two blast furnaces are capable of producing 1.53 mtpa of iron, which matches the 1.9 mtpa of BOS steelmaking capacity on-site. The steelworks is currently midway through a major upgrading program such that by 1989 all the plant's output will be continuously cast. This will result in significant material, energy and labour cost savings.

(1) In the last three years Newcastle has had to import 0.01-0.09 mtpa of coke from Port Kembla to make up the shortfall

Recent capital investments (under the Steel Industry Plan) include:

- relining No.3 blast furnace in 1985 which increased capacity by 0.3 mtpa (at a cost of $36 million)
- improving the coal washery in 1986 to allow the use of lower quality coals ($6m)
- replacement of the BOS primary gas cleaning plant in 1987 ($22 m)
- installation of a 2.0 mtpa continuous caster to make large section blooms ($90 m), and
- refurbishment of the rod mill , including controlled cooling in 1987 ($50 m)

Over the period 1983-88, capital expenditure at Newcastle totalled $350 million.

An inventory of the age and size of the major plant and equipment currently in-place at Newcastle is given in Table 4.2. As can be seen the plant is smaller than Port Kembla and contains reasonably modern equipment. The concerns are that production costs are higher than competing mini-mills and that the coke ovens will need replacing in the mid 1990's.

Due to site restrictions which limit BHP's ability to expand the steelworks the Company has bought land across the Hunter River on Kooragang Island. Plans to build a 0.6 mpta blast furnace there reached an advanced stage but were deferred indefinitely in 1981 following the recession in the steel industry.

Studies published by BHP [1] comparing it with modern plants overseas indicate that Newcastle is slightly more energy intensive than the norm due to the smaller size of its blast furnaces, age of its coke ovens and the lack of a top gas turbine.

(1) Green, G.S., Shannon, W.P and Butt, G.K Energy Optimization in the Australian Steel Industry SEAISI October 1984

4.2 COST STRUCTURE

Due to the heavy capital investment required, the persistent surplus of capacity and depressed steel prices, the iron & steel industry has not been very profitable in recent years. This is the case in both Australia and overseas - for example in 1987 BHP achieved a return of only 4.1% on steel assets worth $4.9 billion.

Although the current returns to BHP are clearly inadequate they are a substantial improvement over those of five years ago - the company having lost money in 1983. It is understood that the company aims to achieve a 15% return on its steelmaking assets by 1990 - which is equal to an after-tax profit of A$800-1000 million or US$70-90/tonne.

To put these returns in perspective, BHP acknowledges that it will need to spend A$50/tonne each year on new plant and equipment just to maintain its facilities in good working order.

The main reason for the losses in 1983 were due to the down-turn in steel demand which affected both prices and operating levels. In response BHP embarked on a massive rationalisation/reconstruction program involving closing down 1.8 mtpa of high cost capacity, reducing the workforce by approximately a half investing 1.6 billion dollars in new plant and equipment. Most of this investment was directed at improving labour productivity and product quality rather than increased capacity.

As can be seen in Figure 4.1 over the last 5 years these efforts have led to a 20-30% real reduction in costs at Port Kembla. A further saving of 10% is expected over the next 2 years. Similar savings have also been achieved at Newcastle. When coupled with the major devaluation of the Australian dollar the end result is that BHP has now re-established its competitive position visa-vis overseas producers.

Table 4.2: Inventory of Major Equipment at Newcastle Steelworks

Equipment	Rated Capacity (mtpa)	Year Installed	Comments
Coal Washery		1944	Improved in 1986
No.5 Coke Oven Battery	0.800	1971/79	
No.2 Sinter Machine		1961	
No.3 Blast Furnace	0.675		Relined in 1985
No.4 Blast Furnace	0.850	1963	Due for reline in 1989
No.1 BOS	0.950	1962	Can be easily expanded to
No.2 BOS	0.950		2.7 mtpa total
Steel Foundry	0.026		Has two 50 t & one 6 t electric furnaces
Oxygen Plant	0.350 O_2	1962/82	Consists of 4 units
Jumbo Bloom Caster	2.000	1987	All steel at Newcastle to be con-cast
No.2 Bloom & Billet	1.800	1975	Can be expanded to 3 mtpa
No.1 Merchant Mill	0.300		Makes light gauge bars
No.2 Merchant Mill	0.500	1968	Makes medium bars
Rod Mill	0.670	1962	Finishing-end upgraded in 1987
Skelp & Strip Mill	0.500	1958	
Cold Rolling Mill	0.024	1935/66	Makes steel strapping

Source: BHP

The relative profitability of BHP versus other steelmakers is given in Figure 4.2. As can be seen, on a "full-cost basis"[1] the NSW iron & steel industry is better than most overseas producers - with the exception of BSC, China Steel Corporation and some North American producers. As discussed before, BHP is aiming to increase its profits from US$25/t at present to over US$70/t by 1990.

The low returns for the South Koreans (POSCO) is due to the heavy interest and depreciation charges associated with the recent expansion program at Kwangyang Bay. On a cash-cost basis POSCO is one of the lowest cost producers in the world.

In practice, a steelmaker's competitiveness is dictated more by cash-costs than after-tax profitability - as the former sets the incentive for selling steel into marginal markets. In other words a high fixed-cost but low cash-cost producer will always operate at near-full capacity even during a recession - as it can sell its product on the world market at a low price.

Figure 4.3 suggests that on a marginal cost basis BHP is competitive with South Korea and Brazil as the company has consistently been able to maintain its operating rate above 80% .

The approximate cash-costs for BHP's Port Kembla and Newcastle steelworks are shown in Table 4.3. Also included are operating costs for selected overseas producers.

As shown in Table 4.3, Port Kembla is currently much cheaper than integrated producers in the US, but US$70-100/tonne more expensive than China or South Korea. Due to the strong Yen and high labour costs the Japanese have the highest costs (though it should be noted that they produce higher quality products which command higher prices).

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(1) As measured after-tax and depreciation & interest charges.

Table 4.3: Estimated cost of making steel in NSW and overseas in 1987 (US$ per tonne of crude steel in June 1988 dollars(1))

Country	Op Level	Raw Matls	Energy	Labour	Other	Total
United States						
- established mill	75%	101	97	158	81	437
- reconstituted mill	80%	87	87	110	74	358
China						
- new integrated mill	95%	67	86	45	60	258
Japan						
- integrated mill	60%	65	90	180	85	420
South Korea						
- new integrated mill	100%	65	85	30	50	230
Australia						
- Port Kembla	85%	70	40	160	60	330
- Newcastle(2)	85%	75	50	130	60	315

(1) Based on an exchange rate of A$1.00 = US$0.75 = 120 Yen = 3.0 Rem

(2) Newcastle specialises in rod & bar products which are less labour intensive to make

Sources: WEFA, PaineWebber and MMP

BHP's competitive advantage comes mainly through access to low cost energy and raw materials - which are estimated to be around $US50-100 per tonne of crude steel cheaper than most producers. However, this advantage is dissipated by higher labour costs. Therefore it is not surprising that much of the company's recent investment in new plant & equipment has been directed towards improving labour productivity rather than energy or material efficiency. To this end BHP has managed to increase productivity at Port Kembla from under 250 tpa of steel made per person in 1983 to over 325 tpa now - with the aim of reaching 400 tpa by 1990.

Over the last 5 years labour productivity at BHP's Newcastle steelworks has improved from 200 to 350 tonnes per annum per employee. Newcastle aims to increase this to 400 tonnes by 1990.

Whilst BHP has made significant gains in productivity they pale in comparison with those achieved overseas - with some US integrated mills operating at over 850 tpa per employee. Mini-mills in Japan routinely achieve 1000 tpa per employee, which is more than double that for Newcastle. WEFA forecasts that over the next 10 years labour productivity will improve by 25% in South Korea, 35% in the US and 40% in Japan and Western Europe. Unless BHP matches these gains its cost competitiveness will be eroded.

Another concern is that, due to their much higher labour productivity, Australian mini-mills can undercut Newcastle's production costs. Evidence for this can be seen in the average selling price of steel out of Newcastle and Port Kembla. According to BHP's *1987 Annual Report* the average selling price for rod & bar products was A$420/t. On the basis that the cash-cost is estimated to be around A$390-400/t, Newcastle's contribution margin was less than A$30/t in 1987. The corresponding selling price for slab & plate produced at Port Kembla was A$540/t, giving an estimated contribution margin of over A$100/t. The large difference in selling price (and hence profitability) between the two steelworks is due to the intense competition from Smorgon's mini-mill for rod & bar products. It is understood that Smorgon's cash-costs are much less than those of Newcastle, and it is for this reason that BHP has elected to build its own mini-mill in Sydney.

4.2.1 Port Kembla steelworks

It is clear that in recent years BHP has regained much of its cost competitiveness through the devaluation of the Australian dollar and massive investment in labour-saving equipment. However, even with its cheaper energy and raw materials, Port Kembla's cost structure is still higher than that of China and South Korea. Furthermore, unless it can continue to match the labour productivity gains being achieved in the higher-cost developed countries BHP could lose its favourable cost position relative to the US and European steelmakers. Consequently the company is not well positioned to compete head-to-head in the export markets, and if it doesn't endeavour to preserve its cost advantage it could be forced out of the international market in the longer term and in Australia, face increased competition from cheap steel imports.

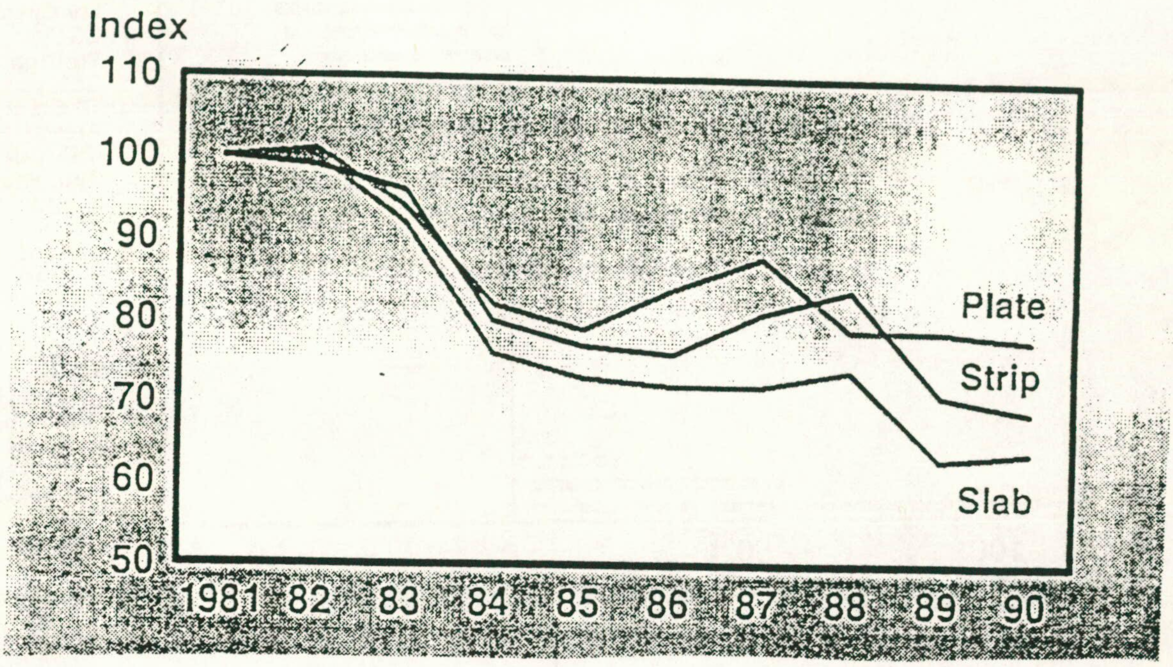
4.2.2 Newcastle steelworks

With respect to Newcastle it appears that, due to high labour and energy requirements of integrated steel production, the plant is more expensive to run than Smorgon's mini-mill. At current prices the plant makes little money on its traditional rod & bar products. The risk is that a downturn in steel demand and/or the establishment of other mini-mills in Australia will lead to a disproportionate cut-back in operating levels at Newcastle. BHP recognizes this vulnerability and intends to transfer its (low value/low profit) rod & bar activities to the company's new mini-mill at Rooty Hill in Sydney. BHP intends to use Newcastle to make higher value speciality rod & bar products. As a result Newcastle will be competing head-to-head against established integrated steelmakers from Japan and Europe. This strategy will only succeed if Newcastle can consistently manage to produce high quality product.

The impact of low cost mini-mills could also spill over to Port Kembla. In particular, the possible development of thin-strip casting will enable mini-mills to enter the profitable strip and plate markets (see Section 5.2.3). The end result will be increased domestic competition and reduced profitability and operating levels for Port Kembla. Such technology, however, is unlikely to be commercialised in Australia before 1993.

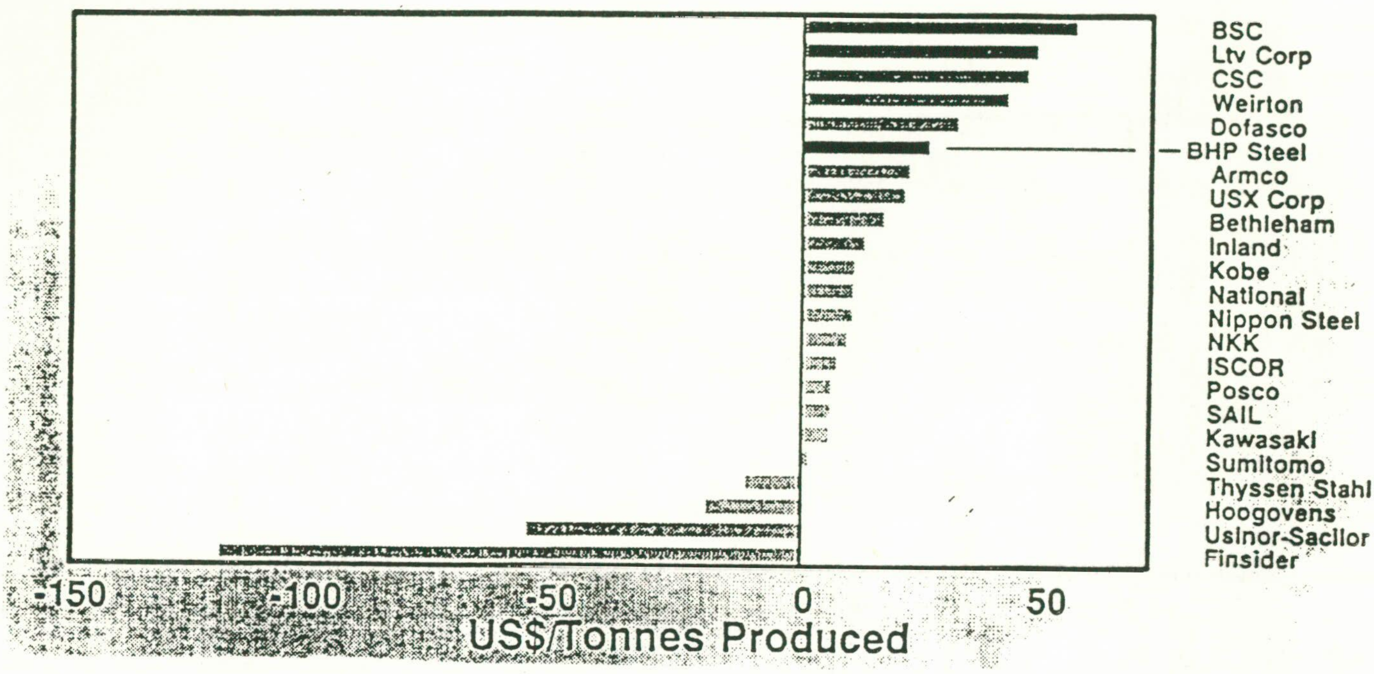
Finally, it almost goes without saying that the NSW iron & steel industry's long term competitive position is very sensitive to movements in currencies and domestic inflation rates.

Figure 4.1: Change in steelmaking costs at Port Kembla : 1981 = 100
(variable costs per tonne in constant Australian dollars)



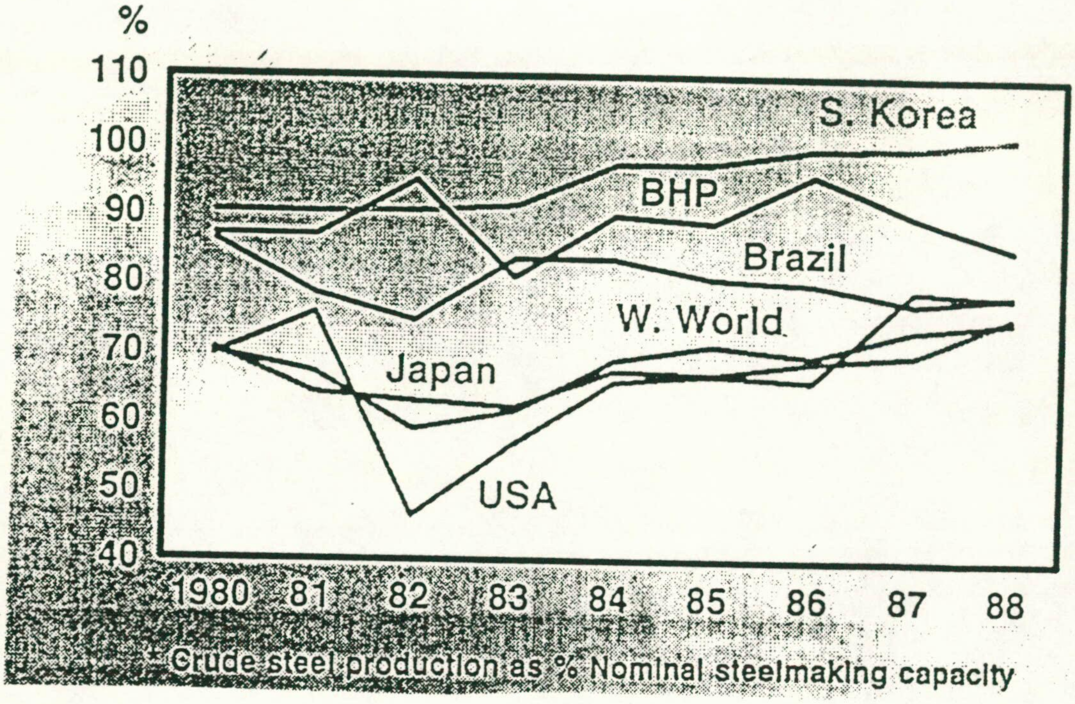
Source: BHP

Figure 4.2: Reported profitability of various steel companies in 1987
(US$/tonne of crude steel after tax and interest charges)



Source: BHP

Figure 4.3: Operating levels for various steel producers (crude steel production as a percentage of nominal steelmaking capacity)



Source: BHP

5 TRENDS IN STEEL TECHNOLOGY

The industry has matured to the point that it is becoming progressively more difficult to achieve major cost savings and technical break-throughs. Nonetheless the industry still has an active R&D program. Since the late 1970s the main thrust has been towards incremental reduction in production costs at reduced scales of operation and with improved product quality.

In the following Sections several key new iron and steelmaking technologies are discussed. These are split into two main groups: those already commercially proven and likely new breakthrough technologies which could radically change the way steel is made (and as a consequence the amount and types of fuels required), and secondly, those incremental energy saving technologies which can be added to BHP's existing plant without major disruption. The key difference between the two groups is that the adoption of the former is driven by overall cost savings/quality issues rather than only energy cost savings.

The breakthrough technologies are covered in this Chapter, with the incremental/energy saving technologies discussed in the following Chapter.

5.1 COMMERCIALLY PROVEN NEW TECHNOLOGIES

Over the last two decades several major new breakthrough technologies have been commercialised. These include:

5.1.1 Direct reduction

Rather than using a coke-fired blast furnace to reduce the iron ore to pig iron, one alternative process rapidly gaining favour is direct-reduction (DR). The process uses natural gas (or in some cases coal) to partially reduce iron ore in a vertical shaft furnace or a rotary kiln. The end product is a 'spongey' material which is 96% iron. DR iron is an excellent substitute for pig iron or steel scrap feed and is generally used in foundries and mini-mill electric arc furnaces.

The main advantage of DR iron route is that the unit capital costs are less than those of a conventional blast furnace and as a result can be operated on a smaller scale. Most DR plants have been located in regions where there are low cost natural gas and iron ore reserves. These include Mexico, Venezuela, Brazil and Malaysia. Several feasibility studies have been carried out on the possibility of a DR plant in Western Australia. However, CRA has publicly stated that its studies showed this site to be uneconomic due to a combination of high infrastructure costs, power and gas charges as well as the inherent difficulties of marketing a high proportion of the plant's output on the export market.

Figure 5.1 shows the speed at which DR capacity and production has built up over the last twenty years. A comparison of operating levels for DR and blast furnaces are given in Figure 5.2. The relatively low operating levels between 1975-85 are due to teething problems with the technology as well as difficulties in gaining export markets for the product - particularly against depressed steel scrap prices. PaineWebber projects that, because additional DR capacity will be installed over the next decade, it will continue to operate at low capacity utilization levels.

In addition to being vulnerable to swings in steel scrap prices, DRI is disadvantaged by that it uses large quantities of gas (13 GJ/tonne) and requires high quality lumpy ore. This restricts DR plants to locations where both raw materials are freely available. If lower quality ore is used, the carry-over of impurities tends to produce large slag volumes when the product is melted in an electric arc furnace. This leads to lower steel yields and higher electrical requirements.

Although large improvements in energy utilization have been achieved in recent years, industry observers claim that DRI is now reaching the limits of its technology, and that fewer gains will be made in the future. Contrary to this view is the recent development of the iron-carbide process, which claims to be A$30/tonne cheaper than conventional DRI processes. If so, it could make a major impact on the industry in the 1990's and beyond (see Section 5.2.1).

5.1.2 Oxygen steelmaking processes

First developed in the early 1950s, the basic oxygen process (BOP) has become the preferred means for steel making in integrated steel plants around the world. In this process a jet of pure oxygen is injected into the molten metal by a lance in a large refractory-lined converter. The oxygen 'burns out' excess carbon, silicon and other impurities such that relatively high quality steel can be quickly and consistently made. The shorter processing times also reduce the unit capital and operating costs required and lead to significant savings in energy.

In recent years several variations of BOP have been developed. These involve injecting other fuels and fluxes into the bath - either through the side or bottom of the converter, with or without the use of the top lance. These variants produce more uniform quality steel and can achieve higher purity levels. One interesting possibility is the direct injection of coal to increase the BOP's ability to melt higher steel scrap charges.

As shown in Figure 5.3 the basic oxygen process has almost replaced the traditional open hearth process for steel making.

5.1.3 Electric steelmaking/mini-mill

A growing alternative to the BOP and open hearth steel making processes is the electric arc furnace. In this process (cold) pig iron, steel scrap and/or DR iron is fed into a furnace and electrically heated. Fluxes are added to remove excess carbon and other impurities so as to produce reasonable quality steel.

The electric arc furnace was first developed at the beginning of the century for producing stainless and alloy steels, including tool steels. Since the 1950s it has been increasingly used for tonnage production of plain carbon steels. When coupled with a continuous bar caster the electric furnace formed the basis for a stand alone steel plant (or mini-mill) producing reinforcing rods and simple structural sections and bars.

The main advantage of the mini-mill is that the unit capital cost is very much reduced over the traditional integrated steel works (made up of a blast furnace and BOP facility). This lowers the minimum economic scale of operations to 0.2-0.5 mtpa and so enables the facility to be sited nearer to the customer thereby minimising freight costs and delivery times. It also allows small countries to have their own steelmaking facilities. In the US the small size of plant has enabled many owners to avoid using unionized labour, thereby reducing their operating costs.

The mini-mill has the disadvantage that it is dependant on the local availability of cheap steel scrap and its operating costs very sensitive to changes in scrap and electricity prices. Furthermore, the material produced generally contains high levels of impurities carried over from the steel scrap. This can be minimised by using DR iron. However, until the recent increase in world scrap prices this has involved a cost penalty of US$10-30/tonne.

In balance most mini-mills have been generally able to produce reinforcing bar at costs substantially lower than that for integrated producers. Consequently and this has led to a rapid growth in the number of mini-mills in western countries. Their operating levels have generally tracked that for the integrated producers (see Figure 5.4).

The next generation of electric furnaces, due in the next ten years, will be able to operate at much higher power levels. This will reduce the melting times and help improve productivity levels.

Ironically, the capacities of some of the larger mini-mills in the US and Japan are now approaching that of existing integrated steel plants (1 mtpa). This trend will continue because of economies of scale, growing local markets for reinforcing bar and the opportunity to make hot rolled strip via the thin strip casting process (see Section 5.2.3).

5.1.4 Continuous casting

As opposed to casting the molten steel into individual ingots, continuous casting involves using a special water cooled oscillating mold to produce a long strand of metal which can be cut into slabs or brooms. Continuous casting (CC) was first commercialized in Europe in the 1950s and was introduced into the US in the 1960s. At present the Japanese lead the world in its application.

The main advantage of CC is that less material is wasted (from cropping the ends of the ingots) and therefore less crude steel is required. Furthermore, the CC slab for rolling into plate can be directly fed into the hot rolling mill with lower reheating requirement. This reduces production costs and improves plant productivity. According to WEFA, the operating cost savings are of the order of US$50/tonne giving a pay back on the CC equipment of less than three years!

Because of the large cost savings possible, CC technology has been quickly adopted throughout the world - particularly in the industrialized countries (see Figure 5.5).

For technical reasons not all steels (especially the highly alloyed grades) can be continuously cast. Industry experts believe that the maximum possible penetration will be 90% of the total steel mix.

5.1.5 Continuous annealing

A recent development, originating from Japan, is the continuous annealing processing line (CAPL) for cold rolled strip. In this process the various cleaning, annealing, cooling, tempering and inspection steps are done in one continuous operation. The strip is looped through a large box (typically measuring 10 metres wide by 50 metres high and 300 metres long) in which the moving strip is heated and quenched in a precisely controlled manner over a period of ten minutes. The process replaces the traditional batch method of slowly heat-treating coils of strip over a period of several days in bell shaped ovens.

The main advantages of the CAPL process are substantial savings in labour and energy as well as producing material of more consistent quality. It also reduces stock turn-around times thereby minimising the amount of working capital locked away in 'work-in-progress'. At throughput levels of 0.5-1.0 mtpa the process is US$10-20/tonne cheaper than the batch process.

Approximately forty percent of all cold rolled steel in Japan is now processed through CAPL. The corresponding figures for Europe and the US are of the order of only 5-10%.

Unfortunately, the process can only be used for a limited range of steel grades, and is only viable at very high throughputs. To date, it has only been adopted to a modest extent in the larger industrialized countries such as Japan, US and western Europe where the market can justify a dedicated 0.5-1.0 mtpa plant. The cost savings achieved, of course, also give these producers a competitive advantage when selling on the export market. With the move towards single product steel plants, more CAPL facilities will be installed in the future.

5.2 Key emerging technologies

New and emerging technologies which haven't been fully commercialised but could prove to have a significant impact on future steel production include:

5.2.1 Iron-carbide direct reduction process

As discussed earlier in Section 5.1.1 conventional DRI processes appear to be reaching their technical limit. One breakthrough technology, which is a type of DR, is the iron-carbide process, in which iron ore fines are partially reduced with natural gas in a fluidised bed - resulting in a carbon rich iron compound (Fe_3C). The material is used as a low cost substitute for steel scrap and/or DR iron in electric arc furnaces.

In addition to being, reportedly, A$30/tonne cheaper than DRI, it is understood that the high carbon levels lower the mini-mill's electricity requirements for melting.

The iron-carbide process was developed in the US with the world-wide rights to the technology taken up by a small Western Australian company called Pact Resources NL. The company is currently endeavouring to form a consortium to build a pilot plant in Western Australia. It is rumoured that local interest has been lukewarm and the first plant will probably now be built in the United States in 1990-91. If successful, a 0.35 mtpa plant may be constructed in Australia in the early 1990's.

5.2.2 Direct smelting process

In the next few years, another route for iron-making, known as direct smelting (DS) is likely to emerge as a serious alternative to the traditional blast furnace. Its proponents claim that the DS process may even surpass the conventional direct reduction process (see Section 5.1.1) and so become the dominant means of making iron in the next century.

The key feature of DS is the continuous production of steel from iron ore via a two-stage operation - involving firstly preheating/pre-reducing the ore, and secondly smelting/reducing the charge to steel.

Several variations of the DS process are being investigated. These processes can be divided into two groups according to the type of energy required:

- combined coal/electricity processes which use gas generated from coal for reducing the ore and electricity to complete the smelting operation (includes Plasmasmelt, Inred, Elred and Combismelt processes)
- all coal processes where all the pre-reduction and smelting is done by the coal (includes the Krupp coal-oxygen-injection process (COIN) and the Korf process)

With respect to the combined coal/electricity route, most DS processes attempt to recover the waste heat to cogenerate electricity on-site. This improves the thermal efficiency and reduces the cost of external power purchases but greatly increases overall capital costs and can cause operating problems (in maintaining steady power generation/ consumption during start-up and under changing coal quality).

In the all-coal process the coal is gasified and the products used to reduce the ore and melt the resulting iron. The off-gases are then used to dry and pre-heat the incoming feed. Whilst this improves the thermal efficiency, tight control over the quality of the coal is required to ensure stable operation (otherwise, it may run out of "puff" or waste too much energy). Ideally, the coal should have a high fixed carbon and low ash content - so as to achieve sufficiently high temperatures to melt the iron and ensure complete reduction. In practice, the various processes can accommodate a wide range of coals and iron ore feeds.

As can be seen the main advantages of direct smelting are that (depending on the process) one can use:

- <u>a wide range of low quality coals</u> which are cheaper than coking coals
- <u>low cost iron ore</u>. There is no need to use lumpy ore or pelletized/sintered material. Instead low cost untreated fines or concentrate can be used

and that:

- <u>smaller scale plants can be built</u>. The minimum economic scale of operations is one-third that of a conventional integrated steel plant. A 0.2-0.3 mtpa DS facility matches steel requirements of many mini-mill operators and third world countries
- <u>there is no need use blended feeds</u>. The greater versatility of the process allows single grade iron ore and coals to be used. This greatly simplifies raw material purchases and reduces capital costs by eliminating the need to build large blending facilities
- <u>pollution levels are reduced</u> due to the elimination of coke ovens and sinter plant
- <u>energy requirements are modest</u>. By installing heat recovery systems many of the DS technologies are as energy efficient as conventional blast furnaces. Furthermore it is possible to "tune" the process such that surplus electricity is available for export

However there is some concern about the stability of operation and the quality of the steel produced (in those processes that use large quantities of low grade high-sulphur coal). Also, in those processes involving a high degree of pre-reduction the problem of fines agglomeration in the feed-shutes can occur (ie the fines "glue" together and block up the equipment).

The key features and likely energy requirements for six different DS processes are given in Table 5.1. Indicative operating and capital costs are summarised in Table 5.2.

Not included in these Tables is CRA's *HIsmelt* process. As indicated in Figure 5.6 *HIsmelt* is similar to the COIN process in that the pre-reduced ore is fed into a molten steel bath and heated via injection of oxygen and powdered coal. The key features of this process is that the intensity of the reduction process lowers capital costs. Also, as the iron ore is only pre-reduced to FeO rather than metallic iron - agglomeration problems are eliminated. Moreover, mixing the ore with limestone captures any sulphur present in the coal - thereby improving steel quality and reducing air pollution.

5.2.3 Thin strip casting

Existing continuous casting (CC) technology produces slabs 300mm thick. However, as most steel products are less than 2-10 mm thick the slab must go through several rolling stages. Consequently present CC hot rolling mills require up to three roughing and six finishing stands - and cost $US300-500 million to build. By comparison, if thinner slabs could be cast (say 30-50mm thick) several rolling steps could be eliminated. Not only would this save processing time and energy, but it would also require only three finishing stands in the hot strip mill, leading to massive savings in capital costs.

The reduced scale of operations will also allow mini mills to enter the strip market (a market central to the large integrated producers). This will result in a fundamental shake-out of the world steel industry.

Table 5.1: Energy requirements of various Direct Smelting Processes (per tonne of hot metal)

Process	Elred		Inred		Plasmasmelt		Coin		KR		Combismelt	
Energy												
Coal (kg)	680		620		200-0	5.2-0	440	12.3	1000	28.0	Reduction	26.0
Electricity (kWh)	617	19.1	370	7.3	1100	11.3	-		-			
Oxygen (NM3)	194		700		130		350	2.8	700	5.0	Smelting	9.2
Auxilaries (kWh)	136		100		-		-		-			
By-product Gas (NM3)			-		-		525	-4.4	2000	-17.6	Energy	
Coke	Power	-3.6	Electricity		50 Kg	1.4	-				Recovery	-16.3
Oil	Generation		Generated		0-140 Kg	0-5.8	-		-			
	Credit											
		-------		-------		-------		-------		-------		-------
Total		15.5 GJ		17.3 GJ		18.0-18.4 GJ		10.7 GJ		15.4 GJ		18.9 GJ
Coal type	Anthracite,		Cheap Gas,		Coal						Lignite. sub-bituminous	
	Bituminous Coal		Anthracite								coal, bituminous coal,	
											anthracite, coke.	
	or Lignite					88					Breeze	
Fixed Carbon %	81		56-51		76	88	- Lean Coal (1.0% S)				44	
Ash %	4		14		8.6	9	- Lignite Coal (0.3% S)		75		27	
Volatile Matter %	32-37		30-25		15.5	3	- 2-3% moisture		9.2		29	
							- 15		14.9		29	
Remarks	Sufficient electrical energy generation from off-gas to operate D.S. and arc furnace and supply 300 kWh/t of credit		Sufficient electric power generated from off-gas to operate electric arc furnace		Plasma Arc heater used to super-heat portion of process off-gas coal dust, and iron ore fines at slag-metal inter-face. Small amount of coke used in the shaft. This process is highly supply.		In the Coin and KR processes a surplus of co-rich gas (by-product gas) as generated and for gas export/sale. The necessary quantities of oxygen can be generated by internal energy utilisation.				Plant allows recovery of energy in the off-gas and from coal discharged from kiln.	

Note: Have assumed heating value of coal is 28.0 GJ/tonne

Source: Adapted from S. Jana, L.L. Teoh, Application of Direct Smelting Technology in Southeast Asia, SEAISI Quarterly, October 1985

Table 5.2: Estimated capital and operating costs for various Direct Smelting Processes (A$ per tonne of hot metal)

Process	Elred	Inred	Plasmasmelt	Coin	KR	Combismelt
Capacity (ktpa)	120 - 400	200 - 400	250 - 450	-	300	200
Ore feed	Fine ore	Fine iron ore, calcined pyrite and sawdust (1) dust containing Zn & Pb from gas cleaner	Fine iron ore	Pellet and 65 Fe lump ore	Pellet	Pellet 65 Fe lump ore
Hot metal composition (%)		Pyrite Magnetite				
Carbon content of hot metal		2.4 for magnetite 3.7 for pyrite		1.2 for lean coal 2.7 - 4.4 for lignite		0.1 low carbon Fe 2 high carbon Fe
Capital Cost (in US$ per tonne of hot metal)	Based on 400 ktpa $350	Based on 400 ktpa $240 - 300	Based on 250 ktpa $230		140 - 170	240 - 260
Operating Cost (US$ per tonne of hot metal)	$36	$26	$21		$29	-
Production Cost per tonne of hot metal	$150	$140 - 170	$140 - 160		$130 in USA $170 in Ruhr	-

(1) Steelworks dust from gas cleaner, can contain zinc and lead compounds.

Source: Adapted from S. Jana, L.L. Teoh, Application of Direct Smelting Technology in Southeast Asia, SEAISI Quarterly October, 1985

Much of the R&D work on thin slab casting (TSC) is being done by the major Japanese integrated producers. In December 1986, Sumitomo commissioned a 50 000 tpa TSC test facility at its Fashima works. The West German Company SMS is currently building the world's first commercial TSC plant (with a capacity of 0.8 mtpa) to come on-line in 1989 at Nucor's mini-mill in the US. Apparently Kawasaki Steel will be able to offer commercial TSC by 1990.

According to Sumitomo the operational cost savings, together with the elimination of several hot strip mill stands, will reduce hot rolling costs by 15- 40% and save about US$10 per tonne of finished steel.

Therefore it is highly likely that by the early to mid 1990s TSC will begin to make an impact on the world steel industry. At present most of the work has been concentrated on getting the slab thickness down to 30-50mm. However, fundamental research is underway to reduce this to 1-2mm. It is too early to predict whether their R&D effects will be successful but in any case it is unlikely that any full scale demonstration plants will be built before the mid 1990s.

Based on experience with similar cost saving technologies it will take several years before TSC technologies are widely adopted. Mini-mills are small and their pool of skilled operators/engineers is limited. Therefore, to be adopted TSC must be relatively simple to operate. Sumitomo privately acknowledge that, as was the case with CC, there will probably be a ten year incubation period followed by at least 20 years of commercialisation to achieve a high rate of adoption by mini-mills.

5.2.4 Steel refining processes

Traditionally, steelworks use a combination of high quality (but more expensive) raw materials and large (but wasteful) BOP slag volumes to produce low phosphorous and sulphur steels.

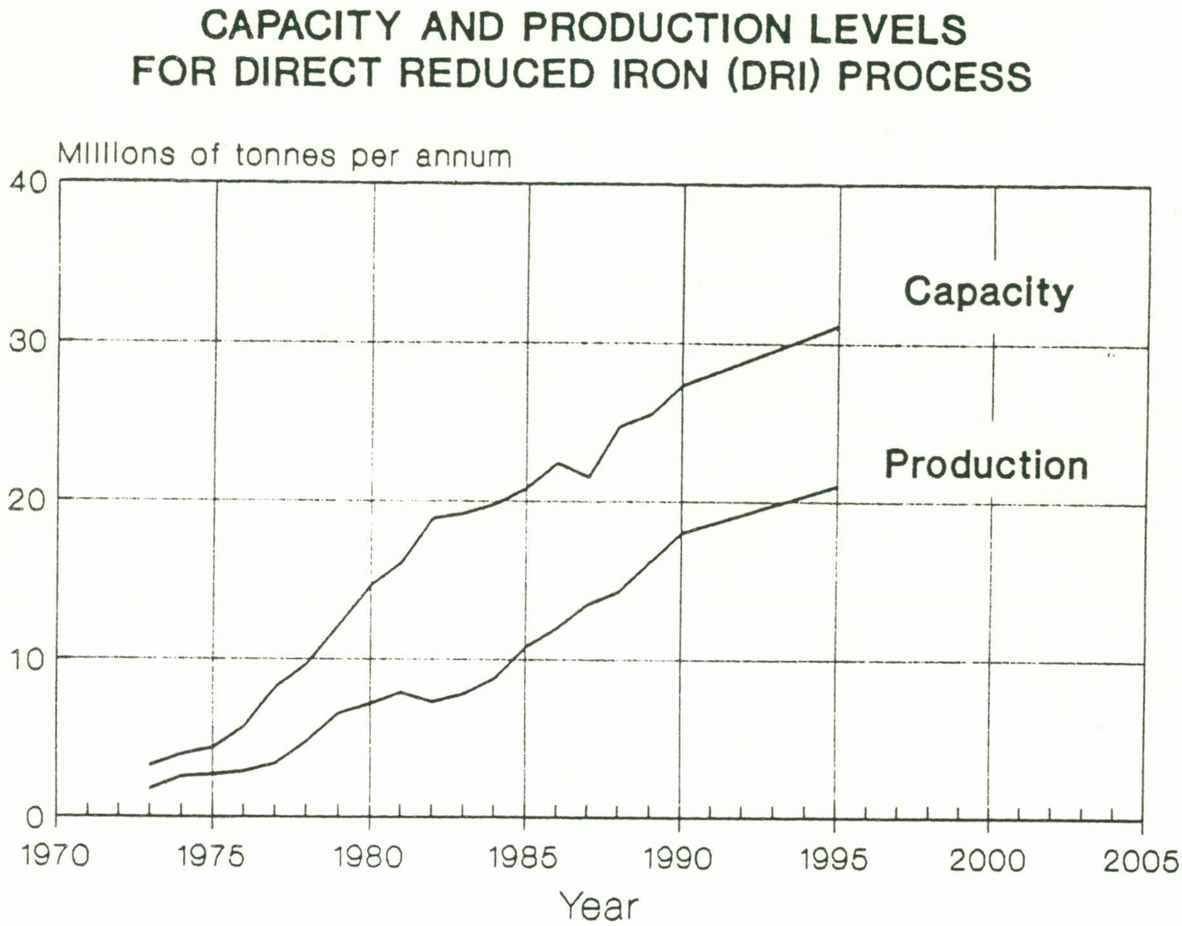
However, since the mid 1970s the Japanese have made large advances in producing high purity steels. Although the various methods differ, Sumitomo, Kawasaki Steel and NSC have all developed steel refining processes in which the hot pig iron (direct from the blast furnace) is treated in several steps with special fluxes to sequentially remove phosphorous, sulphur and other contaminants. The treated metal is then put into the BOS to remove nitrogen and carbon.

The common feature of these process is that by removing each element separately fewer operational compromises have to be made - with the end-result being a much "cleaner" steel. Also, because the impurities have already been removed the BOP generates minimal (or even zero) slag. This boosts the recovery of alloying elements and iron (which would have otherwise gone into the slag) and improves the operating conditions and product cleanliness.

Although additional processing and heating is required, the material savings can justify the extra operating and capital costs involved. The net effect is that a substantially better quality steel can be made for no extra cost.

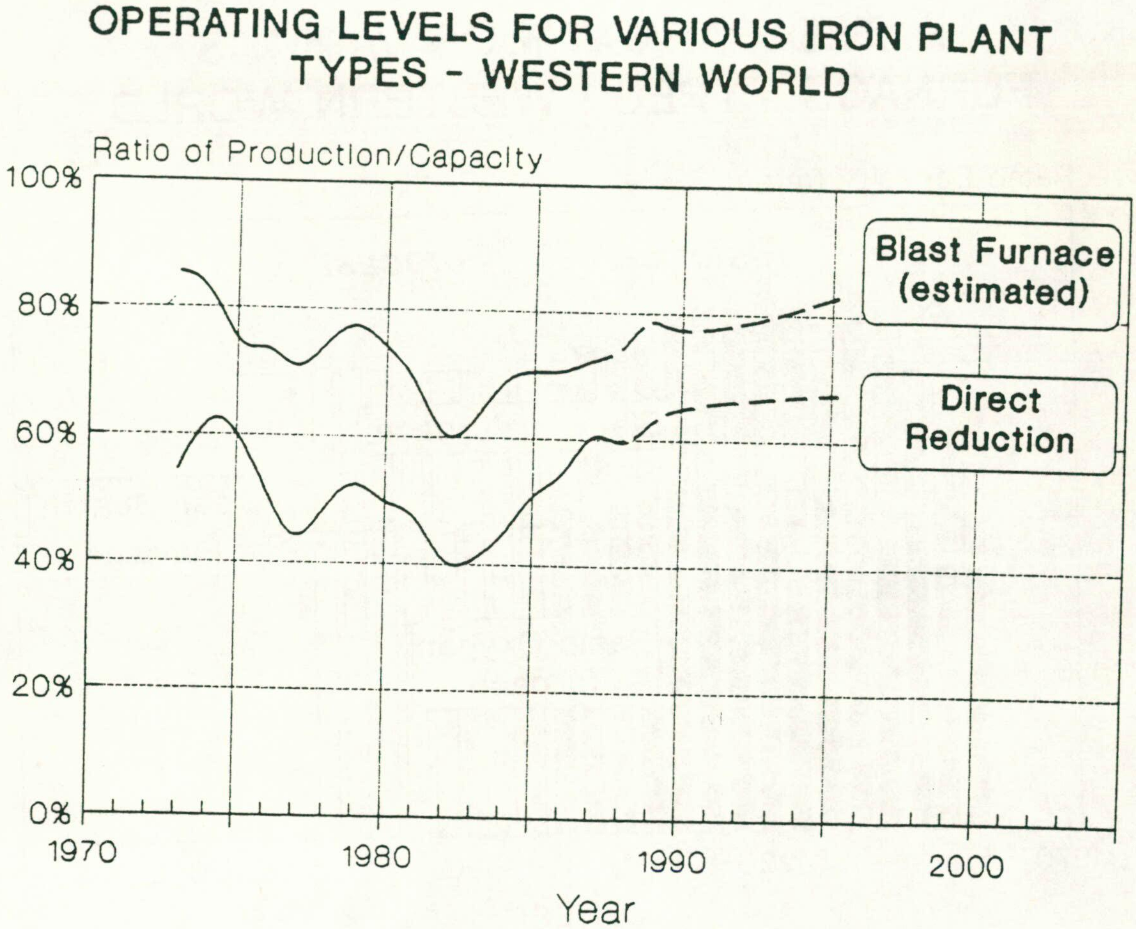
At present about 5% of the Japanese steel production is being treated with these refining technologies. This may double in the next five years as they push their strategy of producing higher value/higher quality steels.

Figure 5.1: Capacity and production levels for direct reduction in the western world (millions of tonnes of product)



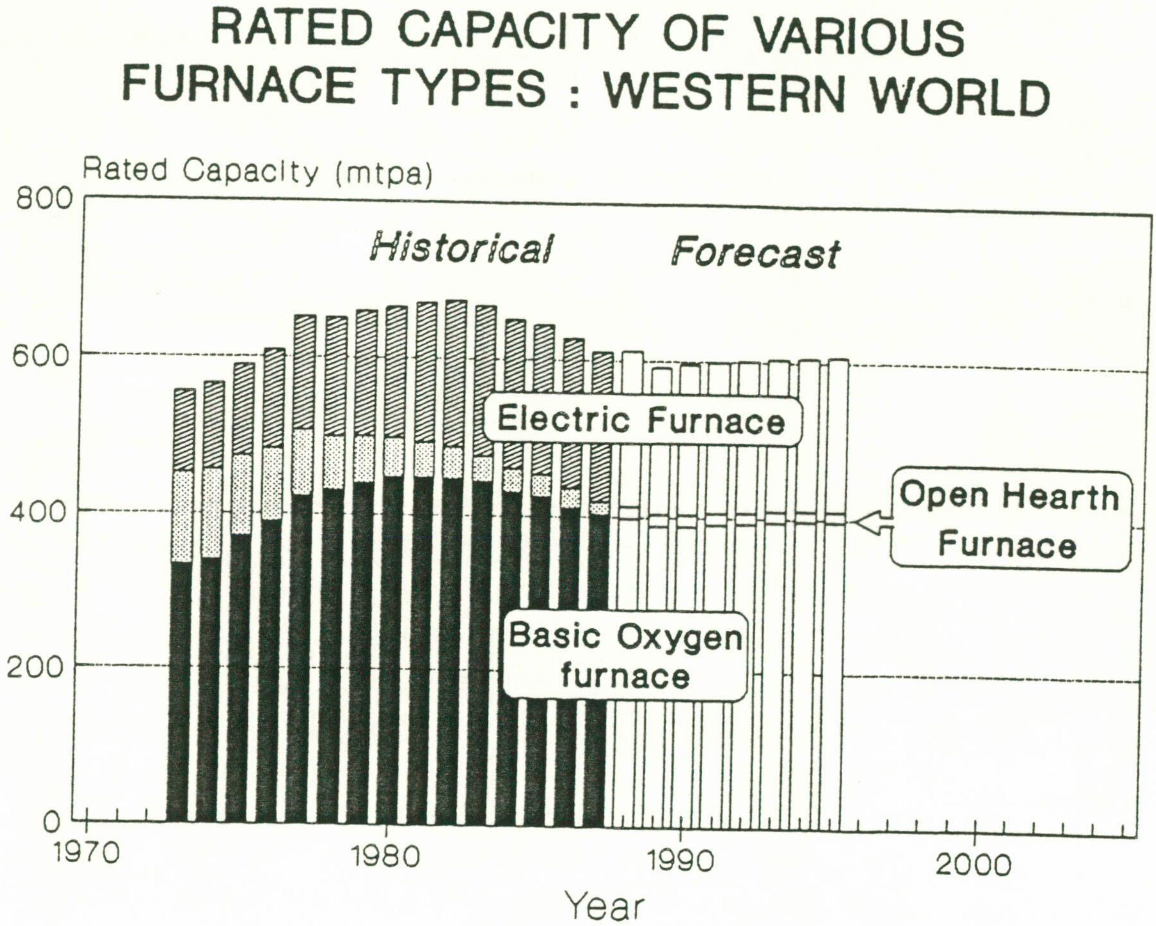
Source: PaineWebber

Figure 5.2: Operating levels for various iron-making technologies in the western world (ratio of output over nameplate capacity)



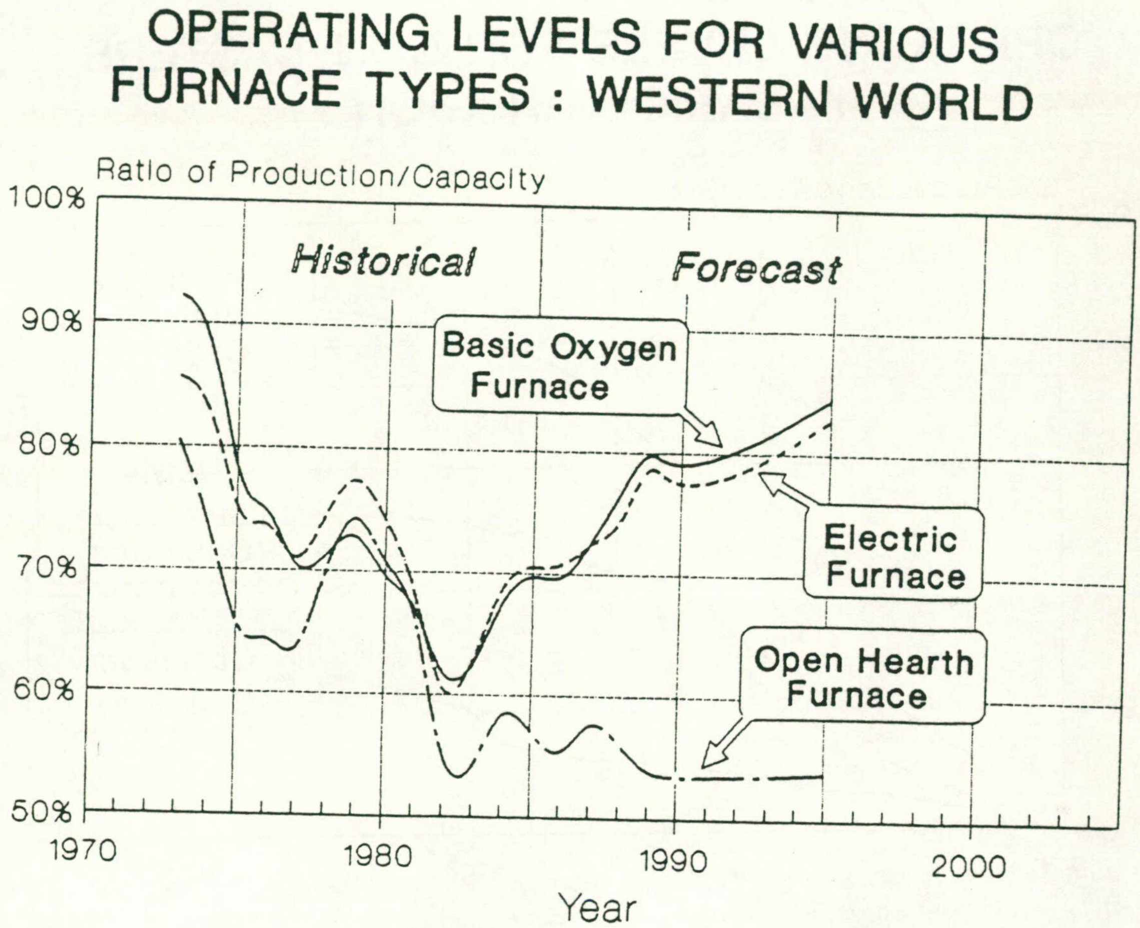
Source: PaineWebber

Figure 5.3: Steelmaking capacity installed in the western world (millions of tonnes of crude steel pa)



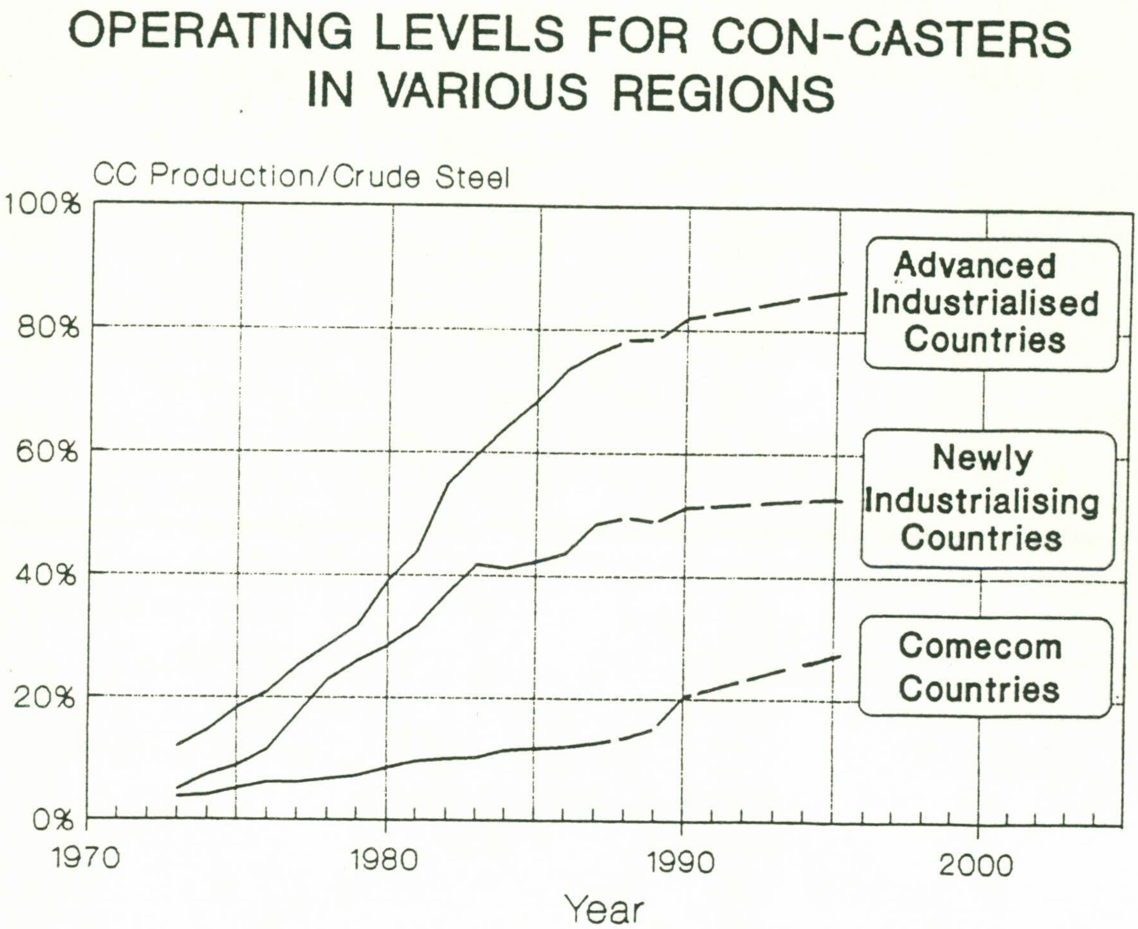
Source: PaineWebber

Figure 5.4: Operating levels for various steel making technologies in the western world (rate of output over name-plate capacity)



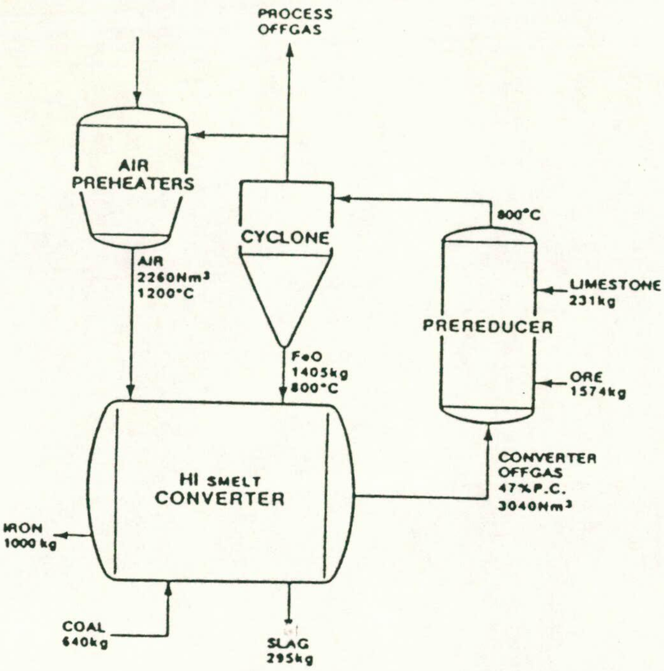
Source: PaineWebber

Figure 5.5: Fraction of crude steel continuously cast (rate of CC production over total crude steel production)



Source: PaineWebber

Figure 5.6: CRA's HIsmelt direct steelmaking process



A flowsheet for the HIsmelt process for the case with 47% Post-Combustion and Pre-reduction to FeO.

Source: CRA

6 FUTURE OPTIONS/DIRECTIONS FOR BHP

6.1 Issues affecting energy usage at BHP's NSW operations

In addition to the external factors outlined in the previous Chapters, the future direction and long term viability of the NSW iron and steel industry is also affected by the following local and internal factors:

- BHP's own investment objectives (ie its commitment to the steel industry and its internal priorities *vis* its other business activities)
- general growth in domestic steel demand and the opportunity/threat of exports/imports
- changes in (local and overseas) Government policies to freer trade versus industry protection.
- level of competition from local and overseas steel producers
- changes in labour and raw material costs
- threat of substitution from competing materials
- general changes in steel technology
- its current mix of plant & equipment.

With respect to the last point it is difficult to justify investment in a new technology if this means reversing previous decisions and/or scrapping existing, but still useful, equipment. Furthermore, the need to tie-in with the capabilities/limitations of existing equipment often dictates where new investments are made.

6.2 Strategic options for the NSW iron & steel industry

According to the Chief Executive Officer of BHP Steel International Group, Mr John Prescott, the company's mission is:

> *"to contribute to significant growth in wealth for BHP shareholders, through being a profitable, Australian-based business producing and supplying steel and steel related products and services to both Australian and international markets"*

and his vision of what the Steel Division will be in the future is:

> *"by world standards, a uniquely performing, broadly based Australian steel company operating internationally, with a high value-added orientation based on a very competitive cost structure, distinctive technologies and market performance heavily integrated to an end-user focus"*

These goals can be achieved in different ways. Possible strategies include:

- lowering costs by expanding operations. The associated *economies of scale* will lower costs but require heavy capital investment and (due to the limited growth opportunities in the domestic market) depends on the company's ability to sell the extra output overseas profitably. This will be difficult in the face of lower cost competition from South Korea and China. In order to compete with developing countries BHP would either need to adopt new steel-making technologies or build a conventional integrated steel plant with a capacity of at least 10 mtpa. Due to industrial relations and logistics issues such a plant would not be built in Newcastle or Port Kembla, with the preferred site probably being Western Australia

  Another means of increasing production would be via reactivating some of the company's mothballed plant. This includes the 0.75 mtpa blast furnace at Kwinana and the 0.5 mtpa No.2 blast furnace at Port Kembla. However, whilst the capital costs for reactivating these facilities is modest, they have high operating costs. Consequently they will be viable if steel prices remain high in the longer term.

- acquire steelmaking operations overseas. The problem of trade barriers can be overcome by building/acquiring iron & steelmaking operations overseas. Profitability can be enhanced through economies of scale via shared corporate functions, combined marketing arrangements and product rationalisation (with each steel plant specialising in a narrow range of goods). Also the opportunity exists for synergy with BHP's other Divisions supplying the overseas plant with coal, ferro-alloys and iron ore

- improve profit margins by rationalising product range. There is a large hidden cost (in the form of higher over-heads and inventory costs) associated with maintaining a wide range of steel products. In other words it is expensive for BHP to try and be *"all things to all customers"* and return on investment could be increased by discarding unprofitable/low volume business. This will involve closing down some sections of the steelworks and/or building dedicated steel plants (such as a mini-mill to produce reinforcing bar formerly made at Newcastle). Hover this goes against John Prescott's vision of developing a "broadly based" industry in Australia.

- go up-market. In other words compete on product quality rather than low cost. This reduces the company's vulnerability to cheap imports from developing countries but means that they will now be competing against established Japanese and European producers

- go downstream. Turn-over can be increased by going into downstream steel fabrication operations. While this creates a new class of captive users (which are not price sensitive or likely to buy imported steel) it is likely to antagonise existing steel distributors and customers. This can be avoided by BHP limiting itself to setting up operations overseas

BHP's present strategy for achieving these goals appears to be a combination of several of the above options.

In the short-term, the company will continue to focus on dominating the domestic market (rather than being export driven) and to improve profitability by reducing costs and improving product quality. This has been achieved through a massive refurbishment of its steelworks[1].

(1) In hindsight the company probably took on an overly ambitious construction program as it severely stretched its engineering resources. On an operational level, the overriding goal is to now get the new facilities running smoothly as quickly as possible.

BHP is now much more aware of its strengths and weaknesses and appears to be discarding its former unstated policy of being "all things to all people". This has led to product rationalisation and the recent abandonment of stainless steel production at Port Kembla, with the material now being imported. Other low tonnage/low profit margin products are likely to follow.

With respect to overseas competition BHP has publicly stated that it intends to go up-market producing higher quality/higher value goods. Implicit within this is that the company will not significantly expand steelmaking capacity but rather use existing facilities to make speciality goods which command higher prices and bigger profit margins. In do doing the company will move away/abandon its lower value/general purpose steel markets. This approach of producing the same amount of steel but selling it at a higher price/profit margins helps achieve the corporate objective of significantly increasing earnings. However, due to BHP's overwhelming dominance of the Australian market, there is a limit to how much higher quality steels can be sold locally. Therefore BHP will ultimately need to look more closely at the export market.

Regarding export markets BHP is yet to fully live up to its name (that of BHP Steel Group) with only 10-15% of its output being sold overseas. However this will change in the future as the company recognizes that it has now outgrown the domestic market. In the short term the main strategy has been to set-up roll-forming and fabrication facilities around the Pacific rim. These plants import cold-rolled steel coils from BHP and sell the product (namely roofing material and the like) locally thereby getting around some of the trade barrier problems.

With respect to the export market, BHP has stated that it will build upon its world-class technology in the zincalum and colorbond coated products areas. This will be achieved through the export of technology as well finished steel products.

It is understood that BHP intends to install a slab caster at its Whyalla steelworks (sometime in 1991 ?) which would increase the effective output of the plant by 10-15% or 0.1-0.2 mtpa. The extra capacity will then allow the company to increase finished steel production from its Westernport plant - principally in the form of high value-added coated steel on the export market.

A similar strategy is being pursued in the rod & bar markets, with the start up of the Sydney mini-mill in 1991-92 enabling Newcastle steelworks to focus more on producing and exporting higher quality/higher-value products.

According to BHP, these two developments will enable the company to increase steel exports from 1.2 mtpa at present to 1.5 mtpa by 1991.

The opportunity also exists to enhance international sales through joint-ventures to build merchant mills, galvanising lines and large rolling mills in overseas. Apparently BHP is considering buying an existing steelmaker in the US - with the aim of supplying steel billets for re-rolling as well as using the existing marketing infrastructure for promoting BHP steel. other options include part equity in a proposed new integrated steelworks in Thailand and the People's Republic of China.

In response to Australian competitors, the company has put out clear signals that it will defend its core markets vigourously. To freeze-out the entry of new producers BHP constructed a merchant (rolling) mill in Brisbane and intends to build a mini-mill in Sydney. One consequence of this is that Newcastle steelworks may reduce the quantity of reinforcing bar made. MMA speculates that a similar tactic will be used when thin-strip casting technology becomes available. This technology will allow Smorgon or any other mini-mill operator to enter, for the first time, the profitable flat product area. BHP's response will probably be to install a unit itself, in an attempt to pre-empt competitors.

Another area for domestic competition is the possible introduction of direct reduction/direct smelting technologies by local companies such as CRA and Pact Resources. Plans have been announced to build facilities in Western Australia, Queensland and Victoria.

It is understood that, due to funding problems, Pact Resources has decided to build its first semi-commercial iron-carbide plant in the United States. Even if the plant is successful, MMA believes that similar plants will not be operational in Australia before the mid-1990s at the earliest. With respect to CRA, it is understood that a decision is to be made by mid-1989 on whether (and where) to build its first prototype HiSmelt plant. The two choices are Victoria and Western Australia, with MMA speculating that past obligations by CRA to the Western Australian Government (to build iron ore processing facilities if it is shown to economic) will mean the plant will go to the West. If approved, the plant will be operational by 1993 and have a capacity of around 0.3-1.0 mtpa. At this stage MMA rates the probability of the CRA plant going ahead at 60% by 1993 and 80% by 1998.

Whilst the primary market for these new plants will be overseas some of the material will invariably be used locally and so affect BHP's operating levels. MMA speculates that BHP will be forced to live with this but that it will vigourously fight any large-scale move to build down-stream processing facilities (such as rolling mills etc).

To match the modest growth in the Australian market (estimated to be 1.2-1.8 mtpa of crude steel over the next 15 years) BHP will carry-out incremental expansions of capacity at its various steelworks around Australia. Obvious expansion steps include installing a continuous caster at Whyalla (the resulting improvement in product yield will effectively increase marketable product output by 10-15% or 0.10.2 mtpa) and re-activating the No.2 blast furnace at Port Kembla (with a capacity of 0.5 mtpa).

MMP believes that the need to improve profitability will effectively drive the Steel Division's strategy over the next decade. As discussed before, in recent years the Division has been achieving a return on assets of less than 4%. Under the *Steel Industry Plan* $1.6 billion was spent on rejuvenating the steelworks and improving their competitiveness . The corporate objective is now to see a good return on this investment and strong cashflows - otherwise the company runs the risk of increasing shareholder discontent and triggering-off another round of take-over threats. Consequently it will be difficult for the Steel Division to ask for more money to finance any further large scale development programs. In other words, it is unlikely that any major new facilities will be installed at the Port Kembla or Newcastle steelworks over the next decade.

Corporate strategy is also influenced by the company's conservative corporate culture. Senior management see little sense in developing new ventures in capricious fields or in unpredictable markets - instead they prefer to *"stick to the knitting"*. Of concern is the fact that in most countries barriers exist to protect local steelmakers against imports, and during a recession selling into these markets can be very difficult/unprofitable. On this basis it is unlikely that the company will increase export sales above 20-25% of total production - with the exception of possible captive customers.

6.3 BASE-CASE SCENARIO

For the base case scenario it is assumed that over the next 15 years:

- There will no major recessions in Australia's or the World's economy

- GDP will grow on average by 2.5% pa in Australia

- Domestic steel demand will grow by 2.0% pa (or 0.5 percent slower than GDP) and will reach 6.9 mtpa of crude steel by 2003. This is a rise of 1.8 mtpa over current levels

- The main growth market in Australia will be in higher value added products such as speciality engineering steels (made in Newcastle) and coated cold rolled products (which use hot-rolled steel feed from Port Kembla)

- After adjusting for differences in inflation and exchange rates, Australia's international competitiveness will remain much the same as that at present[1]

- BHP will continue to be cost competitive against imports and that the Port Kembla and Newcastle steelworks will operate at near full capacity (with excess production being sold on the export market)

- Imports will continue to run at 0.5-0.7 mtpa in the short term and maintain their market share of 11-15% in the longer term

- BHP continues to build captive cold-rolling/steel fabrication facilities around the Pacific rim which are supplied with steel from Port Kembla and Coated Products Division

- Including captive customers overseas, BHP exports at most 25% of its steel production from its NSW steelworks.

- The proposed Sydney mini-mill goes ahead in 1991. This results in the closure of reinforcing bar operations at Newcastle

- Smorgon's mini-mill in Victoria installs a thin-strip caster in 1995 to make hot rolled flat products. This reduces BHP's domestic sales and forces it to sell the extra tonnage on the export market (at low prices)

- A 0.4 mtpa direct reduction or direct smelting plant is built in Western Australia or Queensland in the mid-1990's. Initially all the output is exported

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(1) At the time of writing and running the model, the Australian dollar was worth US$0.70-0.75 and the Trade Weighted Index was 60-62.

- Following the completion of the Steel Industry Plan it is likely no new major plant & equipment will be installed at Port Kembla and Newcastle steelworks before 1995. In later years it is likely that a new coke oven will be built at Newcastle and a thin-strip caster installed at Port Kembla

- Incremental improvements in steelmaking technology result in a steady 1% pa reduction in energy consumption per unit of crude steel made

- No significant differential increase in energy prices occurs

The effect of other scenarios on the NSW's energy requirements are discussed in Sections 8.3 and 8.4.

7 IMPACT OF NEW TECHNOLOGIES ON THE NSW IRON & STEEL INDUSTRY

7.1 INCREMENTAL PROCESS IMPROVEMENTS

In addition to adopting new breakthrough processing routes, the iron & steel industry can also improve its energy efficiency by retro-fitting a range of "off-the-shelf" technologies to its existing process equipment. The merits and applicability of these incremental technologies to BHP's NSW steelworks are discussed below.

7.1.1 Blast furnace top gas recovery turbine

A common feature of all blast furnaces is the need to blow large quantities of air through the bottom of the furnace. The fan uses large amounts of steam or electricity. To improve operations most units maintain a high top pressure with the waste gases being bled-off through a large valve on the top of the furnace. The resulting pressure drop dissipates much of the energy used to "blow" the furnace.

In recent years several overseas companies have developed commercial gas turbine systems which recover this energy in the form of electricity. A 10 MW top gas turbine has been installed on the No.5 blast furnace at Port Kembla. The opportunity exists to install similar units on the No.4 furnace at Port Kembla and on Nos 3 & 4 furnaces at Newcastle. The likely outputs is estimated to be 8, 3 and 4 MW respectively(1).

According to the IISI a top gas turbine can recover 30-40 kWh per tonne of iron made. On this basis the opportunity exists for Port Kembla and Newcastle to each reduce their electricity purchases by around 50 GWh pa. It is understood that such units cost around US$500 to $700 per kW to install(2) and (Australian) 1.0¢/kWh to run.

(1) The Port Kembla No.4 blast furnace figure includes the recently announced upgrade to 1.5 mtpa.

(2) With the higher unit costs associated with the smaller furnaces.

Assuming an exchange rate of A$1.00 = US$0.75 and an after-tax ROI hurdle rate of 20%, this is equal to a full cost of around 4-6¢/kWh. In other words BHP is likely to install a top gas turbine at No.4 blast furnace at Port Kembla when the cost of purchased electricity exceeds 4¢/kWh in constant June 1988 dollars. Due to the smaller blast furnaces the corresponding break-even price at Newcastle will be higher and is estimated to be around 6¢/kWh.

These figures match the views of BHP's steelworks personnel, who stated that under current power costs it would not be possible economically to justify the 10 MW turbine (installed at a time when electricity prices were expected to escalate rapidly) on No.5 blast furnace at Port Kembla.

It should be noted that, for operational reasons, these turbines can only be installed when the blast furnace is down for major repairs. This normally occurs only once every 10-14 years - with Nos.3 furnace at Newcastle and No.4 furnace at Port Kembla currently undergoing a reline, and so will not be redone until the turn of the century. No.4 furnace at Newcastle is due for relining around 1996.

Another factor inhibiting the installation of a top-gas turbine is that these units come in standard "frame sizes". Consequently, the total cost of installing a turbine on the No.4 furnace will be the same as that for the (larger) No.5 blast furnace. The lower power output means that the facility is less economic. However, this could be overcome if the blast furnace is upgraded at the time of its next reline. Such an option is currently under consideration.

7.1.2 Coal & gas injection into the blast furnace

In the 1960's a common iron-making practice was to inject fuel oil into the blast furnace. This substantially increased furnace productivity and reduced aggregate energy consumption (by backing out coke). However with the twin oil shocks in 1973 and 1979 this practice became uneconomic. Since then much work was been carried out on the feasibility of using lower cost natural gas and pulverised coal.

Even though oil prices have fallen in recent years, BHP has not considered changing back to oil injection.

The effect of various injectants on blast furnace performance are summarised in Table 7.1. As can be seen using injectants to back-out coke increases the blast furnace's overall energy consumption level. However, the reduced need for coke and sinter leads to a net energy saving for the overall steelworks.

Table 7.1: Estimated effect of various injectants on the operation of a modern blast furnace (per tonne of hot metal)

Fuel used	Injection rate (kg)	Coke saved (kg)	Increase in productivity (%)	Change in net energy used[1]: blast furnace (GJ)	Change in net energy used[1]: elsewhere (GJ)
Heavy fuel oil	65	83	3.1	0.15	-0.40
Crude coal tar	82	98	3.9	0.18	-0.52
Pulverised coal	111	115	3.9	0.10	-0.54
Natural gas	30[2]	45	1.6	0.17	-0.27
Coke oven gas	38[3]	44	0.9	0.05	-0.20

(1) Although injectants increase the amount of energy used in the blast furnace, it leads to energy savings in the coke ovens and sinter plant

(2) Corresponds to 42 m^3 of natural gas per tonne of hot metal

(3) Corresponds to 76 m^3 of coke oven gas per tonne of hot metal

Sources: IISI and BHP

The decision on which injectant to use (and how much) is dictated not only by the relative cost of the various alternate fuels and the energy savings involved, but also the level of incentive to produce additional tonnes of hot metal.

Based on the cost data supplied in Table 7.2 it is estimated that natural gas injection is currently the most cost effective option for BHP - with a net saving of \$4.00/tonne of hot metal versus \$3.00-3.60/tonne for the other fuels in June 1988 dollars (Table 7.3).

The most serious contender to natural gas is pulverised thermal coal. Although coal is relatively cheap to buy it is expensive to grind and requires expensive processing equipment (estimated to be \$30 million per site). Assuming a minimum pay-back period of 5 years, and a coal price of (say) A\$40/tonne, coal injection is only viable if BHP values the resulting extra hot metal capacity at more than \$80/tonne (Figure 7.1).

In recent years BHP's value for extra hot metal capacity has gone from zero (in 1982-85 when existing capacity was being closed down) to at least \$80-100/tonne at present.[1] On this basis it is now economically feasible to consider installing such equipment.

One key factor influencing the possible switch to coal is the future price of natural gas. As indicated in Figure 7.2, as long as gas prices remain below \$2.00/GJ (in constant June 1988 dollars) it is not worthwhile changing over.

It should be emphasised that the above break-even prices are based on the assumptions outlined in Tables 7.1 to 7.3. Indeed, coal injection may become viable if the current boom in steel demand/steel prices is sustained and/or if a shortage in coking capacity occurs (pushing up the opportunity cost of coke) and/or if natural gas prices rise.

The maximum level of natural gas injection is limited to around 100 m^3 per tonne of hot metal by the strong exothermic reactions that occur which increase the flame temperature and upset steady operations. BHP currently operates at 92 m^3 per tonne of hot metal at Newcastle and Port Kembla.

(1) Implicit in that BHP is seriously considering spending \$165 million to upgrade No.4 blast furnace at Port Kembla by 0.40 mtpa. Assuming a return of 20-25%, the annualised cost of the extra capacity will be \$80-100/t.

Table 7.2: Estimated fuel and other costs associated with blast furnace injection of oil, coal and gas (in June 1988 dollars per tonne of fuel)

	Fuel Cost (A$/t)	Operating cost (A$/t)	Capital cost (A$/annl tonne)
Heavy fuel oil	160 (1)	0.5	16
Crude coal tar	160 est (1)	0.5 est	16 est
Pulverised coal	40	25	350
Natural gas	110 (2)	0.4	12
Coke oven gas	75 (3)	0.4 est	12 est

(1) Corresponds to US$15/barrel for crude oil

(2) Equal to A$2.00/GJ

(3) Equal to A$1.80/GJ

Sources: MMP analysis of published BHP data

Table 7.3: Estimated cost savings associated with using various fuels injected into the blast furnace (dollars per tonne of hot metal in June 1988 prices)

	cost saving (A$/thm)	pay-back period
Heavy fuel oil	$3.00	5 months
Crude coal tar	$3.00	6 months
Pulverized coal	$3.50	3.7 years
Natural gas	$4.00	1 month
Coke oven gas	$3.60	2 months

note: Have assumed coke costs A$120/t, saving energy elsewhere in the plant is worth $1.50/GJ and that each tonne of extra iron-making capacity is worth A$100/tonne of hot metal

Source: MMP analysis based on Tables 7.1 & 7.2

7.1.3 Methane gas for process heating

The opportunity exists for BHP to supplement its steelwork's energy requirements with methane gas extracted from local coal seams. The company already extracts methane from the Appin coal mine near Wollongong with the gas being used to generate 15 MW of electricity for sale to the local council. BHP Engineering is trying to promote the concept both here and overseas.

This gas is similar in composition and heating value to that of natural gas and so could be incorporated into steelworks gas distribution system - thereby backing out natural gas. Apparently BHP has looked at piping methane from its underground collieries in the Newcastle area to the steelworks. Calculations show that, based on the cost data outlined in Tables 7.1-7.3, if the delivered price is less than $1.50/GJ in June 1988 dollars, drainage gas could be a viable alternative to natural gas as an injectant. It is understood that the project is not economic at present.

7.1.4 Modifications to the blast furnace

Apart from a possible switch-over in the type of fuel injected into the blast furnace no other major changes are likely to occur during the study period. Nevertheless modest improvements in thermal efficiency of 2-5% may be achieved over the next 15 years as BHP adopts tighter control over the raw material inputs and processing conditions.

Another possible source of energy savings is the sensible heat of the off-gas and slag, which may be captured. At present the gas is cooled before being used elsewhere in the plant. Approximately 10-15% of the total energy needs of the blast furnace are wasted in this manner. This is equal to 1-2 GJ per tonne of hot metal produced.

In high energy cost countries, such as Japan, expensive heat recovery units have been installed to raise steam from these sources. However, due to inherent difficulties in slag handling and the relatively low temperature of off-gas energy recovery, efficiencies are low. It is understood that these units are not economically viable in New South Wales.

7.1.5 Dry coke quenching

Coke is manufactured by heating coal over several hours to over 1000°C, so as to drive-off any volatiles. The current practice at Newcastle and Port Kembla is to quench the red-hot material in water. However, in Japan processes have recently been developed to capture this energy. The main process considered is *Dry Coke Quenching* (DCQ) in which the coke is quenched with an inert atmosphere inside a sealed chamber (see Figure 7.4). The heat is then recovered as steam.

According to the IISI it is possible to recover 400-500 kg of steam per tonne of dry coke, which is sufficient to generate 80-100 kWh of electricity. This is equal to an energy saving of 0.4-0.6 GJ per tonne of crude steel made.

In addition to saving energy, DCQ also produces a better quality coke (due to the slower/more uniform cooling rate) resulting in improved coke strength and less carry-over of coke breeze - thereby enhancing the operation and thermal efficiency of the blast furnace. Therefore the steelmaker can elect to improve blast furnace operations and/or use a cheaper coking coal.

Another important advantage of the DCQ process is that it eliminates a major source of pollution from the coke ovens.

On the debit side the DCQ process is expensive to install, with capital costs of the order of US$100-170 m in June 1988 dollars for a 4 mtpa plant. This corresponds to 25-50 GJ per US$1000 invested. Therefore on an energy basis BHP can economically only justify installing a DCQ if the energy recovered is worth between US$4 and $8/GJ [(1)]. In practice the break-even price is less than this due to the associated benefits of improved coke quality and lower environmental pollution. Nevertheless it is clear that, unless capital costs come down and/or pollution laws get stricter, DCQ is not a viable option for NSW.

7.1.6 Programmed heating for coke ovens

Significant improvements in coke oven efficiency can be achieved by mote closely controlling the heating rate for coke. According to the IISI the use of computer controls can lower specific fuel consumption by up to 10% . It is understood that the recently commissioned No.7A coke battery at Port Kembla uses such control equipment. The opportunity exists to upgrade the coke ovens at Newcastle when they come due for a major refurbishment in mid to late 1990's.

7.1.7 Modifications to the BOS

The steelmaking process is very energy intensive. The off-gases leaving the BOS are extremely hot (at +1450°C) and contain a high level of combustible gases (mainly CO). The BOS also generates significant quantities of red-hot slag. In recent years, several overseas steelmakers have installed equipment to recover this energy. At present BHP simply flares the gas and dumps the slag.

(1) Based on a simple pay-back period of 5 years. MMA estimates that the avoided cost of fuel in NSW's steelworks is of the order of A$1.5-2/GJ as this corresponds to the cost of using thermal coal to raise steam.

A wide range of commercial recovery systems are available. these include cooling and cleaning the BOS gas to produce a low-grade fuel for process heating and/or raising steam. For comparison, BOS gas has a heating value of around 9 MJ/m^3 - which is less than half that of coke oven gas and a quarter of natural gas. More sophisticated systems include a heat exchanger and water cooled shroud over the BOS vessel to capture the sensible heat of the gas.

One major problem with these recovery systems is that the BOS operates on a short cycle resulting in erratic gas flows. Consequently a large gas holder has to be built.

Apparently an orthodox gas recovery system saves 0.72 GJ per tonne of crude steel produced. Installing sensible-heat recovery equipment raises this figure by an extra 0.20 GJ/tcs. According to the IISI a basic gas recovery system costs around US$14-16 per annual tonne of crude steel in June 1988 dollars, with the heat exchanger costing an extra US$2.40-4.00/tcs. Assuming a simple pay-back period of 5 years, it is only worthwhile BHP installing such equipment if the value of the energy recovered exceeds US$3.5-4/GJ. At Port Kembla and Newcastle it is estimated that by-product energy is currently worth only A$1.5-2/GJ. Consequently, unless its fuel costs rise dramatically, it is not economic for BHP to install gas or heat recovery equipment on its BOS's.

With respect to recovering the sensible heat of the BOS slag systems have been built where the material is blown through a hooded boiler to raise steam. It is reported that up to 160 kg (or 0.48 GJ) of steam can be raised per tonne of slag. although no information is available on their cost effectiveness it is understood that they are not economically viable in NSW.

7.1.8 Modifications to down-stream processing operations

Modest energy savings are possible through better process control during rolling and other down-stream operations. According to engineering personnel at Port Kembla, wider use of computer-assisted controls can both enhance product quality and reduce reject rates - thereby improving product yields. The resulting material savings mean that less crude steel needs to be made per tonne of marketable product. BHP estimates that miscellaneous modifications to down-stream processing operations will reduce energy consumption by 1% pa over the forecast period.

7.2 PROCESS BREAKTHROUGHS

As discussed in Chapter 6 it is unlikely that any major new plant and equipment will be installed at Port Kembla or Newcastle over the next few years. Instead the prime objective is to get the existing equipment working smoothly so as to generate strong profits and cashflows to repay the $1.6 billion spent on capital works in the last five years.

In the longer term, possible new iron & steelmaking facilities in NSW include:

7.2.1 Mini-mill at Rooty Hill

Plans are well advanced to build a 0.25 mtpa mini-mill at Rooty Hill in the western suburbs of Sydney for making reinforcing bar for the construction industry. The plant will cost A$190 m and employ 240 people. On this basis, labour productivity will be over 1000 tpa per employee - making it one of the most efficient plants in the world and twice as productive as existing operations at Port Kembla or Newcastle.

The objective for building the plant is to pre-empt other companies from setting up a similar facility in NSW. The attractions are obvious. Mini-mill technology is now the most cost-effective for producing commercial grade rod and bar products. Sydney is BHP's largest market for these grades. Finally, an adequate supply of steel scrap is available to feed the mill.

Although Council approval has not yet been given for the project, it is assumed that it will startup in late 1990. Annual steel production will be around 0.18 mtpa in 1991 rising to the design capacity of 0.25 mtpa in the following year.

According to information supplied by BHP, at full load the plant will consume 154 GWh of electricity and 265 TJ of natural gas per annum. In addition 51 TJ pa of added-carbon will be used for metallurgical reasons - namely to provide the right carbon content in the hot metal and to produce a "foaming" slag for good process control.

Peak electrical energy requirements will be of the order of 50 MW.

It is estimated that the mini-mill will only consume 3.5 GJ per tonne of steel. This consumption is significantly lower than that for the blast furnace/BOS route (which is around 24-28 GJ/t at normal condition) due to the fact that the former uses scrap steel rather than iron ore.

One consequence of this plant is that it will change the product mix made at Newcastle steelworks. BHP aims to replace the tonnes lost at Newcastle with higher value added speciality rod and bar products.

7.2.2 Thin-strip caster at Port Kembla

As discussed in Section 5.2.3 one major breakthrough technology likely to be commercialized in Australia within the next decade is thin-strip casting. This technology offers the potential for mini-mills to enter the profitable flat products markets - which are currently the exclusive preserve of the integrated producers.

Assuming that the technology is feasible the consequences could turn the world steel industry upside-down. With respect to the Australian market it could encourage increased competition from existing and new mini-mills. It will alter Port Kembla's ability to export flat products.

It is rumoured that Smorgon plans to install such a facility at its Victorian plant sometime in the early 1990's. MMA speculates that, as was the case with the Sydney mini-mill, BHP will install a thin-strip caster to discourage other companies setting up in Australia.

Such a plant would be installed in NSW or Victoria as these are the largest markets for hot rolled flat products. Building the plant will create surplus hot-rolling capacity at Port Kembla.

Given that the likely size of the facility will be 0.4-0.8 mtpa, the caster would best fit into the Westernport or Port Kembla operations, unless the Rooty Hill mini-mill is substantially upgraded.

Apart from changing where the steel is made (ie at Smorgon or BHP Westernport in Victoria or at Port Kembla or Rooty Hill in NSW), the overall impact on energy consumption will be fairly modest. The plant will have similar yield and energy consumption levels as existing continuous casters, with the only savings being associated with lower hot-rolling requirements (estimated at around 0.15 MW or 0.5 GJ of net energy per tonne).

7.2.3 Direct reduction/smelting at Newcastle

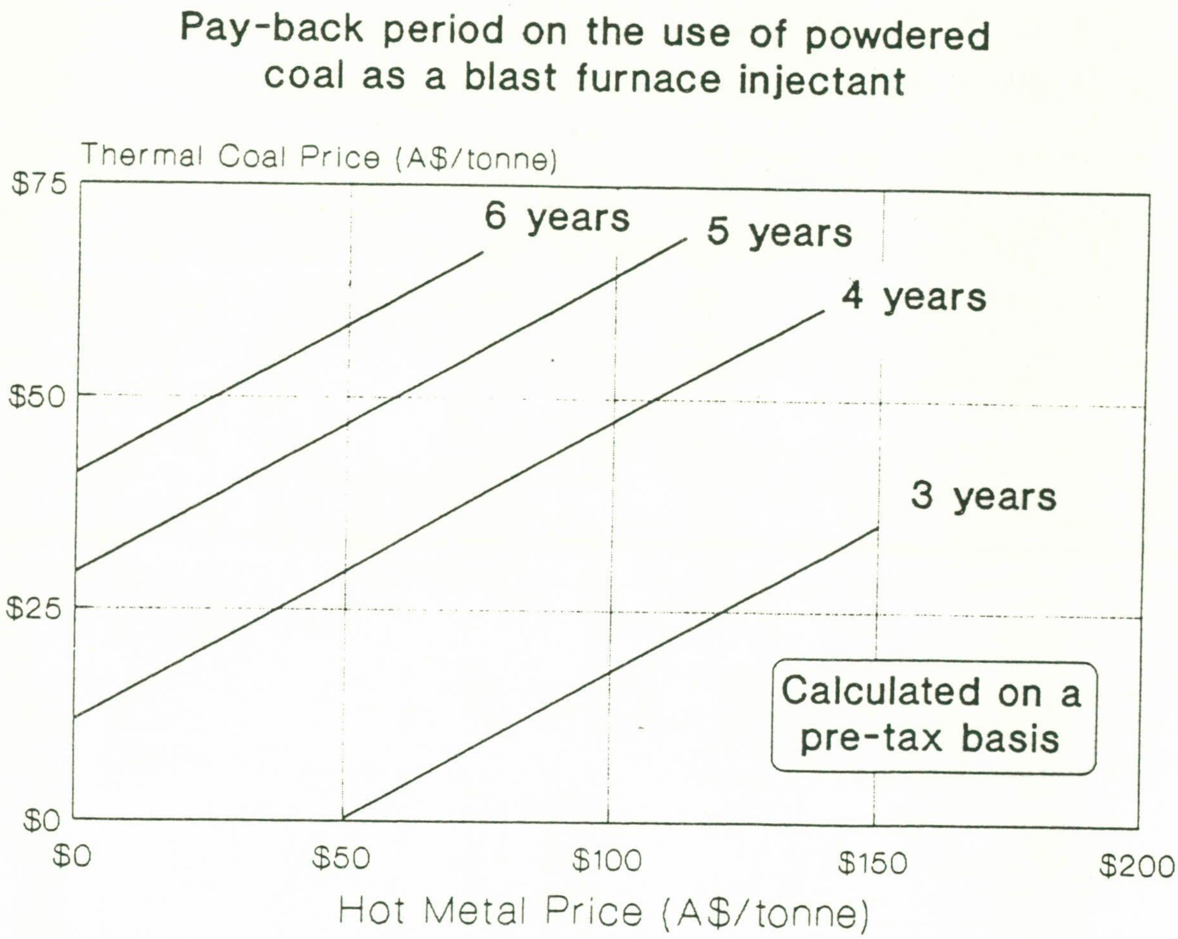
By the mid-1990's the existing coke ovens at Newcastle will need re-bricking/replacing. This is an expensive exercise and may cost over A$100 m in June 1988 dollars. Therefore, it raises the question of whether or not Newcastle steelworks should continue in its present form. The main options are to maintain the status-quo, close down the steelworks, or use an alternative route for making iron/steel. With respect to the latter, this would involve either building a direct reduction (DR) or a direct smelting (DS) plant to replace the existing coke ovens/blast furnace/BOF route

Due to energy cost considerations either process would probably be based on coal rather than natural gas.

With respect to the DR process, an obvious choice would be to build a coal-fired rotary kiln similar to that used by New Zealand Steel (see Section 3.2.1) with the partially reduced material being refined in Newcastle's existing BOS vessels (though some modification would be required). Otherwise new electric arc melting furnaces would need to be built.

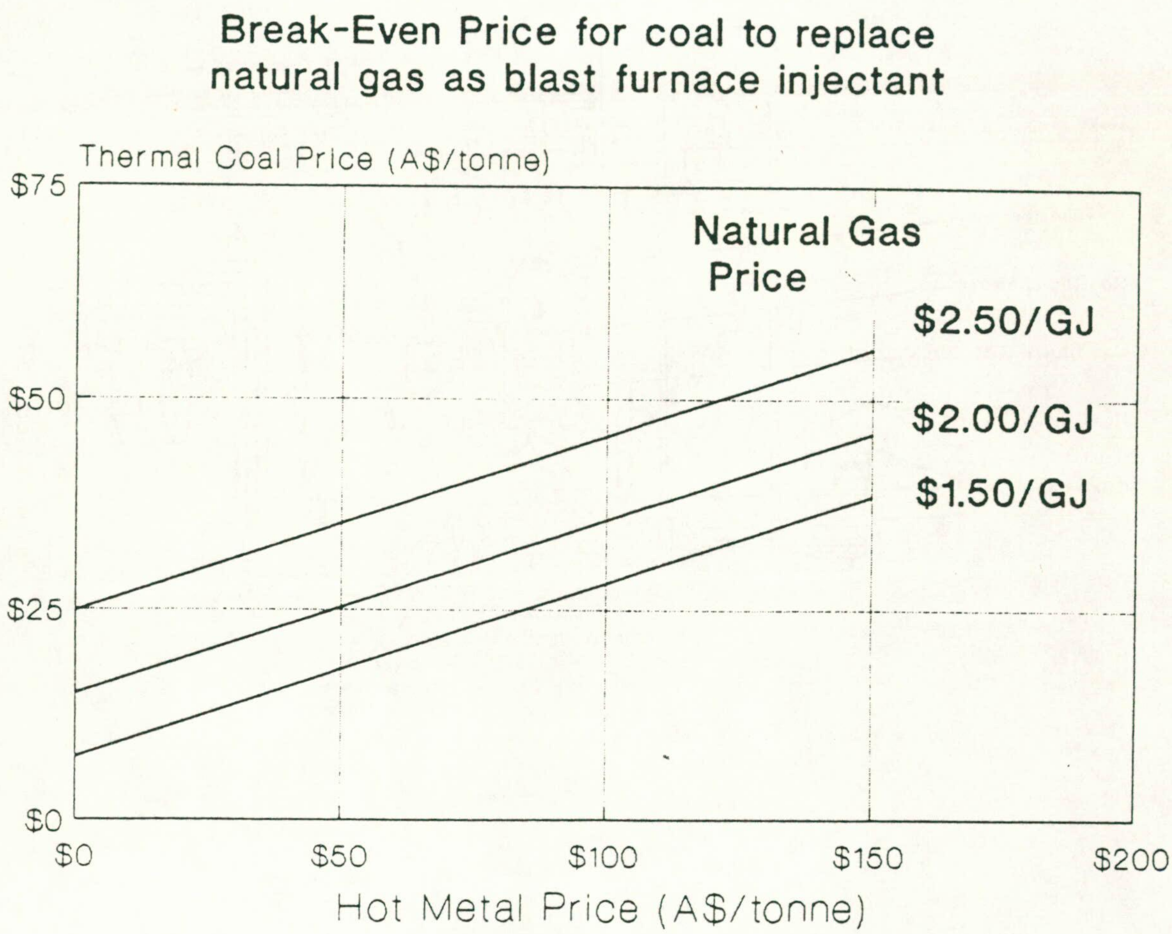
Alternatively one could use a coal-based DS technology like that developed by CRA or Krupp (see Section 5.2.2). In theory the existing BOS furnaces at Newcastle could be modified to carry out the smelting process. However, in practice it may be necessary to build new plant.

Figure 7.1: Estimated pay-back period for installing pulverized coal injection equipment at BHP's steelworks (years)



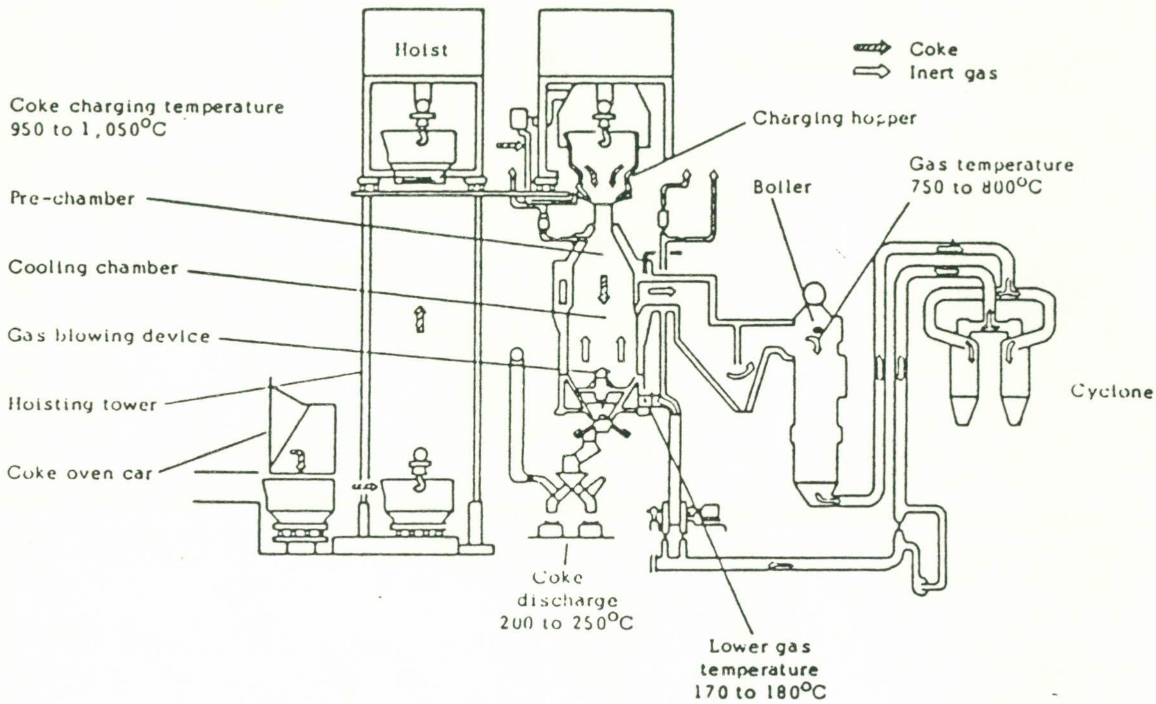
Source: MMP

Figure 7.2: Estimated break-even price for coal versus natural gas injection in BHP's blast furnace (A$/tonne and GJ in constant June 1988 dollars)



Source: MMP

Figure 7.3: Schematic of the dry coke quenching process



Source: IISI

8 FORECAST OF FUTURE ENERGY NEEDS

8.1 HISTORICAL TRENDS IN ENERGY CONSUMPTION

Total and average unit energy consumption of the Australian iron and steel industry over the last 15 years is shown in Figures 8.1 and 8.2 respectively. A detailed breakdown of the types of fuel used can be found in Tables A8.1 and A8.2 appended to this report.

The corresponding information on energy consumption at the Newcastle and Port Kembla steelworks over the last decade can be found in Tables A7 to A11. These figures are based on confidential information supplied by BHP, combined with estimates by MMP.

As can be seen in Figure 8.1, aggregate net energy usage[1] in the Australian basic iron and steel industry dropped by 40% over the last decade (from a peak of 288 PJ in 1975 to a low of 174 PJ in 1987). MMP estimates that NSW steelworks account for three-quarters of this figure - with the remainder coming from BHP's Whyalla and (up to 1981) Kwinana steelworks.

The large drop in energy demand over the last decade is due to the combined effect of a fall in steel production (of 20%) and an improvement in energy efficiency (of 25%) per unit of output.

The aggregate pattern was heavily influenced by reductions in production levels and energy intensity at BHP's Port Kembla and Newcastle steelworks. Aggregate energy usage in 1988 within the NSW iron and steel industry was 125 PJ versus 217 PJ in 1978. In 1988 the unit energy intensity at Port Kembla and Newcastle steelworks was 27.2 and 25.5 GJ/tonne of crude steel made. By comparison, overseas integrated steel producers currently achieve 18-23 GJ/tcs - with the Japanese leading the way in energy efficiency (see Table 8.1). Overseas producers, however, face higher energy prices than apply in Australia.

(1) Net of by-product fuels such as coke exports, cogenerated electricity and coal tars & BTX produced from the coke ovens.

Table 8.1: Comparison of energy usage levels in Australia and overseas (GJ/tonne of crude steel)

	1979	1980	1981	1982	1983	1987
Japan	18.8	19.0	18.7	-	-	17.5 e
USA	25.5	25.0	24.0	-	-	-
Canada	23.0	22.3	-	-	-	-
Sweden (Oxelosund)	-	-	-	25.5	-	-
UK (BSC)	27.1	28.0	26.9	23.7	23.3	21.0 e
France	24.2	23.8	-	-	-	-
South Africa	-	29.9	-	-	-	-
Taiwan (CSC)	28.3	26.8	26.3	26.0	25.9	23.2
IISI reference modern plant	-	-	-	-	19.3	-
Australia (1)	34.9	32.5	30.1	32.2	32.9	27.3

note: e = estimate

(1) Figure is slightly overstated because it includes coke exports from Port Kembla and (up to 1981) pig iron production from Kwinana

Source: MMP

As will be discussed in Section 8.4, the lower energy consumption levels overseas are a reflection of their higher energy costs and economies of scale.

According to Mr Brian Yare (of the Development & Operations group at Newcastle steelworks), another factor influencing the apparent higher energy consumption in NSW is that, in many cases, overseas statistics tend to be based on a *net* rather than *gross* energy basis. They exclude energy used in ancillary operations, such as coal washeries and on-site iron foundries etc.

8.1.1 Newcastle steelworks

At Newcastle, there has been a general reduction over the last decade in the amount of energy consumed per tonne of crude steel produced (Figure 8.2). The short-term increase in 1979-81 was due to cut back in the amount of (then expensive) fuel oil injected into the blast furnace which led to higher coke rates.

Natural gas was introduced as a blast furnace injectant in 1984 - thereby lowering coke requirements and improving steelworks unit energy consumption by (an estimated) 0.4-0.5 GJ/tcs. At present, Newcastle uses 90-100 m^3 of natural gas per tonne of iron made.

In addition to the increased usage of natural gas, energy efficiency was substantially improved between 1982-85 as older/less efficient plant and equipment was replaced. This included:

- No.1 blast furnace in May 1982
- 60 tonne BOP furnace in early 1982
- Nos.1 & 2 coke ovens in September/November 1982
- No.1 bloom and continuous mill in October 1982
- brick plant and brass foundry in October 1982
- No.3 blast furnace in November 1982 (the blast furnace was subsequently upgraded and recommissioned in 1985)
- No.2 blast furnace in 1985

At the same time new/more energy efficient equipment was installed. This included a jumbo bloom caster in 1987 as well as better process controls in various sections of the steelworks.

As discussed before, the huge cut-back in capacity in 1982 was primarily due to the world-wide recession which, at the time, reduced steel demand, lowered steel prices and increased competition from imports. Crude steel production at Newcastle fell from 2.15 mt in 1982 to only 1.52 mt in the following year. This, coupled with the closure of the older/less efficient plant, led to a 30% fall in net energy usage (from 61 PJ in 1982 to only 43 PJ in 1983).

Since then, profitability has been restored and the plant is now operating at 1.8-1.9 mtpa of crude steel - with net energy consumption running at around 24-28 GJ/tcs or 46 PJ per annum.

In terms of current operating practices it is significant to note that the Newcastle steelworks currently:

- has a shortage of coke such that when operating above 1.5-1.6 mtpa of crude steel, coke has to be imported

- has a shortage of fuel during the weekdays - necessitating the purchase of natural gas to supplement blast furnace and coke oven gas for heating. However, the situation is reversed at the weekend due to reduced rolling operations, resulting in a surplus of byproduct gas

- dilutes some of the natural gas with air to produce a "tempered" gas similar in heating value to coke ovens gas. This allows it to be used within the steelworks during weekdays without having to adjust the heating equipment or install extra plumbing.

- uses surplus coke ovens gas to raise steam. The excess coke ovens gas produced during the weekends is burnt in the boilers to raise steam (and so make electricity), thereby backing out steaming coal consumption.

- burns thermal coal to raise steam. To maintain a high operating level for their steam boilers Newcastle typically burns 0.2-0.3 mtpa of middlings (from the coking coal washery) and unwashed thermal coal.

According to confidential information supplied by BHP, the steelworks currently consume around 6-7 PJ per annum of natural gas. Approximately 22% of the gas is tempered and used for process heating within the plant. A further 2-3% is used as fuel in the casting and rolling operations - with the remaining 75% used as an injectant in No.s 3 and 4 blast furnaces.

With respect to fuel oil consumption, the steelworks formerly consumed large

With respect to fuel oil consumption, the steelworks formerly consumed large quantities of oil (30-50 litres per tonne of iron) as an injectant. This practice stopped in 1980-81 as oil prices rose. At present, the only remaining application for oil is as a binding agent for coal in the coke ovens. Consumption levels are currently 6 to 7 litres per tonne of coke solids - which is equal to only 0.17 GJ per tonne of crude steel. This level is unlikely to change materially in the future.

By far the most significant type of fuel used at Newcastle is coal for making coke. According to the Combustion Department's November 1987 six-monthly report, No.s 3 and 4 blast furnaces, use 440 and 415 kg respectively of lumpy coke per tonne of iron produced. This requires 900-950 kg of unwashed coal per tonne of iron. On an energy basis this makes up 70% of all the primary fuels used at the steelworks.

To minimise operating costs and enhance energy efficiency, the steelworks routinely consume all the by-product fuels produced during the manufacture of coke and iron. These intermediate fuels include middlings left over from the coal washery, as well as breeze (or coke fines), and the carbon-monoxide rich gases produced from the coke ovens and blast furnaces.

8.1.2 Port Kembla steelworks

From discussions with personnel at Port Kembla it is understood that, over the last decade, unit energy consumption has been influenced by several factors:

- closure of the No.1 open hearth furnace in 1977. This facility was less energy efficient than the BOP steelmaking route

- commissioning of No.1 slab caster at the end of 1979 which substantially improved finished product yields within the plant

- cessation of use of fuel oil as a blast furnace injectant in 1981. Rising oil prices caused the steelworks to switch-over to coke and natural gas. In the short-term, unit energy efficiencies deteriorated

- closure of the No.2 open hearth furnace in 1982 which was a heavy user of energy within the steelworks

- closure of the No.2 open hearth furnace in 1982 which was a heavy user of energy within the steelworks

- the down-turn in steel demand in 1982-85 which led to the plant running at less than full capacity, thereby adversely affecting unit energy efficiency

- commissioning of No.2 continuous slab caster in November 1986. This boosted finished product yields within the plant

- commissioning of the new 7A coke oven battery in 1987 which incorporated some of the latest energy and material saving technologies.

According to information published by BHP in 1977, Port Kembla's No.1 & 2 open hearth furnaces consumed 5.0 GJ per tonne of product versus only 2.1 GJ/tp for its BOS furnaces. At the time 43% of all crude steel was made via the open hearth route. From this it is estimated that closing down open hearth furnaces, in one step, improved the overall steelworks energy intensity by 1.3 GJ per tonne of crude steel.

With respect to coke production it must be noted that Port Kembla has surplus capacity and has been selling 0.1-0.2 mtpa of coke to the Newcastle steelworks and BHP's ferro-alloy plant in Tasmania. The recent commissioning of the new 7A coke battery has increased the steelworks capacity and (in the short to medium term) the Company intends to export an additional 0.5-0.6 mtpa of lumpy coke.

Although an energy credit of 27 GJ/tonne of coke is assigned to these sales (totalling 20-23 TJ pa) the energy losses of 5.8 GJ/tonne during conversion are included in the steelworks net energy balance - resulting in an apparent increase in energy consumption per tonne of crude steel made[1].

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(1) Given that Newcastle steelworks imports some of its coke needs from Port Kembla, unit energy consumption at Newcastle is correspondingly lower.

In the 1970's, oil was used in the blast furnace and for short-term "peak lopping" needs around the plant - such as warming up mill reheating furnaces. As the price of oil rose the steelworks shifted over to using coke and natural gas (as a blast furnace injectant and as a process heating fuel). Major savings were also achieved through better energy & material management and the installation of computer controls and new reheating furnaces.

The impact of rising oil prices can be seen in Table A.7 which shows that, between 1977 and 1983, fuel oil consumption at Port Kembla fell from an estimated 370 000 tonnes to only 14 000 tonnes per annum. Since then the amount used has been further cut - and is now running at only 3 000 tonnes per annum. On a per unit basis, this corresponds to a reduction in the amount of oil used from 3.3 GJ in 1977 to 0.03 GJ per tonne of crude steel.

With respect to stopping fuel oil injection into the blast furnace, BHP's first response was to increase the coke rate to maintain adequate heating/reduction. Not only did this lead to a reduction in furnace productivity (not critical at the time as BHP then had excess capacity) but it also affected overall energy consumption (as on a unit basis more coke was required to replace the oil). This led to a short-term increase in unit energy consumption at Port Kembla and Newcastle. Energy efficiencies were restored to previous levels when natural gas was made available to Port Kembla steelworks in 1982.

At present, oil is now mainly only used in the coke ovens to bind the coal. Consumption levels are currently 1.4 litres per tonne of coke solids at Port Kembla. By comparison, Newcastle steelworks use 6-7 litres/tonne of coke solids. The higher amount is due to the different coal types used at Newcastle.

It is estimated that Port Kembla currently uses 75 m^3 of natural gas as a blast furnace injectant per tonne of iron produced. Based on an annual output of 2.6 mtpa of iron, this corresponds to over 195 million m^3 or 7.75 PJ of gas per annum. This is 90% of all natural gas consumed at the steelworks (totalling 8.56 PJ in 1987). According to steelworks personnel, the rest of the gas was mainly used in the reheating furnace and finishing sections of the plant.

As a reflection of improved operating practices and the recent change-over from oil to gas injection, coke rates at Port Kembla have dropped from around

As a reflection of improved operating practices and the recent change-over from oil to gas injection, coke rates at Port Kembla have dropped from around 650 kg per tonne of iron in 1977 to 465 kg/t in 1987.

8.2 Computer Model of the Port Kembla & Newcastle Steelworks

To forecast the future energy requirements of the NSW iron & steel industry a computer model was developed to simulate the energy and material flows within BHP's Newcastle and Port Kembla steelworks over the next 15 years.

A detailed description of the model and sample printouts can be found in Volume II of the study[1].

The model basically consists of 13 separate modules, each detailing the energy and material requirements for various key items of steelmaking plant - such as coke ovens, blast furnaces and rolling mills etc. These modules are linked together such that a balanced plant operation is achieved.

Given projections of the amount and type of steel products to be made, as well as information on likely changes in energy and material efficiency, the model was used to estimate the amount of energy and fuel types consumed within each steelworks. Fuels covered included:

- electricity (including cogenerated power)
- coking coal (both unwashed and washed)
- thermal coal (both unwashed and washed)
- middlings from coal washery
- coke (both lumpy and breeze, as well as exports/imports)
- coke oven and blast furnace gas produced in-house

(1) Report by MMP titled "Analysis of future energy use in the NSW iron & steel industry : Volume II - computer model of the Newcastle and Port Kembla steelworks" November 1988

- natural gas
- oil (for binding coal in the coke oven)
- by-product tars and BTX from the coke oven
- process steam produced in-house
- LPG (for flame cutting)

The model also calculated raw iron and crude steel production levels. From this estimates were made of the change in energy intensity (ie GJ per tonne of crude steel) and fuel mix over time.

In addition, the operating levels of the various steelmaking facilities were calculated. This was useful in highlighting possible future areas of capacity constraints and production bottlenecks.

The background data used in developing the model mainly came from confidential information supplied by BHP, plus published reports on overseas steelmakers and a recent report by the International Iron & Steel Institute (IISI) on fuel usage patterns for a hypothetical modern integrated steelworks.

8.2.1 Model accuracy

The model was checked against internal estimates supplied in confidence by BHP - which were derived from computer simulations carried out on its own energy model.

Apparently the BHP model (which was developed over several years and runs on a mainframe computer) is accurate to +/-5% for coal and +/-10% for electricity and natural gas. This assumes no uncertainty in forecasting future steel production levels.

Apart from its reduced complexity, a significant difference between MMP's model and BHP's is that our model simulates plant operations on an annual basis, and so does not cover short-term or dynamic plant operational issues - like the impact of different parts of the plant not operating on a continuous basis. For example, the amount of natural gas consumed at Newcastle varies greatly between weekdays/ week ends as changes in rolling operations affect the amount of surplus coke oven gas available.

Our computer model is unavoidably less precise than BHP's. While the results should be treated with caution, we believe that they provide a valuable insight into the various operational issues facing NSW's steel industry.

8.3 Scenario studies

The following three general scenarios were considered for NSW:

- Base Case scenario
- Low Growth scenario
- High Growth scenario

The general domestic and international economic parameters (such as economic growth, interest, inflation and exchange rates) underlying the first two scenarios correspond to DoE's internal forecasts; namely that, for the low growth and base case scenarios domestic GDP will grow on average by 1.8% or 2.5% pa over the next 15 years. The high growth scenario was developed by MMP and was based on GDP growing at 3.3% pa between 1998-2003.

It should be noted that the present study was limited to the Port Kembla and Newcastle steelworks and the proposed Sydney mini-mill. Energy usage in associated down-stream manufacturing operations (such as Lysaghts) and in transporting goods to the end user has not been determined. Also excluded were the energy requirements for local foundries and the various operations which supply inputs to the steelworks. These include the coal and limestone mining operations, refractory manufacturing and local engineering/fabrication.

8.3.1 Assumptions used in the base case scenario

The base case forecast is based on the following key assumptions:

- There will no major recessions in Australia's or the World's economy
- Australia's GDP will, in the longer term, grow by 2.5% pa
- domestic finished steel demand will grow on average by 2.0% pa over the next 15 years, reaching 6.9 mtpa by 2003. This is 1.8 mtpa higher than current levels and is in agreement with BHP's internal forecasts
- The main growth market in Australia will be in higher value added products such as speciality engineering steels (made in Newcastle) and coated cold rolled products (which use hot-rolled steel feed from Port Kembla)
- After adjusting for differences in inflation and exchange rates, Australia's international competitiveness will remain much the same as at present
- BHP will continue to be cost competitive against imports and that the Port Kembla and Newcastle steelworks will operate at near full capacity (with excess production being sold on the export market). This is not unreasonable given that the recent refurbishment of the Port Kembla and Newcastle steelworks has improved their competitive position visa-vis Smorgon's mini-mill and steelmakers overseas
- Imports will continue to run at 0.6-0.8 mtpa and maintain their market share
- Port Kembla will continue to export surplus coke production to Newcastle and overseas. It is assumed that the coke ovens operate at 90% of rated capacity such that, from 1988 onwards, 0.75-0.85 mtpa of export coke is produced per annum
- Following the completion of the *Steel Industry Plan* no major capital works programs will be carried out over the forecast period[1]. The only exceptions will be the commissioning of the 250 000 tpa Sydney mini-mill in 1991-92 and the replacement of the existing coke ovens at Newcastle in 1992-93, as well as routine relining of blast furnaces
- At Port Kembla no major plant closures are envisaged over the forecast period. However at Newcastle the existing skelp (hot rolled strip) mill will close down in 1991. This will be followed by the No.1 merchant mill in 1993.

(1) Following the expenditure of $1.6 billion in major capital works over the last 5 years, BHP has stated that it does not envisage any major investment in new plant and equipment before the mid 1990s. Instead it is keen to get a fast pay back on its existing investment.

- The relative cost and availability of energy will remain near current levels. In other words, there will be no change in BHP's current operating practices regarding energy conservation and/or inter-fuel substitution

- Most of the growth in BHP's steelmaking activities will be in supplying steel billets and/or technology to overseas plants. In particular, the company will continue to build captive cold-rolling/steel fabrication facilities around the Pacific rim - to be supplied with steel from Port Kembla and Coated Products Division

- Including captive customers overseas, BHP exports at most 25% of its steel production from its NSW steelworks

- The proposed Sydney mini-mill goes ahead in 1991. This results in the closure of reinforcing bar manufacture at Newcastle

- Smorgon's mini-mill in Victoria installs a thin-strip caster in 1995 to make hot rolled flat products. The net effect will be to capture any growth in the domestic market, obviating the incentive for BHP to expand flat products manufacture at Port Kembla

- A 0.4 mtpa direct reduction or direct smelting plant is built in Western Australia or Queensland in the mid-1990's. Initially all the output is exported

- Incremental improvements in steelmaking technology result in a steady 0.5% pa improvement in energy consumption per unit of crude steel made

- No significant differential increase in energy prices occurs

8.3.2 Assumptions used in the low growth scenario

In addition to assumptions outlined above, the low growth forecast is premised on the following key assumptions, namely that:

- The world's economy will slow down over the next 3 years

- Australia's GDP growth rate will drop from 4.0% pa in 1988 to a low of 1.5% in 1991, before rising to 1.8% in the longer term.

- domestic steel demand will grow on average by 1.4% pa over the next 15 years, reaching 6.3 mtpa by 2003. This is in agreement with BHP's internal forecasts

- After adjusting for differences in inflation and exchange rates, BHP's international competitiveness will deteriorate. Whilst the level of imports will (for political reasons) not rise above 20% of the domestic market, BHP's ability to compete on the international market will, in the longer term, be severely impaired

- Imports will rise to 0.9-1.2 mtpa from the mid 1990's onwards

- For the next 2-3 years the Port Kembla and Newcastle steelworks will operate at near full capacity (with production levels matching those given in the base case). At Port Kembla production will remain constant, whereas at Newcastle, reinforcing bar sales will be reduced by 50 000 tpa in 1990 and 1991 as building construction activity slows down

- With the commissioning of the Sydney mini-mill in 1992, crude steel output at Newcastle will 200 000 tpa (or 11%) lower than the base case forecast over the period 1992-99, and 300 000 tpa lower thereafter

- At Port Kembla finished steel production will fall by 80 000 t in 1991 and a further 70 000t in 1993. By the turn of the century, as new steelmaking technologies become more widely used, Port Kembla's output will fall by 50 000 tpa in each year after 1998 The cut-back in production will be in billet exports

- To earn additional revenue Port Kembla will increase export sales of coke production. It is assumed that the coke ovens will operate at full capacity from 1990 onwards, producing 1.1-1.2 mt of export coke per annum. The extra material will be sold to steelmakers in the Pacific basin which, for environmental or economic reasons, have closed down their own coke ovens. BHP's access to low cost coal will ensure that the coke produced will be very price competitive

- Most of the growth in BHP's steelmaking activities will be in supplying steel billets and/or technology to overseas plants. In particular, the company will continue to build captive cold-rolling/steel fabrication facilities around the Pacific rim - to be supplied with steel from Port Kembla and Coated Products Division

- Including captive customers overseas, BHP exports will fall to 10-15%

- Smorgon's mini-mill in Victoria installs a thin-strip caster in 1998 to make hot rolled flat products. This will be at the expense of flat products made at Port Kembla

8.3.3 Assumptions used in the high growth scenario

In addition to assumptions outlined in the base case scenario, the high growth forecast assumes that:

- The world's economy will remain buoyant over the next decade
- Australia's GDP will, in the longer term, grow by 3.3% pa
- domestic steel demand will grow on average by 2.8% pa over the next 15 years, reaching 7.7 mtpa by 2003. This is in general agreement with recent forecasts by WEFA
- After adjusting for differences in inflation and exchange rates, BHP's international competitiveness will improve marginally. This will enable BHP to export more steel profitably
- Imports will remain at 0.5-0.7 mtpa over the forecast period and will mainly be in product categories not supplied by BHP
- Port Kembla and Newcastle steelworks will operate at full capacity over the forecast period. Due to the lag in upgrading the plant, production at the two steelworks will, for the next 3 years, match that given in the base case
- Port Kembla will upgrade its No.4 blast furnace by 0.45 mtpa in 1993 and No.5 furnace by 0.40 mtpa in 1997. The additional capacity is directed towards increased exports of steel billets to captive customers overseas. A 1.0 mtpa thin strip caster is installed in 1997
- A 10 MW top-gas turbine is installed on No.4 blast furnace at Port Kembla in 1993. This will reduce the steelworks purchases of electricity by 80 GWh pa
- At Newcastle the No.3 blast furnace is upgraded by 0.20 mtpa in 1996. The additional capacity is used to increase production of special rod and bar grades
- To earn additional revenue, Port Kembla will increase export sales of coke. It is assumed that the coke ovens will operate at full capacity from 1990 onwards, producing an additional 0.17-0.20 mtpa of coke. However as more coke will be consumed within the steelworks the net amount of coke exported will remain at the level set for the base case (of 0.8 mtpa) in the mid-1990's before dropping to around 0.6-0.7 mtpa thereafter

8.4 Future energy requirements for the NSW iron & steel industry

Using our computer model, and based on economic projections supplied by the DoE, forecasts were made of the likely energy requirements and fuel mix for BHP's Newcastle and Port Kembla steelworks out to the year 2003 under a range of scenarios. Added to this were estimates provided by BHP of the likely energy requirements for the proposed Sydney mini-mill.

8.4.1 Overview

The results of the base case scenario are given in Tables A3 and A4 in Appendix A attached. Figures 8.3 to 8.5 summarise the industry's net electricity, natural gas, coking and thermal coal purchases out to the year 2003 under three different scenarios.

In the base case scenario we forecast that over the next 15 years crude steel production in NSW will rise by 0.54 mt to 5.58 mtpa in 2003. Total energy consumption (net of coke exports) will rise from 122 PJ in 1989 to 136-140 PJ pa from 1993 onwards (see Figure 8.3). The temporary dips in energy consumption in 1992, 1994 and 2000 are due to various blast furnaces at Port Kembla and Newcastle being taken off-line for relining[1].

According to BHP personnel, at this point in time, no plans are underway to increase steel capacity in NSW. Although, it is possible to upgrade Newcastle steelworks to 2.0 mtpa, this has not been written into their 10 year plan.

(1) The 1992 dip is due to No.5 blast furnace at Port Kembla being down for a major reline.

At Port Kembla, the opportunity exists to upgrade existing furnaces and/or reactivate mothballed equipment (the No.2 blast furnace with a capacity of 0.5 mtpa is now being recommissioned after the report was submitted to the Department in late 1988). As outlined in Section 8.3.3, our high growth scenario assumes that No.4 blast furnace is upgraded by 0.45 mtpa in 1993, and No.5 furnace by 0.4 mtpa in 1997.

Under the high growth scenario, energy consumption is projected to rise to 138-142 PJ in the mid 1990's following a 0.45 mt upgrade of the No.4 blast furnace at Port Kembla. Energy consumption is expected to rise by a further 5-8 PJ pa following a 0.20 mt upgrade at the No.3 blast furnace at Newcastle in 1996 and 0.4 mt upgrade of Port Kembla's No.5 blast furnace in 1997.

As discussed before, the large variations in energy usage in recent years are due to improvements in process technology and (more importantly) a major drop in steel production.

Figure 8.4 shows that under the base case scenario washed coking coal purchases are expected to remain at around 4.25-4.35 mtpa over the forecast period, with demand temporarily dropping to 3.56 mt in 1992 as Newcastle replaces its coke ovens.

Coking coal demand in the low and high growth scenarios is forecast to be higher at 4.5-4.6 mtpa. This is due to Port Kembla stepping up exports of coke, with the coke ovens running at 100% of rated capacity rather than 94% under the base case scenario. Cutting back export sales by 100 000 tpa will reduce the steelworks washed coking coal requirements by 130 000 mtpa.

The likely level of coke exports (net of sales from Port Kembla to Newcastle steelworks) under the various scenarios are also given in Figure 8.4. As can be seen, in the base case coke exports are expected to rise from 0.14 mt in 1987 to 0.83 mt by 1991 as the new No.7A coke batteries at Port Kembla become fully operational[2]. By the turn of the century net exports are expected to rise to around 0.85-0.90 mtpa as incremental improvements in energy efficiency at the two steelworks reduce local coke consumption.

Coal middlings and unwashed thermal coal purchases will remain at around 0.35-0.36 mtpa under all three scenarios considered (Figure 8.4). This coal is principally used as a low cost fuel for steam raising and associated generation of electricity.

With respect to electricity purchases it should be noted that both steelworks produce large quantities of power in-house from waste coal washery middlings and surplus coke oven and blast furnace gas. Consequently, external electricity purchases are very sensitive to blast furnace and coke oven operating levels, as well as changes in product mix. This is evidenced in Figure 8.5, which shows that under the base case scenario, electricity purchases are expected to rise by 55% or 600 GWh over the next five years to peak at 1590 GWh in 1993. Part of this growth is due to the startup of the Sydney mini-mill in 1992 which uses an electric furnace to melt steel scrap, and has no power generation. When operating at full load this facility will consume 154 GWh per annum. In the longer term aggregate electricity purchases for the NSW iron and steel industry are expected to vary in the range 1420-1550 GWh pa.

Electricity purchases under low and high growth scenarios are expected to be around 1400-1500 GWh in the mid 1990's. This is lower than the base case because of increased availability of coke oven gas (because of higher coke production) and a higher proportion of billet steel (which is less electricity intensive). Furthermore, in the high growth scenario assumes that a 10 MW top-gas turbine is installed on No.4 blast furnace at Port Kembla in 1993. This will reduce electricity purchases by around 80 GWh per annum.

(2) It should be noted that the figures given include 100 000 tpa of coke breeze sales to domestic customers.

Figure 8.5 shows that natural gas purchases will pick up over the next few years, reaching 15 000 TJ pa by 1993. However, even under the high growth scenario gas usage will not return to the levels experienced in the mid 1980s - when demand peaked at 20 000 TJ pa in 1986.

As discussed before, the major reduction in gas usage over the last five years was mainly due to increased level of continuous casting at both steelworks which reduced the need to reheat slabs prior to hot rolling. Given that both steelworks are aiming to be operating at 100% con-casting from 1989 onwards, the only major remaining application will be as an injectant into the blast furnace for improving thermal efficiency and hot metal productivity. The lower natural gas consumption levels projected for the low growth scenario reflect the reduced need to operate the blast furnaces at full output.

In summary, the main feature to note is that the massive restructuring/capital investment program initiated by BHP in 1983 has resulted in substantial energy savings. The large gains made over the last decade will continue to grow over the next few years. However, once the new equipment becomes fully operational overall energy efficiency will level out in the 1990s. Even so, the mix of fuels used will change over time. In particular, the amount of natural gas will decline as operational efficiencies are achieved within the various steelworks. With respect to electricity, we project that, apart from the startup of the Sydney mini-mill in 1992, purchases by the individual steelworks will remain at near current levels.

The base case results given closely match information provided in confidence by BHP.

The main findings of our base case scenario are also in agreement with the Department of Primary Industry & Energy's forecast of the likely future net energy requirements of the aggregate Australian basic iron & steel industry (Figure 8.1). This is not surprising, as it is understood that the DPIE forecast is sourced directly from BHP's and Smorgon's ten-year plans and reflects the long-term views held by them in 1986.

The implications of higher/lower economic growth scenarios on forecast energy consumption are discussed in Section 8.4.

The likely energy/fuel requirements for NSW's various steelworks are covered in more detail below.

8.4.2 Future energy requirements at Port Kembla

The likely trends in energy consumption at the Port Kembla steelworks are given in Figure 8.6. The corresponding changes in unit energy efficiency are shown in Figure 8.2.

As shown in Figure 8.2, under the base case scenario, unit energy consumption at Port Kembla is expected to drop after 1988 as recently installed plant becomes fully commissioned.

The forecast slowdown in energy efficiency gains is largely due to the completion of plant refurbishment program associated with the *Steel Industry Plan* and the absence of any major follow-on capital projects. In particular, the base case assumes that BHP does not intend to install any major new plant at Port Kembla for at least another five years. As a result there are few opportunities in the short to medium term to materially alter the energy mix or consumption levels.

The temporary increase in unit energy consumption in 1988 and 1999 is due to blast furnaces being down for major relines. In detail, during each blast furnace reline the effective capacity of the steelworks is reduced. For commercial reasons, most of the cutback in production occurs in the lower value-added products - namely export steel billets. Since billets are less energy intensive than the other steel products made by BHP, the change in product mix temporarily increases unit energy consumption.

The short-term decline in steel production also reduces the amount of coke consumed on-site, thereby allowing extra coke to be exported. As discussed before, even after deducting the energy value of the coke sales, there are still significant in-house energy losses associated with these sales.

Part of the 1988 increase is also due to the commissioning of the 7A coke oven battery and the associated opportunity for BHP to export surplus production. From 1988 onwards, we have projected that coke exports under the base case will rise from 0.1-0.2 to around 0.75-0.85 mt of coke per annum (see Figure 8.9). The large increase over that for 198587 is due to the recent commissioning of the No.7A coke oven battery at Port Kembla. Because of reduced steelworks consumption arising from planned reline of No.5 blast furnace, coke exports are expected to peak at 1.0 mtpa in 1997.

It should be noted that approximately 0.10 mtpa of these coke exports will be for coke breeze to various BHP subsidiaries (such as Temco in Bell Bay). It is assumed that this figure does not change for the high and low growth scenarios.

As indicated in Figure 8.9, coke exports are projected to be around 0.20-0.25 mtpa higher under the low growth scenario. This is due to reduced coke requirements at Port Kembla coupled with operating the coke ovens at 100% capacity (rather than 90-95% under the base case scenario). The extra material will be sold to steelmakers in the Pacific basin which, for environmental or economic reasons, have closed down their own coke ovens. BHP's access to low cost coal will ensure that the coke produced will be very price competitive and that Port Kembla's coke ovens will be able to operate at capacity.

Another factor influencing BHP's incentive to export coke, is the selling price of the coke oven by-products - such as BTX and ammonium sulphate. MMP assumes that these markets will improve over time, thereby leading to a stronger push to export coke.

For the high growth scenario, we project that, even though the coke ovens will be running at full capacity, all of the extra output will be used on-site, especially once No.s 4 & 5 blast furnaces are upgraded in 1996 & 1997. In other words, under the high growth scenario coke exports will match those for the base case out to 1997, and be 0.17 mtpa lower thereafter.

As discussed before, the energy losses associated with producing export coke increases the steelworks overall energy requirements, leading to a higher energy usage per tonne of crude steel made.

The forecast purchases/exports for the various fuel types for Port Kembla are given in Tables A8 and A10 attached.

As can be seen in Figure 8.9, under the base case scenario, washed coking coal purchases are projected to rise from 2.9 mt at present to 3.3 mt in 1990 and 1991, then slowly dropping to 3.1-3.2 mt by the end of the forecast period. In the high and low growth scenarios, coking coal purchases levels are the same as both scenarios assume that the coke ovens will operate at 100% of capacity. Consequently coal demand for the high and low growth scenarios is projected to peak at 3.48 mtpa in 1993 before slowly declining over the rest of the forecast period. The gradual reduction in coking coal purchases between 1993 and 2003 is due to reduced coal losses and better lump/fine yields for the coke oven. The main source of these gains will be through on-going improvements in process control and improved coal blending practices.

The major drop in coal requirements 1992 is due to No.4 blast furnace being relined, which reduces the steelworks requirements for coke. It is assumed that export coke sales for coke will not increase in that year.

It is understood that Port Kembla is considering importing some coking coal in from the company's mines in Queensland. However this will only happen if no suitable high quality coal can be found locally.

Figure 8.10 shows the likely natural gas purchases projected for Port Kembla. As can be seen, demand is expected to fluctuate between 6 500 and 7 900 TJ per annum over the forecast period. These variations are largely due to changes in operating levels for the blast furnaces - with increased metal output requiring higher gas injection rates. The reduced blast furnace operating levels under the low growth scenario cause natural gas usage to drop to around 6 100 to 6 500 TJ pa over the next decade. This is 800 to 1 200 TJ pa less than the base case.

In the high growth scenario, natural gas usage is expected to rise following the upgrade of the No.s 4 & 5 blast furnaces in 1993 and 1997. As indicated in Figure 8.9, natural gas purchases are projected to average 8 400 TJ pa between 1994-1996 and 8 900 TJ pa 1998-2003. This is 600 TJ pa and 1 400 TJ pa higher than the corresponding base case estimates.

According to BHP personnel, the dramatic drop-off in natural gas consumption between 1987 and 1989 (from 14 000 TJ to 6 500 TJ) is primarily due to the progressive commissioning of the new continuous caster and associated processing facilities. Steadier operations are expected to improve strip mill heating efficiency. Prior to this, many of the steel slabs/ingots had to be reheated (with natural gas) prior to rolling.

A related factor also affecting natural gas consumption is that any shift towards increased slab exports will reduce the amount of energy needed for reheating At the same time, the increased iron production will generate more blast furnace gas - thereby backing-out natural gas in other sections of the steelworks.

As discussed above, most of the natural gas is used in the blast furnace as an injectant. From discussions with BHP personnel it is understood that the excellent condition of the blast furnaces and coke ovens is such that the company would not consider adopting another process route (such as direct steelmaking) at Port Kembla in the foreseeable future.

With respect to electricity purchases, Figure 8.9 shows that a step increase in demand will occur at Port Kembla over the next two years as recently installed casting and rolling facilities become fully operational. From 1990 onwards term we estimate that, under the base case scenario, the steelworks will buy-in 1 100 GWh pa of electricity. This is in addition to the 430 GWh pa generated on-site. Peak power requirements are currently of the order of 180 MW, of which one-third comes from the steelworks own cogeneration facilities.

BHP actively manages its peak megawatt load requirements through a combination of close process control, demand management techniques and cogeneration. Apparently the load cycles within the steelworks are fairly predictable - with the main area with variable load being the hot rolling mill, where loads vary between 10 to 40 MW.

In the low growth scenario we project that electricity purchases will be reduced by 50 GWh pa from 1993 onwards, with demand falling below 1 000 GWh by the end of the forecast period as steel production drops away.

Electricity purchases under the high growth scenario are estimated to match the base case out to 1993, then run at 2-3% (or 20-30 GWh pa) lower, even though steel production will be 10-15% higher in later years. The reduction in purchases is principally due to the installation of a 10 MW top-gas turbine on No.4 blast furnace in 1993, which will produce 80 GWh pa.

Although not modelled in the three scenarios, the effect of reactivating one of Port Kembla's mothballed furnaces (No.s 1, 2 and 3) can be inferred from the upgrade of No.4 furnace in the high growth scenario. In this scenario it is assumed that the furnace's output is increased by 0.45 mtpa from 1993 onwards.

According to BHP personnel, it is unlikely that No.s 1 or 3 blast furnaces will ever be used again.

Depending on steel prices, it is possible that No.2 blast furnace could be used again. This plant was relined and shut down in 1982, and could restarted at modest cost and short lead time. Its capacity is estimated to be around 0.5 mtpa. However, MMA speculates that the high operating costs for this small furnace are such that BHP will view it as a marginal operation. As such, it would be vulnerable to being shut-down again if steel demand/prices dropped.

8.4.3 Future energy requirements at Newcastle

The forecast trends in net energy consumption at Newcastle under the various scenarios is given in Figure 8.6. The corresponding changes in the main types of fuel purchased are summarised in Figures 8.7 and 8.8.

A detailed breakdown of the various fuel types consumed under the base case scenario can be found in Tables A12 and A14 attached.

As can be seen in Figure 8.2, under the base case scenario, unit energy consumption at Newcastle is expected to drop by nearly 6% or 1.5 GJ/tonne of crude steel over the next six years. much of this is due to the retirement of old (energy inefficient) plant. However, from 1995 onwards these gains will be reversed as the steelworks moves away from making export steel billets to higher value-added (more energy intensive) special steels.

Figure 8.6 highlights the trends in overall net energy consumption under the various scenarios. As can be seen, under the base case scenario energy demand is expected to remain at around 49-51 PJ pa out to 1997. Even though per unit energy consumption is expected to rise in the late 1990's, steel production is projected to fall by 0.10-0.15 mtpa - resulting in an overall drop in energy consumption.

The higher energy consumption in the high growth scenario from 1997 onwards is largely due to increased steel production coming from an upgraded No.3 blast furnace. Similarly, the downward trend in net energy consumption under the low growth scenario is due to reduced steel output as the steelworks becomes less competitive on the export market and local mini-mills.

The forecast purchases/exports for the various fuel types for Newcastle are given in Table A12 attached.

As can be seen in Figure 8.7, under the base case scenario, washed coking coal purchases are projected to remain static at 1.12 mtpa over most of the forecast period. The large drop in 1992 is due to reduced coke production whilst the existing coke ovens are replaced. The associated shortfall in coke production will be made up of coke imports from Port Kembla.

Under the low growth scenario, the fall-off in steel production in the mid-1990's onwards means that the coke ovens will not run at full load. As a result, washed coking coal purchases are expected to decline by 0.05-0.08 mtpa to around 1.05 mtpa by the end of the forecast period. Furthermore, there is no need to import lumpy coke from Port Kembla (Figure 8.7).

In the high growth scenario, coking coal purchases are projected to largely follow that for the base case. The short term variation in 1996 and 1998 is due to differences in timing and size of relining programs for the blast furnaces.

According to BHP, under the base case scenario, the coke ovens will operate at 100% of capacity with supply and demand being in-balance. However, in the high growth scenario, the increased iron production (specially after 1996 when No.3 blast furnace is upgraded by 0.20 mtpa) will require importing 0.12 mtpa of lumpy coke from Port Kembla.

Under all three scenarios thermal coal purchases (used to raise steam for power generation) are estimated to remain constant at 0.25-0.27 mtpa over the forecast period (Figure 8.7).

According to steelworks personnel, Newcastle currently has 59 MW of cogeneration equipment installed at the works. This is made up of 7 boilers and 4 alternators. It is understood that around 350 GWh pa of electricity is produced on-site, giving an operating level of around 80% for the cogeneration equipment. Due to a shortage of intermediate fuels, higher output/additional cogeneration facilities is only (1) possible if Newcastle were to burn natural gas. At this stage, this is not feasible.

(1) Apparently Newcastle steelworks have looked at installing a 20 MW unit, but its feasibility hinges on energy costs and Government approval regarding the use of natural gas for power generation.

In terms of electricity purchases, we forecast that demand will rise by 40% (or 60-80 GWh pa) over the next three years. This is largely due to the commissioning in 1989 of a BOS ladle furnace and a BOS sub-lance. When fully operational, these two units will consume 10-12 MW of power or 55-65 GWh of electricity per annum.

The sub lance will be used to quickly and accurately measure the metal's temperature and carbon level. When combined with the BOS ladle furnace, the tap-to-tap times for the BOS will be reduced, thereby improving plant productivity and steel output.

Under the base case scenario we expect electricity purchases to slowly decline in the 1990's as product yields improve and as more energy-efficient process controls are installed. This trend will be even more pronounced under the low growth scenario as steel production in the electricity-intensive finishing end of the plant is reduced.

With respect to the high growth scenario, the upgrading of the No.3 blast furnace in 1996 and the associated increase in finished steel production is expected to lead to a major increase in electricity purchases in the latter half of the forecast period. As indicated in Figure 8.8, electricity purchases will run at over 300 GWh pa from 1997 onwards, as compared to 210 GWh at present.

As shown in Figure 8.8, natural gas usage is expected to fall by 30% between 1987-89 as the new continuous caster becomes fully operational. Newcastle personnel state that much of this is due to the reduced need for process heating (principally for reheating blooms prior to hot rolling).

In the longer term, under the base case scenario, natural gas consumption is expected to rise to 8 000 TJ pa by 1994 before falling to 5 500 TJ pa by the turn of the century. This is in-line with changes with iron and steel production at Newcastle.

8.4.4 Future energy requirements at Sydney mini-mill

According to information supplied by BHP, when operational, the Sydney mini-mill will consume 154 GWh of electricity and 265 TJ of natural gas per annum. In all three scenarios it is assumed that the mill is commissioned in 1991 and reaches full capacity (of 0.25 mtpa) in the following year.

It is assumed that no heat recovery unit other than for preheating combustion unit is installed on the furnace. At the larger Smorgon mini-mill in Victoria, steam is raised for power generation.

8.5 IMPACT OF NEW TECHNOLOGY AND CHANGES IN ENERGY COSTS

In addition to changes in operating levels and product mix, the amount of energy used within the NSW iron and steel industry will be affected by energy costs and the introduction of new technology.

8.5.1 Energy costs

As indicated in Table 8.1, many overseas producers use 25-35% less energy per tonne of steel than BHP. This has been achieved through a combination of economies of scale (for example Japanese steelworks are typically twice as large as Port Kembla) and the widespread use of process equipment to recover waste energy generated during the various stages of production.

The main driving force behind these savings is the high cost of energy in these countries. For example, in the early 1980's Japanese steelmakers typically paid 13-16 Yen per kWh of electricity - which at exchange rates prevailing at the time was equal to approximately ten

Australian cents per kWh. According to PaineWebber, the recent strengthening of the Yen and the general fall in energy prices, has led to a drop in electricity costs to around 12 Yen/kWh in June 1987. However, in US dollars and other currencies, power costs in Japan are higher than they were in the early 1980's.

As indicated in Table 8.2, PaineWebber estimates that in many western countries, energy costs make up a quarter to a third of total operating costs. By comparison, we estimate that the corresponding figure for NSW is one-half to one-third that of overseas steelmakers - even though they use 30-40% more energy per tonne of steel made.

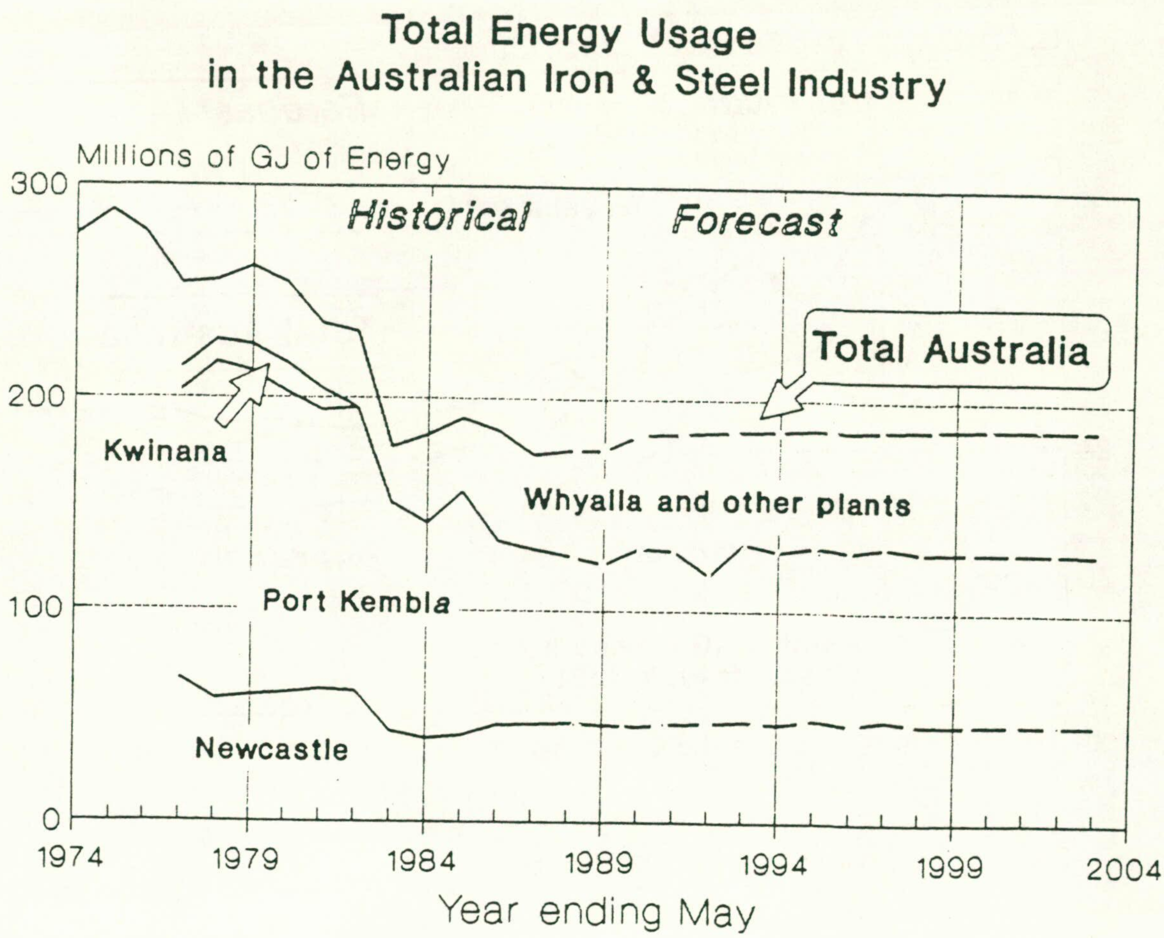
In light of the lower energy costs, the number of energy saving technologies (as outlined in Sections 5 and 7) economically available to BHP are limited. As a result, BHP will continue to lag overseas practices in this area.

Table 8.2: Share of operating costs attributed to energy (%)

	1973	1976	1980	1985	1986	1988
Japan	25.1	38.1	33.7	33.3	29.1	22
USA	17.3	21.1	23.5	26.9	25.8	24
West Germany	21.7	30.6	28.3	33.0	26.6	-
UK	23.0	31.1	31.3	31.0	26.6	-
France	23.9	30.0	28.5	31.0	26.3	-
New South Wales	-	-	11.0	10.5	-	13

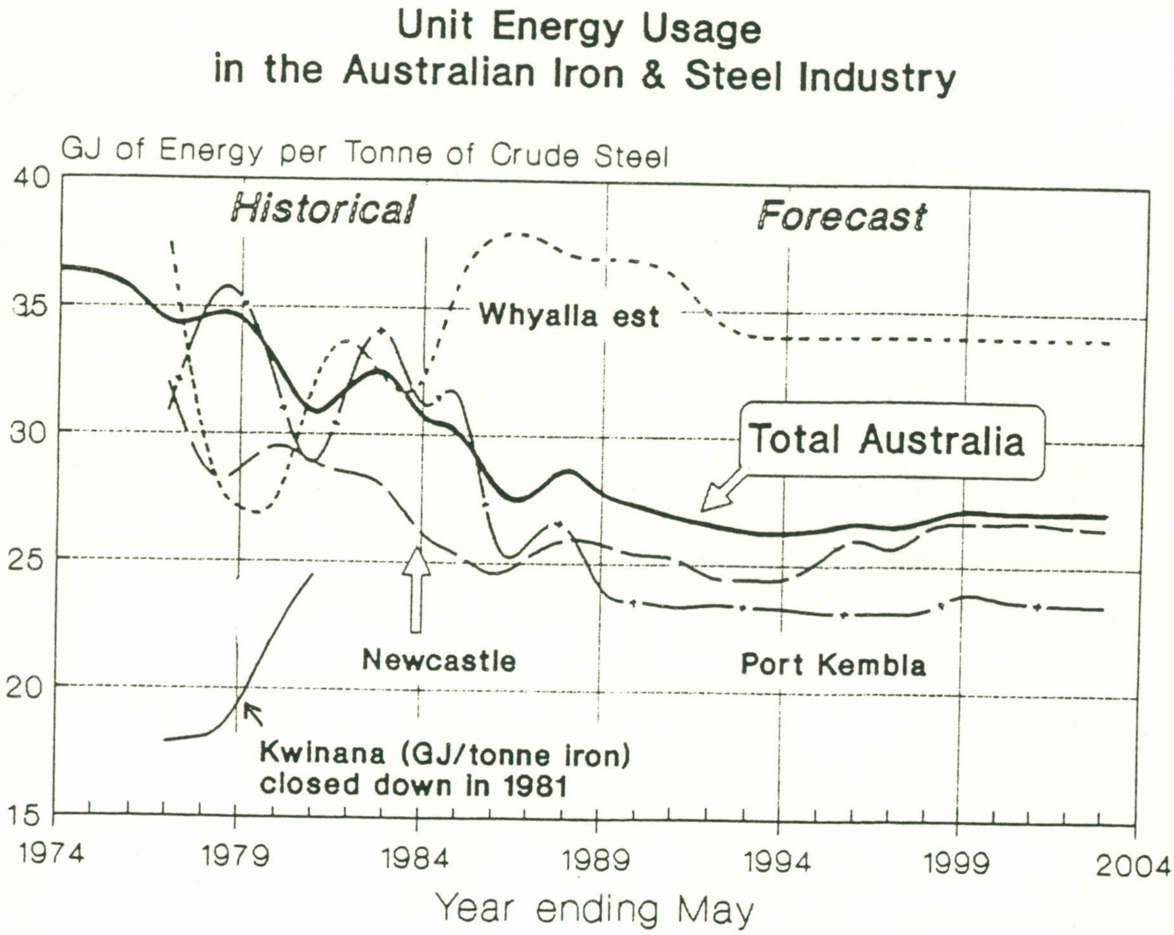
Source: PaineWebber, except for 1988 figures and NSW data - which are MMP estimates

Figure 8.1: Total energy usage in the Australian basic iron & steel industry and crude steel produced (PetaJoules of energy per annum)



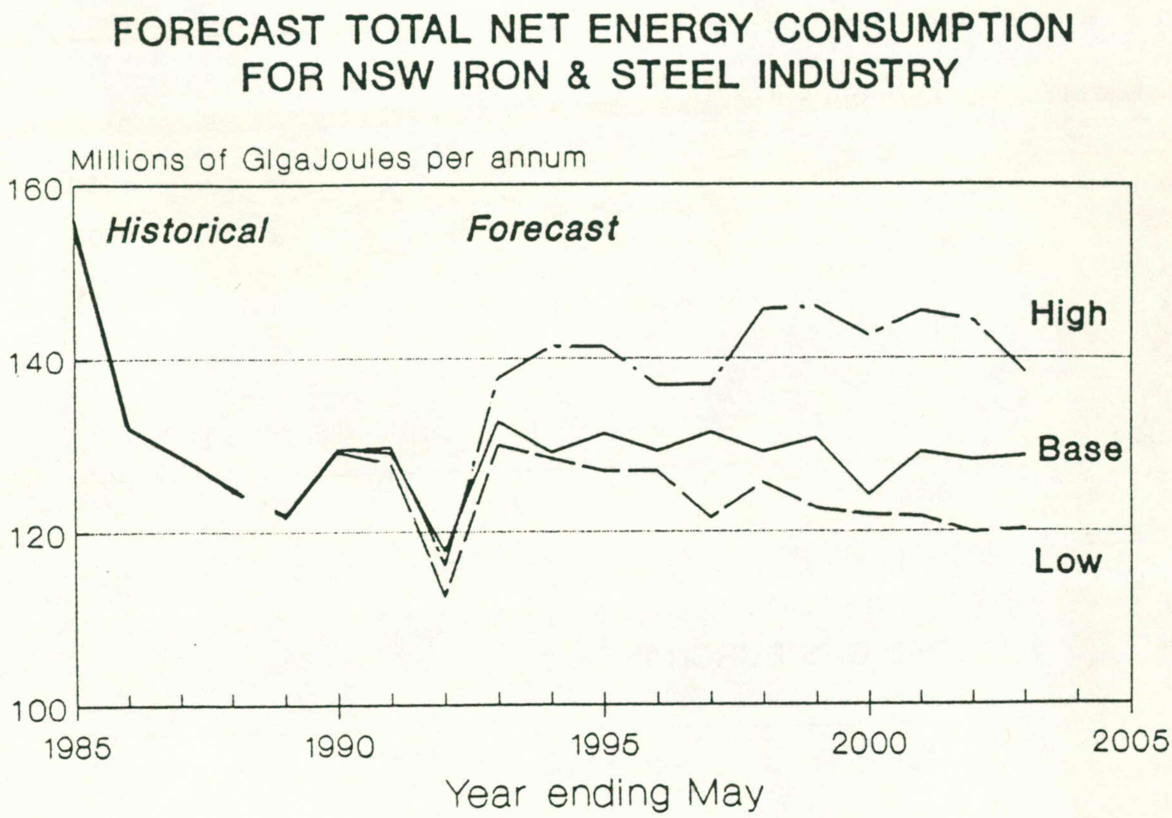
Source: Dept of Primary Industry and Energy

Figure 8.2: Energy intensitiveness of the Australian basic iron & steel industry (GJ per tonne of crude steel)



Source: Dept of Primary Industry and Energy

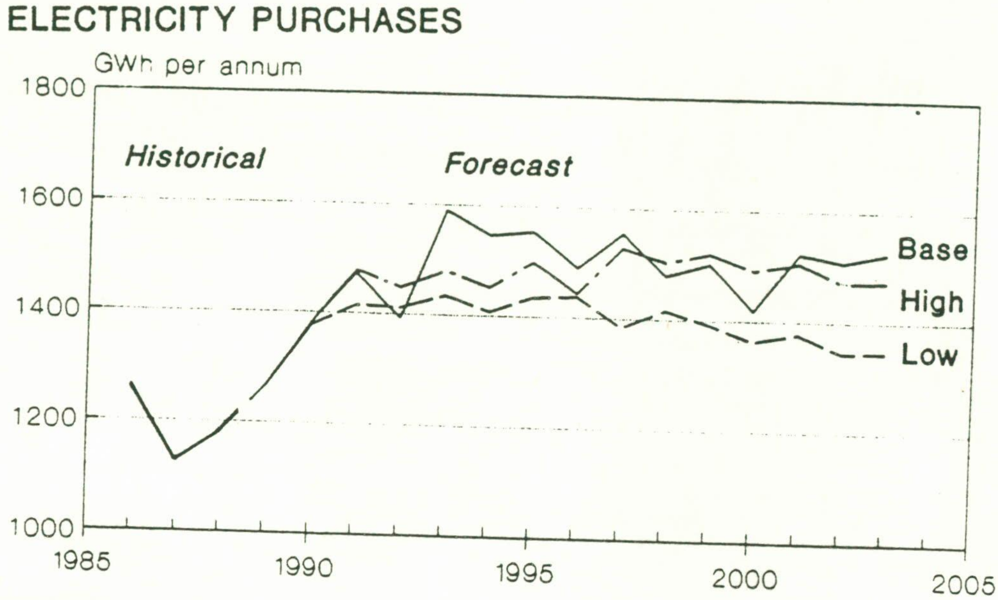
Figure 8.3: Forecast net energy consumption by the NSW iron & steel industry under the base case, high and low growth scenarios : 1985-2003 (PetaJoules per annum)

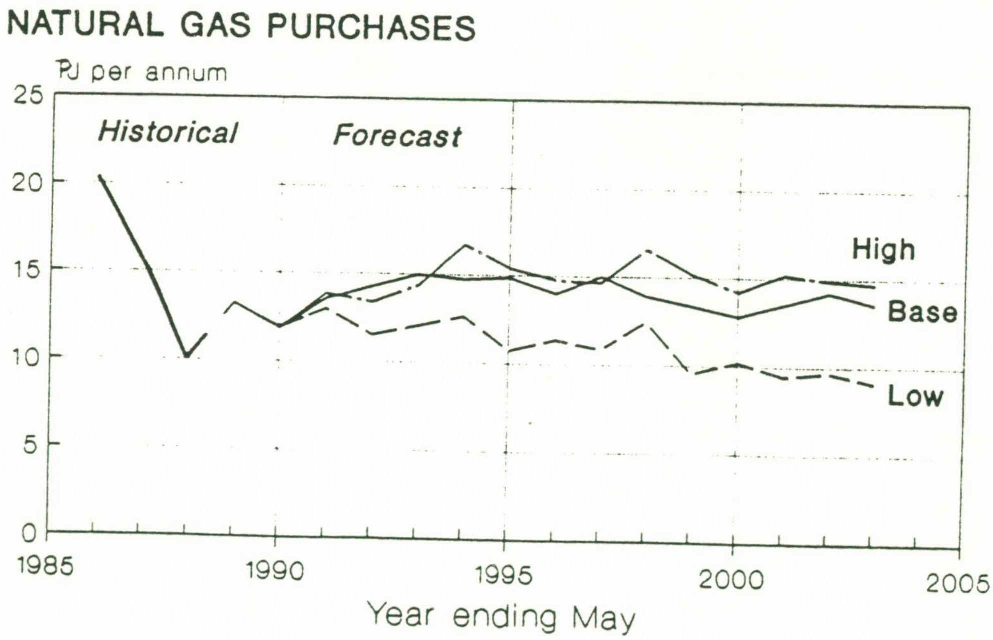


note: Figures cover the Newcastle and Port Kembla steelworks and the proposed Sydney mini-mill. They are also net of sales/purchases of coke and coke oven by-products

Source: MMP

Figure 8.5: Forecast purchases of electricity and natural gas by the NSW iron & steel industry under the base case, high and low growth scenarios : 1985-2003 (GWh and TeraJoules per annum)

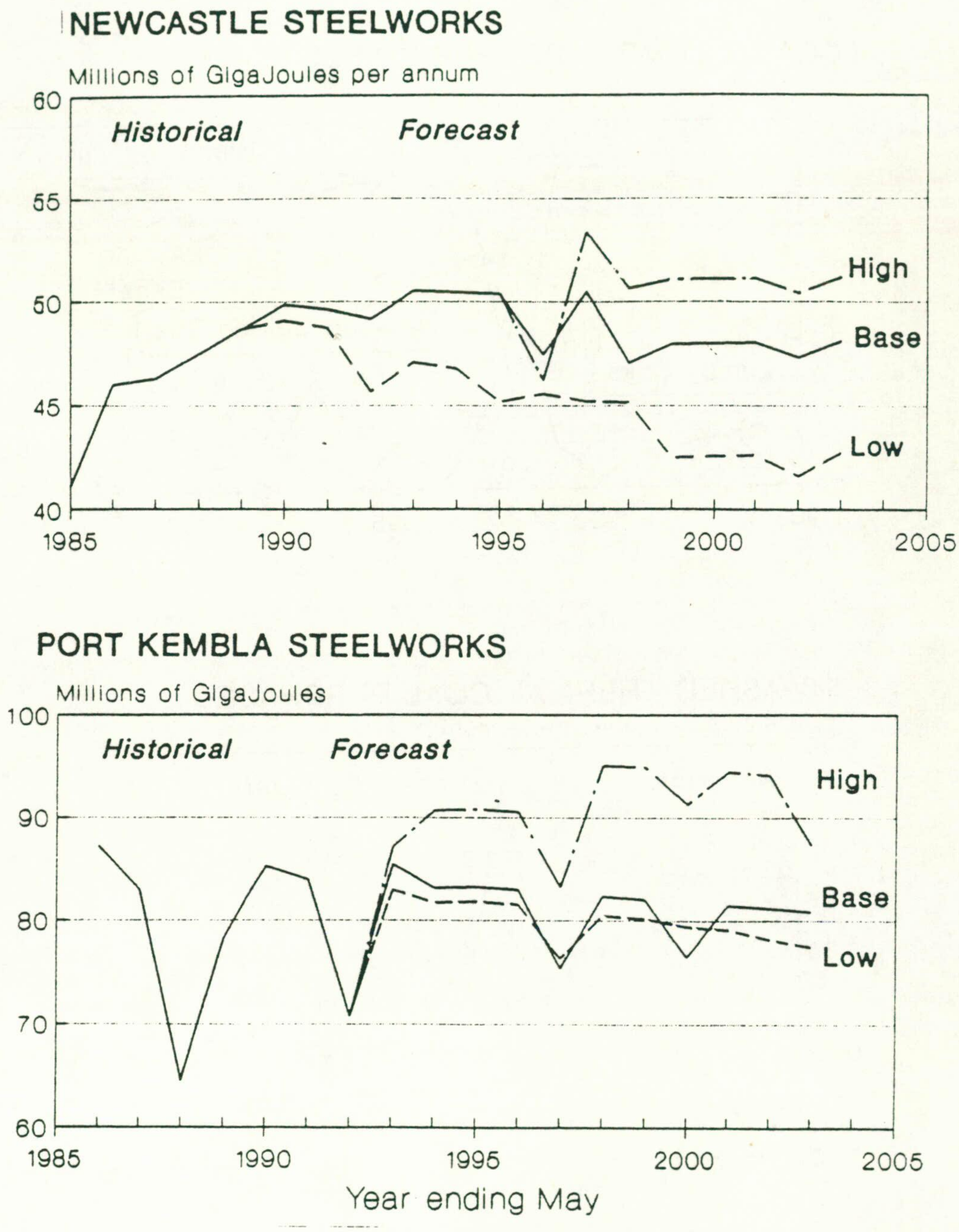




note: 1 PetaJoule = 1000 TeraJoules = 1 million GigaJoules

Source: MMP

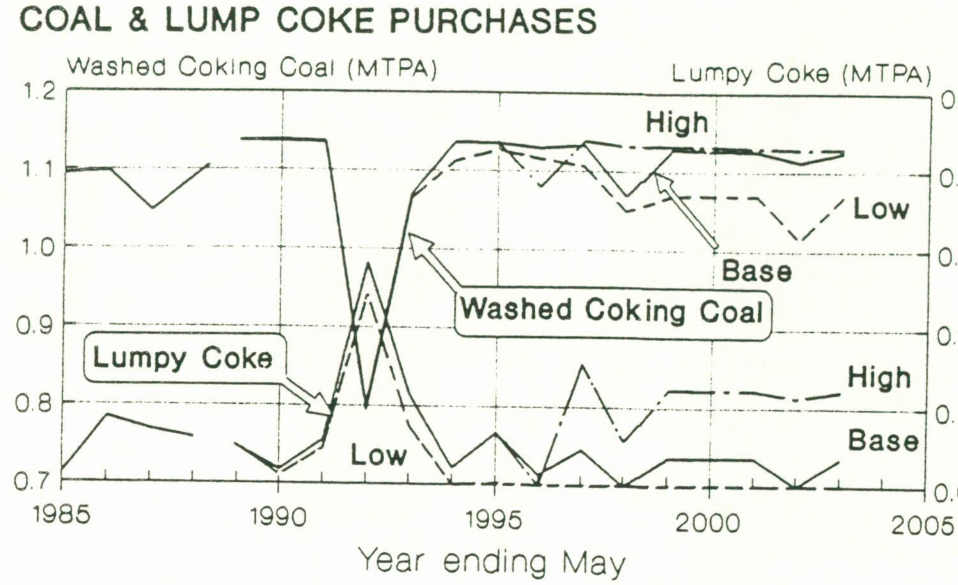
Figure 8.6: Forecast net energy consumption at Newcastle and Port Kembla steelworks under the base case, high and low growth scenarios : 1985-2003 (PetaJoules per annum)

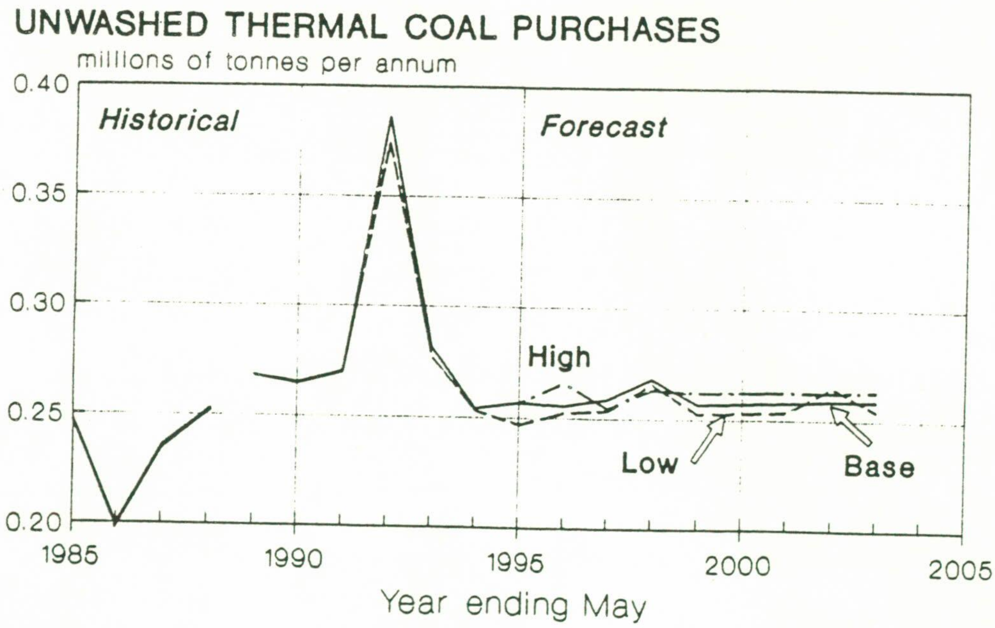


note: Figures are net of sales/purchases of coke and coke oven by-products

Source: MMP

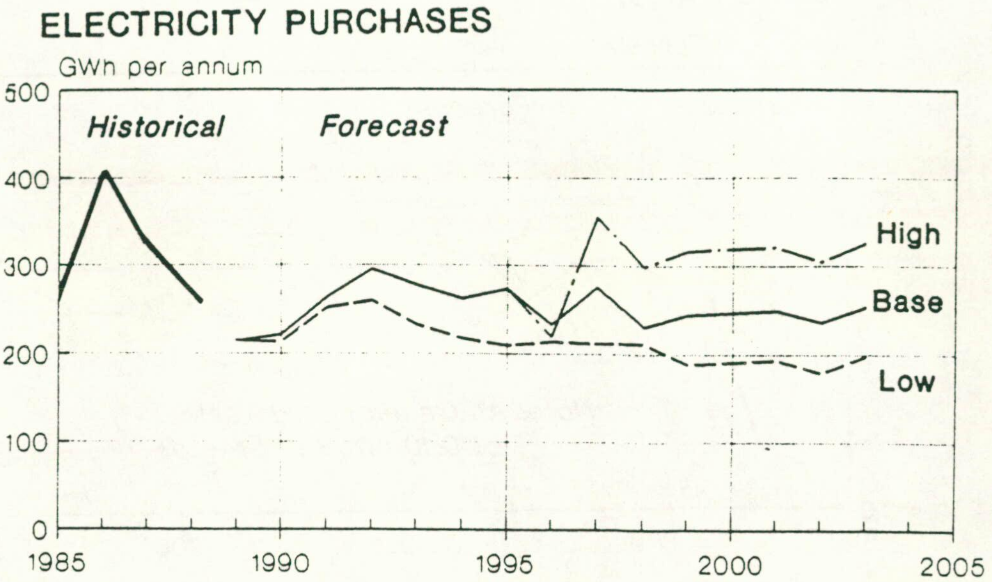
Figure 8.7: Forecast purchases of lumpy coke, washed coking coal and unwashed thermal coal by Newcastle steelworks under the base case, high and low growth scenarios : 1985-2003 (millions of tonnes per annum)

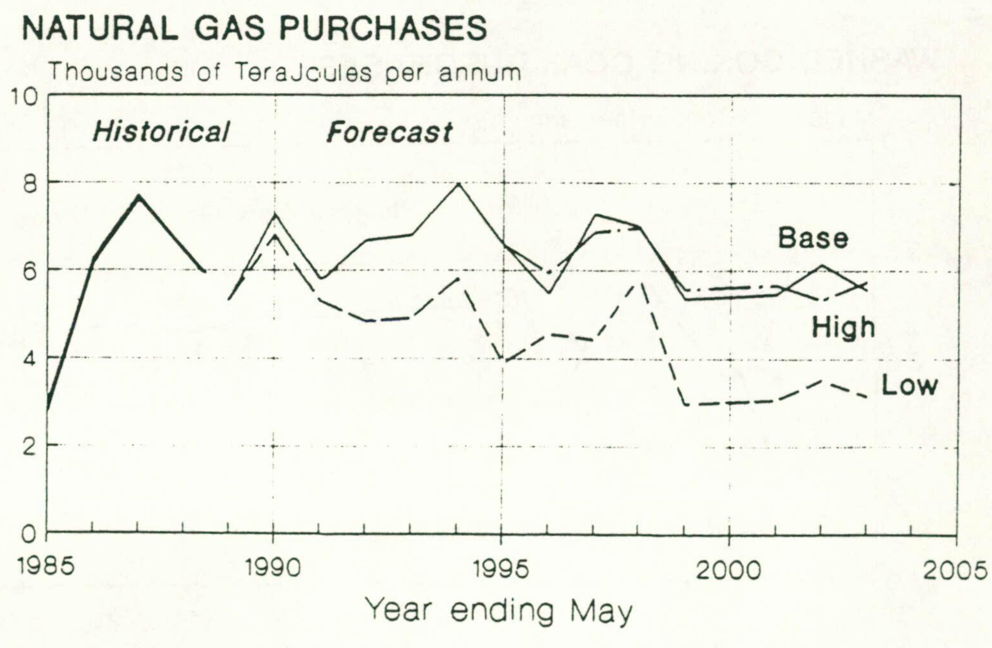




Source: MMP

Figure 8.8: Forecast purchases of electricity and natural gas by Newcastle steelworks under the base case, high and low growth scenarios : 1985-2003 (GWh and TeraJoules per annum)

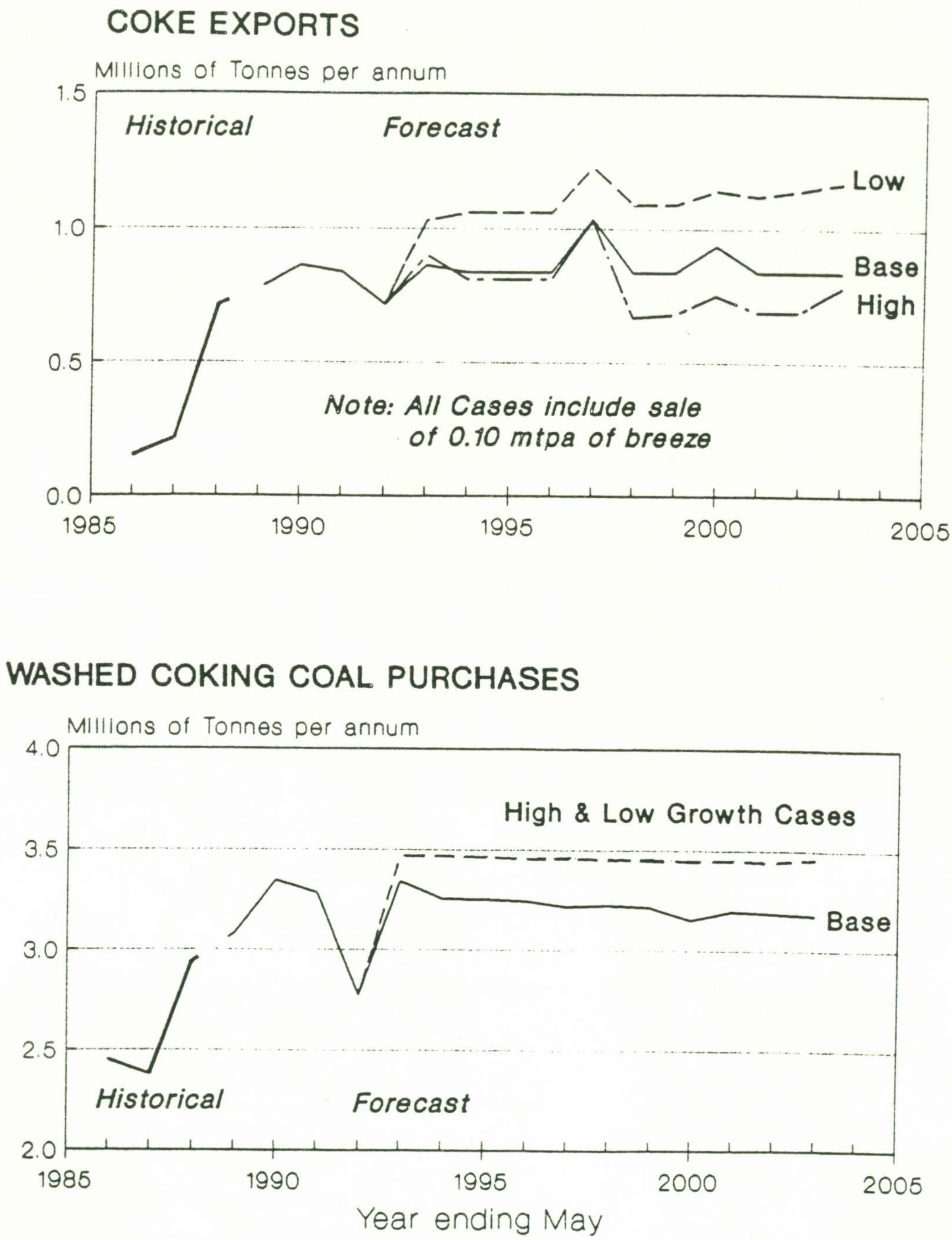




note: 1 PetaJoule = 1000 TeraJoules = 1 million GigaJoules

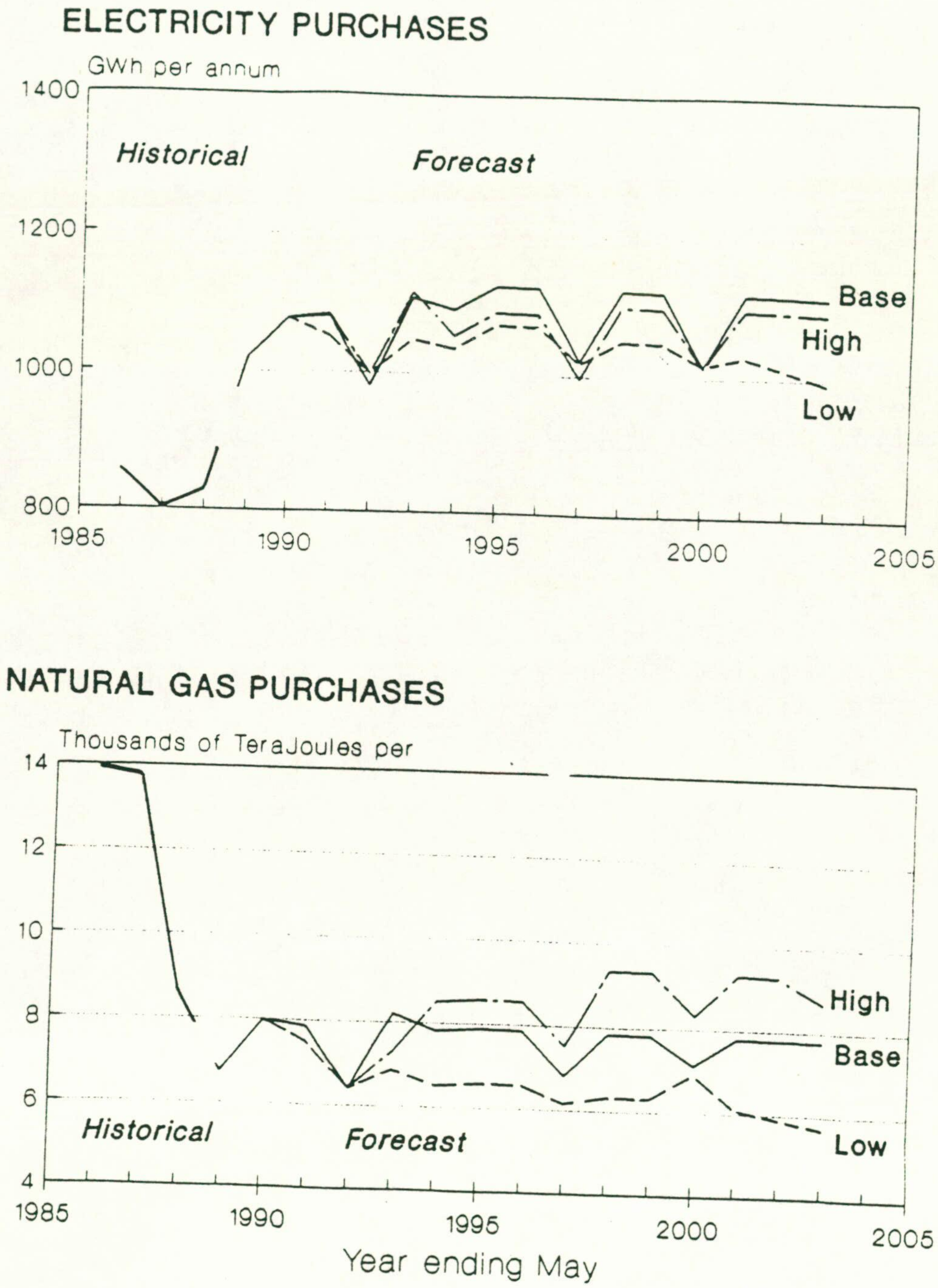
Source: MMP

Figure 8.9: Forecast exports of lumpy coke and purchases of washed coking coal by Port Kembla steelworks under the base case, high and low growth scenarios : 1985-2003 (millions of tonnes per annum)



Source: MMP

Figure 8.10: Forecast purchases of electricity and natural gas by Port Kembla steelworks under the base case, high and low growth scenarios : 1985-2003 (GWh and TeraJoules per annum)



note: 1 PetaJoule = 1000 TeraJoules = 1 million GigaJoules

Source: MMP

APPENDIX A : DETAILED BREAKDOWN OF THE HISTORICAL AND FUTURE LIKELY ENERGY REQUIREMENTS OF THE NSW IRON & STEEL INDUSTRY

The following Tables are attached ...

Table A1: Aggregate energy consumption by fuel type in the Australian basic iron & steel industry
(PetaJoules of energy per annum)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
	<------ historical												------>	<-- MMP est	-->
Crude Steel Make (mtpa)	7.61	7.94	7.76	7.48	7.37	7.51	7.82	7.83	7.18	5.37	6.07	6.21	6.74	6.36	6.01
Primary Fuels used															
Washed Coal	239.1	258.6	246.7	226.1	227.0	230.5	220.7	235.2	213.0	164.6	167.5	174.3	168.0	161.5	175.4
Imported Electricity	12.8	12.7	12.2	12.0	12.8	14.3	14.0	14.5	12.4	10.7	11.0	11.3	11.7	11.9	12.5
Natural & Town Gas	1.7	1.6	1.8	2.2	2.7	4.9	9.2	16.1	17.5	15.9	18.6	20.1	22.8	18.7	17.7
Oil	36.1	30.5	31.3	27.9	26.3	25.9	20.1	11.5	6.0	3.0	2.2	2.2	2.1	1.3	1.1
Other Fuels	3.0	3.1	3.3	2.3	2.6	2.7	2.2	1.7	0.9	0.7	0.6	0.6	0.8	1.0	1.0
Gross Energy Used	292.7	306.5	295.3	270.5	271.4	278.3	266.2	279.0	249.8	194.9	199.9	208.5	205.4	194.4	207.7
less-															
By-Product Exports															
Coke exports (net)	10.6	12.7	12.3	10.7	8.6	7.7	3.9	36.2	9.8	9.1	8.7	8.4	10.8	11.5	22.1
BTX and Tars	5.4	5.4	5.3	5.6	7.2	8.4	8.0	7.5	8.8	9.0	8.6	9.5	9.8	9.3	9.8
Total By-Products	16.0	18.1	17.6	16.3	15.8	16.1	11.9	43.7	18.6	18.1	17.3	17.9	20.6	20.8	31.9
equals -															
Net Energy Used (PJ)	276.7	288.4	277.7	254.2	255.6	262.2	254.3	235.3	231.2	176.8	182.6	190.6	184.8	173.6	175.8

Note: 1 PJ = 1 million GJ

Note: Figures exclude transfers of coke between steelworks

Source: Department of Primary Industries and Energy

Table A2: Energy consumption per unit of steel produced by fuel type in the Australian basic iron & steel industry (GJ per tonne of crude steel)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
	<-------------------------------				historical		-------------------------					------------------->		<-- MMP est -->	
Primary Fuels used															
Washed Coal	31.44	32.58	31.81	30.22	30.80	30.69	28.22	30.04	29.65	30.63	27.59	28.07	24.94	25.39	29.18
Imported Electricity	1.68	1.60	1.57	1.60	1.74	1.90	1.79	1.85	1.73	1.99	1.81	1.82	1.74	1.87	2.08
Natural & Town Gas	0.22	0.20	0.23	0.29	0.37	0.65	1.18	2.06	2.44	2.96	3.06	3.24	3.38	2.94	2.94
Oil	4.75	3.84	4.04	3.73	3.57	3.45	2.57	1.47	0.84	0.56	0.36	0.35	0.31	0.20	0.18
Other Fuels	0.39	0.39	0.43	0.31	0.35	0.36	0.28	0.22	0.13	0.13	0.10	0.10	0.12	0.16	0.17
Gross Energy Used	38.49	38.61	38.07	36.15	36.82	37.06	34.03	35.63	34.78	36.27	32.92	33.58	30.49	30.56	34.55
less-															
By-Product Exports															
Coke exports (net)	1.39	1.60	1.59	1.43	1.17	1.03	0.50	4.62	1.36	1.69	1.43	1.35	1.60	1.81	3.68
BTX and Tars	0.71	0.68	0.68	0.75	0.98	1.12	1.02	0.96	1.23	1.68	1.42	1.53	1.45	1.46	1.63
Total By-Products	2.10	2.28	2.27	2.18	2.14	2.14	1.52	5.58	2.59	3.37	2.85	2.88	3.06	3.27	5.31
equals -															
Net Energy Used per tonne of crude steel (GJ/tcs)	36.38	36.33	35.80	33.97	34.68	34.91	32.51	30.05	32.19	32.91	30.07	30.70	27.43	27.29	29.25

note: 1 PJ = 1 million GJ

note: Figures exclude transfers of coke between steelworks

Source: Department of Primary Industries and Energy and MMP

Table A3: Estimated aggregate future fuel requirements for the NSW iron & steel industry - *Base Case Scenario* : 1989-2003 (in units of fuel)

		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Crude Steel Make	mtpa	5.041	5.359	5.536	5.161	5.806	5.673	5.722	5.553	5.723	5.527	5.579	5.223	5.573	5.533	5.579
Primary Fuels used																
DC Coal to Coke Ovens (a)	mtpa	4.040	4.364	4.320	3.559	4.288	4.197	4.320	4.320	4.320	4.320	4.328	4.280	4.321	4.299	4.301
Boilers Coal (c)	mtpa	0.357	0.360	0.358	0.355	0.359	0.359	0.358	0.360	0.358	0.360	0.359	0.338	0.337	0.338	0.338
Imported Coke (d)	mtpa	(0.748)	(0.777)	(0.823)	(0.448)	(0.728)	(0.747)	(0.801)	(0.837)	(0.800)	(0.837)	(0.801)	(0.901)	(0.801)	(0.837)	(0.801)
Imported Electricity	GWh pa	1264	1381	1473	1393	1590	1547	1554	1490	1555	1480	1503	1418	1522	1508	1524
Natural Gas	TJ pa	13238	11855	13563	14260	14997	14755	14875	14006	14999	13923	13376	12810	13525	14200	13565
Coal Binding Oil	ktpa	7.44	7.79	7.89	6.17	7.48	7.39	7.89	7.89	7.89	7.89	7.89	8.20	8.20	8.20	8.20
By-Product Exports																
BTX	ktpa	33.90	36.16	36.13	29.15	35.20	34.57	36.12	36.12	36.12	36.12	--- included in Tar Figures below ---				
Tar	ktpa	129.88	139.68	138.71	113.44	136.80	134.05	138.71	138.71	138.71	138.71	149.20	170.72	172.15	171.27	171.49

(a) note: Forecast covers Newcastle and Port Kembla steelworks as well as the proposed Sydney mini-mill
(b) note: DC Coal refers to dried coking coal used in the coke ovens.
(c) note: Boilers Coal is unwashed thermal coal with a heat value of 23.8 GJ/tonne
(d) note: Negative number corresponds to coke exports.

Source : BHP and MMP

Table A4: Estimated aggregate future energy requirements for the NSW iron & steel industry - *Base Case Scenario* : 1989-2003 (in millions of GJ)

	Energy Value (GJ/unit)	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Primary Fuels used (PJ)																
DC Coal to Coke Ovens	30.4	122.8	132.7	131.3	108.2	130.4	127.6	131.3	131.3	131.3	131.3	131.6	130.1	131.4	130.7	130.8
Boilers Coal	23.8	8.5	8.6	8.5	8.4	8.5	8.6	8.5	8.6	8.5	8.6	8.6	8.0	8.0	8.0	8.0
Imported Coke	27.0	(20.1)	(21.0)	(22.2)	(12.1)	(19.6)	(20.2)	(21.6)	(22.6)	(21.6)	(22.6)	(21.6)	(24.3)	(21.6)	(22.6)	(21.6)
Imported Electricity	3600.0	4.6	5.0	5.3	5.0	5.7	5.6	5.6	5.4	5.6	5.3	5.4	5.1	5.5	5.4	5.5
Natural Gas	39.7	13.2	11.9	13.6	14.3	15.0	14.8	14.9	14.0	15.0	13.9	13.4	12.8	13.5	14.2	13.6
Coal Binding Oil	40.1	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Miscellaneous Fuels		0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Gross Total Energy Used		129.3	137.4	136.9	124.1	140.4	136.7	139.1	137.1	139.2	136.9	137.7	132.1	137.2	136.2	136.6
less- By-Product Exports																
BTX	37.0	1.3	1.3	1.3	1.1	1.3	1.3	1.3	1.3	1.3	1.3	--- included in Tar Figures below ---				
Tar	46.4	6.0	6.5	6.4	5.3	6.3	6.2	6.4	6.4	6.4	6.4	6.9	7.9	8.0	7.9	8.0
Total By-Products		7.3	7.8	7.8	6.3	7.7	7.5	7.8	7.8	7.8	7.8	6.9	7.9	8.0	7.9	8.0
Net Total Energy Used (PJ)		122.0	129.6	129.1	117.8	132.8	129.2	131.3	129.3	131.5	129.2	130.7	124.2	129.2	128.2	128.7
Energy per tonne of crude steel (GJ/tcs)		24.20	24.18	23.32	22.82	22.86	22.77	22.95	23.28	22.97	23.37	23.43	23.78	23.18	23.18	23.06

(a) note: Forecast covers Newcastle and Port Kembla steelworks as well as the proposed Sydney mini-mill

Source : BHP and MMP

Table A5: Estimated aggregate future fuel requirements for the NSW iron & steel industry - *Low Growth Scenario* : 1989-2003 (in units of fuel)

		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Crude Steel Make	mtpa	5.042	5.317	5.403	4.980	5.282	5.162	5.089	5.114	4.702	5.048	4.903	4.876	4.859	4.787	4.761
Primary Fuels used																
DC Coal to Coke Ovens (a)	mtpa	4.040	4.364	4.336	3.537	4.534	4.580	4.592	4.570	4.563	4.506	4.517	4.520	4.519	4.460	4.527
Boilers Coal (c)	mtpa	0.348	0.344	0.350	0.350	0.352	0.331	0.326	0.330	0.331	0.339	0.327	0.328	0.328	0.336	0.329
Imported Coke (d)	mtpa	(0.746)	(0.777)	(0.837)	(0.476)	(0.955)	(1.060)	(1.058)	(1.060)	(1.230)	(1.090)	(1.090)	(1.140)	(1.120)	(1.140)	(1.170)
Imported Electricity	GWh pa	1264	1376	1415	1413	1435	1408	1435	1438	1384	1417	1392	1363	1378	1345	1346
Natural Gas	TJ pa	13238	11876	12979	11522	12050	12618	10745	11387	10860	12447	9557	10196	9418	9663	9085
Coal Binding Oil	ktpa	8.56	8.90	9.08	7.82	8.76	8.96	9.03	8.97	8.94	8.89	8.78	8.79	8.78	8.55	8.79
By-Product Exports																
BTX & Tar	ktpa	171.47	181.72	187.23	169.88	182.95	185.29	186.04	185.03	184.71	181.93	182.74	182.87	182.81	180.01	183.11

(a) note: Forecast covers Newcastle and Port Kembla steelworks as well as the proposed Sydney mini-mill
(b) note: DC Coal refers to dried coking coal used in the coke ovens.
(c) note: Boilers Coal is unwashed thermal coal with a heat value of 23.8 GJ/tonne
(d) note: Negative number corresponds to coke exports.

Source : BHP and MMP

Table A6: Estimated aggregate future fuel requirements for the NSW iron & steel industry
- *High Growth Scenario* : 1989-2003 (in units of fuel)

		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Crude Steel Make	mtpa	5.042	5.360	5.543	5.158	5.798	6.084	6.111	5.876	5.746	6.508	6.560	6.317	6.565	6.524	6.165
Primary Fuels used																
DC Coal to Coke Ovens (a)	mtpa	4.040	4.364	4.337	3.543	4.539	4.607	4.603	4.537	4.601	4.584	4.590	4.576	4.583	4.570	4.444
Boilers Coal (c)	mtpa	0.348	0.345	0.350	0.350	0.357	0.334	0.336	0.342	0.335	0.342	0.341	0.342	0.342	0.342	0.342
Imported Coke (d)	mtpa	(0.746)	(0.777)	(0.823)	(0.435)	(0.785)	(0.788)	(0.743)	(0.810)	(0.875)	(0.613)	(0.558)	(0.628)	(0.568)	(0.578)	(0.659)
Imported Electricity	GWh pa	1264	1381	1479	1449	1480	1452	1498	1444	1528	1504	1520	1491	1506	1471	1473
Natural Gas	TJ pa	13238	11894	13840	13361	14364	16757	15426	14764	14668	16593	15180	14209	15235	14889	14705
Coal Binding Oil	ktpa	8.56	8.90	9.07	7.62	8.76	9.04	9.04	8.82	9.02	9.01	9.01	8.99	8.99	8.98	8.81
By-Product Exports																
BTX & Tar	ktpa	171.47	181.72	186.90	169.88	182.94	186.29	186.13	183.34	185.84	185.42	185.57	185.03	185.28	184.83	179.95

(a) note: Forecast covers Newcastle and Port Kembla steelworks as well as the proposed Sydney mini-mill
(b) note: DC Coal refers to dried coking coal used in the coke ovens.
(c) note: Boilers Coal is unwashed thermal coal with a heat value of 23.8 GJ/tonne
(d) note: Negative number corresponds to coke exports.

Source : BHP and MMP

Table A7: Estimated fuel requirements for Port Kembla steelworks - *Base Case Scenario* : 1977-1988
(in units of fuel per annum)

		1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
		<-----------------					historical					----------------->	
		4.43	4.42	4.22	4.51	4.84	4.08	3.04	3.44	3.40	3.61	3.20	2.89
Liquid Steel Make	mtpa	4.43	4.42	4.22	4.51	4.84	4.08	3.04	3.44	3.40	3.61	3.20	2.89
Primary Fuels used													
DC Coal to Coke Ovens (a)	mtpa	3.949	4.210	4.001	3.700	3.909	na	2.780	2.832	2.998	2.450	2.377	2.951
Boilers Coal (b)	mtpa	----------			included in C Coal Figure above				----------		0.116	0.127	0.081
Imported Coke (c)	mtpa	0.000	na	(0.617)	(0.209)	(0.083)	na	(0.002)	na	na	(0.151)	(0.209)	(0.719)
Imported Electricity	GWh pa	1200									857	803	831
Natural Gas	TJ pa	0			BHP UNABLE TO GIVE A DETAILED						13956	13807	8560
					BREAKDOWN OF ENERGY USAGE IN								
Coal Binding Oil	ktpa	400			EARLIER YEARS						3.07	3.02	3.06
Propane	ktpa	1.26									0.27	0.20	0.37
By-Product Exports													
BTX	ktpa	24 est									19.32	17.22	20.32
Tar	ktpa	60 est									68.50	73.89	99.11

na = data not available

(a) note: DC Coal refers to dried coking coal used in the coke ovens.
(b) note: Boilers Coal is unwashed thermal coal with a heat value of 23.8 GJ/tonne
(c) note: Negative number corresponds to coke exports.

Source : BHP and MMP

Table A8: Estimated future fuel requirements for Port Kembla steelworks - *Base Case Scenario* : 1989-2003
(in units of fuel per annum)

		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
		<------------ BHP estimate ------------>											<--- MMP estimate --->			
Liquid Steel Make	mtpa	3.260	3.560	3.525	2.987	3.610	3.511	3.540	3.540	3.540	3.540	3.540	3.178	3.522	3.519	3.517
Primary Fuels used																
DC Coal to Coke Ovens (a)	mtpa	2.972	3.291	3.200	2.743	3.291	3.200	3.200	3.200	3.200	3.200	3.200	3.153	3.195	3.186	3.176
Boilers Coal (b)	mtpa	0.022	0.024	0.023	0.020	0.024	0.023	0.023	0.023	0.023	0.023	0.023	- incld in C Coal Figures above -			
Imported Coke (c)	mtpa	(0.777)	(0.861)	(0.837)	(0.717)	(0.861)	(0.837)	(0.837)	(0.837)	(0.837)	(0.837)	(0.837)	(0.937)	(0.837)	(0.837)	(0.837)
Imported Electricity	GWh pa	1025	1135	1104	946	1135	1104	1104	1104	1104	1104	1104	1017	1119	1117	1116
Natural Gas	TJ pa	7199	7973	7751	6644	7973	7751	7751	7751	7751	7751	7751	7146	7781	7781	7742
Coal Binding Oil	ktpa	3.06	3.39	3.29	2.82	3.39	3.29	3.29	3.29	3.29	3.29	3.29	3.60	3.60	3.60	3.60
Propane	ktpa	0.20	0.22	0.22	0.18	0.21	0.22	0.22	0.22	0.22	0.22	0.22	0.60	0.64	0.64	0.64
By-Product Exports																
BTX	ktpa	20.46	22.66	22.03	18.88	22.66	22.03	22.03	22.03	22.03	22.03	22.03	- incld in Tar Figures below -			
Tar	ktpa	89.44	99.05	96.29	82.54	99.05	96.29	96.29	96.29	96.29	96.29	96.29	117.81	119.35	119.02	118.69

(a) note: DC Coal refers to dried coking coal used in the coke ovens.
(b) note: Boilers Coal is unwashed thermal coal with a heat value of 23.8 GJ/tonne

Source : BHP and MMP

Table A9: Estimated energy requirements for Port Kembla steelworks - *Base Case Scenario* : 1977-1988
(in millions of GJ per annum)

	Energy Value (GJ/unit)	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Primary Fuels used (PJ)		<----------				historical					---------->		
DC Coal to Coke Ovens	30.4	120.0	128.0	121.6	112.5	118.8	na	84.5	86.1	91.1	74.5	72.3	89.7
Boilers Coal	23.8	----------			included in C Coal Figure above					----------	2.8	3.0	1.9
Imported Coke	27.0	0.0	na	(16.7)	(5.6)	(1.7)	na	(0.1)	na	na	(4.1)	(5.6)	(19.4)
Imported Electricity	3600.0	4.3									3.1	2.9	3.0
Natural Gas	39.7	0.0									14.0	13.8	8.6
Coal Binding Oil	40.1	16.0									0.1	0.1	0.1
Propane	50.0	0.1									0.0	0.0	0.0
		----									----	----	----
Gross Total Energy Used		140.5									90.3	86.5	83.9
less-						BHP UNABLE TO GIVE A DETAILED BREAKDOWN OF ENERGY USAGE IN EARLIER YEARS							
By-Product Exports													
BTX	37.0	0.9									0.7	0.6	0.8
Tar	46.4	2.8									3.2	3.4	4.6
		----									----	----	----
Total By-Products		3.7									3.9	4.1	5.4
			est	est	est	est	est	est	est	est			
Net Total Energy Used (PJ)		136.8	159	153	142	132	134	108	110	115	86.4	82.4	78.6
Energy per tonne of crude steel (GJ/tcs)		30.91	36.0	36.4	31.5	27.3	32.8	35.3	31.8	33.8	23.97	25.77	27.21

note: 1 PJ = 1 million GJ

Source : BHP and MMP

Table A10: Estimated future energy requirements for Port Kembla steelworks - *Base Case Scenario* : 1989-2003
(in millions of GJ per annum)

	Energy Value (GJ/unit)	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Primary Fuels used (PJ)		<-------------			BHP estimate							----------->	<---	MMP estimate		--->
DC Coal to Coke Ovens	30.4	90.4	100.1	97.3	83.4	100.1	97.3	97.3	97.3	97.3	97.3	97.3	95.9	97.1	96.9	96.6
Boilers Coal	23.8	0.5	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	- incld in C Coal Figures above -			
Imported Coke	27.0	(21.0)	(23.2)	(22.6)	(19.4)	(23.2)	(22.6)	(22.6)	(22.6)	(22.6)	(22.6)	(22.6)	(25.3)	(22.6)	(22.6)	(22.6)
Imported Electricity	3600.0	3.7	4.1	4.0	3.4	4.1	4.0	4.0	4.0	4.0	4.0	4.0	3.7	4.0	4.0	4.0
Natural Gas	39.7	7.2	8.0	7.8	6.6	8.0	7.8	7.8	7.8	7.8	7.8	7.8	7.1	7.8	7.8	7.7
Coal Binding Oil	40.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Propane	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gross Total Energy Used		80.9	89.6	87.1	74.7	89.6	87.1	87.1	87.1	87.1	87.1	87.1	106.8	86.5	86.2	85.9
less-																
By-Product Exports																
BTX	37.0	0.8	0.8	0.8	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	- incld in Tar Figures below -			
Tar	46.4	4.1	4.6	4.5	3.8	4.6	4.5	4.5	4.5	4.5	4.5	4.5	5.5	5.5	5.5	5.5
Total By-Products		4.9	5.4	5.3	4.5	5.4	5.3	5.3	5.3	5.3	5.3	5.3	5.5	5.5	5.5	5.5
Net Total Energy Used (PJ)		76.0	84.2	81.8	70.1	84.2	81.8	81.8	81.8	81.8	81.8	81.8	101.4	81.0	80.7	80.4
Energy per tonne of crude steel (GJ/tcs)		23.31	23.64	23.21	23.48	23.31	23.31	23.11	23.11	23.11	23.11	23.11	31.90	22.99	22.94	22.85

note: 1 PJ = 1 million GJ

Source : BHP and MMP

Table A11: Estimated fuel requirements for Newcastle steelworks - *Base Case Scenario* : 1989-2003 : 1977-1988
(in units of fuel per annum)

		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
		<------------------------------				historical				------------------------------>		
Liquid Steel Make	mtpa	2.091	2.087	2.018	2.159	2.152	1.518	1.538	1.814	1.900	1.824	
Primary Fuels used												
DC Coal to Coke Ovens (a)	mtpa	1.830	1.909	1.907	2.024	1.937	1.325	1.104	1.095	1.099	1.048	
Boilers Coal (b)	mtpa	0.284	0.245	0.242	0.230	0.260	0.195	0.202	0.247	0.193	0.236	
Imported Coke (c)	mtpa	(0.095)	(0.216)	(0.152)	(0.182)	(0.073)	(0.020)	(0.038)	0.013	0.085	0.069	
Imported Electricity	GWh pa	281	348	442	445	406	337	345	260	408	324	
Natural Gas	TJ pa	0	0	0	0	0	487	3057	2849	6289	7726	
Coal Binding Oil	ktpa	32.47	89.22	78.73	41.22	23.00	10.99	5.83	5.56	7.54	7.41	
By-Product Exports												
BTX	ktpa	20.43	21.94	21.48	23.14	22.60	21.64	13.29	12.88	12.82	12.70	
Tar	ktpa	72.32	83.00	87.21	64.26	71.98	60.67	37.10	41.13	41.13	38.69	

(a) note: DC Coal refers to dried coking coal used in the coke ovens.
(b) note: Boilers Coal is a mixture of unwashed thermal coal and middlings from coal washeries. Its heat value is 23.8 GJ/tonne.
(c) note: Negative number corresponds to coke exports.

Source : BHP and MMP

Table A12: Estimated future fuel requirements for Newcastle steelworks - *Base Case Scenario* : 1989-2003
(in units of fuel per annum)

		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
		<------------------------ BHP estimate									-->	<----- MMP estimate ------------->				
Liquid Steel Make	mtpa	1.781	1.799	1.831	1.924	1.946	1.912	1.932	1.763	1.933	1.737	1.789	1.795	1.801	1.764	1.812
Primary Fuels used																
DC Coal to Coke Ovens (a)	mtpa	1.068	1.073	1.120	0.816	0.997	0.997	1.120	1.120	1.120	1.120	1.128	1.127	1.126	1.113	1.125
Boilers Coal (b)	mtpa	0.335	0.336	0.335	0.335	0.335	0.336	0.335	0.337	0.335	0.337	0.336	0.336	0.337	0.338	0.338
Imported Coke (c)	mtpa	0.031	0.084	0.014	0.269	0.135	0.090	0.036	0.000	0.037	0.000	0.036	0.036	0.036	0.000	0.036
Imported Electricity	GWh pa	239	246	258	293	301	289	296	232	297	222	245	247	249	237	254
Natural Gas	TJ pa	6039	3882	5622	7351	6759	6739	6859	5990	6983	5907	5360	5399	5479	6154	5558
Coal Binding Oil	ktpa	4.38	4.41	4.60	3.35	4.09	4.09	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60	4.60
By-Product Exports																
BTX	ktpa	13.44	13.50	14.09	10.27	12.55	12.55	14.09	14.09	14.09	14.09	--- included in Tar figures below ---				
Tar	ktpa	40.45	40.64	42.42	30.90	37.76	37.76	42.42	42.42	42.42	42.42	52.91	52.91	52.80	52.25	52.80

(a) note: DC Coal refers to dried coking coal used in the coke ovens.
(b) note: Boilers Coal is a mixture of unwashed thermal coal and middlings from coal washeries. Its heat value is 23.8 GJ/tonne.

Source : BHP and MMP

Table A13: Estimated energy requirements for Newcastle steelworks : 1977-1988 (in millions of GJ per annum)

	Energy Value (GJ/unit)	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Primary Fuels used (PJ)		<-------------				historical				------------->		
DC Coal to Coke Ovens	30.4	55.6	58.0	58.0	61.5	58.9	40.3	33.6	33.3	33.4	31.9	
Boilers Coal	23.8	6.3	5.8	5.8	5.5	6.2	4.6	4.8	5.9	4.6	5.6	
Imported Coke	27.0	(2.6)	(5.8)	(4.1)	(4.4)	(2.0)	(0.5)	(1.0)	0.4	2.3	1.9	
Imported Electricity	3600.0	1.0	1.3	1.6	1.6	1.5	1.2	1.2	0.9	1.5	1.2	
Natural Gas	39.7	0.0	0.0	0.0	0.0	0.0	0.5	3.1	2.8	6.3	7.7	
Coal Binding Oil	40.1	1.3	3.6	3.2	1.7	0.9	0.4	0.2	0.2	0.3	0.3	
		----	----	----	----	----	----	----	----	----	----	
Gross Total Energy Used		61.7	62.9	64.4	65.9	65.5	46.5	41.9	43.5	48.4	48.5	
less-												
By-Product Exports												
BTX	37.0	0.8	0.8	0.8	0.9	0.8	0.8	0.5	0.5	0.5	0.5	
Tar	46.4	3.4	2.9	3.1	3.0	3.3	2.8	1.7	1.9	1.9	1.8	
		----	----	----	----	----	----	----	----	----	----	
Total By-Products		4.1	3.7	3.9	3.8	4.2	3.6	2.2	2.4	2.4	2.3	
Net Total Energy Used (PJ)		57.6	59.1	60.5	62.0	61.3	42.9	39.7	41.1	46.0	46.3	
Energy per tonne of crude steel (GJ/tcs)		27.52	28.61	29.96	28.74	28.49	28.25	25.79	25.49	24.20	25.36	

note: 1 PJ = 1 million GJ

Source : BHP and MMP

Table A14: Estimated future energy requirements for Newcastle steelworks - *Base Case Scenario* : 1989-2003 (in millions of GJ per annum)

	Energy Value (GJ/unit)	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Primary Fuels used (PJ)		<----------			BHP estimate					------->		<-----	MMP estimate			----->
DC Coal to Coke Ovens	30.4	32.5	32.6	34.0	24.8	30.3	30.3	34.0	34.0	34.0	34.0	34.3	34.3	34.2	33.8	34.2
Boilers Coal	23.8	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Imported Coke	27.0	0.8	2.3	0.4	7.3	3.6	2.4	1.0	0.0	1.0	0.0	1.0	1.0	1.0	0.0	1.0
Imported Electricity	3600.0	0.9	0.9	0.9	1.1	1.1	1.0	1.1	0.8	1.1	0.8	0.9	0.9	0.9	0.9	0.9
Natural Gas	39.7	6.0	3.9	5.6	7.4	6.8	6.7	6.9	6.0	7.0	5.9	5.4	5.4	5.5	6.2	5.6
Coal Binding Oil	40.1	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
		----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Gross Total Energy Used		48.4	47.8	49.1	48.6	49.9	48.7	51.1	49.1	51.3	49.0	49.7	49.7	49.8	49.1	49.9
less-																
By-Product Exports																
BTX	37.0	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.0	0.0
Tar	46.4	1.9	1.9	2.0	1.4	1.8	1.8	2.0	2.0	2.0	2.0	2.5	2.5	2.4	2.4	2.4
		----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Total By-Products		2.4	2.4	2.5	1.8	2.2	2.2	2.5	2.5	2.5	2.5	2.5	2.5	2.4	2.4	2.4
Net Total Energy Used (PJ)		46.0	45.4	46.6	46.8	47.7	46.5	48.6	46.6	48.8	46.5	47.2	47.2	47.3	46.6	47.4
		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Energy per tonne of crude steel (GJ/tcs)		25.82	25.26	25.47	24.31	24.52	24.30	25.16	26.43	25.23	26.75	26.40	26.32	26.28	26.44	26.17
		-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

note: 1 PJ = 1 million GJ

Source : BHP and MMP

Table A15: Estimated future energy requirements for the proposed Sydney mini-mill - *Base Case and Low/High Growth Scenarios* : 1989-2003 (in units of fuel and millions of GJ per annum)

		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
		<------ BHP estimate ------>										<---- MMP estimate ---->				
Steel Billets	mtpa	0.000	0.000	0.180	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250
Primary Fuels used																
Imported Electricity	GWh pa	0	0	111	154	154	154	154	154	154	154	154	154	154	154	154
Natural Gas	TJ pa	0	0	190	265	265	265	265	265	265	265	265	265	265	265	265
Added Carbon (b)	TJ pa	0	0	36	51	51	51	51	51	51	51	51	51	51	51	51
Energy Consumed (PJ)																
Imported Electricity		0.00	0.00	0.40	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
Natural Gas		0.00	0.00	0.19	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Added Carbon		0.00	0.00	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Total Energy Used (PJ)		0.00	0.00	0.63	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Energy per tonne of steel (GJ/ts)		na	na	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48	3.48

(a) note: Have assumed that operating levels and energy requirements are same in low/high and base case scenarios

(b) note: Added Carbon used to meet steel grade requirements and slag control

Source : BHP and MMP