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United Nations Industrial Development Organisation

and

The Government of the Kingdom of Thailand

Master plan for the iron and steel industry in Thailand

FINAL REPORT

WS Atkins International

May 1990

DP / THA / 87 / 021

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Date 29th May 1990

Ext no 2539

Dr Tetsuo Kikutake
Industrial Development Officer
Metallurgical Industries Branch
United Nations Industrial Development Organization
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AUSTRIA

Dear Dr Kikutake

Masterplan for the Iron and Steel Industry in Thailand

We have pleasure in submitting our Final Report concerning the future of the iron and steel industry within the Kingdom of Thailand. The report has been prepared in accordance with the Terms of Reference issued by you in February 1989.

The objective of the assignment was to advise the Government of Thailand on the best way of restructuring the existing industry in the sector and of providing a wider range of products.

As you are aware, we have made two visits to Thailand to undertake field studies. These visits were made in November 1989 and February 1990. The interviews undertaken are described in our weekly progress reports. After the first visit we submitted our Interim Report. In April 1990 we submitted our Draft Final Report.

The terms of reference provide for an overview to be made of all the sub-sectors, followed by a more detailed analysis of the more relevant ones. The Report considers in detail the manufacture of flat and long products and of directly reduced iron to provide feedstock to the electric arc furnaces. Only the foundry industry and the production of special steels have not been covered in a comprehensive fashion. We have carried out some additional work on site location for the proposed flat products plant, as described in our letter of 11th January, 1990 and approved in your telex of 12th March.

We are grateful to the staff of the Office of Basic Industry Development in the Ministry of Industry for all the assistance they have given us in carrying out the study.

Yours faithfully
for and on behalf of
WS ATKINS INTERNATIONAL LIMITED

R A F Collins
Technical Director

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANISATION

AND

THE GOVERNMENT OF THE KINGDOM OF THAILAND

MASTERPLAN FOR THE IRON AND STEEL INDUSTRY IN THAILAND

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Woodcote Grove - Ashley Road

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ABBREVIATIONS USED IN THIS REPORT

Organisations:

MoI	-	Ministry of Industry
OBD	-	Office of Basic Industry Development
BoI	-	Board of Investment
SISCO	-	Siam Iron and Steel Co.
NTS	-	Nakorn Thai Steel
BSI	-	Bangkok Steel Industry
TTP	-	Thai Tinplate Co.
EGAT	-	Electricity Authority of Thailand
PTT	-	Petroleum Authority of Thailand
ESTS	-	Estel Technical Services bv.
EUC	-	USX Engineers and Consultants
SSDP	-	Southern Seaboard Development Programme

Technical terms:

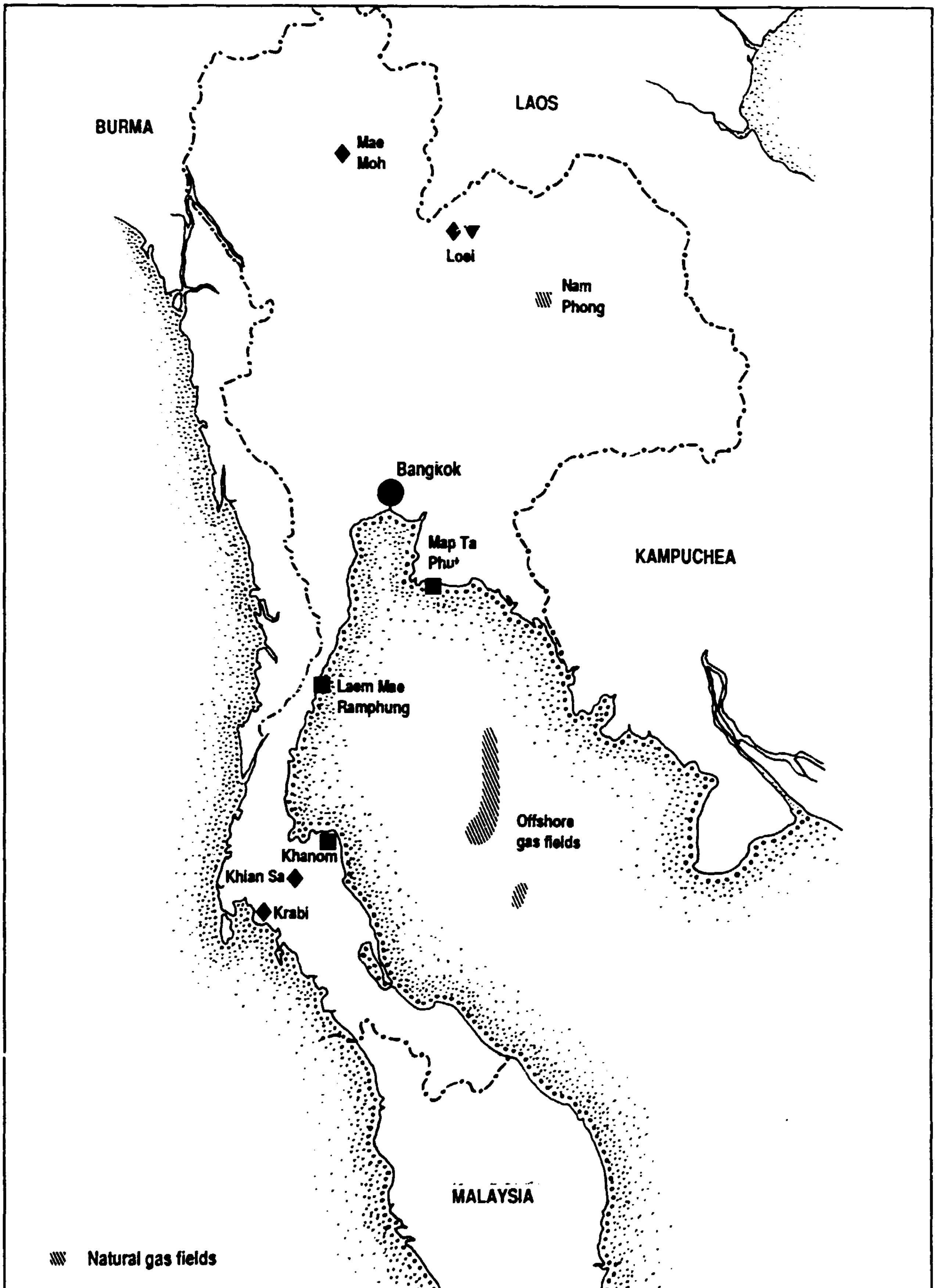
DR/EAF	-	directly reduced iron fed to an electric arc furnace
BF/BOF	-	blast furnace and basic oxygen process route
HBI	-	hot briquetted iron
UHP	-	ultra high power
ERW	-	electric resistance welded
HRC	-	hot rolled coil
CRC	-	cold rolled coil
CSP	-	compact strip production
EOF	-	energy optimisation furnace

Units:

BTU	-	British Thermal Units
mBTU	-	millions of BTU's
scfd	-	standard cubic feed per day
tpa	-	(metric) tonnes per annum
m tonnes	-	million (metric) tonnes
MVA	-	millions of volt-amperes

Land areas are expressed in rai
(1 hectare = 6.17 rai)

Monetary values are expressed in baht and US dollars
(US$1 = 25.5 baht)


BURMA
LAOS
Mae Moh
Loei
Nam Phong
Bangkok
Map Ta Phut
KAMPUCHEA
Laem Mae Ramphung
Offshore gas fields
Khanom
Khian Sa
Krabi
MALAYSIA
Natural gas fields
Iron ore deposits
Ignite deposits
Potential steelworks sites

1. INTRODUCTION

1.1 Background to the Study

The Thai economy is growing at a very rapid rate - indeed it is probably one of the fastest growing economies in the world at the present time. This expansion is particularly notable in the manufacturing sector and with it has come a considerable growth in the demand for steel, a basic raw material for a wide range of industries.

All flat products are currently imported and, while there is a significant capacity for producing long products, even in this market imports are increasing rapidly. In value terms steel represents about 10% of total imports.

The Government of Thailand have responded to this surge in demand by issuing licences to existing steel producers that will allow both the expansion of long products and the introduction of flat products production into the country.

The Ministry of Industry have the task of co-ordinating developments in the iron and steel sector and of formulating future policy regarding its operation. To assist them in this task the United Nations Industrial Development Organization have commissioned a study to update a master plan for the sector originally proposed by the consultants Austroplan in 1978. The plan is to cover the period up to the year 2000.

1.2 Terms of Reference of the Study

The objective of the study is to advise the Ministry on the best way of restructuring the existing industry and of providing a wider range of domestically produced steel products. The study is to provide the Government with an action plan that will enable them to regulate the industry in a way that is beneficial for the country as a whole.

In carrying out the study the Consultants have undertaken investigations into the following key areas:

* the current and projected demand for steel products within Thailand;

* the existing producers of steel (ie long products manufacturers) and the industries associated with transforming intermediate products into finished goods (ie coating and finishing lines for flat products);

* the availability of raw materials and energy, both locally and from import sources;

* the requirements of the industry in terms of infrastructure;

* the viability of new projects for increasing both the quantity and range of domestic production.

1.3 Study Programme

The study has been carried out in two stages. Firstly the Consultants visited Thailand for three weeks in November and December 1989. With the help of staff from the Office of Basic Industry Development they conducted interviews with steel producers and consumers and relevant Government Departments concerning energy and infrastructure. At the end of this visit a number of follow-up interviews were carried out by OBID.

A second field trip was made in February 1990 to conduct further interviews and to present the Consultants' draft conclusions. After this visit the Final Report was written.

1.4 Previous Reports on the Thai Iron and Steel Sector

A number of studies have been carried out either on the whole of, or part of, the steel industry. These have been reviewed by the Consultants and a brief summary of each is presented here.

Austroplan Master Plan Study, 1978

This study forecast a total market for steel products as follows:

Year	Flat products hot rolled ('000 t)	Flat products cold rolled ('000 t)	Long Products ('000 t)
1990	730	1100	1660
1995	1110	1600	2370
2000	1600	2200	3170

The forecasts for 1990 are a little lower than the 1988 actual consumption.

To cater for this demand a flat products works was recommended to be built, starting production in 1987 and expanding in stages. The preferred technology was the use of directly reduced iron in an electric arc furnace (DR/EAF), supplying in the year 2000, 2.1 million tonnes of cold rolled products and 1.7 million tonnes of hot rolled.

This plant would also be able to supply DRI to the existing long products producers as a substitute for scrap. In the 1990's a new long products facility was envisaged, again using DRI.

The choice of DR was based on the assumption of low gas prices (1.4 US dollars per million BTU's) and a recommendation was made that the Government should supply gas at the subsidised price of 1 US dollar per million BTU's. If this was not possible the alternative blast furnace and basic oxygen furnace (BF/BOF) route should be considered, using imported coal. Both schemes would use imported iron-ore.

The financial viability of the proposed schemes was such that no alternative would operate at a profit, but it was pointed out that this was the same situation as in many other parts of the world at that time.

ESTS Feasibility Study, 1982 & 1984

This study was carried out in two parts. The first part identified potential sites for a new steel plant. The second part concentrated on the detailed feasibility of an integrated flat products plant at Laem Mae Ramphung on the West Coast of the Gulf of Thailand.

The market forecasts were as follows:

Year	Flat Products (a) ('000 t)	Long Products ('000 t)
1990	1750	1280
2000	3200	1950

(a) seamless tubes consumption have been removed from the figures

The forecasts for 1990 are much lower than the actual 1988 consumption. This is because the early 1980's were a time of slow growth in steel demand, influencing the forecasts accordingly.

As higher natural gas prices than those assumed in the Austoplan study were then forecast (3.75 US dollars per million BTU), the BF/BOF route was chosen for the proposed development - using imported coal and iron ore.

The project was expected to be profitable with an internal rate of return of 11%.

UEC Pre-feasibility Study, 1988

This study restricted itself to the flat products market and developed an outline plan for EAF-based steelmaking using the recently developed process of thin slab casting. The feedstock was assumed to be a mixture of scrap and DRI, with the latter purchased from an unspecified external source.

The market forecasts were as follows:

Year	Hot Rolled ('000 t)	Cold Rolled ('000 t)
1992	1432	893
1997	1711	1130

The forecasts for 1992 are fairly similar to the actual consumption in 1988. They are therefore conservative. The study team were aware of the large growth in demand occurring in 1987 (though complete figures for that year were not available to them) but they assumed that this was likely to be a short term phenomena - a reasonable assumption at the time considering the overall growth pattern of the preceding years.

In choosing the technology for a new flat products facility, the study differed from the previous two mentioned reports. A smaller steel-making facility was chosen for three reasons:

* the market forecasts were lower than the other studies;

* the technology of mini-mills, thin slab casting and a lighter strip mill was seen as a promising new development for use in countries with smaller flat products markets;

* because the development was to be constructed by the private sector, it was important to restrict the capital investment to manageable proportions.

The latter point is significant. The UEC capital cost estimates for a mini-mill with hot and cold rolling were about one billion US dollars while the ESTS scheme required an investment of 2.5 billion US dollars. (Infrastructure requirements are excluded in each case.)

The report found that stand-alone rolling facilities were not financially very attractive but that when provided with their own steelmaking facilities, returns of 10% and more were obtainable.

1.5 Layout of the Current Study

Section 2 of this study describes the existing steel producers in Thailand. It is followed in Section 3 by a historic review of the market and projections for future growth.

Sections 4 to 7 describe some potential developments for expanding domestic production, together with a discussion on infrastructure and site location. Section 8 estimates the returns on the more promising alternatives, whilst Section 9 deals with Government policy and the steps which need to be taken to assist the industry to grow. Finally, Section 10 summarises the conclusions of the study.

2. THE EXISTING STEEL INDUSTRY IN THAILAND

The existing steel industry in Thailand can be divided into three main sectors, namely:

* long products involving the production of mainly low carbon steel reinforcing bars, wire rods and light sections from continuous cast billets produced in scrap-based electric arc furnaces or imported; or the production of re-rolled reinforcing bars and wire rods by the reheating and rolling of feed stock cut from ship plate, second quality plate, or imported billets

* flat products involving the finishing of imported cold rolled strip into hot dip galvanised sheet, tinplate or tin free steel; and hot rolled strip into electric resistance welded (ERW) pipes, spiral weld or 'UO' pipes and cold formed sections;

* steel castings.

2.1 The Size and Scope of Long Products Production

There are currently 8 scrap based electric arc furnace (EAF) steelmaking facilities equipped with billet continuous casting machines and rolling mills with a total licenced steelmaking capacity of about one million tonnes per annum.

In addition there are a large number of re-rolling mills, claimed to be as many as 48, with an estimated combined production capacity of between 500,000 and 600,000 tonnes per annum of rolled products. This annual re-rolling production capacity appears greatly understated, if we were to accept the annual production of re-rolled products given in Thailand metal statistics compiled by the Metallurgy Division of the Department of Mineral Resources.

Their annual long products productions for the period from 1983 to 1988 are given in Table 2.1 below.

TABLE 2.1 - THAILAND LONG PRODUCTS PRODUCTION FROM 1983 TO 1988
('000 Tonnes)

Works	1983	1984	1985	1986	1987	1988
Melters/Rolling Mills	294	356	406	401	452	496
Re-Rolling Mills	687	491	641	377	912	890
Total Production	981	847	1 047	778	1 364	1 386

Source: Department of Mineral Resources

This table indicates that for many of the years concerned, the re-rollers had levels of production more than double those of the melters. This is believed to be incorrect. In particular, the years 1987 and 1988 show the re-rollers producing around 900,000 tonnes annually, which is over 50 percent greater than their combined production capacities.

Consequently, it is considered that a more accurate assessment of the levels of long products production can be achieved by using the annual tonnages for imported steel scrap and billets given by the Customs Department.

The imported steel scrap comprises melting scrap for the electric arc furnaces (EAFs), re-useable scrap for fabrication and construction, and cobble plate scrap for re-rolling mills. Also, a small amount of imported scrap may go to foundries.

It is difficult to quantify how much steel scrap is classified as re-useable scrap, but several informed industrial sources have estimated it to be over 20 percent, so it has been fixed at 25 percent.

The steel scrap for re-rolling is assumed to be all scrap remaining after subtracting the tonnages of melting and re-useable scrap from the total imported scrap.

Product yields were assumed to be 95 percent from billets and 90 percent from cobble plate scrap.

Table 2.2 gives the estimated long products productions of both the melters, and the re-rollers, for the period 1983 to 1988 based on these assumptions.

This table shows that the overall long products production from 1983 to 1986 fluctuated between 700,000 and 900,000 tonnes annually, with the total melters production being generally between 10 and 20 percent greater than the re-rollers total production.

Production increased to 1.1 million tonnes in 1987, with the re-rollers total production increasing at a greater rate than the melters, giving them an equal share of the total long products production. A further increase in total production to 1.4 million tonnes is shown in 1988.

Table 2.3 gives the estimated breakdown of long products production in 1988.

TABLE 2.2 - ESTIMATED LONG PRODUCTS PRODUCTION 1982 TO 1988
('000 Tonnes)

Item	1983	1984	1985	1986	1987	1988
Imported Scrap						
Total [a]	641	494	658	555	903	1 158
Re-useable (25%)	160	124	165	139	226	290
For steelmaking [b]	28	16	31	28	86	105
For re-rolling	453	354	472	388	591	763
Domestic Scrap						
For steelmaking [b]	376	435	491	510	531	509
Total steelmaking scrap	404	451	522	538	617	614
Billet Prodn. [b]	340	381	447	463	534	555
Billet imports [a]	36	14	44	0	47	159
Total Billets	376	395	491	463	581	714
Products from Billets (95%)	357	375	466	440	552	678
RR Prods. from scrap (90%)	408	319	423	349	532	687
TOTAL Long Products Prodn.	765	694	889	789	1 084	1 365

Sources: (a) Customs Statistics
(b) Thailand Metal Statistics

TABLE 2.3 - ESTIMATED LONG PRODUCTS PRODUCTION IN 1988

('000 tonnes)

Works	Round Bars	Deformed Bars	Wire Rod	P.C Wire Rod	Rolled Sections	Others	Total Prodn.
Melters	139	217	140	26	40	16	578
Re-Rollers	574	153	50	-	10	-	787
Total	713	370	190	26	50	16	1365

The imported scrap consumption of the melters was very low (about 5 percent) during the period from 1983 to 1986, but has progressively increased from that time, until the present when it has reached about 30 percent. Imported scrap has been needed to supplement the limited domestic steel scrap available said to be currently about 500,000 tpa.

2.1.1 Estimated long products production in 1989

Melters/Rolling Mills Production

Statistics of the Department of Mineral Resources show the melters production of long products during the period of January to end September 1989 was 550,000 tonnes, comprising: 116,000 tonnes (21%) round bars, 256,000 tonnes (47%) deformed bars, 110,000 tonnes (20%) wire rod, 24,000 tonnes (4%) prestressed concrete wire, 35,000 tonnes (6%) rolled section and 9,000 tonnes (2%) of other products.

The melters production of continuous cast billets during the same period was 500,000 tonnes. Extrapolation of these tonnages to a 12 months basis, gives the following:

Product	Estimated Production from EAF's ('000 tonnes)
Round bar	154
Deformed bar	341
Wire rod	146
P.C. wire rod	32
Rolled sections	47
Other products	12
Total	732
Billets production	665

Based on a yield of 95 percent, the total billet requirement is 770,000 tonnes, which would comprise of 665,000 tonnes of produced billets plus 105,000 tonnes of imported billets.

Re-Rollers Production

No information was available on the total re-rolled production over any period during 1989.

However, several factors are known which will influence output from the re-rollers. Due to the virtual disappearance of ship plate in the scrap market, the re-rollers during 1989 have been forced to use cobble plate as feed stock to their rolling mills. Cobble plate has historically been a more expensive feedstock than ship plate, and during 1989 it has commanded a high price in the scrap market. To minimise their costs, many re-rollers concentrate their production within a narrow range of reinforcing bar sizes, generally 6 to 12mm diameters. In producing these sizes, the re-rollers production rates will be much lower than the melters, many of whom concentrate their production on the larger bar diameters.

With re-rollers concentrating their production on small reinforcing bar sizes, it is difficult to foresee any great increase in production during 1989, particularly as they are currently close to their combined production capacity. Consequently, the re-rollers production during 1989 is estimated at 668,000 tonnes.

Total Long Products Production

The estimated long products production in 1989 is 1.4 million tonnes, comprising 732,000 tonnes by the melters rolling mills and 668,000 tonnes by the re-rolling mills.

The assumed breakdown of these productions into products is shown in Table 2.4.

TABLE 2.4 - ESTIMATED LONG PRODUCTS PRODUCTION IN 1989

('000 tonnes)

Works	Round Bars	Deformed Bars	Wire Rod	P.C. Wire Rod	Rolled Sections	Others	Total Frodn.
Melters	154	341	146	32	47	12	732
Re-Rollers	542	59	54	-	13	-	668
Total x1000t	696	400	200	32	60	12	1400

2.2 The Technology Employed by the Melters/Rolling Mills

The 8 operating melters/rolling mills in Thailand all have small capacity steelmaking and rolling facilities compared to their European, Japanese and American counterparts. They are generally operating EAF's with nominal capacities of 20 to 30 tonnes but with the two smallest melters operating with EAF's of between 6 and 10 tonnes nominal capacity.

The melter's licensed steelmaking capacities, together with their reported actual productions in 1988, estimated productions during 1989, and recently approved additional steelmaking capacities are shown in Table 2.5.

TABLE 2.5 - MELTERS PRODUCTIONS AND LICENSED CAPACITIES

STEELWORKS	Licensed Steelmaking Capacity tpa	1988 Long Production tpa	1989 Products Production tpa	Licensed New Steelmaking Capacity tpa	Future Total Licensed Steelmaking Capacity tpa
Bangkok Steel Industry	120,000	89,400	114,000	360,000	480,000
Siam Steel Syndicate	120.000 (a)	35,000 (b)	48,000 (b)	-	120,000
Thai India Steel	46,000	20,800 (c)	22,000	-	46,000
Thai Paihana Steel	80,000	22,200	24,000	-	80,000
Thai Steel Bar	144,000	33,400	94,000 (d)	-	144,000
Bangkok Iron & Steel	132,000	103,600 (e)	130,000 (f)	240,000	372,000
Siam Iron & Steel	220,000	235,400 (g)	253,000 (h)	300,000	520,000
Triumph Steel	120,000	37,200 (j)	47,000 (j)	-	120,000
Nakorn Thai Steel	-	-	-	334,000	334,000
Nicco Industry Co.	-	-	-	200,000	200,000
Total	982,000	577,900	732,000	1 434,000	2 416,000

(a) Based on 2 EAF's. Currently only 1 in operation
(b) Wire rod production only
(c) Including 2,500t rolled sections
(d) Including 14,000t wire rod
(e) Including 27,000t wire rod
(f) Including 24,000t wire rod
(g) Including 104,000t wire rod and p.c wire rod
(h) Including 92,000t wire rod and p.c. wire rod
(j) Rolled section production only

During 1989, it is estimated that 3 of the largest steelworks will be producing close to, or above, their licensed capacities, and it is significant to note that all these three steelworks have recently been granted B.O.I. licences to increase their steelmaking capacities.

All the remaining steelworks are operating at between 30 and 65 percent of their steelmaking capacities, due mainly it would seem, to the limitations of their installed equipment. Several of these companies are currently undertaking developments aimed at uprating their production, including the conversion to ultra high power (UHP) of existing EAF's by installing much larger MVA transformers, plus water cooled roof and wall panels in the furnaces, the installation of an additional third strand to an existing billet continuous casting machine or of a second 2 strand billet casting machine, and increasing the billet reheating or rolling capacity of their bar mills.

Table 2.6 gives details of the existing melting, casting and rolling facilities at the 8 steelworks, together with their planned developments.

Steel Scrap

Over the last 2 years the melters have been forced to use more imported heavy melting scrap. The scrap charged to the EAF's is currently 70 to 80 percent domestic scrap, including any works arising scrap (generally good quality) with the remainder being imported from such countries as the USA and Australia.

The domestic scrap is mainly prompt return industrial scrap comprising sheet off-cuts, reject products and turnings. To increase its bulk density, a large quantity of the domestic scrap is pressed into 100kgs bales. All domestic scrap is delivered by road to the melters.

TABLE 2.6 - TECHNICAL DATA ON MELTERS/ROLLERS

STEELWORKS	STEELMAKING	CASTING	ROLLING	PLANNED DEVELOPMENTS
Bangkok Steel Industry Co Ltd	2x25t EAFS. 1 x 18MVA & 1 x 9.5 MVA transfr. 90 mins.tap-to-tap with UHP furnace	1 x 2 strand Concast 100mm billets Casting speed 2.9m/min Casting time 60min.	Semi-continuous rev. rougher + 10 finishing stands 24 tph reheat fce	4 stands to be added Second 2 strand caster to be added Reheat fce 31 tph
Siam Steel Syndicate	1 x 20 EAF 1 x 20 MVA transfr 120 mins tap-to-tap	1 x 2 str. Mitsubishi 100mm billets Casting speed 3 m/m Casting time 55min	Semi-continuous rev. rougher + 15 int./fin. stands 12tph reheat fce	Adding 40,000 tpa light section mill
Thai India Steel Co Ltd	1 x 10t EAF 1 x 6t EAF	Continuous casting	Medium Section/Bar Mill	
Thai Pathana Steel Ind Co Ltd	1 x 20t EAFS 1 x 8t EAF	6" pencil ingots	Medium Section/Bar Mill	
Thai Steel Bar Co Ltd	3 x 20t EAF 3 x 7.5 MVA transfr. 3-3.5 hours tap-to-tap	1 x 2 str Concast 100mm billets Casting speed 3m/min. Casting time 50min.	UBE. Semi-cont. rev. rougher + 20 int./fin. stands. 40 tph reheat fce.	Adding third strand to billet caster
Bangkok Iron and Steelworks Co Ltd	2 x 25t EAFS. 2 x 9MVA transfr. 1 x 15t EAF. 1 x 7.5 MVA 165 mins. tap-to-tap	1 x 3 strand 110mm billets Casting speed 2.2m/min. Casting time 40min.	No.1 mill semi-continuous rod/bar. No.2 mill, semi-continuous bar 15tph reheat fees.	15t EAF being converted to ladle fce
Siam Iron and Steel Co Ltd	2 x 30t EAFS. 2 x 15/18 MVA transfr. 120 mins. tap-to-tap	2 x 3 strand 100mm billets Casting speed 2 m/m	Semi-continuous rev.rougher + 17 int./fin. stands. 30tph reheat fce.	
Triumph Steel Co Ltd	1 x 25t EAF 1 x 12.5 MVA transfr. 10,000 tpm	1x3 str. Mitsubishi 100 140 x 100, 200 x 100 35 tph	No.1 mill rev. rougher + 6 stands. 10,000 t/m No.2 mill rev. rougher + 5 stands. 2,000 t/m	

The imported scrap mainly comprises heavy melting grades together with some scrap bundles and shredded scrap. Imported scrap is generally brought in barges and unloaded at the melters jetty.

Due to operating the EAF's with predominantly poor grade scrap of low bulk density, each heat requires 3 or 4 scrap charges which prolongs the tap-to-tap time, and results in fewer heats being made daily. Several melters are only able to produce 7 heats daily from their EAF's, although the three who have uprated to UHP furnaces can produce up to 16 heats daily.

The EAF operators are well aware of the mounting problem of obtaining good quality steelmaking scrap supplies in the future, when they will be required to compete with the demands of the many scrap based mini-mills that are being installed in Europe, USA and developing countries. Most of these operators are ready to participate in an ASEAN based direct reduced iron (sponge iron) works, providing it could guarantee them supplies of sponge iron at an economic price compared to steelmaking scrap.

Steelmaking

The melters are currently operating with mainly normal power EAF's, that is, with transformer ratings of 300 to 500 KVA per tonne of steel melted.

As previously mentioned, several steelworks have now uprated their furnaces to ultra high power (UHP) capacity by installing transformers rated at 600 to 800 KVA per tonne of steel melted. These larger capacity transformers allow the steel scrap to be melted more rapidly, resulting in shorter tap-to-tap times, and giving more heats from the furnace daily.

At least one steelworks has scrap preheating, although it is not currently used.

Several EAF's are equipped with oxygen lancing, but none are known to be equipped with oxy-fuel burners.

Only SISCO is known to operate their EAF's with a foaming slag practice, with the scrap being melted by the electrodes arcing beneath a thick slag layer. This practice has several operational advantages including reduced energy losses resulting in lower power consumption (SISCO consume 550 KWH/tonne including continuous casting), lower electrode consumption (SISCO consume 4kgs/tonne) and being able to operate at high power inputs for a longer part of the melting cycle.

Other melters charge limestone direct to their EAFs, which requires additional energy for its calcining and results in power consumptions of about 600 KWH/tonne, together with an electrode consumption of 6 kgs/tonne. None of the EAFs are of the eccentric bottom tapping (EBT) type, which ensures virtually slag-free tapping and results in better quality steel being produced.

One melter is installing a ladle furnace, which would allow the EAF to be used solely for melting the steel scrap, with any refining of the steel, and raising of the liquid steel temperature to suit continuous casting, being carried out in the ladle furnace. This results in reduced EAF tap-to-tap times, and consequently increases production by up to 15 percent. The ladle furnace also has the advantage of giving more flexibility to melting shop operations, and is especially useful when programming heats for series casting from the billet casting machine.

It would be difficult for most of the steelworks to install additional steelmaking capacity within their existing melt shops, particularly by installing larger capacity electric arc furnaces. This is because of the limited spare space available, and the existing superstructures only being designed for the current cranage capacity.

Casting

All the melters have billet continuous casting machines, except Thai Pathana which produces 6 inch square "pencil" ingots. Both SISCO, and Bangkok Iron and Steelworks have two - 3 strand machines, whilst Triumph Steel has single 3 strand machine. The remaining steelworks have a single 2 strand machines, with Bangkok Steel Industry currently planning to install a second machine.

All the billet casting machines are of the low head curved type. The machine designs are mainly either Mitsubishi or Concast.

All the steelworks, except Triumph Steel, cast only one size of billets, that is, 100mm square. Triumph Steel, in addition to casting 100mm billets, also casts 140mm x 100mm and 200mm x 100mm billets for rolling into angles, channels and flats.

The casting speed for 100mm billets is generally about 3 metre/minute, with the casting period being between 50 and 60 minutes.

All the billet machines are equipped with ladle stands. However, since many of the steelworks are attempting series casting, it would be beneficial to consider installing either a ladle transfer car, or rotating turret, which will allow the rapid changeover of casting ladles, so necessary for series casting.

At several steelworks, the continuous casting facility is the production "bottleneck", and recognising this, these companies are installing additional capacity, either as a third strand, or with a second machine.

Rolling Mills

All the steelworks have semi-continuous merchant bar mills comprising a reversing roughing stand, followed by cross-country intermediate stands and in-line finishing stands.

The mills use 100mm square billets, mainly produced in their own works, as feedstock. These are reheated in pusher type reheat furnaces, fired with Bunker 'C' fuel oil. The heated billets are broken down through a roughing mill, then continuously rolled through intermediate and finishing stands.

The Bangkok Steel Industry mill operates a slit rolling practice, which slits the bar after the intermediate stage, and finish rolls the two slit bars, giving higher production rates when rolling the smaller diameter bars.

Larger diameter bars (generally 12 to 32mm diameter) are sheared into straight lengths, followed by cooling on a cooling bed and bundling for despatch.

Small diameter wire rod (generally 5.5 to 8mm diameter) is coiled into coils of 350 kgs maximum weight, then cooled on a coil cooling conveyor and banded for despatch.

No mill is currently installed with controlled cooling equipment (Stelmor or Tempcore) to give the wire rod increased tensile properties.

Several mills are planning to convert from semi-continuous to continuous rolling by adding more roughing stands, which will considerably increase their production rates.

Products

With the exception of Triumph Steel and Siam Steel Syndicate, all the other melters rolling mills produce round and deformed bars in mainly the 12mm to 40mm diameter size range.

SISCO, Thai Steel Bar, Bangkok Iron and Steel, and Siam Steel Syndicate produce wire rod of 5.5 to 8 mm size range in coils of up to 350 kgs weight. SISCO also produce prestressed concrete wire rod using imported billets.

Triumph Steel only produce rolled sections comprising 25 to 100mm equal angle, 100 and 125mm x 75mm unequal angles, 75 to 200mm channels, 25 to 125 mm x 4.5 to 25mm flats and 11 to 50mm square bars. Thai India Steel also produce some rolled sections.

New Developments

The Ministry of Industry has granted licences for new long products steelmaking capacity totalling 1.434 million tonnes per annum to 5 steelmaking companies. These comprise 3 existing melters/rolling mills (Bangkok Steel Industry, Bangkok Iron and Steelworks and SISCO), together with the largest re-roller, Nakorn Thai Steel (NTS) and NICCO Industry Company.

Bangkok Steel Industry (BSI) have permission to increase their current long products production by 360,000 tonnes/year. BSI are currently studying two proposals, either to install the additional production capacity at its present steelworks site at Samatprakarn, or to construct it at a new site location.

Bangkok Iron and Steelworks have permission to increase their current long products production by 240,000 tonnes/year. They wish to instal this additional production capacity at their present steelworks site at Samatprakarn. It would comprise a 50/60 tonnes nominal capacity UHP electric arc furnace, a 50/60 tonnes ladle furnace, a 4 strand billet continuous casting machine to produce

140mm square billets and a high speed continuous rod/bar mill to produce wire rod and rebar in the size range 5.5 to 55mm diameter.

Siam Iron and Steel Co. (SISCO) have permission to increase their current long products production by 300,000 tonnes/year. This additional production capacity would be installed at a new site, and would comprise of a single 70 tonnes nominal capacity UHP electric arc furnace, a 70 tonnes capacity ladle furnace, a 4 strand billet continuous casting machine to produce billets in the 120 to 140mm square size range, and a continuous bar mill to produce round and deformed bar of 12 to 40mm diameter size range.

Nakorn Thai Steel (NTS) have permission to supplement their re-rolled production capacity, by 334,000 tonnes/year of rolled long products production. This new rolled production capacity would be installed at a new site, and would comprise of single 75 tonnes nominal capacity UHP electric arc furnace of the eccentric bottom tapping type, a 75 tonnes capacity ladle furnace, a 4 strand billet continuous casting machine and a continuous rod/bar mill to produce wire rod and reinforcing bars.

Nicco Industry Company have permission to install 200,000 tones/year of long products production. The new works would be located at the Map Ta Phut industrial estate and would comprise either 2 x 25 tonnes or 1 x 50 tonnes nominal capacity UHP electric arc furnace, continuous casting of 80,100 and 120mm square billets and a high speed continuous rod/bar mill to produce wire rod and reinforcing bars in the size range 5.5 to 28mm diameter.

Both SISCO and NTS are well advanced in their negotiations with plant suppliers, and orders for their new facilities should be placed by mid-1990. If their site locations can be fixed without delay, these two developments could commence production by early 1992. The other three developments are not so advanced, and it is assumed production will not commence at these new installation before 1993 at the earliest.

Based on a production build-up at the new developments of 50 percent in the first full year, 80 percent in the second full year, and 100 percent in the third full year, it is estimated that the combined steelmaking capacities of the melter/rolling mills during the next 5 years will be as follows:

	Tonnes/annum
1990	1.0 million
1991	1.0 million
1992	1.3 million
1993	1.9 million
1994	2.3 million
1995	2.4 million

2.3 The Technology Employed by the Re-Rollers

It has been reported by the M.O.I. that there are currently about 48 re-rolling mills operating, with a combined re-rolling capacity of 566,400 tonnes per annum.

It is believed that there are at least 3 re-rollers with production capacities in excess of 50,000 tpa, with Nakorn Thai being the largest, with a combined capacity from their 2 works of around 160,000 tonnes/annum. A further 6 re-rollers have production capacities of between 20,000 and 50,000 tpa, with the remaining 40 having capacities below 10,000 tpa.

Feedstock

Due to the virtual disappearance from the market of scrap ship plate, nearly all the re-roller's feedstock is second quality or cobble plate imported from Australia, North America and Europe. Small quantities of rails and rolled sections are also cut-up for feedstock.

Cobble plates are purchased in 6 metres lengths of mixed thickness ranging from 20 to 40mm. These plates are flame cut or sheared into mill feedstock of 900 to 1200mm length and 50 to 75mm width, depending on the plates thickness.

The yield from cobble plate to products is about 90 percent, with the remainder comprising about 4 percent steelmaking scrap and 6 percent scrap offcuts for sale to the small capacity re-rollers.

Until recently, only small quantities of imported billets were rolled annually by the re-rollers. However, at the present time the cost of imported billets has dropped to a level where several of the larger re-rollers are using them as their main feedstock. Nakorn Thai Steel have 2 mills capable of rolling 100mm square billets, but the other re-rollers are only capable of rolling 50mm square billets.

Due to the current low cost of imported billets, it is known that several re-rollers are currently uprating their roughing stands to allow their mills operate with 100mm billet feedstock.

Re-Rolling Mills

The larger re-rollers have semi-continuous cross country type bar mills comprising 1 or 2 roughing stands, where 7 to 9 reversing passes are undertaken, followed by about 10 finishing stands.

Feedstock is reheated in a pusher type continuous reheating furnace, fired with Bunker 'C' fuel oil.

Products exiting from the finishing stand are sheared into 6 to 12 metres lengths, then cooled on a cooling bank, followed by bundling and wrapping for despatch by road vehicles.

Products

The re-rollers generally concentrate their production within the 6 to 12mm diameter size range, with 9mm diameter being the principal size re-rolled. All re-rolled reinforcing bar must be produced in the plain round bar section.

Since the cobble plate is of varied "off-specification" grades, the resulting re-rolled bars exhibit large variations in their mechanical properties.

Due to the uncertainty in quality of re-rolled bars, The Thai Industrial Standards Institute restricts their usage to domestic and minor building structures. No re-rolled bars may be used in the construction of tower blocks, bridges or other major engineering projects.

Some deformed reinforcing bar is produced by the re-rollers, whilst Nakorn Thai produce wire rod and the Sahaviriya Group produce small rolled sections, all using imported or locally manufactured billets.

2.4 Flat Products

Thailand does not currently have a flat rolled steel production facility. Consequently, the present flat products industry comprises works that produce tinplate, tin free steel and galvanised sheet from imported cold rolled coils, and ERW, 'UO' and spiral weld pipes and cold formed sections from imported hot rolled strip coils.

However, in November 1989 the Government gave approval for the Sahavariya Group to construct a flat products works. This works would comprise:

* a hot strip mill of 1.8 million tonnes per annum capacity, producing 15 tonne coils of hot rolled sheet 1.524 metre wide x 1.2 to 12 mm thickness (85 percent of 1.2 to 3mm) using imported continuous cast slabs

* a cold rolling mill of 670,000 tpa capacity

* an electro-galvanising line of 135,000 tpa capacity, producing 1.5 metre wide x 0.3 to 1.6 mm thickness galvanised sheet.

Sahaviriya have indicated that negotiations are proceeding with plant suppliers, and production was scheduled by them to begin on the hot strip mill and electro-galvanising line by the end of 1992, and the cold rolling mills by the end of 1993. These production start-up dates are, of course, dependent on a suitable site location with adequate infrastructure being selected without delay.

2.4.1 Tinplate

Thai Tinplate Co (TTP)

TTP are currently the only producer of tinplate and tinfree steel strip using imported black plate coils from Japan.

TTP have 2 electrolytic tinning lines in operation, No.1 installed in 1973 with a line speed of 150 metres/minute and a rated capacity of 60,000 tpa, and No.2 installed in 1982 with a line speed of 190 metres/minute and a rated capacity of 90,000 tpa. In addition, TTP in a joint venture with Kawasaki Steel has just completed the installation of third line, which is currently being commissioned and is scheduled to start production by December 1989. This latest electrolytic tinning line will be high speed, 300 metres/minute, and have a rated capacity of 150,000 tpa. The No.2 line is of the dual type, capable of producing either tinplate, or tin free steel strip.

The lines use 10 tonne coil feedstock of blackplate, which is high quality thin gauge sheet of 0.18 to 0.35 mm thickness (0.22mm average) x 1.045 metres wide.

Each line has shearing and stack pilers on-line together with a separate shearing line housed in a dust free enclosure (to meet food industry cleanliness requirements).

Various developments, including increasing line speeds and adding new plating cells, have enabled TTP to raise the rated capacities of their Nos. 1 and 2 lines to 100,000 and 110,000 tpa respectively.

TTP productions for the years 1983 to 1988 are given in Table 2.7.

TABLE 2.7 - TINPLATE PRODUCTION 1983 TO 1988
('000 tonnes)

Product	1983	1984	1985	1986	1987	1988
Tinplate	73	92	68	104	119	145
Tin Free Steel	7	14	17	22	35	45
Total	80	106	85	126	154	190

Source: Department of Mineral Resources

It can be seen from Table 2.7 that tinplate production in 1983 was only about 80,000 tonnes, mainly from No.1 line, as the No.2 line was only just coming into production. During the next 5 years, tinplate production increased by over 100,000 tonnes per annum, as No.2 line increased its production towards its rated capacity. By 1988, tinplate production had reached 190,000 tonnes per annum, with No.1 line producing about 80,000 tonnes and No.2 line producing 110,000 tonnes.

During the 6 year period shown, tin free steel production from No.2 line increased from nearly 7,000 tonnes in 1983 (the first year of its production), to 45,000 tonnes in 1988 (i.e. 24 percent of total tinplate production).

With No.3 electrolytic tinning line commencing production in 1990, and assuming a production build-up of 60 percent in its first year of operation, 85 percent in the second year and 100 percent in its third year, the achievable total production of tinplate and tin free steel by TTP during 1989 and the following years could be:

	Tonnes/annum
1989	200,000
1990	290,000
1991	330,000
1992	350,000

It is anticipated that the No.2 dual electrolytic tinning/tin free line will become increasingly used for tin free steel production, which depending on market demands might increase from about 50,000 tonnes/annum in 1989 to 80,000 tonnes/annum by 1992.

Other Companies

Two companies have licences for tinplate developments, these being Charm Pineapple and Siam Tinplate (STP). Charm Pineapple are a major Thailand cannery, which has held a licence since 1982, but currently does not appear to have made any progress with a tinplate development.

However, STP in a joint venture with several Japanese companies including Sumitomo, Mitsubishi and Nippon Steel, are installing a high speed (275 metres/minute) dual electrolytic tinplate and tin free steel line with a rated capacity of 120,000 tpa at Map Ta Phut.

This line is designed for feedstock of 10 tonnes maximum coils of high quality blackplate of 457 to 965 mm width x 0.15 to 0.39 mm thickness.

Production is scheduled to commence in December 1991 and is expected to comprise 70 percent tinplate and 30 percent tin free steel.

Based on a production build-up of 60 percent in the first year of operation, 85 percent in the second year and 100 percent in the third year, the achievable total production capacity of tinplate and tin free steel by STP in 1992 and its following years would be:

	Tonnes/annum
1992	60,000
1993	100,000
1994	120,000

Of this total production, tin free steel production could be about 20,000, 30,000 and 40,000 tpa respectively.

To summarise, the proposed developments at TTP and STP will allow total tinplate plus tin free steel production capacity to increase as follows:

	Tonnes/annum
1990	290,000
1991	330,000
1992	410,000
1993	450,000
1994	470,000

2.4.2 Galvanised sheet

Existing Facilities

There are currently 4 producers of hot dip galvanised sheet using feedstock of imported coils, mainly from Japan, of good surface quality, principally very thin gauge cold rolled sheet.

There is no capacity for producing electro-galvanised sheet, nor for applying zinc and aluminium coatings. However, at least one of the galvanised sheet producers has 2 colour coating lines, and a second producer is currently installing a colour coating line.

The 4 hot dip galvanised sheet producers comprise:

* Sangkasi Thai Co. (STC), who commenced production in 1960, and are currently the largest hot dip galvanised sheet producer in

Thailand, with a rated production capacity from their 8 semi-continuous h.d. galvanising lines of 120,000 tpa (i.e. 8 x 15,000).

STC imports all its 5 tonnes maximum feedstock coils of cold rolled strip of 914mm (3 feet) width x 26 to 35 USG thickness from Japan. These coils are sheared into packs on their 4 shearing lines, as feedstock for their semi-continuous hot dip galvanising lines. The cut sheets are manually fed to the galvanising lines which each include pickling, rinsing, hot dip zinc coating, cooling and chromate coating tanks.

STC also has 2 colour coating lines of 20,000 tpa combined capacity, which apply paint coatings (choice of 4 colours) to both sides of the h.d. galvanised sheets.

Small or large round profile, or ribbed profile corrugations are produced in separate corrugating machines.

* Bangkok Steel Industry (BSI), who commenced production in 1985 with a single continuous h.d. galvanising line of 60,000 tpa nominal rated capacity. This h.d. galvanising line uses 9 tonnes maximum coils of cold rolled strip 2.5 to 4 feet width x 0.19 to 1.6 mm thickness imported from Japan. The line is of the fully continuous type and includes 2 uncoilers, butt welder, vertical looping towers, pickling, rinsing, hot dip zinc coating, cooling and chromate coating, flying shear and sheet pilers.

* Thailand Iron Work, who commenced production in 1960 and has h.d. galvanising facilities with a combined production capacity of 60,000 tpa

* Sangkasi Far East Co., who commenced production in 1964 and has h.d. galvanising facilities with a combined production capacity of 60,000 tpa.

Galvanised Sheet Production

Around 85 percent of the hot dip galvanised sheet production is made from very light gauge (less than 0.4 mm thickness) full hard cold rolled sheet. The product is corrugated, and used as roof or side sheeting mainly by farmers, for domestic and agricultural buildings.

The remaining h.d. galvanised sheet production is made from medium gauge sheet (up to 1.6 mm thickness) and used for furniture, H and V ducting and commercial equipment.

Due to the seasonal demand for corrugated galvanised sheet, the annual productions achieved by the 4 galvanised sheet producers is generally between 50 and 70 percent of their nominal production capacity. This is illustrated by STC, which during both 1988 and 1989 has had annual productions of about 60,000 tpa, although it has a total production capacity of 120,000 tpa. This situation is probably similar at Thailand Iron Works and Sangkasi Far East who also mainly produce corrugated sheet products. However, it is not true of BSI, whose production comprises only 50 percent corrugated sheet products, with the other 50 percent being medium gauge galvanised sheet for H and V ducting, iceboxes, bus interiors etc. This latter production is not restricted by seasonal demand, and BSI production in both 1988 and 1989 was between 50,000 and 60,000 tonnes/annum, i.e. at, or close to, its rated production capacity.

Based on data compiled by the Department of Mineral Resources, the galvanised sheet production in Thailand during the years 1983 to 1988 was as follows:

	Tonnes
1983	111,048
1984	136,383
1985	118,368
1986	130,000
1987	165,450
1988	182,310

From 1983 to 1985, all the galvanised sheet production was produced by Sankasi Thai Co., Thailand Iron Works and Sankasi Far East Co., with the former accounting for about 50 percent of the total production, and the other two companies sharing the remaining production. From 1986, BSI has progressively built-up production until by 1988 it was producing about 50,000 tonnes/annum, the remaining 3 galvanised sheet producers total production being maintained at about 110,000 to 130,000 tonnes/annum during the years 1986 to 1988.

It is estimated that the current total production from the 4 galvanised sheet producers is about 200,000 tonnes.

New Developments

BSI are currently constructing a second continuous hot dip galvanising line of 60,000 tonnes/annum rated capacity. This line is scheduled to commence production in April 1991.

Also, BSI are constructing a 20,000 tonnes/annum continuous paint coating line, which is scheduled to commence production in October 1990.

Assuming a build-up of production on the BSI galvanising line of 50 percent in 1991, 85 percent in 1992 and 100 percent in 1993, the total h.d. galvanised sheet production capacity in Thailand would be:

	Tonnes/annum
1990	300,000
1991	330,000
1992	350,000
1993	360,000

Also, by 1992 there will be 60,000 tonnes/annum of colour coating lines capacity.

Finally, Sahaviriya are planning to instal a 135,000 tpa electro-galvanising line within their flat rolling complex, and this is scheduled to commence production by 1993.

2.4.3 Pipe mills

Welded pipes from ½ to 120 inches diameter are manufactured in Thailand from imported coils of hot rolled strip. Small and medium diameter pipes (½ to 8 inches) are produced in electric resistance welded (ERW) pipe mills, whilst large diameter pipes, (10 to 120 inches) are produced in spiral weld or 'UO' pipe mills.

There is no capacity to produce seamless pipe.

ERW Pipe Mills

There are 14 ERW pipe mills known to be currently in production producing black pipes and galvanised pipes for water and gas services, mechanical pipes, electrical conduit, round and square tube for furniture manufacture and stainless steel pipes. The combined production capacity of these pipe mills exceeds 500,000 tpa.

None of these ERW pipe mills have American Petroleum Institute (API) certification necessary for production of boiler tubing for oil and gas field services.

Spiral Weld and 'UO' Pipe Mills

There are 10 spiral weld or 'UO' pipe mills currently in production in Thailand producing large diameter pipes, mainly for the water services industry, these mill have a combined production capacity of over 150,000 tpa.

Around 70 percent of the welded pipe produced in Thailand is sold in export markets. Production was about 350,000 tonnes in 1987 and 1988, but has subsequently dropped to about 300,000 tpa, due to the current export market restrictions.

2.4.4 Cold Formers

There are 7 cold forming companies licensed by the MOI to produce cold formed sections to the Thai Industrial Standards. These companies consume imported coils of hot rolled sheet to produce a range of angles, channels and Z sections for sale mainly to the construction industry for fabrication into purlins, sheeting rails, roof trusses etc.

Five companies can produce a range of equal and unequal angles, channels and lip channels, whilst the remaining 2 companies only produce lip channels. Also, several of these companies produce Z and lip Z sections.

In addition to the licensed companies, there are many companies operating without licences, and producing cold formed sections which do not comply with the Thai Industrial Standards.

Little information is available on current cold formed section production, but it has been estimated at over 300,000 tonnes/annum by UEC in their recent report.

2.5 Foundries

There are around 50 foundries licensed by the MOI, the majority of whom produce grey cast iron castings. Although several of these foundries also produce nodular (SG) iron, alloy cast iron and steel castings.

In addition, there is reported to be a large number of small factories with limited production capacity engaged on foundry production.

Foundries products include castings for industrial and agricultural machines, cast iron pipes and fittings, engine blocks and spare parts, pump and valve bodies etc.

The bulk of production is castings of below 100 kgs weight, although several foundries have capacity to produce castings of up to 10 tonnes weight.

The iron foundries generally use cupolas, whilst the steel foundries use electric induction furnaces to melt domestic scrap, and/or imported pig iron.

Castings are mainly produced by hand moulding, or manually operated machine moulding using the green sand process.

However, the largest foundry, Siam Nawaloha Foundry is a highly automated foundry equipped with 9 induction furnaces of 0.5 to 8 tonnes capacity, together with Disamatic and Shinto moulding lines. This foundry produces carbon, low alloy and high alloy steel, high alloy cast iron and general engineering cast iron castings for its parent company, Siam Cement Group, and for various customers in the automotive, glass, sugar, agricultural and cement industries. It also exports castings to ASEAN and other foreign countries.

Little information is available on annual productions from foundries, but it has been estimated by industry sources to be currently about 100,000 tpa.

3. THE MARKET FOR STEEL IN THAILAND

This section outlines the more important trends which have occurred in the Thai economy over the last few years and how these have affected the market for steel. Some projections of future demand are given, based on assumptions concerning future economic growth rates.

3.1 Trends in the Economy

3.1.1 GDP growth

Since 1970 GDP growth in Thailand has averaged 6½ percent per annum. Despite considerable changes in the world economic environment, the rate of growth has been remarkably constant. There have, however, been important shifts in structure. In particular the share of agriculture has declined and that of manufacturing increased. In 1978 agriculture accounted for 25 percent, and manufacturing for 20 percent of GDP. Ten years later, in 1988, the shares were 17 percent and 24 percent respectively.

In 1987 GDP growth accelerated. An increase of 8.5 percent was recorded in that year, rising to about 11 percent in 1988 and 1989. A slightly lower rate is forecast for 1990, but still around 10 percent.

Figure 3.1 shows GDP and its composition with regard to the more important sectors for steel consumption. Figures 3.2 and 3.3 show annual growth rates for the manufacturing and construction sectors as compared to overall GDP growth. It will be seen that manufacturing growth has generally matched or outpaced overall GDP growth while the construction sector has experienced cycles of expansion and contraction.

Figure 3.1 GDP by Sector

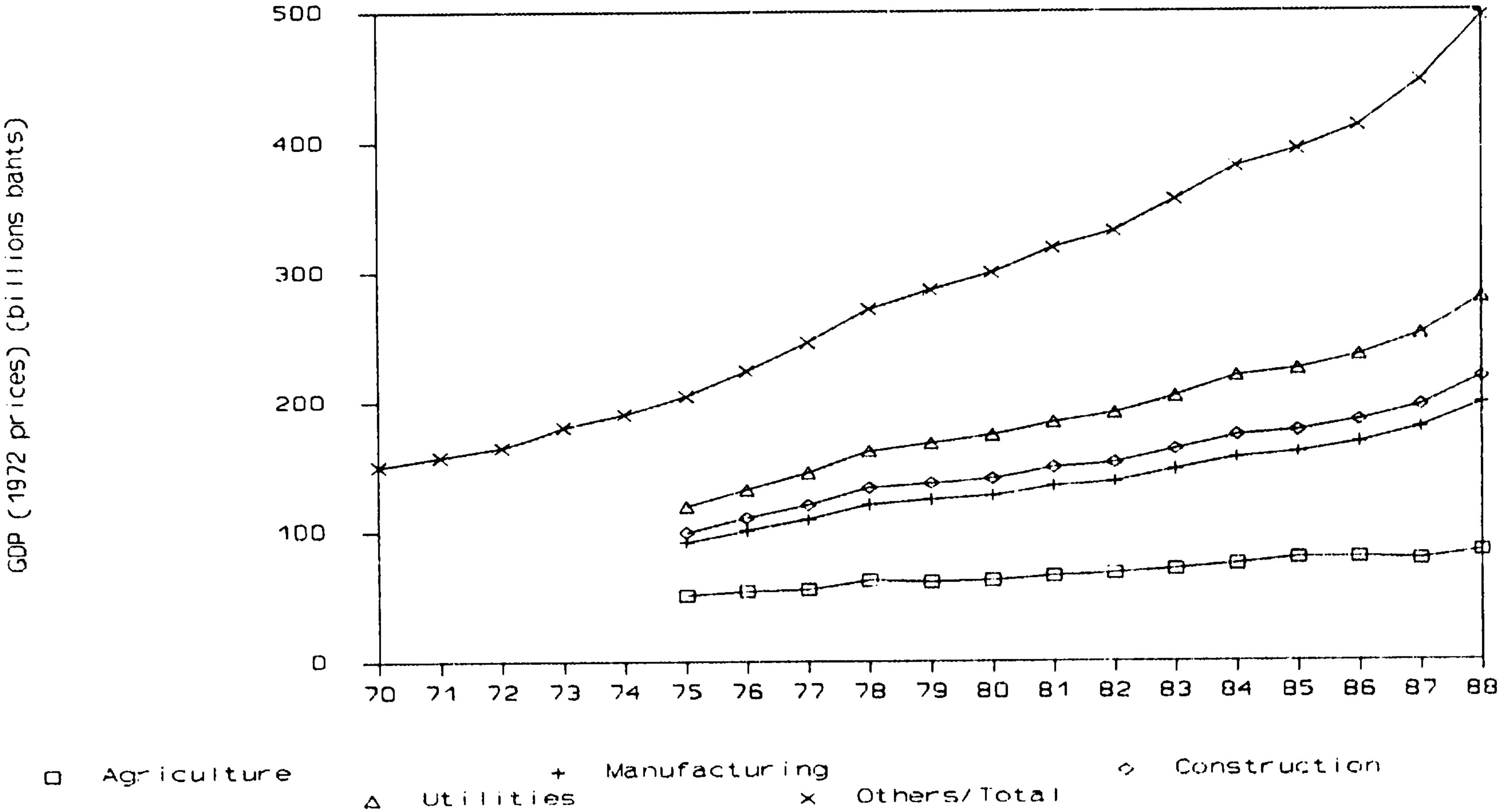


Figure 3.2 Manufacturing Growth Rates

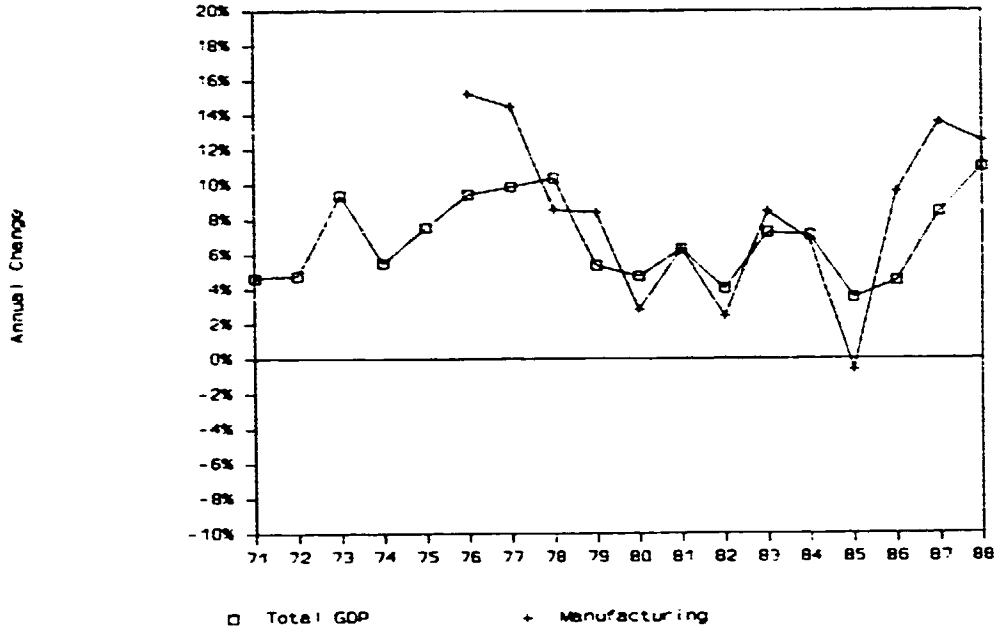
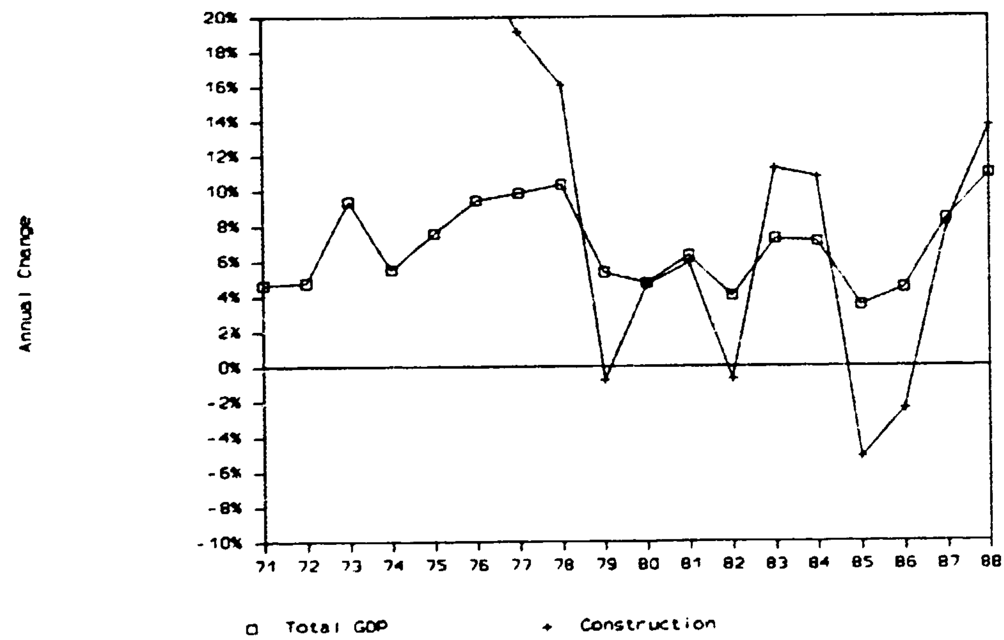


Figure 3.3 Construction Growth Rates



3.1.2 Trade and industrial policy

Foreign trade is an important component of the economy and export growth has been an important factor in Thailands recent success. Table 3.1 shows the composition of imports and exports in 1988. Exports still include large contributions from agriculture products and mining but it is the manufacturing sector which is providing the most growth. Imports mainly consisted of raw materials for the industrial sector and capital goods. Steel imports (including scrap) amounted to 48 billion baht, or 10 percent of the total. Overall there was a large trade deficit but this was more than balanced by invisibles such as tourism and by foreign investment, and so the balance of payments was in surplus (by 40 billion baht).

TABLE 3.1 - THE MAKE-UP OF IMPORTS AND EXPORTS, 1988

Item	Billion Baht
Exports	
Agric. products and minerals (a)	170
Textiles	59
Manufactured goods	175
Total	404
Imports	
Consumer goods	39
Oil	39
Raw materials & semi-finished goods	180
Capital goods	193
Other	59
Total	510

(a) including canned food
Source: Bank of Thailand 1988 Annual Report

One way to reduce the trade deficit is to substitute imported semi-finished goods by domestically made products and so increase the 'local content' of finished products. This process of backward integration has been occurring for a number of years, helped by a tariff policy that protects newly emerging industries.

A good example is the automobile industry. At one time all components were imported in knocked-down form and assembled in Thailand. The local content was simply the labour. As industrial development proceeded a parts industry grew up, firstly for the after-market and then for new vehicles. Body pressing followed and then some production of machine tools, moulds and dies etc. Currently the major imported components are engines and gear boxes, and efforts are being made to source these within the country over the next few years. Because of the relatively low volumes required by the domestic market, however, manufacturing costs are high and vehicles cannot compete in the export market. The final stage of development will be reached when exports can be made at a price that is competitive in world terms.

Another way in which industrial development has occurred has been by increasing the added value of agricultural exports. The canning industry is an example of this process and provides significant foreign exchange earnings.

3.1.3 Investment and infrastructure

Investment has been particularly strong over the last 2-3 years. Gross fixed capital formation was 26% of GDP in 1988. Much of this has been carried out by the private sector and often with foreign funding. In 1988, for example, 76 percent of capital formation was from the private sector with 12 percent each from central or local government and from state enterprises. One of the reasons for the lower government investment is that in the mid-1980s there was concern about the level of foreign debt. In response to this concern a fiscal surplus was generated in 1988 and will again exist in 1989.

One of the outcomes is that infrastructure development has not kept pace with private investment. This has been exacerbated by capacity problems in the construction sector which has led to rising prices and delays in completing projects. There will be a need for increasing expenditure in infrastructure and the private sector will be encouraged to participate in this by such schemes as 'build, operate and transfer'.

3.1.4 Regional policy

The government is aware that too much expansion has taken place within Bangkok. Plans are being implemented to develop the Eastern Seaboard, particularly at the new ports of Laem Chabang and Map Ta Phut. Irrigation projects and some industrial development are scheduled for the North and Central regions. Further behind, but of considerable importance in the future will be the opening up of the South of the country. Plans include the development of lignite mines, power stations and industrial zones, and the construction of new ports at Krabi and Khanom, and possibly a land bridge between them.

3.2 The Demand for Flat Products

While there are coating lines in Thailand producing tinplate, tin-free steel (TFS) and galvanised sheets, the cold-rolled feedstock for these and other applications comes from imports. The main statistical source for establishing the demand for flat products is therefore the Customs Department of the Ministry of Finance.

In 1988 a new and more useful categorisation of steel products was adopted. This distinguishes between hot and cold rolled products and gives a good indication of the dimensions of products, particularly thickness. This information was not available for previous studies where total demand was broken down into categories based on estimates from a small sample of end-users.

In this section trends in the total consumption of flat products during the period 1970 to 1988 are described. Then a more detailed picture of consumption in 1988 is given.

Special steels are excluded from the analysis. In 1988, 54,000 tonnes of stainless steel and 37,000 tonnes of alloy steel were imported in coils and sheets.

3.2.1 Historical consumption for all flat products

Figure 3.4 shows the historic demand for all flat products together with a fitted exponential growth curve. The average annual growth rate using this method comes to 10.2 percent per annum. There are larger increases recorded in the years 1987 and 1988, but some of this growth would have gone into stock building.

To investigate the correlation between flat products demand and GDP, the data was fitted to a regression equation of the following form:

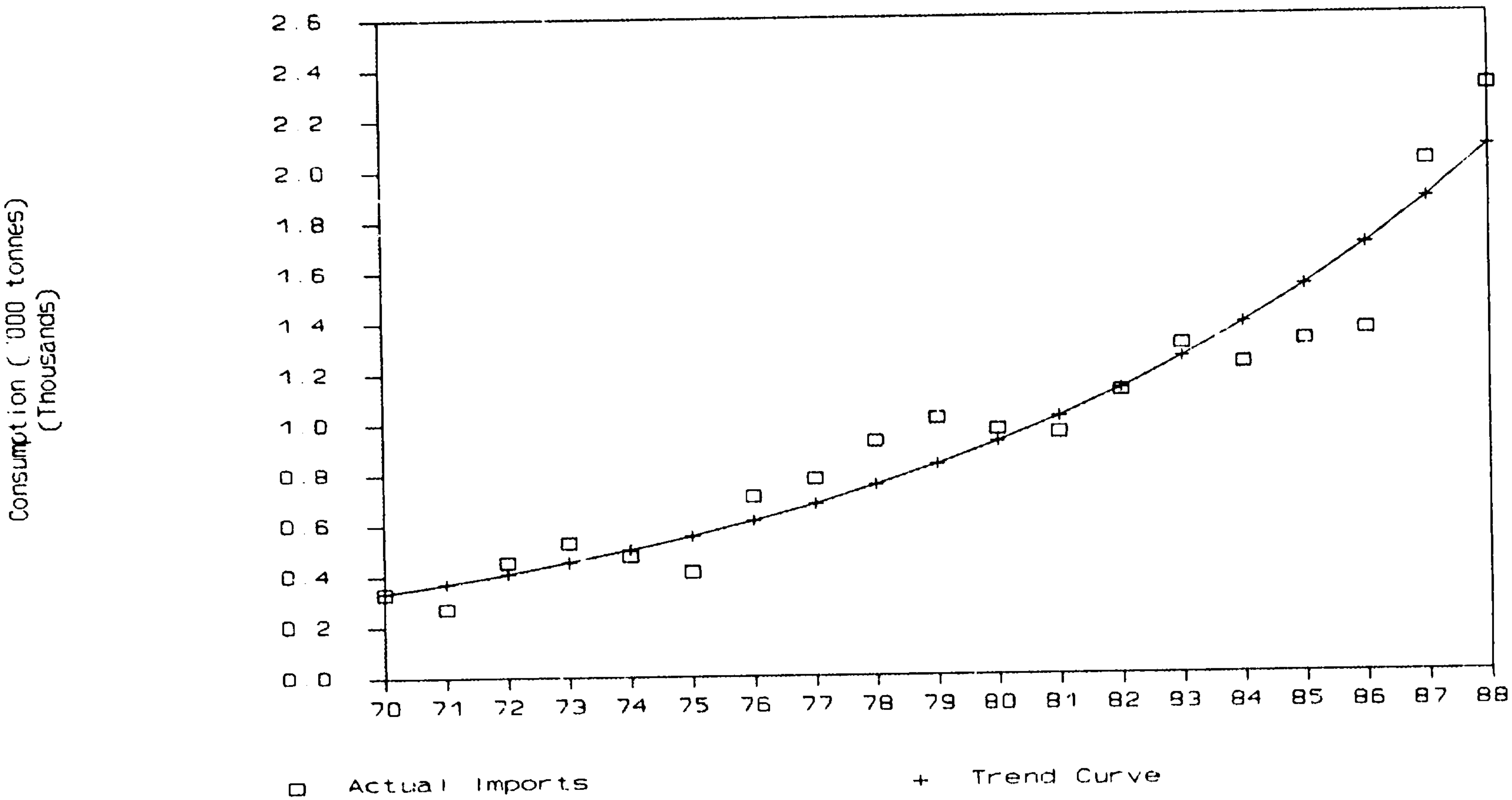
$$\text{Demand} = k\ \text{GDP}^a$$

where k, a are constants

The constant 'a' is analogous to the income elasticity of demand and was calculated to be 1.54. A good correlation was obtained, with r^2 having a value of 94 percent. This means that, over the period, for every one percent rise in GDP, there has been a 1.54 percent rise in the demand for flat products.

This result is typical of many countries in a similar development stage to Thailand but, if used for extrapolation purposes, it needs to be treated with care. It is a measure of the growth in steel entering the country in the form of coils and sheets and does not take into account the steel that in previous years came to Thailand in the form of end-user products. Thus taking the example of vehicle manufacturing again, in past years a large proportion of bodies were imported directly and therefore do not appear in the figures for total flat products demand. Only the proportion that were actually pressed in the country will be recorded and the rise in this proportion is a contributing element of the elasticity. Similar arguments would apply to household appliances and other products where the local content has increased over the years.

Figure 3.4 Flat Products Consumption



The true income elasticity, therefore, measured on a historic basis, lies at something less than 1.54. Experience elsewhere suggests that steel elasticity reduces with increased development, due to substitution, better design and a move away from heavy industry. Thailand is in an interesting position in this respect. It cannot be considered a 'developed' country but, because of the considerable investment coming from overseas, many of its emerging industries are more typical of a 'developed' country than a 'developing' one. They make modern products and do not involve heavy engineering in any significant way. A future elasticity of, say, 1.3 appears to be appropriate.

Figure 3.5 shows flat products demand and GDP growth trends presented as indices. This shows the way in which demand has grown faster than GDP. This has been particularly true in 1987 and 1988, even though GDP growth itself was high in those years.

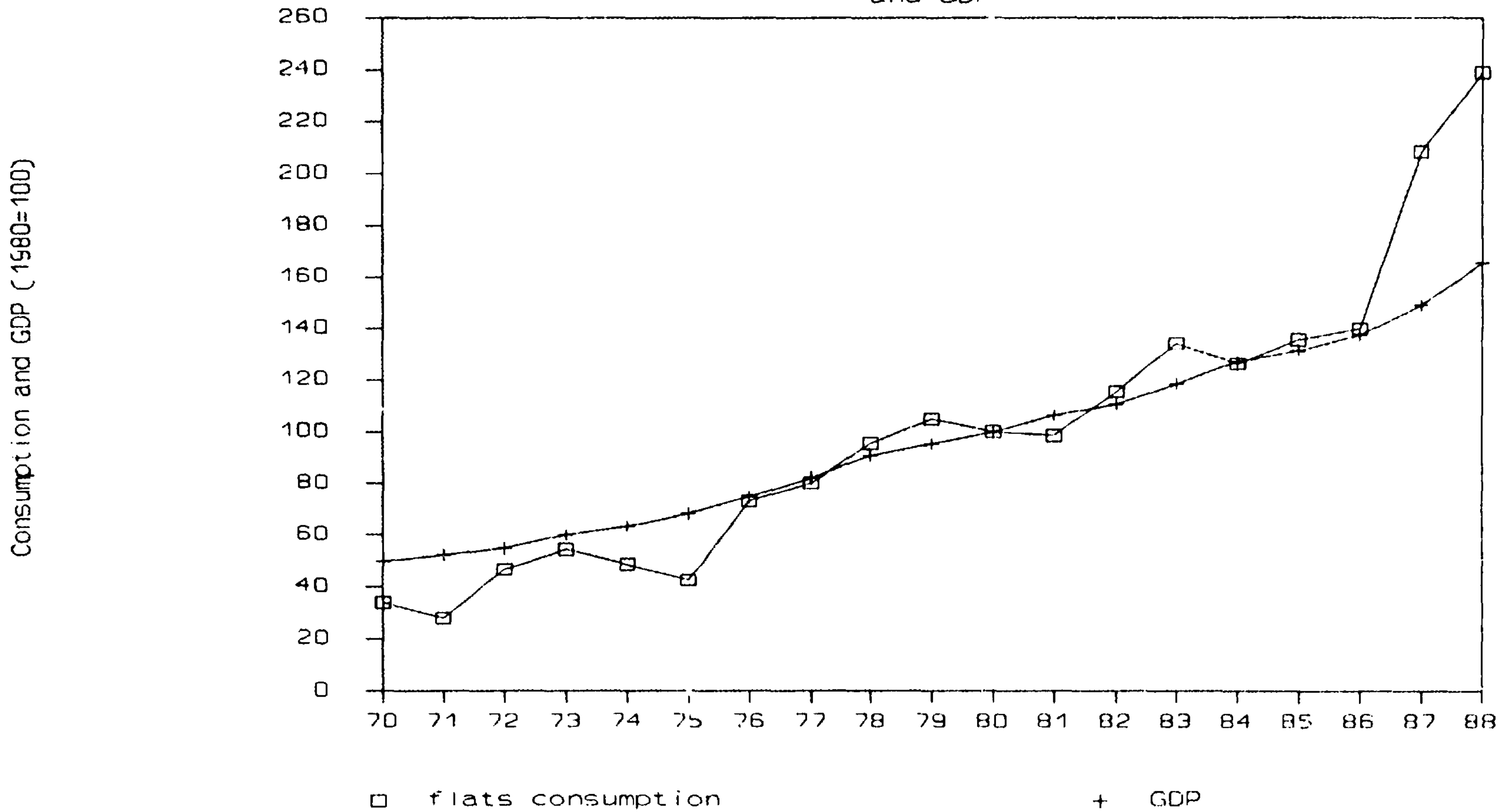
3.2.2 Consumption in 1988

Consumption in 1988 together with an indication of end-usage is shown in Figure 3.6. It can be seen that about 60 percent of both hot and cold rolled products go directly to four important steel processing industries, i.e. pipe manufacture, cold-forming, tinning and galvanising. The remainder is used in a more dispersed way in many manufacturing industries and for construction.

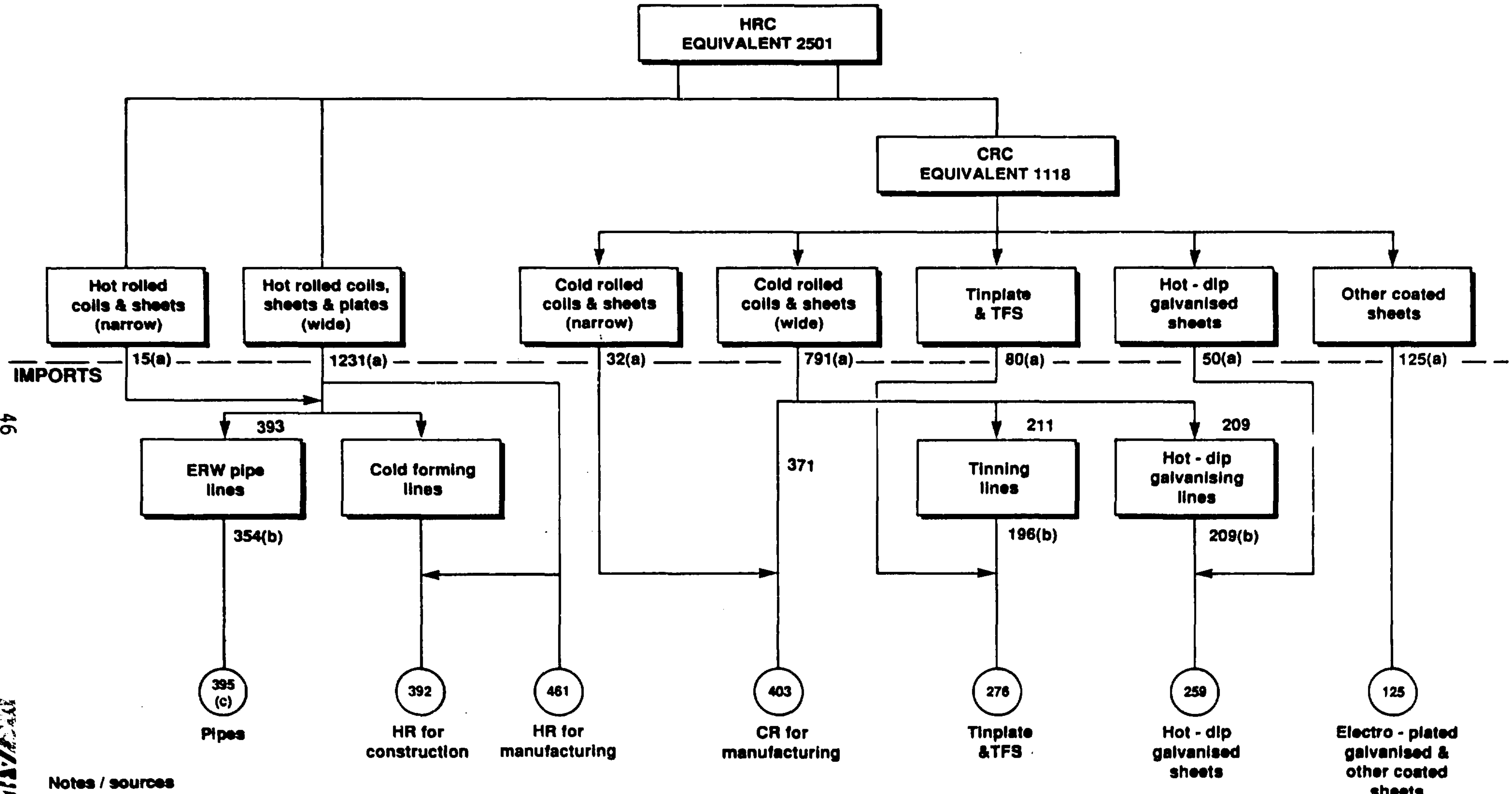
The Consultants have carried out a small number of interviews with end-users in order to arrive at the broad market split shown in Figure 3.6, but the UEC Report gives a more detailed break-down of these. For 1987, they estimated the proportion of hot and cold rolled products going to different manufacturing and construction users as shown in Table 3.2. Our findings do not significantly differ from these conclusions.

Figure 3.5. Flat Products Consumption

and GDP



Atkins



Notes / sources
(a) Customs statistics, Dept of Finance
(b) Industrial statistics, MOI
(c) Includes 41,000 tonnes of imports

All other figures are consultants' estimates

Figure 3.6 **Flat product usage, 1988 ('000 tonnes)**

TABLE 3.2 - END-USERS OF HOT AND COLD ROLLED PRODUCTS, 1987

Use	Hot rolled	Cold rolled
Tinning lines		30%
Galvanising lines		28%
Pipe manufacture	30%	
Cold forming	26%	
Construction	6%	7%
Packaging	3%	6%
Motor vehicles, appliances, etc	4%	16%
Furniture	2%	7%
Other	29%	7%
Total	100%	100%

Source: UEC Report, 1988

Table 3.3 shows imports expressed in terms of hot and cold rolled coil. The total demand for hot rolled products (including that produced for cold rolling) is estimated to be 2.5 million tonnes. For cold rolled the equivalent figure is 1.1 million tonnes. The significance of these figures is that there is already sufficient demand in Thailand to fill a fairly large flat products rolling plant, ignoring any further growth that may occur in the lead time required to build such a steelworks.

While hot rolled steel is obtained from all over the world, 70% of cold rolled comes from Japan. This illustrates the significant influence of the Japanese in tinplate, the automobile industry and the production of domestic appliances.

From the customs information it is possible to estimate the distribution of thickness. This information is shown in Tables 3.4 and 3.5. When compared to other, more industrialised countries, the product mix is weighted towards light gauge material.

TABLE 3.3 - FLAT PRODUCTS IMPORTS IN 1988 EXPRESSED IN TERMS OF HOT AND COLD ROLLED COIL ('000 tonnes)

Item	Quantity	CRC equiv.	HRC equiv.
Wide strip (a)			
HR coils	952		952
HR sheets & plates	279		294
CR coils & sheets	791	824	877
Tinplate/TFS	80	86	92
Galv. products	110	110	117
Other coated	65	65	69
Total wide	2 277	1 085	2 401
Narrow strip			
HR coils & sheets	15		16
CR coils & sheets	15	16	17
Coated	17	17	18
Total narrow	47	33	51
Grand total	2 324	1 118	2 452

Assumptions:

HR sheets/HRC	95%
CRC/HRC	94%
CR coils & sheets/CRC	96%
Tinplate sheets/CRC	93%
Galv. sheets/CRC	100%
Other coated sheets/CRC	100%

(a) wide strip is defined in the customs statistics as more than 600mm

Source: Customs Statistics and Consultants' estimates

TABLE 3.4 - THICKNESS OF HOT ROLLED PRODUCTS (a)

Thicknesses	Hot rolled products (000 t)	For cold rolling (000 t)	Total (000 t)	Percent
>10mm	251		251	10%
4.75-10mm	338		338	14%
3-4.75mm	273	150	423	18%
<3mm	384	1 004	1 388	58%
Total	1 246	1 154	2 401	100%

(a) excluding narrow strip, expressed in terms of HRC equivalent
Source: Customs Statistics and Consultants' estimates

TABLE 3.5 - THICKNESS OF COLD ROLLED PRODUCTS (a)

Thicknesses	Uncoated products (000 t)	Coated products (000 t)	Total (000 t)	Percent
>3mm	25	12	37	3%
1-3mm	180	65	245	23%
0.5-1mm	219	80	299	28%
<0.5mm	400	104	504	46%
Total	824	261	1 085	100%

(a) excluding narrow strip, expressed in terms of CRC equivalent
Source: Customs Statistics and Consultants' estimates

3.3 The Demand for Long Products

While total flat product consumption in previous years can be estimated solely from the Customs statistics, this is not the case with long products. As has been described in Section 2, the majority of these products are manufactured within Thailand. Furthermore the extent of this production is unclear when it comes to the amount of products directly re-rolled from ship-plate and cobble plate.

As with flat products, special steels are excluded from the analysis. In 1988, 7000 tonnes of stainless steel and 42000 tonnes of alloy steel were imported in the form of bars and sections.

3.3.1 Historical consumption of all long products

Figure 3.7 shows the consumption of long products together with a fitted exponential growth curve. The average annual growth rate between 1970 and 1988 was 6 percent but, as with flat products, demand has risen sharply in 1987 and 1988. The data upon which this graph is based comes from the ESTS report for the years 1970 to 1982, and from the Consultants estimates for the years following.

When compared with GDP growth, an elasticity of 0.92 is obtained. This means that for each 1 percent growth in GDP, there has been a 0.92 percent increase in the consumption of long products. However, the statistical fit is not very good, with an r^2 value of 81 percent. Long products consumption is of course linked to the level of activity in the construction sector, not overall GDP. Various statistical relationships were tried but none showed any statistically significant correlation between the two. This is due to the volatility in the construction series and the inaccuracy of the apparent consumption.

Figure 3.8 shows indices of long products consumption and GDP. The two building booms experienced in Thailand, one at the end of the 1970s and one at the end of the 1980s can be clearly seen.

3.3.2 The product mix in 1988

By combining the production figures quoted in Table 2.3 with information from the Customs Statistics, it is possible to estimate the overall product mix for 1988. This is shown in Table 3.6.

Figure 3.7 Long Products Consumption

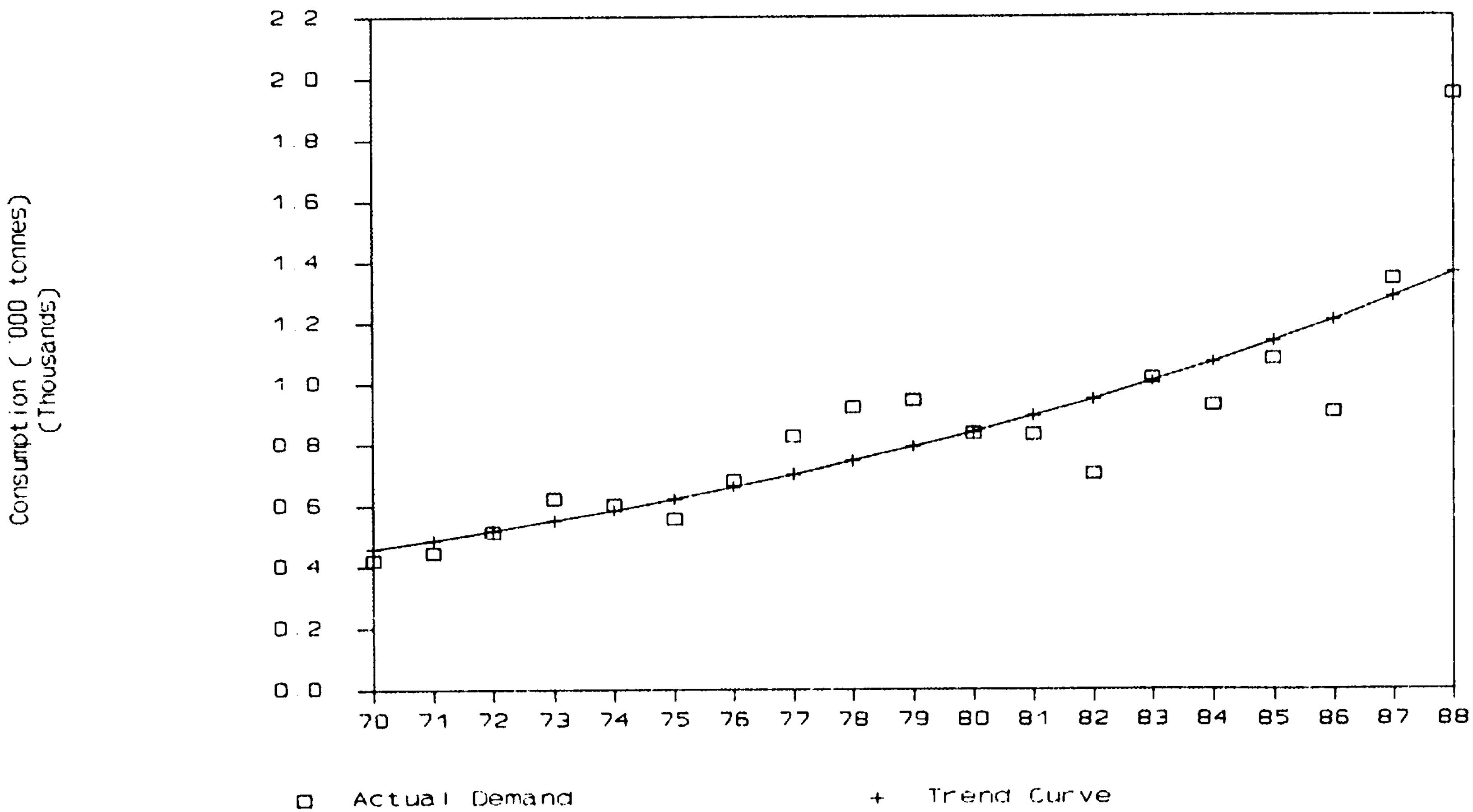


Figure 3.8 Long Products Consumption

and GDP Indices

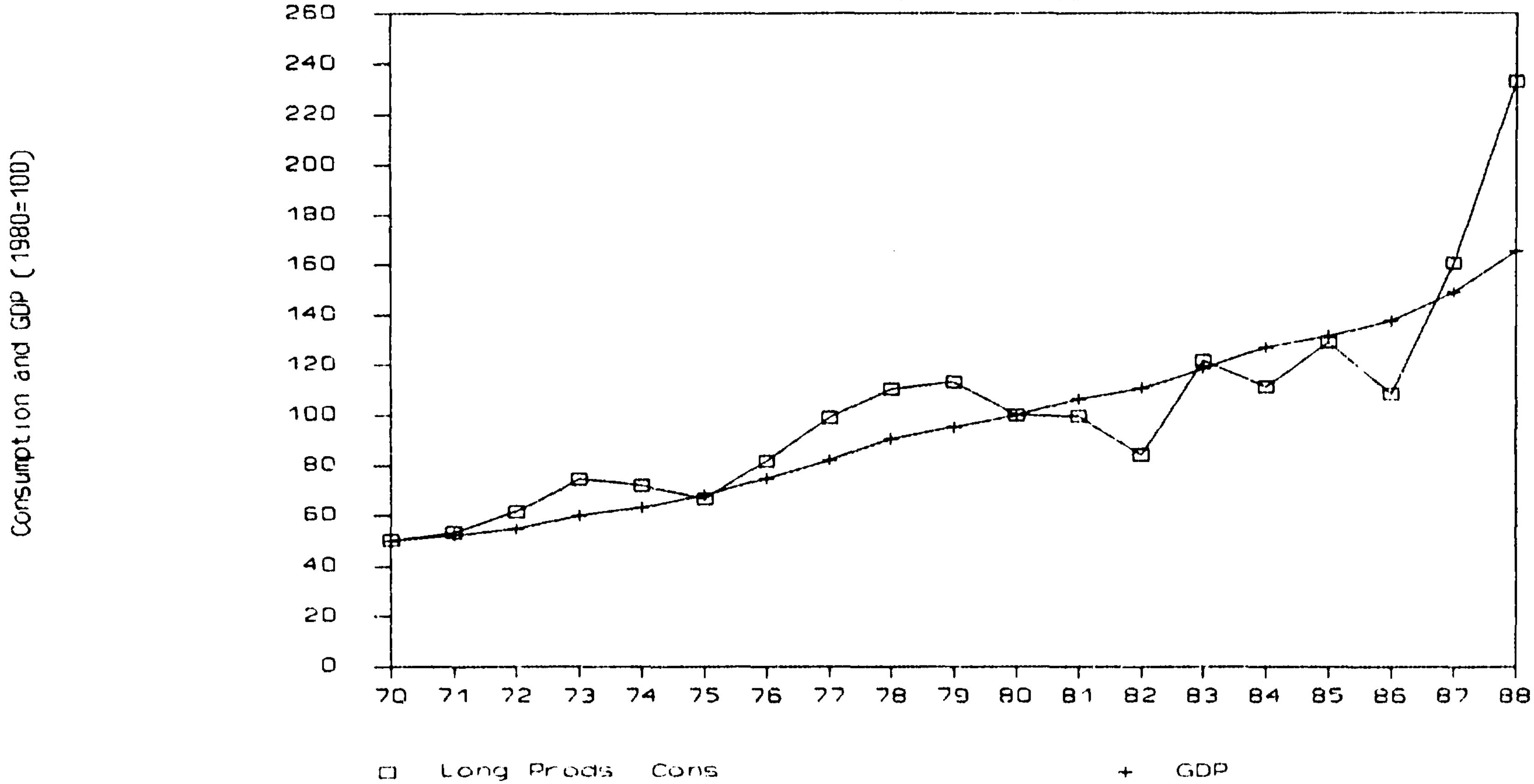


TABLE 3.6 - LONG PRODUCTS CONSUMPTION - 1988 ('000t)

Item	Domestic Production	Imports (a)	Exports	Total
Reinforcing bar-				
- round	713	86	(2)	797
- deformed	370	140	(9)	501
Wire rod	216	180	-	396
Light Sections	50	44	(11)	83
Heavy sections	-	144	0	144
Other	16	6	-	22
Total	1365	600	(22)	1943

(a) Consultants' estimated product split

3.4 Projections of Future Demand

This section describes the Consultants base scenario for economic growth in Thailand and our projections of the demand for steel. Three forecasting methods are used. Firstly, long term trends for consumption are extrapolated at their historic growth rates. Secondly, attempts are made to relate demand to future growth rates of GDP. Thirdly an approximate sectoral breakdown is made.

In all cases, the total market is forecast, that is, including products that are unlikely to be made in Thailand in the period under consideration. These products are dealt with and excluded in Section 5.

3.4.1 Future prospects for the economy

As described in Section 3.1, Thailand is experiencing a boom in investment, industrial activity and tourism. It is benefitting from the fast growth in East and South-east Asia generally and has been seen as a low-cost producer by such countries as Japan.

For planning purposes the Consultants have assumed that the rate of GDP growth will fall after 1990. This is based on a number of factors that might inhibit growth in the country:

* inflation, which has historically been low in Thailand is now approaching 6 percent, showing some overheating of the economy;

* world trade will slow down;

* some manufactured goods that are exported have already achieved fairly high market shares in world trade, eg canned foods;

* infrastructure development needs to 'catch up' with other areas of investment;

* other supply-side constraints will present themselves as growth continues, e.g. there is likely to be a shortage of skilled manpower.

These considerations lead to the forecasts for economic growth shown in Table 3.8. It can be seen that both manufacturing and construction are expected to continue to grow faster than GDP. Construction, in particular, will grow strongly in the next few years while the current 'back-log' of projects is worked out of the system.

The forecasts are lower than current estimates made by the Thailand Development Research Institute - generally by 1 or 2 percentage points. TDRI expect strong, export-led growth to continue, arguing that the geographical and product diversity of exports will allow Thailand to expand its market share, even if worldwide growth falters. They accept the need to control inflation and to provide more infrastructure and skilled manpower but believe that these problems will be resolved over the next few years.

Growth in the construction sector is particularly difficult to forecast as it has exhibited strong cycles in the past and is currently experiencing an unprecedented boom. Much of the demand is coming from the private sector but the Government share will increase in the short term as a number of large projects get underway. Most observers agree that growth rates for the sector will fall to more normal levels by the middle of the decade.

TABLE 3.8 - GDP GROWTH ANTICIPATED TO 2000

Item	1989	1990	1991-95	1996-2000
Total GDP	10.5%	9.0%	7.0%	5.5%
Manufacturing	12.0%	11.0%	8.0%	6.0%
Construction	14.0%	15.0%	9.0%	4.5%

3.4.2 Projections of demand for flat products

Three different methods of projecting demand are described in this section, together with the results obtained by each.

Method A - extrapolation of past trends

As already shown in Figure 3.4, the growth of imported flat products has been 10.2 percent per annum. Because of the very high growth rates recorded in 1987 and 1988, the 'trend' figure for 1988 is lower than the actual imports. If one extrapolates this curve and converts the mix of products imported to their hot and cold rolled equivalent tonnages, one obtains the following forecasts:

Year	Hot rolled (a) ('000 tonnes)	Cold rolled ('000 tonnes)
1990	2700	1200
1995	4500	2000
2000	7400	3400

(a) including HRC for cold rolling

Method B - Use of projections of GDP growth

Table 3.8 shows the Consultants' estimates of future growth rates for GDP. Applying an elasticity multiplier of 1.3 to these figures gives another projection of flat products demand. In this case, the forecast uses the (higher) actual 1988 import figures as their base. Converting into HRC and CRC equivalents, as before, yields the following results:

Year	Hot rolled (a) ('000 tonnes)	Cold rolled ('000 tonnes)
1990	3100	1400
1995	4800	2200
2000	6800	3100

(a) including HRC for cold rolling

Method B starts from a higher base than Method A, and so the 1990 and 1995 forecasts are higher. The forecasts for 2000 are lower. This is because, with Method A, the trend growth rate of 10 percent is assumed to continue throughout the whole period while that estimated from GDP is only 7.2 percent after 1995. (ie. 5.5 percent GDP growth times a multiplier of 1.3 = 7.2 percent).

Method C - Sector based forecasts

An alternative method of forecasting is to consider the potential for growth in each of the steel consuming sectors. To do this properly requires a considerable amount of survey work among existing customers and this has not been possible in the time available. A rather aggregated sub-division of customers has, therefore, been necessary.

The Consultants have divided the market into six major sectors - tinplate, galvanised sheets, feedstock for pipe manufacture, feedstock for cold forming and other construction related uses, and hot and cold rolled products for general manufacturing. Growth rates have been estimated for each.

Tinplate

The tinplate and TFS market has grown by an average 9.5 percent per annum since 1970. This growth has been brought about by the considerable export success of canned fish and pineapple. Cans are also used domestically for dairy products. Growth may well be slower in future years as export trades already have a 50 percent share of overall world trade. Opportunities for diversifying into other products are being explored, however, and tomatoes are another crop with considerable potential.

It has been assumed that growth in 1989 was 9 percent and will come down in stages to 7 percent in 1991 and 6 percent in 1996.

Galvanised sheets

In contrast to tinplate, hot-dip galvanised sheets are primarily used in the domestic market - for roof and side sheeting. Growth in this market has averaged 5 percent per annum but the last few years have seen a much faster rate of increase. A 5 percent growth rate is assumed for the future.

Electro-galvanised and other coated sheets are assumed to grow at the same rate as manufacturing (see below).

Feedstock for pipe manufacture

Pipe manufacturers produce about 70 percent of their output for export and 30 percent for domestic production. The former proportion depends upon price considerations but also on the amount of protection that producers in other countries are given. In 1988, 60% of exports went to the United States and this may well be curtailed in future years. Domestic output should increase with water supply and other infrastructure projects. A nominal 3 percent annual growth rate is assumed in the total production of pipes.

Cold forming and other construction uses for hot rolled steel

As described in Section 2, cold forming appears to account for a significant proportion of the total demand for hot rolled steel. Its growth will be affected by two conflicting trends. Firstly the construction sector is set to grow at a rapid pace, at least for the next few years, and so this will enlarge the market. Secondly, however, it is likely that rolled sections will compete more effectively with this product in the future. Thailand is unusual in the amount of formed sections used compared to rolled sections.

Apart from sections, there is a significant use of hot rolled products in fabrication, domestic storage tanks, concrete formwork etc.

All of this demand has been assumed to grow in line with growth in the construction sector.

Cold rolled steel for manufacturing

This sector is the largest user of cold rolled steel, but is itself, of course, a diverse group of industries. It includes automobile, bicycle and motorcycle production and the manufacture of household appliances, office furniture, and light gauge materials for the construction industry. Some of these products are just starting to be exported, but not in large quantities. For the future, the estimates in Table 3.8 of the growth rate for the manufacturing sector are used. This sector is assumed to grow faster than GDP with the assumption of some export prospects, for example in household appliances.

Hot rolled steel for manufacturing

This sector is even more diverse than that for cold rolled. It includes those mentioned previously, and those related to agricultural implements and machinery. The manufacturing sector annual growth rate is again used as a predictor of future demand.

Aggregating these demands gives a forecast which is lower than that obtained by Methods A and B above. This is because, when looked at individually, the demand from several consumers (notably but not solely pipe manufacturers) are assumed to grow less fast than the extrapolation of their past performance.

This type of analysis can yield an underestimate of demand because it is based on existing consumers and ignores the possibility of new steel-intensive industries emerging. For example, Thailand would like to develop a shipbuilding and repair industry. In the Consultants' opinion this is not likely to be a significant steel user before the year 2000, but this may be proved wrong. Similarly new export-based industries, such as the manufacture of freight containers, become useful new customers for steel.

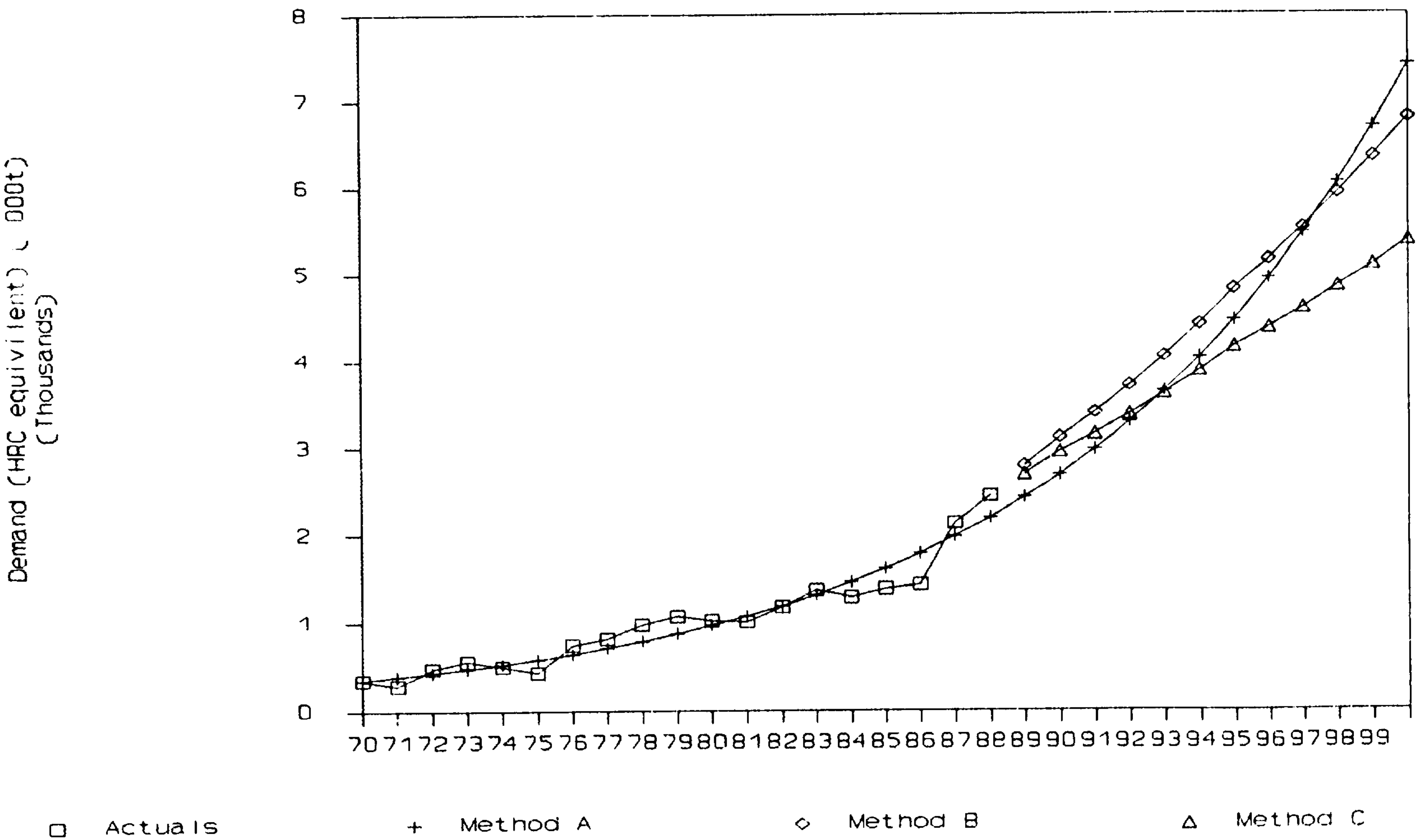
Presented in the same format as before, the forecasts are as follows:

Year	Hot rolled (a) ('000 tonnes)	Cold rolled ('000 tonnes)
1990	2900	1300
1995	4100	1900
2000	5400	2500

(a) including HRC for cold rolling

Figure 3.9 shows the three forecasts described above.

Figure 3.9 Flat Products Forecasts



3.4.3 The chosen scenarios

For the purposes of evaluating projects in the flat products sector, three scenarios will be used concerning the demand for steel:

* 'high' scenario, based on the mean of the projections made using Methods A and B

* an 'expected' scenario, based on the projections resulting from Method C

* a 'low' scenario, based on 90 percent of the expected scenario.

This may appear unduly pessimistic but the Thai economy is in a tremendous state of flux, leading to considerable uncertainty about the future. It is usually preferable to under-invest and then operate at a good utilisation than to build plants that, on completion, have to wait for the market to catch up with them. This is especially so in the present context where sufficient markets already exist to allow reasonable economies of scale to be obtained, where exports would almost certainly be hard to achieve, and where imports are unlikely to be very much more expensive than the domestic product. Competition from imports is also likely to be a healthy stimulus for cost effective production.

The three scenarios are summarised in Table 3.9.

TABLE 3.9 - THE THREE SCENARIOS FOR FLAT PRODUCT DEMAND ('000 tonnes)

Year	Low	Expected	High
Hot Rolled Coil-Total (a)			
1938 (actual)	2 451	2 451	2 451
1990	2 650	2 944	2 897
1995	3 734	4 149	4 633
2000	4 830	5 367	7 098
Average growth rate (b)	5.8%	6.7%	9.3%
Hot Rolled Products			
1988 (actual)	1 262	1 262	1 262
1990	1 373	1 525	1 491
1995	1 932	2 147	2 385
2000	2 441	2 712	3 654
Average growth rate (b)	5.7%	6.6%	9.3%
Cold Rolled Coil			
1988 (actual)	1 118	1 118	1 118
1990	1 200	1 334	1 321
1995	1 693	1 881	2 113
2000	2 246	2 495	3 238
Average growth rate (b)	6.0%	6.9%	9.3%

(a) including HRC for cold rolling
(b) from 1988 to 2000, expressed as an annual growth rate

3.4.4 Projections of demand for long products

As with flat products, three methods have been used for projecting total future demand for long products. The results of each are presented in this section and summarised in the next.

Method A - Extrapolation of Past Trends

Historic growth in long products has averaged 6% per annum since 1970. In 1987 and 1988 very large increases have occurred and this means that the 'trend' position for 1988 is much lower than the actual figure. The trend curve shows 1.3 million tonnes, whilst the actual consumption was about 1.9 million tonnes. This means that if the trend is extrapolated, it takes until 1994 for demand to reach the 1988 levels again. The forecasts are:

Year	Long Products ('000 tonnes)
1990	1500
1995	2100
2000	2800

Method B - Use of Projections of GDP growth

The elasticity of long products demand in the period 1970 to 1988 was 0.92. That is, demand has been growing slightly slower than GDP (though obviously this is not the case in 1987 and 1988). Using the GDP projections in Table 3.8 and applying the multiplier, gives the following forecasts:

Year	Long Products ('000 tonnes)
1990	2300
1995	3200
2000	4000

These figures are much higher than those derived by Method A. This is not because the annual increases assumed are larger, but because the starting point of the forecast is much higher - relating to actual consumption in 1988, not the trend position. They are, however, also rather illogical as long products have only a tenuous link with GDP growth.

Method C - Product based forecasts

In the case of long products, the vast majority of the demand is taken up by the construction sector. Thus instead of seperating out different products, the forecasts for the construction industry (as shown in Table 3.8) are taken as a proxy for future demand growth. This leads to the following forecasts:

Year	Long Products ('000 tonnes)
1990	2600
1995	3900
2000	4900

These figures are similar to, but slightly higher than those produced by Method B. The starting point for the forecasts are the same but the overall growth rate is slightly higher.

Figure 3.10 shows the three forecasts described above.

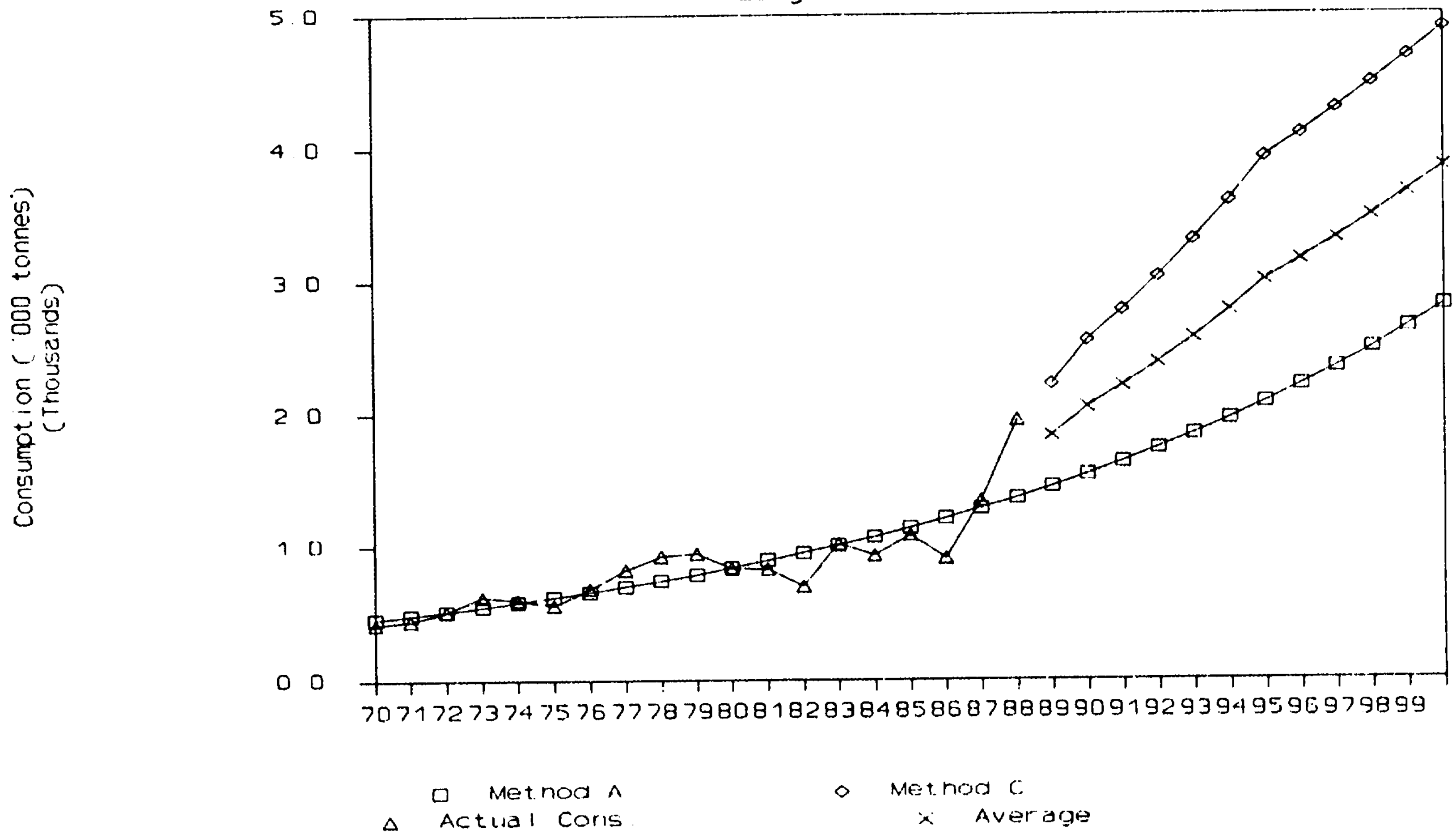
3.4.5 The chosen scenarios for long products

As can be seen, forecasting long products demand is rather difficult. Unlike flat products, where demand is generated by a number of different industries, long products are nearly all used by a single sector - the construction industry. This makes demand more variable and is compounded by the fact that the level of construction itself is often cyclical. It is dependent on the investment cycle in the economy as a whole.

Since 1970, long products have grown less strongly than GDP and in general so has the construction sector. The present construction boom which started in 1987 and is expected to run at least through 1990 has changed the position dramatically. From 1986 to 1988, the construction sector grew by 23% compared to a GDP growth of 20%. Long products consumption, however, appears to have grown by 100% in the same two years.

Figure 3.10 Projections of

Long Products Demand



Some of this growth will be accounted for by stock-building but this still leaves a very large multiplier effect to be explained. It must be remembered that production figures in all years, ie the ESTS figures from 1970 to 1982 and the Consultants' from 1983 to 1988, all have possible errors, due to the uncertainty in the output of the re-rollers.

For the future, the question is whether the current level of demand forms a basis from which to predict further growth or whether it is at or near to a peak and will decline at some future time. As already stated the Consultants expect construction activity to have been buoyant in 1989 and to be so again in 1990, but a downturn may well come later in the decade.

As a lower bound, the Consultants have used the extrapolation of past trends (ie Method A). As an upper bound they have used the forecast which uses the construction sector growth rate and the 1988 apparent consumption as its starting point (ie Method C). For the 'expected' scenario, the average of these two forecasts has been used.

The uncertainty of long products demand is a major contributory reason why companies with licenses for new developments are acting so cautiously with regard to bringing their proposed projects on-stream. The three scenarios are outlined in Table 3.10.

TABLE 3.10 - THE THREE SCENARIOS FOR LONG PRODUCT DEMAND
(000 tonnes)

Year	Low	Expected	High
1988	1946	1946	1946
1990	(b)	2044	2551
1995	2077	3001	3925
2000	2808	3850	4892
Average growth rate (a)	3.1%	7.3%	8.0%

(a) From 1988 to 2000, expressed as an annual growth rate
(b) Trend Forecast inappropriate

3.4.6 Other measures of growth

One trend often observed in a developing country is a steadily increasing proportion of flat products within the total consumption of steel. Using historic consumption figures and the 'expected' forecasts presented in this section, the following trend results:

Year	Proportion of flat products
1970-1979	47%
1980-1989	57%
1990-1999	58%

The 1980's figure of 57% is high for a country like Thailand as 60% is usually considered to be close to the maximum. The relatively large pipe and tinplate industries, and extensive use of flat products in construction would be part of the explanation.

Another broad measure used for international comparisons is the per capita consumption of steel. Currently Thailand's population is 55 million and growing at about 2% per annum. Steel consumption (on a products basis) is about 75kg per person. With the projections presented earlier, and a population of 70 million people, the per capita consumption in the year 2000 would be 130kg. This is about the sort of level that one would expect from a country with a GNP of about $2000 per capita. (Malaysia for example has a consumption of about 100kg/head on a products basis.)

In the longer term, if Thailand were to become a much more industrialised country, figures of around 200-250kg plus, would not be exceptional. Thus, there would appear to be considerable scope for further expansion.

4. FACTORS AFFECTING FUTURE DEVELOPMENTS

This section describes world-wide trends in the market for steel products, in the availability of raw materials, and in steel production technologies. Some general conclusions are drawn concerning the conditions under which future developments of the Thai steel industry will need to operate.

4.1 Trends in the World Market for Steel

From 1960 to the first oil shock of 1973, the market for steel expanded rapidly both in industrialised and developing countries. At the end of the period the industry was operating close to its capacity and prices were rising. This encouraged considerable investment in new capacity.

In 1973 demand in the industrialised countries fell - leaving a widening gap between supply and demand. Initially, companies continued to operate at low capacity levels and it was not until 1980, encouraged by Government assistance, that surplus capacity began to be closed. Since then capacity has continued to decline with much old and obsolete plant being taken out of service. Most western companies are again operating at a high level of utilisation. With uneconomic plant removed, labour forces much reduced, and high prices of products, the iron and steel industry is again reporting profits.

Experience in the developing countries has been a little different. Demand continued to rise during the 1970's and additional capacity was installed. In those countries where some form of central planning was involved, the aims have been twofold - to save foreign exchange by import substitution and to foster the growth of downstream industries.

Utilisation, at least at the more efficient works, has remained high but many companies are still not making profits. This is due to poor operating practises, or large debt burdens, or the inability to reduce costs. Most are government owned and have required subsidies or significant tariff protection. Protection is necessary to counter 'unfair' competition, but when it becomes excessive it is the downstream industries who usually suffer, defeating one of the purposes of erecting the steelworks in the first place.

Table 4.1 shows the composition of world trade in steel products in 1987, the last year for which full figures are available. For Thailand, two important points emerge:

* Thailand's flat product imports represent about 3% of the total world trade in these products. This is not a high figure but it is one that will rise significantly over the next decade if domestic production does not commence in the meantime.

* The trade in semi-finished products represents a small proportion of the total and most of this is in billets. Slab exports only registered 3.6m tonnes, though the figure has risen since that time, with both Mexico and Brazil exporting fairly significant quantities.

Mexican slabs come from the new Sicartsa II plant located on the Pacific coast. Originally the plan was to roll these slabs into plate but, because of a downturn in the Mexican market, the mill has never been completed. When it is eventually built, the number of slabs sold will be reduced or stopped altogether.

This example shows the danger of relying too heavily on importing slabs. In general the trade is a result of works being temporarily out of balance, as all companies wish to roll their own semis where possible, in order to maximise the added value of their output.

TABLE 4.1 THE COMPOSITION OF WORLD TRADE, 1987

Product	Amount (million tonnes)	Percent of total
Semi-finished prods	14	11%
Long products	32	24%
Flat products	64	48%
Tubes	16	12%
Others	8	6%
Total	135	100%

4.1.1 Trends in international prices

The broad picture concerning price trends over the last thirty years is as follows:

* during the 1960's and 1970's, prices rose in nominal terms, due to the general inflationary trends of the period, and in real terms due to high capacity utilisation;

* the peak was reached in 1980 after which prices fell, reaching their lowest point around 1985;

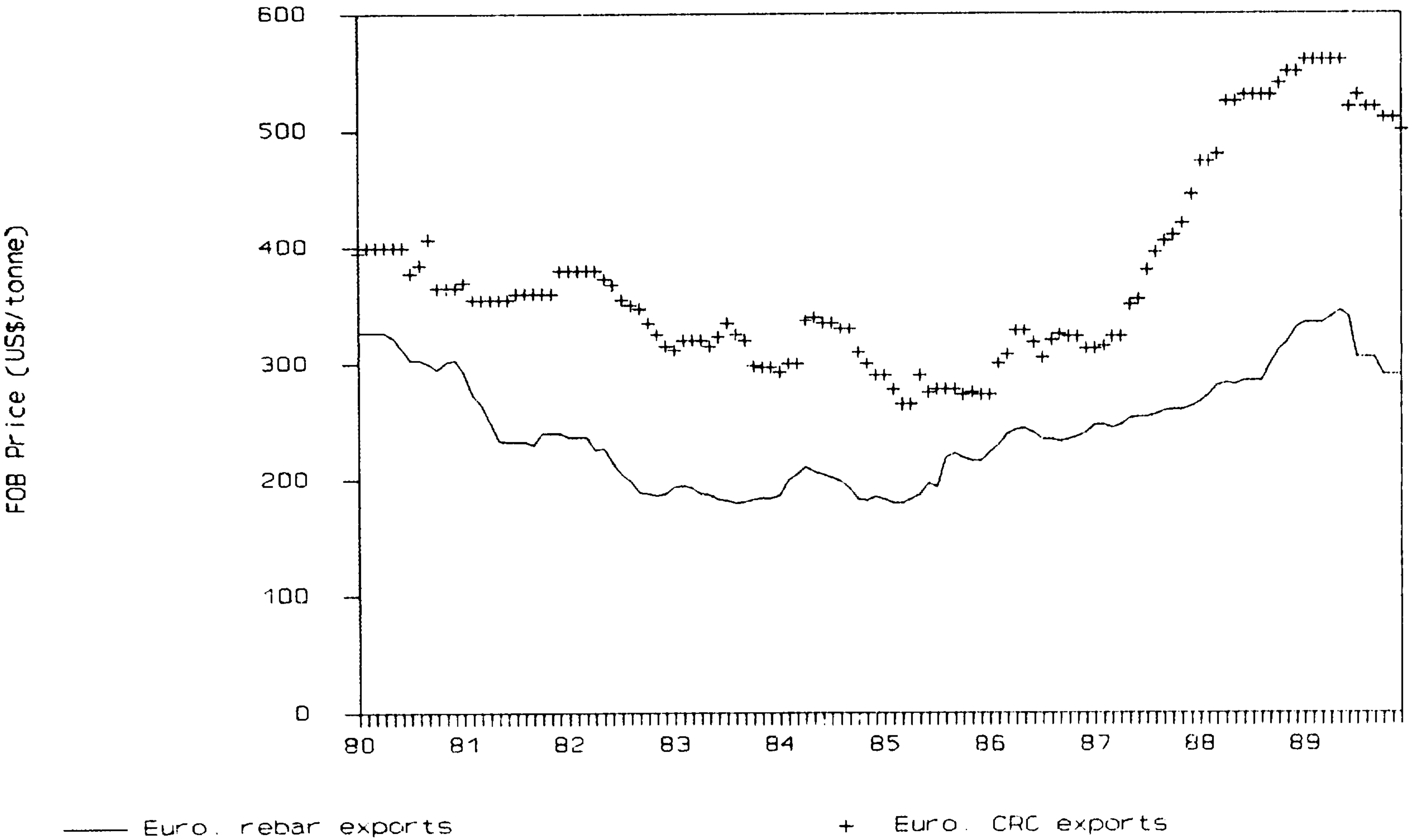
* since then prices have increased sharply as supply and demand have once more become roughly balanced;

* the last half of 1989 has shown a slight decline and most commentators suggest a gradual fall in the underlying trend for the future.

Figure 4.1 shows export prices for reinforcement bar and cold rolled coil from Europe during the 1980's, with the trends described above.

Within this overall context, the prices of the more important product groups in Thailand are discussed below.

Figure 4.1 European Export Prices



Hot rolled coil

The cif values for different thicknesses of hot rolled products are shown below:

Thickness	Av. Value (baht/t)	Av. Value (US$/t)
>10mm	8,800	345
4.75-10mm	9,600	376
3-4.75mm	9,700	380
<3mm	10,600	416
Weighted av.	9,800	384

The Japanese average export price in 1988 was US$400, fob. This is inconsistent with the average Thai import value and is due to Japan only suppling Thailand with a small proportion of its hot rolled products, and mainly in the thinner gauges. The remainder comes from a variety of sources and a significant proportion consists of seconds or over-rolled coils.

Cold rolled coil

The customs statistics give the following cif values for imported cold rolled products in 1988:

Thickness	Av. Value (baht/t)	Av. Value (US$/t)
>3mm	11,200	439
1-3mm	12,400	486
0.5-1mm	13,000	510
<0.5mm	14,400	565
Weighted av.	13,500	529

About 70% of these imports came from Japan. From the Japanese export statistics, the average fob price of cold rolled products was $US490.

The price differential between hot and cold rolled imports was (US$529 - US$384) US$145. This is larger than the differentials found in the market generally, for the reasons given above. That is, the cold rolled product mix consists of high quality, thin material; whilst the hot rolled product mix is of rather low quality.

Coated cold rolled products

From the customs statistics the cif values of imported tinplate and galvanised sheets were 16,900 baht/t (US$663) and 16,300 baht/t (US$639) respectively. After taxes, duties and port charges, this implies a sales price of 20,300 baht for tinplate and 22,000 baht for galvanised sheets. From what information is available it would appear that domestically produced tinplate sells at a slightly higher price than the imported product, whilst locally made galvanised sheet sells at a lower price.

Long products

At the end of 1987 there was a shortage of rod and bar for construction purposes in Thailand and prices were rising rapidly. This was causing bottlenecks and cost over-runs in the construction sector and the Government responded in a number of ways. Import restrictions were lifted on some products and duties were reduced from 25% to 15%, and later to 10%. These actions relieved some of the pressures in the market and imports of long products rose from about 300,000 tonnes in 1987 to about 600,000 tonnes in 1988. The cif value of these imports was 8500 baht/tonne (US$333) which, at the lower rates of duties and including business and municipal taxes, led to a total price of about 10,900 baht (US$427).

The Ministry of Commerce issues a price index for 6mm reinforcing bar. This showed an average price of 9,300 baht in 1987 and 11,200 baht in 1988. The product chosen for this series is at the upper end of the price range because it is the thinnest gauge. The weighted average price over all thicknesses would be a little less than this, say about 95% of the price for 6mm bar. The average price was therefore about 10,600 baht (US$416) in 1988.

In 1989 the price continued to rise. The weighted average price in 1989 is estimated to be about 13,000 baht but falling towards the end of the year.

Because of the current demand for reinforcing bar, it would appear that there is very little differential in prices between products directly rolled from scrap and those rolled from domestically cast billets.

Semi Finished Products

As explained above, the prices of semi finished products tend to be volatile and depend upon the supply and demand position at the time orders are placed.

Imported billets in 1988 had a cif value of 6,600 baht/t (US$260) and the average price in 1989 is believed to have been similar. At the end of the year, however prices had dropped to around US$220.

Currently Thailand does not import slabs, but Brazilian slabs are being imported to Europe at a cif price of about US$ 300.

4.2 The Availability and Prices of Raw Materials and Energy

This section describes the current trends in the market for the major inputs to the steel industry. For the traditional blast furnace route, the basic raw materials are iron ore in the form of lump ore, sinter fines or oxide pellets, and coking coal. Alternative process routes based on direct reduction use lump ore and oxide pellets with either low grade coals, lignite or natural gas as their fuel and reductant. Scrap is another feedstock for electric arc steelmaking, and all processes need fluxes, ferro alloys and electricity.

4.2.1 Iron ore

Current ironmaking practice is to use high grade iron bearing materials, generally containing between 62 and 67 percent Fe. Blast furnaces are operated on burdens comprising mainly sized sinter, which is produced by sintering iron ore fines of 0 to 10mm size range, together with lump ore of 10 to 30mm size range and oxide pellets of 6 to 15mm size range. Shaft type direct reduction furnaces use burdens comprising mainly oxide pellets of 6 to 15mm size range, together with lump ore of 10 to 30mm size range. Rotary kiln type direct reduction processes are operationally more flexible and can use burdens comprising iron ore concentrates (fines) only, or in combination with lump ore and oxide pellets.

Present knowledge on iron ore deposits in Thailand is based on exploration work undertaken by the Department of Mineral Resources (DMR), and is summarised in Table 4.2.

The DMR has stated that the only high grade iron ore deposits currently discovered in Thailand are at Loei in the north east region. These deposits were surveyed in 1969 by a United States geological survey team in association with the DMR. Their findings indicated that the Phu Yang (Chiang Khan) deposit contained 14.25 million tonnes of proven and possible iron ore reserves, whilst the Phu Ang deposit contained 11 million tonnes of reserves.

Their conclusions were that the Phu Yang deposit could be economically open pit mined with minimal stripping, although only 2.0 million tonnes was of haematite/magnetite ore of 62.4 percent Fe. The remaining 12.25 million tonnes of iron ore contained 45.9 percent Fe, but also 6 percent pyrite, which would require high processing costs for its removal from the ore.

TABLE 4.2 - THAILAND'S IRON ORE DEPOSITS

(Reserves more of than 1 million tons)

No.	Resource	Location	Reserve (mill. tons)	% Fe	Distance from Bangkok	Comments
	Central Region					
1.	1. Nong Bon	Tambon Plang Yao Amphoe Bangkhla Changwat Chachoengsao	6.2	40.0-57.9	139	Laterite
2.	2. Lad Krating	Amphoe Phanom Sarakham Changwat Chachoengsao	2.5-2.8	25.0-35.0	154	Laterite
3.	3. Prachantakham	Amphoe Prachantakham Changwat Prachinburi	8.0-12.0	25.1-29.3	180	Laterite
4.	4. Eastern of Prachinburi	Amphoe Muang Changwat Prachinburi	12.0	16.1-39.8	175	Laterite
5.	5. Nong Wha Ean	Tambon Sri Maha Phot Amphoe Sri Maha Phot Changwat Prachinburi	1.61	33.59-41.35	n/a	Laterite
6.	6. Khao Tap Kwai	Tambon Huay Pong Amphoe Khok Samrong Changwat Lopburi	6.8	48.4-66.4	179	Siam Cement Co
7.	7. Khao Um Krum	Amphoe Bo Phloi Changwat Karnchanaburi	4.87	40.5	182	Low Grade Fe

Table 4.2 cont.

No.	Resource	Location	Reserve (mill. tons)	% Fe	Distance from Bangkok	Comments
	North-Eastern					
8.	1. Chiang Khan - Phu Yang - Phu Sang - Phu Hiet - Phu Lek	Amphoe Chiang Khan Changwat Loei	14.25	50.85	699	High Grade Fe
9.	2. Phu Ang - Phu Khok - Phu Khumthong - Phu Hin Lek Fai	Amphoe Muang Changwat Loei	11.0	43.0-58.6	658	High Grade Fe
	Souther Region					
10.	1. Ko Cham	Amphoe Ko Lanta Changwat Krabi	12.0	57.69	1,118	Fe Analysis too high
11.	2. Khuan Pot	Tambon Chalung Changwat Satun	8.0-10.0	28.0	1,392	
12.	3. Khao Noi Khao Phang	Tambon Tunglong Amphoe Khanom Changwat Nakhon Sri Thammarat	3.0	n/a	750	
	Northern Region					
13.	1. Huay Bo Lek	Ban Pha Chong Amphoe Mae Cheam Changwat Chiang Mai	1.0	69.85	956	High Grade Fe

Source: Department of Mineral Resources, 1st October 1987

The Phu Ang deposit could also be economically open pit mined for 7.6 million tonnes of oxidised ore of 58.6 percent Fe. However, the remaining 3.4 million tonnes of unoxidised ore of 43 percent Fe, and over 6 percent pyrite, was at a depth of 50 metres, which would result in its having high mining and processing costs.

From these conclusions, it appears that only about 10 million tonnes of iron ore could be economically mined from these two deposits. This amount of mineable iron ore reserves is insufficient to meet the requirements of an integrated steelworks, since it is generally accepted that a dedicated mining source should have proven reserves to meet at least 20 years operations of the steelworks that it supplies. For an integrated steelworks of 3 million tonnes/annum capacity, this would mean an iron ore reserve of about 100 million tonnes.

Ironmaking production for such a steelworks in Thailand at the present time would need to be based on imported high grade iron ores purchased on the extensive world iron ore market, which currently amounts to about 400 million tonnes annually.

Many countries export sinter fines, lump ores and oxide pellets, the major suppliers being Australia, India and Brazil. Whilst direct reduction quality oxide pellets are available from at least 8 countries including Brazil, Sweden, India and Canada.

Current CIF prices for these iron bearing materials are estimated as:

Sinster fines	US $	30 per tonne
lump ore	US $	35 per tonne
b.f. pellets	US $	43 per tonne
d.r. pellets	US $	45 per tonne

The economically mineable ore reserves of 10 million tonnes at Loei would only be sufficient to meet the annual iron ore requirements of a small direct reduction plant of about 300,000 tonnes/annum.

Alternatively, these ores could be used for blending with imported ores in the integrated steelworks.

4.2.2 Coking coal

For the blast furnace - basic oxygen steelmaking process route, a large quantity of metallurgical coke (about 500 Kgs per tonne of hot metal) is used in the blast furnace. This coke serves two purposes; to provide the energy for melting, and to reduce the charged iron oxides to metallic iron. Metallurgical coke is produced from bituminous coals (ie. hard or black coals). Sub-bituminous coals and lignites (ie. soft or brown coals) do not produce acceptable quality metallurgical coke.

No sources of bituminous coal, have yet been discovered in Thailand. Consequently, an integrated steelworks based on the blast furnace - basic oxygen steelmaking process route would be dependent on the import of coking coal for its production of metallurgical coke.

Whilst the supplies of coking coals are becoming scarer the Consultants are confident that the current substantial world market in coking coals, of over 100 million tonnes annually, will exist well into the next century.

Australia and the USA are two of the largest exporters of coking coals, and for the purpose of this study, it is assumed that all coal imports will be supplied from these countries.

The estimated CIF price for imported coking coal is US $ 55 per tonne.

4.2.3 Lignite

Several rotary kiln based direct reduction processes can use sub-bituminous coals or lignite as their fuel and reductant.

To ensure an economically sized plant, the recommended lignite analysis should be:

moisture	20 percent max.
fixed carbon	40 percent min.
volatile matter	35 percent max.
ash	20 percent max.
sulphur	1.5 percent max.
Calorific value	4,700 kcal/kg min.

Thailand's geological lignite reserves are estimated to total 2.2 billion tonnes, of which an estimated 800 to 950 million tonnes are economically mineable reserves. Over 600 million tonnes of these reserves are located in Mae Moh in northern Thailand.

There are currently lignite mines in production in 3 regions, namely Mae Moh, Krabi and Li. The Electricity Generating Authority of Thailand (EGAT) mines at Mae Moh (over 6 million tonnes/annum) and Krabi (about 250,000 tonnes/annum). Whilst private companies mine lignite at many deposits in the Li region, with their combined production estimated at 2 million tonnes/annum.

Lignite production has increased during the 1980's from 600,000 to over 8 million tonnes/annum, and is scheduled to expand to 24 million tonnes by 1995, and 38 million tonnes by the year 2000, according to the World Bank Joint Report on Thailand Coal Development and Utilisation, 1989.

The privately mined lignite from the Li region has a low calorific value of 3500 kcal/kg, together with low fixed carbon of 30 percent. Whilst this quality of lignite could be used to heat and reduce iron ore in a rotary kiln, it would require about 1.4 tonnes of it to produce a tonne of sponge iron. Due to the large volume the lignite would occupy in the rotary kiln, the production rate will be low, resulting in a high production cost of the sponge iron.

The DMR is currently considering bids from private mining companies to exploit lignite reserves in the Khian Sa basin, situated about 60 Kms south of Surat Thani.

The results of the exploration survey on the north and south Khao Sin La deposits of the Khian Sa basin show total estimated reserves of 6.4 million tonnes, with a further 24.3 million tonnes of probable reserves. These lignites have a higher calorific value than the Li lignites, ie. 4200 Kcal/Kg average, but their fixed carbon is only about 34 percent, and they have a high sulphur content of over 7.5 percent. If this lignite were used for direct reduction, some of the sulphur would be absorbed into the reduced product, and will prove difficult to remove during the subsequent steelmaking, Consequently, the Khao Sin La lignites would be difficult to use for sponge iron production.

Whilst the Li lignite would probably not prove acceptable on its own for sponge iron production, it should be possible to blend it with an imported higher quality coal for this purpose.

4.2.4 Ferro-alloys

The two ferro-alloys mainly consumed in steelmaking are ferro-manganese (FeMn) and ferro-silicon (FeSi). Neither of these materials are produced in Thailand at the present time, so they would need to be imported. In recent years, the prices of these commodities have fallen and their current CIF price is about US $600 per tonne.

4.2.5 Fluxes

Various fluxing materials, such as limestone, dolomite, quartzite and fluorite, are used to produce slags during iron and steelmaking. All these materials are mined in Thailand.

Deposits of suitable quality limestone and dolomite exist throughout Thailand, whilst quartzite is available from the northern part of the west coast, and good metallurgical grade fluorite is mined in north Thailand. The estimated ex-mine prices for these materials are:

Limestone	Bahts	85 to 90 per tonne
Dolomite	Bahts	350 per tonne
Quartzite	Bahts	600 per tonne
Fluorite	Bahts	1500 per tonne

4.2.6 Scrap

About 40% of the world's liquid steel is made from scrap. This comes from three sources - within works themselves, from process industries, and from the scrapping of capital items. Scrap in the first category is declining as production methods become more efficient. Process scrap naturally rises with consumption. In developed economies, about 15% of consumption is recirculated to steel plants. Capital scrap depends on the level of development in the country about a decade earlier.

Thailand produces about 0.6m tonnes of scrap each year (excluding scrap recycled within steelworks) and it is consumed in the electric arc furnaces of the long products works and in foundries. Most of it is process scrap or generated by the re-rollers, as the level of capital scrap is small. If by the year 2000 Thailand is consuming 8m tonnes of steel, then one would expect scrap arising to amount to between 1m and 1.5m tonnes per year. This will be insufficient to meet the requirements of the existing and planned long products mills and so imports will continue to be needed. Due to the large tonnages required, the Consultants believe that it would be dangerous to plan large-scale production of flat products with 100% scrap as feedstock.

World consumption of scrap was around 250 million tonnes in 1987, and the export trade amounted to 27m tonnes. The chief exporters were the USA and Europe. With the introduction of more scrap-based steelmaking capacity worldwide, it is generally held that underlying international prices must rise so that it becomes economic to collect a higher proportion of the potential scrap available.

Figure 4.2 shows the trends that have occurred in US internal scrap prices in the long term. Prices have followed the major movements in product prices. The argument above suggests that, while this may continue, scrap prices in general will be higher than they are now, when expressed as a proportion of product prices.

In 1989, the long products producers were paying between US$130 and US$150 per tonne for imported scrap. Taxes, duties and port charges account for about 5% of this cost, making an average cif price of about US$135.

Domestic scrap for melting ranged in price from 2,800 to 3,200 baht/tonne - depending upon quality. It is therefore cheaper than imported scrap on a tonnage basis, but probably very similar in price when qualities are properly taken into account.

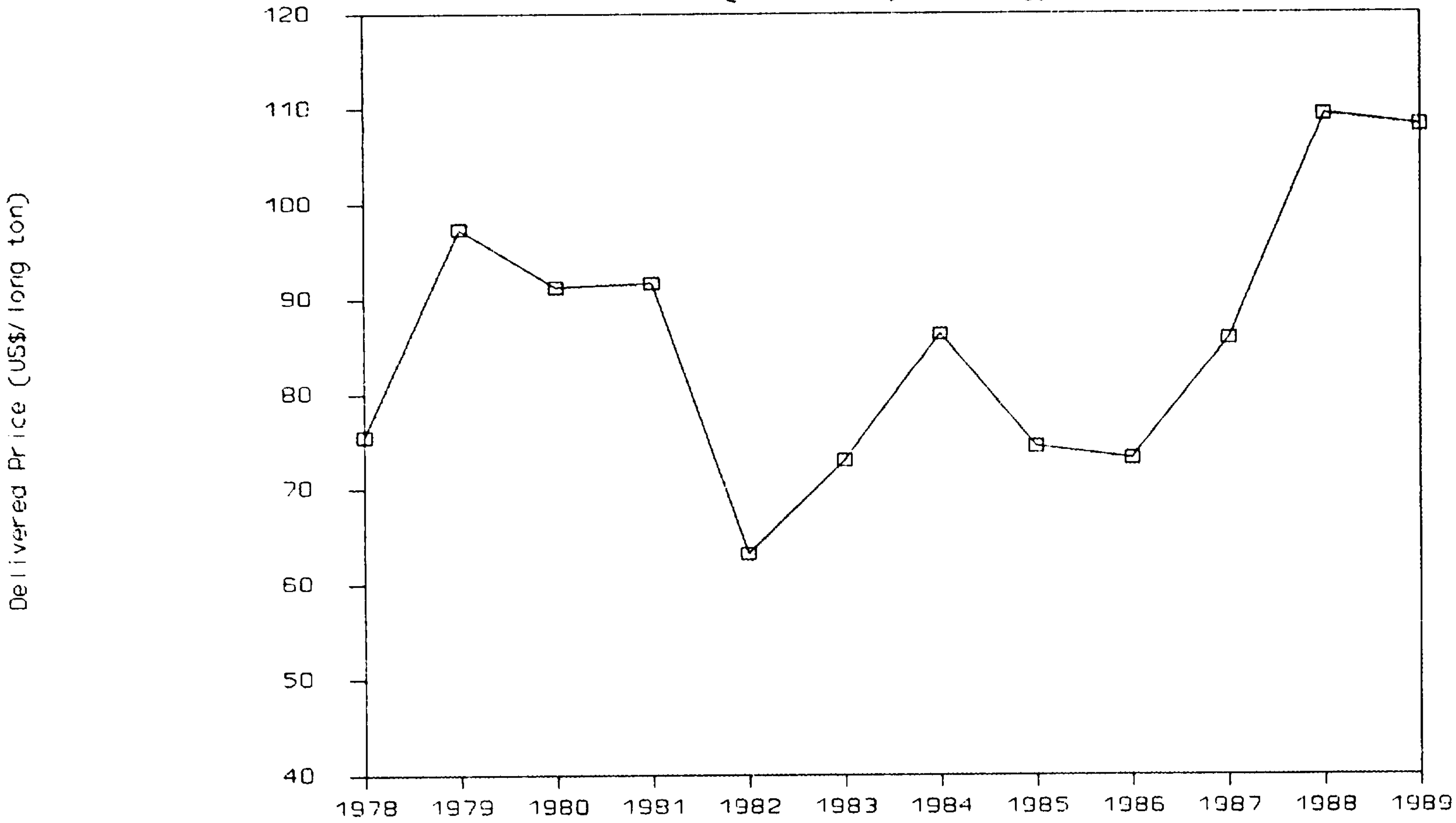
Scrap for re-rolling is a special case and needs to be treated differently than melting scrap. It consists of a (declining) proportion of ship-plate, second-quality hot rolled coils and cobble plate. Re-rollers are finding it increasingly difficult to secure feedstock and the price is rising accordingly. The 1988 customs statistics give an average cif value of US$260 for all kinds of scrap, ie melting and rolling scrap. This implies a delivered price of about US$280 for rolling scrap, and this compares well with industry sources. The average cif price for cobble plate in 1989 is stated to be about US$300 - rather higher than the equivalent price for billets.

4.2.7 Electricity

The Electricity Generating Authority of Thailand (EGAT) is responsible for the generation and bulk distribution of electricity throughout the whole of Thailand. It has been in operation since 1969. Power is sold to two distribution companies and a small number of direct customers.

Figure 4.2 US Scrap Prices

(No 1 Heavy Melting)



Current installed capacity is 7,250 MW, of which 31% is from hydro-power, 55% from thermal stations burning oil, gas or lignite, and 14% from combined cycle and gas turbines. A number of the thermal stations are dual-fired and EGAT can take advantage of the flexibility this gives with respect to the choice of fuels. It is for this reason that natural gas is sold to EGAT at the (energy) equivalent price of fuel oil. Gas currently supplies about 50% of the total power generated by EGAT.

In 1989 EGAT generated 36,500 GWh, with a peak load of 6,200 MW. Because of the rapid pace of development, EGAT sales of electricity have increased at more than 10% per annum for many years. The latest development plans forecast an average increase in generating capacity of over 900 MW per year to the end of the decade.

Electricity prices have remained unchanged since 1987. For industries such as steelmaking, the tariff is made up of three components:

* an energy charge of 1.20 baht/kWh;

* a demand charge of 165 baht per maximum 15 minute kWs per month;

* a discount of 4% of the demand and energy charges.

For a typical electric arc furnace producer, this leads to an average cost of 1.5 baht/kWh. This is equivalent to about 6 US cents per kWh and is slightly higher than that paid by steel producers in neighbouring Malaysia. As far as the Consultants are aware, this price allows EGAT to make a small return on its assets, and is thus close to a true economic price.

4.2.8 Natural gas

Natural gas from offshore installations in the Gulf of Thailand came on stream in 1981 with a production level of 100m standard cubic feet per day. Currently output is about 550M scfd and this is scheduled to rise to 850M scfd by the end of the decade. In addition on-shore gas has been found in the north east of the country and this is expected to yield a further 250M scfd when it reaches full production. By the end of the decade, therefore, about 1100M scfd will be produced. The majority of this output will be sold to EGAT and to petro-chemical plants, but about 110M scfd is earmarked for industrial users.

Currently natural gas is shipped to the Eastern Seaboard by submarine pipeline. A new line will be built to the Southern Seaboard from the offshore fields, with deliveries due to start in 1995 at the earliest. Gas from the Nam Phong field will be brought by pipeline to join the existing distribution system near the Bang Pakong power station.

As explained in the previous section, natural gas is priced to be equivalent to fuel oil. This is currently about 76 baht per MBTU. This represents an economic price, as fuel oil would need to be imported to replace gas if it were not available. Government policy is to adhere to this price mechanism and no discounts will be given for industrial users.

At this price (US$3 per mBTU) natural gas in Thailand is more expensive than in some other countries where DR plants have been economically viable. In Malaysia the price is about US$2.3 per mBTU and in Mexico US$2 per mBTU.

4.3 Trends in Steelmaking Technology

Since the 1950's the blast furnace - basic oxygen furnace process route has been the main route selected for integrated steelworks. The main products from these steelworks being plate, hot or cold rolled strip or rolled sections.

Smaller steelworks, termed mini-mills, are generally comprised of scrap based electric steelmaking shops which supply blooms or billets to rod/bar or light section mills.

During the last 20 years, various direct reduction processes have been proven commercially, and certain of these have been uprated in capacity so that they now are able to produce the large annual tonnage needed by an integrated steelworks, and can compete with the blast furnace - basic oxygen steelmaking route.

Direct reduction processes can be broadly divided into two groups, namely:

* shaft furnaces;

* rotary kilns.

4.3.1 Shaft furnace DR processes

Shaft furnace direct reduction processes generally use natural gas as the fuel and reductant. The process is based on the principle of counter-current flow in which the iron-oxide materials descend through a shaft furnace where they are heated and reduced by a rising stream of hot reducing gas. The shaft furnace has a circular cross section and comprises a refractory lined upper reduction shaft extended for more than one-half the height of the furnace and an uninsulated lower inverted conical cooling section.

Catalytic reformers are used to produce the reducing gas. Mixing valves control the composition of the feed gas, which is a mixture of natural gas and cleaned process gas. The reformers are fired with mainly process off gas enriched with natural gas. Recuperators use the exit gas from the combustion burners to preheat the combustion air. The feed gas can also be added to the reducing gas in controlled amounts to obtain the desired carbon content in the DRI.

The iron-bearing raw material can be iron ore pellets, briquetted ore fines or lump iron ore. However, the type of raw material used can have an effect on the operating performance. Some lump ores will decrepitate during reduction and generate fines that decrease the efficiency of the operation and lower the overall yield. The most desirable materials are those with low gangue contents and a sulphur content below 0.01 percent.

The Midrex Process

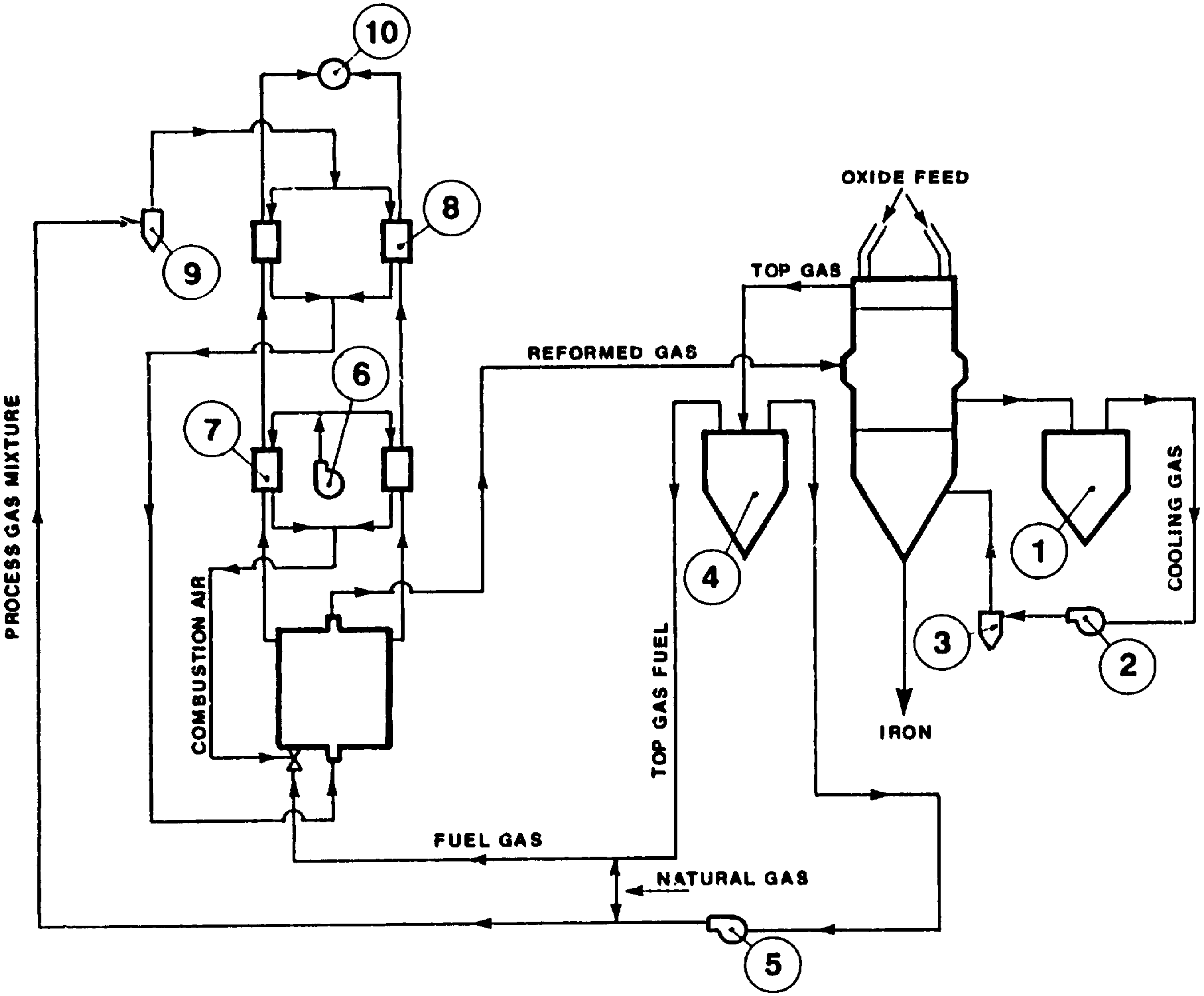
Midrex have the most extensive reference list of natural gas based shaft furnace direct reduction plants, claiming 50 furnace modules installed or under construction, totalling over 20 million tonnes per annum capacity. Midrex plants have produced over 65 million tonnes of direct reduced iron since their first plant began operation in 1969.

Midrex supply 3 sizes of shaft furnace with capacities varying from 400,000 to over 1 million tpa per furnace. During the last 5 years, Midrex have supplied five units which produce hot briquetted iron (HBI), instead of DRI (sponge iron) as their product. Due to its greater density than sponge iron, HBI is claimed to be a better charge material for electric steelmaking, and it can be transported safely, since it is non-pyrophoric.

Figure 4.3 shows a schematic diagram of the Midrex process.

The HYL Process

The main competitor to the Midrex process is the HYL III process, although it has only a limited reference list of 4 units of 250,000 or 500,000 tpa capacity in operation in Mexico, together with a further 2 units of 500,000 tpa capacity scheduled for construction.



1. COOLING GAS SCRUBBER
2. COOLING GAS COMPRESSOR
3. MIST ELIMINATOR
4. TOP GAS SCRUBBER
5. PROCESS GAS COMPRESSOR
6. COMBUSTION AIR BLOWER
7. AIR RECUPERATORS
8. PROCESS GAS PREHEATERS
9. PROCESS GAS MIST ELIMINATOR
10. EXHAUST STACK

FIGURE 4.3 MIDREX SYSTEM

4.3.2 Rotary kiln DR processes

The SL/RN Process

Of the rotary kiln coal based direct reduction processes that are currently available, the SL/RN process holds a leading position. Lurgi, West Germany who hold the licences for the process have great experience designing DRI units to meet their clients needs. They have around 40 rotary kilns for the reduction of iron ore to DRI with a combined capacity of 5.5 million tpa, either operating or under construction around the world.

The SL/RN direct reduction process uses a refractory lined rotary kiln equipped with combustion air inlets along its length, and a central burner located at the discharge end. The raw materials for the process, ore and coal are proportioned and fed to the kiln, where drying and preheating occurs in the first part of the kiln. Thereafter the iron ore is reduced to DRI by means of carbon monoxide, which is generated in the kiln from the charged coal.

The temperatures required for reduction are controlled by the injection of combustion air into the kiln along its length. The reduction temperature varies with the materials being processed, but is controlled in the range of 1000 to 1100°C. After reduction the DRI and remaining char are cooled to ambient temperature and discharged in a stable condition which avoids reoxidation. The magnetic materials are separated by screening. Hot charging from the rotary kiln to the steelmaking furnaces is possible in special cases.

In normal operations the hot gases flow counter current to the material charge and exit from the kiln at the feed end to waste heat recovery and gas cleaning plants.

SL/RN kilns have been in operation for over 20 years, and have demonstrated their flexibility, mainly with regard to their ability to process a large number of varying types of iron ores and coals for DRI production. The production capability of the SL/RN kilns are between 150,000 and 250,000 tpa of DRI, depending on the quality of the ores and coals employed.

Figure 4.4 shows a schematic diagram of the SLRN Process.

Lurgi's claims for the SL/RN process include:

* the direct use of non-coking coals as process energy

* high specific kiln throughputs by underbed air injection and short preheating times

* the possibility of hot charging of DRI product to steelmaking units

* safe operations with high plant availability

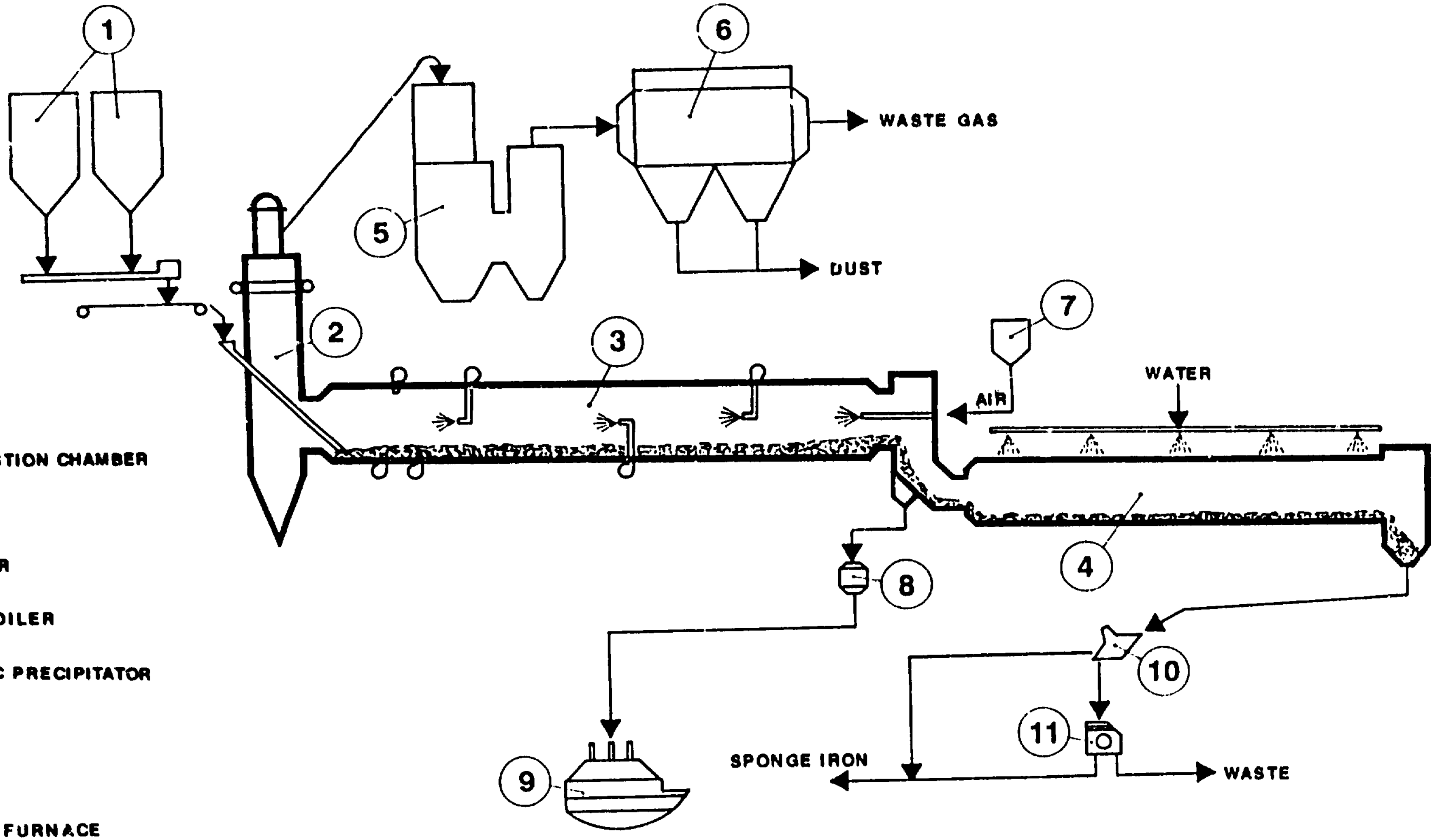
* possibility of converting between 30 to 50% of the total waste gas energy to steam or electricity

* close quality control with respect to degree of metallisation and sulphur content.

SL/RN rotary kilns can use coals ranging from high volatile lignites to bituminous coals and anthracites, for the reduction of lump iron ores (5-20mm) or oxide pellets.

The Grate-CAR Process

The main competitor to the SL/RN rotary kiln process is the Grate - CAR system, which incorporates a travelling grate with an ACCAR designed rotary kiln. This system utilises a travelling grate to dry and preheat balled concentrate prior to its transfer into a ported rotary kiln. The transfer of hot pellets of sufficient physical strength, accompanied by the addition of solid fuel in the transfer chute and/or fluid fuel through the rotary kiln ports, allows the reduction reaction to proceed almost upon entry into the kiln.



1. RAW MATERIAL
2. AFTER COMBUSTION CHAMBER
3. ROTARY KILN
4. ROTARY COOLER
5. WASTE HEAT BOILER
6. ELECTROSTATIC PRECIPITATOR
7. COAL
8. HOT CHARGING
9. ELECTRIC ARC FURNACE
10. SCREENING
11. MAGNETIC SEPARATION

FIGURE 4.4 SL/RN SYSTEM

Reducing exhaust gases issuing from the kiln are combusted in an after-burner chamber so that an oxidizing gas stream is provided for process requirements associated with the travelling grate.

There are only two Grate - CAR plants in commercial operation with capacities of 160,000 and 230,000 tpa respectively. Figure 4.5 shows schematic diagrams of the Grate - CAR System.

The Corex Process

During the mid 1980's the COREX process was introduced by Korf in association with Deutsche Voest Alpine to compete with the traditional blast furnace in the production of hot metal.

The COREX process separates the iron ore reduction and melting steps into two reactors. Generation of reducing gas and liberation of energy from coal for melting occurs in melter gasifier, and reduction of iron ore occurs in a shaft furnace. Because of this separation, a wide variety of untreated coals can be used.

The process is designed to operate under an elevated pressure of up to 5 bar with coal and iron ore being charged through a lock hopper system. The coal is stored in a pressurised feed bin and charged by a speed-controlled feed screw into the melter gasifier, where it comes into contact with a reducing gas atmosphere at a temperature of 1000 to 1200°C. Instantaneous drying and degasification of the coal particles occurs in this upper portion of the melter gasifier.

Reducing gas is generated in a fluidised bed by the partial oxidation of the coal. After the carbon is oxidised to CO_2, the CO_2 reacts with free carbon to form CO. The gas temperature in the fluidised bed ranges from 1600 to 1700°C. The temperature conditions in the freeboard zone above the fluidised bed result in production of a high-quality reducing gas containing 65 to 70% CO, 20 to 25% H_2 and 2 to 4% CO_2. The remaining constituents are methane, nitrogen and steam.

1. BALLING DRUM

2. TRAVELLING GRATE

3. PORTED ROTARY KILN

4. ROTARY COOLER

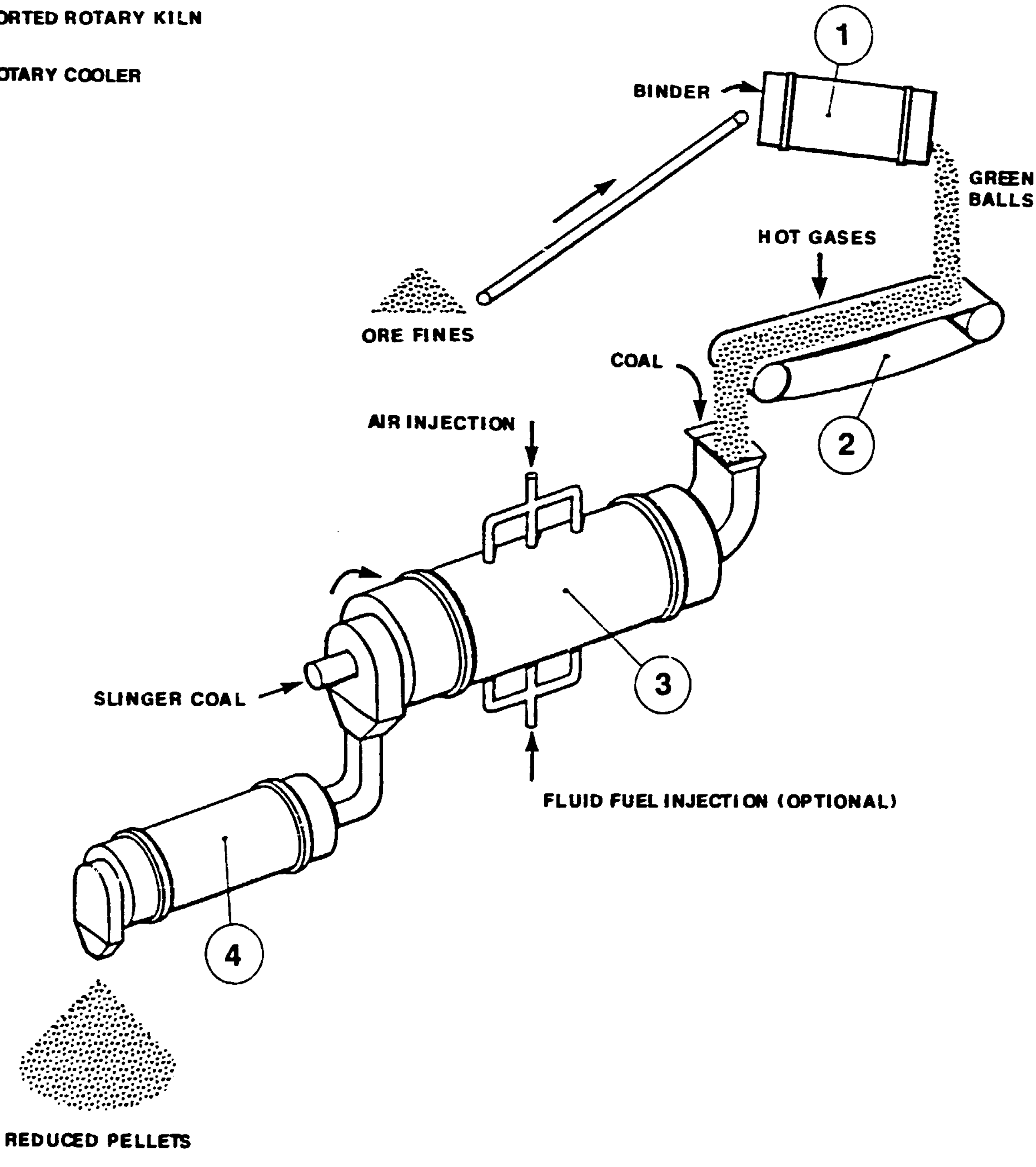


FIGURE 4.5 GRATE CAR SYSTEM

After leaving the melter gasifier, the hot raw gas is mixed with cooling gas to attain a temperature of 850 to 900°C. The gas is then cleaned in hot cyclones and fed to the shaft furnace as reducing gas.

The reducing gas is fed into the reaction furnace through a bustle pipe and ascends counterflow through the iron burden. Iron ore is charged into the shaft furnace through a lock hopper system and descends by gravity. The direct reduced iron is transferred from the reduction furnace to the melter gasifier by a controllable transport system which discharges into connected downcomers. Metallisation of the reduced iron averages 95%, and its carbon content ranges from 3 to 6% depending on the raw materials and operating conditions. The top gas is cleaned and cooled in a scrubber, and is then available for export.

The direct reduced iron is charged continuously to the melter gasifier at a temperature of 800 to 900°C. The velocity of fall of the sponge iron particles is decreased in the fluidised bed so that complete reduction, preheating and melting occurs. Hot metal and slag descend to the bottom of the melter gasifier and are discharged by tapping procedures similar to those used in blast furnaces.

Figure 4.6 shows a schematic diagram of the Corex process.

Depending on coal composition and quality, the specific oxygen consumption is 500 to 600 NM3/tonne of hot metal; the energy for oxygen production is provided by approximately one-third of the excess process gas. Coal consumption depends on coal quality and is in the range of 0.5 to 0.7 tonne fixed carbon/tonne of hot metal.

The most important property of the coal used in the process is its volatile content, which determines the gasification temperature. Low-volatile coals generate a high temperature when gasified with oxygen, releasing energy for melting the sponge iron. High-volatile coals, such as lignite, result in a low temperature, since the volatile hydrocarbons must be cracked before gasification can occur. Therefore, if they are to be utilised, such coals must be mixed with anthracite, low-volatile bituminous coal, charcoal or coke breeze.

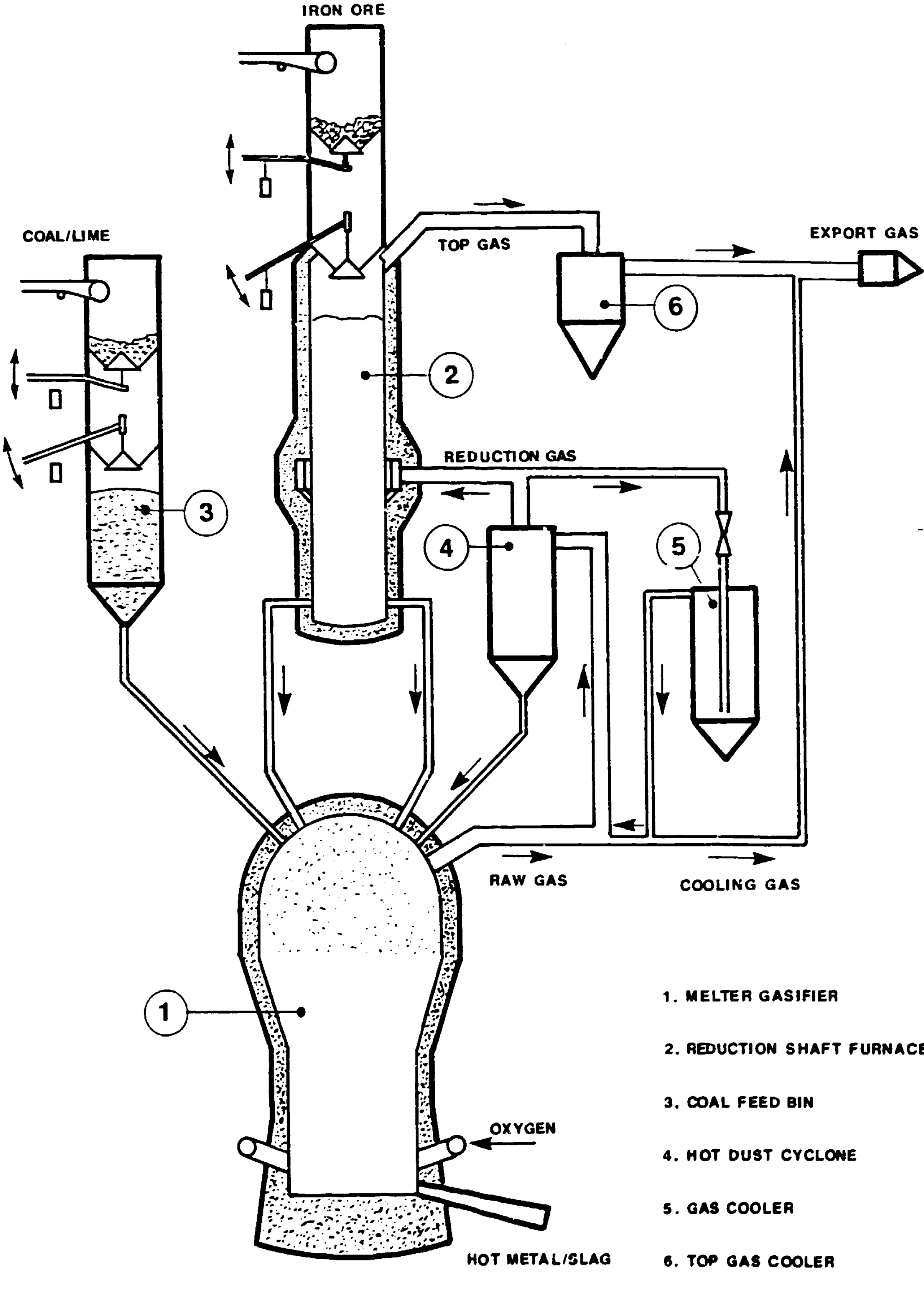


FIGURE 4.6 COREX SYSTEM

Advantages of the COREX process are claimed to include:

* independence from coking coals and coke ovens
* environmental acceptability
* generation of clean fuel gas as by-product
* low investment cost
* high flexibility
* economical production of hot metal.

The first commercial Corex plant is installed at Iscor, Pretoria in South Africa. This plant has a capacity of 300,000 tpa and came into operation in September 1987. During its first 2 years of operation it has experienced several operational problems, which have limited its operating time during this period to about 6 months.

Summary

Of the ironmaking processes previously described, only the Midrex process has been proven for the tonnages required by an integrated flat products steelworks. The rotary kiln processes, although they are able to use lignite instead of natural gas as their fuel and reductant, are of such a small capacity per unit, that an unacceptable number of kilns would be needed to produce the integrated steelworks ironmaking requirements. The COREX process is of similar small capacity per unit, and is not yet proven commercially.

4.3.3 Thin slab casting

Until the late 1980's, the conventional production route for hot rolled strip was by the continuous casting of thick slabs (200 to 250mm thick), followed by slab reheating and rolling in a hot strip mill comprising a roughing stands group and a 5 to 7 stands finishing train. As the product strip thickness is generally between 1.5 and 20mm, a large degree of reduction is involved, with consequent high energy consumptions being required.

Conventional hot strip mills require high capital investment, and only achieve an economical production at outputs of over 1.5 million tpa.

Due to their large production capacities, conventional hot strip mills were not compatible with mini-mill developments, whose steelmaking capacities were between 400,000 and 800,000 tpa. Consequently, mini-mills have until recently been confined to long products mills, which have economic production levels of below 500,000 tpa.

The introduction of thin slab casting has allowed mini-mills to product hot rolled strip economically. The Compact Strip Production (CSP) casting and rolling process developed by Schloemann - Siemag, West Germany, allows the casting of slabs only 40 to 60mm thick, followed by temperature equalising in a roller hearth furnace and direct rolling into 1.5 to 20mm thick strip in a compact hot strip mill. This mill has only 4 or 5 finishing stands, instead of the roughing stands and 6 or 7 finishing stands of a conventional hot strip mill.

It is claimed that CSP plants can product hot rolled strip economically with productions starting at 500,000 tpa.

The first CSP plant is installed at Nucor, USA, and came into production in June 1989. It has a single strand caster of 800,000 tpa capacity of slabs 900 to 1350mm width x 40 to 50mm thickness. These slabs are rolled in the CSP mill to strip of final thickness 2.5 to 12.7mm.

SMS have two further CSP orders, a second 1 million tpa plant for Nucor, and a 1.5 to 2 million tpa plant comprising two single strand casters and a 5 stand hot strip mill for Taiwan.

It is claimed that Nucor expect a saving of more than US dollars 50 per tonnes over a conventioral hot strip mills production cost.

Nucor have initially only produced commercial quality cold rolled strip from their thin slabs. However, the Consultants would expect that ultimately automotive and appliance quality strip will also be produced.

Since there will be no world market in thin slabs for many years to come, any current thin slab development in Thailand would need to be accompanied by its own steelmaking facility.

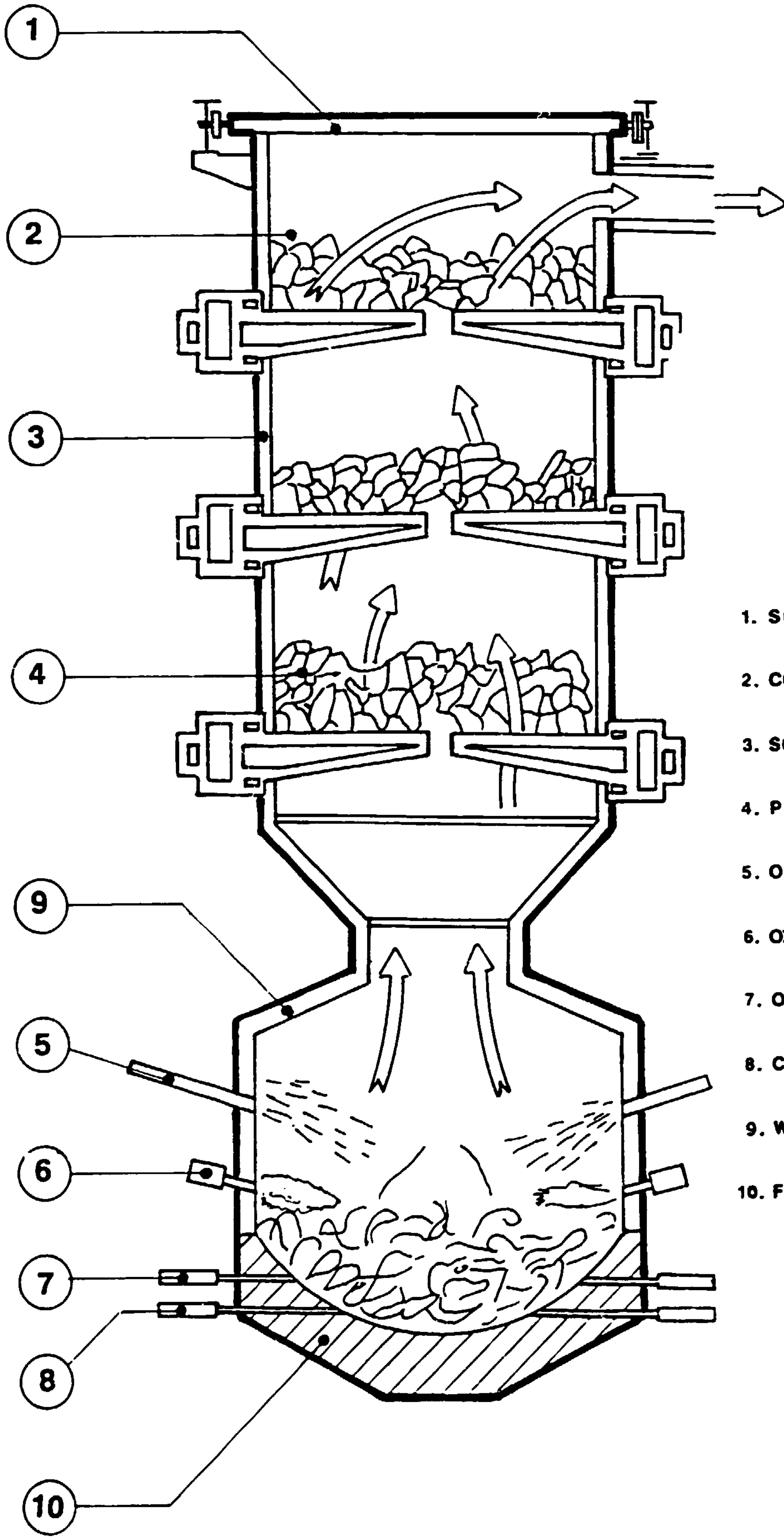
4.3.4 The Energy Optimisation Furnace

During the 1980's a new oxygen steelmaking process was developed by Korf, West Germany, called the Energy Optimisation Furnace (EOF). The process was originally designed for charges containing about 70 percent hot metal, with the balance being steel scrap and pig iron. There will be four units in production by 1990, operating with this type of furnace charge. Three units are installed and in production in Brazil, 2 of 30 tonnes capacity, and one of 60 tonnes capacity. The other unit of 80 tonnes capacity is being constructed at TISCO, India, and will commence production in 1990.

The process has recently been modified to allow it to operate with a 100 percent scrap charge. The first unit to operate on all scrap charges has been constructed at Rifs, Rhode Island USA, and was scheduled to commence production by the end of 1989. A series of all scrap charge tests have been made in an existing EOF unit in Brazil, and the results were sufficiently encouraging for the decision to proceed with the Rifs project. The EOF all scrap charge process would have merits for sites that have only a weak power supply available, since power consumption is only about 35KWH/tonne compared to 500KWH/tonne for electric steelmaking. However, this must be offset against the EOF requirement of about 130Nm^3 oxygen and 110Kgs of coal fines injected per tonne liquid steel. This is basically because the EOF process is an oxygen steelmaking process which has combined side blowing of oxygen into the furnace. The oxygen is blown horizontally via tuyeres situated below the surface of the bath to oxidise silicon, manganese, phosphorus and carbon, whilst further oxygen is injected into the furnace atmosphere above the bath for secondary combustion of carbon monoxide (CO) and hydrogen.

The heat generated by the oxygen reactions is used to melt scrap that has been previously preheated. The carbon requirements for the oxygen reactions are supplied via injected solid carbon (coal fines) which reacts with the liquid steel to produce an artificial hot metal. The sensible heat of the waste gases as they exit via the roof of the furnace is used to preheat scrap to about 850°C.

The geometry of the EOF is similar to that of an electric arc furnace, that is, a cylindrical vessel with refractory lined hearth and water-cooled roof and side walls, as shown in Figure 4.7. The submerged tuyeres for oxygen blowing and pneumatic injection of coal fines are water cooled, with nitrogen or carbon dioxide (CO_2) being injected to prevent "clogging" of the tuyeres when they are not in operation. Oxygen injectors for secondary combustion and oxy-fuel burners are fitted into the furnace sidewalls, the burners being used to maintain the furnace temperature during idle periods and for the heating-up of a relined hearth. Scrap is preheated by the counter-flow of furnace off-gases whilst held on three stages within a refractory-lined scrap preheater above the furnace. Sealed scrap buckets equipped with hydraulic bottom discharge gates supply scrap to the upper stage of the scrap preheater, after its water-cooled roof has been opened. The scrap is then dropped to the second stage, to allow the upper stage to be loaded from another scrap basket. This procedure is repeated a third time to complete the loading of all three stages in the scrap preheater.



1. SCRAP CHARGING COVER
2. COLD SCRAP
3. SCRAP PREHEATER
4. PREHEATED SCRAP
5. OXYGEN INJECTION
6. OXY FUEL BURNERS
7. O_2 SUBMERGED TUYERES
8. COAL AND LIME INJECTION
9. WATER COOLED ELEMENTS
10. FURNACE BOTTOM

FIGURE 4.7 EOF (ENERGY OPTIMIZI[redacted]E)

Fluxes are discharged into the furnace through the roof from overhead storage hoppers.

Liquid steel is tapped through a taphole into a casting ladle, whilst the foamed slag is removed from the slag door at the rear of the furnace. The early EOFs were of the fixed type, but those now being constructed are of the tilting type, which improves emptying and shortens tapping times.

When the EOF is operated with a solid charge practice ie. 100 percent steel scrap or a mixture of steel scrap and pig iron, a liquid "heel" must be retained in the furnace after each tapping. This liquid heel would be about 50 percent of the tapped weight.

It is claimed that the EOF process has lower investment and operating costs when compared to the equivalent capacity electric arc furnace steelmaking facility.

4.4 Implications For Development Strategies in Thailand

Using the material presented above, this section summarises the agreements upon which the Consultants' strategy for developments in the steel industry in Thailand are based. Details of the strategy are described in Section 5 and financial evaluations of the more promising alternatives are presented in Section 8.

* Product prices are currently high when compared to historic trends. Whilst the Consultants expect a modest downturn in these prices, in general the market should be more favourable in the 1990's compared to the 1980's.

* Some developing countries have not been able to operate economically efficient steelworks. In these cases the level of duties levied have been such that downstream industries have been adversely affected. In Thailand these industries are of considerable importance to the economy as a whole and so care must be taken not to follow this route.

* Scrap prices are expected to harden as more mini-mill developments take place. Thailand will import considerable quantities of scrap for the long products developments currently being planned. A flat products works based on scrap as the primary feedstock would be a risky undertaking.

* Iron ore deposits in Thailand are not sufficient to provide raw materials to an integrated works. There are no reserves of coking coal and so, if the blast furnace route is chosen, it must be at a coastal site.

* Gas prices are higher than in most countries where DR plants have proved to be economically viable. In addition, a large DR plant would require all of the gas currently allocated to industrial users in future years.

* Lignite based DR plants operate on a smaller scale than would be required for an integrated works.

* Small DR plants, based on gas or lignite are technically feasible and may become attractive in the medium to long term if scrap prices continue to rise.

* Re-rollers will continue to find suitable feedstock difficult to obtain and will modify their mills, where possible, in order to be able to roll billets instead.

5. ALTERNATIVE STRATEGIES FOR DEVELOPMENT

This section sets out some alternative ways of developing the flat and long products industries within Thailand. In each case the existing industry and the decisions already taken about its development are used as the starting point for developing a strategy for expansion. In the case of flat products, where planning is still in the early stages, the Consultants have also developed a contingency plan in case the proposed development does not come to fruition.

5.1 Flat Products Development

The central forecast presented in Section 3 shows a total demand, in the year 2000, of 2.7m tonnes of hot rolled steel and 2.5m tonnes of cold rolled steel. Because of the range of dimensions and qualities, however, not all these amounts will be able to be rolled within a single works.

To meet the demand, the development of an integrated works is proposed. This development is based on the expansion of the Sahaviriya project which has been awarded a license by the Ministry of Industry and promotional status by the Board of Investment. The project is not fully defined at this stage but the Consultants have used the basic information given to them and formed their own conclusions where detail is lacking. It is assumed that the works will be built in two stages:

* a hot strip mill of 1.8m tonnes capacity, together with an electro-galvanising line of capacity 135,000 tonnes;

* the expansion of the hot mill to 3 million tonnes capacity, the introduction of steelmaking and 670,000 tonnes of cold rolling facilities;

As described in Section 4, two technologies exist for large-scale steelmaking - the blast furnace and basic oxygen furnace (BF/BOF) process route; and the direct reduction and electric arc steelmaking (DR/EAF) process route. The rolling mill configurations will, however, be the same for either process route.

Infrastructure requirements and the timescales for developing an integrated steelworks are such that it is unlikely that a single works could produce more than these quantities before the year 2000 (see Sections 6 and 7). This means that, for the period of the plan, demand will significantly exceed supply.

Table 5.1 shows the supply and demand balance forecast for the year 2000 with the Sahaviriya plant working at full capacity. It can be seen that the hot rolled market is fully satisfied, but there is a considerable shortfall in cold rolled products.

Blackplate, the feedstock for tinplate manufacture, is a high quality product. Currently Thai Tinplate import their feedstock only from Japan, partly for commercial considerations but partly due to genuine concerns about quality from other sources. The Consultants recommend that the integrated works restricts itself to making the other cold rolled products. This will lessen the initial training requirements and the levels of skills needed by the operators. It will also significantly reduce the capital costs of the cold mill equipment.

From the national point of view this allows the Government the opportunity to promote a separate cold mill joint venture to import hot rolled coil and make blackplate within Thailand. In view of the size of the market for cold rolled products, a development of, say, 500,000 tpa will not pose a threat to the integrated works.

If this second project were to proceed, a further 1.3m tonnes of cold rolled steel would still need to be imported in order to satisfy the demand. This means that another integrated works can be developed towards the end of the century. It would need to concentrate initially on cold rolled products but within a few years the market for hot rolled would provide additional opportunities. This suggests a development which integrates backwards from cold rolling to hot rolling and then steelmaking. It could possibly be based on thin slab casting technology.

TABLE 5.1 PROJECTED SUPPLY AND DEMAND BALANCE IN YEAR 2000

Item	Total Market '000t	Production (integrated works) '000t	Balance '000t
Hot Rolled Products			
Total market	2710		
Not made (a)	4300		
Potential market	2280	2260	20
Cold Rolled Products			
For tinplate	660		660
For coating	810	330	480
For general manuf.	1030	340	690
Potential market	2500	670	1830

(a) This includes plate with a thickness of more than 20mm and sheets wider than 1.5m (Consultants estimate).

At this early stage, there are two possible threats to the Sahaviriya project:

* the possible inability of its backers to obtain sufficient finance;

* unacceptable delays occurring in finding a suitable location.

As a contingency plan, the Consultants have chosen an option which is intended to lessen the impact of these potential problems. That is, the building of a stand-alone cold mill of, say, 1m tonnes, using imported hot rolled coil, at least in its early stages. This solution does not address the market requirements but is deliberately set at the other end of the scale to the integrated works, that is with lower capital cost and less infrastructure requirements.

As is the case with the Sahaviriya development, this type of project will not preclude further steelworks being built when infrastructure constraints have been overcome. For example a new works on the Southern Seaboard could be built making hot and cold rolled products and possibly supplying feedstock to a stand-alone cold mill as well.

In the following sections, the technical details of the various options are discussed. Figure 5.1 shows a simple flow sheet of the proposed development. The electro-galvanising line is excluded for the sake of clarity. Figures 5.2 and 5.3 show the supply and demand balances.

5.1.1 The hot strip mill

Sahaviriya plan to install a strip mill with a capacity of 1.8 million tonnes of hot rolled coils. The mill would be designed for future expansion to 3 million tonnes. It would be a 1.524m wide mill, and would roll slabs of 200 or 250mm thickness x 10 metres length into strip of 1.2 to 12mm thickness. A slab weight of 30 tonnes or 20kgs/mm width will be necessary to allow the mill capacity to be increased to 3 million tonnes.

As with most recent hot strip mill installations, it will be of the semi-continuous type and incorporate a coil box before the finishing stands. The coil box overcomes the problem of bar temperature run-down in the finishing stands by coiling the bar and returning it, tail end first, into the first stand of the finishing train. The overall length of this type of mill can be up to 100 metres less than the requirement for a continuous mill, resulting in significant cost savings in roller tables, foundations and buildings.

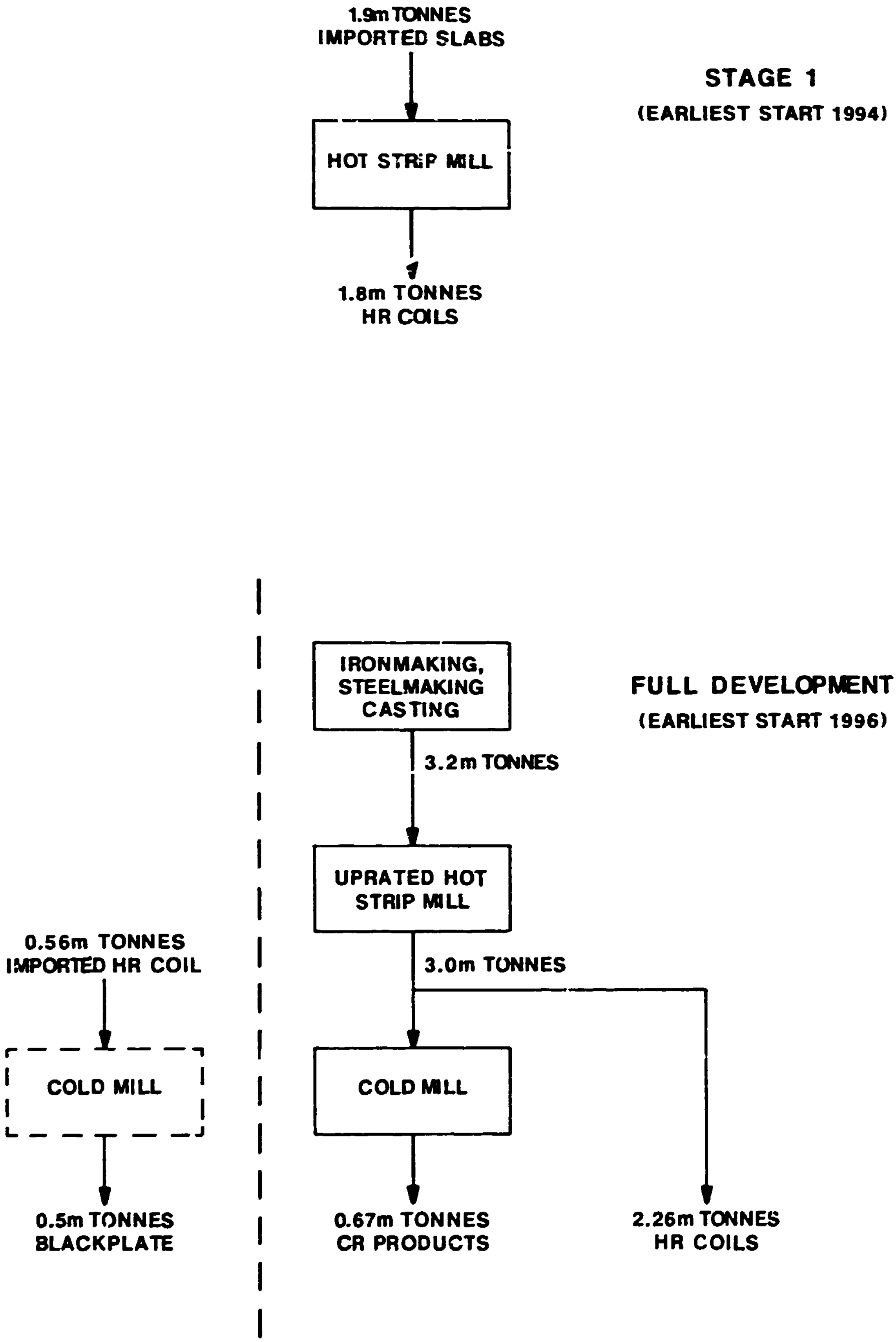


FIGURE 5.1 THE PROPOSED DEVELOPMENT

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Figure 5.2 Supply and Demand

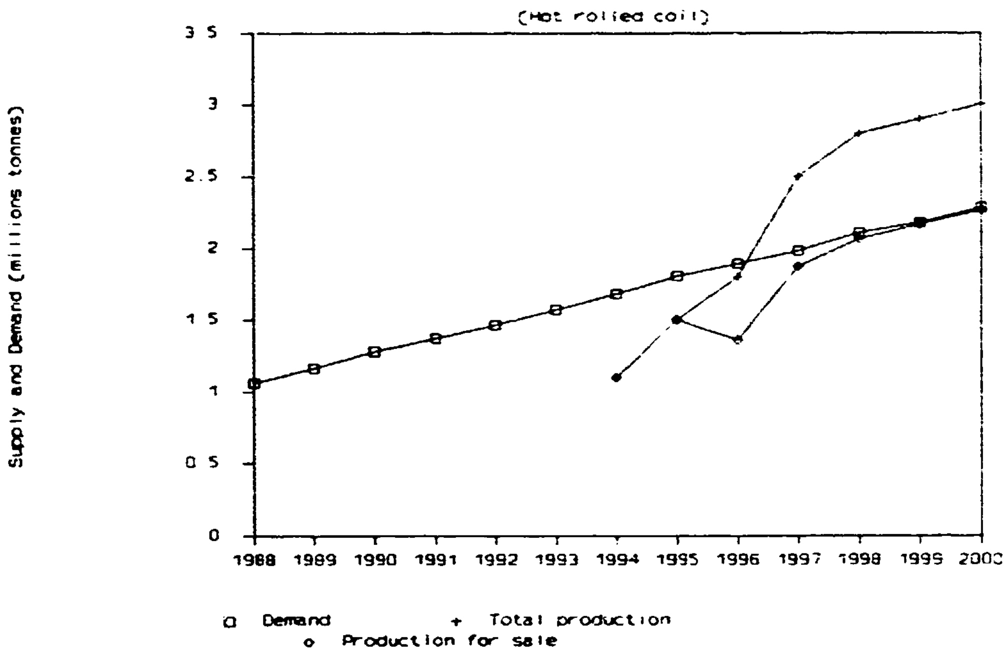
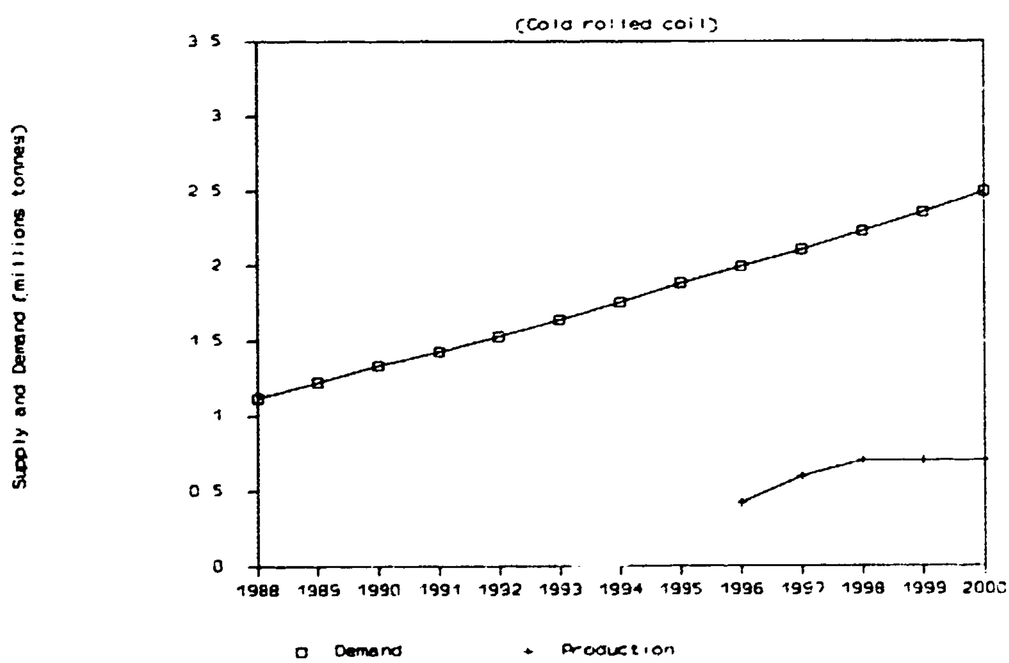


Figure 5.3 Supply and Demand



The initial feedstock will consist of 200 to 250mm thick imported slabs. With 7 finishing stands, the entry thickness would need to be 15mm when rolling the thinnest gauge coils. To reduce a 250mm slab to 15mm would require at least 8 passes. This could be achieved using a reversing sizing stand, followed by a reversing rougher. When the mills capacity is increased to 3 million tonnes, a further two intermediate stands in tandem, would need to be installed.

The mill will require a single 400tph continuous slab reheating furnace and two coilers for a throughput of 1.8m tonnes. When expanded to 3.0m tonnes, another furnace and coiler would be added.

Prior to the cold mill being commissioned, all hot rolled products will be sold to the domestic market and dispatched in coils. A hot strip cut-up line would be needed to supply customer ordered coil sizes which are smaller than the in-process coils (30 tonnes max. weight).

5.1.2 The cold mill

Sahaviriya plan to build a cold mill with a capacity of 670,000 tonnes of finished products. If blackplate is excluded, as the Consultants recommend, this mill could produce the following product range, when working at full capacity:

* 335,000 tonnes of commercial quality cold rolled coils (of which about half would need to be electrolytically cleaned);

* 135,000 tonnes of cold rolled, annealed and tempered coils for electro-galvanising;

* 200,000 tonnes of full hard coils for hot dip galvanising.

Figure 5.4 shows the materials balance for the hot and cold mills at full capacity.

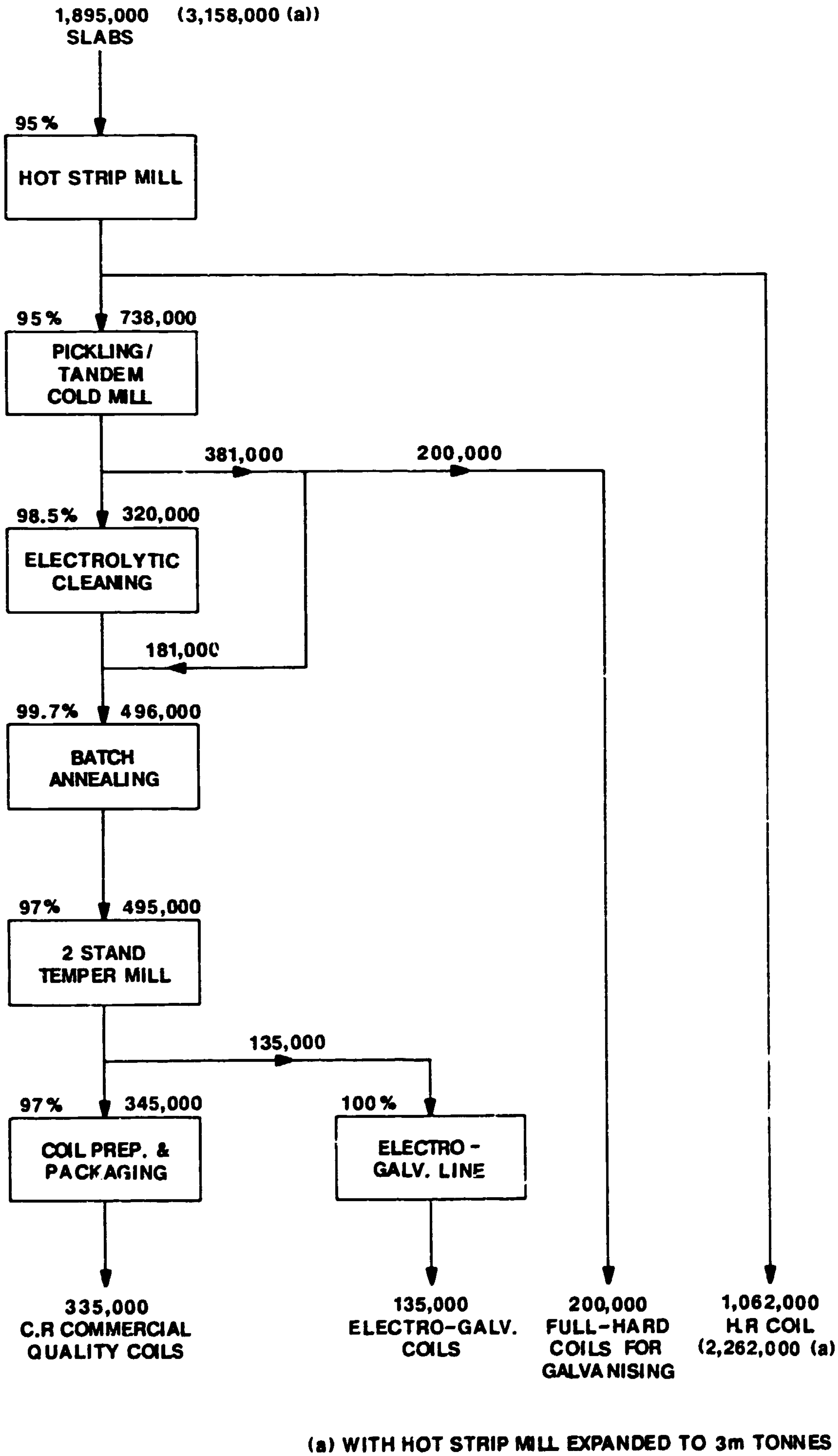


FIGURE 5.4 THE SAHAVIRIYA DEVELOPMENT

WS Atkins

It is assumed that this cold mill complex will comprise:

* a single 750,000 tonnes rated capacity high speed pickling line to descale the hot rolled coils prior to cold rolling

* a 5 stand tandem mill. The production from this mill will be between 600,000 and 1 million tonnes, depending on the tonnage of thin gauge being produced.

* a continuous electrolytic cleaning line. Of the commercial quality production, about 165,000 tonnes (50% of the total) will need to be electrolytically cleaned before annealing and tempering. This, together with the electro-galvanised production, will mean that about 320,000 tonnes will need to be cleaned. Full hard strip for hot dip galvanising does not require cleaning or annealing and is sold direct from cold rolling.

* a batch annealing facility comprising about 30 single stack furnaces to anneal the commercial quality and electro-galvanised coils.

* a single 2 stand temper mill to meet the tempering requirements of the thin gauge product.

* a coil preparation and packaging line to supply customer-ordered coil sizes which are smaller than the in-process coils.

5.1.3 Steelmaking alternatives

When, in stage 2 of the development, the hot strip mill is producing 3m tonnes per year, it is considered essential that the steelworks produces its own slabs, rather than having to rely on their availability on the world market at an economic price. Outline descriptions of the two steelmaking process routes. That could be used are given below.

The blast furnace - basic oxygen furnace route

The materials balance for a steelworks producing 3m tonnes of hot rolled coil by the BF/BOF route is shown in Figure 5.5. The main elements of the package are:

* Imported raw materials comprising 4.6m tonnes of sinter fines and 2.5m tonnes of coking coal would be unloaded at a deep water jetty near to the works and transported by conveyors to the raw materials stockyard. Storage capacity for at least two months of production requirements will be provided. Other raw materials, such as 750,000 tonnes of limestone and 150,000 tonnes of dolomite are assumed to be available locally and would be brought in by road or rail to the stockyard.

* For the annual coke demand of 1.85m tonnes, a total of 172 - 6.2 metres high coke ovens will be required. They will be arranged in 2 batteries of 86 ovens.

* A single sinter strand of 480 m2, operating at an average production rate of 33 tonnes/m2/day will be able to produce the annual sinter demand of 5.7m tonnes. Alternatively, imported pellets or lump ore could be fed to the blast furnace and the sinter requirement reduced.

* The hot metal production of 3.1m tonnes could be produced in a single 14.5m diameter hearth blast furnace, or two 11m diameter furnaces. Whilst the two furnaces would give greater operational flexibility, their additional cost could not be justified and the single large diameter furnace is selected.

* Hot metal would be tapped into 450 tonnes capacity torpedo ladles for transport to the BOF shop. Any surplus hot metal would be cast into solid pig iron for sale to the foundry industry, or to form part of the steelmaking charge.

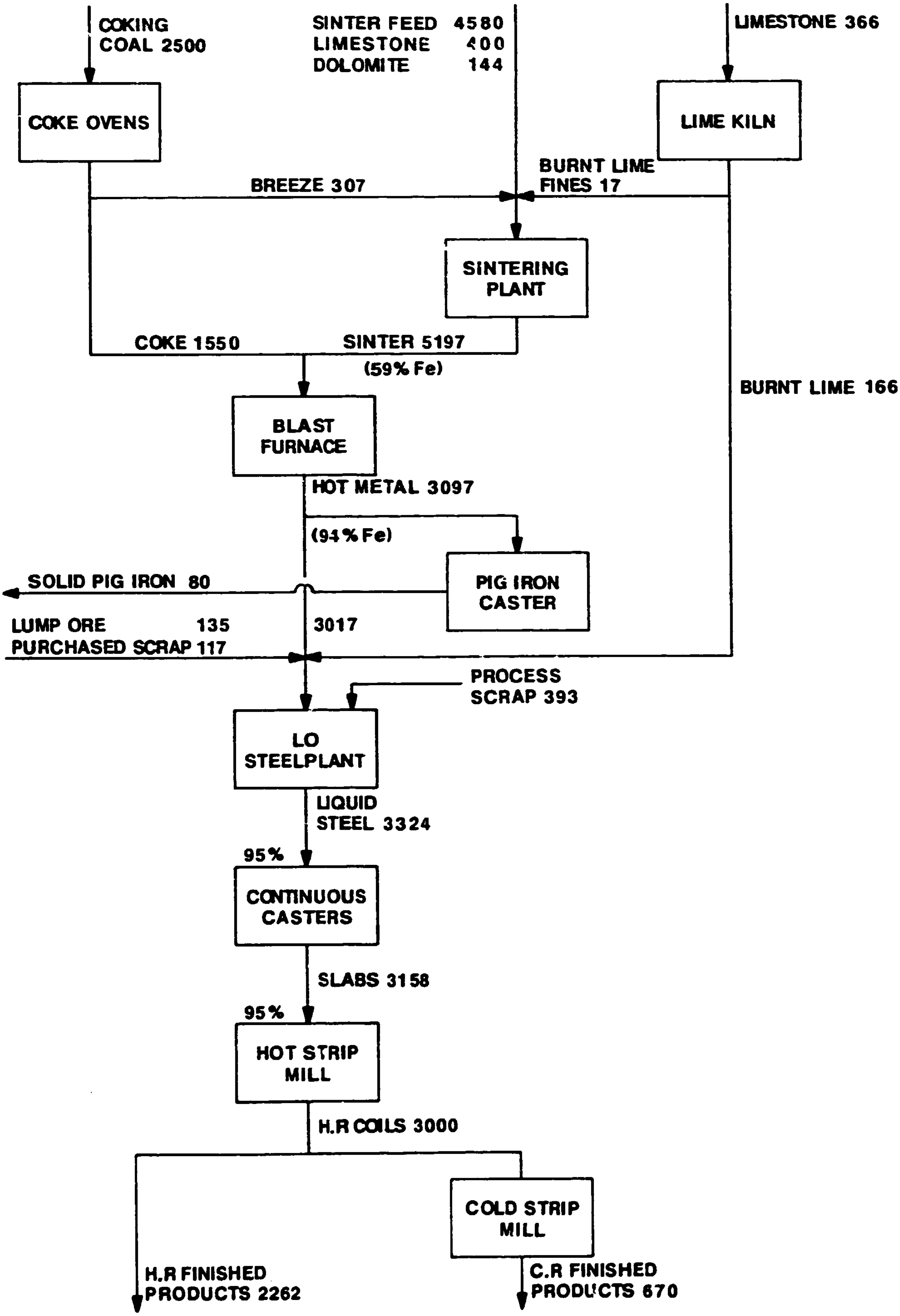


FIGURE 5.5 MATERIALS BALANCE - BF/BOF ROUTE

* Liquid steel would be produced in two 310 tonnes rated capacity BOF convertors. One would be in operation, with the other on standby. With cycle times of 40 minutes, it would be possible to make 10,700 heats annually, equivalent to a liquid steel production of 3.3m tonnes.

* Two 2 strand continuous casting machines will cast the liquid steel into 250mm thick slabs at a nominal casting speed of 1 metre per minute. (Thin slab casting has not been considered at this stage of the development because the backward integration must continue from a conventional hot strip mill.)

The direct reduction - electric arc furnace route

The materials balance for a steelworks producing 3m tonnes of hot rolled coil by the DR/EAF route is shown in Figure 5.6. The main elements of the package are described below:

* Imported iron ore and oxide pellets totalling 5.3m tonnes per year would be unloaded at the port and transported by conveyor to the raw materials stockyard within the works. The 440,000 tpa of limestone would be obtained from local quarries and brought by road or rail to the stockyard.

* The direct reduction plant will comprise three shaft furnaces of 1.1m tonnes rated capacity each. The bulk of the DR plants' production will be used with steel scrap to form an 80:20 charge for the electric arc furnaces. The surplus of 300,000 tonnes would be available for sale to the long products steelmakers. The DR plant would produce hot briquetted iron (HBI) which has a higher density than sponge iron, and is consequently more readily absorbed into the furnace bath. HBI is also chemically more stable than DRI and can be stored and transported without the problem of combustion.

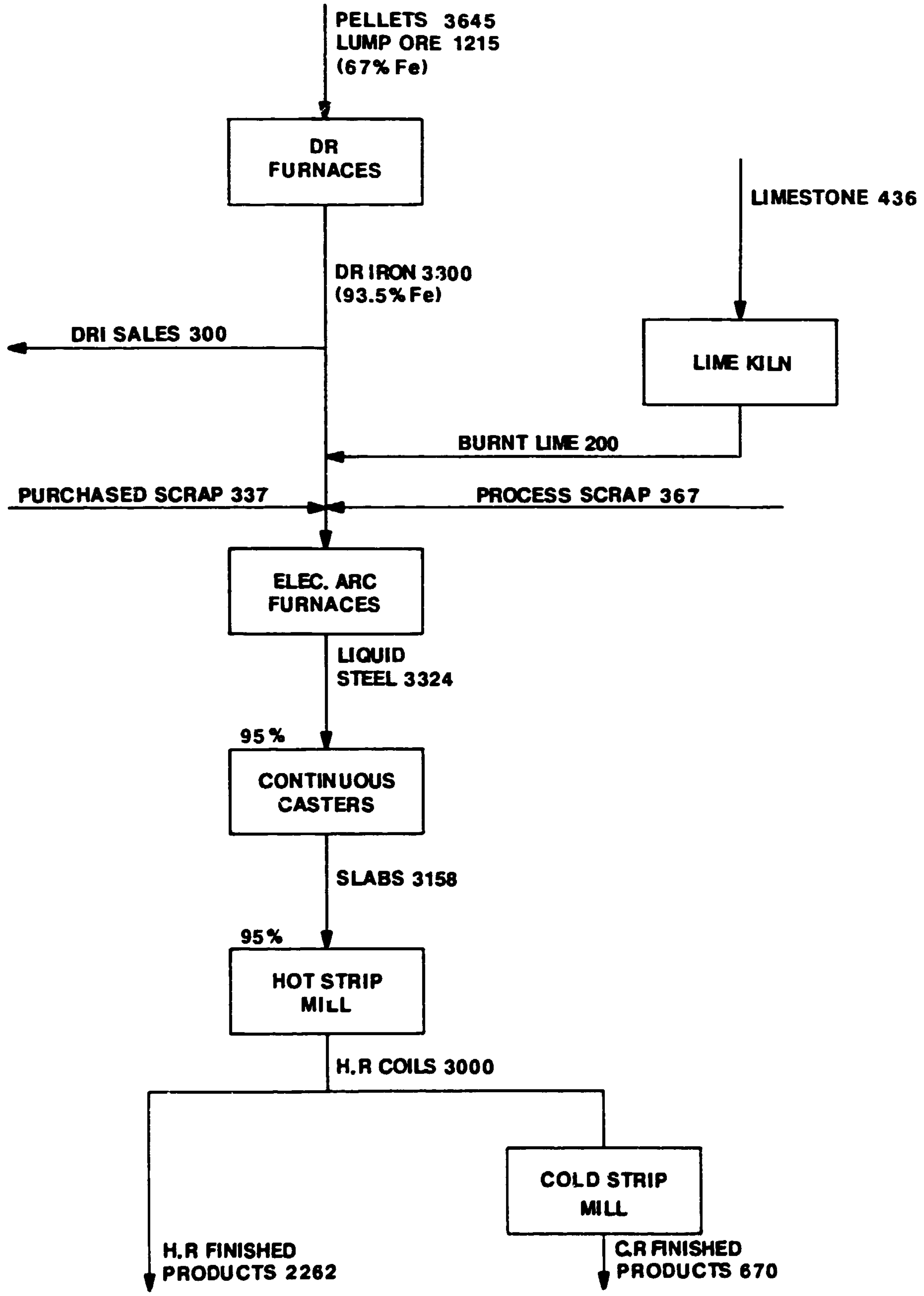


FIGURE 5.6 MATERIALS BALANCE - DR/EAF ROUTE

* Liquid steel will be produced in two 240 tonnes ultra high power electric arc furnaces of the eccentric bottom tapping type, each equipped with a 160MVA transformer. Ladle furnaces will be installed to undertake steel refining and tapping temperature adjustments. With cycle time of 60 minutes, it would be possible for each furnace to produce 7,000 heats each year. This would result in the production 3.4m tpa of liquid steel.

* The casting requirements will be the same as described under the BF/BOF route.

5.1.4 The contingency plan

If the Sahaviriya project does not proceed, a sensible option would be to instal a 1 million tpa cold mill to produce part of the cold rolled coil demand. This mill would initially use imported hot rolled coils. Since these imported coils could include high quality thin gauge material, it would be possible to include blackplate production in the range of products produced by the cold mill.

Based on this reasoning, the proposed production of the cold mill is;

* 400,000 tonnes blackplate coils for the tinplate market

* 400,000 commercial quality cold rolled coils (of which about 50 percent is assumed to require electrolytic cleaning, with the remainder uncleaned)

* 200,000 tonnes of full hard coils for hot dip galvanising.

Figure 5.7 shows the materials balance for this cold mill arrangement.

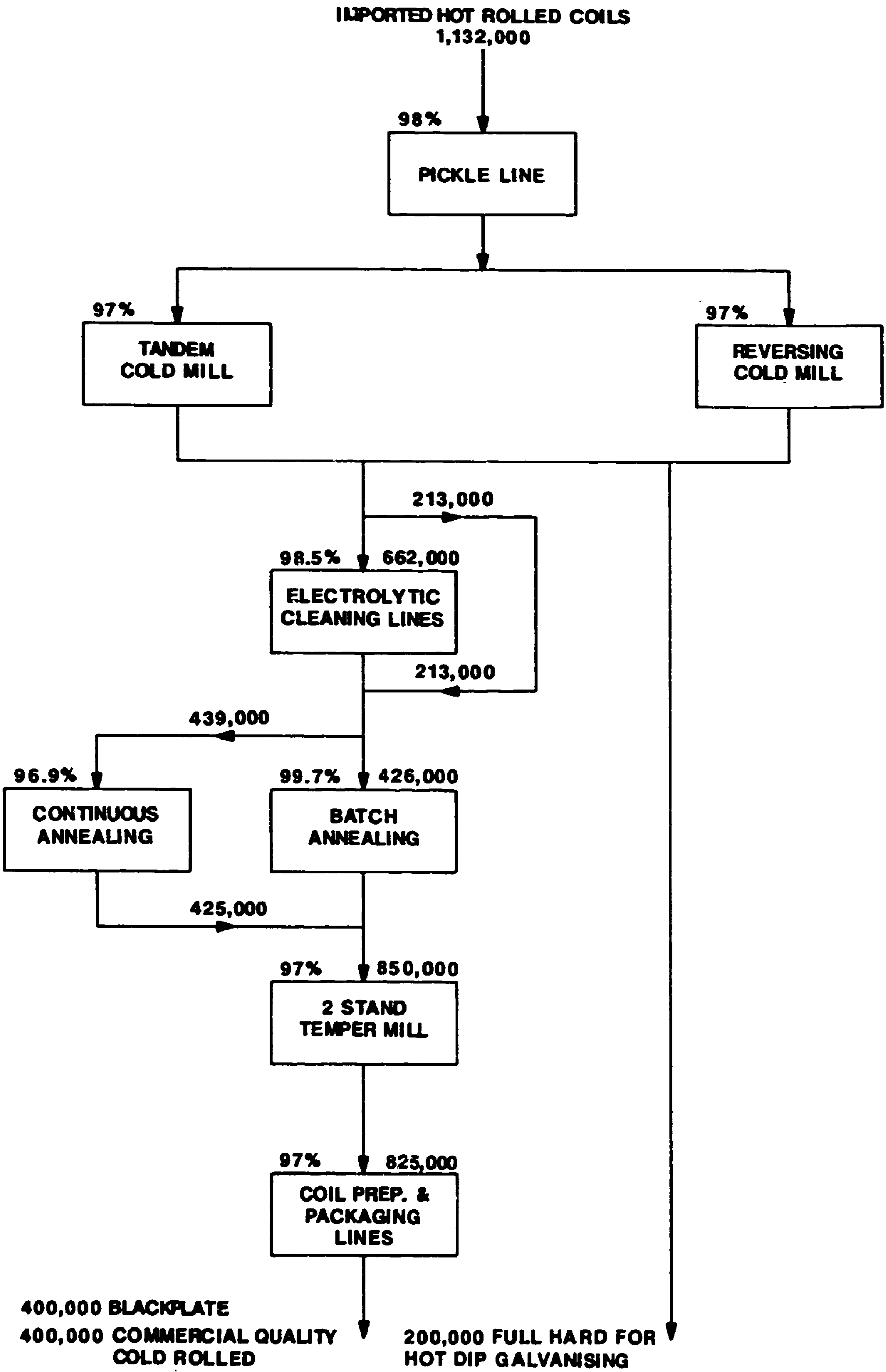


FIGURE 5.7 A STAND ALONE 1m tpa COLD MILL

It is assumed that the mill would comprise the following equipment:

* a single 1.2 million tonnes rated capacity high speed pickle line to descale the imported hot rolled coils prior to cold rolling

* a 5 stand tandem cold mill. Since the bulk of the tandem mills production is below 0.4mm thickness, it will have an annual production of about 750,000 tonnes. Consequently, a second cold mill will be needed to roll the outstanding production. A reversing cold mill, or possibly a combination mill, which combines cold reduction and temper rolling, will be the most economical solution. This second mill would be used to produce the thicker gauges, say above 0.5mm thickness.

* Two electrolytic cleaning lines to clean about 660,000 tonnes of coils, which would comprise 50 percent of the commercial quality cold rolled production, together with all the blackplate production.

* A batch annealing facility comprising about 30 single stack furnaces to batch anneal, the commercial quality cold rolled coils, and a continuous high speed annealing line to anneal the blackplate coils.

* A single 2 stand temper mill to ensure strip quality of the thin gauge material.

* Two coil preparation and packaging lines to supply customer ordered coil sizes which are smaller than the in-process coils.

5.2 Long Products Developments

Table 5.2 shows the long products market forecast taken from Section 3, broken down into its constituent parts. This breakdown assumes that the share of each product remains as now.

TABLE 5.2 - FUTURE LONG PRODUCT MARKETS
('000 tonnes)

Item	1995	2000
Reinforcing bar	2010	2580
Wire rod	600	770
Light Sections (<80mm)	150	190
Medium/Heavy Sections (>80mm)	210	270
Other	30	40
Total	3 000	3 850

Source: Table 3.10 and Consultants' estimates

In practise there will be changes in these shares. Firstly it is possible that rolled sections will replace the current reinforced concrete construction in high rise buildings. Such a trend will increase the demand for large sections (currently not produced in Thailand) and reduce the demand for rebar. Secondly it is possible that rolled sections will replace cold formed sections for some structural applications. Both these trends have been witnessed in other countries, but the rate of change will depend on developments within Thailand itself. For example changes in building design standards, the cost of labour, tariff levels and specific marketing initiatives.

As stated in Section 2.2, if all the five new licensed long products steelworks developments proceed without undue delay, the melter/rolling mills will have a total steelmaking capacity of 2.4 million tonnes by 1995.

Since many of the melter/rolling mills use rod/bar mills, they can vary their production between rebar and wire rod depending on the market conditions prevailing. Consequently, it is only possible to indicate potential production ranges for these products. By 1995, the melter/rolling mills would have the capability to produce up to 2.2 million tonnes.

It they produced 100,000 tonnes of sections, they could then make either about 1.2m tonnes of rebar and 0.6m tonnes of wire rod, or 1.8m tonnes of rebar and 0.3m tonnes of wire rod.

In addition, the re-rollers would have production capacity for 700,000 tonnes of rebar.

Thus, the total production capacities of the melter/rolling mills and re-rollers in 1995 could be:

* 1.9 to 2.5 tonnes rebar

* 0.3 to 0.6 million tonnes wire rod

* 100,000 tonnes rolled sections (below 80mm).

These production capacities will meet the projected long products demand in 1995, given in Table 5.2.

By the year 2000, the projected demand for rebar and wire rod will have increased to 3.3 million tonnes, which is about 600,000 tonnes in excess of installed production capacity. Consequently, during the second half of the 1990's, it will be necessary to allocate licences for possibly 2 developments to meet this shortfall in production capacity.

Whilst the installed production capacity for small rolled sections (below 80mm) is adequate until 1995, it should be increased by an additional 100,000 tonnes during the second half of the 1990's. Also, since in the Consultants opinion, there will be a switch in demand from cold formed sections to rolled sections, it should become economically viable to instal a medium section (up to 150mm) mill development of about 250,000 tonnes during this period.

5.3 Other Developments

The demand for heavy plate and seamless tube by the year 2000 is insufficient to justify any developments. The minimum economic plant sizes are held to be about 500,000 tonnes for plate, and 100,000 tonnes for a seamless tube development.

Similarly, the low demand for alloy steel and stainless steel products would not warrant any development. However, since many of the melters arc now installing ladle furnaces, it should be possible for them to increase the range of steels they product, which could include some alloy steel qualities.

In connection with the expansion of the melters and their move to a higher proportion of quality products, it may be possible at some future date to justify some local production of DRI or HBI. This development has been studied many times before within the context of an ASEAN joint venture but has never shown sufficient returns to justify its implementation.

DRI and HBI prices are obviously linked to scrap prices, for which they provide a substitute. If, as suggested in Section 4, scrap prices rise in real terms, the production of DRI or HBI should become more economic. Another trend that will encourage a project of this nature, is the increasing amount of wire rod that will be produced in the new plants. As DRI provides a cleaner feedstock than scrap for the production of these quality products.

Any DR plant considered in the short to medium term would need to use imported iron ore and be at a coastal site. In the long term, however, a DR plant in the North East of Thailand, using locally mined ores and either gas from Nam Phong or lignite from Li or elsewhere could be a feasible option. Such a development might provide employment opportunities in a region the Government wish to develop, but it would require considerable exploration and study before it could be considered seriously and might require subsidies of some sort for it to be economic.

6. INFRASTRUCTURE REQUIREMENTS

This section describes the infrastructure requirements for the developments proposed in Section 5. The Consultants have concentrated on the flat products developments as this is the area where Government intervention and assistance is most needed if the plant is to be built within a reasonable timescale, and national development priorities are to be maintained.

The new long products works will be of much smaller scale. If they are all located in the Eastern Seaboard, as the Government wants, there may be temporary problems in obtaining sufficient water and power but these should be resolved fairly quickly. The remaining requirement is for berths to import scrap. Some works will use the new jetty at Map Ta Phut which should be completed by the time they are commissioned. Demands on this quay will need to be monitored carefully as it must serve a number of users. One firm may develop a scrap handling facility in Si Racha, for their own imports and possibly those of others.

A flat products steelworks complex will involve considerable demands on the infrastructure in the region within which it is located. Such a steelworks consumes large quantities of electrical power and fresh water, and for the DR process routes, natural gas.

In addition, the steelworks site occupies a large area of land, and requires good road and rail links with national networks.

Since steelworks are generally dependent on the import of large tonnages of raw materials, they are mainly located at deep water coastal sites, allowing the unloading of bulk materials carriers.

The infrastructure requirements of the propcsed developments can be grouped under three headings, namely:

* utilities (electricity, water and natural gas)

* land and housing

* transport links (road, rail and berthing facilities).

6.1 Utilities

The estimated annual consumptions of the principal utilities for the various proposed developments are shown in Table 6.1 below.

TABLE 6.1 - ESTIMATED ANNUAL UTILITIES CONSUMPTION

Development	Electricity		Water x 10^6 M^3/yr	Nat.gas x10^6 MBTU/yr
	GWH/yr	Max. 15min Demand. MW		
Stage 1 1.8m HSM	350	90	1.7	3.7[*]
Stage 2: 3m BF-BOF 0.67m Cold Mill	1545	275	9.0	4.8[*]
Stage 2: 3m DR-EAF 0.67m Cold Mill	3165	490	8.5	39.8
Contingency 1m Cold Mill	205	55	0.8	1.1[*]

* or equivalent fuel oil.

These utilities consumptions are based on the proposed developments operating at rated outputs.

6.1.1 Power supply

For Stage 1, involving only the proposed Sahaviriya 1.8 million tonnes per annum hot strip mill, and the 135,000 tonnes electro-galvanising line, the estimated annual power consumption is 350 GwH. The average power load would be 60MW, with a 15 minutes peak load of 90MW.

When Stage 2, the 3 million tpa integrated steelworks is installed, the annual power consumption increases to an estimated 1545 GWH for a blast furnace (BF) - basic oxygen furnace (BOF) steelworks, or 3165 GWH for a direct reduction (DR) - electric arc furnace (EAF) steelworks. The power demands of the DR-EAF steelworks being double those of the BF-BOF steelworks, due to the high power consumptions of electric steelmaking.

The electrical load characteristic of an integrated steelworks is a high base power load with frequent peak loads superimposed. In the case of an electric arc steel plant very high peaks of reactive power may also be demanded. This requires a "stiff" grid supply system with a high short circuit fault capacity to avoid the steelworks imposing unacceptable voltage fluctuations on other consumers.

The required grid supply characteristics can only be achieved by having large power generating stations relatively near the steelworks (10 to 20 km). In the case of the Stage 1 hot strip mill the nearby power station capacity required should be at least 300 MW, and for the 3m tpa electric arc steelworks a capacity of about 1500 MW is needed. This latter development would therefore have to be carried out in close collaboration with EGAT.

If the contingency development of a 1 million tonnes cold mill were to be installed, it would require an estimated annual power consumption of 205 GWH, and a peak power load of 55 MW.

6.1.2 Water supply

Due to the scarcity of fresh water in Thailand during the dry season, it will be necessary for the steelworks to include efficient water recirculation systems that ensure the maximum re-use of process water.

On this basis, the annual water make-up requirements are estimated at 1.7 million M^3 for Stage 1 and 9 million M^3 for Stage 2. This latter water demand represents a flow of 0.3 cusecs.

6.1.3 Natural gas supply

Only the DR-EAF steelworks development would be solely dependent on a supply of natural gas. If the 3 million tonnes DR-EAF steelworks were to be installed it would require an estimated gas consumption of 39.8 x 10^6 million BTU's. This is equivalent to a daily gas consumption of 114 million standard cubic feet, which would represent all the natural gas being allocated after 1995 by the Petroleum Authority of Thailand (PTT) for private industry consumers.

For the 3 million tonnes BF-BOF steelworks, blast furnace gas, coke oven gas, and possibly steelmaking off-gas would be used to heat the coke ovens, blast furnace stoves and mill furnaces. Surplus gases would be used in the steelworks power plant to generate about 25MW of electrical power. To balance the energy production and demands of the steelworks, about 20 percent of the total energy requirements (4.8 x 10^6 million BTU's) would need to be purchased fuel. This fuel could be either fuel oil or natural gas.

Similarly, for the Stage 1 and contingency developments, either fuel oil or natural gas can be used to heat the mill furnaces.

6.2 Land and Housing

The layout of a steelworks development is governed to a great extent by the physical features of the site upon which it is to be installed.

However, integrated steelworks sites generally tend to be of rectangular shape, with the raw materials stockyards located near to the unloading berths to minimise lengths of supply conveyors, and the other facilities for ironmaking, steelmaking and rolling/finishing following in a process flow pattern.

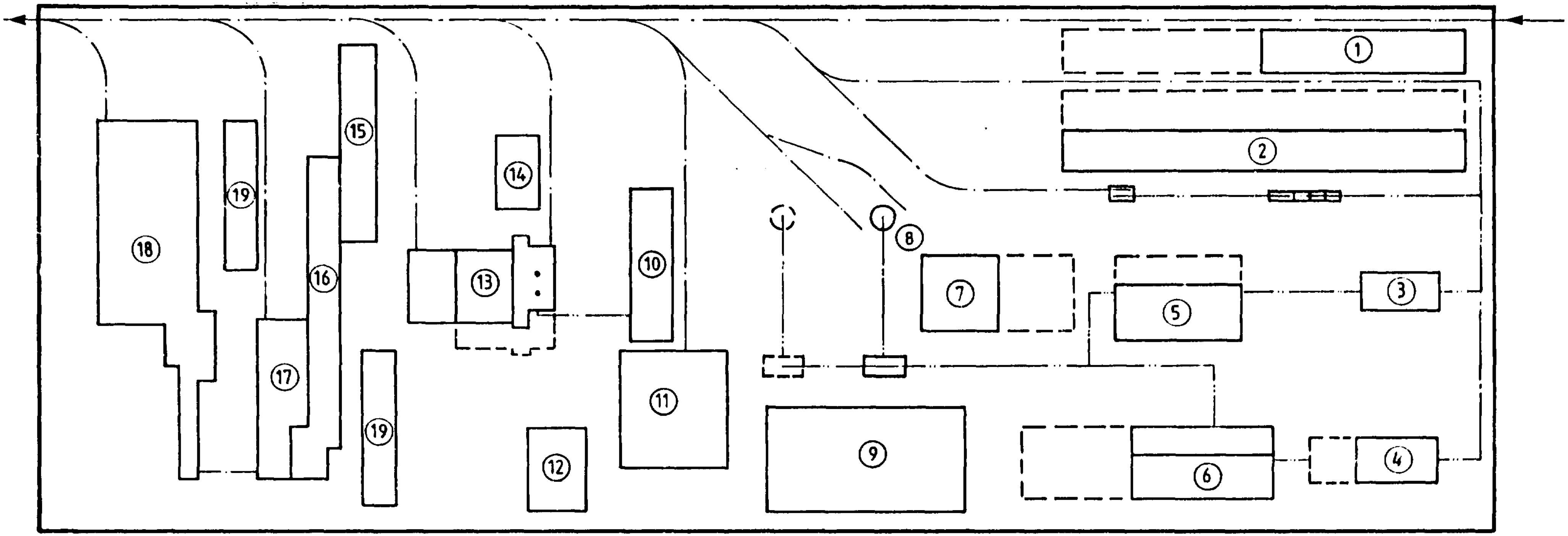
A typical layout for an integrated BF-BOF steelworks is shown in Figure 6.1. It is estimated that a fully developed steelworks for Stage 2 (BF-BOF) would occupy 3000 Rais of land. This would compare with the 600 Hectares (3700 Rais) of land occupied by the Llanwern steelworks of British Steel, United Kingdom. Llanwern is an integrated BF-BOF steelworks of 3 million tonnes steelmaking capacity, and includes a 2.5 million tonnes hot strip mill and a 1 million tonnes cold mill. Their larger area being required to accommodate three blast furnaces and three sinter plants, rather than the single units proposed for the Stage 2 development.

A DR-EAF steelworks would occupy less land area than its equivalent BF-BOF steelworks, since it would not require any coke ovens and their by-products plant, nor a sinter plant, together with their associated coal, coke and sinter stockyards. Figure 6.2 shows a typical layout. It is estimated that a fully integrated steelworks for Stage 2 (DR-EAF) would occupy 2100 Rais of land.

The Stage 1 hot strip mill together with its associated works service would require an area of about 300 Rais.

For the contingency development of a 1 million tonnes cold mill, an area of about 450 Rais will be required.

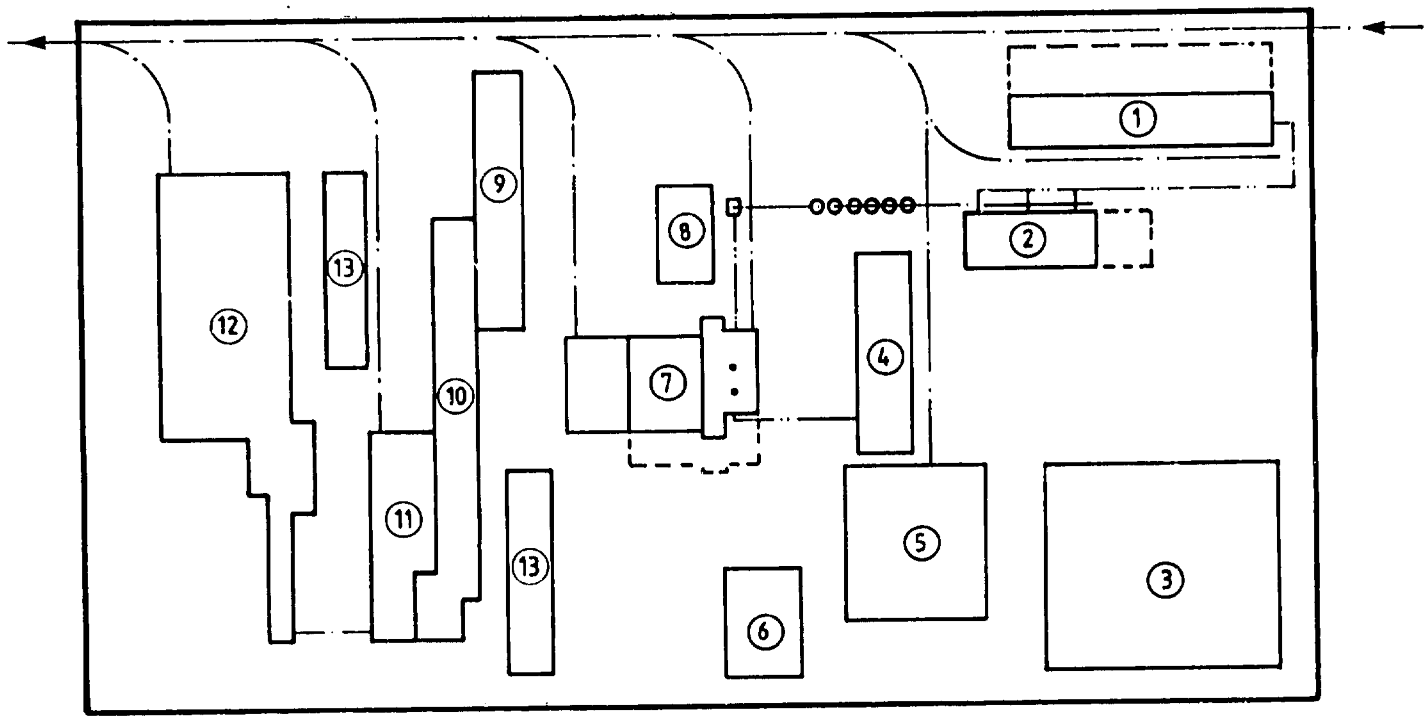
If the proposed steelworks is located in a remote region of Thailand, it will probably be necessary to construct a small Township to house a large portion of the workforce. The estimated total workforce employed in Stage 1 is 1600, increasing to 6500 in Stage 2. In addition to housing, the township would need to include medical, school, shopping and recreational facilities.



1. ORE STOCKYARD
2. COAL STOCKYARD
3. BLENDING BED SINTER PLANT
4. BLENDING BED COKE OVENS
5. SINTER PLANT
6. COKE OVEN & BY-PRODUCTS
7. POWER PLANT
8. BLAST FURNACE
9. MAINTENANCE WORKSHOP, LABORATORY & OFFICES
10. LIME PLANT
11. SCRAP PREPARATION
12. SLAG PROCESSING
13. LD STEEL PLANT
14. OXYGEN PLANT
15. SLAB STORAGE
16. HOT ROLLING MILL
17. HR FINISHING & STORAGE
18. COLD ROLLING MILL
19. UTILITIES

100 50 0 100 200 300 400 500M
SCALE

FIGURE 6.1 TYPICAL BF/BOF STEELWORKS LAYOUT



1. ORE STOCKYARD
2. DIRECT REDUCTION PLANT
3. MAINTENANCE WORKSHOP, LABORATORY & OFFICES
4. LIME PLANT
5. SCRAP PREPARATION
6. SLAG PROCESSING
7. LD STEEL PLANT
8. OXYGEN PLANT
9. SLAB STORAGE
10. HOT ROLLING MILL
11. HR FINISHING & STORAGE
12. COLD ROLLING MILL
13. UTILITIES

100 50 0 100 200 300 400 500 M
SCALE

FIGURE 6.2 TYPICAL DR/EAF STEELWORKS LAYOUT

6.3 Transport Links

6.3.1 Road and rail

Any steelworks and its associated port will need appropriate connections with the national highway and railway systems.

A two lane access road linking the steelworks to the national highway is needed to ensure good traffic flow of road vehicles transporting raw materials, products and personnel to and from the steelworks.

Also, a single line rail linking the steelworks to the national railway systems is needed to allow certain domestic raw materials to be received in trains of rail wagons, and for possibly products to be delivered by rail to customers.

6.3.2 Port facilities

The handling requirements of the berthing facilities within the associated port can be divided into 3 main categories. These are:

* unloading of construction plant and equipment
* unloading of imported materials
* loading of products.

Imported Construction Material

Temporary berthing facilities will be required during the construction period, to allow the unloading of imported plant and equipment.

Slab Imports

Slabs will be imported from various locations around the world. In general, shipments will average about 30,000 tonnes.

The Stage 1 development would require the annual import of 1.9 million tonnes of slabs which would be delivered in 60-80 ships. These ships would be berthed for an average of 5 days, which represents a requirement for 2 berths. Each berth would need a depth of water of 13 metres and a length of 250 metres. There will be some surplus handling capacity for shipments of other cargoes, including spares, consumables and finished products.

Bulk Cargoes

The requirements for the Stage 2 integrated steelworks would be:

Stage 2 (BF-BOF)

Iron Ore	4.6 million tonnes
Coal	2.5 million tonnes
Annual Total	7.1 million tonnes

If bulk carriers of 150,000 DWT are used for the imports of iron ore and coal, then, for Stage 2 (BF-BOF) there will be a requirement for about 50 ships to be unloaded.

With an average unloading time of 4 days, these bulk carriers could be unloaded at a single berth with an occupancy of around 60 percent. The berth would need a depth of water of 18-20 metres and length of 320 metres.

Stage 2 (DR-EAF)

Iron Ore/pellets 4.7 million tonnes

Using 150,000 DWT bulk carriers for the imports of iron ore and pellets, there will be a requirement for about 35 ships to be unloaded. A single berth, similar to that for the Stage 2 (BF-BOF) development would be required, although its occupancy will drop to 40%.

Hot Rolled Coils

Imported hot rolled coils in shipments of about 30,000 tonnes would be purchased mainly from Japan, Korea or Europe.

The Contingency development of a 1 million tonnes cold mill would involve the import of 1.1 million tonnes of hot rolled coils. This annual tonnage could be delivered in about 40 ships. These ships would be berthed for an average of 5 days during unloading, which could be handled by a single berth with an occupancy of 60 percent. The berth would need a depth of water of 13 metres and length of 250 metres.

Products Shipments

The proportion of finished products shipped by sea will depend on site location. If the steelworks were located on the Eastern Seaboard, then it is probable that all products will be despatched by road to consumers. However, if the steelworks were located in southern Thailand, then, it is probable that nearly all products will be shipped by sea to Bangkok.

The Stage 1 development would produce about 1.7 million tonnes of finished products annually. If all this output was shipped by sea in up to 5000 DWT coasters, about 500 of them would be required. With a turn-round time of 2 days, at least 4 berths would be required, each of 120 metres length and with a depth of water of 8 to 9 metres. The Stage 2 developments would produce about 2.9 million tonnes of finished products annually. Similarly, if all the output was shipped by sea, it would require about 800 coasters per year. A minimum of 6 berths of the same dimensions as above would be required.

The Contingency development would produce 1 million tonnes of finished products, which if it were all shipped by sea, would require 3 berths of 120 metres length.

6.4 Environmental Pollution

The problems of air and water pollution caused by a large steelworks are well known. All new works must incorporate gas cleaning and effluent treatment plants to ensure that any emissions or effluents are only discharged at environmentally safe levels.

The various processes within a steelworks produce large quantities of dusts and waste gases containing sulphur dioxide and carbon monoxide. These can be harmful to works personnel and local residents and can attack trees, plants and soils in a wide area around the works. Also, large quantities of effluents containing phenols, oils and acids are produced in the coke ovens and rolling mills. These can poison local rivers if they are discharged untreated.

Since the BF-BOF steelworks uses mainly coal as its energy source, it produces a greater amount of pollutants per tonne than a gas based DR-EAF steelworks which uses natural gas and electricity.

Ideally, steelworks should be located some distance from populated areas, in a non-agricultural region. For coastal sites, the prevailing wind should carry any fumes away from land.

7. SITE LOCATION

This section examines the prospects for locating the proposed flat products works in different locations in Thailand. First the broad alternatives are outlined, then three representative sites are examined in some detail.

7.1 Background

Section 6 describes the infrastructure requirements for a large integrated works, built in stages. In the country's present stage of development, there are three fundamental alternatives for the location of the works.

Firstly the plant could be built in the Eastern Seaboard as originally conceived in the master plan for Map Ta Phut. The short-term plan for that port is now being implemented and, whilst there have been some minor changes in the design, it would still be possible to complete the development of this port with the inclusion of the steelworks on mainly reclaimed land.

The Eastern Seaboard is the fastest growing region in Thailand, accommodating many of the new industrial developments coming on stream in the current wave of investment. In particular it is the only place where significant new port facilities are being provided. There are some temporary problems with water, power and communications but urgent measures are being taken to deal with these.

Towards the end of the decade the Government expect to move the development focus to the Southern Seaboard, particularly for heavy industrial developments. This is the second alternative location for a new plant.

At the moment studies concerning the development of this region are just starting to get underway. It will therefore be some time before potential sites are selected. When the programme is planned and implemented, however, infrastructure will be provided for all types of developments in a similar way to those currently being provided in the Eastern Seaboard.

This alternative implies delays but eventually good infrastructure which will be shared with other developments and therefore provided at low cost.

It should be noted that, according to the Consultants' projections of demand, a second flat products works will be needed at the end of the decade. It is likely, therefore, that the steel industry will form part of the Southern Seaboard Development Programme (SSDP), irrespective of developments built prior to its commencement.

The third alternative is to build a plant in a different location altogether. That is, an isolated development with most or all infrastructure requirements being provided as dedicated facilities for the steel plants own use. This has the advantage that, if such a site can be found, it can be developed without waiting for the planning of the Southern Seaboard to be completed. It has the obvious disadvantage that, all other things being equal, infrastructure will be more expensive and will need to be developed from scratch.

The ESTS Reports of 1982 and 1984 were written before the SSDP was conceived. They looked at a number of alternative sites for a steelworks, all of which were expected to be in isolated locations with their own dedicated port facilities. Heavy investments were required for the provision of water and power, and in the case of the DR alternative, natural gas. Roads and rail links were much less of a problem, but it was assumed that most products would be moved by sea to the main markets in Bangkok. This in turn added to port investment costs.

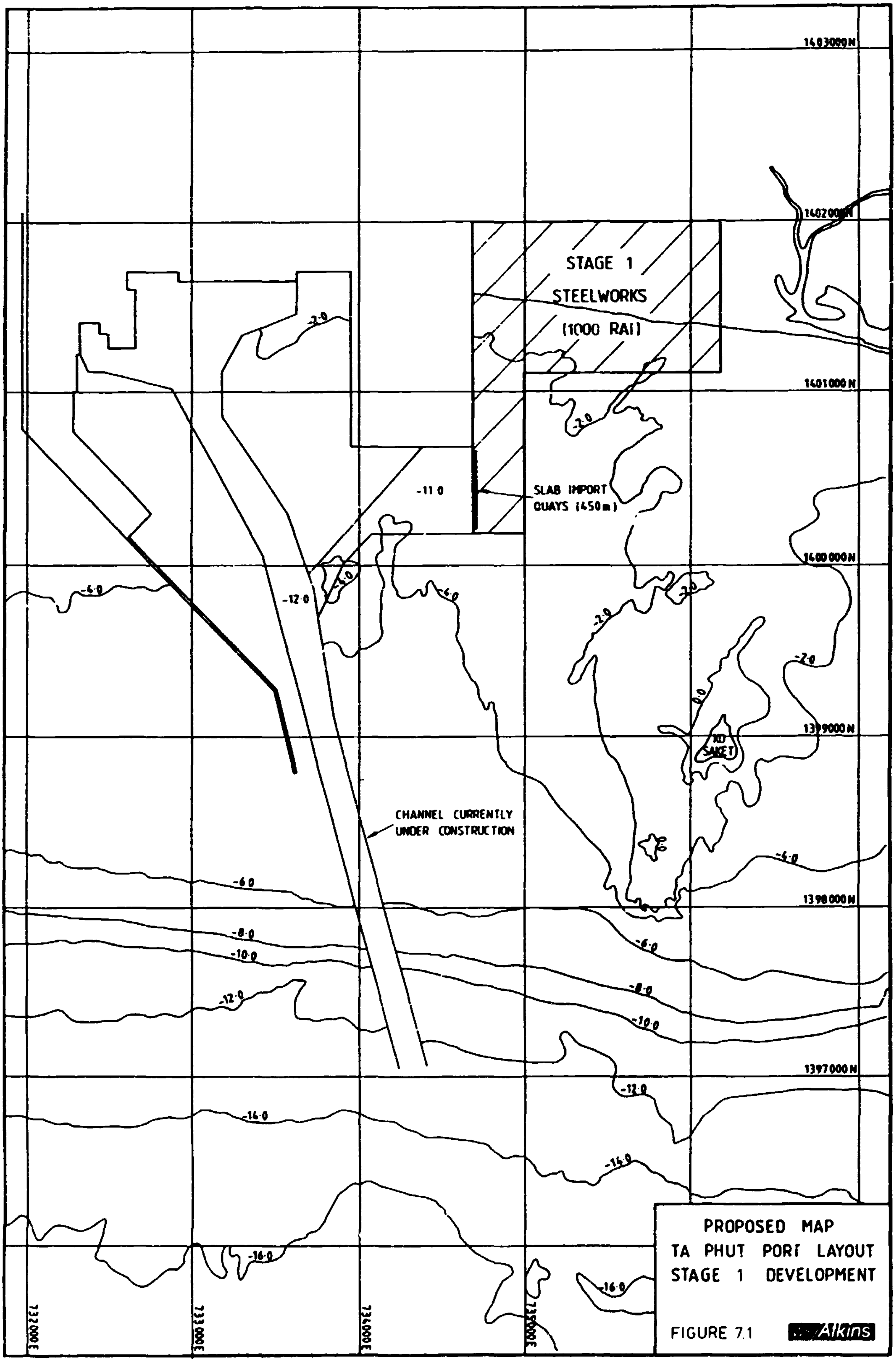
The Consultants have visited two of the sites shortlisted by ESTS; Laem Mae Ramphung and Khanom. Laem Mae Ramphung was the ESTS preferred site, performing marginally better than the others on a least-cost comparison, whilst Khanom would be close to where the Southern Seaboard developments would take place. Current sketches of possible developments in the South show the ESTS site at Khanom used as a general industrial zone. Whether it will be developed for steel in the way suggested by ESTS will depend on the requirements of the bigger programme.

It must be empnasised that very little detailed engineering was carried out on the two isolated sites. Conceptual designs were made, but a number of uncertainties remained, particularly with regard to site conditions, and the provision of fresh water.

7.2 Map Ta Phut

As stated above, the master plan for Map Ta Phut envisaged that land would be reclaimed on the eastern side of the port for a steel works site. The Consultants have considered how this development might proceed in order to meet the requirements of the two stages of the proposed flat products works. They have also noted that private sources are considering a coal fired station to be built on the island of Ko Saket, 3kms offshore.

Figure 7.1 shows a possible layout for Stage 1. This would provide about 850 rai of land for the steelworks alone. Of this area, about half would be onshore and half would be reclaimed land. Two berths of 225m length are planned for importing slabs together with a paved area behind them for transport and stocking purposes. The total land area required therefore is about 1000 rai. The land would be sufficient for both a hot and cold mill even though in the first stage only the former will actually be built. The entry channel to the berths would be 11 metres below datum, with a pocket at the berths themselves of 13 metres. It is envisaged that material for the reclaimed land would be provided by spoil arising from dredging the channel, augmented by offshore borrow area.



PROPOSED MAP
TA PHUT PORT LAYOUT
STAGE 1 DEVELOPMENT

FIGURE 7.1

The berths would be exposed to southerly waves and there would be some downtime in the months of March to May. The utilisation of the berths is low enough, however, for this not to be a problem.

During this stage of the development, only a small proportion of finished products could be shipped to Bangkok by sea, unless that is, other general purpose berths in the port had spare capacity.

Approximate capital costs are estimated as follows:

* Dredging, reclamation and land purchase - US$45 million;

* Quays and paved areas - US$17 million;

* Handling equipment - US$4 million.

The total cost, with a 15% contingency allowance, would be about US$76 million.

For the second stage, an additional 1850 rai of land would be reclaimed. Substantial offshore borrow areas would be required to provide the necessary fill volumes. After use, these could serve as an anchorage for waiting bulk carriers.

Two bulk berths would be provided, each of 300 metres length. It would not be possible to change the use of the slab import berths for this purpose as there will be an overlap in the demand for the two type of berths. The slab berths will therefore become products and general cargo berths in Stage 2.

The bulk berths have been sited at the seaward end of the site to reduce dredging costs and to be able to serve the power station if it went ahead. (Sufficient handling could be provided for the coal requirements of a 600 MW station.) A channel depth of -16 metres is assumed, which will allow 100,000 dwt vessels to use the facility. This size restriction could possibly be relaxed if the economies of scale required it, but it would be necessary to carefully consider the approach channels as shallow water exists at quite a distance from the shore. Some realignment of the channel might also be required for very large vessels. The current channel width is probably sufficient, but it could be widened quite cheaply by changes in the dredging plan.

Figure 7.2 shows the layout. The estimated capital costs would be as follows:

* Dredging and reclamation - US$59 million;

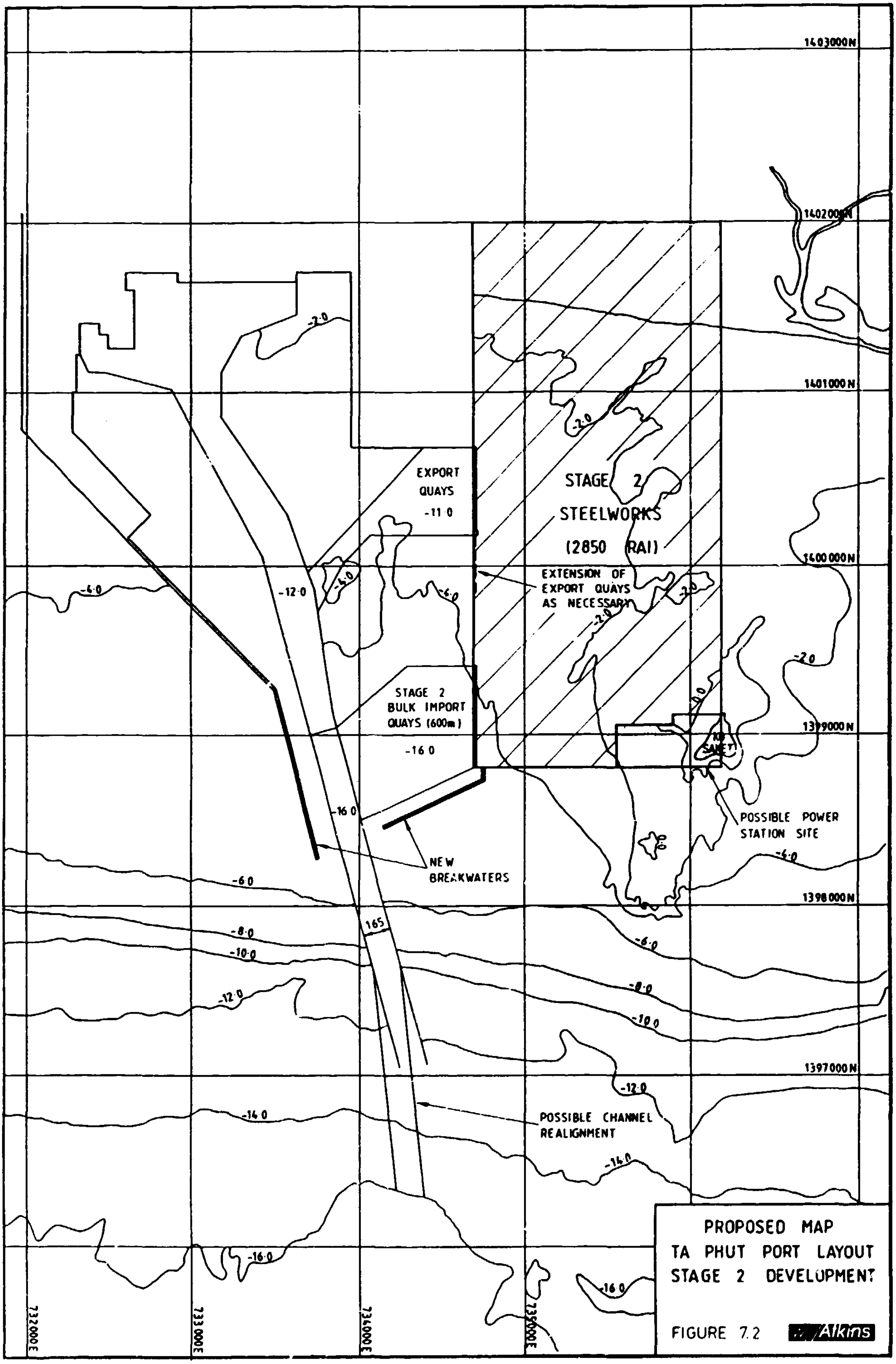
* Breakwater, quays etc. - US$46 million;

* Handling equipment - US$20 million.

With a 15% contingency allowance, the cost of Stage 2 would be about US$144 million, making a grand total, for both stages of US$220.

The Consultants understand that there could be legal problems in approving the reclamation of such a large area. However they have assumed that a final decision will be made before the end of 1990, and if this was the case, the first stage of the steelworks could be operating by 1994. The second stage could then start in 1996, but it should be noted that an early commitment to this stage would be needed to achieve this. Figure 7.3 shows an outline programme of activities.

Other infrastructure requirements should not delay the project as both water and electricity will be available in sufficient quantities for the two stages of the project. For water, a second reservoir at Nong Phrai is being constructed and is scheduled to come into operation in 1992. For electricity EGAT are constructing additional generating units at Rayong.



PROPOSED MAP
TA PHUT PORT LAYOUT
STAGE 2 DEVELOPMENT

FIGURE 7.2

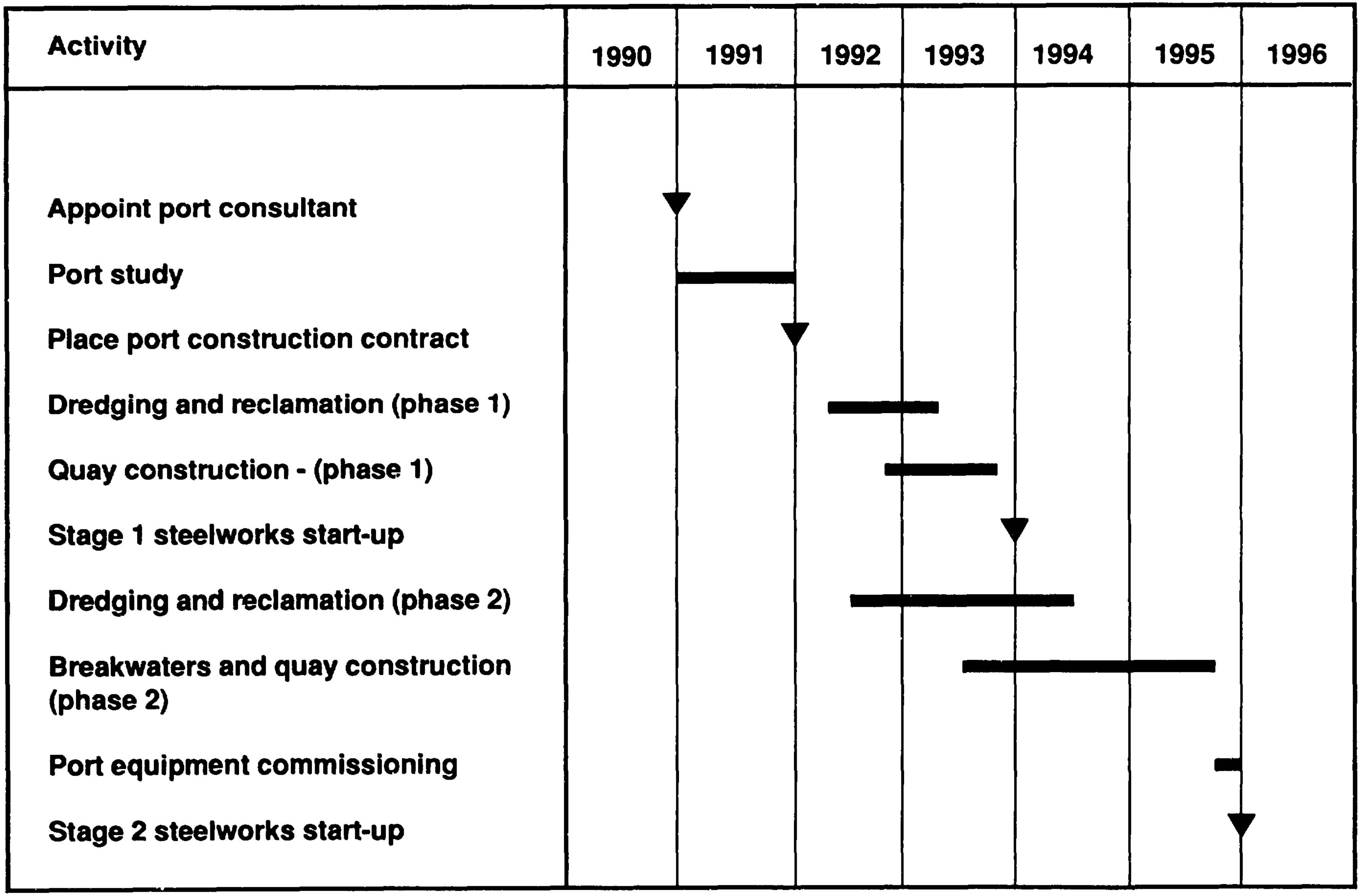


Figure 7.3 Programme for the development of Map Ta Phut

7.3 Laem Mae Ramphung

ESTS concluded that, of all the isolated sites available on the west coast of Thailand, Laem Mae Ramphung was the most attractive. Its principal advantages were low dredging costs, the availability of a reasonable plot of land for the steelworks, and good access to existing inland transport links with Bangkok. The problems were twofold: a power station would need to be constructed for the steelworks; and water would need to be collected from new reservoirs some distance away. The final solution concerning water supply is not clear from the reports, but it is worth noting that the sums allowed for reservoir construction appear to be low given the required storage volumes.

The Consultants have updated the capital cost estimates made in 1984 and adjusted them where necessary. It is assumed that two bulk berths would be needed rather than one. This is because the proposed plant is larger than the ESTS reference design and because it is likely that coal will need to be imported for the power station. The cost of the export quays have been increased by 50% in order to be able to cater for slab imports during stage 1. Finally a cost of US$24 million have been assumed for port handling equipment. This was not included in the ESTS estimates.

With these adjustments and a contingency allowance of 15%, the total cost would be about US$193 million. This figure excludes the provision of water and power.

If a decision were made by the end of 1990, and if site conditions were favourable, slabs could be imported from mid-1994 onwards. As with Map Ta Phut, the slab berths would eventually become export berths for products and separate bulk berths would be needed for coal and ore imports.

It is likely that water could be provided for Stage 1 by that date and, similarly, power could be made available by strengthening the transmission line from Bangkok.

For Stage 2 a 600 MW power station would need to be constructed, which EGAT have stated would require about 5 years to install. Steelmaking could probably start operations in 1996, therefore, as in Map Ta Phut.

7.4 Khanom

ESTS concluded that the site at Khanom performed less well than Laem Mae Ramphung. Port costs were lower, but site preparation, the provision of water, electricity and links to inland transport were all more expensive.

Due to the uncertainty about water in Laem Mae Ramphung, the Consultants consider that the resulting costs might be greater than at Khanom. The irrigation department are currently constructing a barrage across the Khlong Ta Tong and it will have sufficient water available for the steelworks. It would, however, need to be carried in a 30 km pipeline. In addition the rail link might be dispensed with since Khanom is so far removed from Bangkok.

More importantly, the site has become a possible location for the eastern end of the proposed land-bridge. This means that power and inland transport connections will be supplied on a multi-user basis if the SSDP goes ahead. It also means, however, that the land might be required for other purposes. Its size is restricted by some hills and it would be difficult for it to be shared with other industries.

A problem at Khanom will be airborne pollution affecting the island of Ko Samui, a tourist area situated only 20 kms off the coast. Even with the strictest of environmental controls, it is likely that emissions will be carried over the island.

It is difficult to forecast timescales for the start of operations. If it were not for the wider development programme, the lead time would be similar to that at Laem Mae Ramphung, except that a small power station does now exist that might be sufficient for the Stage l power requirements. In the context of the SSDP, the lead time is likely to be longer, as no decisions can be made until the World Bank funded study has been undertaken.

7.5 Site Conclusions

While there are considerable uncertainties about the estimates that have been made, the costs of providing land and berths at Map Ta Phut are expected to be broadly the same as at Laem Mae Ramphung. This conclusion is likely to hold for any other isolated development. For an isolated site, however, the provision of power and water will need to be dedicated to the requirements of the steelworks. Based solely on cost grounds, therefore, the Consultants first choice for a flat products development is Map Ta Phut.

This choice is strengthened when transport costs to Bangkok are taken into account. On environmental grounds too, it is generally preferable to extend existing areas of heavy industry rather than to create new ones in isolated areas. In this respect, however, the case is less clear. The prevailing winds at Laem Mae Ramphong would be offshore whilst in Map Ta Phut they would carry pollutants inland.

If a site at Map Ta Phut is not possible for reasons of national planning, or other priorities, there are two alternatives - to wait for the SSDP to be planned and to include the steelworks in that plan; or to find a site that can draw on the infrastructure that will be provided as part of the SSDP, but be at a sufficient distance away from the main developments that planning can commence before the Programme is finalised.

8. EVALUATION OF ALTERNATIVES

In this section the data used in the financial calculations is presented, together with the results obtained.

All the developments are evaluated on a cash flow basis, before financing and taxation. The analysis is therefore based on forecasting the four elements of the net cash flow - revenues, capital costs, operating costs and working capital requirements.

Constant prices (end-1989 baht) are used, with an exchange rate of 25.5 baht/US$.

Each calculation is based on twenty years from the start-up of operations. At this time the residual value of the plant is taken to be 15% of its cost. In addition all working capital is assumed to be recovered at this time.

The calculations are intended to show the costs and benefits to a private investor operating both with and without tarrif protection. For a project to be financially attractive in this context, the Consultants estimate that a real rate of return of about 10% is required. This is based on the assumption that funding will be provided in three tranches:

* 30% equity, with a real return of 20%;

* 40% suppliers credits, with a real interest rate of 3-5%;

* 30% domestic credit (including short term loans to meet working capital requirements), with a real interest rate of 6-8%.

Finished product prices are based initially on the landed cost of equivalent imported goods, that is, cif prices plus port dues and charges. This assumes that no protection is granted in the way of import duties. Results are presented for different levels of protection.

Where port infrastructure is required, calculations are carried out with and without the capital costs involved.

The rate of return calculated for the case where product prices are set at landed costs, and port infrastructure costs are charged to the project, will approximate to an 'economic' rate of return. This is because the majority of inputs are either imported or, in the case of domestic inputs such as energy and manpower, priced at close to their 'economic' cost.

Firstly the various flat products developments are evaluated, then a 'typical' new long products works and finally a stand alone DR plant using natural gas as its energy source.

8.1 Flat Products Developments

The five options considered in this section are the same as those described in Section 6, but with the second stage of the integrated works split into two parts in order to show the effect of adding the cold mill on its own. That is:

* Option 1 Stage 1. - a 1.8m tpa hot strip mill plus a 135,000 tpa electro-galv line;

* Option 1 Stage 2a - the addition of a cold mill of capacity 0.67m tpa;

* Option 1 Stage 2 (BF-BOF) - the expansion of the hot strip mill to 3m tpa, plus BF/BOF steelmaking to produce 3.2m tpa of slabs;

* Option 1 Stage 2 (DR-E^F)3 - as above but with DR/EAF steelmaking to produce 3._m tpa of slabs;

* Option 2 (the contingency plan) - a stand-alone cold mill producing 1m tpa of cold rolled products

8.1.1 Revenues

Table 8.1 shows the products that will be made for each alternative, when the plant is operating at full capacity. It has been assumed that in the first year of operations a unit will produce at 60% of its capacity, in the second year 85%, and in the third year 100%. (When the cold mill of Option 2 starts up, it is assumed that black plate production is not attempted in the first year.)

TABLE 8.1 - SALES AT FULL PRODUCTION CAPACITY ('000 TONNES)

Item	Option 1 Stage 1	Optio- 1 Stage 2a	Option 1 Stage 2 (BF-BOF)	Option 1 Stage 2 (DR-EAF)	Option 2
Blackplate		0	0	0	400
Commercial grade CR		335	335	335	400
CR - full hard		200	200	200	200
Electro-galv. sheet	135	135	135	135	
Hot rolled coil	1800	1062	2262	2262	
Total	1935	1732	2932	2932	1000

Table 8.2 shows the prices that have been used for the evaluation. The starting point is the 1988 cif prices taken from the Customs statistics. The Consultants believe that these prices are higher than are to be expected in the latter half of the 1990's, when the flat products works will be operating. They have therefore been reduced by 10%. A cost of 200 bahts/tonne has been assumed for unloading and handling.

In addition, two adjustments have been made to take into account changes in product mix. Firstly US$10 has been added to the average hot rolled price. This is to take account of the high proportion of seconds currently imported. Except for a few years, and depending upon the start date, the steel mill will not meet all the requirements of the market and so will be able to address itself to the higher quality material. Secondly, because the plant is assumed not to make blackplate, the average price of cold rolled coil is reduced by US$10. These adjustments bring the differential between hot and cold rolled products more into line with other markets.

For the contingency plan the cold rolled price is not adjusted as in this case it is assumed that blackplate is made.

TABLE 8.2 - LONG TERM BORDER PRICES OF FLAT PRODUCTS (US$/tonne)

Item	1988 cif price	Long Term cif price (unadj.)	Long Term cif price (adj.)	Long Term landed price
Hot rolled coil	384	346	356	364
Cold rolled products	529	476	466	474
Electro-galv	639	575	575	583

8.1.2 Capital Costs

Table 8.3 shows the capital costs of each option. The prices have been obtained from discussions with suppliers of equipment and from the Consultants' experience of similar projects. They include erection, civil works and the provision of services. An allowance of 10% of the total costs is assumed for contingencies. Import duties are not included, as Board of Investment promotion is assumed.

The land and port costs are based on the requirements laid down in Section 6 and the cost analysis of Section 7. They assume the use of reclaimed land at Map Ta Phut, and would provide some spare capacity for importing coal to the proposed power station. (Land

and port costs at an isolated site would be similar, but extra investments would be required to secure power and water supplies.)

The figures include pre-operating costs for the training of staff and commissioning the works. In the schedules it is assumed that a 15% down-payment will be required at the time of ordering the equipment and that 10% of the cost will be held back as a retention against guarantee of performance. Approximately 70% of the costs would be incurred in foreign currency.

TABLE 8.3 - CAPITAL COSTS FOR FLAT PRODUCTS DEVELOPMENTS (million US$)

Item	Option 1 Stage 1	Option 1 Stage 2a	Option 1 Stage 2 (BF-BOF)	Option 1 Stage 2 (DR-EAF)	Option 2
Land and Port	66	66	191	191	66
Hot Strip Mill	414	414	570	570	
Cold Mill		328	328	328	396
Electro-galv. line	45	45	45	45	
Sinter Plant			182		
Coke Ovens/By-prods Plant	352				
Blast Furnace/Pig Caster	372				
BOF/Lime Plant			266		
Slab Continuous Casting	253	253			
DR Plant				471	
Electric Arc Furnace				332	
General Works Services	129	220	474	400	111
Pre-op expenses	10	15	40	30	10
Total (million US$)	664	1088	3073	2620	583
Contingency	66	109	307	262	58
Total (million US$)	730	1197	3380	2882	641
Total (billion baht)	19	31	86	73	16

8.1.3 Operating Costs

Table 8.4 shows the yields and unit consumptions for each process, given BF-BOF steelmaking. Table 8.5 shows the same information for the DR-EAF route. The figures assume good practise and are based on actual operating performances in similar plants. The item "sp/con/misc" covers spares, consumables and other small item of costs that have been aggregated under this heading. Water requirements are deliberately shown separately, not because they are a large cost item but because it is important to know the requirements for infrastructure planning purposes.

For the BF-BOF case, by-product gases will provide the bulk of the fuel used in the steelworks. With the DR-EAF route, these processes will use natural gas. Apart from this difference, from the slab casters onwards, the two options are identical. Some by-product gas will probably be used in an on-site power plant. By-product gases and other by-products are represented in the calculations simply as a financial credit to the works.

Table 8.6 shows the unit cost of input materials and energy. The majority of items are imported and for these, landed prices are used. It is therefore assumed that duties on coal and iron ore will be minimal in the future. For domestic energy, market prices are used.

Table 8.7 shows the manning levels required by the different process centres. The levels are 25% higher than those currently used in more experienced steelmaking countries, where employment costs are high. They are much lower than similar steelworks in many other developing countries, however. In the more extreme cases, manpower levels of more than double the quoted figures can be found.

TABLE 8.4 - YIELDS AND CONSUMPTIONS - BF-BOF STEELMAKING

Process	Item	Units	Amount
Raw Materials stockyard	Electricity	kWh/t	4
	Water	m3/t	0.15
	Sp/cons/misc	US$/t	1
Sinter plant	Ore fines	kg/t	881
	Coke fines	kg/t	59
	Limestone	kg/t	77
	Dolomite	kg/t	28
	Electricity	kWh/t	30
	Water	m3/t	0.03
	Sp/cons/misc	US$/t	4
Coke Ovens (incl. by-prods plant)	Coal	kg/t	1350
	Electricity	kWh/t	57
	Water	m3/t	1.5
	Sp/cons/misc	US$/t	10
	By-product credit	US$/t	(8)
Lime plant	Limestone	kg/t	2000
	Electricity	kWh/t	30
	Water	m3/t	0.2
	Sp/cons/misc	US$/t	5
Oxygen plant	Electricity	kWh/m3	0.5
	Sp/cons/misc	US$/m3	0.02
Blast furnace	Sinter	kg/t	1680
	Coke	kg/t	500
	Electricity	kWh/t	140
	Oxygen	m3/t	0.3
	Water	m3/t	0.5
	Reline provision	US$/t	3
	Sp/cons/misc	US$/t	16
	By-product credit	US$/t	(3)
BOF	Hot metal	kt/t	908
	Scrap (a)	kt/t	153
	Lump ore	kt/t	41
	Electricity	kWh/t	30
	Oxygen	m3/t	50
	Ferro-alloys	kg/t	10
	Burnt lime	kg/t	50
	Water	m3/t	0.2
	Sp/cons/misc	US$/t	15
Continuous caster	Liq.steel	kg/t	1053
	Fuel oil	Mbtu/t	0.1
	Electricity	kWh/t	19
	Water	m3/t	0.5
	Oxygen	m3/t	3
	Sp/cons/misc	US$/t	11
Hot strip mill	Slabs	kg/t	1053
	Electricity	kWh/t	120
	Fuel oil	Mbtu/t	1.61
	Water	m3/t	0.6
	Oxygen	m3/t	2
	Sp/cons/misc	US$/t	15
Cold mill - yields	Pickling/tandem mill		95.0%
	Electro-clean line		98.5%
	Cont. annealing		96.9%
	Batch annealing		99.7%
	Temper Mill		97.0%
	Coil prep/package		97.0%
- av. consumptions	Electricity	kWh/t	180
	Fuel oil	Mbtu/t	1.14
	Water	m3/t	0.6
	Sp/cons/misc	US$/t	25
Electro-galv. line	CR feedstock	kg/t	1000
	Electricity	kWh/t	130
	Zinc	kg/t	6
	Sp/cons/misc	US$/t	4.5

(a) including return scrap arising within the plant

Source: Consultants database - average operating performance assumed

TABLE 8.5 - YIELDS AND CONSUMPTIONS - DR-EAF STEELMAKING

Process	Item	Units	Amount
Raw Materials stockyard	Electricity	kWh/t	4.5
	Water	m3/t	0.1
	Sp/cons/misc	US$/t	0.8
Lime plant	Limestone	kg/t	200
	Electricity	kWh/t	30
	Natural gas	MBTU/t	3.6
	Water	m3/t	0.2
	Sp/cons/misc	US$/t	5
Oxygen plant	Electricity	kWh/m3	0.5
	Sp/cons/misc	US$/t	0.02
DR plant	Oxide pellets	kg/t	1104
	Lump ore	kg/t	368
	Natural gas	mBTU/t	10.3
	Electricity	kWh/t	130
	Water	m3/t	0.5
	Sp/cons/misc	US$/t	6
Electric Arc Furnace	HBI	kg/t	903
	Scrap (a)	kg/t	212
	Electricity	kWh/t	650
	Fuel oil	lt/t	2
	Coal	kg/t	10
	Burnt lime	kt/t	60
	Oxygen	m3/t	22
	Ferro-alloys	kg/t	10
	Water	m3/t	0.8
	Electrodes	kg/t	4
	Sp/cons/misc	US$/t	15
Continuous caster	Liq. steel	kg/t	1053
	Electricity	kWh/t	19
	Natural gas	mBTU/t	0.1
	Water	m3/t	0.5
	Oxygen	m3/t	3
	Sp/cons/misc	US$/t	11
Hot strip mill	Slabs	kg/t	1053
	Electricity	kWh/t	120
	Natural gas	Mbtu/t	1.61
	Water	m3/t	0.6
	Oxygen	m3/t	2
	Sp/cons/misc	US$/t	15
Cold mill - yields	Pickling/tandem mill		95.0%
	Electro-clean line		98.5%
	Cont. annealing		96.9%
	Batch annealing		99.7%
	Temper Mill		97.0%
	Coil prep/package		97.0%
- av. consumptions	Electricity	kWh/t	180
	Natural gas	Mbtu/t	1.14
	Water	m3/t	0.6
	Sp/cons/misc	US$/t	25
Electro-galv. line	CR feedstock	kg/t	1000
	Electricity	kWh/t	130
	Zinc	kg/t	6
	Sp/cons/misc	US$/t	4.5

(a) including return scrap arising within the plant

Source: Consultants database - average operating performance assumed

TABLE 8.6 - DELIVERED COSTS OF INPUT MATERIALS AND ENERGY

Item	Price (US$/t)	Price (baht/t)
Ferrous Materials		
Slabs	285	7268
Oxide pellets	46	1173
Lump ore	36	918
Ore fines	31	791
Scrap (imported)	140	3570
Galv. feedstock	500	12750
Energy		
Coal (imported)	56	1428
Electricity (c)		1.5
Natural gas / Fuel oil (a)		76
Other materials		
Limestone / Dolomite		180
Ferro-alloys	600	15300
Zinc		40000
Electrodes	1930	49215
Water (b)		10

(a) per mBTU
(b) per m3
(c) per kWh

TABLE 8.7 - MANPOWER LEVELS

Process Centre	Option 1 Stage 1	Option 1 Stage 2a	Option 1 Stage 2 (BF-BOF)	Option 1 Stage 2 (DR-EAF)	Option 2
Hot Strip Mill	770	770	1140	1140	
Cold Mill		890	890	890	1345
Electro-galv. line	125	125	125	125	
Sinter Plant			325		
Coke Ovens/By-products			245		
Blast Furnace/Pig Caster			325		
BOF/Lime Plant			325		
Cont. Caster			325	325	
DR Plant				570	
Electric Arc Furnace/Lime Plant				325	
General Works Services	160	325	570	570	220
Administration & sales	160	325	850	740	250
	1215	2435	5120	4685	1815

Manpower costs are based on current wage rates in the iron and steel sector. A weighted average cost has been calculated as follows:

Grade	Percentage of workforce	Annual Salary (baht/y)
Senior Management	1%	4000,000
Managers/Supervisors	4%	240,000
Skilled labour/Foremen	35%	110,000
Semi-skilled labour	30%	80,000
Unskilled labour	30%	40,000
Weighted Average	100%	88,100

8.1.4 Working capital requirements

Working capital items have been calculated according to the following rules:

Debtors - 45 days of sales revenues

Creditors

- 45 days of non-manpower costs
- 30 days of manpower costs

Stocks

- 60 days of material purchases
- 20 days of sales

8.1.5 The results

'Economic' rates of return for each option are shown in Table 8.8. These returns have been calculated on the assumption that product prices are equivalent to landed prices of imports and that the full cost of port facilities are costed to the project, where appropriate.

TABLE 8.8 - 'ECONOMIC' RATES OF RETURN FOR THE FLAT PRODUCTS DEVELOPMENTS

Case	Project Return	Incremental Return (a)
Option 1. The Proposed Development		
Stage 1.	6.6%	
Stage 1a	5.2%	1.6%
Stage 2. BF-BOF	8.7%	9.4%
Stage 2. DR-EAF	8.5%	9.3%
Option 2. The Contingency Plan	1.8%	

(a) compared to Stage 1.

Stage 1, the hot strip mill development, yields a real return of 6.6%. Adding the cold mill without expanding the strip mill or providing steel-making facilities does not appear to be a good proposition. The incremental return on the extra investment associated with the cold mill, is only 1.6%. Stage 2 taken as a whole, however, yields an incremental return of 9.4%. Expanding the hot mill to 3m tpa without the cold mill would mean that sales of hot rolled coil would greatly exceed the domestic market and on these grounds the cold mill would still need to be built.

At full capacity, the added value generated by Stage 1 is about 2,200 million baht per year, and for Stage 2, about 11,900 baht per year.

The stand alone cold mill, or contingency plan does not perform well, giving a real return of only 1.8%.

It can be seen that the returns from BF-BOF steelmaking and DR-EAF steelmaking are almost the same. The former route is preferred by the Consultants, however, as the amounts of natural gas required for the DR route are more than can be safely expected from current projections of supplies to private industry.

Table 8.9 shows the returns obtained when the market prices of finished products are increased over and above landed prices.

Currently the rate of duty on hot rolled products is about 14%, when business and municipal taxes are included. Duties on cold rolled products are less than this. This is an anomaly in the tariff structure and the Consultants assume that these duties would be made equivalent to those on hot rolled products in the future. At this rate of duty, all stages of the proposed project, and even the contingency plan, become attractive to a private investor.

TABLE 8.9 - RETURNS AT MARKET PRICES

Case	Rate of Duty		
	10%	15%	20%
Option 1. The Proposed Development			
Stage 1.	13.9%	17.0%	19.8%
Stage 1a	10.8%	13.3%	15.6%
Stage 2. BF-BOF	11.6%	13.0%	14.3%
Stage 2. DR-EAF	11.8%	13.4%	14.9%
Option 2. The Contingency Plan	8.5%	11.2%	13.6%

Table 8.10 shows the implications for returns on different input prices. All calculations are based on a duty rate of 15%. It also shows the effect of port infrastructure being provided by the Government free of charge, and of an overrun on capital costs.

Stage 1 is obviously very sensitive to the price of slabs and cold rolled feedstock. They represent 90% of the operating costs. The changes in the rates of return would however be less dramatic in practise, as an increase in the prices of feedstock would probably be reflected in an increase in international product prices as well.

For Stage 2, the most sensitive parameters are the capital costs, and for DR, gas and electricity prices.

TABLE 8.10 - SENSITIVITY TESTS

Case	Stage 1	Stage 2 (BF-BOF)	Stage 2 (DR-EAF)
Base Case			
- 15% duty assumed	17.0%	13.0%	13.4%
Fe Materials price			
- rises 10%	11.6%	12.2%	12.3%
- falls 10%	21.7%	13.7%	14.5%
Gas price			
- rises 10%	16.9%	12.9%	13.1%
- falls 10%	17.0%	13.0%	13.7%
Electricity price			
- rises 10%	16.8%	12.8%	13.0%
- falls 10%	17.1%	13.1%	13.8%
Costs of port facilities excluded	18.6%	14.0%	14.7%
Capital cost			
- rises 10%	15.8%	11.9%	12.3%
- falls 10%	18.3%	14.2%	14.7%

Table 8.11 shows the unit operating costs for different products, compared to their equivalent international prices.

TABLE 8.11 - UNIT COSTS OF PRODUCTION (US$/tonne)

Item	Stage 1. (imp. slabs) HRC	Stage 2. (BOF-BF) (own slabs)		
		Slabs	HRC	CRC
Ferrous materials	294	62	65	61
Other materials	15	64	83	118
Energy	12	61	76	98
Labour	3	4	6	14
Total	324	191	230	291
Landed price	364	285	[illegible]	474
Operating margin	40	94	134	183

8.2 A 'Typical' Long Products Development

This section looks at the returns associated with the construction of a typical new long products works. A unit with a nominal capacity of 300,000 tpa has been taken. Such a plant will consist of a single 50 tonne rated capacity ultra high power arc furnace with a 30 MVA transformer, a ladle furnace, a 4 strand continuous billet caster and a combined rod and bar mill. The mill will be equipped with controlled cooling for coils and rake type cooling beds for bars.

8.2.1 Revenues

It is assumed that the plant will produce 100,000 tpa of wire rod and 200,000 tpa of rebar. A long term landed price of US$330 is taken for wire rod and US$300 for rebar. This is based on similar arguments to those used for obtaining flat products prices.

The production build-up assumed is 50% in the first year, 80% in the second year and 100% in the third year.

8.2.2 Capital costs

Table 8.12 shows the capital costs. While scrap will almost certainly need to be imported, a development of this size will not need a dedicated berth. In practise, companies have different plans regarding the way they will import their feedstock. For evaluation purposes, a figure of US$30m has been included to cover both land costs and a contribution to port construction costs. The land on its own is assumed to cost US$12.

TABLE 8.12 - CAPITAL COSTS FOR A TYPICAL LONG PRODUCTS DEVELOPMENT (million US$)

Item	Amount
Land and Port	30
Electric arc furnace	67
Rod/bar mill	72
General works services	14
Pre-op expenses	4
Sub-total (million US$)	187
Contingency	19
Total (million US$)	206
Total (billion baht)	5.2

8.2.3 Operating costs

Table 8.13 shows the yields and unit consumptions for each process centre. Prices are as listed in Table 8.6.

TABLE 8.13 - YIELDS AND CONSUMPTIONS - LONG PRODUCTS WORKS

Process	Item	Units	Amount
Electric Arc Furnace	Scrap (a)	kg/t	1075
	Electricity	kWh/t	480
	Fuel oil	mBTU/t	0.1
	Coal	kg/t	10
	Burnt lime	kg/t	40
	Oxygen	m3/t	22
	Ferro-alloys	kg/t	10
	Water	m3/t	0.8
	Electrodes	kg/t	4
	Sp/cons/misc	US$/t	15
Continuous caster	Liq.steel	kg/t	1044
	Electricity	kWh/t	15
	Fuel oil	mBTU/t	0.1
	Water	m3/t	0.4
	Oxygen	m3/t	0.8
	Sp/cons/misc	US$/t	11
Rod/bar mill	Billets	kg/t	1070
	Electricity	kWh/t	130
	Fuel oil	mBTU/t	1.3
	Water	m3/t	0.7
	Sp/cons/misc	US$/t	5

(a) including return scrap arising within the plant

Source: Consultants database - average operating performance assumed

It should be noted that a cost squeeze is assumed for long products producers in the long term. That is, the Consultants' are forecasting higher scrap prices than at present and much lower product prices. Currently rebar sells at about 12,500 baht per tonne (ie US$490). This price reflects local market shortages, fuelled by uncertainty about the rates of duty that will pertain after April 1990 as well as a tax and duty structure that adds about 20% to landed costs.

Manpower costs are based on a total requirement of 500 men, each working a 48 hour week. The breakdown of this workforce and the wages paid to each grade are assumed to be the same as that described in Section 8.1.4.

8.2.4 Working capital requirements

The rules for working capital are the same as those described in Section 8.1.4.

8.2.5 The results

Table 8.14 shows the calculated rates of returns under different assumptions. The economic rate of return, that is, allowing for the cost of port facilities, and with no tariff protection at all, is 4.4% in real terms. In this case, the cumulative cash flow becomes positive only after 14 years. The added value generated by the plant when operating at full capacity is about 450 million baht per annum.

The rate of return rises rapidly with increases in the prices obtained for products. With a 20% increase, it reaches 13% in real terms. This increase is equivalent to the current duty rate, when business and municipal taxes are included. (Alternatively such an increase might arise from higher than forecast international prices, and lower duties.) The conclusion is, therefore, that with current rates of duty a project of this nature is likely to be attractive to a private investor.

TABLE 8.14 - RATES OF RETURN FOR A TYPICAL LONG PRODUCTS DEVELOPMENT

Case	Rate of Duty		
	0%	10%	20%
Base Case -project pays for port facilities	4.4%	9.1%	13.1%
Scrap price -rises 10% -falls 10%	 1.7% 6.8%	 6.8% 11.2%	 11.1% 15.0%
Electricity price -rises 10% -falls 10%	 3.7% 5.0%	 8.5% 9.6%	 12.6% 13.6%
Costs of port facilities excluded	5.3%	10.3%	14.6%

The two key inputs are scrap and electricity. The scrap price is the more significant of the two, but as international scrap and products prices are likely to be correlated in the long term, the risk is smaller than stated. If the port facilities are provided by the Government, the rate of return increases by about 1%.

8.3 A Stand-alone DR Plant

This section examines the costs and benefits of a gas based DR plant producing hot briquetted iron (HBI) to sell to the melters as a substitute for scrap. A shaft type furnace with an assumed production capability of 700,000 tonnes per annum is used. The plant would consume imported ore and be located at a coastal site.

8.3.1 Revenues

HBI sells at a premium of about US$15 over heavy melting scrap. Not all producers would be prepared to pay such a premium, however, especially if they are only making rebar. The market is therefore a restricted one and 700,000 tpa is considered to be the maximum demand. (If the flat products works used a DR route, it would have about 300,000 tpa of excess product to sell. In this case, a stand-alone plant would not be viable.

With a long term landed price of scrap of US$140, HBI would sell at US$155. If the plant were located in the South, the ex-works price would be less than this, say, US$150.

The production build-up can be rapid, and it is assumed that the plant will operate at 70% capacity in the first year, 90% in the second year and 100% in the third year.

8.3.2 Capital costs

Table 8.15 shows the capital costs of the project, including pre-operating expenses. The cost of the HBI module has been obtained from discussions with Midrex. The land and port costs are made up of US$20 million for the land and US$60 million for the building and equipping of a single berth which will be used for importing iron ore and pellets, and shipping the HBI to steelworks in the Bangkok area. They are obviously nominal figures as a location for the plant has not been chosen. The port costs would be less than stated if the development was part of a wider scheme.

TABLE 8.15 - CAPITAL COST FOR STAND ALONE DR PLANT
(million US$)

Item	Amount
Land and Port	80
HBI Plant	97
Raw Materials	20
General works services	20
Pre-op expenses	10
Sub-total (million US$)	227
Contingency	23
Total (million US$)	250
Total (billion baht)	6.4

8.3.3 Operating costs

Table 8.16 shows the unit consumptions for the plant. Prices are as given in Table 8.6.

Manpower costs are based on a total of 140 employees (including administration) with a weighted average costs of 88,100 baht per person per year.

TABLE 8.16 - UNIT CONSUMPTIONS - DR PLANT

Process	Item	Units	Amount
DR Plant	Pellets	kg/t	1204
	Lump ore	kg/t	368
	Natural gas	mBTU/t	10.3
	Electricity	kWh/t	130
	Water	m3/t	1.5
	Sp/cons/misc	US$/t	6

Source: Consultants database - average operating performance assumed

8.3.4 Working capital requirements

The rules for working capital are the same as those described in Section 8.1.4.

8.3.5 The results

Pricing the HBI at landed international prices, and assuming that the project pays the full cost of port infrastructure, gives a real rate of return for the project of 7.1%. The cumulative cash flow becomes positive 11 years after the commencement of operations. When working at full capacity, the plant creates an added-value of about 650 million baht per annum.

If the Government were to provide the port facilities for the plant, the rate of return would increase to 10.6%.

Currently scrap imports are exempt from duty. It is unlikely that the Government would want to protect a DR plant through raising tariffs on scrap as this would lead to higher long products prices and the likelihood of some melters buying billets instead of making them. Changes in the price obtained for HBI, therefore, will result only from changes in the international market for scrap and DRI/HBI. As part of the base case, the Consultants' have assumed a real rise in these prices and sensitivity tests have been carried out for both increases and decreases.

Table 8.17 shows the returns for a number of cases. Not surprisingly, price is the key variable. If the real price rose by 10%, the project would start to look attractive for a private investor. It might do so if the Government were to provide port facilities for the development at no cost. The prices of gas and ferrous materials have some impact, but in practise the latter will be correlated with the product price anyway.

TABLE 8.17 - RATES OF RETURN FOR A STAND ALONE DR PLANT

Case	Price Increase/Decrease		
	-10%	0%	10%
Base Case - project pays for port facilities	2.1%	7.1%	11.3%
Fe Materials price			
- rises 10%	-0.7%	4.9%	9.4%
- falls 10%	4.5%	9.1%	13.2%
Gas price			
- rises 10%	0.9%	6.1%	10.5%
- falls 10%	3.2%	8.0%	12.2%
Costs of port facilities excluded	4.6%	10.6%	15.7%

8.4 Conclusions

From the point of view of the national economy, both the flat products integrated works and the stand-alone DR plant perform well, w,th returns in the region of 7% to 9%. The scrap-based mini mills for long products and the hot strip mill using imported slabs give slightly lower returns. It should be noted, however, that the Consultants' projections for finished products prices are lower than current international prices. The reverse is true for the DR plant, where prices of its competing product, melting scrap, are projected to rise in the future.

From the point of view of the private investor, current rates of duty for finished products are sufficient to boost returns to attractive levels. For the DR plant, it would be difficult to make the project more attractive by means of protection. Duties on scrap would only serve to discourage melting and encourage the import of billets.

In the long term, if scrap prices rise as projected, a joint-venture consisting of long products producers, and possibly an iron ore producer, might find it attractive to invest in a DR plant. If the Government were to provide port facilities as part of the Southern Seaboard Development Programme, the project should become viable. This would have the intangible benefit of diversifying the supply of feedstock to the mini-mills and make them less dependent on fluctuations in the international scrap market.

The stand-alone cold mill, put forward as a contingency plan if sufficient port facilities could not be found for the integrated works, does not perform well. The results suggest that Stage 1 of the Sahaviriya project gives a larger return than the contingency plan.

9. GOVERNMENT POLICIES AND ACTION PLAN

The main roles of Government in the sector consist of:

* regulating existing producers
* encouraging new projects
* setting appropriate tariff levels.

The first role is undertaken primarily by the Ministry of Industry (MoI), the second by the Board of Investment (BoI) and the MoI, and the third by a committee consisting of representatives from a number of Government departments. Each role is discussed in the following sections.

Currently there is no direct involvement by the Government in steelmaking projects, neither are there plans to do so in the future.

9.1 The Regulation of Existing Producers

The Thai Industrial Standards Institute are responsible for setting and maintaining standards for the domestic producers of steel products.

Different standards apply to products made from billets and those made from the direct rolling of cobbled plate. Samples are taken from plants at approximately two-month intervals and from stockists by a staff of about 10 people. If samples pass their tensile tests, a certificate is given for the consignment tested.

There are three Thai Industrial Standards for rebar, namely:

* TIS 24-2527 for deformed bars in three grades, SD30 (31 tpsi tensile stress), SD40 (36tpsi) and SD50 (40 tpsi);

* TIS 20-2527 for round bars of SR24 grade (25 tpsi);

* TIS 211-2527 for re-rolled round bars of SSR 24 grade (25 tpsi).

Contractors allege that there is fairly widespread flouting of the standards by the re-rolling companies, particularly in terms of products being thinner than the quoted size. Whilst the Consultants are unable to verify this, it would appear that the situation could easily arise. The Ministry has very little idea of the scale of production by the re-rollers let alone the quality of their products.

9.2 The Encouragement of New Projects

The Government has a number of measures that it can use in order to encourage new projects in the iron and steel sector. Financial incentives can be provided, assistance can be given regarding the provision of land and infrastructure, and tariffs can be adjusted to protect domestic industries.

9.2.1 Financial incentives

Financial incentives for new projects which meet certain guidelines are given by the Board of Investment. The coverage of approved projects is wide but the Board are particularly keen to promote projects which:

* strengthen the balance of payments;

* support Thailand's resource development;

* provide significant employment;

* locate themselves outside Bangkok and adjacent provinces;

* establish industries that are seen as encouraging downstream activity.

For the long products developments, the initial invitation to expand came from the Ministry of Industry when, in 1988, it became clear that there was a shortage of capacity for the production of rebar. About 40 firms made submissions, of which five were chosen. No further licenses will be issued for 5 years. The BoI have granted promotional status to all firms, provided they locate themselves outside the Bangkok area. Three have so far found provisional sites in the Eastern Seaboard. Of the others, one would like to develop in Samut Prakarn at their present works site, whilst the other is looking at several different site options. The sole advantage of promotional status lies in being able to import plant and machinery exempt from import duties.

As shown in Section 5, the amount of new capacity authorised is consistent with the Consultants' forecasts of demand. The MoI must now monitor progress carefully and be willing to re-allocate the licenses of those projects which are unlikely to come to fruition. New plants will be needed by the end of the period of the moratorium.

For the flat products works, the BoI has also granted promotional status and the MoI has given an undertaking that a competing firm will not be licensed during the next 10 years. The Consultants understand that this latter concession can be reviewed if circumstances change.

The company undertaking the development will receive exemptions on the duties payable for imported plant and machinery, corporation tax holidays for eight years with further years at a reduced rate, and a reduction in duties on imported raw materials for up to three years.

The Sahaviriya project will satisfy the market for hot rolled products but will not meet the demand for cold rolled products. Other firms could be invited to submit proposals to make this product, without threatening Sahaviriya.

9.2.2 The provision of infrastructure

Apart from financial incentives, new projects need help in coordinating the infrastructure they need. If they are locating in an industrial estate like Map Ta Phut, the Industrial Estates Authority of Thailand (or similar private companies) will assist in the arrangements. Land will be leased and services will be supplied. Locations elsewhere require more effort on the part of the participating company and direct negotiations with EGAT and municipal agencies will be required as plans progress.

This type of approach is appropriate in the case of smaller developments and appears to be working for long products. The Consultants' doubt, however, whether it is the correct way to plan a large flat products works. As described in Sections 6 and 7, the infrastructure required is of a much larger scale and the site location problem a difficult issue.

Active assistance by the MoI will be needed in order to find a suitable location within a reasonable timescale. This will require participation from a number of Government departments and agencies. In the Consultants' opinion, the following steps should be taken:

* The MoI should request from Sahaviriya a statement about their requirements for land, port facilities and utilities.

* This statement should be passed to the Eastern Seaboard Development Committee to decide on the feasibility and cost of

providing sufficient land at Map Ta Phut, for both Stages 1 and 2 of the development.

* If it is decided that Map Ta Phut is unsuitable for this, the project will enter a period of time in which very little progress can be made unless, that is, the MoI can find a site in the South that will integrate with, but not interfere with the Southern Seaboard Development Programme. In the Consultants' opinion, an isolated site such as Laem Mae Ramphung is not a desirable proposition.

* Other projects could go ahead at Map Ta Phut without significant reclamation. There are three alternatives. Either Stage 1 of the Sahaviriya project could be located there on the understanding that any backwards integration of steel-making would take place at a different site, or a large stand-alone cold mill could be built (as in the so-called contingency plan), or a smaller cold mill, dedicated to making black plate, might be considered. Each of these projects would require more berthing facilities than are currently envisaged for the port, but there is space available if the fertiliser quay was re-allocated to the steel industry. The hot strip mill is likely to yield the highest rate of return.

* Whatever is built at Map Ta Phut, the Government should be planning for a second steel plant in the South, as part of its development strategy. To avoid similar problems to those faced at the present, infrastructure should be provided by the Government (and charged for if required), and licenses should be granted only on the understanding that the plant will be built at that location.

9.2.3 Manpower training

Another way in which Government can assist the steel industry as it develops, is to ensure an adequate supply of skilled manpower.

Currently Thailand produces about 3000 graduate engineers per year from its universities and technical institutes, and the Government recognises the need to increase this amount. Similar shortages exist in the skilled manual trades.

The expansion of training facilities almost always takes a long time as it is constrained by the number of teachers available. In the present economic climate within Thailand this is a particular problem as rapid growth in the private sector has led to potential staff being attracted into industry. This means that early steps need to be taken to plan for the requirements of the industry.

It is worth noting that training costs are small when compared to the capital costs involved in building a steel works. At the same time, efficient operations are the key to making a steel plant financially successful.

9.3 The Setting of Appropriate Tariff Levels

Changes to tariff levels are made by the Customs Committee, chaired by the Permanent Secretary of the Ministry of Finance and with representatives from all the major government departments. The committee meets twice each month and considers submissions from producers, their customers, and government agencies.

For the major groups of finished products the tariffs are given in Table 9.1.

TABLE 9.1 - CURRENT DUTY RATES FOR STEEL PRODUCTS

Item	Customs duty	Standard Profit	Business tax	Total taxes and duties
Rod and bar	10.0%	6.5%	9.0%	22%
Cold rolled prods (a)	400 b/t	6.5%	1.5%	5%
Hot rolled prods	12.0%	6.5%	1.5%	14%
Tinplate	17.0%	6.5%	1.5%	19%
Galvanised sheets	20.4%	11.0%	9.0%	34%

(a) Total taxes and duty percentage is based on the 1988 cif price

Duties on rod and bar were reduced in 1988 from 25% to 15%, and again in 1989 to 10%. This was due to a shortage of material and escalating costs in the construction sector which seriously affected a number of projects. This reduction is to be reviewed again in April.

Prices of imported bar are still firm and the Consultants believe that the long products producers can continue to make profits at the current rate of duties. As shown in Section 8 new projects could still proceed. The reduction on duty can, therefore, be maintained without detrimental effects to the companies concerned.

The duties on hot and cold rolled products do not follow the general pattern of increasing the level of duty with the degree of processing. If Sahaviriya are to be encouraged to extend into cold rolling, a higher rate of duty will be required on this product.

The position regarding flat products duties will need to be monitored carefully. The new project will face some duty-free competition from imports to promoted industries or export industries who can reclaim their import duties. Even so, it will capture a large share of the market and too heavy levels of protection will be detrimental to down-stream industries. In Section 8 are shown the different rates of return that will accrue to the project with different tariff levels. It can be seen that, according to the Consultants' estimates, tariffs for hot rolled products need not be set at higher levels than currently exist. It would be better to assist the project with favourable terms for the provision of infrastructure rather than to provide high levels of protection.

The coated cold rolled products have the highest rate of duty. In both tinplate production and galvanising, new projects are underway and existing plants are working at fairly high levels of utilisation. No additional duties seem to be needed.

During 1990 or 1991 it is likely that a system of value added tax will be introduced to replace business tax. For exporters, such as the pipe manufacturers, there will be advantages in the new system as they will be able to reclaim the VAT paid on domestic purchases. For importers, such as flat products users, they will have to pay VAT but this will be offset by the receipts collected on finished products. In general it will mean the lowering of tariff protection to producers, which will need to be taken into account at the time the change is made.

Table 9.2 shows the current rate of duties for the more important materials used by the steel industry. In the Consultants' opinion there is scope for small changes in the rates.

Firstly the rate of duty on billets should be made the same as that on scrap for re-rolling. This would encourage the re-rollers to buy billets rather than cobble plate and would be a positive step in improving the quality of the re-rollers production.

This could be done in one of two ways. Either the duty on billets could be eliminated, or duties could be increased on re-rolling scrap. In the first case it might be necessary to assist the melters by simultaneously reducing or eliminating duties on imported electrodes and ferro-alloys. In the second case it would be the re-rollers who would incur extra costs. It would be necessary to distinguish between melting and re-rolling scrap and apply the current rate of duty for billets to the latter.

Secondly there seems little logic or merit in allowing scrap to enter free of duty but not ships for breaking. This too should be exempt from duty. This will not result in major changes in the almost moribund Thai ship-breaking industry, as ship scrapping rates are low world-wide. It might allow, however, some diversification of the scrap supply - to melters as well as re-rollers.

In Section 2, it is mentioned that it appears that fairly large tonnages of material classified as scrap are entering the country at a zero rate of duty and then being re-used as second quality flat products. This loophole should be closed.

TABLE 9.2 CURRENT DUTY RATES FOR MAJOR INPUTS TO STEEL INDUSTRY

Item	Customs duty	Standard Profit	Business tax	Total taxes and duties
Ships for breaking	2.5%	11.0%	1.5%	4%
Scrap	0.0%	6.5%	1.5%	2%
Billets	5.0%	6.5%	1.5%	7%
Ferro-alloys	6.0%	6.5%	1.5%	8%
Electrodes	15.0%	6.5%	9.0%	27%

10. SUMMARY OF CONCLUSIONS

10.1 The Existing Iron and Steel Industry

The Thai steel industry consists of three sectors:

* long products manufacturers, either melting or directly re-rolling scrap;

* coating lines, making tinplate and galvanised sheets;

* foundries making iron and steel castings.

Throughout the early 1980's the industry has struggled with low prices and the under-utilisation of facilities. This situation started to change in 1987 and now steel producers are working at close to their capacity and are making profits.

In 1988, steel products and scrap represented about 10% of total imports. Developments are being planned that will add to the domestic capacity, but at the same time demand is growing at a fast rate, in line with the country's surge in manufacturing and construction.

10.2 Flat Products Developments

In 1988, the total consumption of flat products was 2.5 million tonnes, when expressed in terms of hot rolled coil equivalent. This will rise to 5.4 million tonnes by the year 2000. This figure consists of about 2.3 million tonnes of hot rolled products that could be made in Thailand, 0.4 million tonnes of thicker or wider material that could not be made without specialist equipment, and 2.5 miilion tonnes of cold rolled products.

The capacity of existing and planned coating lines (including the proposed electro-galvanising line) is sufficient for the projected levels of demand to the year 1995.

The Sahaviriya project consists of a 1.8 million tonnes hot strip mill, augmented at a later date by a 0.7 million tonne cold mill. The Consultants consider that a second stage of the project would be viable, extending the capacity of the hot strip mill and introducing steelmaking by the BF-BOF process route.

Even at this size, there will be a considerable shortfall in the supply of cold rolled products. A second works concentrating on the production of cold rolled steel can be justified on the basis of supply and demand.

While the market opportunity exists, the chief problem for the development of the flat products industry lies in its need of supporting infrastructure, in particular a suitable deep-water port.

The Consultants favour the use of reclaimed land at Map Ta Phut for the Sahaviriya plant. The cost of port facilities will be similar to that at an isolated site but the Eastern Seaboard is the only place where sufficient quantities of power, water and links to the existing land transport network could be supplied at reasonable cost and within reasonable timescales.

If this is not possible, the steelworks should be located in the South of Thailand, preferably at a location which would allow detailed planning to commence before the completion of the Southern Seaboard Development Programme.

Because of the scale of the infrastructure requirements, the Consultants believe that the Government will need to be more active in assisting flat products developments to find suitable locations. The levels of duty on flat products, however, need not be higher than they are now, for the new projects to be viable.

10.3 Long Products Developments

The total consumption of long products in 1988 was about 1.9 million tonnes. This is projected to increase to about 3.9 million tonnes by the year 2000.

The licenses which have recently been issued will allow the demand to 1995 to be met, but further facilities will be required after this date.

Licensees are making progress with their plans, although some still have problems regarding site location. Other companies should be given the opportunity to expand their production, if the licensed projects look unlikely to proceed.

Because many of the new facilities are to incorporate better technology than the existing works, the product range will be broadened, to include high carbon wire rod, and possibly some alloy steels.

With existing international prices for long products, the current reduced rates of duty can be maintained without detriment to existing producers or the new projects. The re-rollers should be encouraged to use more billets and less cobble plate, by making the duties for the two the same.

The size of the market for heavy sections is unlikely to be sufficient for a new plant to be viable within the planning period.

10.4 Other Issues

There have been a number of attempts to establish a stand alone DR plant in Thailand. With expanded long products capacity and higher international scrap prices, such a development might become viable in the longer term. If this were the case, the Consultants favour a gas-based process rather than those that could use the poor quality indigenous lignite.

All the ironmaking developments studied have assumed the use of imported iron ore. Thailand's proven reserves are insufficient for any major projects. Very little work has been carried out in recent years to establish whether larger deposits exist, however. For the longer term, a source of supply near to the onshore gas fields, might provide a development opportunity in the North East of the country. Further exploration should be carried out. Co-operation with Laos in this matter might also be considered.

With the significant expansion of the sector will come higher demands for qualified personnel. Many more graduate engineers and technicians will be needed.