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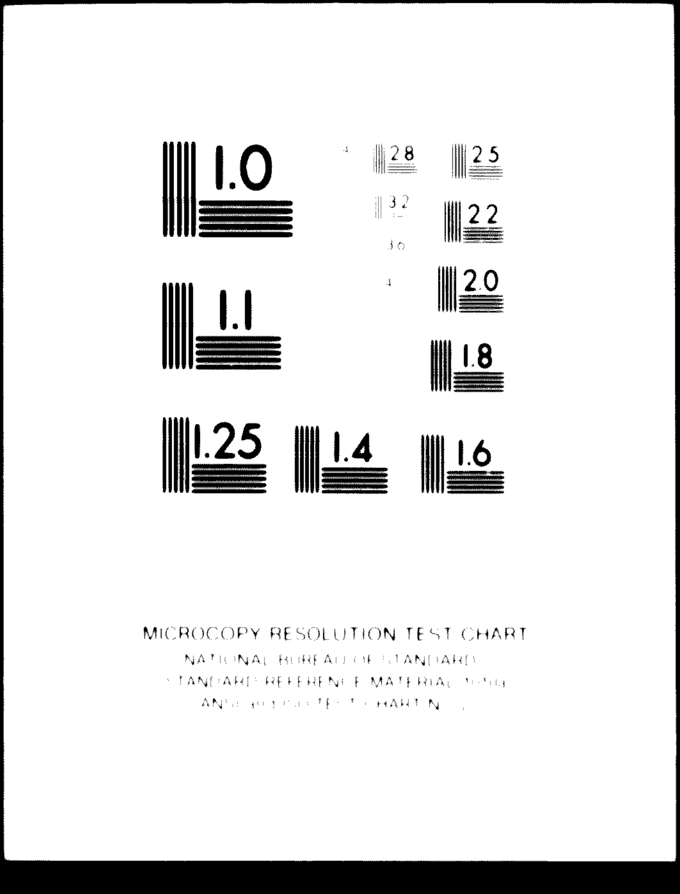
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ADVISORY SERVICES REPORT

FOR

METALS INDUSTRY RESEARCH AND DEVELOPMENT CENTER
GOVERNMENT OF THE PHILIPPINES

ON

LONG-TERM DEVELOPMENT PLAN FOR THE PHILIPPINE IRON AND STEEL INDUSTRY

BY

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Regional Adviser on Metallurgical Industries

AUGUST 1973

ECONOMIC COMMISSION FOR ASIA AND THE FAR EAST
Bangkok, Thailand

RESTRICTED

LONG-TERM DEVELOPMENT PLAN

FOR THE PHILIPPINE IRON AND STEEL INDUSTRY

August 1973

This report has not been cleared with the United Nations Industrial Development Organization which does not, therefore, necessarily share the views expressed.

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APPENDICES

CONFRONTING THE PHILIPPINE STEEL DILEMMA

an annotated action-plan

PROBLEM: How to bridge the widening gap between rising steel demand in the Philippines and stagnant indigenous capacity. If new capacity is to be created, which technology would be appropriate? And when and where are new plants to be built?

BACKGROUND

Scope of work

This five-week study by the UNIDO/ECAFE regional metallurgical adviser reviews salient aspects of the above questions and, as desired by the Metals Industry Development Center, evaluates the new direct reduction processes in the context of the overall development programme of the Philippine steel industry.

A number of plants were visited and persons met (Appendix I) whose co-operation is gratefully acknowledged. Dr. Arizabal, his colleagues at MIRDC, and the staff of the Iligan Integrated Steel Mill Inc were most helpful. Visits were made to possible plant sites around Lemery and Cagayan de Oro as well as to IISMI at Iligan and the Atlas concentrator in Cebu.

EXISTING STEEL FACILITIES

Consumption pattern

Philippine steel consumption peaked to almost a million tons in 1969, dropped sharply in the next two years, then recovered to 991,000 tons in 1972. This year (1973), with measures taken for economic recovery and stability, it should cross the million-ton level, but may not due to the global steel shortage and abnormal prices. Annex I reviews the existing steel situation.

/ The

The bulk (85 per cent) of present consumption is based on imports of rolled steel or semis. This makes economic growth particularly vulnerable to the vagaries of the international steel market, and the import bill of almost one hundred million US dollars a year places an undue strain on balance of payments, (paras 5-10).[a]

The consumption pattern shows a preponderance of flat products (over 60 per cent of total), particularly cold rolled materials - a proportion much higher than in other developing countries. Further, there is practically no use made of structural sections.

Under-utilization of capacity

The RP steel industry is characterised by gross under-ntilization of capacity. Actual output is under two-thirds of installed steelmaking facilities (although billets are in short supply). Bar rolling, tinning, galvanizing and pipe-making operate at only one-fourth of rated capacities and expansive flat hot rolling capacity at IISMI lies completely idle, (Table 3). The proper utilization of many million dollars of idle equipment must receive high priority, in the overall national interest.

FUTURE STEEL DEMAND

2.3 million tons by 1980

Based on recent estimates of 'steel intensity co-efficients' (that is, apparent consumption per GNP dollar in countries at various stage of development), demand in the Philippines is expected to rise to 2.31 million tons by 1980 and 3.27 by 1985 (Figure 1 on next page). This implies a doubling of 1972 consumption by 1978, that is, in about six years, which is in line with experience of countries at similar stages of growth. Analyses of demand are presented in Annex II.

/ Compared

a/ Figures in brackets refer to paragraphs and tables in the text of the annexes.

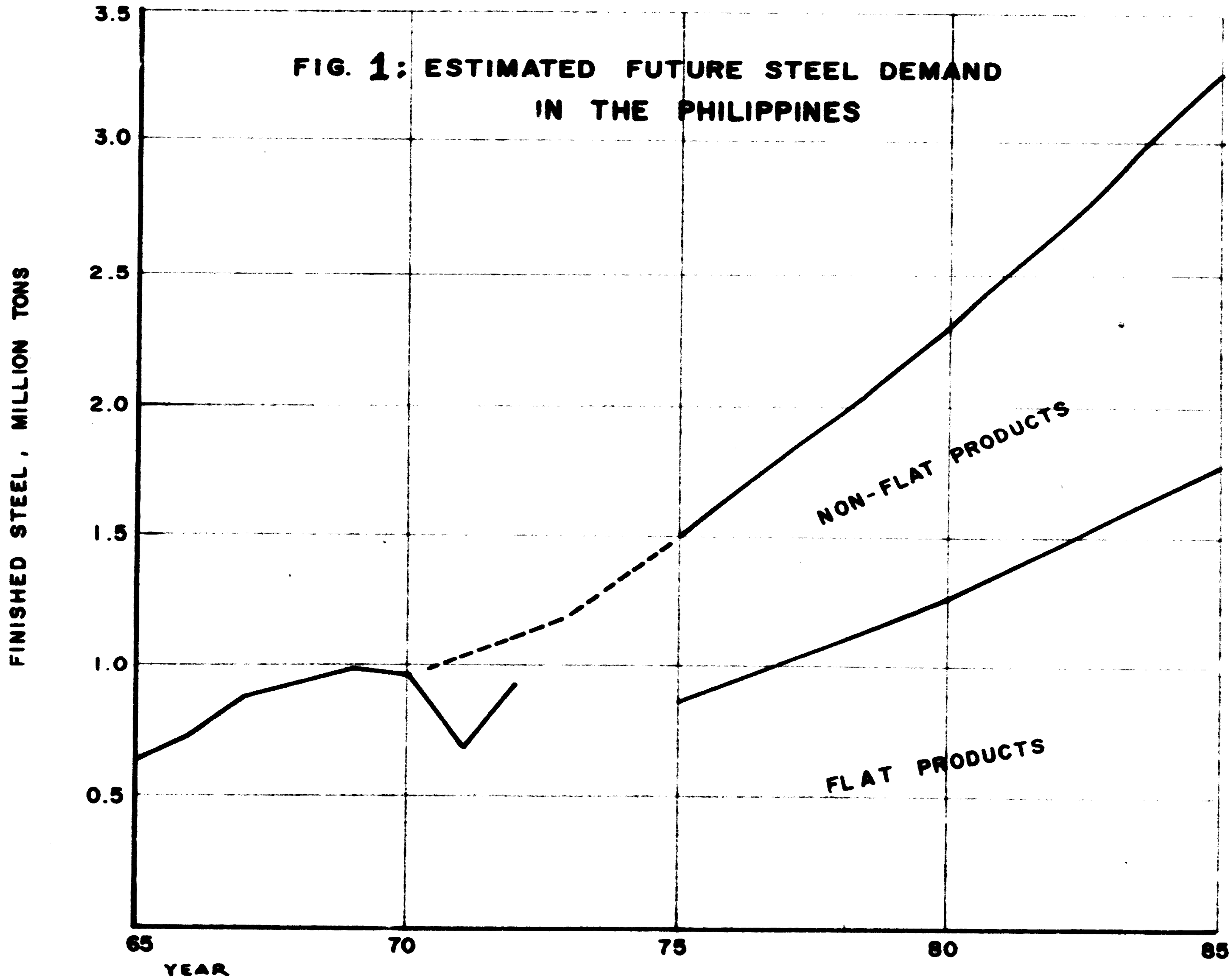

FIG. 1: ESTIMATED FUTURE STEEL DEMAND IN THE PHILIPPINES

Compared to a growth rate of about 12 per cent a year in the 15-year period upto 1970, the above estimates represent a rise of 9.2 per cent annually from 1970 to 1975, 9.1 per cent till 1980 and 6.9 per cent till 1985. Even so, per capita consumption would continue to be only one-fourth of the world average (56 kg in RP compared to 210 kg in the world in 1980).

As heavy industrial construction increases, the proportion of flat products would decrease, while use of structurals for steel-framed buildings should develop. Category-wise demand is estimated below:

Category-wise steel demands, 1975, 1980, 1985
(thousand tons)

	1975	1980	1985
Flat products			
HR: Plate	95	170	260
Sheet and skelp	175	290	430
CR: Galvanized	230	300	390
Tinplate	170	250	330
Other products	185	260	360
Sub-total:	855	1,270	1,770
Non-flat products			
Bars, rods and wire	565	890	1,280
Structural sections	80	158	220
Sub-total:	645	1,048	1,500
Total Finished Steel:	1,500	2,318	3,270
Slab equivalent @ 86%	995	1,480	2,060
Billet equivalent @ 94%	690	1,115	1,600
Total Steel Semis:	1,685	2,595	3,660

Lines of expansion

Probable demands would require that capacity for hot and cold rolling of flat products be augmented soon. Further, substantial steelmaking capacity must be created at the earliest for production of slabs. Tinplate capacity needs marginal improvement and expansion to meet 1975 demand, but existing galvanizing as well as bar rolling capacity should be more than adequate.

/ Possibilities

Possibilities of regional co-operation

Fair export possibilities

Steel demand in other countries of the sub-region (Indonesia, Malaysia, Singapore, Thailand, Khmer Republic, Laos and Republic of Viet-Nam) is estimated at 4.5 million tons in 1975 and 6.4 million tons in 1980. Allowing for probable increases in steelmaking capacity, there would still be substantial shortfalls of over 3 million tons in 1975 and 2 million tons in 1980. If RP could install a major iron and steelmaking facility by 1980, it could take a fair share of the growing south-east Asia market.

At the same time, there is indeed scope for - and economies in - formulating an integrated planning strategy for steel development in the sub-region. Recent studies[a] have pinpointed the problems and quantified the benefits of such cooperation. Now initiative is needed for experts of the governments concerned to discuss in concrete terms. RP could well take a lead in this matter.

RAW MATERIALS BASE

Of the countries in south-east Asia, the Philippines has perhaps the best raw materials endowment for a major iron and steel industry. It also has the advantages of a skilled, readily-trainable work force and low labour costs. In Annex III the availability and prices of raw materials and supplies for iron-making are discussed.

Iron ore

Iron ore reserves have been estimated at over 100 million tons. Exports of iron-bearing minerals have been 1 to 1.5 million tons annually, (Table 15). But the Philippine Iron Mines is now experiencing difficulties in raising and concentrating ore of

/ requisite

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a/ Report of the Expert Team on Regional Co-operation for Steel Billet Production, AIDC (8)/10, January 1973.

Report of the Asian Industrial Survey for Regional Co-operation, ECAFE, March 1973.

requisite quality at Larap for pellet production while the other major source at Santa Inez still awaits proper development. The locations of ores in relation to possible sites under consideration for an integrated steel mill are shown in Figure 24.

Geological studies essential

A 'crash programme' of geological investigations and beneficiation studies is essential, in order to feed the proposed integrated steel plant with indigenous materials. Without at least partial use of local ore and coal, the case for such a mill is weakened. While initially the plant could start on imported ores and coal, the objective must be to use a fair proportion (say 30 per cent) of Santa Inez and other ores in the expansion if not the initial phase.

Pellet availability real asset

The output of around 700,000 tons/year of high-grade pellets at the Pellet Corporation of Philippines represents a valuable resource, and when the present export contract expires in mid-1974, new arrangements should be such as to enable PIM/PCP to continue operations and supply pellets for use within the country, as needed. This may require that the diminishing output of Larap be supplemented by magnetite concentrates from Atlas (say 250,000 tons/year) and Philex (180,000 tons/year). If local pellets (66-67% Fe) could be supplied at about $ 16/ton f.o.b. Larap, this would be a sound base for a sponge iron plant, (paras. 70-76).

Coking coal

Initial import necessary

Available data on RP coals is not encouraging. Of the 125 million ton reserve, only a small part (under 5 million tons at Malangas) has coking characteristics which would enable use in coal blends for blast furnace iron-making. Therefore, at least initially, all coking coal would have to be imported from USA and Australia. Average cost is estimated at $ 26 c.&f. Due to the upsurge in global iron-making, coke prices have been rising at around 5 per cent annually, (paras. 83-88).

/ Steel

Steel scrap

An essential material for the iron and steel industry is scrap. Wide fluctuations in scrap prices and availability are a constant headache for the arc furnace steelmaker. Imported scrap has doubled to almost $ 90-100 per ton in the last year.

Domestic scrap availability is limited (currently around 100,000 tons/year at about $ 50 per ton) and in future more scrap would have to be imported, from the US, Australia and Europe. For process cost comparisons in this study, an average price, part home and balance imported scrap, of US$ 80 per ton scrap is taken.

Scrap study needed

MIRDC/PISI need to initiate a detailed study on scrap availability and organize a proper system of collection, preparation and distribution.

Naptha

Difficulties in scrap supply are forcing countries to look closely at production of metallized or reduced ore and pellets (popularly known as 'sponge iron'). As natural gas is not available in the Philippines, some other hydro-carbon such as virgin straight-run naptha could be used as a gaseous reductant source. A 400,000 tons/year sponge iron plant would need about 3,000 barrels/day, by say 1976-77.

National fuel policy

Currently no naptha is produced in the Philippines, but this could be readily done if there was a steady, sizeable off-take. Current naptha prices are typically around $ 3-3.50 per barrel in countries of this region. Prices are rising together with the posted prices of crude, particularly as naptha is a clean fuel source as well as feed-stock for fertilizers and chemicals industries. However, the rational allocation of naptha supplies and setting of price guide-lines are matters of government policy.

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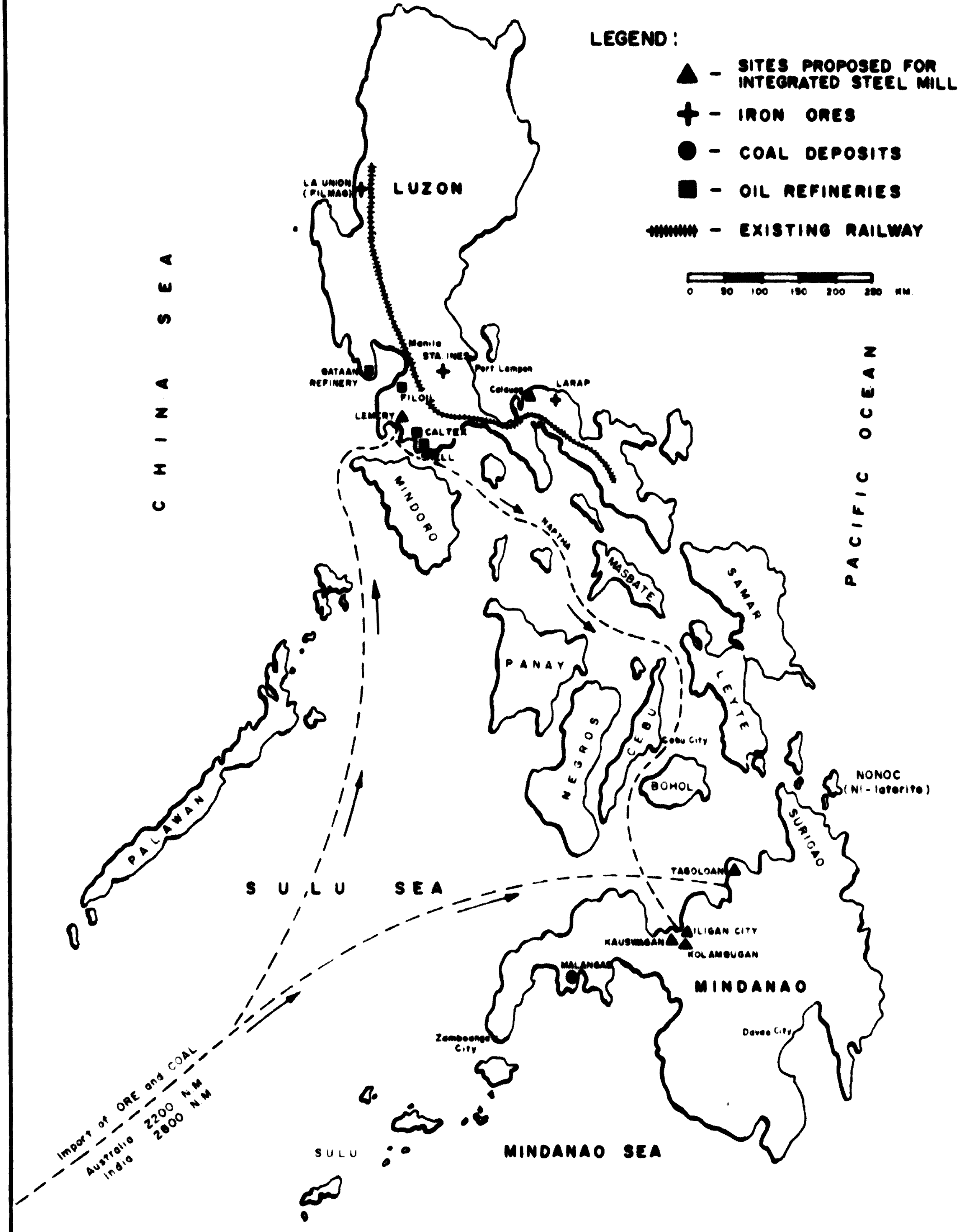


FIG.24 RAW MATERIALS AND LOCATIONS FOR PROPOSED STEEL MILLS IN THE PHILIPPINES

For this study a naptha price of $ 3.85 per bbl is taken (that is, $ 0.742 per million BTU). A rise of one dollar per barrel (that is, 27 per cent rise) would increase the price of steel billets/slabs by $ 2.40, that is, about 2 per cent of the total production cost of these semis.

Electric power

Both integrated and semi-integrated plants are major consumers of electric power. Given advance notice, the requisite power could be made available. Average costs are estimated at $ 0.007/unit in northern Mindanao and $ 0.014 at other locations.

CHOICE OF TECHNOLOGY

Options available

Annex IV discusses the technological options now available to RP in expanding its steel industry. The modern blast furnace continues to be an economic process for producing large tonnages of iron to be converted to steel. But it needs coking coal (not available in RP) and it needs large outputs of over a million tons to justify the tremendous investment needed. For these reasons, an alternate technology - electric arc furnace steelmaking - has made major advances throughout the world.

In both developed and developing countries, semi-integrated plants based on arc furnaces are producing as much as 40 per cent of total steel (paras. 114 - 119, tables 22-24). The investments involved are small - only say $ 160 per annual ton, against double this for an integrated mill. Further, operating costs are low, the plant can be put up in two years or so and earn quick returns, the process employed is simple, and local man-power can be readily trained to handle it.

/ But

But such 'mini-mills' need scrap. Alternatively, part of the scrap could be replaced by sponge iron.

Sponge iron warrants consideration

While the Philippines is on the threshold of major steel industry expansion, it is urged that the planners take a close look at the new technology of sponge iron making. Till only a couple of years ago, many knowledgeable people were understandably sceptical about sponge iron. Today, however, processes using gaseous reductants can be considered to be commercially established and viable in many situations (paras 130-139, Appendix V). In the Philippines, a major semi-integrated plant based on sponge iron could very usefully complement a large integrated steelworks based on blast furnaces.

World capacity for sponge iron is today around 4 million tons a year and will exceed 6 million when plants under construction are completed. The manner in which capacity has grown is shown in Figure 3. Plants are being actively planned in India, Malaysia, Singapore, Republic of Korea, Thailand and also in the Philippines.

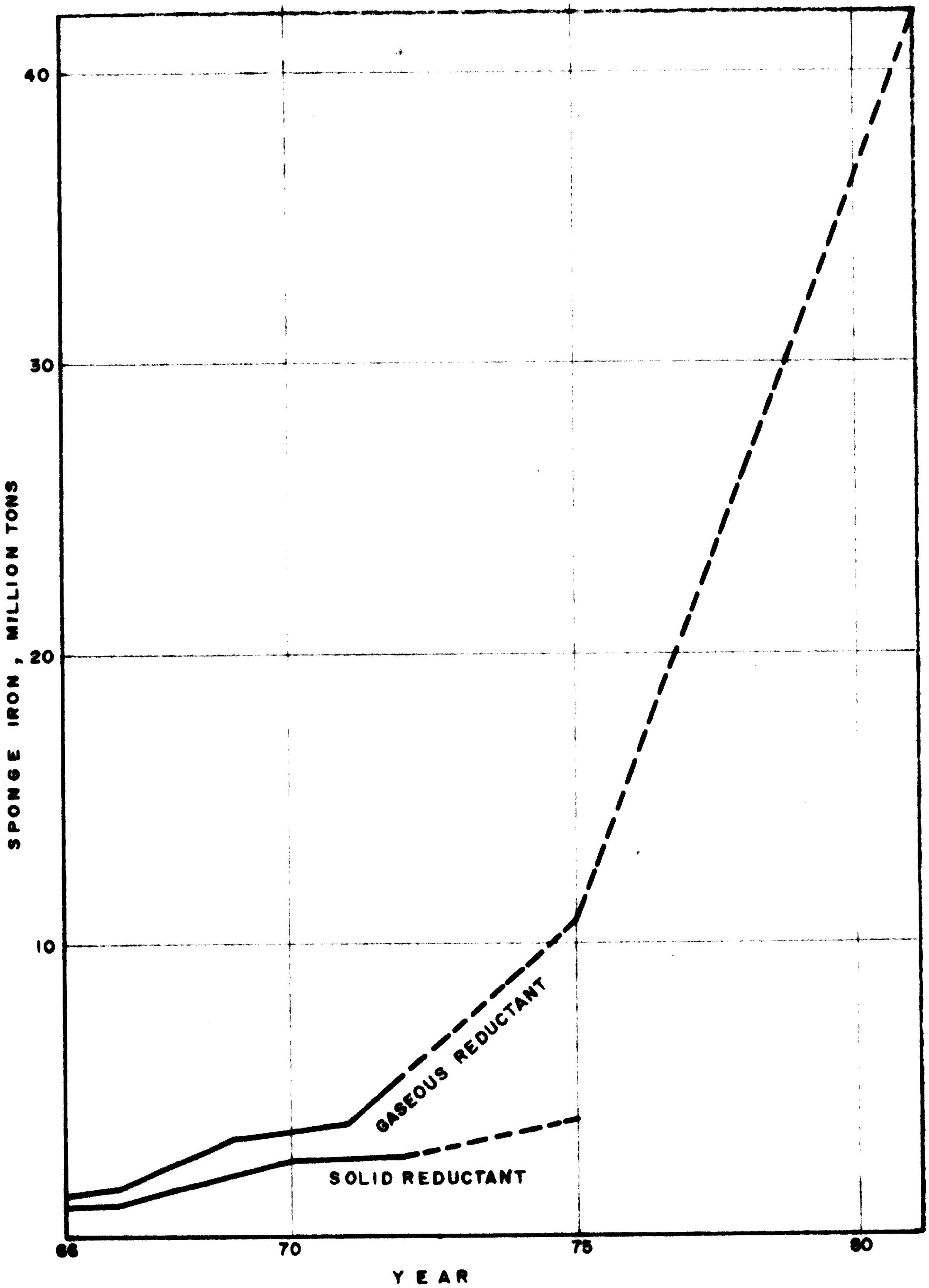
Sponge iron schemes in RP

The sponge iron production schemes of three Filipino entrepreneurs were discussed, (paras. 140-141). Two of these - Engineering Equipment and Philmag - are planning solid reductant processes. Unfortunately, many such processes in various countries have given unsatisfactory results, and these entrepreneurs should make the most careful pilot tests and feasibility studies before committing major funds to commercial projects.

The third company - Marcelo Steel - visualizes a 400,000 ton sponge iron plant based on the Midrex processes. Of the three local schemes, this has the best chances of succeeding.

/ MATCHING

Fig: 3 ESTIMATED GROWTH OF WORLD SPONGE IRON CAPACITY.



MATCHING NEW CAPACITY TO FUTURE DEMAND

The Philippines has already lost a precious decade in building up an integrated steel industry. Bold plans are now needed. There may be serious penalties for a diffident approach, less for a dynamic far-sighted steel policy.

Two alternatives examined

Process routes which can now be considered viable are conventional blast furnace iron-making and electric arc furnaces with high proportions of sponge iron in the charge. Both routes start with iron ore.

In order to build new capacity to satisfy future steel demand, two schemes are examined in Annex VI:

Alternative I: Build a single major integrated steelworks, starting operations with about 1.4 million tons/year capacity by 1979.

Expand this in a continuing manner to 3.0 million tons by 1982/83.

Alternative II: Start construction simultaneously on an integrated plant with 1.1 million tons initial capacity to be commissioned by 1979, as well as on a semi-integrated plant to produce 400,000 tons/year of slabs to feed IISMI, which could be in operation by 1976/77.

Expand the integrated plant rapidly to 2.4 million tons by 1982/83. In effect, the plant is fully designed for 2.4 million tons output, of which 1.1 million is only an intermediate construction phase.

Bridging the shortfall

Figure 7 attempts to show how demands, separately for flat and non-flat products (expressed as slab and billet equivalent), could be met under Alternatives I and II. It is seen that in Alt. II (with integrated and semi-integrated plants) the short-falls are covered somewhat earlier. Even so, imports, particularly of flat products, would be substantial right up to 1982.

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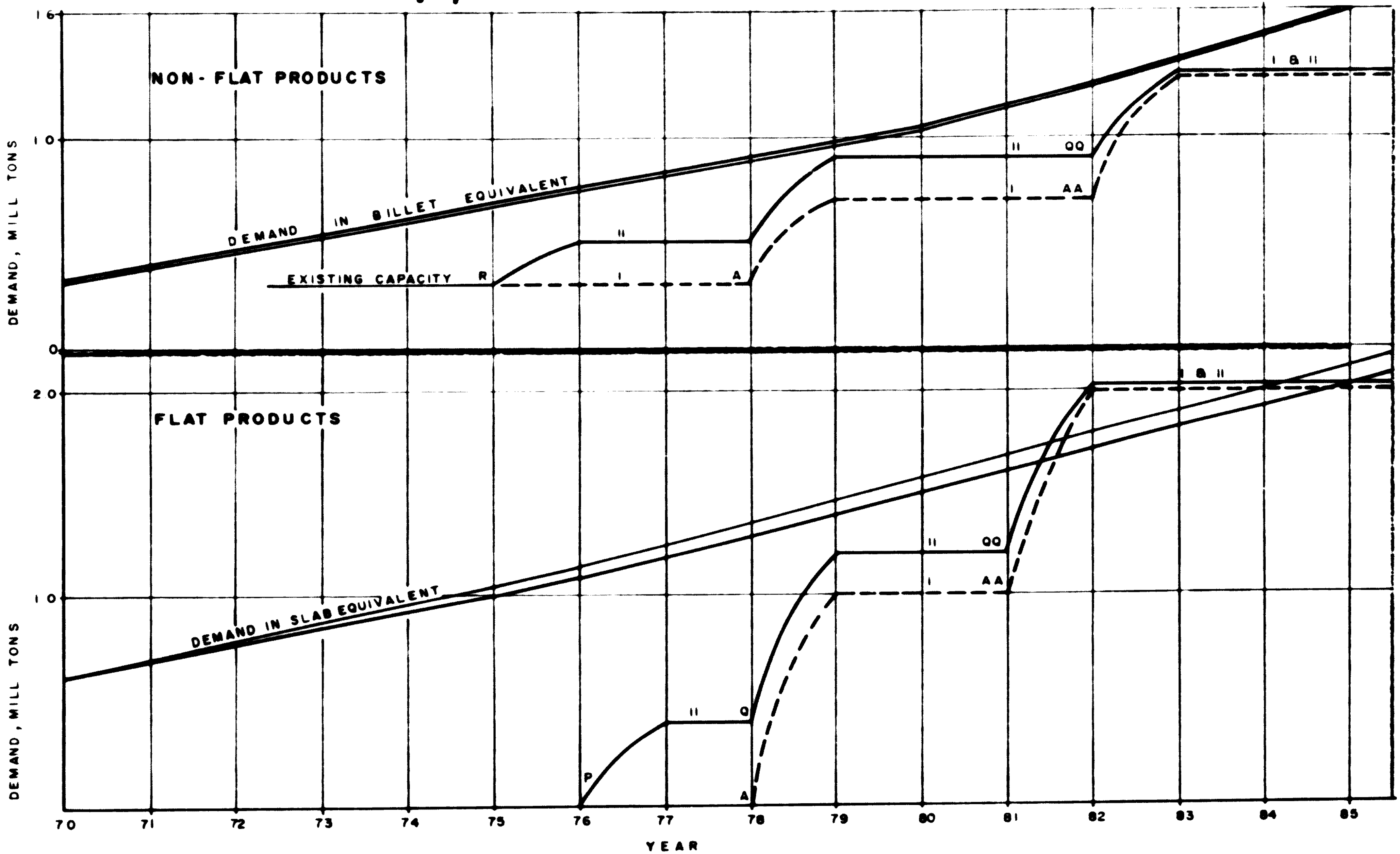
Fig: 7 MATCHING CAPACITY TO STEEL DEMAND



It should be noted that the best laid plans of Midc and men can go awry, and delays may well occur. Steel output and demand cannot be made to match with any precision and there may well be periods of excess capacity in some categories, alternating with critical shortages.

Advantages of two-pronged approach (Alt. II)

The main conclusion of this study is that RP should go ahead with the major blast-furnace-based plant at a suitable location and with an arc-furnace-based shop at Iligan, as outlined in Alt. II above. The future demands justify this approach, technical and economic considerations favour it, and the urgency of making IISMI viable warrant it.

Lower costs, better continuity

The significant advantages of this approach are as follows:

(i) Total investment in creating equivalent steel capacity would in fact be lower (by over $ 100 million) with two plants than with one, strange as it may seem.

(ii) Import substitution through the indigenous production of 800,000 tons of slabs two years earlier than in Alt. I. would result in a net foreign exchange saving of US$ 75 million - that is, almost three times the foreign currency cost of setting up the semi-integrated plant.

(iii) Activity dispersal: Additional employment and industrial activity would be created at two nucleii for growth.

(iv) Spreading of risks: Adoption of two process routes would give better protection and continuity against stoppages in one plant or the other

(v) Better utilization of IISMI: A captive source of slabs would insulate IISMI from total dependence on outside supplies, and enable quicker utilization of the US$ 100 million investment in its plant.

/ Arguments

Arguments could be raised against a two-plant strategy:

Question: Why not advance the single integrated plant itself by two years, to 1976/77?

Response: A major integrated steelworks at a green-field site could not be completed in three or four years from now. A sponge iron/ arc furnace shop at IISMI could.

Question: What about economies of scale? Won't the large integrated plant produce at lower costs than the smaller arc furnace plant?

Response: No. All over the world, semi-integrated plants are able to co-exist with - and often under-sell - giant steelworks, in certain situations. In this sense, the integrated and semi-integrated routes are complementary, not competitive. IISMI has the additional advantage of cheap electric power. Slab cost at IISMI would be lower than at the initial stage of the integrated mill. Figure 17 shows how this happens. With different assumptions the two curves may move slightly up or down, but the 'cross-over point' would remain beyond 2 million tons. Thus, only in 1982/83 when the integrated plant has doubled its output could its costs be slightly lower than the semi-integrated mill.

Question: Why not build one larger plant, that is, including the output of the semi-integrated mill?

Response: Because a starting capacity of even 1.1 million tons based on a single blast furnace is large enough. On the other hand, adoption of two smaller furnaces would be more expensive.

Question: Why take a risk with sponge iron?

Response: HyL and Midrex plants have now been operating commercially for some years. Even so, there are risks but with proper planning and design these could be further reduced. Because the risk is higher than with conventional processes, the investors have a right to expect - and would hopefully get - higher returns on their investment.

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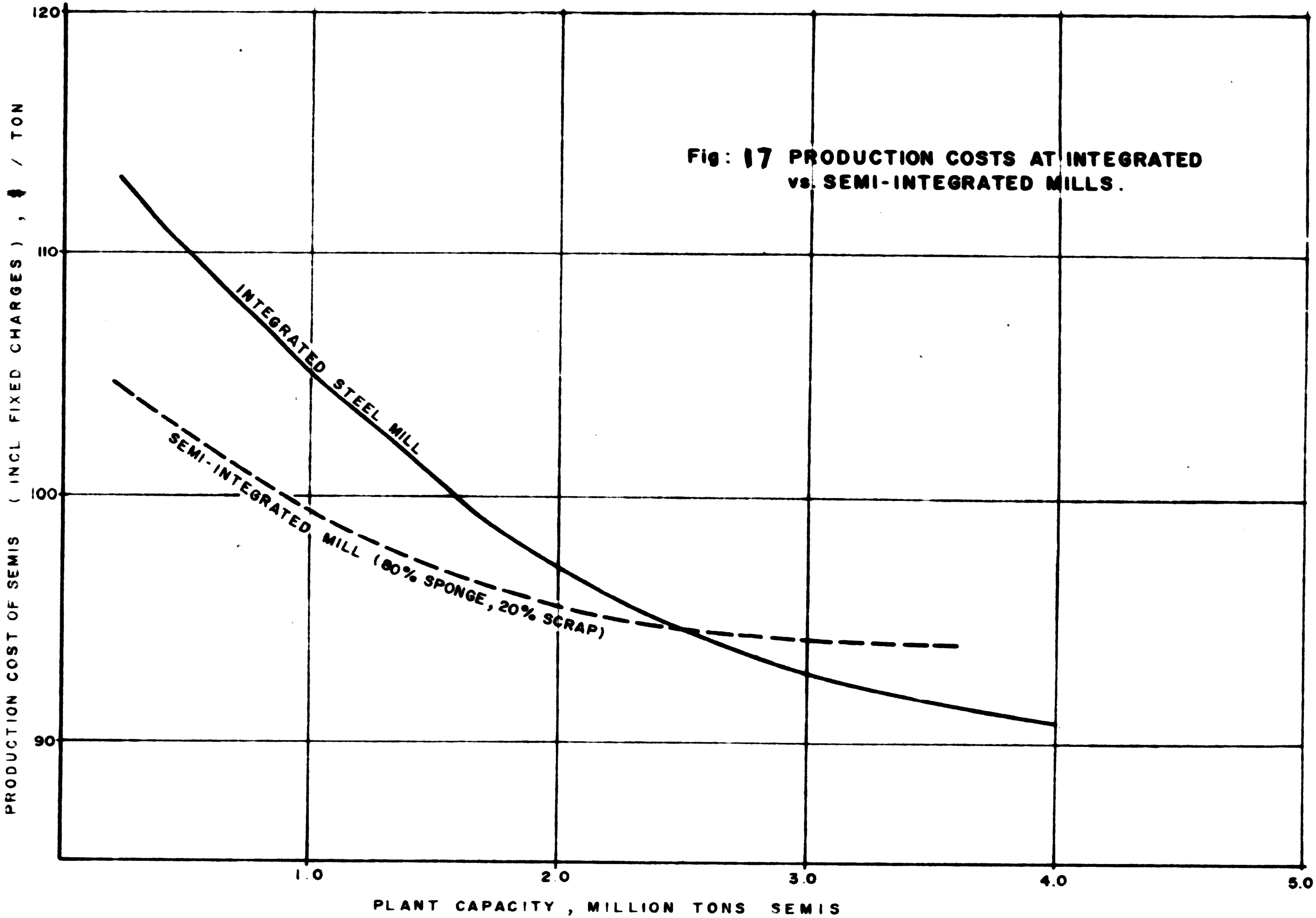

Fig: 17 PRODUCTION COSTS AT INTEGRATED vs. SEMI-INTEGRATED MILLS.

Question: And what about naptha? Aren't prices shooting up?

Response: All petroleum-product prices have risen, but, where necessary, power generation, transportation and other systems will just have to continue to be based on oil.

Moreover, as already discussed, even a big jump in naptha price would raise slab costs only marginally. And further, even coking coal required by the blast furnace route is going up by over 5 per cent a year.

OPTIMIZING THE POTENTIAL AT IISMI

One million dollars a month

IISMI's plan for back integration to iron-making has remained unfulfilled. For this and other reasons, only a part of its installed capacity is in operation. Interest and depreciation charges alone on the expensive unutilized facilities are costing the country one million dollars a month. It is imperative, therefore, that plans for bringing IISMI to a sound viable position receive the highest priority, (paras. 145-151).

IISMI's advantages & disadvantages

IISMI has the advantages of cheap power and abundant water. It has a cadre of technical managers and operators with first-hand experience in problems of constructing and commissioning a steel mill. Moreover, the built-in provision in utility systems, storages, etc would facilitate expansion.

However, IISMI has some significant limitations. The available land area (about 47 ha in the existing perimeter and perhaps another 50 ha outside) may be just enough for an integrated plant of upto say 2 million tons. But expansion beyond this would require expensive land levelling and reclamation. Further, the site is far from the major steel market and potential ore sources at Luzon.

/ Taking

Three-part programme

Taking into account IISMI's net endowment, this study suggests that (i) plans to install blast furnaces be abandoned and (ii) plans to increase capacity by adding-modifying rolling mills be shelved. Instead, a three-part integration and diversification programme for better and fuller utilization of existing facilities is proposed:

<u>one</u>: Build a new arc furnace steelmaking shop at Iligan to feed 400,000 tons of slabs to the existing IISMI hot rolling mill complex, as discussed earlier.

<u>two</u>: Convert the existing 25-ton arc furnace (and 18-ton furnace under planning) to production of alloy and special steels.

<u>three</u>: Install one of the available ELKEM smelting furnaces for production of foundry iron and the second for ferro-manganese.

The existing situation at IISMI is reviewed in <u>Annex V</u> and suggested future action in subsequent annexes.

PROPOSED DIRECT REDUCTION/ARC FURNACE PLANT AT IISMI

Large high-powered arc furnaces and efficient slab casting machines would constitute a modern high-production shop. The addition of the sponge iron plant would make IISMI practically self-sufficient in metallics. Supply from this complex of 400,000 tons a year of slabs to the existing combination/steckel mills would enable the company to reach rated capacities. In the next phase, the installation of alloy and special steel producing facilities would give IISMI a diversified, high-value product mix, further improving viability. Raw material requirements, layout, costs and other aspects of the DR/AF plant are detailed in <u>Annex VII</u>.

/ Facilities

Facilities

The following major facilities are proposed:

Facility	Capacity tons/yr
Sponge iron plant of Midrex or HyL type, based on pellets from PIM/PCP and naptha.	400,000 tons sponge iron
Meltshop consisting of two 85-ton arc furnaces with 45 MVA transformers each, producing average 7.5 heats/day, based on 80% sponge iron in charge, 20% scrap.	420,000 tons liquid steel
Continuous casting: two single-strand machines to cast slabs 36" to 60" width and 6" to 8" thick. (alternatively one slab caster for 300,000 tons slabs and a six-strand billet machine for 100,000 tons billets could be adopted)	400,000 tons slabs

Provision for expansion

A typical flow-sheet for the proposed plant is shown in Figure 8. Provision should be made in the initial layout design for adding a third 85-ton arc furnace and a third continuous casting machine to raise output to 600,000 tons/year in future. Space should also be provided for doubling the output of the sponge iron plant to 800,000 tons. Then, about 600,000 tons could be utilized at the expanded melt-shop, 100,000 tons at the existing 25-ton and planned 18-ton arc furnaces, and the balance readily sold.

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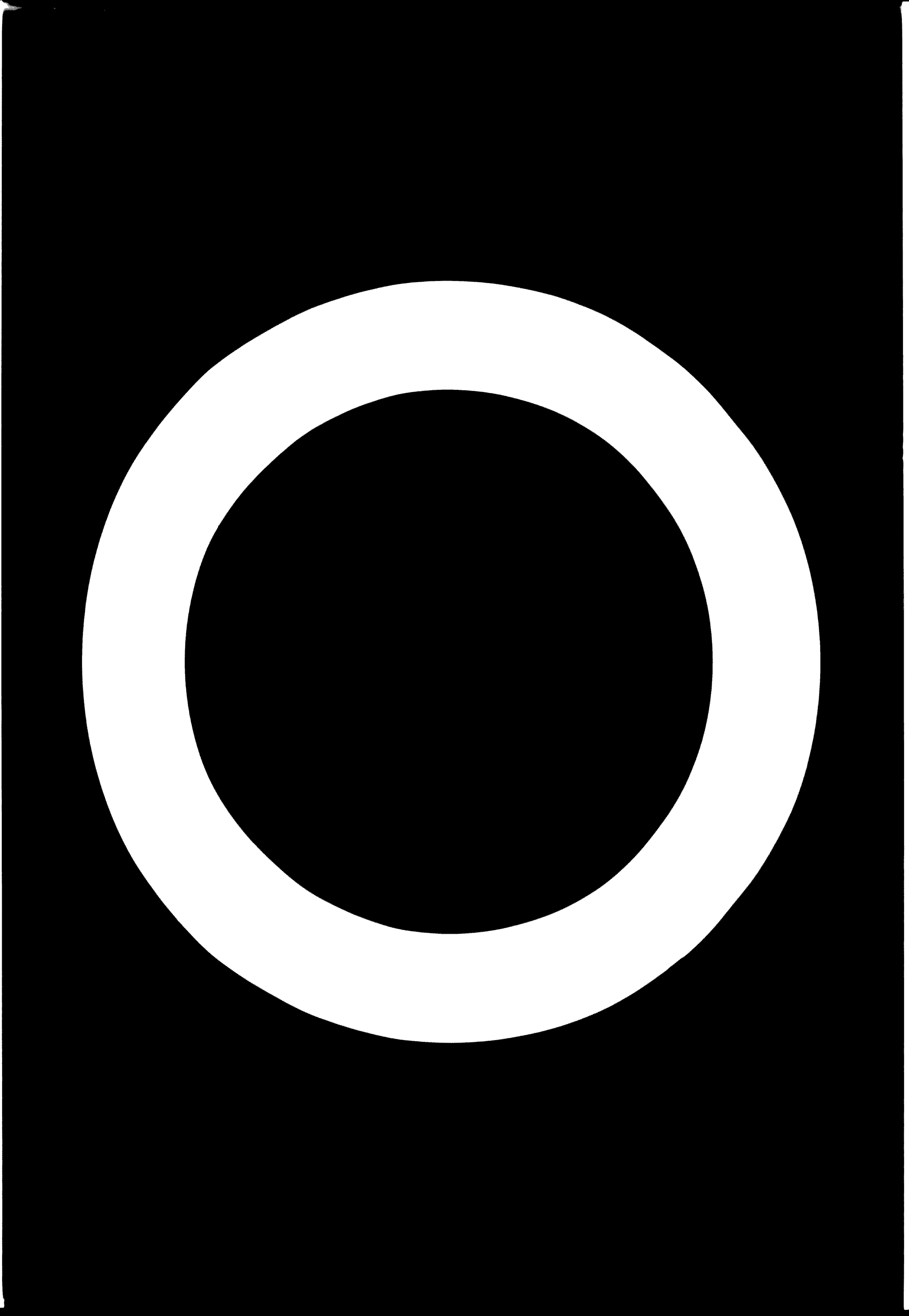


On the basis of high-grade pellets with 67-68 % Fe and under 4 per cent gaugue, the sponge iron produced can be expected to have thefollowing characteristics:

	%
Fe (total)	92
Fe (metallic)	86
Gaugue	6
Reduction degree	95
Metallisation degree	93.5

The proportion of sponge iron that could be economically used in the arc furnace charge as well as the degrees of metallisation and reduction desirable to give a good refining 'boil' need careful thought. Even so, it is only during actual operations that optimum solutions would be found.

Plant layout

Location

The DR/AF plant could be located inside the existing IISMI perimeter, to the north and east of the existing 25-ton arc furnace, or alternatively outside the plant, to the south-east. The latter location would allow more space for initial facilities as well as expansion. A tentative layout is shown in Figure 11. There is also a third possibility, namely, install the arc furnace shop inside the existing perimeter and the sponge iron plant outside, to be operated by a separate company.

Construction schedule

The first 85-ton arc furnace and one c.c. m/c could be commissioned by about mid-1976, followed a few months later by the second furnace and second c.c. m/c. Finally, the sponge iron plant could be started up by about mid-1977. All units should reach rated capacity by early 1978. This tight schedule requires firm decisions to go ahead with this IISMI Integration Project (Phase I) by January 1974.

/ Ideally

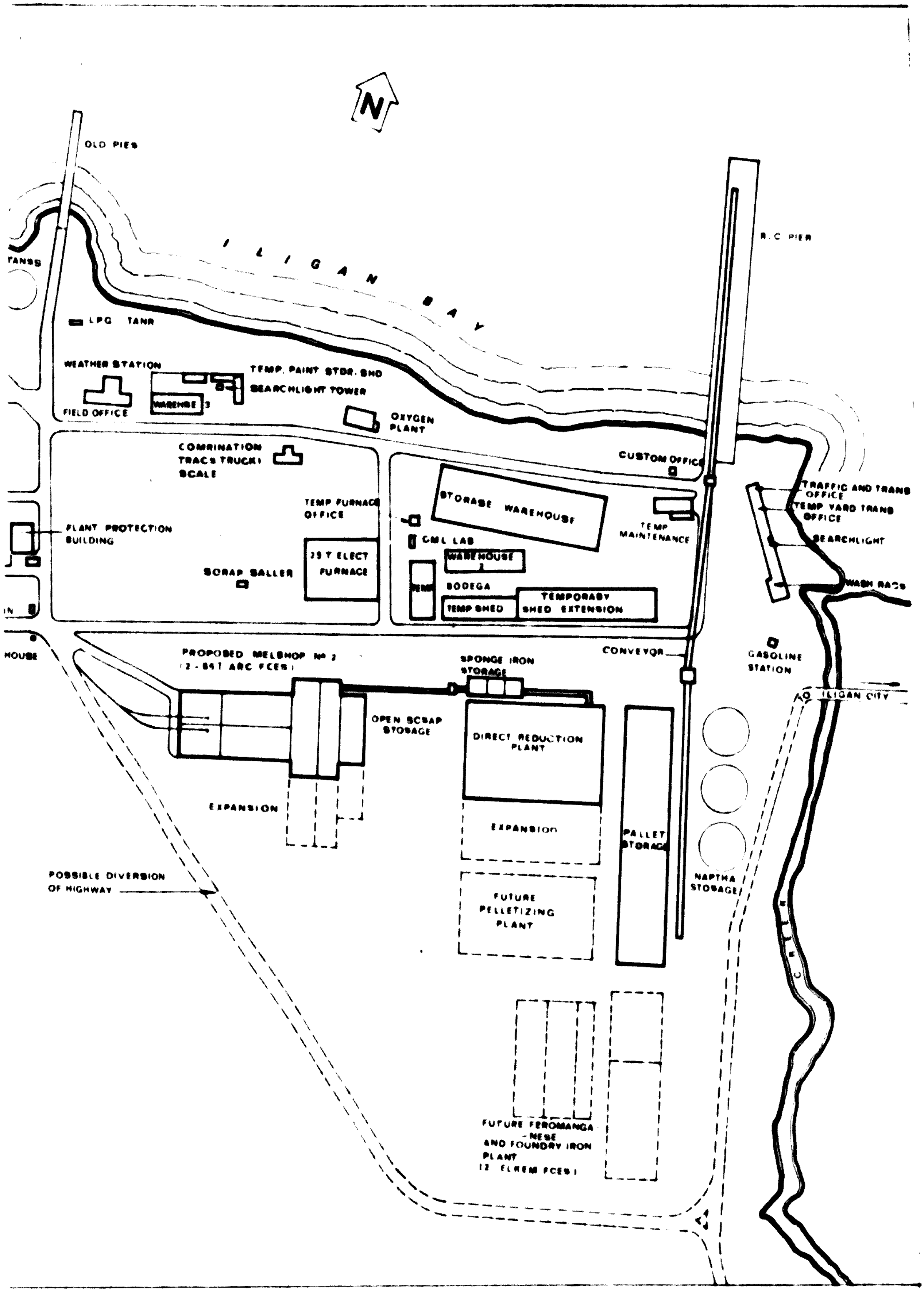


FIG. 11. LAYOUT OF PROPOSED SPONGE IRON/ARC FURNACE PLANT

(ALT. II - SOUTH-EAST OF EXISTING IISMI PLANT)

Ideally, the DR/AF facilities should be owned and operated by IISMI as captive units. Alternatively, the sponge iron plant alone or both sponge iron and arc furnace plants may be a separate company, in which IISMI, PIM/PCP and Marcelo Steel (which has done work on the sponge iron project) may be partners.

The production of alloy and special steels at IISMI would require installation of a forge shop, ingot/billet conditioning facilities, jobbing bar mill, heat-treatment and finishing. A tentative layout for this is shown in Figure 12.

Proposed product-mix

A suggested product-mix for the proposed integration and diversification programmes is shown below:

Suggested product-mix for IISMI

	Integration Phase I - 1977	Diversification Phase II - 1980
Tonnage steels		
HR sheet & skelp	60,000	100,000
Plate	50,000	60,000
Tinplate	40,000	50,000
CR sheet	180,000	190,000
Sub-total flats	330,000	400,000
Bars & rods	80,000	100,000
Total tonnage steels:	410,000	500,000
Special steels		
Carbon & alloy structural		30,000
Spring steels		10,000
Bearing steels		5,000
Alloy tool steels		5,000
Total special steels:	--	50,000
Total tonnage & special steels:	410,000	550,000

/ Capital

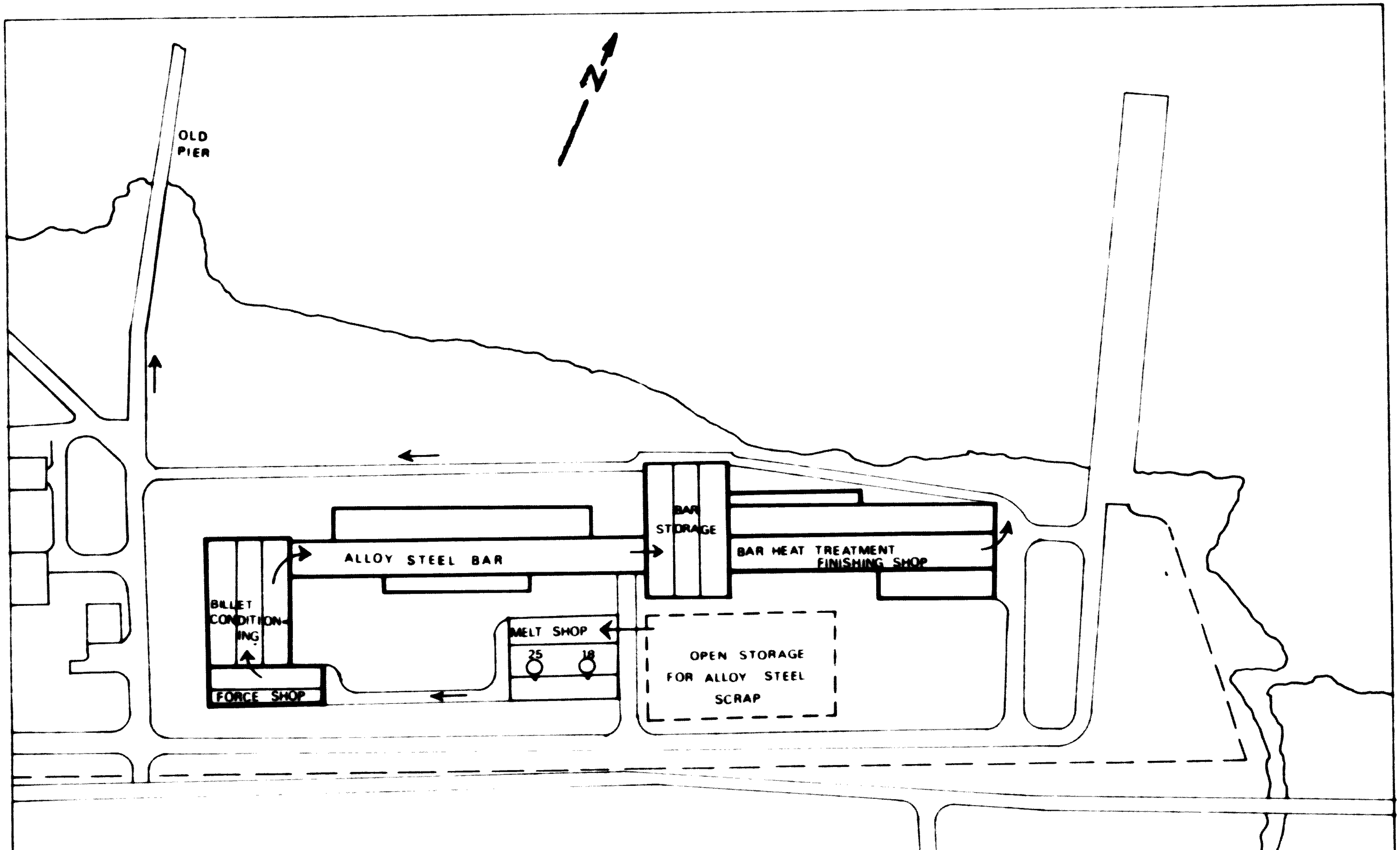


FIG 12 : LAYOUT OF PROPOSED ALLOY STEEL PLANT

Capital cost

Preliminary estimates

Costs and profitability of the DR/AF plant are presented in Annex VIII. Estimates are preliminary and need confirmation by proper project studies.

Preliminary cost estimate for semi-integrated plant
(capacity: 400,000 tons/yr slabs)

	Arc furnace conti casting shop ($)	Sponge iron plant ($)	Composite DR/AF plant ($)
Plant cost	17,750,000	20,100,000	37,850,000
Engineering & contingences	2,750,000	3,100,000	5,850,000
Total plant cost:	20,500,000	23,200,000	43,700,000
Pre-operational expenses & interest during construction	3,500,000	2,800,000	6,300,000
Total investment:	24,000,000	26,000,000	50,000,000
Working capital	10,360,000	--	8,020,000
TOTAL CAPITAL EMPLOYED:	34,360,000	26,000,000	58,020,000

Manpower

The plant would have a labour force of about 520 persons (para. 203). Average labour cost, including all perquisites, is taken at $ 0.50 per hour, which is higher than present costs in the steel industry.

Production costs

Production costs of sponge iron and slabs are estimated in the annex, (paras. 208-209). Taking interest on long-term loans at 9.9 per cent (average for foreign and domestic) and depreciation at 7 per cent, the total costs would be as follows:

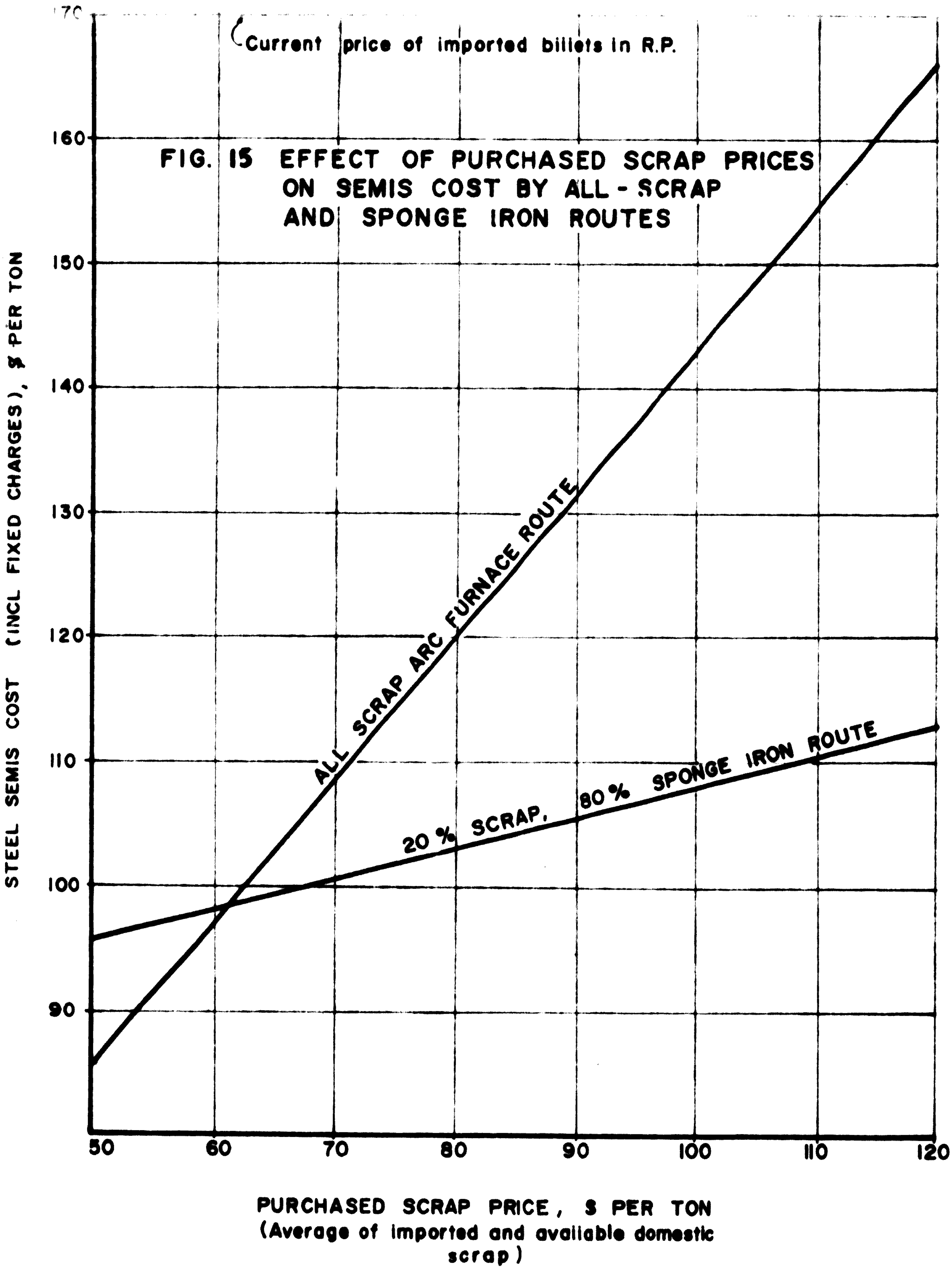
/ Production

Production costs of sponge iron and semis

	All scrap charge ($/ton)	Sponge/scrap charge ($/ton)
Sponge iron		
Works cost	-	40.06
Depreciation	-	4.55
Interest @ 9.9%	-	6.45
Cost of sponge (incl. fixed charges)	-	$51.06
Semis (billets/slabs)		
Works cost	109.95	82.00
Depreciation @ 7%	4.20	8.75
Interest @ 9.9%	5.94	12.40
Cost of semis (incl. fixed charges)	$120.09	$103.15

It is difficult to tell how international scrap prices would behave in the future. Figure 15 gives the effect of varying scrap prices on total cost of semis. This indicates that if and when the price of purchased scrap (average of imported and available domestic) falls below $ 60 per ton, the use of sponge iron may not be attractive. At higher scrap prices, direct reduction warrants serious consideration under the conditions of this study for RP. However, if scrap prices come down or if Government would like to wait another year before committing itself to a sponge iron process, then work could still go ahead on a 400,000 ton arc furnace shop at IISMI. Profitability may be slightly lower, but IISMI would still be greatly benefited.

/ Sensitivity


Current price of imported billets in R.P.
FIG. 15 EFFECT OF PURCHASED SCRAP PRICES ON SEMIS COST BY ALL-SCRAP AND SPONGE IRON ROUTES
ALL SCRAP ARC FURNACE ROUTE
20 % SCRAP, 80 % SPONGE IRON ROUTE
STEEL SEMIS COST (INCL FIXED CHARGES), $ PER TON
170
160
150
140
130
120
110
100
90
50
60
70
80
90
100
110
120
PURCHASED SCRAP PRICE, $ PER TON
(Average of imported and available domestic scrap)

Sensitivity of sponge iron cost

Cost of iron ore pellets and naptha are major componenets of sponge iron cost and effect of varying these is shown in Figure 14. If both iron ore and naptha rose simultaneously by 50 per cent over present levels, then cost of sponge would rise to around $ 65 per ton, which would still be lower than the present average of $ 80 per ton for purchased scrap.

Estimate of profitability

Further **assumptions**

The following additional assumptions are made:

(i) Pre-operational expenses and interest during construction are amortized in equal installments over 15 years.

(ii) Equity to loan ratio is taken as 1:5 for financing the project.

(iii) Working capital is borrowed at commercial rates of 14 per cent.

(iv) Selling price of slabs is taken at $ 135 per ton on a conservative basis. Currently billets/slabs are practically not purchasable at even $ 145-150 c.&f. (para. 221).

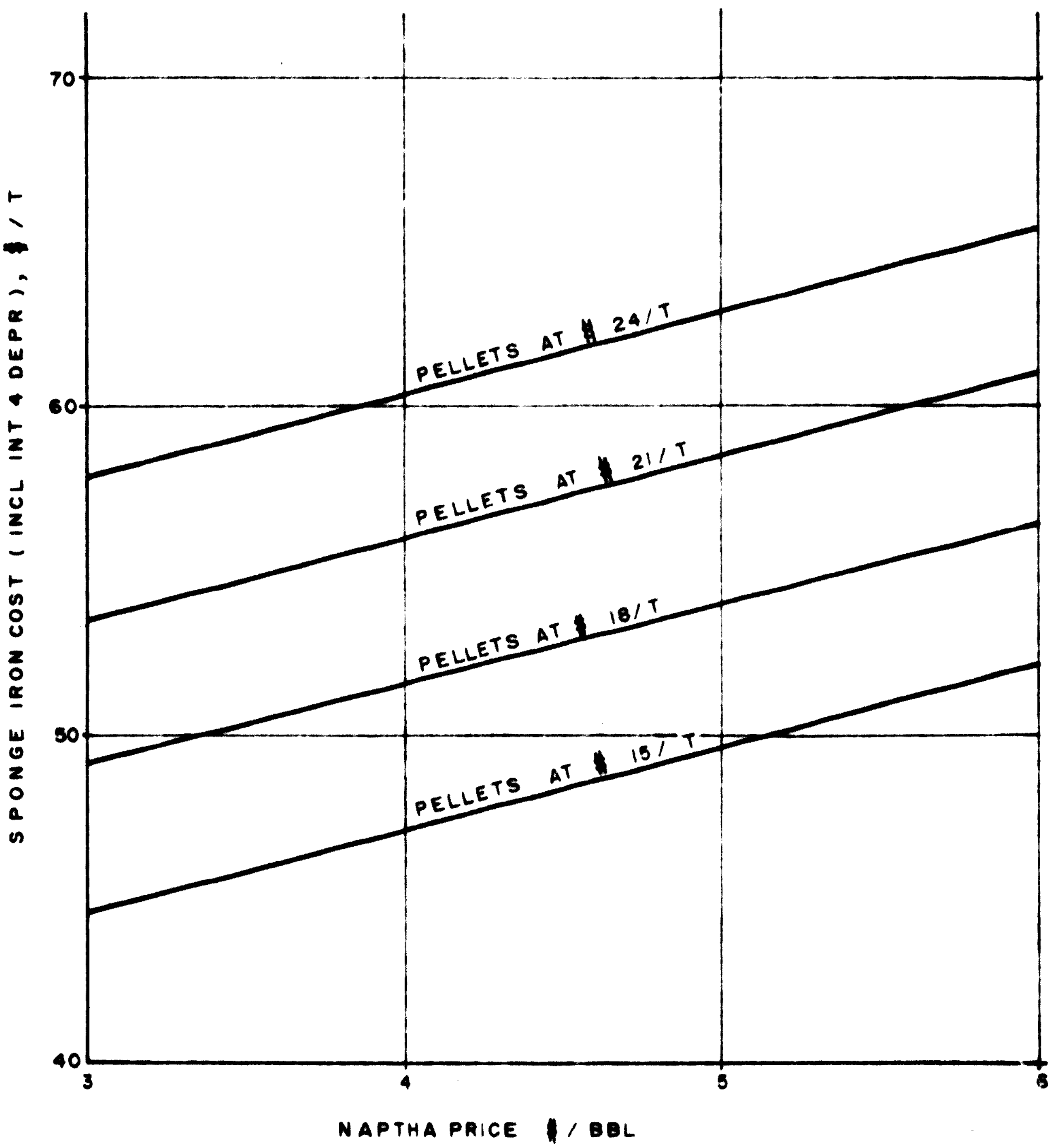
(v) Value added is taken as the difference between sales realization and costs of materials and supplies.

(vi) Foreign exchange component of production cost is cost of imported materials (including naptha) plus foreign exchange component of depreciation plus interest on foreign loans.

The profitability estimates indicate pre-tax returns of 24.7 % on total investment for the semi-integrated plant with sponge iron. Value added represents 48 per cent of sales realisation and foreign exchange component is 35 per cent of sales value.

/ Profitability

Fig: 14 EFFECT OF VARYING NAPTHA AND PELLET PRICES ON SPONGE IRON COSTS



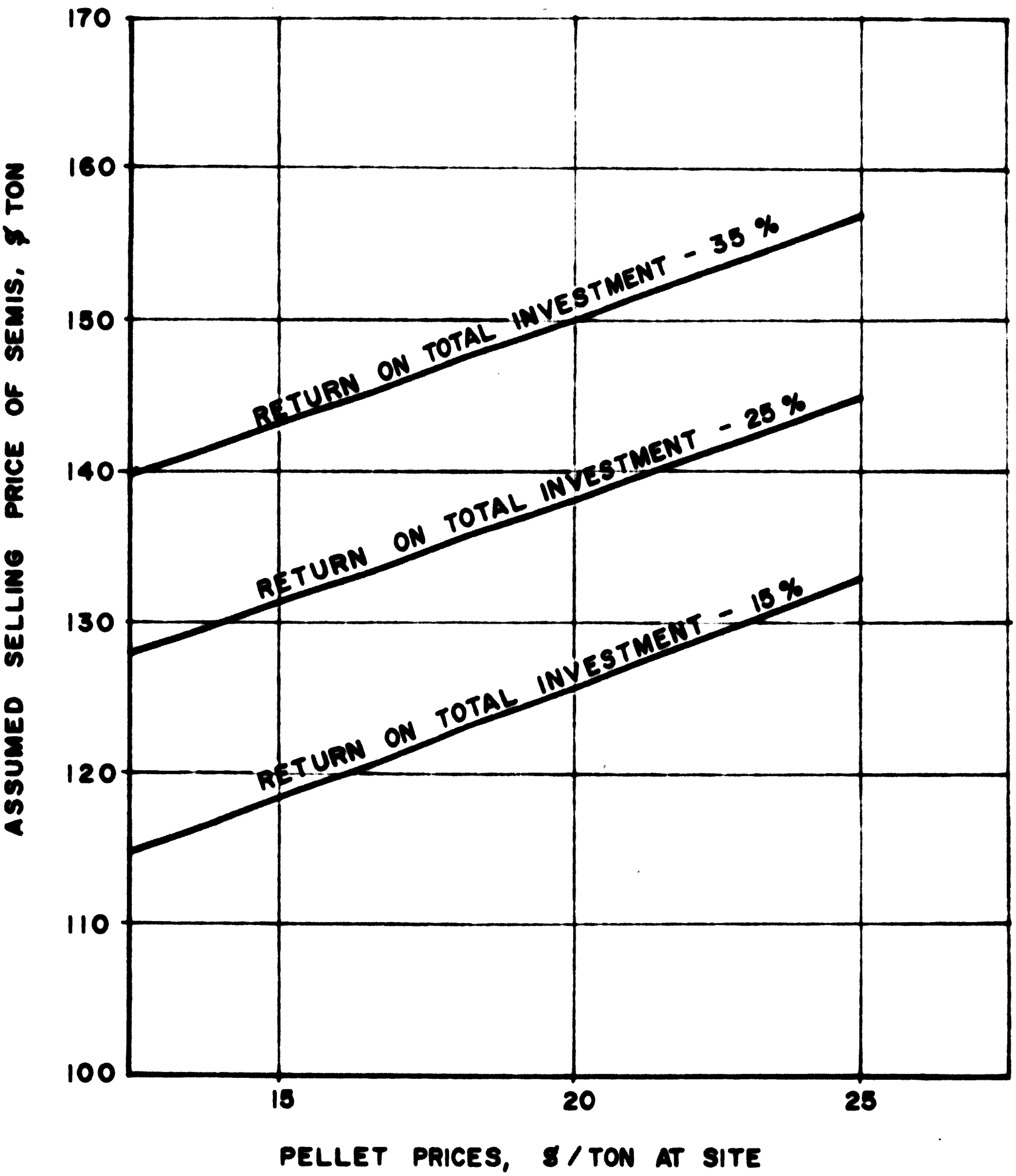
Profitability estimates
(in thousand US $)

	Arc furnace and conti-casting (all scrap charge)	Direct redn/arc fce/ and conti-casting (sponge/scrap charge)
Total investment	24,000	50,000
Share capital	4,000	8,330
Sales volume, tons	400,000	400,000
Income (@ $ 135/t semis)	54,000	54,000
Cost of production	43,980	32,800
Other expenses/charges		
Administration	96	96
Interest on working capital	1,590	1,120
Depreciation on investment (incl. pre-operational expenses)	1,680	3,500
Interest on long-term loan	1,980	4,125
Total cost:	49,326	41,641
Earnings (before taxes)	4,674	12,359
Pre-tax earnings/share capital	116.9%	148.5%
Pre-tax earnings/total investment	19.5%	24.7%
Pre-tax earnings/sales	8.7%	22.9%
Value added	13,200	25,976
Value added/sales	24.5%	48.0%
Foreign exchange component of production cost	22,110	18,795
Foreign exchange/sales	40.8%	34.8%

The effects of the two most significant variables - pellet cost and slab selling price - on profitability are shown in Figure 16. If pellet costs rose to $ 20/ton and at the same time slab prices dropped to $ 125 - both of which could happen - then return on total investment would fall to 15 per cent.

/Fig. 16

FIG. 16 EFFECTS OF VARYING PRODUCT SELLING PRICES & PELLET PRICES ON PROFITS.



UTILIZING IISMI'S ELECTRIC SMELTERS

The rehabilitation work needed and costs for erecting the two ancient-but-unused 19.5 MW pig iron smelting furnaces need careful study, in close consultation with ELKEM, the original supplier. Conversion to ferro-silicon production is considered impracticable, but one furnace could be modified for ferro-manganese while the other used for producing foundry iron. Outputs could be expected as follows:

	Tons/day	Tons/year
Foundry iron	140	42,000
FeMn (75% gr)	110	33,000

FeMn demand

There should be no difficulty in selling these quantities, domestically and abroad. Demand in the Asia-Australia region is expected to reach 2,585,000 tons FeMn by 1980. Even after possible expansions in ferro-alloy capacity in Japan, Australia and India, there may still be a shortfall of 1,285,000 tons. Philippines own consumption in 1980 could rise to 17,600 tons FeMn.

Works costs at the IISMI smelter are estimated at $ 73 per ton pig iron and $ 118 per ton FeMn (para. 251, Table 41). These would leave substantial margins for fixed charges and profits. Some aspects of producing ferro-alloys and pig iron by electric smelting at IISMI are covered in Annex IX.

Possibilities of exporting ferro-manganese are attractive, particularly as electric power is cheap, manganese ores are indigenous, and the decade old furnace can be considered to be written off!

/ PROPOSED

PROPOSED INTEGRATED STEELWORKS

Product-mix & facilities

Salient features of the proposed new integrated steelworks are discussed in Annex X. Initial and expanded product-mix as well as tentative selection and sizes of major equipment are shown below and the flow of materials indicated in Figure 19. While LD steelmaking is suggested, the new Q-BOP process should also be given consideration at the project engineering stage.

Facilities and investment for Alt. II
(integrated & semi-integrated mills)

INTEGRATED MILL

Product-mix	Integrated plant (Q)	After expansion (QQ)
HR sheet/coil/skelp	370,000	750,000
CR sheet/coil	300,000	450,000
Tinning	-	150,000
Billets	300,000	350,000
Merchant products	-	400,000
Total finished steel:	970,000	2,100,000
Semis equivalent	1,140,000	2,400,000
Facilities		
Coke	Two 50-oven batteries	Four 50-oven batteries
Sinter	One 200 sq. m. machine	Two 200 sq. m. machines
Iron	One 3,500 tons/day furnace	Two 3,500 tons/day furnaces
Steel	Two 130-ton LD vessels	Three 130-ton LD vessels
Continuous casting	---	Two 2-strand slab
Rolling	One blooming/slabbing mill One 1,675 mm hot strip mill (semi-continuous), Shearing/trimming line, Tandem CR mill	One blooming/slabbing mill One 1,675 mm hot strip mill (addl. stands for continuous), Shearing/trimming line, Plate mill, Cold rolling, annealing, temper, cleaning, shearing, etc. Billet mill, Merchant mill
Plant capital cost (incl. start-up exp., training, etc.)	US$ 364 million (i.e. $ 320 annual ton of semis)	US$ 840 million (i.e. $ 350 annual ton of semis)

/ Fig. 19

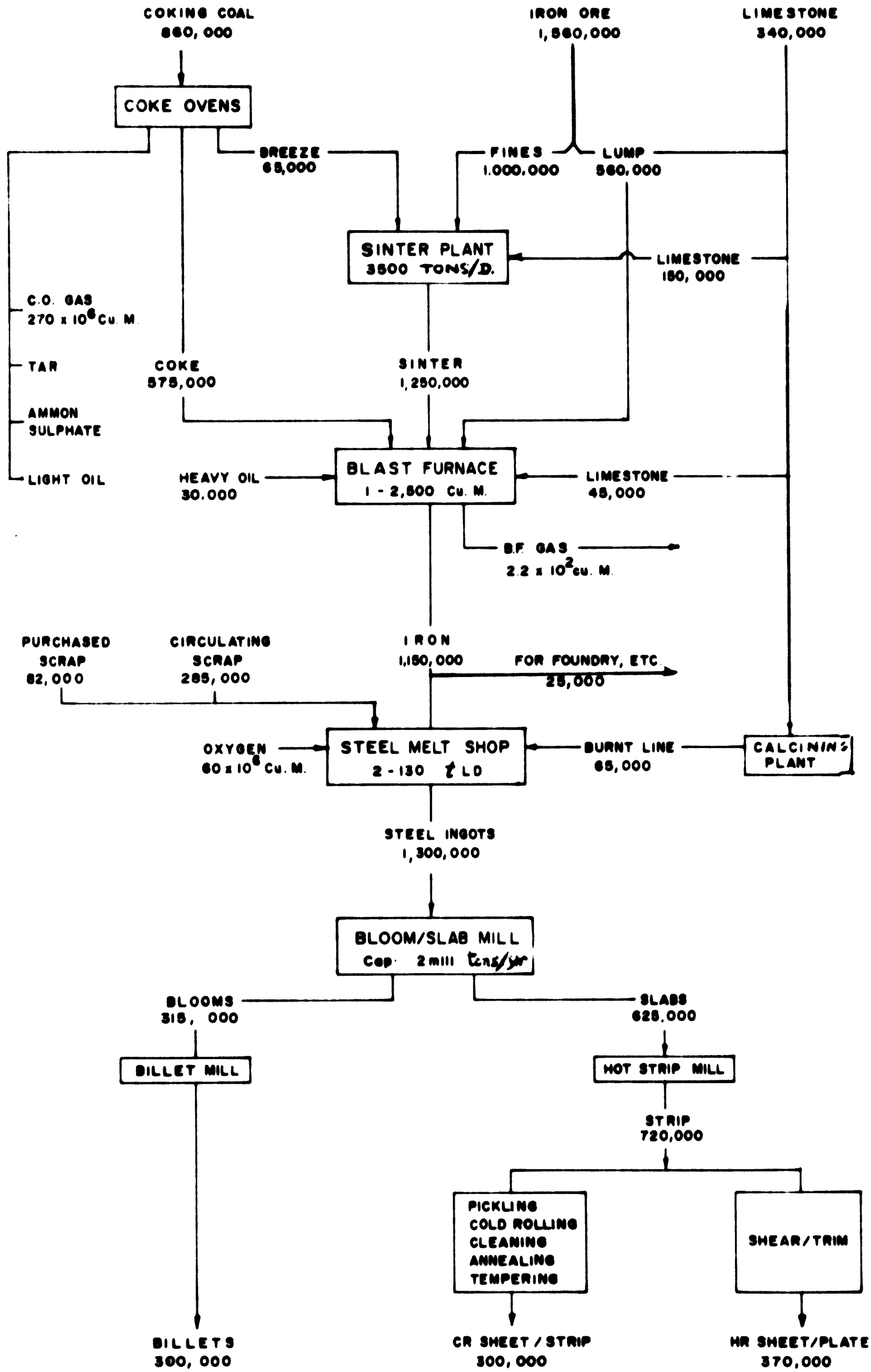


FIG. 19 : FLOWSHEET FOR INTEGRATED STEELWORKS

(PHASE I – CAPACITY 1.14 mill t)

Provision for 10 million ton capacity

It is recommended that plant layout and utility services be so designed that construction can proceed uninterruptedly to the 2.4 million ton stage with two blast furnaces, the 1.14 million ton facilities serving as only an intermediate phase. At the same time, rational provision of space must be made for expansion to say 10 million ton capacity, as and when needed.

Layout

There seems to be some confusion and controversy regarding the extent of land required for the integrated mill and plots of 300 ha, and then 700 ha, have been sought. Major steelworks in the United States - such as Fairless (US Steel) and Sparrows Point (Bethlehem) - have 1,500 to 2,000 ha within the perimeter. Layouts of plants designed for 10 million ton capacity and over are shown in the annex (Figures 20, 21 and 22).

At least 1,000 ha must be acquired

In order to meet the long-term steel needs of the Philippine economy, it is recommended that an area of about 1,000 ha be acquired and kept reserved for the steel plant proper, together with additional areas for twonship, ancillary activities, slag dumps, etc. If today this land is not acquired, a decade hence it may not be available at all, or available only at many times higher price.

A rough sketch of the layout at one of the better sites under consideration (Tagloan in Mindanao) is shown in Figure 26. It will be seen that only one rolling mill complex with throughput of about 3-4 million tons could be accommodated in an area of 4,000 ha (to the west of the existing highway). A second and third complex to raise capacity to 10 million tons would require about 1,000 ha.

/ Costs

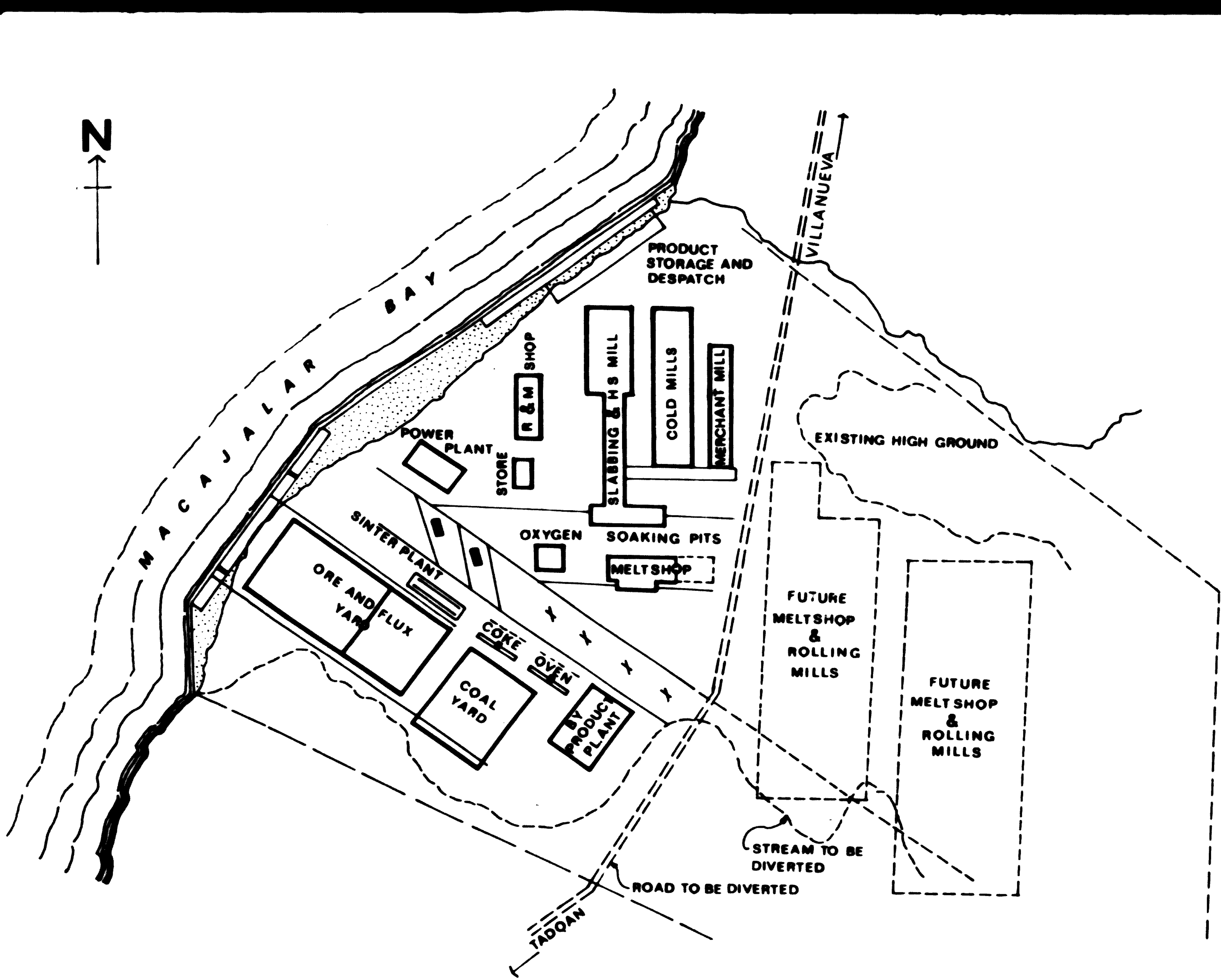


FIG 26 SUGGESTED LAYOUT FOR STEELWORKS - TAGLOAN

Costs

The proposed 1.1 million ton plant is estimated to cost around $ 364 million (para. 267, Table 43). This does not include cost escalations during construction, land, spares and interest during construction. This also does not include the cost of all off-site and infrastructural facilities.

Construction

If prompt decisions could be taken, funds are assured, and other factors are not unfavourable, the cold mill facilities could be commissioned by end-1978 and the complete integrated plant in 1979.

The construction of this steel mill will be a unique opportunity for RP to also enlarge existing construction, manufacturing and design capabilities. The bulk of the design for plant and general buildings could be prepared locally; at the same time, Philippine engineers should be closely associated with the overall planning, specifications, utility systems and equipment foundations designs.

'Tied aid'

The experience in many developing countries is that the cost of project equipment may be 10 to 15 per cent higher if tied wholly to credit from a single country. Therefore, circumstances and financing arrangements permitting, it would be desirable to invite bids for major plant units from selected companies in two or more countries and keep options open until final order placement.

Low profitability of steel projects

It should be noted that in any country, developed or developing, returns on investment in a steel mill are not attractive. For instance, the 1970 financial results of 32 major international steel companies show that 5 incurred losses, 19 gave return of under 4% on total assets (less depreciation), and 8 gave return of over 4% but with a maximum of only 5.8% (of the 5 companies incurring losses, 4 were government-owned).

/ The reasons

Why a **steel mill**?

The reasons for installing capacity is that steel has a far-reaching impact on the national economy, on the balance of payments, on indigenous resource utilization, on exports, as well as on the growth of agriculture, transport and other key sectors. A steelworks is capital intensive, requiring investment of almost $ 40,000 per person employed; but the experience is that for every worker at the mill, employment is generated for 14 others in up-stream and down-stream activities. Thus, if a 'social profitability' calculation were made, returns would be significantly higher than by normal commercial yardsticks.

Moreover, the country's development and defence have to be insulated against the possibility - as at present - when practically no steel can be bought at all on the international market.

LOCATION OF THE INTEGRATED STEELWORKS

The location of a major national undertaking is often the subject of heated debate in developing as well as developed countries. The techno-economic factors at alternative sites can be evaluated; but other considerations - such as environmental problems or the need for regional development, which depend on government policies and local aspirations - are often decisive. Annex XI highlights some aspects of steelworks location.

A detailed location study is now underway in RP which should provide the comparative cost and other data for the Government to take an informed decision. The search seems to have narrowed down to sites along the Balayan Bay in south-west Luzon and the Iligan and Macajaler Bays in northern Mindanao.

/ Tagloan

Tagloan vs Lemery sites

Tagloan

In Mindanao, the site examined at Tagloan, about 25 km north of Cagayan de Oro appears attractive. Flat land is available between the national highway and the sea - a width of average 2 km and length about 2 km. However, the effort should be to re-route the highway and secure at least 1,000 hectares, if this location is selected. The Tagloan river has good perenial water flow, reported to be 48 cum per sec. Low-cost hydro-power would be available from the Agus river development.

Lemery

Sites near Lemery have the advantage of proximity to the Manila market as well as to a future possible ore supply from Santa Inez. But the land available is narrow in width while power and water costs would be higher.

Overall power and transport costs

If construction costs and other factors at Lemery and Tagloan would be about equal - which has yet to be established - one could, at this stage, consider only three factors, namely, electric power cost, indigenous materials assembly cost, and product distribution costs (paras. 286-291).

The overall effect of these operating cost factors is summarised below:

Transport and power costs at Lemery and Tagloan
(million $/year)

	Phase I (1.1 mill t capacity)		Phase II (2.4 mill t capacity)	
	Lemery	Tagloan	Lemery	Tagloan
Materials assembly	-	-	4.24	5.83
Product distribution	1.84	3.04	4.00	6.59
Electric power	5.60	2.60	14.00	7.00
Total:	7.44	5.64	22.24	19.42

/ It is

It is seen that the advantages of Lemery with respect to proximity to markets and materials may be more than neutralized by the lower annual power costs at Tagloan. However, the net advantage of Tagloan is only $ 1.6 million per year in Phase I and $ 2.82 million in Phase II - that is, less than 1 per cent of the annual sales realisations of the project.

Trend to market <u>orientation</u>

While on the one hand, there are advantages in siting a major industrial project in a hitherto backward region to catalyse its development, on the other, there are benefits that a steel plant could derive from linkages with existing industries. Such localisation economies favour location near existing industrial concentrations within a country. In view of the need for flexibility and speed in serving steel buyers, the trend is to locate plants close to markets.

Based on detailed cost and other data which should hopefully be forthcoming, Government will have to take an early decision on the siting of the new integrated steelworks. The creation of the Iron and Steel Authority, the project studies under preparation, and other initiatives being taken augur well for the rational and rapid development of this vital industry.

POSSIBILITIES OF UNDP/UNIDO TECHNICAL ASSISTANCE

Arising out of the suggestions made in this report, a number of studies need to be initiated, including those indicated below. Technical assistance from UNDP/UNIDO in the form of S.I.S. projects could be given consideration:

1. <u>Report on ancillary developments for integrated steel project</u> (sub-contract on consulting engineering firm)

   <u>Object</u>: To secure independent assessments of specific supporting aspects of the project.

/ Scope

Scope of work: The contractor shall prepare a techno-economic study covering the following sub-studies:

(i) Project evaluation, based on cost and other data in Nippon Steel feasibility study; social cost-benefit analysis.

(ii) Raw materials - based on the data available, evaluate availability/quality of indigenous iron and steel-making materials and propose programmes for their development.

(iii) Infrastructure development - indicate requirements and suggest plans for building-up facilities such as water, transportation, township.

(iv) Ancillary projects - identify candidate industries and prepare profiles for those needed to make supplies to the iron and steel industry as well as to process its products and by-products.

Duration: About five months.

Costs (UNDP input)

	US$
Manpower: 10 man-months	30,000
Travel & subsistence	7,000
Report preparation	3,000
Total:	40,000

2. Project report on semi-integrated steel mill at IISMI (sub-contract on steel plant consulting firm)

Object: To prepare a project study on a 400,000 t/yr sponge iron and 400,000 t/yr arc furnace/continuous casting plant.

Scope of work: The following pertinent aspects shall be covered:

(i) Selection of process and equipment, including specifications.

(ii) Availability and costs of scrap, pellets, naptha, etc. from indigenous and foreign sources.

(iii) Plant layout

(iv) Capital and operating costs

(v) Financial analysis.

/ Duration

Duration: About six months.

Costs (UNDP input)

	US$
Manpower: 12 man-months	36,000
Travel & subsistence	9,000
Report preparation	5,000
Total:	50,000

3. Improving arc furnace steelmaking operations

Object: To enable existing arc furnace steelmakers to raise their production to rated capacity and reduce costs.

Scope of work: A furnace operator with practical experience shall be engaged for a period of 4 months in order to:

(i) Demonstrate techniques such as use of oxygen, scrap preparation, quality control, in steelmaking.

(ii) Suggest modifications in equipment and layout to improve productivity.

(iii) Review availability and costs of scrap and other steelmaking supplies; propose schemes for cost reduction.

(iv) Formulate and implement an incentive bonus plan for meltshop personnel.

Duration: 4 months.

Costs:

	US$
Manpower	10,000
Travel, etc.	2,000
Total:	12,000

4. Advisory services on further studies for integrated and semi-integrated mills

Object: To help MIRDC/BOI in problems of acquiring appropriate technology for steel industry development.

/ Scope

Scope of work: The services of the UNIDO/ECAFE regional adviser on technology transfer could be made available for some of the following topics:

(i) Assist in discussions with Nippon Steel team and other agencies on choice of technology and layout of integrated steel mill.

(ii) Assist in technical know-how and other negotiations for implementing the sponge iron/arc furnace project at IISMI.

(iii) Examine specific possibilities of regional cooperation between countries of south-east Asia in industrial development.

(iv) Review design and engineering capability in RP and suggest measures for augmenting this, to facilitate the acquisition and adaptation of technology.

ANNEXES

I. STEEL INDUSTRY IN THE PHILIPPINES

1. Of the countries of south-east Asia, the Philippines has perhaps the best raw materials endowment for an integrated iron and steel industry. It also has the advantages of skilled manpower and of a greater sophistication of existing processing facilities. Its plans for full integration, starting with iron ore, are now being more energetically pursued than those of other countries in this region.

The bulk (85 per cent) of present consumption is based on imports of rolled steel or semis. This makes economic growth particularly vulnerable to the vagaries of the international steel market, and the import bill of almost one hundred million US dollars a year places an undue strain on balance of payments.

The RP steel industry is characterised by gross underutilization of capacity. Actual output is under two-thirds of installed steelmaking facilities (although billets are in short supply). Bar rolling, tinning, galvanizing and pipe-making operate at only one-fourth of rated capacities and expensive flat hot rolling capacity at IISMI lies completely idle.

Steel consumption

2. In the 15-year period up to 1970, steel consumption grew at an annual rate of around 12 per cent. The main growth products were GI sheets for construction, CR and HR sheets for durable consumer goods, tinplate for food and chemical products, and bars for housing and other construction.

3. The consumption of finished steel had reached a peak of 996,000 tons in 1969 and then dropped to only 682,000 by 1971 following the float of the peso and other adverse conditions. It recovered to around 991,000 tons in 1972 in spite of the bad flood situation.

4. In 1973, steel demand is strong following the active measures taken for economic recovery and stability. But due to a global steel shortage and steel price hikes, the domestic consumption (which is based largely

/on imports

on imports) will again be low. In the view of local producers of bar products, total consumption in 1973 would be well over one million tons if steel were readily available; however, producers of tinplate and GI sheets are less optimistic about demand.

Imports

5. The bulk of present consumption (over 85 per cent) is based on imported rolled products or from products rolled locally from imported semis (billets and hot rolled coils).

6. Apparent consumption figures based on Central Bank statistics for imports do not include steel imported through Japanese reparations or on turn-key type projects. Further, these relate to rolled steel consumption while the steel-content of imported plant and equipment is itself quite substantial.

7. Consumption data from other sources show slight variations, partly because there may be some over-lap in figures for imported semis and the finished products rolled from them within the country.

8. Steel imports increased from 296,000 tons (value US$53 million) in 1962 to 941,000 tons (US$133 million) in 1970, and have dropped since then. Average annual increase has been about 10-11 per cent over the last decade.

9. Steel imports in the Philippines and in other ECAFE countries during 1970 are shown in Table 1. The import pattern for all ECAFE developing countries is compared to that in the Philippines in Table 2.

/Table 1:

Table 1: Imports of steel products in selected ECAFE countries, 1970

	Ingots & Semis	Railway-track materials	Heavy sections	Light sections	Wire rods	Strip	Plates	Sheets	Tubes & fittings	Wire	Tinplate	Wheels tyres & axles	TOTAL
Afghanistan	-	-	-	9.6	1.5	-	-	2.1	0.3	0.5	0.1	-	14.1
Burma	16.8	0.2	0.6	8.5	1.1	1.1	-	4.3	8.1	5.8	1.0	0.1	47.6
China	146.2	49.4	32.0	398.9	167.8	38.8	796.1	691.8	531.7	32.2	130.3	12.6	3,027.8
Hong Kong	35.5	2.5	45.4	144.2	11.9	13.3	55.2	67.7	20.4	17.7	24.9	0.4	439.1
India	210.2	0.8	57.4	92.8	64.0	75.8	468.7	463.1	41.3	16.9	63.8	42.3	1,597.1
Indonesia	0.5	8.7	13.0	66.6	3.0	12.1	22.2	97.4	147.6	34.9	16.0	0.4	422.4
Iran	300.6	3.0	222.0	115.6	22.9	9.7	172.8	301.7	107.2	18.7	41.2	-	1,315.4
Korea, Rep of	473.0	3.5	24.6	11.5	24.0	18.0	61.9	120.4	45.1	2.1	4.2	3.0	791.3
Laos	-	-	-	3.7	-	-	0.1	1.2	0.1	1.0	0.1	-	6.2
Malaysia	5.6	3.6	34.0	35.2	25.8	36.0	48.8	73.9	20.0	9.9	32.1	0.9	325.8
Pakistan	150.4	44.7	15.8	27.6	3.9	17.8	28.5	117.0	61.4	9.4	27.4	2.1	506.0
Philippines	230.0	3.2	18.7	23.8	10.1	11.2	53.9	150.7	28.9	10.1	38.5	-	579.1
Singapore	12.0	5.6	138.3	63.6	24.2	22.2	166.5	84.4	112.1	20.3	46.8	0.2	696.2
Sri Lanka	25.0	4.8	0.5	2.5	8.4	2.8	4.4	25.0	0.9	14.6	5.3	1.2	95.4
Thailand	64.1	27.5	37.1	67.7	33.7	35.5	70.5	222.9	22.2	31.0	40.7	-	652.9
Viet-Nam, Rep of	18.7	-	6.4	42.3	44.2	1.0	4.2	90.7	7.9	1.9	22.1	-	239.4
Others	58.3	1.0	20.0	22.7	7.0	1.1	16.0	17.7	89.6	4.9	5.2	-	243.5
TOTAL:	1,746.9	158.5	665.8	1,136.8	453.5	296.4	1,969.8	2,532.0	1,244.8	231.9	499.7	63.2	10,999.3

Source: Statistics of World Trade in Steel, United Nations, 1971.

- , -

Table 2: Product pattern of steel imports, 1970
(per cent of totals)

	ECAFE developing countries	Philippines
Ingots and semis	15.83	39.65
Railway track materials	1.44	0.55
Wheel tyres & axles	0.57	-
Heavy sections	6.05	3.23
Light sections	10.30	4.10
Wire rods	4.14	1.73
Wire	2.12	1.75
Strip	2.70	1.94
Plates	18.00	9.30
Sheet	23.00	26.10
Tin plate	4.55	6.65
Tubes & fittings	11.30	5.00
Total	100.00	100.00

10. The pre-ponderance of ingots and semis in RP imports is clear. Further, the proportion of heavy and light sections is only half that in other Asian developing countries.

Exports

11. Small exports from the Philippines have been undertaken since 1965, reaching a peak of 82,000 tons (value US$12.3 million) in 1970 and dropping to 62,000 tons (US$8.7 million) in 1971. These have been mainly in flat products.

Existing facilities

12. The availability of scrap after the Second World War and the need for reinforcing bars for reconstruction led to the installation of re-rolling mill by Philippine Blooming Mills Inc (1952), arc furnaces by Marcelo Steel Corporation (1953), and electric arc furnace with rolling mill by National Shipyard and Steel Corporation (1955).

/13.

13. They were joined by other bar mills, by several galvanized sheet producers, by tube makers, by Elizalde Iron and Steel Corporation for hot-dip tinplate (1962) and electrolytic tinning (1963); and by the first cold rolling mill of Southern Rolling Mills in 1963 (now taken over by Visayan Integrated Steel Corporation).

14. The main existing production facilities in the Philippines and recent outputs are shown in Table 3.

Table 3: Main steel-making and processing facilities capacity and production

	No. of plants	Capacity (t/yr.)	Production, t/yr.		
			1970	1971	1972
Steelmaking	10	340,000 a/	107,000	233,000	168,840
Bar rolling mills	31	1,335,000	282,000	306,000	320,940
Sheet rolling mills:					
Hot rolling	1	300,000	140,000	80,380	-
Cold rolling	3	460,000	320,000	240,720	92,880
Sheet galvanizing	8	445,000	133,000	114,000	132,000
Tinning plants	2	137,000	96,000	55,000	49,860
Pipe and tube mills	8	133,000	30,000	18,096	27,770

a/ In addition, under installation are a 40-ton arc furnace at Philippine Blooming Mills, smaller arc furnaces at Apollo Steel and Marsteel Corporation, and new plant of Steel-casters.

15. The above figures reveal a gross under-utilization of installed capacity, ranging from about 50 per cent in steel-making, 75 per cent in bar rolling and no utilization at all (100 per cent under-utilization) in the case of expensive slab and strip hot rolling mills last year. Similarly, tube mills, tinning and galvanizing plants are operating at only a fraction of their stated capacities.

/16.

16. In some instances, the capacity rating itself may be exaggerated, and even if demand, materials and other inputs were available, production would not be able to reach these levels. Nevertheless, the fact remains that many expensive facilities are lying idle for various reasons. The proper utilization of this equipment must receive high priority, in the overall national interest.

17. Another fact emerging from Table 3 is the major imbalance between primary steelmaking capacity and available finishing mills. This makes the RP steel industry largely dependent upon import of semis and therefore very vulnerable to the vagaries of international steel trade.

Ingot-making and bar rolling

18. The actual production of steel has been only half of billet-making capacity, while till recently around 200,000 tons of billets were imported annually. This is partly due to lack of modern equipment and poor practices, but also to past tariff policies.

19. The present capacity for steelmaking (shown in Table 4) is around 346,000 tons. Additional furnaces now planned (40-ton at Philippine Blooming Mills and smaller furnaces at Apollo and Marsteel) could raise capacity to 500,000 tons by 1975.

Table 4: Steelmaking capacity in the Philippines

Works	Melting unit	Annual rated capacity (tons)
Philippine Blooming Mills	2-40 t open hearth	100,000
Marcelo Steel	1- 8 t arc furnace 1-10 t arc furnace 1-12 t arc furnace 3- 3 t arc furnace	76,000
Iligan Steel Mills	1-25 t arc furnace	45,000
General Construction Supply Co.	2-15 t arc furnace	54,000
Apollo Steel Mills	1-10 t arc furnace	18,000
Marsteel Corp.	1- 5 t arc furnace	10,000
Union Steel	1- 5 t arc furnace	7,500
Globe Steel	1-10 t arc furnace	20,000
Armstrong Industries	1- 5 t arc furnace	12,000
Master Steel Products	2- 3 t induction furnace	3,500
Total		346,000

/20.

20. The under-utilization of capacity in the bar milling mills is even more serious -- actual output is less than one-fourth of rated capacity. Breakdown of capacity is shown in Table 5.

Table 5: Bar rolling capacity in the Philippines

Name of firm	Location	Start of operation	Annual rated capacity (MT)
Philippine Blooming Mills	Mangahan, Pasig, Rizal	1952	135,000
Central Steel Manufac. Co	Baesa, Quezon City	1952	50,000
Marcelo Steel Corp	Sta. Ana, Manila	1952	45,000
Globe Steel Corp	Quezon City	1960	54,000
Marsteel Corp	Novaliches, Quezon City	1966	50,000
Iligan Integrated Steel	Iligan City, Mindanao	1955	72,000
Union Steel Manufac. Co	Grace Park, Caloocan City	1958	27,000
Apollo Steel Mills	Mandaluyong, Rizal	1970	24,000
Fidelity Steel Manufac. Co	Caloocan City	1965	18,000
Commercial Steel Corp	Quezon City	N.A.	54,000
Island Metal Manufac. Corp	Quezon City	N.A.	15,000
Firestone Ceramics Inc	Manila	1970	7,000
Armstrong Industries Inc	Bulacan	1967	14,000
Interworld Steel Mills	Bulacan	N.A.	22,000
Metro Metal Smelting Corp	Bulacan	1963	36,000
Filipino Metals Corp	Bulacan	1967	29,000
Continental Steel	Bulacan	1966	22,000
Stansteel Industries Inc	Muntinlupa, Rizal	1969	18,000
Carolina Steel	Novaliches, Quezon City	1967	15,000
Galaxy Steel Corp	Novaliches, Quezon City	1972	14,000
Cathay Metal Corp	Novaliches, Quezon City	1968	24,000
Universal Steel Smelting	Balong Bato, Quezon City	1967	45,000
Pacific Metals Manufac. Corp	Caloocan City	1957	22,000
ZIT Steel	Quezon City	N.A.	600
Merchant Steel	Quezon City	1970	8,000
Pag-asa Steel Works	Pasig, Rizal	1967	36,000
United Resources Corp	Cainta, Rizal	1968	24,000
Zion Steel Corp	Tauig, Rizal	1970	22,000
Oca Steel Mills	Paranaque, Rizal	1970	16,000
General Construction	Las Pinas, Rizal	1966	50,000
Philippine Steel	Cainta, Rizal	N.A.	29,000

/21.

21. Rerollers without melting facilities are handicapped by the shortage of domestic production and wide fluctuations in availability and price of imported billets. Their mill facilities are often obsolete and product sub-standard. If equipment and practices were improved, and adequate raw materials, credit facilities and trained personnel made available, the bar rolling capacity existing today would be adequate for the country's needs for years to come.

Flat products

22. The hot rolling facilities in the country - the combination slabbing/plate mill and steckel mill of IISMI - have operated only sporadically and have been shut down since 1971. In the meantime, the demand for hot rolled coil (primarily for cold rolling, to be processed to galvanized sheet, tinplate and other light fabricated products) rose to over 500,000 tons in 1970 and most of this had to be imported.

23. The cold rolling mill facilities are shown in Table 6.

Table 6: Cold rolling capacity in the Philippines

Firm	Facilities	Start of operation	Capacity (tons/yr.)
Southern Rolling Mill (now Visayan Integrated Steel Corporation-VISCO)	Not visited (plant shut down)	1963	70,000
Iligan Integrated Steel Mills, Inc (IISMI)	4-stand tandem Product: 0.0105"-0.0625" x 20"-36" width	1969	240,000
Elizalde Steel Rolling Mills (ELIROL)	Single stand, reversing Product: 16-36 gauge x 36"	1969	150,000
	Total		460,000

24. Cold rolled products demand had risen to 467,000 tons in 1970, then dropped, and can be expected to cross the half-million ton mark by 1975. Tariff protection should stimulate indigenous production, but the lack of hot-rolled materials will continue to be a bottleneck until such time as back-integration to steel and iron making has been completed. Cold rolling capacity of under 400,000 tons (without VISCO) barely matches present requirements, and will soon be short.

/25.

25. The position regarding hot rolling is much more serious. Even if the IISMI mills were restarted by end-1973 (as now planned) using imported slabs, demand for the coils and plates would not be met.

Tinning and galvanizing

26. Existing capacities are shown in Table 7 and Table 8.

Table 7: Tinplate making capacity in the Philippines

Name of firm	Start of operation	Capacity (MT/year)	Method of Production	Products
Elizalde Iron & Steel Corp, Pasig, Rizal	Nov 1962	12,000 (shut down since 1972)	Hot-Dip Tinning	Common, standard and best cokes; 24" x 18" to 36" x 36"; 70 to 135 lbs/BB
	Nov 1963	75,000	Electrolytic, Tinning (Halogen line & Super coat line)	Electrolytic tinplates 70 to 135 lbs/BB. 24" x 18" to 37" x 37"
Iligan Integrated Steel Mills (IISMI), Mindanao	March 1969	50,000	Electrolytic, Tinning (Ferrostan Line)	Electrolytic tinplates 70 to 95 lbs/BB. 20" x 18" to 43" x 36"

27. Demand for tinplate has stagnated at around 100,000 tons/year, but there is potential for high production and exports, due to availability of good facilities.

28. Galvanized plate consumption has shown a growth rate of around 5 per cent per year, but capacity is in excess and remains under-utilized. With smart economic recovery in RP, demand for both GI sheets for construction and tinplate for containers can be expected to grow more rapidly than in the past.

/Table 8:

Table 8: Galvanizing capacity in the Philippines

Name of company	Location	Start of operation	Plant capacity	Production line
Puyat Steel Plant	Mandaluyong, Rizal	1957	110,000	2-semi-continuous 2-batch
Jacinto Steel Mills	Novaliches, Quezon City	1958	65,000	2-batch
Southern Industrial Projects	Corte, Bohol	1958	25,000 (stopped operation)	2-batch
Bacnotan Consolidated Industries	a) La Union b) Davao City c) Cebu	1963	45,000	4-batch
Davao Steel Corp	Mandaue, Cebu	1965	50,000	2-batch
St. Christopher Steel Corp	Pasig, Rizal	1966	65,000	2-batch
Jacinto Iron & Steel Sheets Corp	Novaliches, Quezon City	1968	35,000	2-semi-continuous
Rizal Integrated Steel Mill Corp	Cainta, Rizal	1969	50,000	1-batch

/Pipes ...

Pipes and tubes

29. Existing facilities are outlined in Table 9.

Table 9: Tube-making capacity in the Philippines

Manufacturer	Location	Start date	Annual rated capacity (MT)	Method of production	Sizes produced (inches)
Tubes:					
Goodyear Steel Pipes	Baesa, Quezon City	1964	21,000	Induction Welding	1/2 - 4
Republic Steel Tubes, Inc	Las Pinas, Rizal	1957	21,000	Electric resistance Welding	1/2 - 3
Super Industrial Corporation	Domingo Cainta, Rizal	1964	16,200	Induction Welding	1/2 - 2
Union Pipes & Tubes, Inc	Paranaque, Rizal	1965	17,500	Induction Welding	1/2 - 2 1/2
Mayer Steel Pipes	Bulacan	1971	15,000	Induction Welding	1/2 - 2
Pipes:					
International Pipe Industries Corp	Ortigas Ave. Bo. Ugong, Pasig, Rizal	1967	15,000	Spiral Welding	4 - 60
Philippine Pipes & Merchandizing	Bo. Malhacan, Meycauyan, Bulacan	1956	9,000	Pipe forming & Butt Welding	10 & above
La Filipina Enterprises, Inc	29 General Concepcison, Caloocan City	1968	N.A.	Pipe Forming & Butt Welding	18 & above
Goodyear Steel Pipes	108 A. Bonifacio Baesa, Quezon City	1972	18,000	Induction Welding	4 - 10

/30.

30. There is considerable under-utilization of tube-making capacity, at the same time, almost half the country's pipe and tube requirements were imported. Major national development projects can be exported to improve demand, and domestic production should also increase with new tariff policies.

31. The overall picture at present is one of ample capacity in bar products rolling, galvanizing and pipe-making, but a growing shortage of hot and cold rolling flat product capacity.

Iligan Integrated Steel Mills (IISMI)

32. IISMI represents a substantial investment in flat products hot and cold processing facilities as well as in arc furnace steelmaking and bar rolling. Due to various unfortunate circumstances, the plant is operating at only part of its capacity.

33. The available facilities are described in Annex V and a proposal made for further optimum development of IISMI.

/II.

II. FUTURE STEEL DEMAND

Demand in the Philippines is expected to rise to 2.31 million tons by 1980 and 3.27 by 1985. This implies a doubling of 1972 consumption by 1978 ... Even so, per capita consumption would continue to be only one-fourth of the world average.

... If RP could install a major iron and steelmaking facility by 1980, it could take a fair share of the growing south-east Asia market ... At the same time, there is indeed scope for - and economies in - formulating an integrated planning strategy for steel development in the sub-region.

34. Any long-term steel plan must keep the 1980-85 horizon in view, because a major integrated steelworks could only be fully developed on time to serve the steel needs of this period and beyond.

Forecasting methods

35. Previous steel forecasts have depended on co-relations between steel consumption and macro-economic indicators over past years, which are then extrapolated into the future. For a developing economy which has undergone drastic structural changes in the past and where the pace and pattern of future growth are being deliberately accelerated, such projections may at times be misleading.

36. The "steel intensity method" is based upon the experience of apparent steel consumption (in kgs per $ of gross national product) in different countries over a period of time. The statistical co-relation and the steel intensity methods both give an indication of total steel demand. However, for planning a steel development programme, the demand should be known in each product category and this can best be done by an "end-use approach". In this method the quantities of various steel products going into each metal-consuming item or sector are estimated together with forecasts of probable future output levels in each of these items. Such an end-use analysis needs to be prepared for the Philippine economy.

/ RP

RP demand estimates

37. Last year the International Iron and Steel Institute (IISI) made projections of demand in various geographical regions using the steel intensity model. A new steel forecast for RP can be made utilizing this approach, which could serve as a rough cross-check of other estimates.

38. IISI estimates for steel intensity ratios and growth rates for sub-regions in Asia are shown in Table 10.

Table 10: Steel intensity and growth estimates for Asian regions

	1965-69	1975	1980	1985
Steel intensity, apparent consumption, kg/GNP				
Japan	.474	.461	.405	.360
India	.144	.159	.182	.205
China & North Korea	.243	.337	.392	.443
Other Asia	.106	.144	.162	.168
Total World	.226	.229	.225	.217
Steel consumption growth rates, % per annum				
Japan	19.6	5.3	4.3	3.5
India	- 3.5	10.6	7.1	6.[illegible]
China & North Korea	9.3	9.7	8.5	8.3
Other Asia	9.3	12.0	9.1	6.9
Total World	5.4	4.8	4.6	4.0

Source: Projection 85, International Iron & Steel Institute, 1972

39. Estimates above for "Other Asia" include the Philippines. However, at the starting point, the steel intensity in the Philippines was 82 per cent that of "Other Asia", and figures for the Philippines may therefore be taken as follows:

/ 1975

	kg/$ GNP
1975	0.118
1980	0.133
1985	0.138

The growth rates taken are the same as IISI estimates for "Other Asia".

40. Projected population and GNP estimates for RP are taken from the recent AIDC/ECAFE Industrial Survey for Regional Co-operation, 1973 (Table 11).

Table 11: Projected population and gross national product in the Philippines

	1970	1975	1980	1985
Population[a/]	37	44	52.5	62.2
Gross national product	10,080	13,490	18,050	24,720
GNP per capita[b/]	280	310	340	400

a/ Growth rates 3.5% for 1970-75, 3.6 for 1975-80, 3.4 for 1980-85

b/ Growth rates 2.2% for 1970-75, 2.4 for 1975-80, 3.0 for 1980-85

41. On the above basis, we have a new series of steel forecasts for the Philippines.

Steel demand forecasts
(1000 tons finished steel)

	1975	1980	1985
Steel intensity basis	1,590	2,400	3,410
Growth rate basis	1,500	2,318	3,270

42. The slightly lower figures above may be taken. An economy which used almost one million tons steel as early as 1969, should be in a position to consume 1.5 million by 1975, given conditions of continuing stability.

43. Disregarding the economic set-back of 1970-71, this projection visualises that the 1972 consumption of 991,000 tons would double by 1978, that is, in about 6 years. This is in line with experience of other countries at similar stages of growth. After 1975, when the per capita GNP has crossed the $ 300 mark, the pace of steel consumption can be expected to quicken.

/ The above

44. The above forecasts of course assume that (a) conditions of stability would continue and (b) steel would be available, indigenously or from imports. If unfortunately these conditions are not met, consumption could again be set back (as happened in 1970-71). For instance, in such a case, the demands estimated above may be realized one or two years later than anticipated, that is, a consumption level of 2.34 million tons would be reached in say 1982 and not in 1980. However, this would not significantly change the upward thrust of future demand, or the validity of the steel expansion programme now proposed.

<u>Country comparisons</u>

45. The estimated demands for RP would be equivalent to 42 kgs crude steel per capita in 1975, 56 kgs in 1980 and 66 kgs in 1985. Average per capita world consumption is expected to be about 185 kgs in 1975, 210 kgs in 1980 and 231 kgs in 1985. In other words, consumption in the Philippines may continue to be only one-fourth of the world average. The demands estimated for the Philippines would correspond to levels expected in the Republic of China in the coming decade.

46. The future steel needs and past consumptions are shown in Fig. 1. The corresponding annual growth rates of steel demand are as follows:

	Growth rates % per year
1970-75	9.2
1975-80	9.1
1980-85	6.9
Overall 1970-85	8.5

47. It may be mentioned that demand forecasts made by simple extrapolation of past consumptions (as done by MIRDC) give somewhat lower estimates. Forecasts made by UN and other agencies as well as this study are summarised in Table 12.

/ Fig. 1

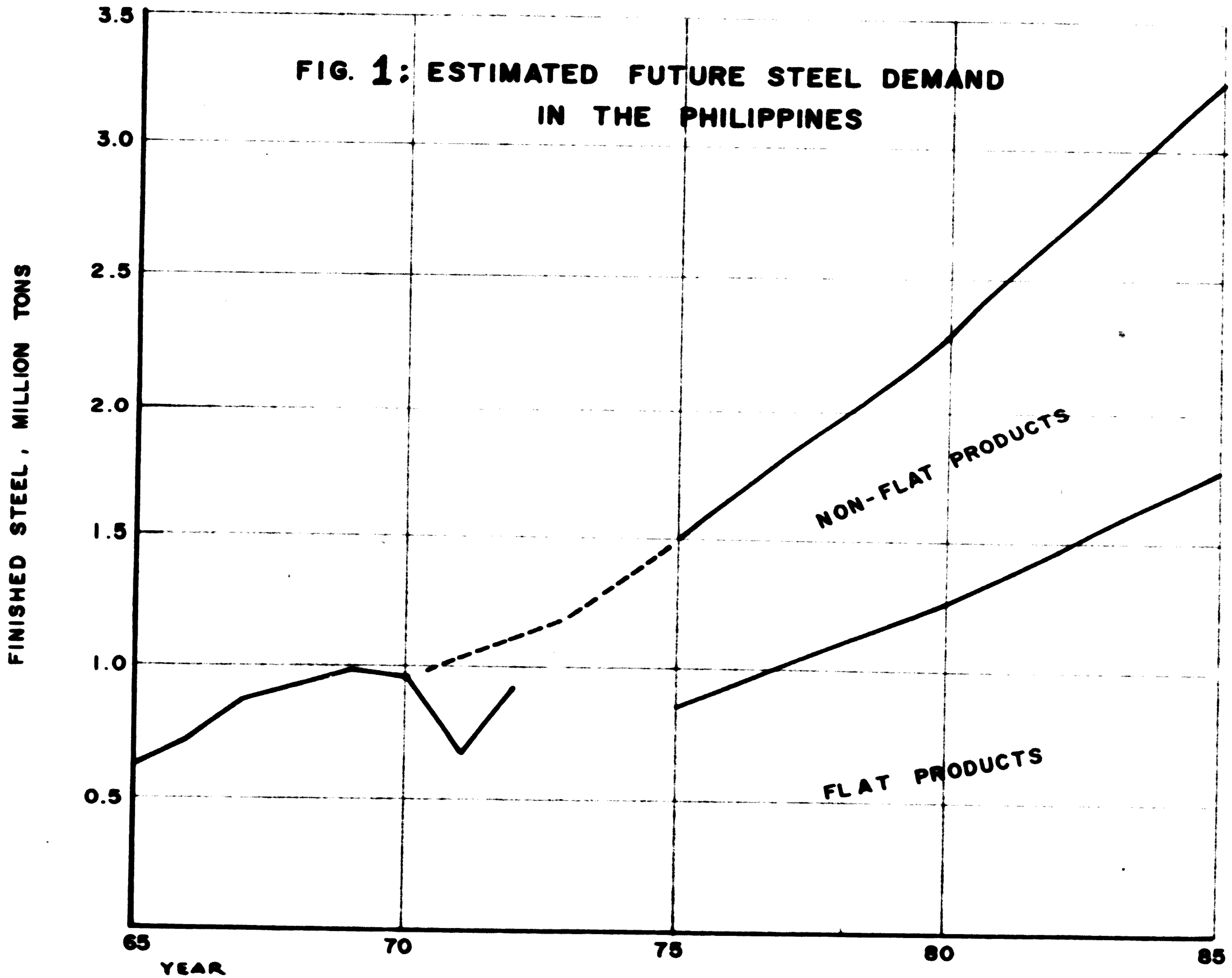


FIG. 1: ESTIMATED FUTURE STEEL DEMAND IN THE PHILIPPINES

Table 12: Forecasts of steel demand in the Philippines, 1975, 1980 and 1985
(1000 tons finished steel)

	1975			1980			1985		
	Flat	Others	Total	Flat	Others	Total	Flat	Others	Total
ECAFE, 1967	609	679	1,288	822	917	1,739	1,054	1,177	2,231
Japan/AIDC, 1968	671	707	1,378	882	955	1,837	1,134	1,236	2,370
Atkins, 1971	1,045	570	1,615	1,655	812	2,467	2,541	1,215	3,756
ECAFE Billet mission, 1972	600	650	1,250	1,100	1,100	2,200	-	-	-
AIDC Regional Co-operation Survey, 1973	-	-	1,435	-	-	1,980	-	-	2,629
This study, 1973	855	645	1,500	1,270	1,048	2,318	1,770	1,500	3,270

48. It must be noted that in developing economies the creation of indigenous steel capacity generates even larger demands, so that substantial tonnages would continue to be imported. There are short periods of excess capacity but demand soon overtakes supply.

49. Of the total steel demands, a part (say 10-20 per cent) may have to be imported for technical and economic reasons, because a steel plant can only be designed to produce a certain optimum product range. On the other hand, the need to export non-traditional metal-based goods and rolled steel itself will require assured steel supplies.

50. By and large, the forecasts made above can be considered as reasonable capacity targets for planning the expansion of the Philippine iron and steel industry.

Possibilities of steel exports to south-east Asia

51. Based on estimates made by this adviser for the UNIDO/ECAFE regional billet plant survey, 1972, steel demands in the sub-region are summarized in Table 13.

Table 13: Steel demand in south-east Asia, 1975 & 1980 (in tons)

South-east Asia (excluding Philippines)	1975	1980
Indonesia	1,000,000	1,500,000
Malaysia	785,000	1,100,000
Singapore	1,100,000	1,450,000
Thailand	1,250,000	1,700,000
Khmer, Laos & Rep. of Viet-Nam	363,000	609,000
Total	4,498,000	6,359,000

52. Against this, probable steelmaking capacity in the above countries (again excluding RP) and shortfalls can be expected to develop as follows:

Probable steel capacity in south-east Asia, 1975 & 1980
(in tons)

South-east Asia (excluding Philippines)	1975	1980
Integrated plants with blast furnaces	140,000	1,200,000
Semi-integrated plants with arc furnaces	1,300,000	2,800,000
Total :	1,440,000	4,000,000
Steel shortfall:	3,058,000	2,359,000

53. It is likely that over 2 million tons of steel products would have to be imported by south-east Asia countries by 1980. If Philippines could install major iron and steel-making capacity in the next seven years, it may take a significant share of this market. It would not be unreasonable to export say 15 - 20 per cent of RP steel production, and include this tonnage in long-term steel development plans.

54. In principle, there could be substantial economies through an integrated planning strategy for steel development on a sub-regional basis. The technical and economic implications as well as financing, tariff and other problems have been pointed out in the recent ECAFE/UNIDO report on 'Regional Co-operation for Steel Billet Production' (AIDC(3)/10, January 1973). Fresh initiatives and concrete action are now needed. At this point, it is also interesting to see the probable requirements of ore and scrap in south-east Asia, because these requirements would also exert pressure on prices for ore and scrap purchases by RP. It would also indicate the future potential for sponge iron in the region.

/Probable ore

Probable ore/scrap requirements in south-east Asia, 1975 & 1980

Ore/scrap requirements (excl. Philippines)	1973	1980
Iron ore (60% Fe) for blast furnaces	230,000	2,000,000
Steel scrap required for arc furnaces	1,475,000	3,180,000
Domestic scrap availability	600,000	900,000
Scrap shortfalls	875,000	2,280,000

Consumption by product categories

55. A characteristic of past Philippine steel consumption has been that flat products constitute as much as 60 per cent of total, and of flat products themselves cold rolled flats have been two-thirds. Proportion of cold rolled products (and of all flat products) would go down slightly as the pace of heavy industrial construction and equipment manufacture increases, while non-flat products would rise to a similar level as in other developing countries. In the past there has been practically no consumption of structural shapes as all construction has been reinforced concrete. But by 1975 and thereafter, use of steel-framed buildings should develop.

56. From review of past import data, the future pattern can be expected to be roughly in the following proportions of total consumption:

	1969-71	1975	1980	1985
Non-flat	40	43	45	46
Flat: Hot-rolled	18	18	20	21
Cold-rolled	42	39	35	33
	100	100	100	100

/ On this

57. On this basis category-wise breakdown of demand can be expected as shown in Table 14.

Table 14: Category-wise steel demands, 1975, 1980, 1985 (thousand tons)

	1975	1980	1985
Flat products			
HR: Plate	95	170	260
Sheet and skelp	175	290	430
CR: Galvanized	230	300	390
Tinplate	170	250	330
Other products	185	260	360
Sub-total:	855	1,270	1,770
Non-flat products			
Bars, rods and wire	565	890	1,280
Structural sections	80	158	220
Sub-total:	645	1,048	1,500
Total Finished Steel:	1,500	2,318	3,270
Slab equivalent @ 86%	995	1,480	2,060
Billet equivalent @ 94%	690	1,115	1,600
Total Steel Semis	1,685	2,595	3,660

58. A comparison of the anticipated product-mix in RP and in Thailand in 1980 (as estimated in a 1972 study by this adviser) is interesting. The high proportion of flats, particularly CR products, in the Philippines is significant:

/ Thailand

	Thailand 1980		Philippines 1980	
	'000 t	%	'000 t	%
Flat products				
HR	270	16	460	20
CR	370	22	810	35
Sub-total:	640	38	1,270	55
Non-flats				
Bars, rods	900	53	890	38
Structurals	160	9	158	7
Sub-total:	1,060	62	1,048	45
Total Finished Steel:	1,700	100	2,318	100
Per capita consumption:	43 kgs		56 kgs	

59. The demand estimates for RP show the following annual growth over past levels:

	Cum. growth rate, %	
	1962-70	1972-80
Galvanized sheet	5.5	10.6
Tinplate	13.8	13.0
Bars & rods	8.4	13.5

60. A detailed market study is now being made by a Japanese team which should give good estimates of product-wise demand. The above approximations are preliminary and only intended to indicate order-of-magnitude figures for considerati[illegible] of the pattern and pace of future steel expansion.

61. The recent MIRDC estimates for 1975 for identifiable product categories and estimates of this study are compared with available capacities below: (in thousand tons)

	1975 Demand		Existing
	MIRDC estimate	This study	capacity
G.I. sheets	155	230	445
Tinplate	112	170	137
Bars and rods	438	565	1,335

/ Expansion

Expansion of processing capacity

62. It is axiomatic that where steel producing or processing facilities already exist, these should be enabled to operate at rated capacities. Moreover, it is generally cheaper to expand existing plants than build new ones. The investment in equipment, infrastructure and technical skills is better utilized - and cost reduced - as output increases.

63. The following measures suggest themselves:

a) Till about 1980 existing bar rolling capacity should be adequate, but facilities and practices would need improvement and rationalization in order to produce quality products.

b) Existing arc furnace steelmaking operations need to be up-graded. With better practices and some balancing equipment, the existing firms should produce enough billets/ingots for the country's full requirements of bars and rods in 1975 (that is, about half-million tons).

c) Tinplate capacity needs marginal improvements and expansion in order to meet 1975 demand, but existing galvanizing capacity should be adequate.

d) Cold rolling capacity for flat products, and particularly hot rolling capacity for slabs and strip, will soon be short, and plans for augmenting these need urgent attention.

e) Further, substantial steelmaking capacity has to be created as soon as possible for production of slabs to be further hot-rolled, cold-rolled and processed.

f) Plans need to be prepared for production of low-alloy constructional steels and alloy tool and die steels (in bar shapes) and of stainless steels (in flats). Demand for such alloy steels could reach about 100,000 tons by 1980.

/ III.

III. RAW MATERIALS BASE

Of the countries in south-east Asia, the Philippines has perhaps the best raw materials endowment for a major iron and steel industry. It also has the advantages of a skilled, readily-trainable work force and low labour costs.

A 'crash programme' of geological investigations and beneficiation studies is essential, in order to feed the proposed integrated steel plant with indigenous materials. Without at least partial use of local ore and coal, the case for such a mill is weakened.

64. For a fully integrated iron and steel industry in RP, the materials required for iron-making are iron ore (lump, fines, pellets) and reductant (coal, natural gas, naptha). Fluxes such as limestone and dolomite can generally be found in most areas.

Iron ore resources

65. Lump and fine iron ore reserves have been estimated at 106 million tons but the average iron content of around 40 per cent is too low for economic iron-making. This should be over 60 per cent Fe for blast furnace operation and preferably over 65 per cent for direct reduction processes.

66. Three of the four operating mining companies in RP produce titaniferrous iron sands whose TiO_2 contents of 6 to 7 per cent would only enable small proportions to be blended with other ores for a blast furnace burden.

67. Recent data on total iron ore reserves is shown in Appendix II. The vast Surigao nickeliferrous laterite deposits of 3,000 million tons and titaniferrous magnetite sand deposits of over 66 million tons await proper exploitation.

/ Ore

Ore exports

68. Exports from RP have been 100,000 - 300,000 tons of ore and 1 to 1.5 million tons concentrates annually (Table 15).

Table 15: Exports of iron ore

	Iron ore		Iron concentrates		TOTAL	
	M.T.	($)	M.T.	($)	M.T.	($)
1960[a/]	479,683	(8,231,706)	57,214.1	(1,031,858)	536,897.1	(9,263,564)
1961[a/]	958,492	(18,107,560)	32,451	(598,101)	990,943	(18,705,661)
1962	404,365	4,059,186	47,800	393,879	452,165	4,453,065
1963	593,087	5,116,326	50,800	426,720	643,887	5,543,065
1964	788,169	6,251,054	117,250	1,188,210	905,419	7,439,273
1965	837,933	6,991,638	381,536	4,049,887	1,279,270[b/]	11,486,325
1966	673,574	5,701,353	441,864	5,096,592	1,416,640[b/]	12,827,007
1967	438,161	3,629,352	1,018,854	9,853,641	1,457,015	13,482,993
1968	57,500	519,270	258,369	4,964,100	315,869	5,483,370
1969	209,500	1,902,415	971,126	8,599,748	1,180,509	10,502,163
1970	363,096	3,183,203	1,182,593	10,780,172	1,545,689	13,963,375
1971	185,915	1,461,257	1,338,488	9,294,005	1,524,403	10,755,262
1972	102,629	1,401,064	750,484	8,275,833	853,113	9,676,897

a/ 1960 and 1961 values are in pesos

b/ Also includes magnetic concentrates

/ Iron ore

69. Iron ore contract prices in 1972 have been as follows:

Japan

Atlas Consolidated	- US$ 8.724/DMT based on 65% Fe
Anglo Oil & Mining	- US$ 5.15 /DMT based on 58% Fe
Filmag (Phils.), Inc.	- US$ 6.25 /DMT based on 57% Fe
Phil. Iron Mines	- US$ 8.45 /DMT based on 65-68% Fe
Philex Mining Corp.	- US$ 8.40 /DMT

U.S.A.

Long Beach Mining	- US$ 6.45 /DMT

Ore sources for RP steel industry

70. Of immediate interest is the Larap mine of Philippine Iron Mines (PIM) in Luzon, which has been supplying around 700,000 tons of concentrates (about 65% Fe) to its associate company, the Pellet Corporation of Philippines (PCP) for pelletization and export to Japan. The net ore reserves of PIM after decades of exploitation and the minable reserves (as of September 1972) are shown in Table 16.

Table 16: Iron ore reserves at Larap

	Location	DMT	%Mag. Fe
Total geologic ore reserves (as of 30 September 1971)	Bussar	2,886,435	35.5
	Bessemer	13,171,032	24.2
	Dangkalan	28,783,776	25.5
	Stockpile F	182,000	19.0
	Enchanted Island	81,700	56.0
	Total:	45,084,943	25.8
Mineable ore reserves (as of 30 September 1972)	Bussar (Main Pit)	120,000	30.0
	Bessemer (Bessemer Pit)	3,605,000	23.6
	Dangkalan (Underground) Above -550' Level	5,845,148	27.1
	Below -550' Level but above -800' Level	7,106,880	25.8
	Stockpile F	182,000	19.0
	Total:	16,859,028	25.7

/ PCP

71. PCP buys the concentrates at $8.45 per dry ton and exports about 720,000 tons of pellets annually to Japan at price of $13.40 f.o.b. After the present PIM - PCP contract expires in mid-1974, PIM intends to acquire the pelletizing plant facilities (assets valued at about P 2 million). However, due to depleting iron ore reserves, PIM will change its main activity by early-75 to copper extraction, so that iron ore concentrate availability will drop to around 250,000 tons/year.

72. This, together with by-product magnetite concentrates from Atlas (about 250,000 tons/year) and Philex (about 180,000 tons/year) would enable the pellet plant to continue operations at the present rate of about 700,000 tons/year. This quantity and quality may be appropriate for sponge iron plant.

73. For this purpose, negotiations may be started with Atlas, Philex, PIM and PCP, so that long-term supplies can be ensured.

74. Present pellet quality is shown below (Table 17).

<u>Table 17</u>: PCP pellet quality

Tumbler Index	
+5 mm (%)	93.0
-1 mm (%)	3.8
Crushing Strength	
$\bar{x}$ (kg/pellet)	253.0
	67.7
Size (mm)	13 x 18
Porosity (%)	22.8
Degradation Index during reduction	
+5 mm (%)	99.5
-1 mm (%)	0.4
Degree of Reduction (%)	54.0
Crushing Strength after reduction	
$\bar{x}$ (kg/pellet)	77.3
	39.2
Swelling index (%)	9.6
Chemical Composition	
T. Fe (%)	62.48
FeO	1.31
SiO_2	6.09
CaO	0.72
Al_2O_3	1.76
MgO	0.65
S	0.018

/Discussion

75. Discussions with PIM/PCP and Atlas indicated that concentrates of 67-68 % Fe could be supplied by additional grinding. Pellets of 67% Fe grade could be sold by PCP at say US cents 24 per Fe unit, that is $ 16.10 f.o.b. Larap.

76. If this good source of pellets is to be utilized for indigenous sponge iron production, government needs to move quickly and make appropriate arrangements with PCP and suppliers of concentrates.

77. A potential source of local ore for an integrated steel mill is the Santa Inez deposit containing some 30 million tons of 51-60% Fe grade. This would also need beneficiation and pelletization. Studies on this deposit need to be initiated at the earliest. Full geological investigations, mines development and setting up concentration and agglomeration facilities take considerable time - perhaps longer than building the integrated steel plant itself.

78. An earlier study by a UNIDO expert (December 1968) had indicated that the production cost of pig iron produced by using indigenous pellets from a new mining - beneficiation - pelletization plant at Santa Inez would be slightly less than by using imported ores. But, as already noted, the development time and costs for supplying indigenous ores for a million-ton blast furnace would be considerable, and initially such a plant could be based on imported ores. However, the long-term objective must be to utilize local raw materials in optimum proportions and at the earliest opportunity.

79. There appears to be a good possibility of blending say 25-35 per cent local ores in the future with imported ore, and this should be kept in mind while locating and designing a new steelworks.

80. On the other hand, for a direct reduction plant, the small quantity of high grade pellets needed could be procured locally if long-term contracts could be negotiated. High-grade pellets (67% Fe) could be delivered at plant site for under US$ 18 per ton. These would be a significant advantage if the sponge iron plant could have a captive source of pellets.

/ Imported

Imported ore prices

81. The decline in iron ore prices from developing countries over the last decade has now levelled out. Australia and India may be good ore sources for the Philippines. Typical analyses of pellets from selected countries are shown in Table 18.

Table 18: Chemical analyses of pellets from selected countries

	Fe %	SiO_2 %	Al_2O_3 %	CaO %	MgO %	P %	S %
Africa							
Liberia	64.50	4.20	2.00	1.10	0.06	0.06	0.003
Morocco	65.50	2.60	1.20	0.80	0.97	0.006	0.008
Europe							
Sweden	64.60	4.40	1.15	0.62	0.63	0.045	0.007
Norway	68.60	0.59	0.35	0.48	0.30	0.013	0.011
South America							
Brazil	66.00	1.30	0.70	-	-	0.025	-
Peru	67.50	1.00	0.45	0.18	0.56	0.010	0.050
Oceania							
Australia	67.50	1.50	0.25	-	-	0.020	-
India							
Goa	66.00	2.00	1.7	-	-	-	-

82. For the purpose of this exercise it is estimated that lump ore (64% Fe grade) could be delivered at the selected site at US$ 16 per ton c & f, ore fines at US$ 14 per ton and pellets (67% Fe) at US$ 18 per ton.

Coking coal

83. Indigenous non-coking coals could be used for a direct reduction process based on solid reductant, however, such rotary kiln processes are experiencing considerable difficulties in various part of the world. For the conventional blast furnace process, coking coal is essential.

/ Of the

84. Of the estimated 125 million tons of coal reserves in RP (Appendix III), some of the Malangas coals (less than 5 million tons) have coking characteristics. At best, these could be used in blends (say 20%) with imported coking coal for a blast furnace operation.

85. The integrated steelworks would produce its own coke from coal which could be imported from **Australia** or the United States. The world reserves of coal are shown in Table 19, while imports and exports from selected countries are given in Table 20.

<u>Table 19</u>: World reserves of coal (billion tons)

		Total all coal	Coking coal
U.S.A.	..	1,505	256
Canada	..	87	17
Columbia	..	12	3
Others - Western Hemisphere	..	11	3
Germany	..	286	74
United Kingdom	..	171	56
Czechoslovakia	..	19	2
Poland	..	80	22
France	..	13	4
Others - Europe	..	34	3
South Africa	..	68	19
Australia	..	58	6
Others - Africa and Australia	..	3	1
U.S.S.R.	..	1,200	220
China	..	1,011	223
India	..	63	14
Japan	..	10	4
Others - Asia	..	8	1
Total World Resources		4,639	928

<u>Source:</u> U.S. Geological Survey and Occidental Petroleum Corporation - Market Research Department.

/ Table 20

Table 20: Imports and exports of coal by some selected countries in 1969 (thousand tons)

Country	Imports	Exports
U.S.A.	109	56,862
Belgium	7,236	991
France	13,794	1,214
West Germany	6,987	19,342
Italy	12,861	-
Netherlands	6,535	1,975
Poland	1,199	29,063
U.K.	100	3,809
Australia	-	15,880
Canada	17,212	1,375
Japan	45,361	25

Source: World Coal Trade, National Coal Association, USA, 1970.

86. Prices currently being paid by the Japanese iron and steel industry for coking coal imports, and their estimates of 1975 prices are shown in Table 21.

Table 21: Imported coking coal prices in Japan (US$ per wet ton)

	1973			1975		
	F O B	FRE	C & F	F O B	FRE	C & F
A. Coking coal from USA						
Low volatile	26.00	6.30	32.30	29.00	6.30	35.30
Middle Volatile	24.00	6.30	30.30	27.00	6.30	33.30
High volatile	22.00	6.30	28.30	25.00	6.30	31.30
Average	24.50	6.30	30.80	27.50	6.30	33.80
B. Coking coal from Australia						
Average	17.30	4.20	21.50	19.30	4.40	23.70

87. The US and Australian coals are used in a 40 : 60 proportion in Japan. This would give a weighted average cost of $ 25.5 (in 1973). However, it must be noted that Japan imports very substantial tonnages from established sources whereas RP will be a new buyer for a comparatively small quantity.

/ For

88. For this report, price of imported coking coal is taken at average \$ 26 per ton c.&f. On this basis, production cost of BF coke (including fixed charges) at an integrated steel mill would be about \$ 45. Present price of imported coke in RP is said to be \$ 56/ton f.o.b., but this becomes over \$ 100 per ton by the time it reaches the foundries.

Naptha

89. As natural gas is not available in the Philippines, some other hydro-carbon such as virgin straight-run naptha could be used as source of reductant for the process requirements and also as fuel for pre-heaters, reformers, etc. A sponge iron plant of 400,000 tons/year capacity would need around 3,000 barrels of naptha per day by 1976/77.

90. Oil refining capacity of the existing four units in RP is about 270,000 barrels per day, and some units are scheduled for expansion by 1975. Currently no naptha is produced, but there is said to be surplus refining capacity for naptha if required by the market.

91. In studies made on direct reduction possibilities in Malaysia (March 1973) and Republic of Korea (December 1972) international oil companies had quoted naptha prices of US\$ 2.70 to \$ 3.00 per barrel, ex-refinery. Naptha price in Korea has officially been raised to US\$ 3.10 per barrel this month (August 1973).

92. Fuel prices in the Philippines are generally lower than in the other Asian countries. On the other hand, with continuous rises in petroleum prices and the increasing use of naptha as a clean fuel as well as feed-stock for fertilizers and chemical industries, supplies are likely to be short and naptha prices can be expected to go up. One of the fertilizer companies has made recent naptha imports at about \$ 2.80 C&F Philippines port, and the contracted price for the Nonoc Island nickel project is reported to be of the same order.

93. During discussions with one of the RP oil companies, they gave a current (1 August 1973) naptha price estimate of \$ 4.50 per barrel (excluding taxes), C&F Iligan. Further negotiations would be required

/ to

to arrive at a more realistic price. It was also pointed out by the oil company that there may be some price reduction if large vessels could make naptha drops at the proposed Palawan and Nonoc projects and at the Iligan in one combined route.

94. For this study, a naptha price of US$ 3.50 per barrel ex-RP refinery, is taken plus $ 0.30 for ship transport to say Iligan site, that is, total $ 3.80 per barrel. This comes to US$ 0.742 per million BTU. Production costs of steel are also estimated for higher naptha prices. It may be mentioned that a rise of one US dollar in naptha price would increase the price of steel semis by US$ 2.40, that is about 2 per cent of the total production cost of slabs/billets.

95. Finally, it is a matter of government policy to organize the rational allocation of domestic naptha to various consumers as well as to set price guidelines, in the overall national interest. Price would also depend upon the then prevailing posted prices for crude, tanker availability and the then available refining capacity (1976/77).

Steel scrap

96. The proposed integrated steel maill would need some purchased scrap because with use of continuous casting and production of semi-finished products, the plant return scrap would not be adequate for the LD converters. Semi-integrated plants based on arc furnaces would need even larger scrap proportions. Moreover, even if sponge iron were available, some scrap would be needed for steel-making in the electric arc furnace. Typical test data indicates good results when using about 65 per cent metallized pellet (less than 4% acid gauge) through a continuous charging system, the balance being steel scrap. Generally, larger proportions of sponge iron would result in increases in consumption of fluxes, manganese addition, electrodes and refractories. However, depending upon the scrap/sponge iron prices, sponge iron quality and operating practice, upto about 80 per cent sponge could be used in the arc furnace charge.

/ Wide

97. Wide fluctuations in availability and price of scrap are serious problems for arc furnace operators. Home prices of No. 1 heavy melting scrap in the US - the world's major scrap exporter - have bounced, like a yo-yo, between $ 30 and $ 40 per ton, except in early 1957 and now in 1973 when it has reached peaks of $ 60. (To these prices must be added $ 20-25 per ton for freight, etc. to Philippines).

98. The alternating peaks and valleys are shown in Figure 2. The peak scrap prices, corresponding to high global steel production, come every three to five years, and then drop again.

99. Imported scrap which cost US$ 50 per ton C&F Manila last October is now as much as $ 90-100. This may drop again but perhaps never again to $ 50. International scrap prices were dropping gradually from 1957 to 1967. But since 1967, with the growth of semi-integrated mini-mills, the overall trend is now gradually upward. The long-term expectation is that the increasing world-wide production of sponge iron may help to prevent run-away scrap prices.

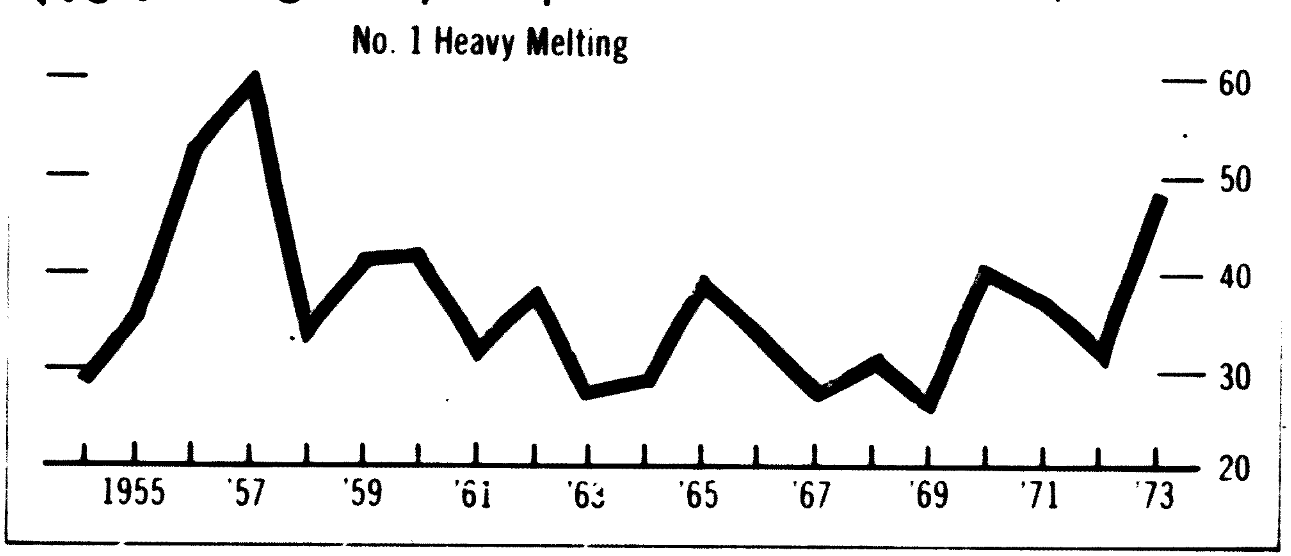
100. Current generation of melting scrap in RP is estimated at about 100,000 tons annually, while about 70,000 tons have been imported. In future, even larger imports from US, Australia and Europe may be needed. Substantial scrap tonnages are currently used in foundries, while arc furnaces plant were using domestic and imported scrap in a 70 : 30 ratio. In future, domestic scrap may meet only half or less of total requirements and the balance would have to be imported.

101. A thorough study needs to be made by MIRDC/PISI of probable future scrap availability. At the same time, suitable scrap collection and preparation organizations need to be set up.

102. For this exercise, it is assumed that domestic scrap would be available at US$ 60 per ton and imported scrap at US$ 100 per ton ex-steelworks, that is, an average price, taking both home and imported scrap, of US$ 80 per ton. Prices presently being paid by the Luzon arc furnace operators or by IISMI are lower.

/ Electric

FIG 2: Iron Age Scrap Composite Price



Electric power

103. An integrated steel mill is a major power consumer, requiring 300 to 400 units per ton of output. Moreover, the hot strip mill imposes severe fluctuations on the system. It is therefore necessary that supply of bulk power is assured from a strong reliable grid system. Further, it may be desirable to generate part of the electric power for emergency and peak conditions at the steel plant itself. The semi-integrated steel mill with arc furnace also has large power requirements together with drastic peak loads.

104. The bulk of electric power in the Philippines is produced by the National Power Corporation (420 MW for Luzon and Mindanao) and by the Manila Electric Company (1,210 MW for the greater Manila area). When the location, phasing and power requirements of new steel-making capacity are decided, the electricity generation and distribution systems can be planned to meet these needs within a three or four year period.

105. Electric arc furnace operators are reportedly paying an average of around US$ 0.012/kWh in the Manila area while at Iligan power based on the Maria Cristina Falls costs much less (under $ 0.006/kWh).

106. Unit power costs for the steel industry in other developing countries are generally higher than in RP. With rising costs of fuel as well as pollution control facilities and exchange rate changes, power costs here also are likely to rise. The use of nuclear power reactors providing the heat and power needs for sponge iron and arc furnace steel-making may well be a possibility in the foreseeable future.

107. For this study, it may be assumed that average unit cost would be $ 0.007 at Iligan and $ 0.014 at other locations. Again, these prices are much higher than those being currently incurred.

/ IV.

IV. CHOICE OF PRODUCTION PROCESSES

108. The problem now is to develop capacity to match probable steel demand of about 2.3 million tons in 1980 and 3.2 million tons in 1985, under the following constraints:

(a) Utilize existing steelmaking, bar rolling, hot and cold sheet rolling capacity to the extent possible, in order to reduce additional investments.

(b) Back integrate to production of iron in the Philippines (pig iron in blast furnaces or sponge iron or both, as may be technically and economically viable), in order to minimize dependence on imported scrap and steel semis.

(c) Phase the new capacity in an optimum manner so that steel products are made available as required, for overall economic growth.

While the Philippines is on the threshold of major steel industry expansion, it is urged that the planners take a close look at the new technology of sponge iron making. Til only a couple of years ago, many knowledgeable people were understandably sceptical about sponge iron. Today, however, processes using gaseous reductants can be considered to be commercially established and viable in many situations. In the Philippines, a major semi-integrated plant based on sponge iron could very usefully complement a large integrated steel-works based on blast furnaces.

Two viable process routes

109. The two main process possibilities are:

A. An integrated plant with blast furnace to produce iron which is then refined in basic oxygen converters (BF + LD); and

B. A direct reduction plant to produce metallized ore (or "sponge iron") which is converted to steel in electric arc furnaces (DR + AF). Even this route would start with iron ore.

/The objective

110. The objective is to build a viable industry. In the final analysis, it does not matter whether new capacity is based on blast furnaces or other appropriate process, whether it is integrated, semi-integrated or unintegrated, as long as the industry can produce the large tonnages of steel which will be needed at reasonable costs, social and economic.

The blast furnace route

Time schedule: A new integrated mill based on blast furnace is a major undertaking, requiring vast investments and technical resources. Experience in developing countries indicates that even with decisions being made on a "crash programme" basis, it would require about 2 years to prepare detailed project studies, arrange financing, invite bids and place equipment orders, and then take 3 to 4 years to build the plant. After the plant is commissioned, 1 or 2 years would be needed to bring production up to rated capacity.

111. Thus, if the "go-ahead" signal is given in early 1974, construction could be completed in 1978 and full production reached in 1979/80. It could be done earlier, but the chances are that it may take longer.

Capacity: It is often contended that due to lack of skills in developing countries and the need to maintain continuity of operations, etc., a new steel mill should start with two smaller blast furnaces rather than a single large one. However, under conditions in the Philippines, it is recommended that the proposed plant start with one large blast furnace. It takes as much time to build a large unit as a small one, and it requires similar skills to operate either. After three years or so when the first blast furnace is due to shutdown for re-lining, the second new furnace should be ready, in a continuing expansion programme.

112. The saving in capital and operating costs of one furnace (compared to two of smaller capacity) are substantial. In a basic industry like steel, cost reduction is a major consideration and this can best be achieved by taking advantage of modern proven technology and optimum equipment sizes.

113. The output of a single modern blast furnace has been rising rapidly. Furnaces of over 5,000 tons/day (and upto 10,000 tons) are now operating in

/some industrialized

some industrialized countries. However, for a country starting its first integrated steel mill even a 3,000 tons/day blast furnace (corresponding to say 2,000 cu m. working volume) is large indeed and should be considered as an optimum initial size. This would produce enough iron for a total output of about 1 - 1.2 million tons steel products per year.

114. Some pertinent aspects of the blast furnace route for the Philippines are discussed in . . . The proposed plant should have extensive ore handling/blending facilities, a sinter plant and requisite coke ovens. Steel-making may be by the LD process, however, the newly-developed OBM (or QBOP) process should be given consideration at the project implementation stage.

115. For the flexibility in operations, a high-lift blooming slabbing mill may be preferred in the first stage, followed by continuous casting of slabs in the second stage.

116. The new integrated steel plant at Pohang (POSCO) in Republic of Korea is well worth study by developing countries embarking upon a steel programme. A one-million ton plant (based on single blast furnace) has been completed at a cost of around $310 million (1972 estimate) and within three years of order placement. It is to be expanded to 2.6 million tons by 1976, at an additional cost of $300 million. Salient features of the POSCO plant are described in Appendix IV.

<u>The sponge iron/arc furnace route</u>

117. While the Philippines today stands on the threshold of a major steel industry development programme, it is urged that the planners take a hard look not only at the well-established blast furnace integrated route but also at the new technology of sponge iron making and electric arc furnace steel production. Till only a year ago, many knowledgeable people were understandably sceptical about sponge iron processes as well as about the economies of small-scale semi-integrated mills. Today, however, recent developments in gaseous reductant processes (such as HyL and Midrex) and the global steel situation are forcing countries and companies to fully investigate and negotiage sponge iron plants.

/Capacity:

Capacity: While earlier HyL plants had capacities of 100,000 - 200,000 tons of sponge iron per year, new installations will have larger outputs. Minimum size for the Midrex process is about 400,000 tons/year. For conditions in RP, a sponge iron plant with an initial capacity of 400,000 tons/year would be appropriate. This could be processed to about 400,000 tons of steel billets or slabs. It should be located close to the arc furnace plants which would consume the sponge iron produced.

The advent of the "mini-mill"

118. One of the revolutions in the steel industry of this decade has been the rapid growth of semi-integrated steel mills which melt scrap in high-powered electric arc furnaces and cast steel continuously into billets, blooms and slabs. These plants (known popularly as "mini-mills") have capacities of 20,000 to 400,000 tons/year and are now able to compete with large integrated steelworks. A number are being built in both developing and developed countries. The trend in industrialised countries is shown in Table 22. Almost 40 per cent of total steel production in Spain now comes from mini-mills ranging in size from 50,000 tons/year to 250,000 tons/year. Western Europe has about 60 such plants with capacities of 10,000 to 300,000 tons/year.

/Table 22:

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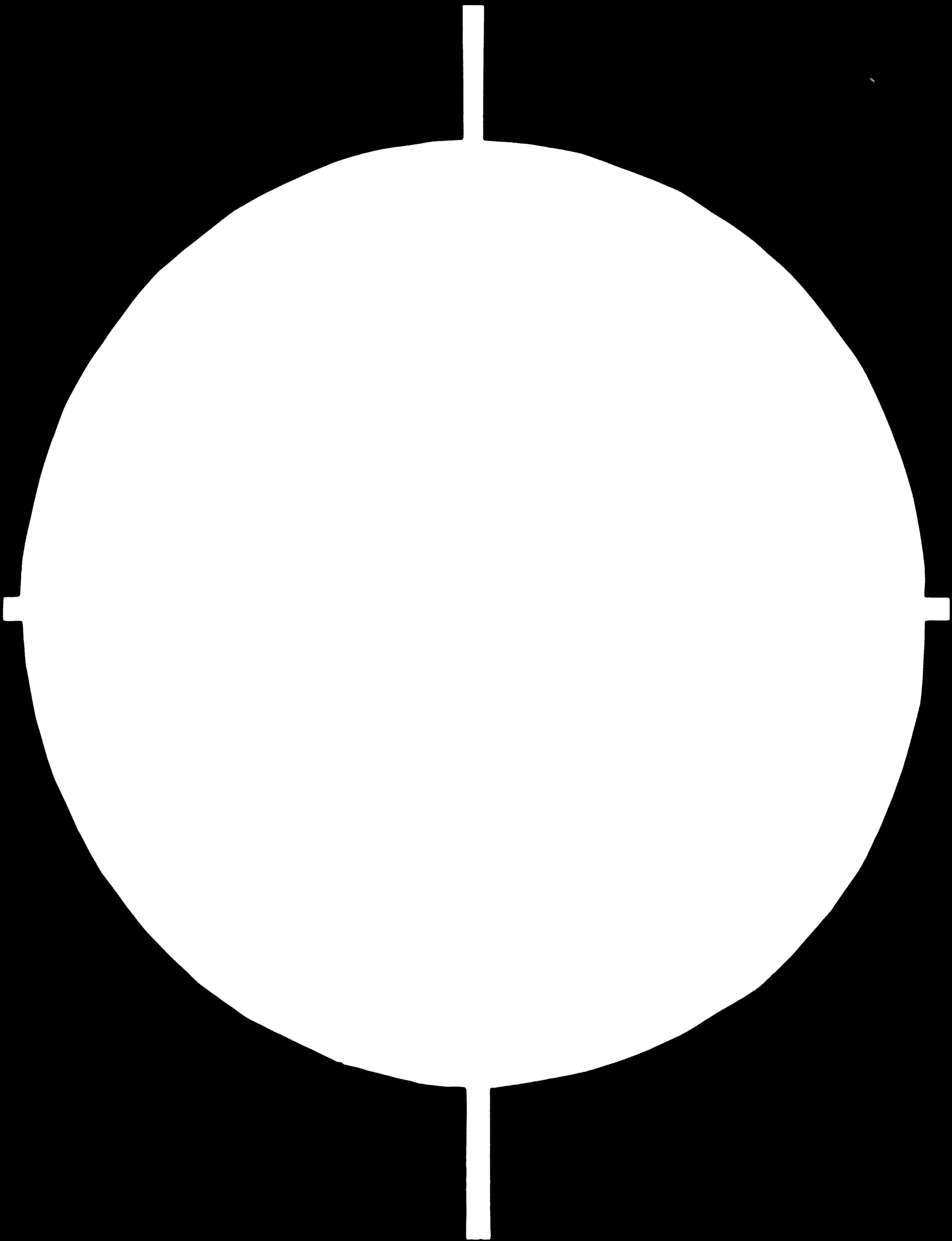

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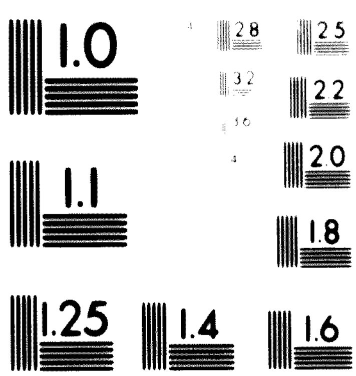

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Table 22: Semi-integrated steel plants in industrialized countries

Country	Total crude steel output 1970 ('000t)	Semi-integrated steel mills: No. of plants	Output ('000t)	% of total crude steel	Output per plant ('000t/yr)
U.S.A.	118,995	44	5,965	5.0	135
S. Africa	4,580	2	330	7.2	165
Spain	7,390	25	2,935	39.7	117
Italy	17,277	23	2,735	15.8	119
Greece	450	2	210	16.7	105
Switzerland	520	2	190	36.5	95
W. Europe	72,905	59	7,295	10.0	124

119. The same trend is evident in the countries of Latin America (Table 23). In the two large producers - Brazil and Mexico - about 15 per cent of output is from mini-mills, while in Argentina as high as 41 per cent.

Table 23: Semi-integrated steel plants in Latin America

Country	Total crude stool output 1970 ('000t)	Semi-integrated steel mills: No. of plants	Output ('000t)	% of total crude steel	Output per plant ('000t/yr)
Brazil	5,367	18	882	16.5	49
Argentina	1,882	7	783	41.5	112
Mexico	3,881	9	548	14.2	61
Chile	591	1	44	7.5	44
Colombia	248	2	50	20.2	25
Peru	92	1	20	21.7	20
Venezuela	927	1	138	14.9	138

/It may be

120. It may be mentioned that of the 39 semi-integrated plants in Latin America, 22 were in the capacity range 20,000-50,000 tons/yr, ten in the range 50,000-100,000 tons/yr, and six over 200,000 tons/yr.

121. In most of the developing Asian countries, there are no integrated plants and therefore 100 per cent of steelmaking is in mini-mills. The 1970 situation is shown in Table 24.

Table 24: Semi-integrated steel plants in selected Asian countries

Country	Total crude steel output 1970 ('000t)	Semi-integrated steel mills			
		No. of plants	Output ('000t)	% of total crude steel	Output per plant ('000t/yr)
Indonesia	10	3	10	100	3
Philippines	306	10	306	100	31
Singapore	149	1	146	100	146
Thailand	300	5	300	100	60
India	6,227	80	1,000	16	14
Malaysia	150	2	30	20	15

122. Arc furnace steelmaking capacity is expected to rise in India to over 3 million tons in 1975. Similarly, capacity of semi-integrated plants in the five countries of southeast Asia is being raised from 900,000 tons in 1971 to over 1.5 million tons by 1975.

123. Globally, electric furnace steel production is expected to rise to over 100 million tons by 1975 out of an anticipated world steel production of 700 million tons. And the bulk of this will be commercial-quality tonnage steel and not alloy or special steel.

The advantages of the arc furnace route

124. A semi-integrated mill can operate viably at an output of even 20,000 tons annually from one 10-ton arc furnace, while a fully integrated plant needs an output of around one million tons per year, corresponding to

/a single modern

a single modern blast furnace. Moreover, the blast furnace needs coking coal, and reserves of such coal in the Philippines are not satisfactory.

125. The low investment in a mini-mill is one of its strongest motivations, specially in developing countries where capital is a scarce resource. An arc furnace, continuous casting and bar mill plant of say 100,000 tons per year can be built for about $16 million, that is, $160 per annual ton. Against this, an integrated steelworks of a million ton capacity may cost $350 million, or $350 per annual ton. Taking interest and depreciation charges at 20 per cent, this means a substantial cost advantage of $38 per ton for the mini-mill, quite apart from the relative ease of financing a smaller project.

126. Moreover, there are other savings in operating costs. The productivity at a semi-integrated mill may be 500 tons per man-year VS only 200 tons per man-year at a fully integrated plant. The small mill also incurs smaller administration and sales overheads, less laboratory, maintenance and services costs.

127. Another important consideration is that the semi-integrated plant can be constructed in about three years, that is by end 1976, while the integrated plant would take atleast two years longer. This means that it can rapidly exploit the market and earn quick returns on capital. It needs a stable electric power source but little other infrastructure.

128. The processes the mini-mill employs are simple and local man-power can be trained readily to handle these. It has flexibility to serve its market promptly and efficiently.

129. Finally, while the semi-integrated plant may today be viable up to 1-2 million tons, the integrated plant's viability **starts** from that level. Therefore, the two routes must now be looked upon as complementary, not competitive. Where the demand and other conditions warrant, both could develop side by side.

/Status of

Status of sponge iron processes

130. The rising prices of coking coal for blast furnace iron-making on the one hand, and the volatility of scrap prices for arc furnace steelmaking on the other, make it inevitable that sponge iron will be used increasingly in future to supplement scrap.

131. The nomenclature in this field is still inconsistent, but generally the term "direct reduction" is used to denote the reduction of ore by means other than a blast furnace. The product is referred to as "sponge iron", or also as "reduced pellets" and "metallized ore".

132. World capacity for sponge iron is today around 4 million tons and will exceed 6 million when plants under construction are completed. The manner in which capacity has grown is shown in Fig. 3. Further, plants are being actively planned in India, Malaysia, Singapore, Republic of Korea, Thailand and also in the Philippines.

133. The main processing routes currently used for producing sponge iron are shown in Fig. 4. The iron ore may be in the form of lump ore, oxide pellets, green pellets, fine ore or concentrate. The other major input is the reducing agent. Its availability and cost has an important effect on choice of direct reduction process. Processes fall broadly into those using solid reductant/fuel (for example, coal) or gaseous reductant/fuel (for example, reformed petroleum, natural gas, naptha and other hydro-carbon bearing gases). Processes can also be classified by the manner of feeding (continuous or batch) and the type of reaction system (kiln, shaft fixed bed or fluidised bed). The major processes are briefly described in Appendix 5.

/ Solid reductant

Fig: 3 ESTIMATED GROWTH OF WORLD SPONGE IRON CAPACITY.

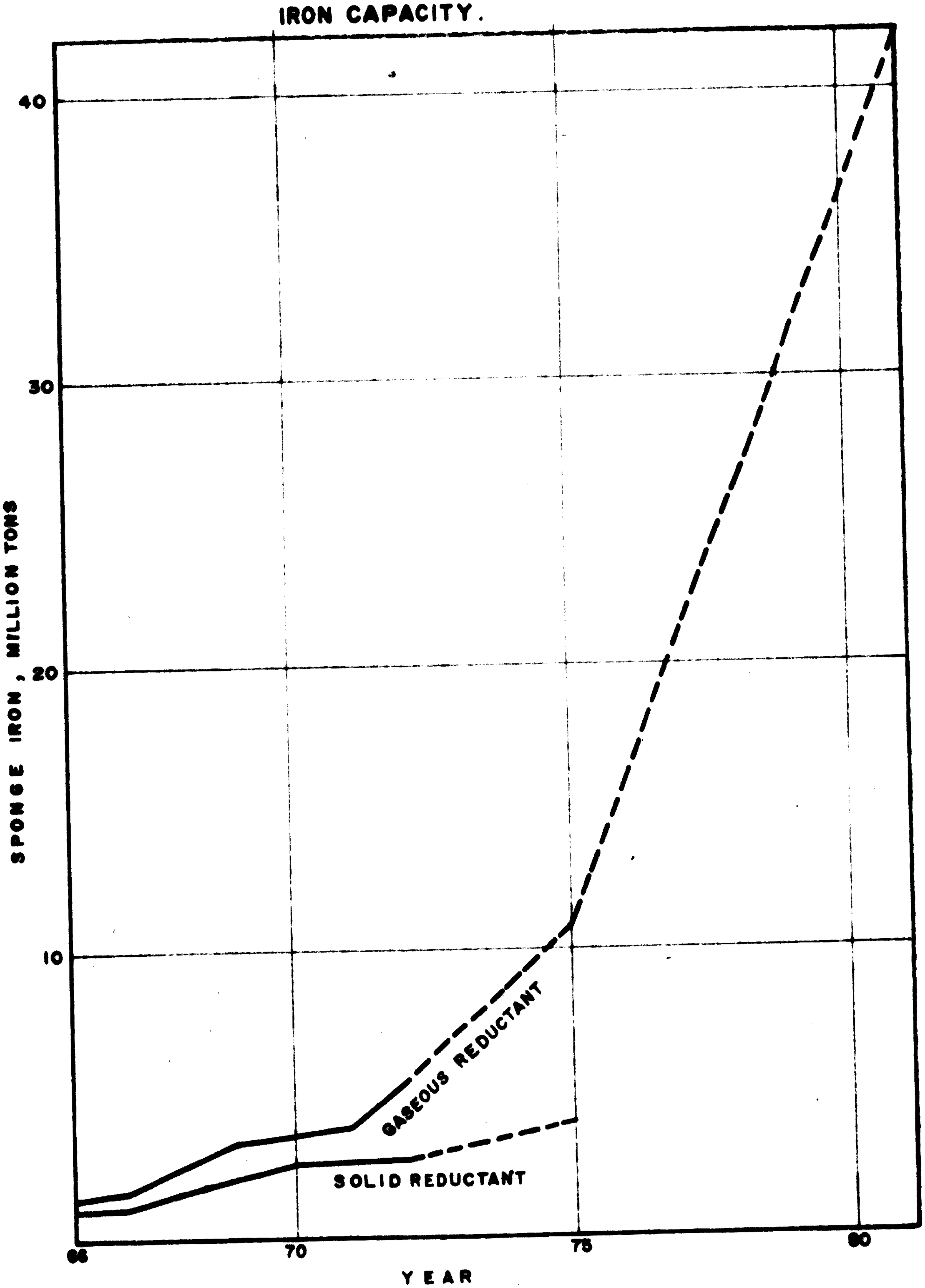
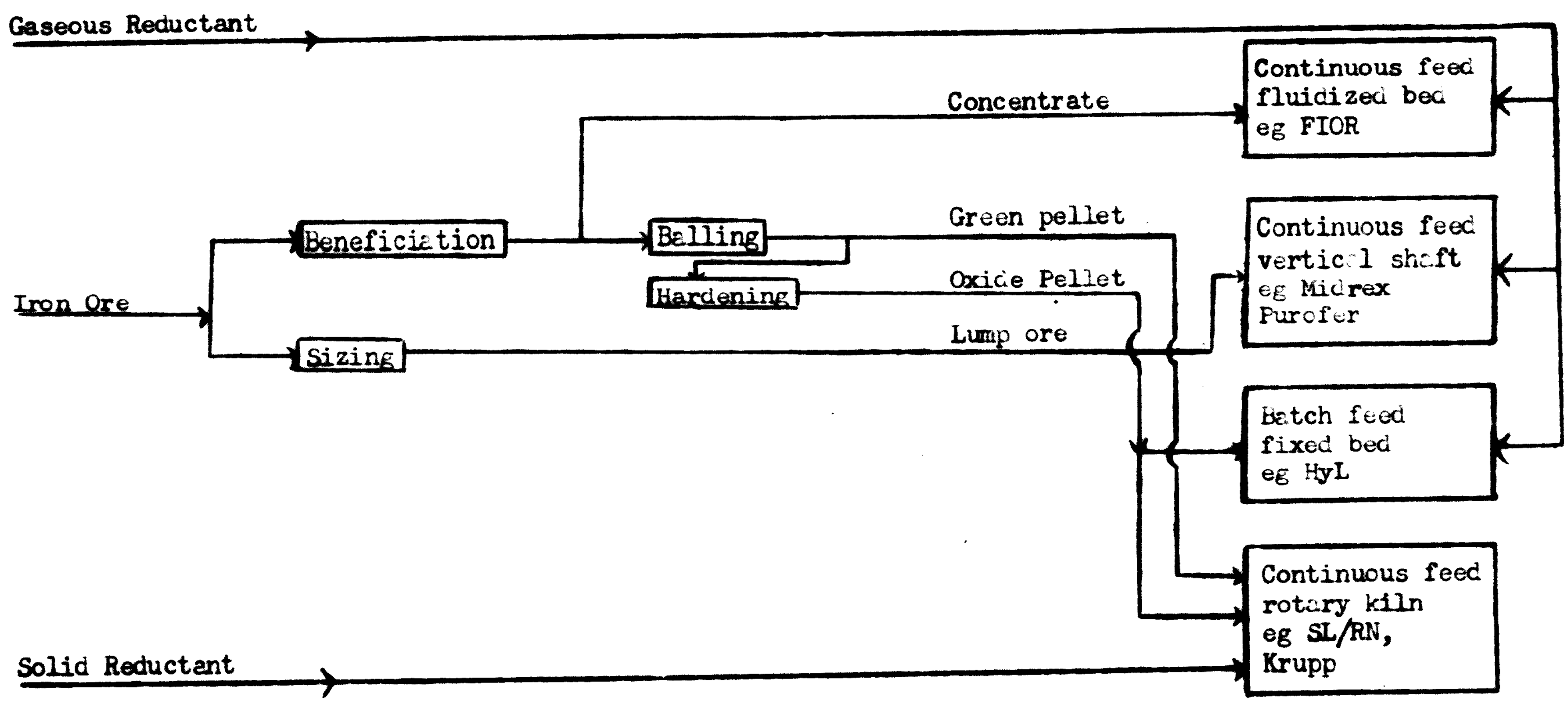


Fig. 4: Types of direct reduction processes



Solid reductant process

134. Plants using solid reductants in batch operations (such as Hoeganaes, Echeverria and Nuevo Processo) as well as rotary kilns (SL/RN and Krupp) are shown in Table 25. Schematic arrangements of typical processes are shown in Fig. 5.

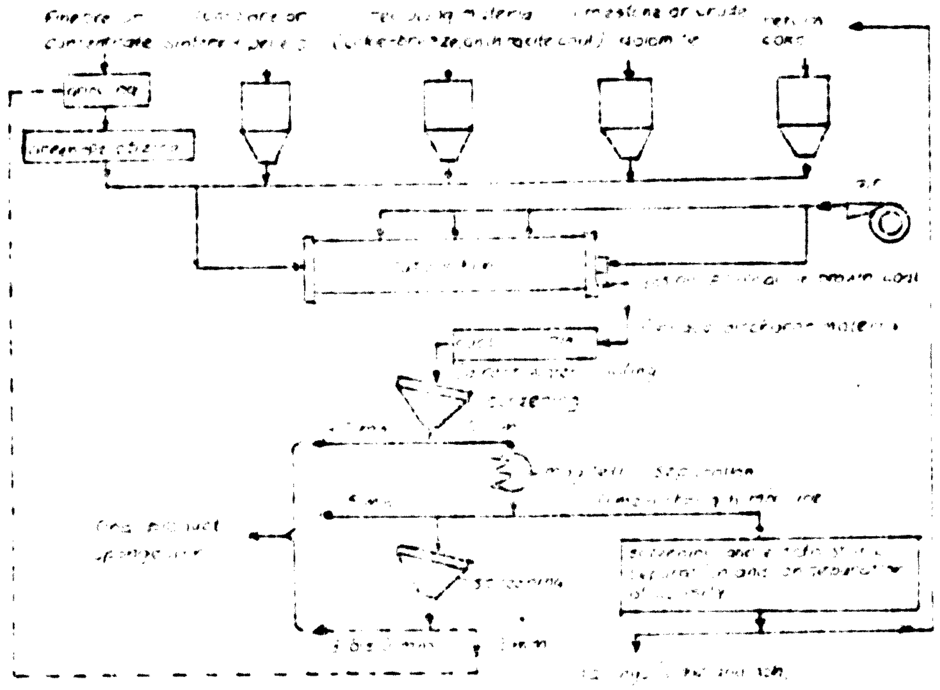
135. Existing rotary kiln plants at New Zealand Steel and Falconbridge Canada, have experienced severe operating problems necessitating many changes in flow-sheet. Due to difficulty in reaching rated capacity and market conditions, the Falconbridge kiln closed down in end 1972. Operating results of the Krupp plant at Dunswart Iron and Steel Works, South Africa (150,000 t/yr) and SL/RN plant at Piratini, Brazil (65,000 t/yr) which were both commissioned in early 1973, are still awaited.

/Table 25

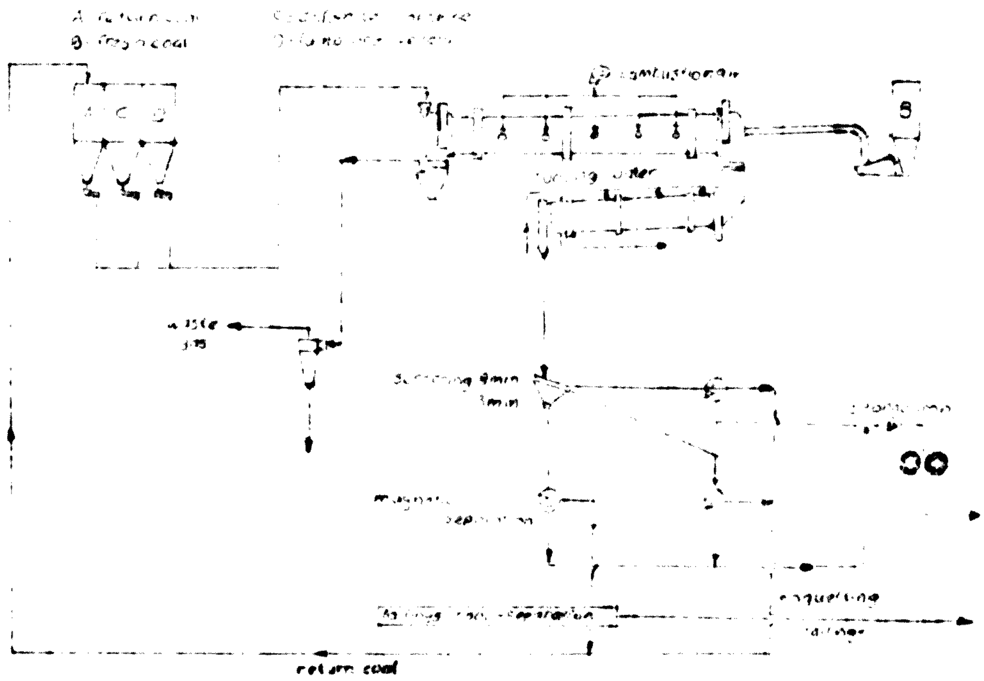
Table 4. Sponge iron plants with solid reductions

Process	KILN PROCESSES				BATCH PROCESSES		
	SL/RN	SL/RN	KRUPP	SL/RN	Hoeganaes	Echeverria	Nuevo Proces
..t and location	New Zealand Steel Ltd, Glenbrook, New Zealand	Falconbridge Nickel Mines Ltd, Sudbury, Canada	Dunswart Iron & Steel Works, Benoni, South Africa	Aços Finos Piratini S.A., Charqueadas, Brazil	Hoeganaes, Sweden Oxelosund, Sweden Riverton, USA	Patricio Echeverria S.A. Legazpia, Spain	Siderurgica Monfalcone (SIMO), Ital
..city, T/yr - sponge	150,000	300,000	150,000	65,000	130,000 (total)	20,000	30,000
..duction equipment	One kiln 4 m ∅ 75 m	One kiln 5 m ∅ x 50 m, with pre-heating grate	One kiln 4.6 m ∅ 74 m	One kiln 3.6 m ∅ x 50 m	Silicon carbide saggers	40 Nos of alloy steel retorts	8 Nos of sil con carbide lined vessel
materials: ..ron ore - quality	Iron sand green pellets/concentrate Fe - 61% SiO_2 - 1.1% Al_2O_3 - 2.8% TiO_2 - 8.5%	Pyrrhotite pellets Fe - 65-67% Ni - 0.5 - 1%	Lump ore Fe - 65-67%	Itabira lump ore Fe - 67%	High grade concentrate	Lumpy hematite ore Fe - 54-60% SiO_2 - 8-12%	N.A.
- size range	4 - 8 mm	10 - 12 mm	5 - 25 mm	5 -30 mm	-30 mesh	10 - 50 mm	N.A.
..ctant	Brown coal (dry) P.C. - 52% VM - 43.3% Ash - 4.7% - 10 mm size	Bituminous coal F.C. - 55% VM - 39% Ash - 3.7%	Anthracite F.C. - 79% Ash - 11-12% Duff coal F.C. - 57% VM - 26.5% Ash - 16.5%	Bituminous coal F.C. - 58.5% VM - 26.5% Ash - 35% 1-25 mm size	Coke breeze	Anthracite coal VM - 8.2% Ash - 27.3% F.C. - 62.5% S - 1.1%	Low grade co
					Producer gas	Producer gas	Propane
..t up	1970	1971	Early 1973	Mid 1973	1911	1958 (closed since 1965)	1972

Fig.5 Schematic Arrangement of Krupp and SL/RN plants



Schematic arrangement of a large-scale [illegible]
sponge iron plant



Schematic arrangement of a large-scale [illegible] plant

Gaseous reductant plants

136. Plants using gaseous reductants have made better progress and capacity in operation or commissioning is over 3 million tons, with about 2 million tons now under construction (Table 26). Energy requirements vary between 3.5 to 4.5 mill Kcal/ton of sponge iron. Reliable techniques are available for economical production of reducing gases from various hydrocarbon sources. Gas-re-cycling and re-use of top gas improves the economies. Processes using oil or gas in rotary kilns are under development. Typical processes are shown in Fig. 6.

Sponge iron applications

137. Sponge iron can be used as a feed for iron-making or for steelmaking. Tests carried out in USA, Japan, Canada and USSR indicate that with 30 to 40 per cent reduced pellets in the burden of a blast furnace, output increased by 18 to 23 per cent while coke rate dropped by 18 to 20 per cent. When the saving in coke and increased productivity is high enough to off-set the cost of reduced pellets, their use in blast furnaces would increase rapidly.

138. Rotating kiln plants have been tried to pre-reduce the charge to an electric smelting furnace, in order to lower the power consumption and increase throughout. However, results at Inchon-Korea, Skopje-Yugoslavia and Manazas-Venezuela have been very unsatisfactory, due to problems of kiln build-up, fluctuations in the reduction degree of the product, and carry over of surplus carbon (Table 27).

139. The major successful use of sponge iron has been to replace part of the scrap charge in electric arc furnaces. A number of investigations have been made in various plants with varying proportions of sponge iron. Generally, it can be said that using highly metallized pellet with less than 4 per cent acid gangue and a continuous charging system, the refining time would be reduced (or even eliminated) as compared to all-scrap charges. Also, electric energy would be better utilized. However, with more than 65 per cent sponge iron, productivity may decrease and power consumption increase, due to the increased slag volumes.

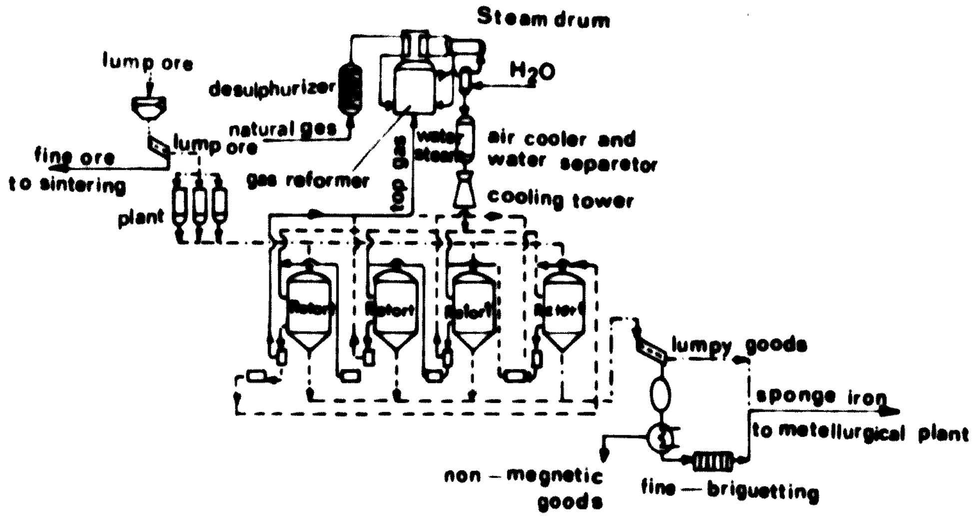
/Table 26:

Table 26: Sponge iron plants with gaseous reductants

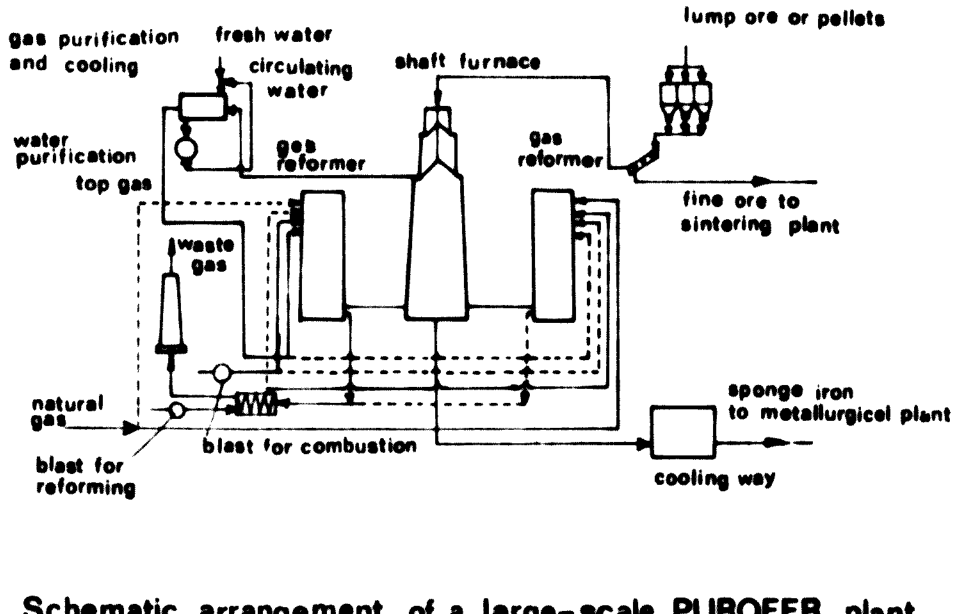
Process	Reduction unit	Plant location	Capacity in operation and commissioning	Capacity under construction
HyL	Retort	Monterrey, Mexico	I 105,000 II 220,000	III 370,000
		Vera Cruz, Mexico	175,000	
		Puebla, Mexico	245,000	
		Balira, Brazil		245,000
Midrex	Shaft	Portland, USA	365,000	
		Georgetown, USA	365,000	
		Louisiana, USA		800,000
		Hamburg, W. Germany	365,000	
		Contrecoeur, Canada		400,000
Armco	Shaft	Houston, USA	320,000	
HIB	Fluidised bed	Puerto Ordaz, Venezuela	1,000,000 a/	
Esso-Fior	Fluidised bed	Guayana, Venezuela		400,000
		TOTAL (May 1973)	3,160,000	2,215,000

a/ Pre-reduced ore for feed to blast furnaces.

Fig Schematic Arrangement of HyL and Purofer Plant



Schematic arrangement of a large-scale HyL plant



Schematic arrangement of a large-scale PUROFER plant

Table 6. Pre-reduction kiln plants for electric smelting furnaces

Pre-reduction process plant & location	Yawata Ariake Iron & Steel Co Japan	Stegie-Udy Orino Steel Plant Matanzas Venezuela	Elkem Rudnici-i-Zelezarnica Skopje Yugoslavia	Highveld Highveld Steel and Vanadium Corporation Witbank, S. Africa	SL/RN Inchon Iron & Steel Co Seoul, South Korea
Plant capacity, tons/year:					
Hot metal	40,000	120,000	540,000	480,000	175,000
Production equipment:					
Rotary kiln - Nos	One	One	Five	Five	One
- Size	3.5 m ∅ x 75 m	3.35 m ∅ x 107 m	4.15 m ∅ x 95 m	4 m ∅ x 60 m	4 m ∅ x 60 m with preheating grate
Smelting furnace - Nos	One	One	Three & Two	Four	One
- Capacity	14 mVA	33 mVA	33 mVA 43 mVA	33 mVA	28 mVA
Raw materials:					
Iron ore - Quality	Beneficiated iron sand Fe - 57% TiO_2 - 12%	Fines concentrate Fe 50-55%	Lump ore Fe - 40-42% SiO_2 - 16-17% Al_2O_3 - 8-9%	Lump ore Fe - 55% V_2O_5 - 1.6% TiO_2 - 13%	Lump ore and pellet Fe - 49-56%
- Size range	N.A.	- 10 m	10 - 40 mm	N.A.	8 - 20 mm
Reductant - Quality	Natural coke F.C. - 73% VM - 5% Ash - 21%	Low grade coal F.C. - 40% VM - 44% Ash - 15%	Dry lignite & Coke F.C. - 35% Ash 10% VM - 45% Ash - 20%	Bituminous coal F.C. - 55% VM - 32% Ash - 12%	Anthracite F.C. - 62% VM - 5% Ash - 33%
- Size range	-15 m	Fines	20-60 mm	-	Fines
Product & usage	Pre-reduced, cold charged	Pre-reduced, hot charged	Upto 95% reduction, hot charged	35% pre-reduction hot charged	70% pre-reduction, cold charged
Start up	1961	1963	1966	1968	1969

Sponge iron production plans in the Philippines

136. The Philippines has many conditions which favour sponge iron production, for example:

(i) An existing electric arc furnace capacity of about 350,000 tons which depends partly on imported scrap;

(ii) The need to expand steelmaking output to meet the demand in the shortest possible time (a blast furnace plant would take 6 or 7 years to commission);

(iii) Existing facilities at PIM/PCP for concentration and pelletization of iron ores together with good potential ore reserves;

(iv) Lack of coking coal;

(v) The need to deploy limited financial resources in an effective manner, so that more steel is available for development at minimum capital investment.

137. It is therefore logical that some RP iron ore mining companies as well as steel mills have been investigating the possibility of putting up direct reduction plants. The regional adviser, accompanied by representative of MIRDC, had general discussions with three such entrepreneurs:

(i) Engineering Equipment Inc: Based upon an idea suggested by its American consultant, EEI has started a P 200,000 pilot programme at the University of Philippines. It is hoped to reduce ore-coke briquettes in an inclined shaft (10' long x 0.75' dia) whose upper half is heated externally by gas and lower part by induction coil. Starting with briquettes of say 84% ore, 10% fine coal/coke and 6% binder, pre-reduced product with 95% total Fe and 1% C is expected, to be used for foundry operations.

Some problems experienced in this type of process and the difficulties of scaling up to commercial application were discussed with the proponents. It is considered useful to pursue research for development of a process to suit local conditions and at the same time to acquaint technologists with the techniques needed. However, any major sponge iron plant in RP must be based on a commercially-proved process.

/ (ii)

(ii) Philmag (Philippines) Inc: It would appear that the following sequence of processes is being planned:

(a) Charge iron sand concentrate (without pelletizing) in rotating kiln with solid reductant (coal) to produce reduced material.

(b) Hot transfer this reduced material to an electric smelting furnace to produce liquid iron and a vanadium-bearing slag.

(c) Attempt to recover vanadium from the slag.

(d) In a separate rotating kiln produce sponge iron from iron sand concentrate.

(e) This sponge iron together with liquid iron from step (b) is to be charged into an electric arc furnace to produce steel, which would be continuously cast to 60,000 tons/year of billets.

This is an ambitious step-by-step programme, involving very substantial investments. Experiences with similar schemes at Ariake-Japan, Orinoco-Venezuela, Skopje-Yugoslavia and Inchon-Korea (see Table 27) have not been happy. This was explained and Philmag cautioned to examine all technical and economic aspects carefully.

Philmag is planning pilot-scale tests in Japan. It is confident that the process problems have been solved by its Japanese collaborator. In order to share this confidence, the test results and a proper feasibility study would need to be examined.

(iii) Marcelo Steel Corp: The company has had negotiations with HyL and Midrex for setting up a sponge iron, arc furnace and continuous casting plant to produce about 400,000 tons/year of billets at Iligan, Mindanao. Some bench scale tests have been conducted by HyL and Midrex on ore concentrate/pellet samples from RP.

The project is similar to that proposed by the regional adviser in this report (Annex VII and VIII). It is considered technically sound and commercially viable.

V. OPTIMIZING THE POTENTIAL AT IISMI

IISMI's plan for back integration to iron-making has remained unfulfilled ... Interest and depreciation charges alone on the expensive unutilized facilities are costing the country one million dollars a month. It is imperative, therefore, that plans for bringing IISMI to a sound viable position receive the highest priority.

Taking into account IISMI's net endowment, this study suggests that plans to install blast furnaces be abandoned, and plans to increase capacity by adding/modifying rolling mills be shelved. Instead, a three-part integration and diversification programme for better and fuller utilization of existing facilities is proposed.

142. The planning of an integrated steel mill in the Philippines in the early-60s represented a bold and worthwhile concept, at a time when local demand was relatively small and capital hard to find. The Iligan Integrated Steel Mills Inc (IISMI) was organized in 1963 to set up this plant. Unfortunately, due to various difficulties and delays, the back-integration to iron-making has not been completed, and the rolling mill facilities installed are being partially operated under government aegis.

Existing facilities

143. Preliminary studies for the integrated mill were initiated in the early-50s and a Government-company National Shipyards and Steel Corporation, set up in 1955 to establish this. However, there were soon pressures to undertake the project as a joint venture with the private sector, and the Government had to finally place the venture entirely in private hands. In 1964 a credit line of US$ 62 million could be secured by IISMI from the Export-Import Bank of the United States. Civil work was started in August 1965, cold-mill facilities completed in end-1968, and hot mill in end-1969.

/The facilities

144. The facilities presently available at IISMI include the following:

- Soaking pits (4 batteries of 4 pits each, partly erected);
- Slab heating furnace (80 tons/hr);
- Combination slabbing/plate mill, 114" wide (capacity 500,000 tons 'break-downs'/yr);
- Single-stand reversing hot strip mill (steckel), 66" wide (capacity 388,000 tons/yr hot coil from break-downs);
- Hot rolled shearing and trimming line, 20" to 60" wide coils;
- Hot rolled slitting line, 20" to 60" wide coils.

- Tandem cold mill, four stand, 66" wide;
- Continuous pickling line, coil weight 30,000 lbs;
- Cold rolled shearing and tinning line, 20" to 60" wide coils;
- Alkali cleaning line, 20" to 38" wide;
- Electrolytic 'Ferrostan' tinning line, capacity 50,000 tons/yr.
- Annealing furnaces, 18 single-stack furnaces and 54 solid-seal bases.

- Electric arc furnace, 25 ton;
- Merchant mill, capacity 70,000 tons/year.

IISMI product-mix

145. The product-mix visualized in the "1967 Plan" was as follows:

Flat products	tons/yr
HR sheet & light plate	70,000
Skelp	60,000
Tinplate	40,000
CR sheet	200,000
Sub-total flats	370,000
Non-flat products	
Bars	10,000
Merchant bars	50,000
Sub-total shapes	60,000
TOTAL	430,000

146. The actual production is indicated in Table 28.

Table 28: IISMI production data

	1969	1970	1971	1972
Metric tons produced				
Billets	--	5,035	34,770	17,938
Steel bars	23,300	24,448	14,832	11,030
Cold rolled coils	17,410	95,437	86,353	567
Cold rolled sheets	14,231	50,781	27,379	5,542
Tinplate	5,271	44,863	29,980	3,179
Hot rolled sheets & plates	2,822	27,571	21,491	5,235
H.R. strip & skelp	1,268	10,292	26,691	4,007
Medium & heavy plates	--	6,976	5,493	--
Hot rolled coils	--	67,043	140,899	--
Total metric tons imported				
Slabs	--	200,790	--	--
Hot rolled coils	172,664	105,785	--	19,708
Cold rolled coils/sheets	--	--	--	--
Billets	--	10,617	--	--

147. The combination mill has never been operated as a two-high reversing slabber, and even its operation as a four-high break-down mill for slabs has stopped since 1971. It is hoped to import slabs again and restart. Operation of other IISMI units for June 1973 - and corresponding annual rates are shown in Table 28A.

/Table 28A

Table 28A: Present operations at IISMI
(in tons)

	Annual Rated capacity	Output June 1973	Annual production rate
Combination mill	500,000	--	--
Steckel mill	388,000	--	--
Tandem mill	260,000	16,267	195,000
Tinning line	50,000	2,545	30,600
Steelmelt shop	60,000	3,421	41,052
Merchant mill	70,000	3,167	38,000

Hot mill capacities

148. The choice of appropriate technology for hot rolling of flat products in developing countries has always been hazardous, due to low initial demands for such products and the enormously high output (and investment) of a modern continuous hot strip mill. IISMI chose the steckel mill which, inspite of its limitations, could play a significant role.

149. If both combination mill and steckel mill at IISMI operate eventually for 20 turns a week and delays represent 20% of scheduled hours, then:

Effective operating hours = 20 turns x 8 hrs x 52 wks x .80
= 6,656 hrs/year

Combination mill: For this exercise it is assumed that the combination mill will only operate in the 4-high configuration starting with suitable-sized slabs, rolling 15 pieces/hr of average 6 tons per piece. If it rolls break-downs for the steckel mill for say 5,656 hours and plate for 1,000 hours, then taking yield of about 87%,

Break-downs	:	90 tons/hr x 5,656 x .87	=	443,000 tons/yr.
Plate	:	90 tons/hr x 1,000 x .87	=	77,000 tons/yr.
		Total		520,000 tons/yr.

/Steckel mill:

Steckel mill: At an approximate average rolling rate of 10 pieces/hr of about 6 tons each, that is 60 tons/hr and 97% yield, the steckel mill would have an output of

Hot bands : 60 tons/hr x 6,656 x .97 = 388,000 tons/hr.

150. The steckel mill capacity would obviously restrict the throughput of the combination mill, which would have to lie idle for almost 2 minutes after rolling a slab down in 4 minutes. Rolling of a plate and a break down alternately may be impracticable.

151. The task now is to put the hot mills back into operation, and get the maximum throughput out of the existing facilities.

The plan for integration

152. Originally it was planned to back-integrate to iron-making in two submerged-arc electric smelting furnaces. Considering the small tonnage of iron required and the very low cost of electric power at Iligan, if the two ELKEM furnaces already purchased had been installed in the 1960s, they might have made a significant contribution to the metallics needed by the RP economy.

153. However, these furnaces still lie (in crates) at Iligan while iron demand has risen to a point where a blast furnace may be more economical. Moreover, the cost of rehabilitating and 'modernizing' 10-year old smelting furnaces may not be justified.

154. The IISMI technical management has drawn up various fresh plans for full integration based on blast furnace, addition of new strip mill, etc.

155 The Atkins study, 1971, proposed that a blast furnace with LD converters (2-120t vessels) and continuous casting be installed at IISMI to provide 234,000 tons of ingots and 222,000 tons of slabs to the IISMI rolling mills (plus 650,000 tons of billets for sale). In phase II, iron and steel-making capacity was to be raised to 2.4 million tons and a new semi-continuous strip mill built.

156. Another two years have gone by but the IISMI dilemma continues.

/IISMI's strengths

IISMI's strengths and weaknesses

157. In order to plan the proper exploitation of IISMI's potential its inherent strengths and weaknesses should be recognized. The advantages of the existing set-up are as follows:

(i) The lowest electric power cost (under 5 mills/unit) in Asia - and among the lowest in the world - due to proximity to the Argus river hydro-electric system. IISMI would have significant advantage over other locations for all power-intensive operations,

(ii) Abundant water from a major river as it enters the ocean - requiring no pre-treatment and permitting a 'once-through' system,

(iii) A cadre of technical managers and operators who have had first-hand experience of the construction and commissioning of a steelworks,

(iv) Built-in provision in water/power distribution systems, pier facilities, and maintenance/storages, which would facilitate expansion. Of the US$ 100 million investment at IISMI, almost $10 million represent such facilities for back-integration.

158. The disadvantages at IISMI are as follows:

(i) Land available is inadequate - only 47 ha in the existing perimeter and perhaps another 50 ha to the south-east. This is a serious limitation, if a major integrated mill is to be planned.

(ii) The site is far from indigenous iron ore deposits. It is also far from the existing Manila area steel market.

159. In the available land area, an integrated plant of about 1 million ton output could readily be built, based on a single blast furnace with requisite material storages, coke ovens, sinter plant, LD shop and additional mills. This could also be expanded marginally. But expansion beyond say 2 million tons is considered to be difficult and expensive.

160. In the context of rising steel demand and to take advantage of recent technology, the site for a new integrated steelworks should be such as could permit rational expansion to 8-10 million tons in future. The IISMI site

/unfortunately does

unfortunately does not have this potential (in this context it may be mentioned that a steelworks with 100,000 ton initial capacity was started in 1906 by the Tata family at Jamshedpur, India, with space provision which permitted expansion to 2 million tons today; the plant is now being further expanded to 4.5 million tons).

Suggested lines of action

161. IISMI has fairly modern flat rolling and finishing facilities, which still await full utilization. The fixed charges (at say 7% depreciation and 10% interest) on the un-utilized facilities are now costing the country over US$ one million per month!

162. Operation of all facilities to near-full capacity and increased sales realisations can be achieved only if IISMI has an assured supply of ingots/slabs from a captive source. This could be realised along the lines of the suggestions below, for consideration:

(i) IISMI should not embark upon blast-furnace iron-making, for which it has no resource endowment.

(ii) IISMI should not, at this stage, spend scarce finances on expanding its rolling/finishing operations, and its plans for (a) converting the present steckel mill to semi-continuous HSM, (b) adding fifth stand to steckel mill, (c) building a new 56" continuous mill, etc. be shelved. These could be considered later when required and if viable.

(iii) IISMI should make a detailed project study for installing electric arc furnaces and continuous casting plant to produce slabs for its flat product mills. The possibility of producing sponge iron should also be given careful consideration. This forms of back-integration would involve relatively small capital and permit better utilization of existing investment.

(iv) Some balancing facilities may be needed at this stage itself (for instance, facilities for handling and finishing longer plates), in order to improve specifications of existing product lines.

(v) The existing 25-ton arc furnace shop (together with the proposed 18 ton furnace) should be converted in future to alloy and special steelmaking. A jobbing bar mill, forging hammers, and finishing facilities for alloy steels could be added.

163. These possibilities are discussed in Annexes VII and VIII. The advantages of starting semi-integrated mill at IISMI together and concurrent with a fully integrated plant elsewhere are brought out in Annex VI. Suggestions for utilizing IISMI's electric smelting furnaces are given in Annex IX.

VI. MATCHING NEW CAPACITY TO FUTURE DEMAND

The Philippines has already lost a precious decade in building up an integrated steel industry. Bold plans are now needed. There may be serious penalties for a diffident approach, less for a dynamic far-sighted steel policy.

The main conclusion of this study is that RP should go ahead with the major blast-furnace-based integrated plant at a suitable location and with an arc-furnace-based shop at Iligan. The future demands justify this approach, technical and economic considerations favour it, and the urgency of making IISMI viable warrants it.

164. In order to build new capacity to satisfy probable steel demand, two alternative schemes are considered:

Alternative I: this consists of starting immediately with construction of a 1.4 million tons steelworks (with single blast furnace) to be fully commissioned by 1979, although part of the rolling mills would start a year earlier.

This plant is then expanded by addition of a second blast furnace to raise capacity to 3.0 million tons in 1982/83.

Alternative II: work is started simultaneously on an integrated steel project of 1.1 million ton capacity (with single blast furnace) to be fully commissioned by 1979, as well as on a semi-integrated plant to produce 400,000 tons/year of slabs/billets at Iligan (based on two large electric arc furnaces) to be commissioned in 1976/1977. At the same time, the existing arc furnace shops are permitted to expand to about 500,000 tons billets/ingots to feed existing bar mills.

The integrated steel plant is expanded by adding a second blast furnace, etc. to a capacity of 2.4 million tons in 1982/83 while the semi-integrated plant could be expanded in future to 600,000 tons/year by adding a third electric arc furnace, when required.

/165.

165. Capacity and phasing of the two alternatives are summarized in Table 29.

Table 29: Alternative production schemes to match steel demand

	Start-up	Capacity, mill tons		
		Total	Flat	Non-Flat
Alternative I				
A - Integrated steel mill	1979	1.4	1.0	0.4
AA - Expansion of above mill	1983	1.6	1.0	0.6
Sub-Total (A + AA)		3.0	2.0	1.0
Existing ingot capacity		0.3	-	0.3
Total		3.3	2.0	1.3
Alternative II				
P - Semi-integrated slab mill (with sponge iron)	1977	0.4	0.4	-
Q - Integrated steel mill	1979	1.1	0.8	0.3
QQ - Expansion of above mill	1983	1.3	0.8	0.5
Sub-Total (Q + QQ)		2.4	1.6	0.8
R - Existing ingot capacity expansion	1976	0.5	-	0.5
Total		3.3	2.0	1.3

166. Figure 7 attempts to show how demands, separately for flat and non-flat products (expressed as slab and billet equivalent), could be met under alternative I and alternative II. It is seen that in alternative II (with integrated and semi-integrated plants) the short-falls are covered somewhat earlier. Even so, imports, particularly of flat products, would be substantial right up to 1982.

167. Suggested product-mix, choice of major facilities and plant capital cost for alternative I is shown in Table 30 and for alternative II in Table 31. The equipment suggested and costs indicated must be considered preliminary and only intended to give a broad comparison of the alternate routes.

/Figure 7

Fig: 7 MATCHING CAPACITY TO STEEL DEMAND

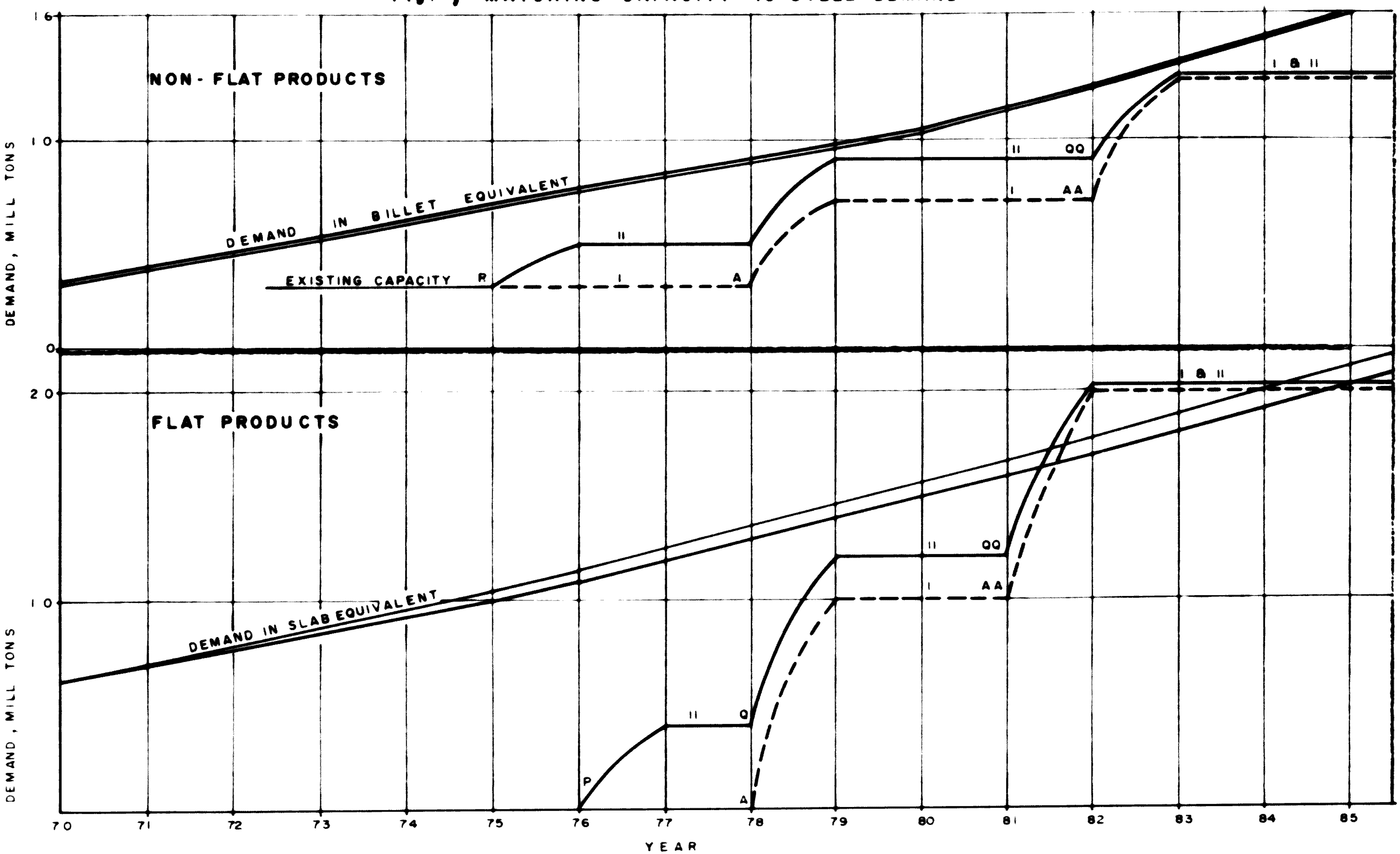


Table 30: Facilities and investment for alt. I (only integrated mill)

A - INTEGRATED MILL

Product mix	Integrated plant (A)	After expansion (AA)
Slabs (to IISMI)	200,000	300,000
HR sheet/coil/skelp	350,000	550,000
CR sheet/coil	300,000	500,000
Plate	-	200,000
Tinning	-	150,000
Billets	400,000	450,000
Merchant products	-	500,000
Total finished steel	1,250,000	2,650,000
Semis equivalent	1,400,000	3,000,000

Facilities		
Coke	Two 60-oven batteries	Four 60-oven batteries
Sinter	One 200 sq. m. machine	Two 200 sq. m. machines
Iron	One 4,300 ton/day bd. ft.	Two 4,500 ton/day fees
Steel	Two 160-ton LD vessels	Three 160-ton LD vessels
Continuous casting	---	Two 2-strand slab
Rolling	One blooming/slabbing mill, One 1,675 mm hot strip mill (semi-continuous), Shearing/trimming line, Tandem CR mill, Billet mill	One blooming/slabbing mill, One 1,675 mm hot strip mill (addl. stands for continuous), Shearing/trimming line Plate mill Cold rolling, annealing temper rolling, cleaning shearing, etc. Electrolytic tinning line, Billet mill, Merchant mill
Plant capital cost (including start-up expenses, training, etc.)	US$ 440 million (i.e. $314 annual ton of semis)	US$ 1,010 million (i.e. $337 annual ton of semis) a/

a/ Higher per-ton cost for the expanded plant is due to the much greater finishing facilities.

/Table 31:

Table 31: Facilities and investment for alt. II (integrated & semi-integrated mills)

Q - INTEGRATED MILL

Product-mix	Integrated plant (Q)	After expansion (QQ)
HR sheet/coil/skelp	370,000	750,000
CR sheet/coil	300,000	450,000
Tinning	-	150,000
Billets	300,000	350,000
Merchant products	-	400,000
Total finished steel	970,000	2,100,000
Semis equivalent	1,140,000	2,400,000

Facilities		
Coke	Two 50-oven batteries	Four 50-oven batteries
Sinter	One 200 sq. m. machine	Two 200 sq. m. machines
Iron	One 3,500 ton/day furnace	Two 3,500 ton/day furnaces
Steel	Two 130-ton LD vessels	Three 130-ton LD vessels
Continuous casting	---	Two 2-strand slab
Rolling	One blooming/slabbing mill One 1,675 mm hot strip mill (semi-continuous), Shearing/trimming line, Tandem CR mill Billet mill	One blooming/slabbing mill One 1,675 mm hot strip mill (addl. stands for continuous), Shearing/trimming line, Plate mill, Cold rolling, annealing, temper, cleaning, shearing, etc. Billet mill, Merchant mill
Plant capital cost (including start-up expenses, training, etc.)	US$ 364 million (i.e. $320 annual ton of semis)	US$ 840 million (i.e. $350 annual ton of semis)

/P - SEMI

P - SEMI-INTEGRATED MILL
(to feed slabs to IISMI)

Output

Sponge iron (% Fe total)	400,000 tons (for self-use)
Slabs	400,000 tons

(Alternatively, 300,000 tons slabs and 100,000 tons billets could be produced.)

Facilities	Capacity (tons/year)
Direct reduction plant (gaseous reductant)	400,000 tons sponge
Two 85-ton electric arc furnaces with 45,000 KVA transformers producing average 7.5 heats/day (using 80 per cent sponge iron, 20 per cent scrap)	420,000 tons liquid steel
Two single-strand slab machines	400,000 tons slabs (with provision for adding third arc furnace and caster to raise output to 600,000 tons of semis/yr.)

Plant capital cost
(including start-up expenses, training, etc.)

US$ 26 million for steel making/continuous casting
US$ 24 million for sponge iron making
US$ 50 million

R - EXPANSION OF EXISTING ARC FURNACE CAPACITY
(to feed billets to existing bar mills)

Output

Billets (75 mm sq. 100 mm sq.)	200,000 tons

Facilities

Assume one 20-ton arc furnace (with 10,000 KVA transformer) is added at each of four existing arc furnace plants, and produces average 7.5 heats/day	212,000 tons liquid steel (total of 4 furnaces)
Conventional ingot casting or double-strand continuous casting	200,000 tons billets

Total capital cost
for expansions — US$ 14 million

/Advantages ...

Advantages of two-pronged approach

168. Starting work on an integrated steel mill and simultaneously on an electric arc furnace shop to utilize the IISMI facilities at the earliest (alternative II) has some significant advantages over a single slightly larger integrated plant (alternative I):

(i) Investments

Capital costs and their phasing are estimated as follows:
(In million US$)

	Alternative I		Alternative II		
	Integrated mill and its expansion (3 mill t)		Arc furnace shop at Iligan (0.4 mill t)	Integrated mill and its expansion (2.4 mill t)	
1974	10		6	8	
1975	85		15	70	
1976	145		20	117	
1977	110		9	95	
1978	70		-	60	
1979	20	110	-	14	95
1980	-	165	-	-	140
1981	-	230	-	-	190
1982	-	65	-	-	51
Sub-Totals	440	570	50	364	476 ($840)
Totals	$ 1,010 mill (i.e. $337 per annual ton)		$ 890 mill (i.e. $318 per annual ton)		

While scale-economies favour the larger integrated plant (3 mill t vs 2.4 mill t) the overall cost is lower in alternative II due to the low investment in the arc furnace/sponge iron shop. Total operating costs in both schemes would be similar, (see Annex VIII).

/(ii)

(ii) Import substitution

As steel would be available to the RP economy two years earlier in alt. II compared to alt. I, the need for imports would be less in the initial years. The production of about 800,000 tons of slabs/billets indigenously would result in a net import substitution of about US$ 75 million in foreign exchange -- that is, almost three-times the foreign currency cost of setting up the plant.

(iii) Dispersal of activity

Starting major activities at two locations, would give considerable impetus to industrialization in the north Mindanao region. At the same time it would reduce concentration in south-east Luzon, with its attendant problems of pollution. Additional employment opportunities would be created at two nucleii for growth.

(iv) Better utilization of IISMI facilities

By providing a captive source of slabs, the existing flat product rolling facilities at IISMI would be insulated from total-dependency on outside sources, and the considerable investment of US$ 100 million in fixed assets put to quicker use.

(v) Spreading of risks

Rather than putting "all billets in one basket", the adoption of two process routes would give better protection and continuity against failures in one plant or the other. Also for strategic considerations, two locations may be better.

The two-pronged approach (alt. II) is recommended for serious consideration, in view of its advantages. The steel demand in 1980 and beyond would justify such a strategy for steel development.

/169.

169. Against the proposed two-plant alternative it could be argued as follows:

(1) The integrated plant itself may be advanced by two years, to 1976/77. However, with the best will in the world, it seems unlikely that such a major undertaking, at a green-field site, requiring collosal engineering and construction inputs, could be completed in 3 or 4 years.

(2) The integrated plant could start with a larger initial capacity (that is, including the output of the semi-integrated mill). However, a single blast furnace for such a large capacity may well be too large when it is the first (and only one) of its kind in the country; on the other hand, adoption of two furnaces would be more expensive.

(3) When the integrated plant starts production, it could send slabs to IISMI at lower costs than producing them at semi-integrated facilities at IISMI. However, estimates in Annex VIII indicate that steel cost at IISMI would be lower than at the initial stage of the integrated mill. Only in 1982/83, when the integrated plant has doubled its output, would its costs be slightly lower.

/VII.

VII. PROPOSED DIRECT REDUCTION/ARC FURNACE PLANT AT IISMI

Large high-powered arc furnaces and efficient slab casting machines would constitute a modern high-production shop. The addition of the sponge iron plant would make IISMI practically self-sufficient in metallics. Supply from this complex of 400,000 tons a year of slabs to the existing combination/steckel mills would enable the company to reach rated capacities. In the next phase, the installation of alloy and special steel producing facilities would give IISMI a diversified, high-value product-mix, further improving its viability.

170. This study proposes that an arc furnace steelmelt shop with continuous casting be installed rapidly at Iligan by 1976/77. Further, to minimize dependence on imported scrap, a direct reduction plant should also be installed by 1977.

<u>Process flow-sheet</u>

171. For the proposed sponge iron plant, either HyL or Midrex processes could be considered. HyL plants have been in commercial operation since 1957 and Midrex plants since 1969. Both claim to achieve a metallisation degree of up to 95 per cent, although HyL plants prefer to operate at around 90 per cent.

172. From the view-point of ore quality, in the Midrex process sulphur should be low (under 0.01 per cent), otherwise recirculation of part of the spent gas through the reformer may poison the catalyst. As no spent gas is passed through reformer in the HyL process, the limit for sulphur could be as high as 0.15 per cent.

173. Typical energy requirements for the two processes per ton of sponge iron are generally reported to be as follows:

	Midrex	HyL
Natural gas, mill BTU/ton	12.5	17.5
Electric power, kWh/ton	135	10

/ As

As electricity is cheap at Iligan and naptha is expensive, energy/fuel costs of the Midrex process would be lower. The final choice of process would depend on negotiations with each process promoter, actual laboratory/pilot plant tests on the selected ore/pellet and careful comparison of technical and economic factors.

174. Two electric arc furnaces of 85-ton heat size each are considered appropriate. They would have 45,000 kVA transformers for high-power operation. Each furnace is expected to average 7.5 heats per day over 330 days of scheduled operating time, to give about 420,000 tons liquid steel per year.

175. For casting slabs of 36" to 60" width and 6" to 8" thickness, two single-strand continuous casting machines are provided. The types of machines to be selected can be decided at the project implementation stage. (Alternatively, one slab machine for about 300,000 tons slabs and one billet machine for 100,000 tons billets could be adopted. In order to be able to cast 3" x 3" billets, one six-strand continuous casting machine would be needed).

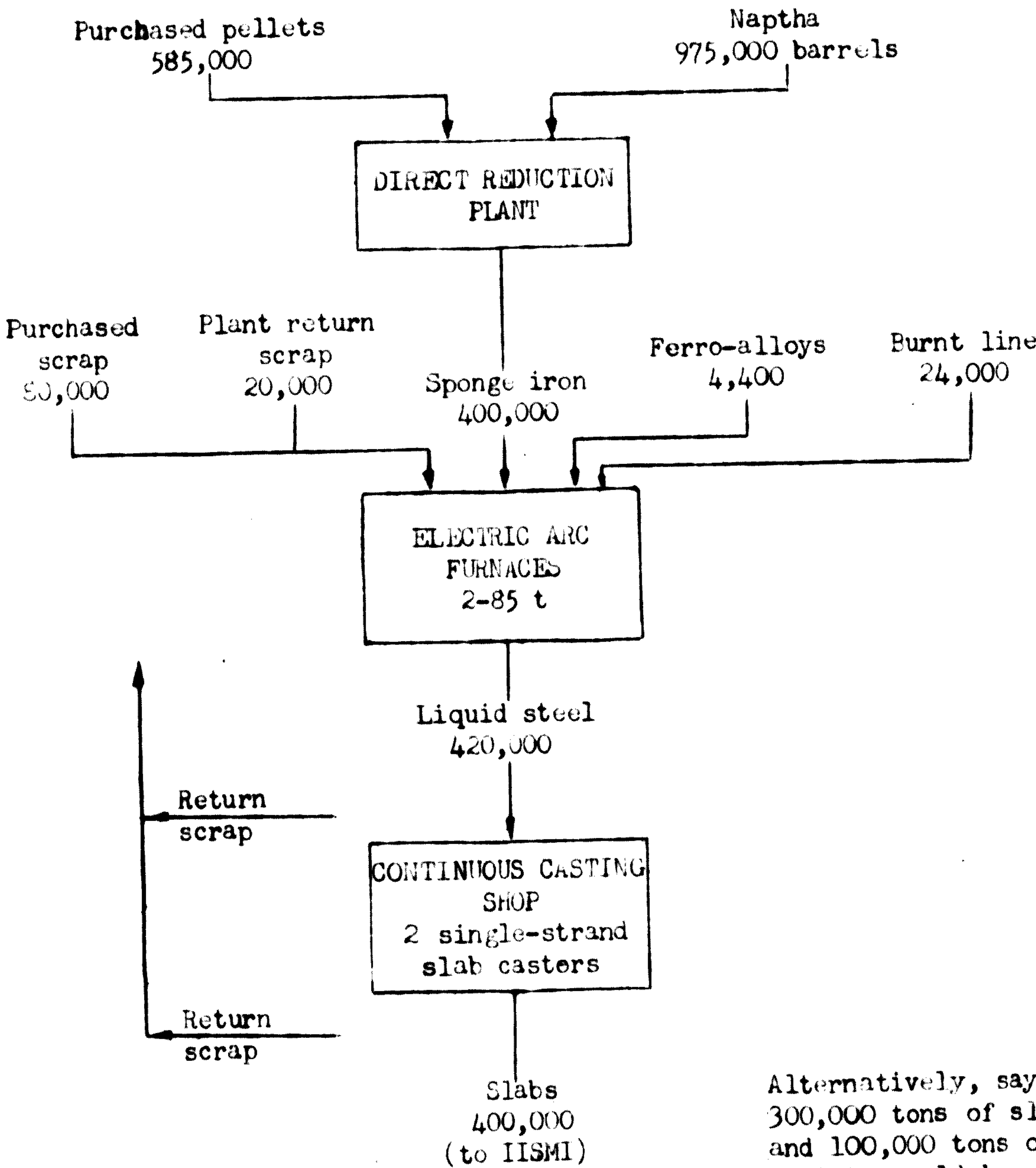
176. A typical materials flowsheet for the proposed plant is shown in Figure 8. A suggested layout for the arc furnace melt-shop is shown in Figure 9.

177. If furnaces of this size are to produce steel of requisite quality and temperature for continuous casting and at a fast tempo, day-in and day-out, then the shop must be carefully designed with full provision for materials handling and maintenance. Facilities for continuous charging of sponge iron and proper preparation of scrap are envisaged. Further, a fume collection and cleaning system of the PA-venturi type is suggested at each furnace, particularly for oxygen-blowing operations.

<u>Provision for expansion</u>

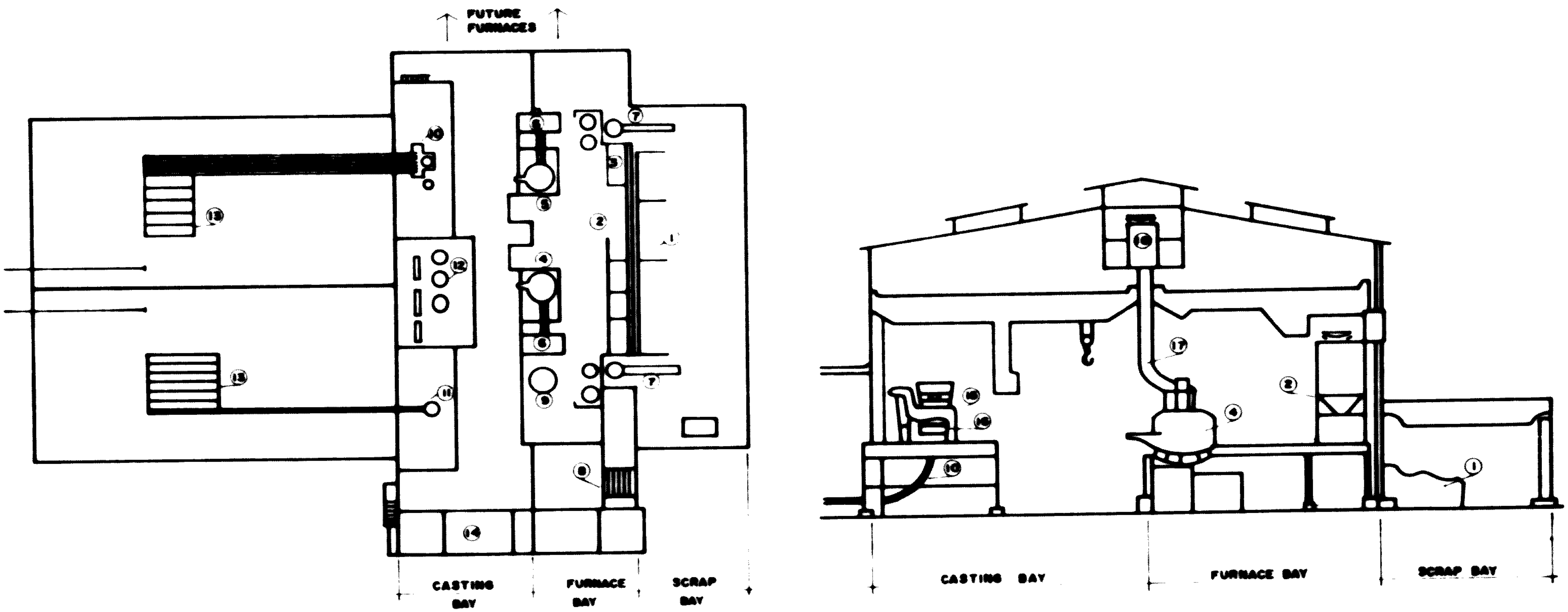
178. The three-bay arrangement of the melt-shop with continuous casting perpendicular to the furnace line is considered desirable for the rational expansion of this plant. Provision must be made in the initial design for

/ adding



Alternatively, say 300,000 tons of slabs and 100,000 tons of billets could be produced.

FIG. 8: FLOWSHEET FOR SEMI-INTEGRATED MILL (based on gaseous direct reduction)



LEGEND

1 SCRAP BINS
2 ADDITION BINS
3 STAGE LABORATORY
4 NO. 1 ARC FURNACE 65 T
5 NO. 2 ARC FURNACE 65 T
6 TRANSFORMERS
7 SCRAP TRANSFER
8 ROOF KNOCK - OUT
9 ROOF RE - LINING
10 BILLET CASTER
11 SLAB CASTER
12 LADLE / TUNDISH REPAIR
13 COOLING BEDS
14 OFFICES
15 LADLE CAR
16 TUNDISH CAR
17 FUME EXTRACTION
18 SPONGE IRON CHARGING SYSTEM

FIG. 9 PROPOSED ARC FURNACE CONTINUOUS CASTING SHOP AT IISMI.

adding a third 85-ton arc furnace and a third continuous caster, in order to raise output to 600,000 tons/year (say 470,000 tons slabs and 130,000 tons billets).

179. Space should also be provided for doubling the capacity of the sponge iron plant to 800,000 tons/year in future. Then, about 600,000 tons could be utilized at the expanded melt-shop, 100,000 tons at the existing 25-ton and proposed 18-ton arc furnaces, and the balance sold to other arc furnace operators.

Raw material requirements

180. For production of 400,000 tons sponge iron per year and 400,000 tons steel semis, the materials needed are shown below:

	Tons/year
Iron ore pellets, tons	585,000
Naptha, barrels	975,000
Purchased scrap (domestic and imported)	100,000
Ferro-alloys	4,400
Burnt lime	24,000

181. Ore: It is assumed that iron ore pellets would be available, partly from indigenous sources and balance from imports, of the following average analysis:

	Pellets, %
Fe	67 - 68
SiO_2	2 - 3
Al_2O_3	1 - 2

To get a high Fe content in the sponge iron, the gangue in the pellets should be as low as possible, preferably total 2-3 per cent. However, due to the lower Fe content of the Larap concentrate, a compromise has to be made.

/ Naptha

182. Naptha: Straight run naptha from one of the RP refineries would be utilised. Approximately 3,000 barrels per day would be required.

183. Scrap: It is proposed to use sponge iron and scrap in a 80 : 20 ratio for arc furnace steelmaking. About 20,000 tons of return scrap would be available from the meltshop/concast plant itself and perhaps another 50,000 tons from the IISMI rolling operations. The balance 30,000 tons would have to be purchased from other domestic sources and U.S./Australia.

184. Product: The sponge iron produced can be expected to have the following characteristics:

	Sponge iron, %
Fe (total)	92
Fe (metallic)	86
Gangue	6
Reduction degree	95
Metallisation degree	93.5

If possible the direct reduction plant should be fed with pellets containing 68% Fe and under 4% gangue, in order that the resultant sponge contains less than 6% gangue.

Plant layout

185. With regard to the location of the sponge iron/arc furnace/concast facilities at IISMI, there are two possibilities:

186. Scheme I: Inside existing IISMI perimeter. This is shown in Figure 10. This has the advantage of short leads from pier to pellet stockyard and naptha tank farm as well as from slab caster to steckel mill slab conditioning.

187. However, it requires the dismantling and re-location of existing warehouses. Further, it tends to 'crowd' the limited space available.

/ Scheme II

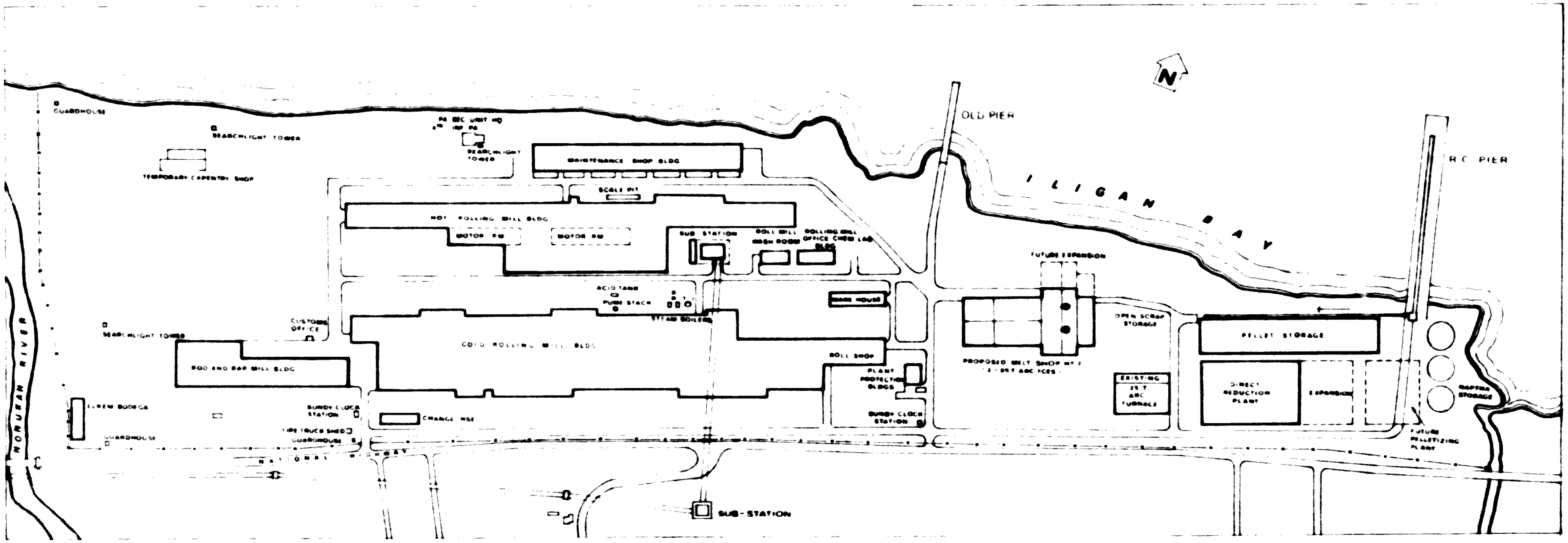


FIG 10

LAYOUT OF PROPOSED SPONGE IRON / ARC FURNACE PLANT

(ALT I - INSIDE EXISTING ISMI PLANT)

188. Scheme II: South-east of existing IISMI plant. This is shown in Figure 11. The advantages of this layout are that it allows more space for initial facilities as well as future expansion. Moreover, there is ample space for installing the existing ELKEM smelting furnaces further south, and materials handling conveyor system could be enlarged to feed these furnaces also.

189. In future, it is suggested that the existing 25-ton arc furnace be converted to alloy steelmaking. Then, the additional facilities needed (conditioning, forge shop, bar rolling and heat-treatment) could be conveniently installed within the plant perimeter (as shown in Figure 12).

190. The location of the 400,000-ton DR/AF plant outside the existing IISMI perimeter is preferred and recommended. A new pier would be needed at west end of the plant (near the existing searchlight tower/carpentry shop) for despatch of all finished rolled products.

Alloy-steel making

191. It is suggested that IISMI give serious consideration to converting its existing arc furnace steelmaking (25-ton and planned 18-ton furnaces) to production of low-alloy machinery steels as well as high-alloy stainless and tool steels (Figure 12). With an average of 5 heats/day these two furnaces could produce about 71,000 tons steel/year. This could be forged/rolled and finished to give 50,000 tons of alloy and special steels.

192. In spite of plans by Marsteel and others, there would be a growing short-fall in alloy steel materials. The cheap electric power available for arc furnaces at IISMI and the sponge iron (with low residuals content) to be produced would be ideal for alloy-steelmaking. The production of high-cost steels would greatly improve the profit-picture at IISMI. Additional investment in the alloy steel project would be about US$ 20 million.

/ IISMI

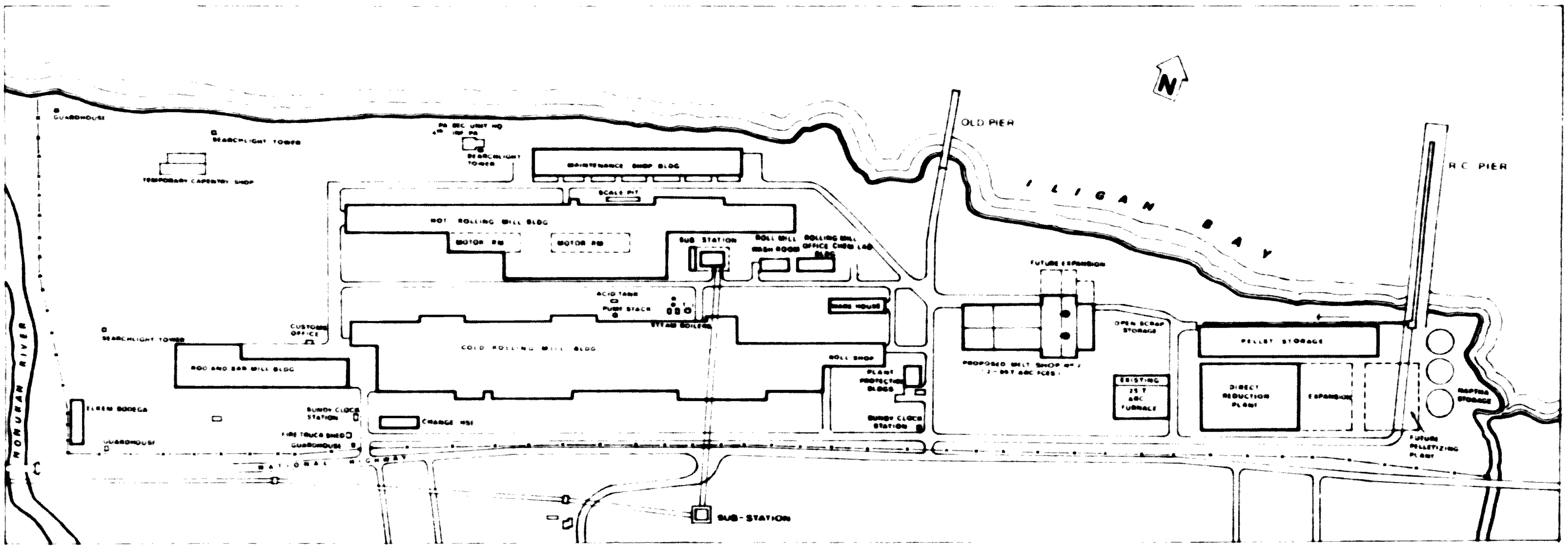


FIG 10

LAYOUT OF PROPOSED SPONGE IRON / ARC FURNACE PLANT

(ALT I - INSIDE EXISTING NSM PLANT)

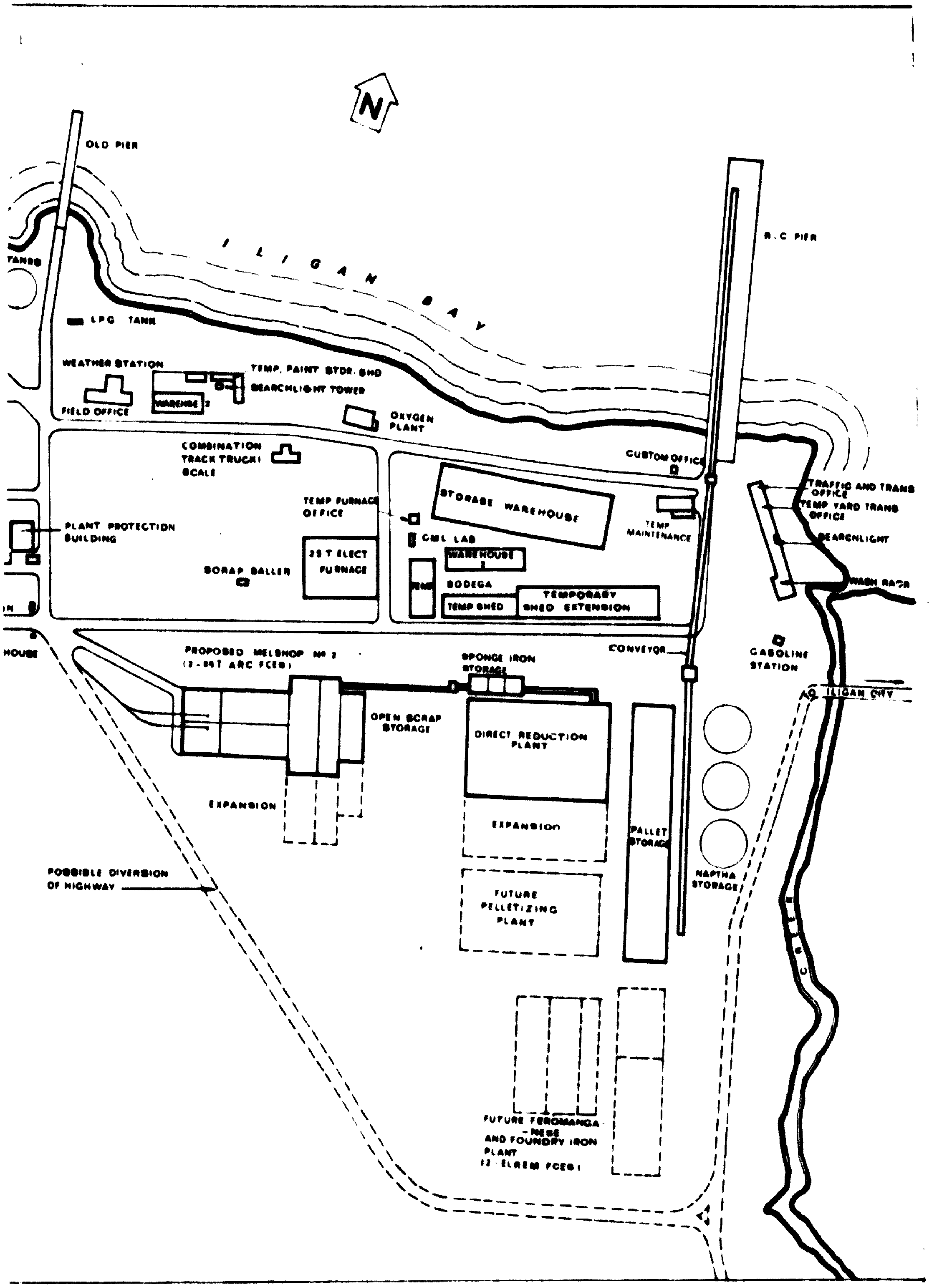


FIG. 11. LAYOUT OF PROPOSED SPONGE IRON/ARC FURNACE PLANT

(ALT. II - SOUTH-EAST OF EXISTING IISMI PLANT)

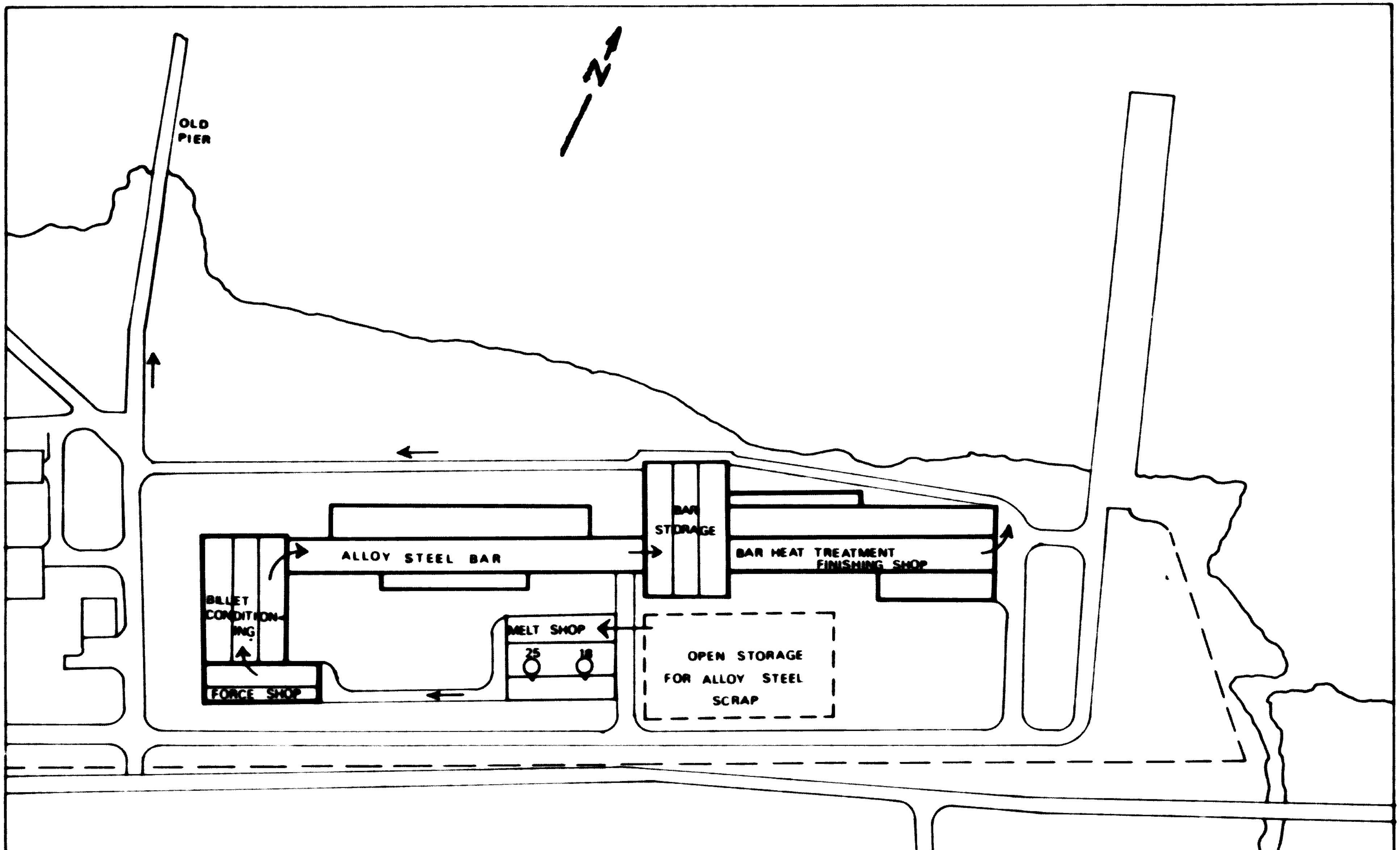


FIG 12 : LAYOUT OF PROPOSED ALLOY STEEL PLANT

IISMI expansion plan

193. On the above considerations, a tentative product-mix is suggested for IISMI (Table 32). This is only one of many possibilities which need to be evaluated in the coming months for the rational back integration and diversification of IISMI.

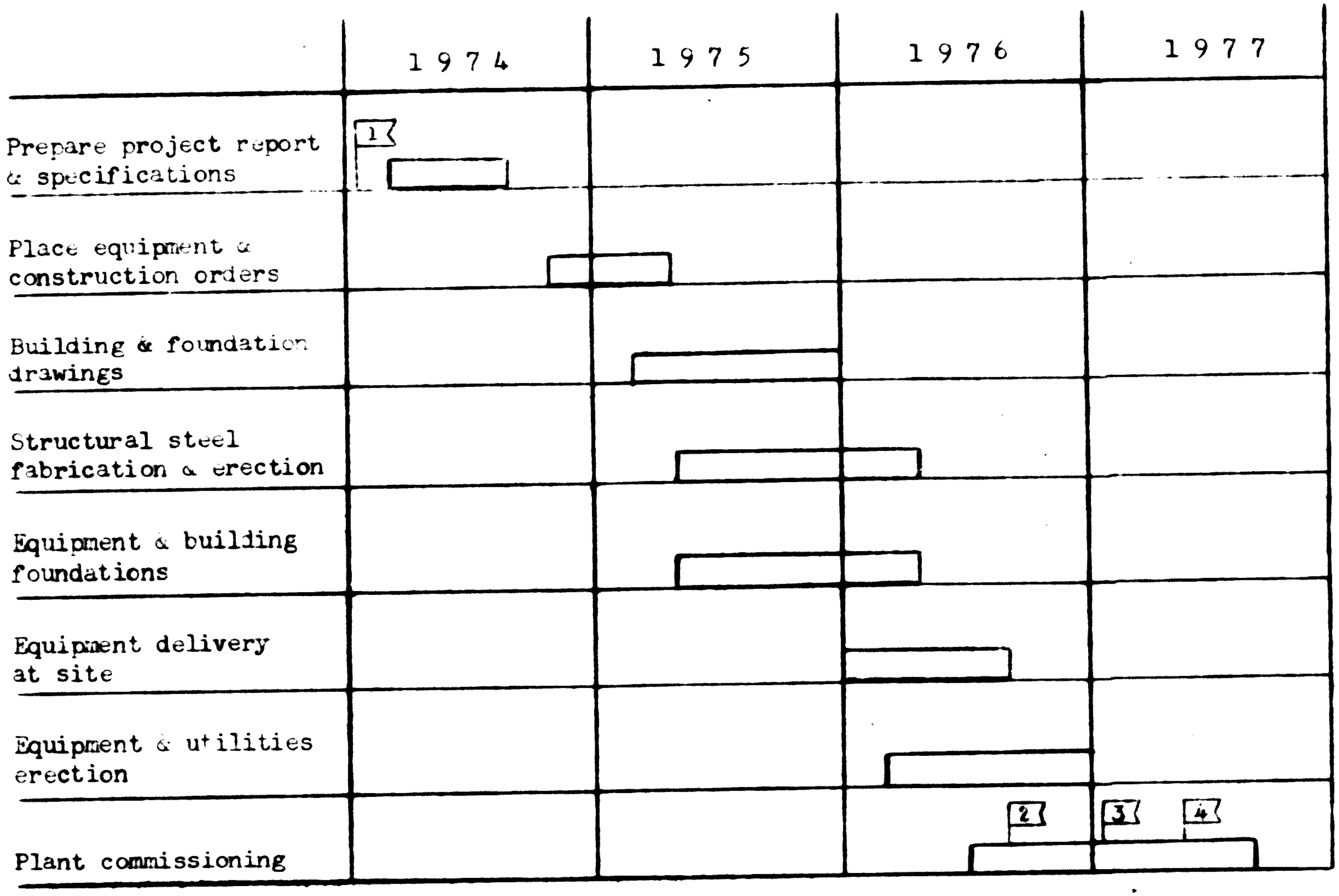
Table 32: Suggested product-mix for IISMI

	Integration Phase I - 1977	Diversification Phase II - 1980
Tonnage steels		
HR sheet & skelp	60,000	100,000
Plate	50,000	60,000
Tinplate	40,000	50,000
CR sheet	180,000	190,000
Sub-total flats	330,000	400,000
Bars & rods	80,000	100,000
Total tonnage steels:	410,000	500,000
Special steels		
Carbon & alloy structural		30,000
Spring steels		10,000
Bearing steels		5,000
Alloy tool steels		5,000
Total special steels:	-	50,000
Total tonnage & special steel:	410,000	550,000

Construction schedule - Phase I

194. Figure 13 shows the possible phasing of major activities on the proposed DR/AF plant at IISMI. A plant of this type can be constructed in two years after equipment orders. Before orders are placed, a year may be needed for project investigations, financing arrangements, etc.

FIG. 13: SCHEDULE FOR SEMI-INTEGRATED PLANT AT IISMI



1. Start detailed planning work
2. Start first arc furnace & c.c. m/c
3. Start second arc furnace & c.c. m/c
4. Start sponge iron plant

195. It is considered necessary that the design specifications, layout and construction supervision are undertaken by independent technical consultants in order that the plant is completed on schedule and within budgeted costs.

196. The first 85-ton arc furnace and one c.c. m/c could be commissioned by about mid-1976, followed a few months later by the second furnace and second c.c. m/c. Finally, the sponge iron plant could be started up by about mid-1977. All units should reach full rated capacity by end-1977. This tight schedule requires firm decisions to go ahead with this IISMI Back Integration Project (Phase I) by January 1974.

/ VIII.

VIII. COSTS AND PROFITABILITY OF DIRECT REDUCTION/ARC FURNACE PLANT

The profitability estimates indicate pre-tax returns of 24.7 % on total investment for the semi-integrated plant with sponge iron. Value added represents 48 % of sales realization and foreign exchange component is 35 per cent.

... If scrap price comes down or if Government would like to wait another year before committing itself to a sponge iron process, then work could still go ahead on a 400,000 ton arc furnace shop at IISMI. Profitability may be slightly lower, but IISMI would still be greatly benefited.

197. Estimates are presented in this annex for capital and operating costs of the direct reduction/arc furnace (DR/AF) route. Costs are estimated separately for steelmaking and for direct reduction, in case it is decided to back-integrate. But the steelmaking project may be viable without sponge iron, and may well precede it.

198. Costs of the semi-integrated route are then compared with those at a large fully integrated steelworks based on blast furnace. It must be emphasised that these estimates are preliminary; definitive figures require a project study based on the finally selected location, capacity, raw material sources, etc. In this study the exchange rate has been taken as US $ 1 = P. 6.66.

Capital cost

199. Capital costs are shown in Table 33 for arc furnace/continuous casting plant and separately for the sponge iron plant,

200. Engineering and administration costs are provided at about 5 per cent of plant cost and contingencies at 10 per cent. Pre-operational expenses to be capitalised include promotional costs, training and

/start

start up. Interest during construction is provided on foreign and domestic loans incurred year by year.

Table 33: Preliminary capital cost estimates for semi-integrated mill (400,000 tons semis/year capacity) (in U.S. dollars)

	Arc furnace/ con-cast plant	Sponge iron plant	Total sponge iron/ arc furnace/ con-cast plant
Equipment as erected	9,200,000	10,800,000	20,000,000
Civil and structural works	8,550,000	9,300,000	17,850,000
Plant cost	17,750,000	20,100,000	37,850,000
Engineering and administration	890,000	1,000,000	1,890,000
Contingencies	1,860,000	2,100,000	3,960,000
Total plant cost	20,500,000	23,200,000	43,700,000
Pre-operational expenses	400,000	300,000	700,000
Interest during construction	3,100,000	2,500,000	5,600,000
Total investment	24,000,000	26,000,000	50,000,000
Working capital	10,360,000	-	8,020,000
TOTAL CAPITAL EMPLOYED	34,360,000	26,000,000	58,020,000

201. It is estimated that 55 per cent of total investment will be in foreign currency, the balance in pesos.

Total investment per annual ton comes to the following:

	$ 60	per ton semis for steelmaking and continuous casting
	$ 65	per ton sponge iron for direct reduction plant
Total	$ 125	per ton semis for direct reduction and steelmaking.

/ Material costs

Material costs

202. For preparing preliminary production cost estimates, the costs of major materials and supplies have been derived in Annex III and summarized in Table 34

Table 34: Costs of major materials and supplies at site (in US dollars per ton)

Item	Cost
Iron ore pellets	18.00
Naptha, per mill BTU	0.742
Scrap purchased (average domestic and imported)	80.00
Limestone	3.00
Burnt lime	18.00
Electrodes	500.00
Ferro-silicon (78%)	350.00
Ferro-manganese (78%)	250.00
Electric power, per kWh	0.007

Manpower

203. The proposed plant would have a labour force as follows:

Direct reduction plant	50
Steel melt shop	110
Continuous casting	55
Sub-total production	215
Materials/scrap yards	45
Utilities and services	90
Maintenance	95
Administration	75
Sub-total services	305
TOTAL	520

/Distribution

204. Distribution of the services staff can be taken as 40% for direct reduction plant and 60% for melt-shop/concast plant.

205. Typical salaries and wages, with all perquisites, are estimated to be as follows: The average cost taken of $ 0.50 per man-hour is substantially higher than current costs of IISMI, which can be expected to rise in future.

	P/month	US$/month
Plant director	5,000	750
Chief engineer	3,500	525
Departmental superintendent	1,800	270
Foreman	1,000	150
Chemist/inspector	700	105
Skilled worker	550	84
Unskilled worker	260	39
Average cost per steel worker, per month	625	94
Average hourly cost	3.13	0.47 (say $ 0.50/hr)

Production costs

206. Table 35 gives the works cost of producing sponge iron. It will be noted that iron ore and naptha are the main cost components, accounting for 66 per cent and 23 per cent respectively of the works cost of $ 40 per ton sponge iron.

207. Effects of varying naptha and pellet prices on sponge iron costs are shown in Fig. 14. If pellets of requisite quality could be secured from PCP/PIM at say $ 17 per ton (instead of $ 18 assumed), there would be a reduction of $ 1.46 in sponge iron cost.

208. If price of naptha rose to say $ 5 per barrel (against the estimated present level of $ 3.85, that is, a rise of 30 per cent), then total sponge iron cost (including fixed charged) would increase from $ 51 to $ 53.8 per ton, that is, a rise of 5.5 per cent.

/Table 35

Table 35: Preliminary production cost estimate for sponge iron
Basis: 400,000 tons sponge/year

	Price/ton material ($)	Consumption/t (kgs)	Cost/t ($)
Cost of materials			
Iron ore pellets	18.00	1,460	26.28
Naptha, mill BTU	0.742	12.5	9.28
Materials cost			35.56
Cost above materials			
Labour and supervision, man-hours	0.50	1.00	0.50
Electric power, kWh	0.007	135	0.95
Water, cu. m.	0.08	10	0.80
Maintenance materials			0.90
Chemicals			0.20
Royalty/technical assistance			0.65
General plant expense			0.50
Cost above materials			4.50
Works cost of sponge iron (excluding fixed charges)			40.06

209. Costs of producing semis (billets or slabs) are estimated in Table 36 for two alternatives, namely, using a 100% scrap charge at the current high scrap prices, and with 20% scrap: 80% sponge iron in case it is decided to go in for a direct reduction plant.

210. The main component of billet cost is metallics (scrap constituting 92% of total for all scrap operation, and scrap/sponge constituting 73% in the second case). As scrap cost assumed is twice that of the estimated sponge iron cost, the works cost of billets by the all-scrap route is significantly higher. But when fixed charges on investment are added, the cost difference is reduced.

/Figure 14

Fig: 14 EFFECT OF VARYING NAPTHA AND PELLET PRICES ON SPONGE IRON COSTS

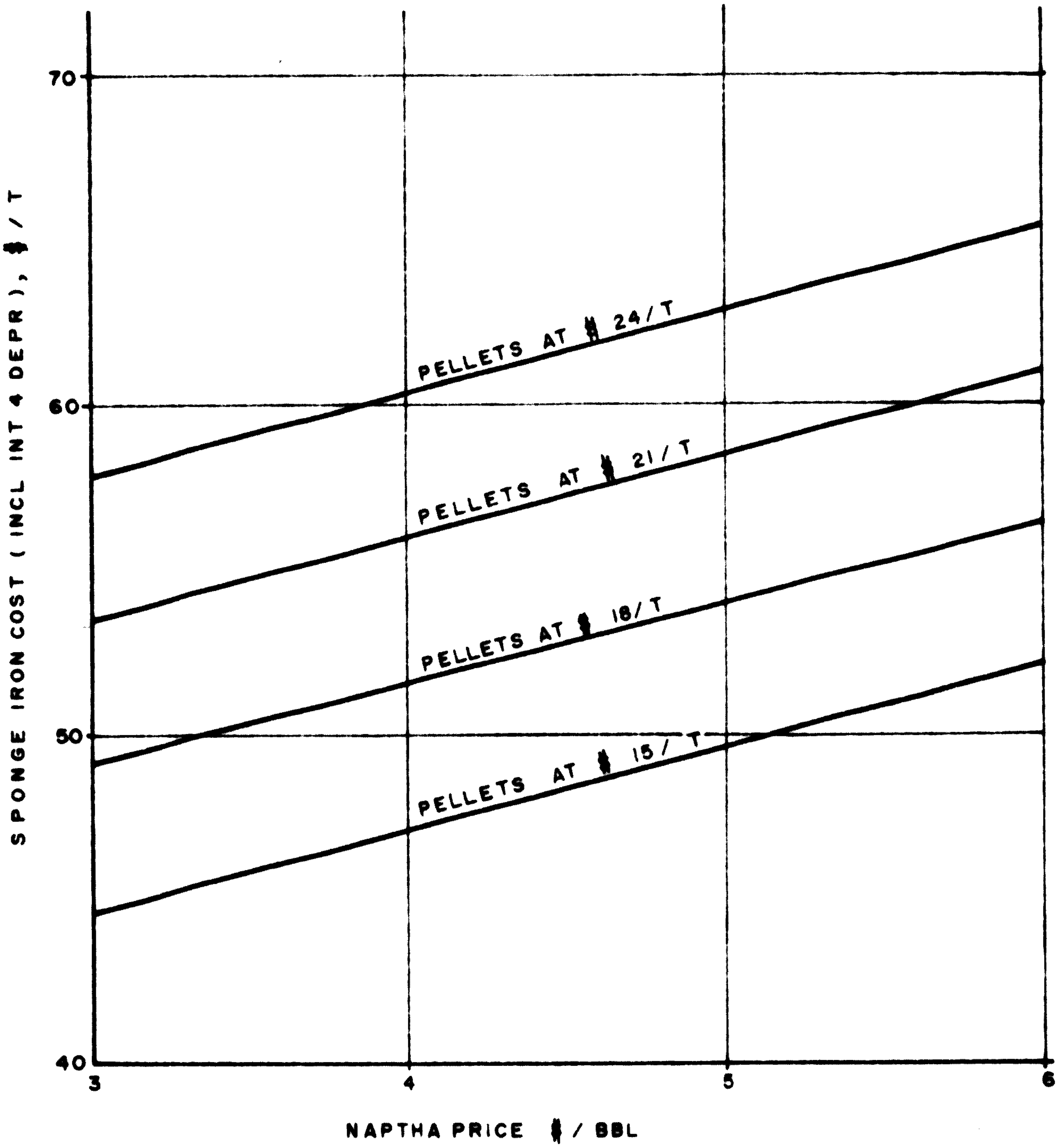


Table 36: Preliminary production cost estimates for steel semis
(steelmaking and continuous casting)
Basis: 250,000 tons/year slabs
150,000 tons/year billets

	Price/ton material ($)	All-scrap charge Consump-tion/t (kgs)	All-scrap charge Cost/t ($)	80% sponge, 20% scrap Consump-tion/t (kgs)	80% sponge, 20% scrap Cost/t ($)
Costs of materials					
Sponge iron	40.06	-	-	1,000	40.06
Scrap	80.00	1,150	92.00	250	20.00
Ferro-manganese	250.00	8	2.00	8	2.00
Ferro-silicon	350.00	3	1.05	3	1.05
Burnt lime	18.00	35	0.63	60	1.08
Others			2.44		3.04
Sub-total			98.12		67.23
Less scrap credit	80.00	50	(-4.00)	50	(-4.00)
Net materials cost			94.12		63.23
Electric power, kWh	0.007	575	4.03	655	4.59
Electrodes	500.00	6	3.00	7.25	3.63
Total materials & power			7.03		8.22
Cost above materials					
Labour & supervision	0.50	2.0 m-hr	1.00	2.1 m-hr	1.05
Maintenance materials			2.60		2.60
Utilities and services			2.00		2.00
Refractories (furnace, ladle and tundish)			2.30		4.00
General plant expense			0.90		0.90
Cost above materials			8.80		10.55
Work cost of semis (excluding fixed charges)			109.95		82.00

/It is

211. It is interesting to compare sponge iron and steel costs estimated in this study with those in the Atkins report (1971) for the Philippines:

	Atkins study (1971)	This study (1973)
Process	SL/RN	Midrex/HyL type
Capacity	1,000,000 t/yr.	400,000 t/yr.
Materials costs		
Ore	$13.25/t fines	$18/t pellets
Reductant	$15/t coal	$0.742/mill BTU naptha
Electric power	$0.010/kWh	$0.007/kWh
Production costs	$/ton	$/ton
Sponge iron	31.77	40.06
Steel	60.90	82.00
Capital charges	19.50	21.15
Total steel cost	$80.40 (liq. steel)	$103.15 (billets)

212. The processes adopted and other assumption made are different, Unfortunately, the Atkins study gave no consideration or estimates for gaseous reduction processes.

Depreciation and interest charges

213. In consultation with MIRDC, the following assumptions have been made:

(1) Long-term loans in foreign currency would be available at 9 per cent per annum and in local currency at 11 per cent. As the foreign exchange component of investment is taken at 55 per cent of total, the average interest rate would come to around 9.9 per cent.

/(2)

(2) Depreciation is taken on straight-line basis at average 7 per cent per year, on the basis of 15-year average life of the plant and facilities.

214. Costs including depreciation and interest would be as follows:

	All scrap charge ($/ton)	Sponge/scrap charge ($/ton)
Sponge iron		
Works cost	-	40.06
Depreciation @7%	-	4.55
Interest @9.9%	-	6.45
Cost of sponge (incl. fixed charges)	-	$51.06
Semis (billets/slabs)		
Works cost	109.95	82.00
Depreciation @7%	4.20	8.75
Interest @9.9%	5.94	12.40
Cost of semis (incl. fixed charges)	$120.09	$103.15

Effect of scrap price on alternative routes

215. Due to the current high price of scrap, the all-scrap arc furnace route is more expensive than use of sponge iron. If the same analysis had been made a year ago, when imported scrap price was only half of that today, the sponge iron route may not have been justified.

216. It is difficult to tell how international scrap prices would behave in the future. Fig. 15 gives the effect of varying scrap prices on total cost of semis. This indicates that if and when the price of purchased scrap (average of imported and available domestic) falls below $60 per ton, the use of sponge iron may not be economically attractive. At average scrap prices over $60, direct reduction warrants serious consideration under the condition of this study for RP.

/Figure 15

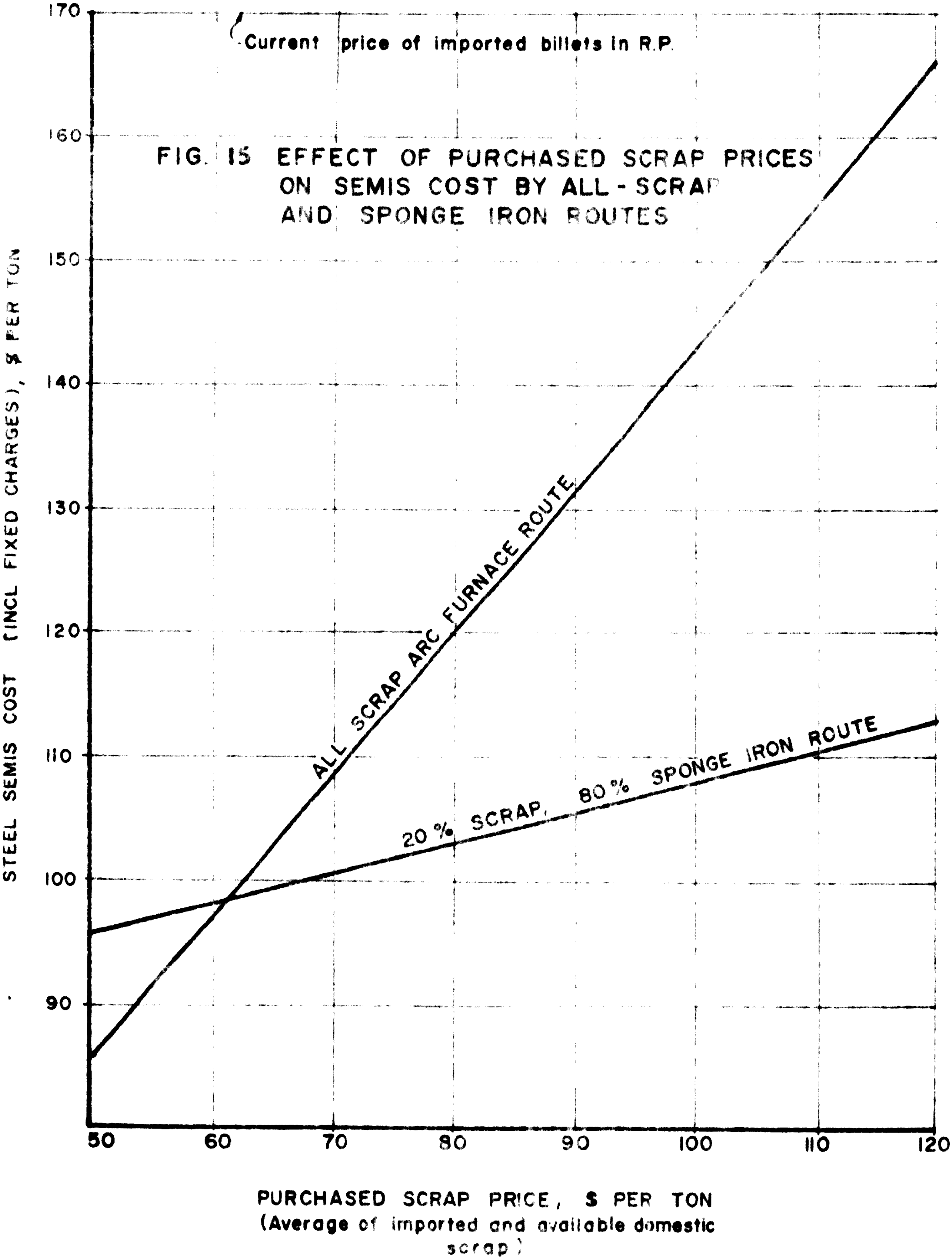


FIG. 15 EFFECT OF PURCHASED SCRAP PRICES ON SEMIS COST BY ALL-SCRAP AND SPONGE IRON ROUTES

Possibilities of reducing sponge iron cost

217. As noted earlier, cost of iron ore pellets and naptha have predominant effect on production cost of sponge iron. Depreciation and interest charges on investment are also significant but unless there is a major break-through in technology (or unless plants of one million ton sponge iron and over can be successfully operated) there may not be much chance of reducing capital costs below about $ 60-65 per annual ton.

218. The effect of varying iron ore pellet and naptha costs on sponge iron cost at the proposed plant has been discussed. Quick estimation of sponge costs can be made from Figure 14 with pellet prices varying from $15/ton to $24/ton, and naptha prices from $3 to $6/barrel.

219. If both iron ore pellets and naptha prices rose simultaneously by 50 per cent over presently estimated levels, then cost of sponge iron would rise to around $ 65 per ton, which is still lower than present price of $ 80/ton for purchased scrap. Conversely, in order to reach present scrap prices, cost of naptha for sponge iron making would have to rise to $ 6 per ton and iron ore pellets to $ 28 per ton.

220. It must be noted that scrap, which contains over 99% Fe, is better charge material for tonnage steelmaking than sponge iron, which may contain only 90% Fe. If purchased scrap price is taken at $ 80, then sponge iron would have to cost $ 72 for comparable metallic content.

Estimate of profitability

221. In order to evaluate the profitability of the composite DR/AF project, the following additional assumptions have been made:

(1) Pre-operational expenses and interest during construction are amortized in equal installments over 15 years, in the same manner as the plant cost.

(2) Equity to loan ratio is taken as 1:5 for financing the project. Thus, equity is $8.33 million and

/loan

loan \$41.66 million. In addition, working capital is borrowed.

(3) Working capital is provided for (a) 2 months stock of iron ore pellets, scrap and consumables, and half-months stock of naptha, (b) 1 month stock of sponge iron, and (c) 1 month stock of semis. It is assumed to be borrowed at short-term commercial rates of 14 per cent per annum.

(4) Selling price of semis. Due to the present global shortage of steel, semis are generally not available and prices are very high. Billets from Australia for import to RP have been quoted (July 1973) at \$145-150 C&F. Allowing 10% tariff, 2% commission, and port charges of P.20/t, landed price approaches \$170/ton. Foreign domestic prices for re-rolling billets last month (June 1973) were as follows:

	US	UK	Australia	Japan
Billets, \$/t	138.60	130.23	128.88	no quote

222. If a 'fair selling price' were taken as the current domestic price in say Australia plus freight to Manila, this would come to around \$140/ton. (This would also be in correspondence with the high price of \$100/t assumed in this study for imported scrap).

223. However, it should be noted that steel prices are notoriously volatile, thus, average C & F billet prices in the Philippines have been as follows:

	1969	1970	1971	1972	1973
Billets, \$/ton C & F Manila	72	132	94	96	145

/For a

224. For a conservative profitability estimate, selling price of slabs and billets is taken at $135 per ton, ex-works.

225. Based on the above, the profitability is estimated in Table 37 with the following clarifications:

Value added is taken as the difference between sales realisation and costs of materials and supplies.

Foreign exchange component of production cost is taken as cost of imported raw materials plus foreign exchange component of depreciation plus interest on foreign loan. The cost of naptha is taken as being incurred in foreign exchange while half the cost of pellets is in foreign exchange, the balance being procured from PIM/PCM.

226. It is seen that due primarily to high scrap prices, the use of sponge iron for steelmaking shows better profitability. Pre-tax earnings on total investment are 24.7% and on equity 148.5%. Value added is 48% of sales realisation, and foreign exchange constitutes about 35% of selling price.

227. The largest single item in manufacture of semis is the cost of iron ore pellets, which has been taken at an average (from imported and domestic sources) of $18 per ton. Another significant variable is the selling price assumed for semis. Fig. 16 shows the effect of varying these two factors on the return on total investment.

Comparison with integrated steel mill

228. It is of course essential that engineering industries in the Philippines are not penalised in future by having to use high-priced locally-produced steel, as this would raise prices of a wide range of products, both in domestic and export markets. Steel produced at Iligan should therefore be competitive with steel from a fully integrated mill.

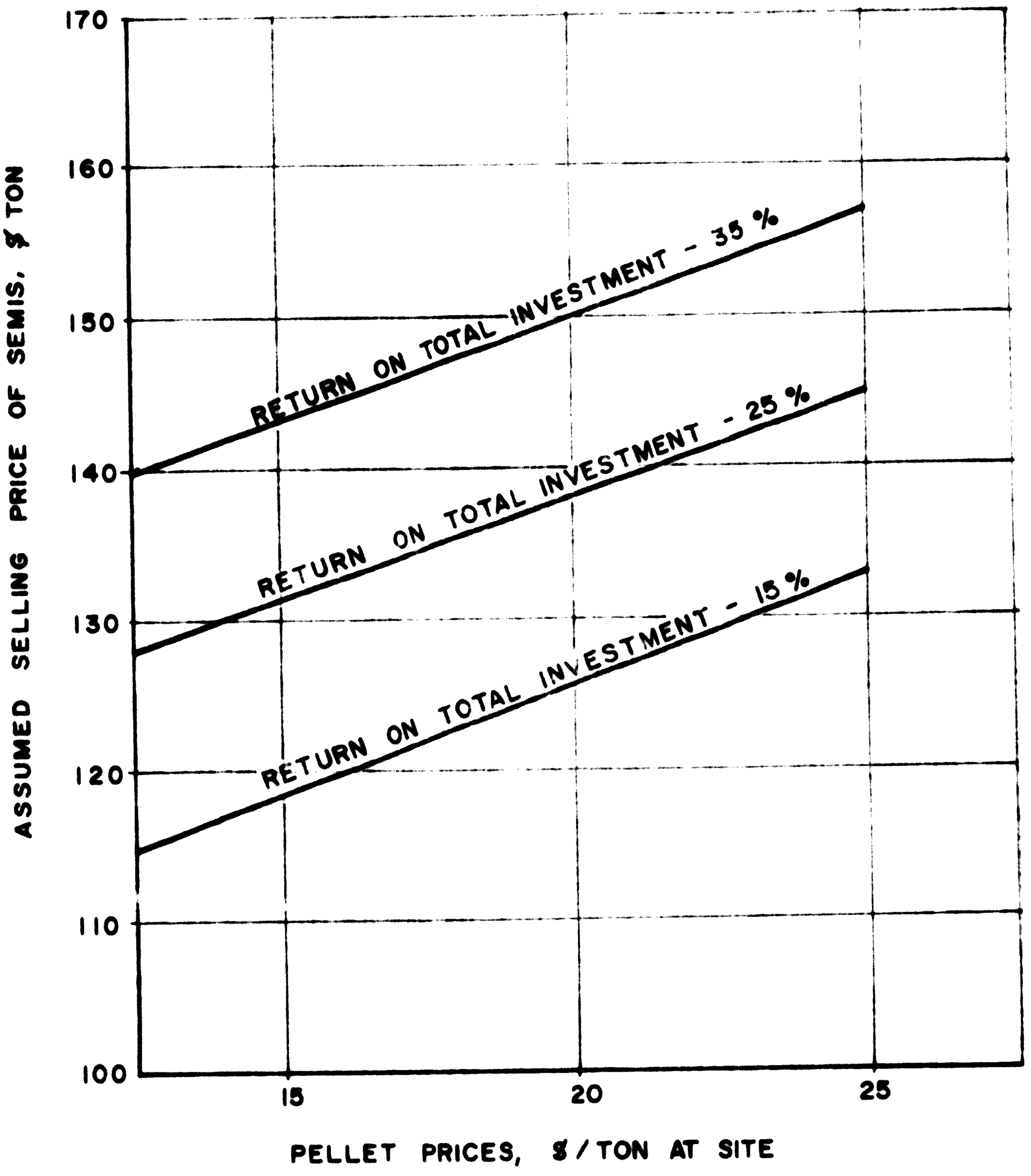
/Table 37

Table 37: Profitability Estimates
(in thousand US $)

	Arc furnace and cont-casting (all scrap charge)	Direct redu/arc/fce/ and cont-casting (sponge/scrap charge)
Total investment	24,000	50,000
Share capital	4,000	8,330
Sales volume, tons	400,000	400,000
Income (@ $135/t semis)	54,000	54,000
Cost of production	43,980	32,800
Other expenses/charges		
Administration	96	96
Interest on working capital	1,590	1,120
Depreciation on investment (incl. pre-operational expenses)	1,680	3,500
Interest on long-term loan	1,980	4,125
Total cost	49,326	41,641
Earnings (before taxes)	4,674	12,359
Pre-tax earnings/share capital	116.9%	148.5%
Pre-tax earnings/total investment	19.5%	24.7%
Pre-tax earnings/sales	8.7%	22.9%
Value added	13,200	25,976
Value added/sales	24.5%	48.0%
Foreign exchange component of production cost	22,110	18,795
Foreign exchange/sales	40.8%	34.8%

/Figure 16

FIG. 16 EFFECTS OF VARYING PRODUCT SELLING PRICES & PELLET PRICES ON PROFITS.



229. Table 38 estimates the production cost of semis produced at an integrated steel mill under conditions as in RP, using the same raw material prices and other assumptions for the proposed semi-integrated mill at Iligan. Works cost is estimated at $ 75.49 per ton, based on imported coal at $ 26, lump ore at $ 16 and ore fines at $ 14.

230. It is estimated that fixed investment up to the semis-stage only would be $ 190 million (out of the total investment of $ 364 million for the complete 1.14 million ton integrated mill), that is $ 167 per ton of annual capacity. Taking 17% interest and depreciation charges, the total production cost (incl. fixed charges) is $ 103.88 per ton semis. Assuming that this integrated plant is sited at Lemery and adding $ 2 per ton for freight charges from Lemery to Iligan, the semis would cost $ 105.88 ex-IISMI steckel mill. This would be higher than the cost of $ 103.15 of slabs produced at a semi-integrated plant at Iligan itself.

<u>Economies of scale</u>

231. The Japan/AIDC report (1969) gave rough indication of the economies of scale in integrated steel mills. Up to the billet stage, these estimates would be as follows:

Plant size, t	0.25 mill	1 mill	2 mill	3 mill
Investment, $ per annual t (up to billet stage)	170	136	117	110
Works cost of billets, $ per ton	72	68.70	64.40	63.30

232. The estimate made in this 1973 study of works semis cost of $ 75.49 per ton is 10 per cent higher than the 1969 estimate of $ 68.70. The investment cost estimate in this study is 23 per cent higher. This is not surprising in view of the large escalations that have taken place in the last 4 years.

/Table 38

Table 38: Estimate of production cost at integrated steel mill
Basis: 1.14 million tons semis/year

IRON (Blast Furnace)	Price/ton material ($)	Consumption/t steel (kgs)	Cost/t ($)
Cost of materials			
Ore	16	490	7.85
Sinter	15	1,200	18.00
Coke	38	500	19.00
Heavy oil	22	50	1.10
Sub-total			45.95
Less credit for gas			(- 2.50)
Net materials cost			43.45
Cost above materials			
Labour & supervision			0.40
Utilities, repairs, refractories			5.60
General plant expense			1.20
Cost above			7.20
Works Cost of Iron			50.65
STEEL SEMIS (LD and blooming mill)			
Cost of materials			
Hot metal	50.65	890	45.08
Scrap	80.00	280	22.40
Ferro-alloys			2.30
Burnt lime	18.00	70	1.26
Misc. materials			0.50
Sub-total			71.54
Less credit for scrap	80.00	60	(- 4.80)
Net materials cost			66.76
Cost above materials			
Labour & supervision			0.65
Utilities, repair, refractories			6.60
General plant expense			1.50
Cost above			8.75
Works Cost of Semis			75.49
Fixed charges @ 17% on $ 167			28.39
Total cost of semis (incl. fixed charges)			$103.88

/Using

233. Using the above cost data, the curve in Fig. 17 have been prepared to show the scale economies at the proposed semi-integrated and fully integrated plants. At lower plant capacities (under 2 million tons) production costs at the semi-integrated plant are much lower than at a fully integrated plant of the same output. Costs at the integrated plant drop sharply and become lower when it has reached a capacity of about 2.3 million tons and over.

234. The above 'cross-over' point is in accordance with similar comparative studies made in other countries. Detailed analysis by the British Steel Corporation[a/] showed that under UK conditions (with similar coking coal and ore prices but higher electric power price), the cross-over point was at 1.5 million tons. In the Philippines, with lower electric power rates, the semi-integrated plant remains viable upto a slightly higher capacity.

235. To reiterate, when the integrated plant expands in its second phase (to say over 2 million tons by 1982) its production cost would be lowered to $ 97, enabling it to deliver slabs to IISMI at a price ($ 99) lower than that at a 400,000 ton semi-integrated plant at Iligan itself. If, however, steelmaking at Iligan were also allowed to expand, this price differential would become less and not significant.

a/ R. Scholey, Present Situation Regarding Pre-reduced iron ore and Coke-making Technology, IISI 1972 Report of Proceedings.

/Figure 17

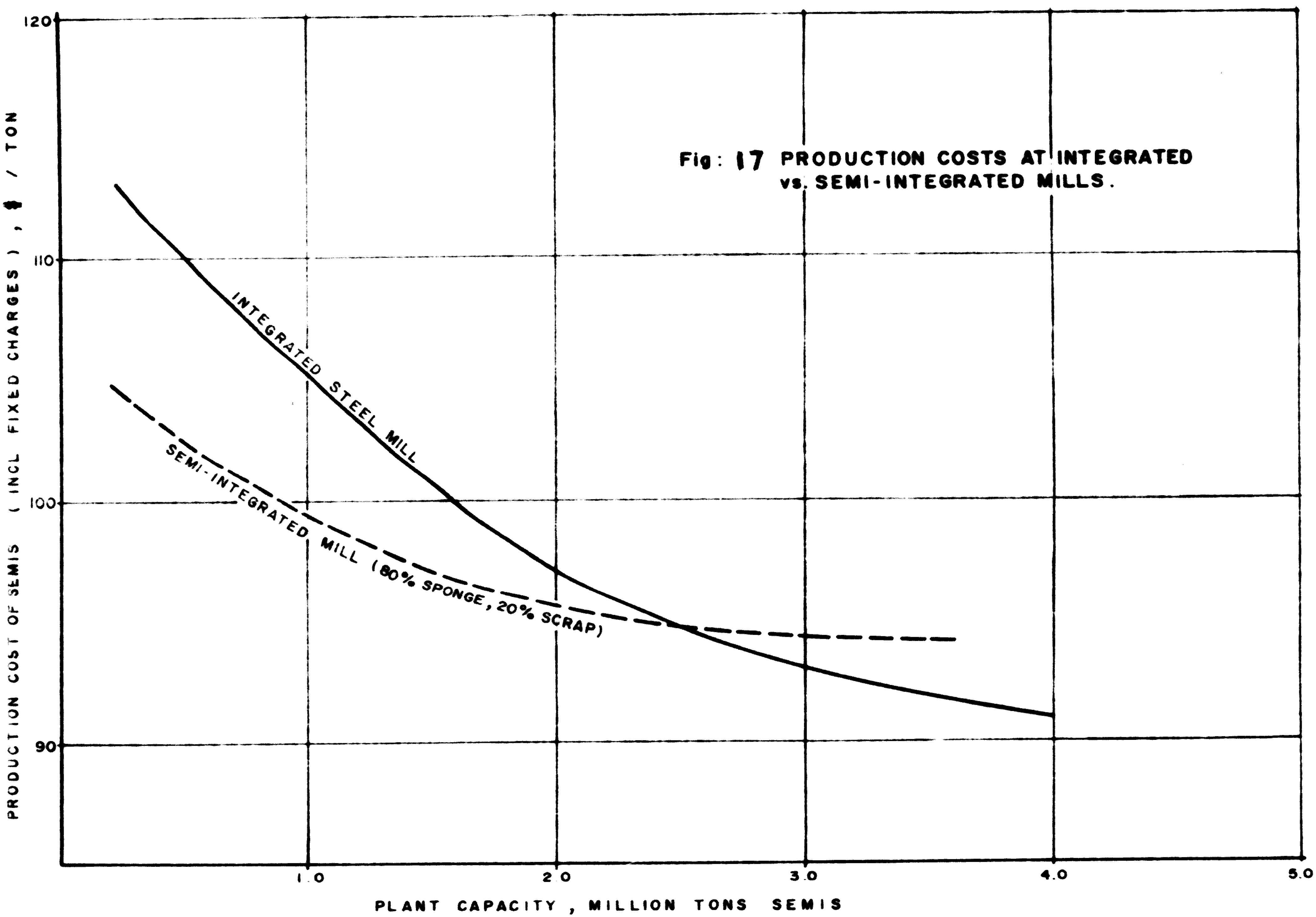


Fig: 17 PRODUCTION COSTS AT INTEGRATED vs. SEMI-INTEGRATED MILLS.
INTEGRATED STEEL MILL
SEMI-INTEGRATED MILL (80% SPONGE, 20% SCRAP)
PRODUCTION COST OF SEMIS (INCL FIXED CHARGES), $ / TON
120
110
100
90
1.0
2.0
3.0
4.0
5.0
PLANT CAPACITY, MILLION TONS SEMIS

IX. UTILIZING IISMI'S ELECTRIC SMELTERS

Modification possibilities

236. Two electric smelting pig iron furnaces of 19.5 MW each were seen, in their crates, at IISMI and plant management is keen to utilize these in an optimum manner. In the last decade or so since this equipment was manufactured, there have been major advances in furnace design and efficiency. The cost and other inputs for 'resurrecting' the two IISMI furnaces need careful study, in close consultation with ELKEM, the original supplier.

Conversion to ferro-silicon production is considered impracticable, but one furnace could be modified for ferro-manganese while the other used for producing foundry iron.

Works costs at the IISMI smelter are estimated at $ 73 per ton pig iron and $ 118 per ton FeMn. These would leave substantial margins for fixed charges and profits.

The possibilities of exporting ferro-manganese are attractive, particularly as electric power is cheap, manganese ores are indigenous, and the decade-old furnace can be considered to be written off!

237. The temperatures needed and metallurgy of producing ferro-silicon are very different from those of pig iron, and it would not be advisable to convert these furnaces to ferro-silicon, although there is a lucrative international market in this alloy.

238. Present demand for foundry iron in the Philippines is very high and so are prices of imported iron. One smelter could be utilized for producing foundry iron at IISMI, where the electric power cost is very favourable. The second could be adapted for producing ferro-manganese for future domestic needs.

/Ferro-alloy ...

Ferro-alloy/pig iron capacity

239. A graph has been prepared by the adviser (Fig. 18) showing the output of products in various typical ferroalloy furnaces with varying power inputs and different electrode diameters. This assumes well-prepared raw materials and average operating conditions.

240. Based on the furnace size, transformer capacity, electrode dia etc. of the IISMI smelters, they should be able to operate for FeMn and for foundry iron on an average load of about 15 MVA. For foundry iron, specific power consumption would be about 2,400 kWh per ton, and for FeMn (75% gr) about 3,000 - 3,500 kWh per ton. On this basis, the daily and annual outputs could be expected as follows:

	Tons/day	Tons/year
Pig iron	140	42,000
FeMn (75% gr)	110	33,000

With experience, larger outputs may be realized in future. It may be mentioned that two methods - flux process and flux-less process - are adopted in electric smelting for ferromanganese. In the flux process, the slag has low manganese content of 8 to 12 per cent. In the flux-less process, slag has 25 to 40 per cent manganese and is used for production of silico-manganese. In this study, domestic ore with about 46 per cent Mn, 6 per cent Fe is considered. The flux process is adopted to ensure maximum recovery of manganese.

Raw materials

241. Raw materials should have the following characteristics:

	Physical	Chemical	
Iron ore	lump	Fe	64% (min)
Manganese	hard	Mn	46% (min)
		Mn/Fe	7:1
Limestone	non-crystalline	CaO	48%
		SiO_2	less than 6%
Coke	small (nut)	FC	85% (approx)
		Ash	11% (approx)

/Fig. 18

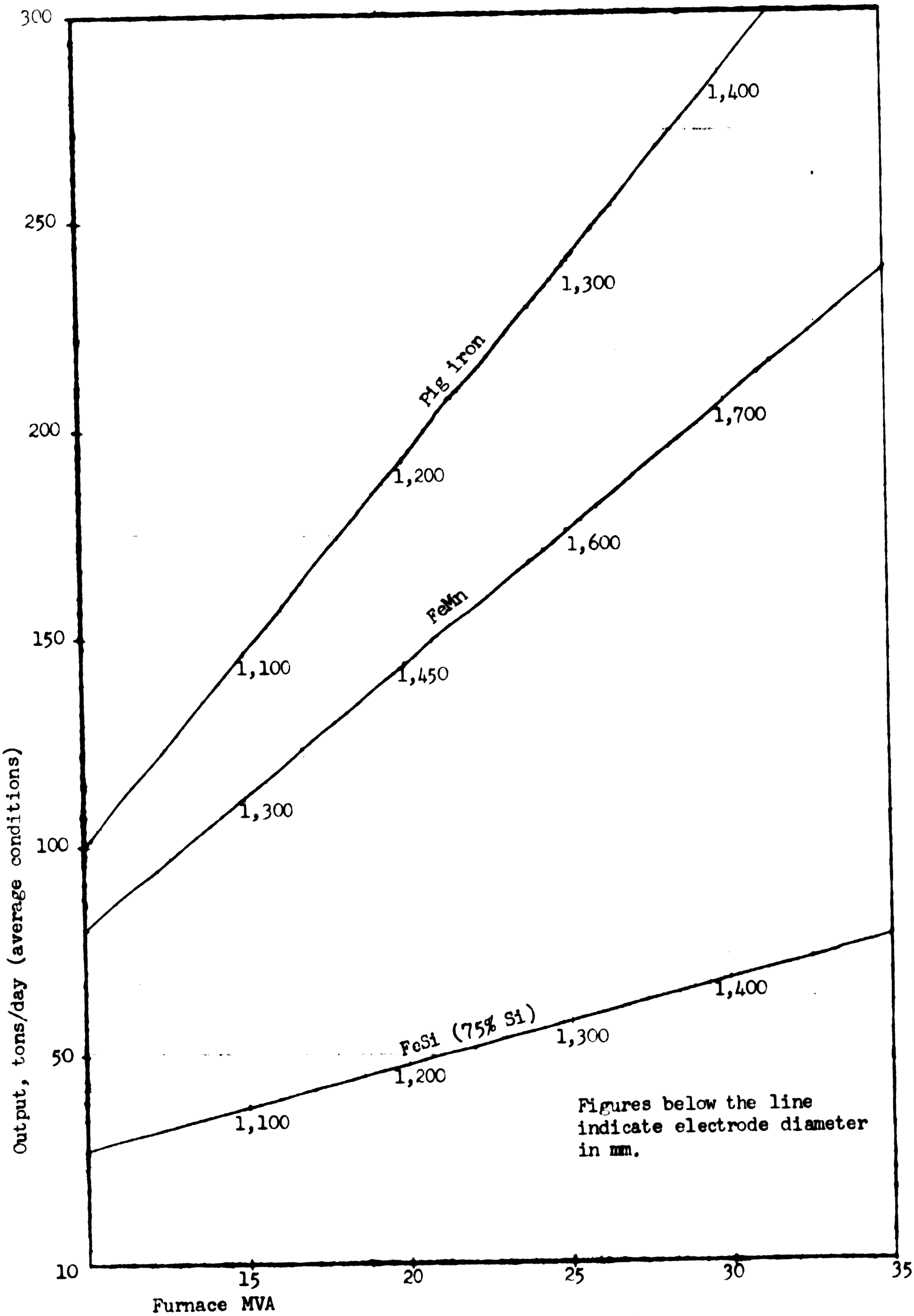


Figure 18: Ferro-alloy outputs

242. As reductant, a mixture of small-sized coke and bituminous coal or wood charcoal would be needed. Some proportion of indigenous Malangas coal or petroleum coke could also be tried.

243. The approximate specific consumptions and annual quantities of raw materials are indicated below:

	Pig iron		Ferro-manganese	
	Consumption kg/ton iron	Annual requirement, t	Consumption kg/ton FeMn	Annual requirement,t
Iron ore	1,650	75,000	-	-
Coke/coal	450	20,000	600	20,000
Electrode paste	25	1,050	30	1,000
Manganese ore	-	-	2,200	73,000
Limestone	250	11,000	500	16,500

FeSi & FeMn demand

244. When LD steelmaking starts in Philippines (in say 1979) and electric arc furnace steelmaking expands, local demand for ferroalloys will rise significantly. Specific consumption varies for different practices in various countries; the following figures are typical for international practice:

	FeSi (75% gr) kgs/ton product	FeMn (75% gr) kgs/ton product
Tonnage steel	2-4	8-12
Alloy & special steels	9	10
Steel castings	7	10
Iron castings	8	-

The main ferro-alloy consumptions are for production of tonnage steels, while miscellaneous users generally represent about 10% of this. Domestic demands for 1976, 1980 and 1985 are roughly estimated in Table 39.

/Table 39:

Table 39: Philippine ferro-alloy demand

	Estimated steel production (tons)	FeSi required (tons)	FeMn required (tons)
1976			
Tonnage steel	0.5 mill	1,000	4,000
Miscellaneous (castings, etc.) @ 10%		100	400
TOTAL ...	... ...	1,100	4,400
1980			
Tonnage steel	2.0 mill	4,000	16,000
Miscellaneous (castings, etc.) @ 10%		400	1,600
TOTAL ...	... ...	4,400	17,600
1985			
Tonnage steel	3.3 mill	6,600	26,400
Miscellaneous (castings, etc.) @ 10%		600	2,600
TOTAL ...	... ...	7,200	29,000

Regional market

245. In order to examine the possibility of exporting FeSi and FeMn from RP, the probable demand in the Asia - Australia region and the possible production capacity in the area has to be examined. Current and probable future demands in the region are estimated (Table 40) on the basis of 2 kg FeSi/ton steel and 10 kg FeMn/ton steel:

/Table 40:

Table 40: -- Asia - Australia region ferroalloy demand

	Estimated steel production (tons)	FeSi required (tons)	FeMn required (tons)
Current			
Tonnage steel	155 mill	310,000	1,550,000
Miscellaneous @ 10%		31,000	155,000
TOTAL		341,000	1,705,000
1976			
Tonnage steel	195 mill	390,000	1,950,000
Miscellaneous @ 10%		39,000	195,000
TOTAL		429,000	2,145,000
1980			
Tonnage steel	235 mill	470,000	2,350,000
Miscellaneous @ 10%		47,000	235,000
TOTAL		517,000	2,585,000

Ferro-alloy availability in 1976 & 1980

246. The main ferro-alloy producers in the ECAFE region are Japan, India and Australia. There are also small plants in south-east Asia. Assuming that ferro-alloy production rises in Japan at 5% per year, India at 7% per year and Australia at 10% per year, the probable production has been estimated in a recent study[a] as 415,000 tons of ferro-silicon and 1,300,000 tons of ferro-manganese by 1980. Figures for 1981 can be assumed to be about 7 per cent higher.

247. Thus, the probable regional shortfalls can be expected to be of the magnitudes indicated below:

/Probable ...

a/ Dastur Engineering International GmgH, "Feasibility Report to UNIDO on Inter-regional Ferro-alloy Study in Mekong Basin", March, 1972.

Probable regional ferroalloy shortfall, 1980

	FeSi	FeMn
Demand	517,000	2,585,000
Availability	415,000	1,300,000
Shortfall	102,000	1,285,000

248. IISMI's proposed production of 33,000 tons FeMn has to be viewed in the perspective of RP and regional shortfalls. IISMI's output would represent only 2.6 per cent of the regional gap; it should be possible to meet local demand and export the small surplus provided production costs and quality are comparable to those of international products.

Costs

249. In order to make a preliminary estimate of production costs, the following raw materials prices ex-IISMI are taken:

	US$ per ton
Iron ore	16.00
Reductant (small coke/coal)	25.00
Electrode paste	170.00
Manganese ore	25.00
Limestone	3.00

250. The major cost element is electric power. In most countries, there is a special electricity tariff for electro-metallurgical industries such as aluminium smelting and ferro-alloy production. The electric smelter consumes a large bulk of power at high power factor and high load factor and is therefore an ideal client from the view-point of the electricity generating and distributing company. For this exercise, the normal rate at IISMI (about US$ 0.007/kWh) is taken.

Production cost estimates

251. Production cost estimates are presented in Table 41.

/Table 41:

Table 41: Works cost of iron & FeMn

Basis: 42,000 tons of iron per year
33,000 tons of FeMn (75%) per year

	Materials cost $ per ton	Pig iron		Ferro-manganese	
		Consumption, kg per ton iron	Cost $ per ton iron	Consumption, kg per ton FeMn	Cost $ per ton FeMn
Raw materials					
Iron ore	16.00	1,650	26.40	-	-
Coke/coal	25.00	450	15.00	600	15.00
Manganese ore	25.00	-	-	2,200	55.00
Limestone	3.00	250	1.20	500	1.50
Electrode paste	170.00	25	4.25	30	5.10
Total cost of materials			46.85		76.60
Cost above materials					
Labour & supervision			3.50		5.20
Smelting power, kWh	0.007	2,400 kWh	16.80	3,500 kWh	24.50
Utilities services etc			1.70		2.00
Repair & maintenance material			3.00		3.50
Relining reserve			0.80		0.65
Casting/packing			2.00		2.50
General plant expense			2.50		3.70
Total cost above materials			30.30		42.05
Total works cost (excluding interest & depreciation charges)			72.95		118.65

252. Clearly, the works cost of foundry iron by electric smelter is much higher than that of iron produced in a blast furnace (Table 38); however, it is lower than present selling prices of foundry iron in RP.

253. Compared to the selling price of around $ 250 per ton ferro-manganese, the works cost of $ 118 estimated above leaves a substantial margin for fixed charges, profit, etc.

/X.

X. PROPOSED INTEGRATED STEELWORKS

254. It is proposed that, simultaneously with the semi-integrated plant at IISMI, decisions be taken and work started at the earliest on a fully integrated steel mill with an initial capacity of 1.14 million tons semis (970,000 tons finished products). Then, in a continuing manner this should be expanded to 2.4 million tons by 1982.

It is recommended that plant layout and utility services be so designed that construction can proceed uninterruptedly to the 2.4 million ton stage with two blast furnaces, the 1.14 million ton facilities serving as only an intermediate phase. At the same time, rational provision of space must be made for expansion to say 10 million ton capacity, as and when needed.

... an area of about 1,000 ha be acquired and kept reserved for the steel plant proper, together with additional areas for township, ancillary activities, slag dumps, etc.

255. Initial and expanded product-mix as well as tentative selection and sizes of major equipment have been shown in Table 31. Thoughts on location are indicated in Annex XI. As a detailed feasibility study on an integrated mill is expected shortly, only some considerations are outlined below.

Materials flow

256. Figures 19 and 19A give the suggested flow of materials for the initial and expanded plant. The approximate requirements of principal materials is indicated below (Table 42).

Table 42: Raw materials requirements of integrated works (tons/year)

	PHASE I	PHASE II
Iron ore - lump	560,000	1,100,000
- fines	1,000,000	2,100,000
Coking coal	860,000	1,800,000
Limestone	340,000	710,000
Fluospar	8,000	17,000
Ferro-manganese	15,000	31,000
Ferro-silicon	5,000	11,000

/ As

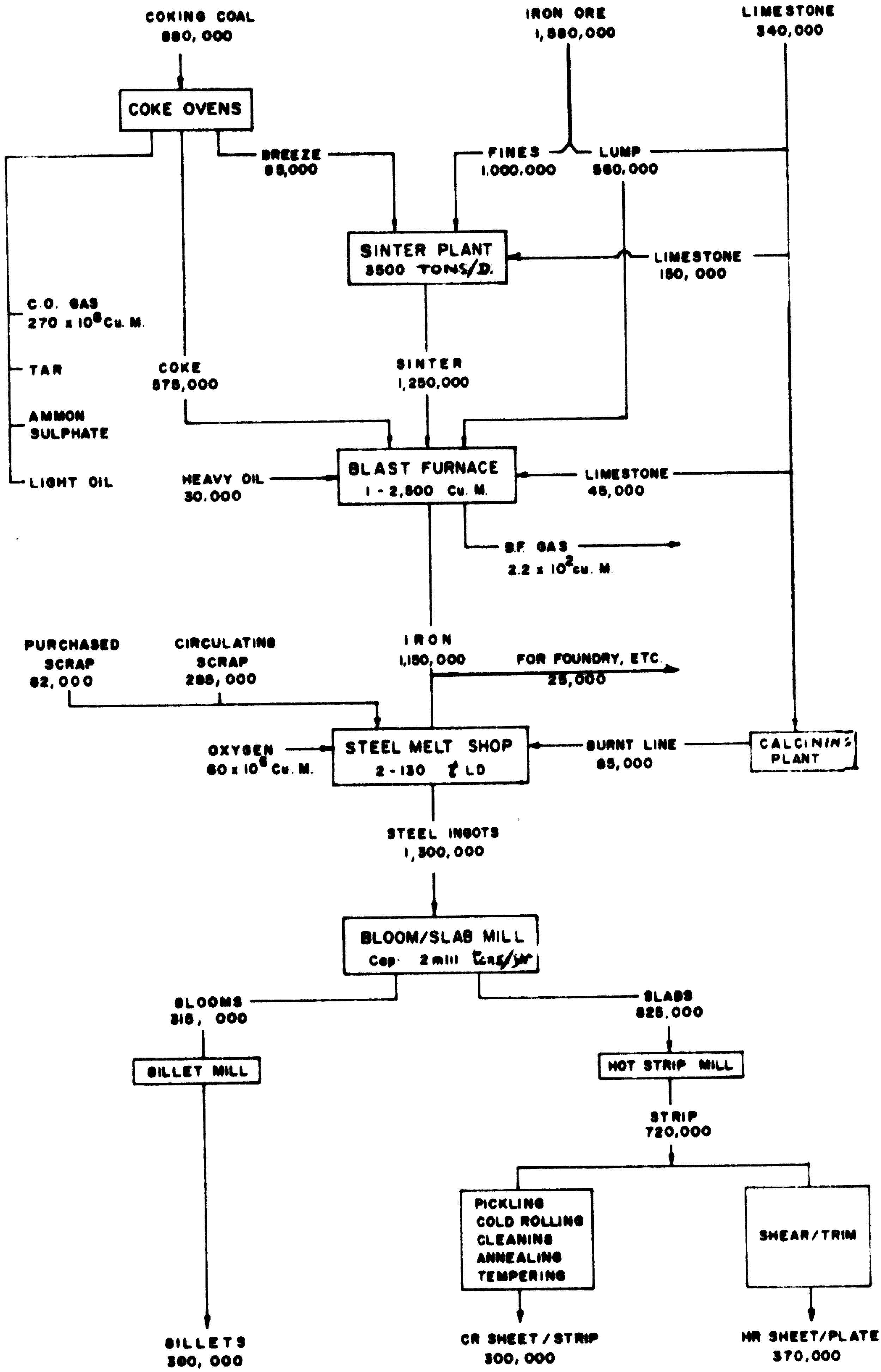


FIG. 19 : FLOWSHEET FOR INTEGRATED STEELWORKS
(PHASE I - CAPACITY 1.14 mill t)

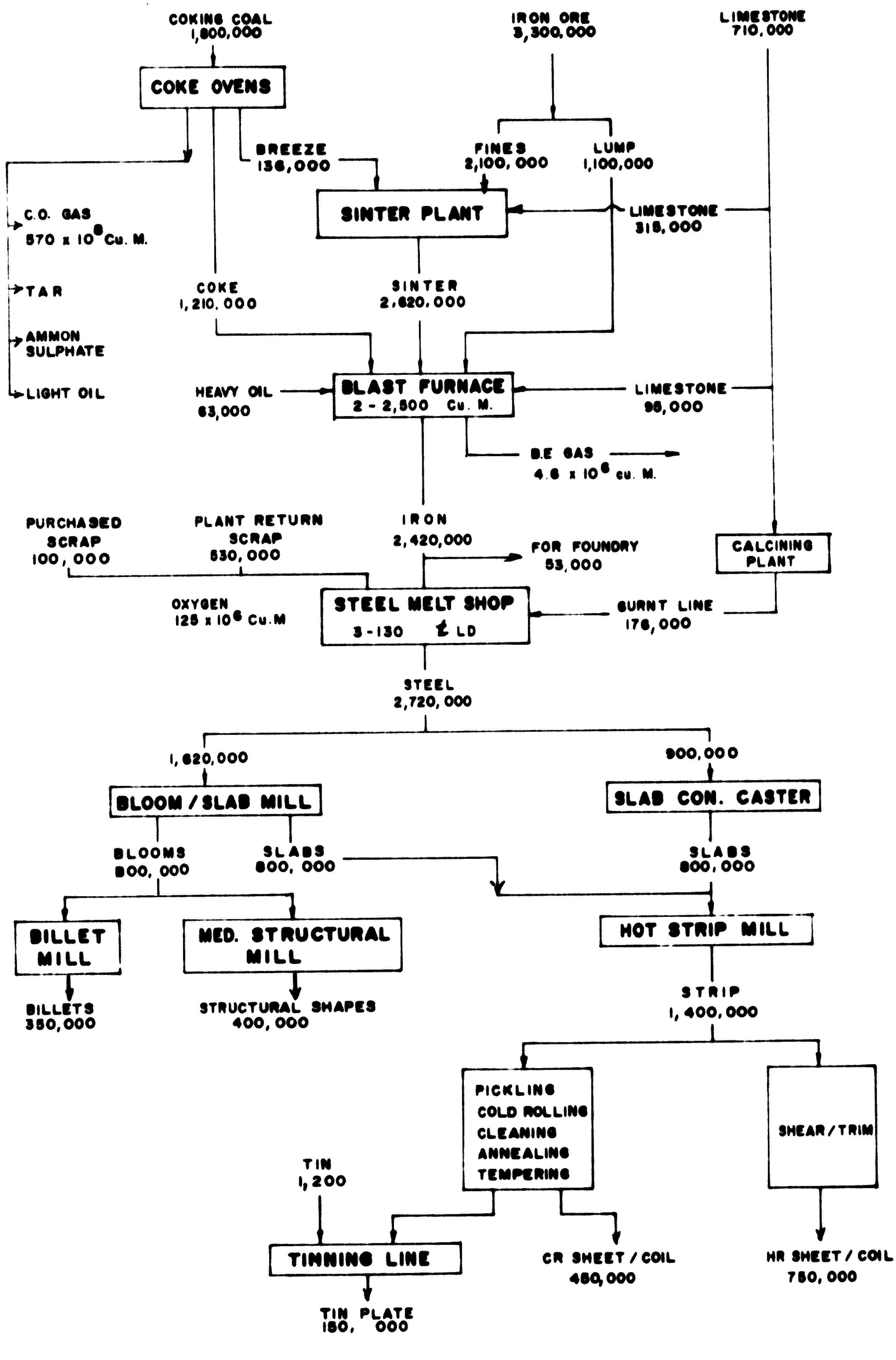


FIG. 29A: FLOWSHEET FOR INTEGRATED STEELWORKS
(PHASE II - CAPACITY 2.4 MILLION TONS)

257. As Phase II will only be operational in 1982, there is enough time to embark on a 'crash programme' of iron ore and coal development, so that a reasonable proportion of indigenous materials could be blended with imported ones. Foreign exchange requirements would thus be reduced (although overall plant economics may not necessarily improve).

Layout and land requirements

258. It is recommended that plant layout and utility services be so designed that construction can proceed uninterruptedly to the 2.4 million ton stage, with the 1.14 million ton facilities serving as only an intermediate phase. At the same time, rational provision of space must be made for expansion to say 10 million ton capacity, as and when needed.

A study on plant size and layout[a/] states:

> "The size of steelworks is on the increase all over the world because rising steel demands are most economically met by expanding the capacity of existing plants. Bearing this trend in mind, developing countries - where many new steelworks are being built - would be clearly lacking in foresight if they did not make provision in their plant layouts today for steel that will be required a decade or two hence ... This provision in design and space need not add much to the initial investment but has been known to pay handsome dividends at a later date."

259. There seems to be some controversy (and confusion) regarding the area of land required for an integrated steel mill. IISMI, for instance, was planning a major project with a 'conveniently-available' area of a mere 100 ha, and subsequent events have shown that this was grossly inadequate.

260. As recently as last month, the Nippon Steel Corporation team, now preparing a feasibility study, arbitarily chose "2,000,000 tons as integrated mill capacity", and stated that "assuming that production ratio

/ of land

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a/ Dastur & Lalkaka, Layout of Large Integrated Steelworks, The Iron and Steel Institute, U.K., Special Report 78, 1964 of land is 1 ton/sq m, 2,000,000 sq m (200 ha) is required. In addition to that, 700,000 sq m (70 ha) for slag waste and the land for future expansion required."

261. In the opinion of this metallurgical adviser, the above land areas are totally inadequate. Some of the major steelworks in the US, each approaching 10 million tons/year capacity, have the following plant areas:

	Hectres
Sparrows Point (Bethlehem Steel)	2,000
Gary (US Steel)	1,100
Fairless (US Steel)	1,500
Burns Harbour (Bethlehem Steel)	1,570

262. Layouts of the Sparrows Point, Gary and Burns Harbour plants are shown in Figure 20. Commissioning of Burns Harbour started in 1966 with a plate mill in Phase I, iron and steelmaking in 1966 with capacity of 2 million tons in Phase II, and expansion to 4 million tons in 1972 as Phase III. A general view of Burus Harbour is shown in Figure 21.

263. The Soviet norms for land usage have been as follows:[a/]

Integrated mill capacity (mill. tons)	Area, ha (excluding coke ovens & by-product plant)
2	220
4	300
6	400
8	570

264. The experience of India in this respect is interesting. As noted earlier, as early as 1906 the Tatas had set aside 650 ha for their integrated mill. Plants built in the 1950's with German, Soviet and British assistance had areas of only 500 ha each, and it was later realized that this was a mistake as these plants could not be conveniently expanded beyond about 4 million tons. For a new coastal steelworks at Vishakapatnam

/ The State

a/ "Contemporary Problems in Metallurgy", edited by A. Samarin, 1962.

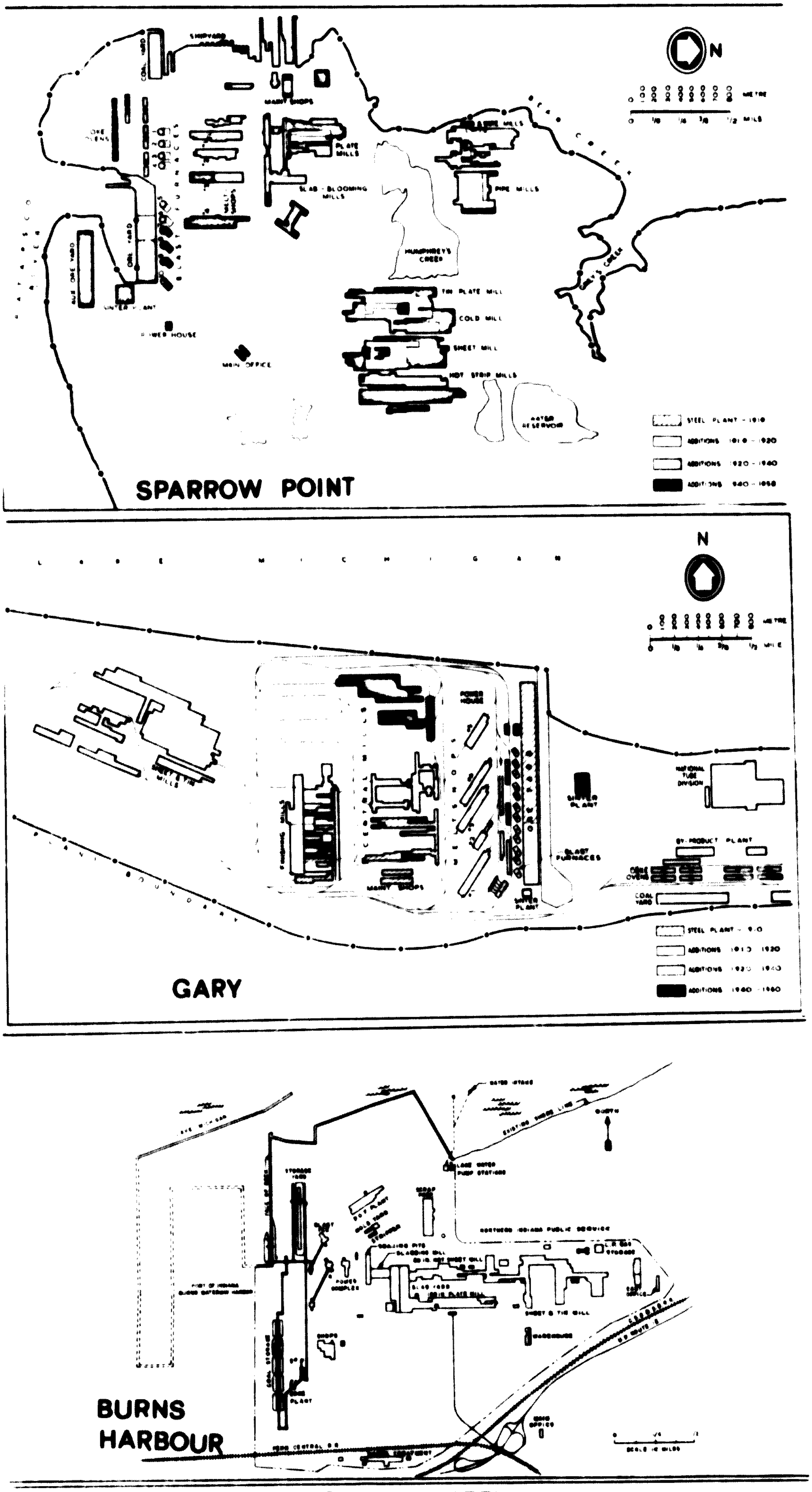


FIG. 20: LAYOUT OF MAJOR U.S STEEL.

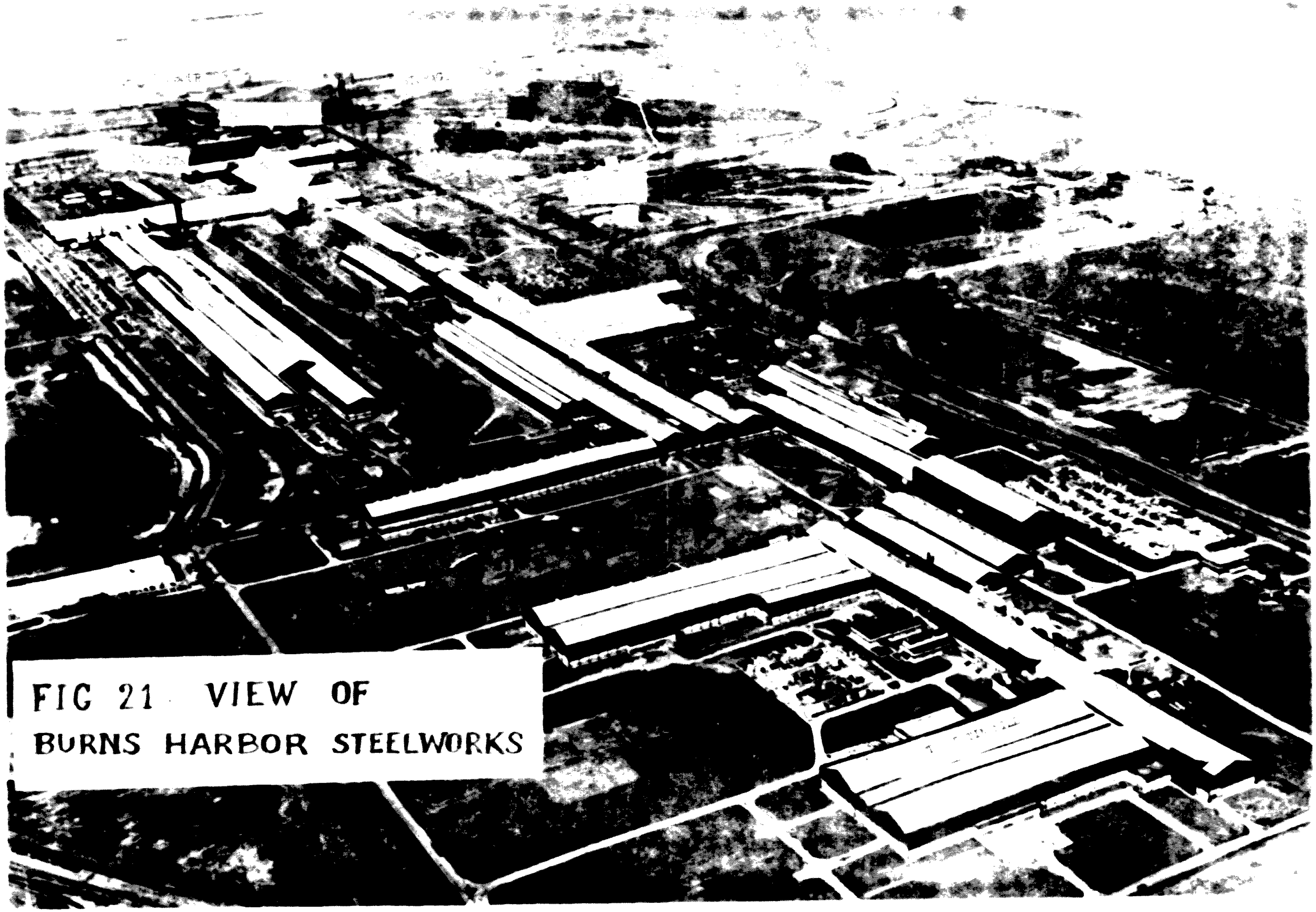


FIG 21 VIEW OF BURNS HARBOR STEELWORKS

the State Government notified a total area of 22,500 ha in 1966. Out of this area, the following areas are now being acquired for the construction of this steel mill (which will have a future capacity of over 10 million tons).

Plant proper	2,240 ha
Ancillary industries	1,500 ha
Township	2,000 ha
Slag dumps, etc.	300 ha
Marshalling yards	50 ha

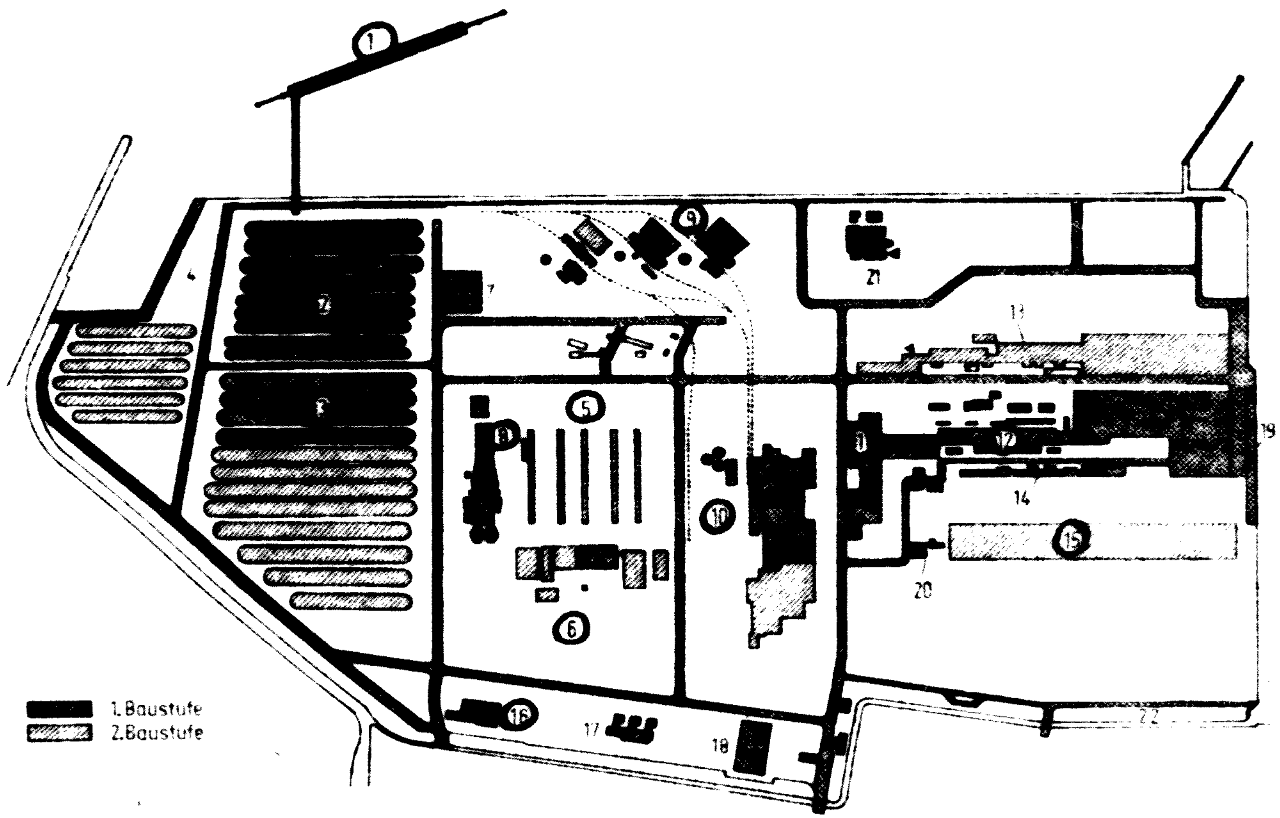
265. With recent advances in technology and increases in equipment sizes, land area now required may be slightly less. In a country such as Japan, with tremendous pressure on land requiring expensive reclamation, plant layouts have to be compact, within limited sites. Thus, Nippon Steel's new Oita plant has an area of about 700 ha and is being planned for 12 million tons. Similarly Pohang Plant in Republic of Korea (POSCO) has an area of 720 ha, but already the plant management feels that this is inadequate for expansion beyond 7-8 million tons. Layouts of Oita and POSCO are shown in Figure 22 and 22A.

266. In order to meet the long-term needs of the Philippine economy, it is recommended that an area of about 1,000 ha be acquired and kept reserved for the steel plant proper, together with additional areas for township, ancillary activities, slag debris dumps, etc.

A rough sketch of the layout of integrated steel mill facilities at one of the sites under consideration (Tagloan in Mindanao) is shown in Figure 26. It will be seen that only one rolling mill complex with throughput of about 3-4 million tons could be accommodated in an area of 400 ha (to the west of the existing highway). A second and third complex to raise capacity to 10 million tons would require a total of about 1,000 ha.

Capital cost

267. A rough indication of capital cost is shown in Table 43. This does not include provision for escalations that would occur during the construction period.



1. Harbour
2. Ore stock-yard
3. Coal stock-yard
5. Coke ovens
6. By-product plant
8. Sinter plant
9. Blast furnace
10. Steel-melt shop
11. Soaking pits
12. Hot strip mill
15. Cold rolling mill
16. Repair & maintenance shop

FIG. 22: LAYOUT OF OITA STEELWORKS (JAPAN)

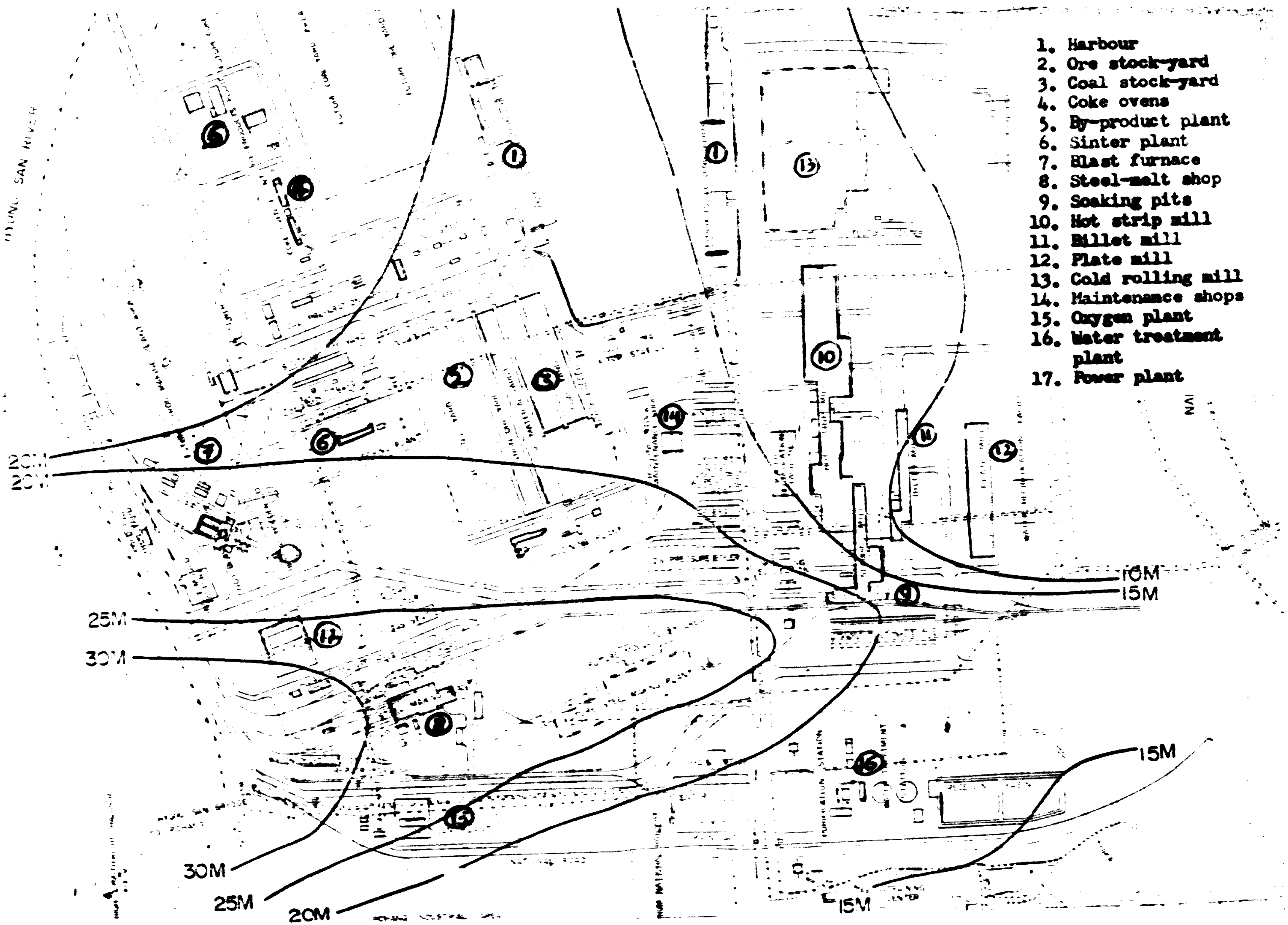


FIG. 22A: LAYOUT OF POHANG STEELWORKS (REPUBLIC OF KOREA)

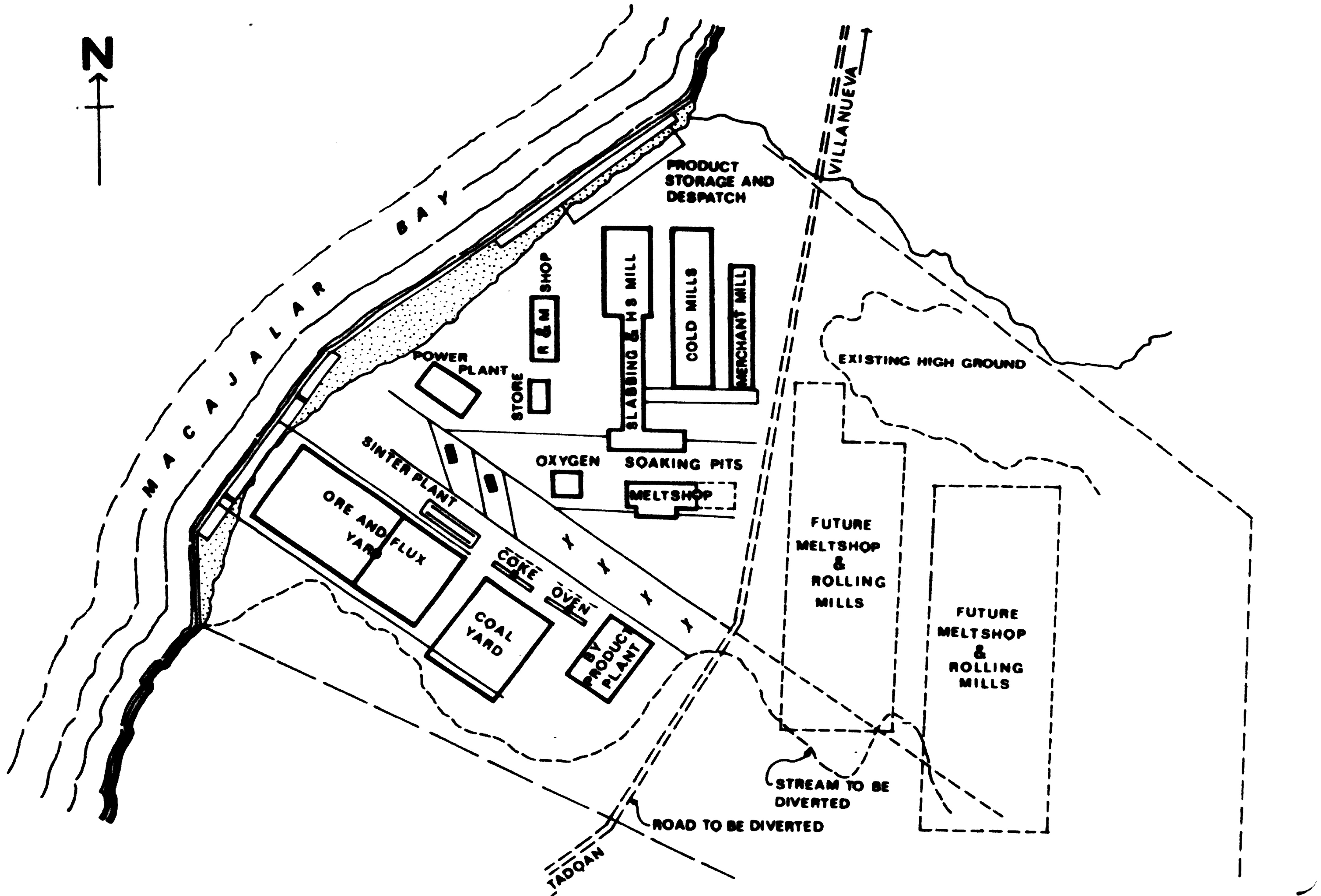


FIG 26 SUGGESTED LAYOUT FOR STEELWORKS - TAGLOAN

Table 43: Estimated plant capital cost

	Million US$
Plant and general buildings	45
Equipment as erected including foundations	220
Plant utilities	35
Construction facilities	4
Design, engineering & construction administration	25
Contingencies	35
Plant cost:	364 a/

a/ Excludes cost of land, spares and interest during construction. as well as cost escalations.

268. If prompt decisions could be taken, funds are assured and other factors are not unfavourable, the cold mill facilities could be commissioned by end-1978 and the complete integrated plant in 1979.

269. The construction of this steel mill will be a unique opportunity for RP to also expand existing construction, manufacturing and design facilities. The bulk of the design for plant and general buildings could be done locally; at the same time, Philippine engineers should be closely associated with the overall planning, specifications, utility systems and equipment foundations designs.

270. To secure optimum indigenous content in the plant construction as well as to ensure that designs and processes are best suited to RP requirements, it is necessary that independent consulting engineers are engaged.

Profitability

271. The experience in many developing countries is that in the initial years a new integrated plant produces steel at costs which may be somewhat higher than imported materials, provided that all costs including interest payments and depreciation are fully accounted. Foreign producers often export steel on the basis of marginal costs whereby export prices may not carry the full fixed charges which their domestic markets

/ have to

have to bear. Also, the foreign plant may be partly depreciated, and supported by a well-developed infrastructure and well-experienced personnel.

272. It should be noted that in any country, developed or developing, returns on investment in a steel mill are not attractive. For instance, the 1970 financial results of 32 major international steel companies show that 5 incurred losses, 19 gave return of under 4% on total assets (less depreciation), and 8 gave return of over 4% but with a maximum of only 5.8% (Of the 5 companies incurring losses, 4 were government-owned).

273. The reasons for installing capacity is that steel has a far-reaching impact on the national economy, on the balance of payments, on employment in up-stream and down-stream activities, on indigenous resource utilization, on exports, as well as on the growth of agriculture, transport and other key sectors. Thus, if a 'social profitability' calculation were made, returns would be significantly higher than by normal commercial yardstick.

274. Moreover, the country's development and defence have to be insulated against the vagaries of the international steel market.

275. The Philippine Government, unlike many others in Asia, has now appreciated these imperatives and is going full-steam ahead on building a viable steel industry.

/ XI.

XI. LOCATION OF THE INTEGRATED STEELWORKS

While on the one hand, there are advantages in siting a major industrial project in a hitherto backward region to catalyse its development, on the other, there are benefits that a steel plant could derive from linkages with existing industries.

... Based on detailed cost and other data (which should hopefully be forthcoming), Government will have to take an early decision on the siting of the new integrated steelworks. The creation of the Iron and Steel Authority, the project studies under preparation, and other initiatives being taken augur well for the rational and rapid development of this vital industry.

276. The factors affecting the location of the proposed integrated steel plant are of two categories, namely, those which relate primarily to technical and economic aspects and those which generally concern environmental and policy matters. These factors are shown in Fig. 23. The techno-economic factors can be quantified for evaluating the relative merits of alternative sites. The other factors are conditioned by governmental policies; their impact is more difficult to evaluate but it often outweighs the economic and technical considerations.

Main criteria

277. The main technical criteria to be met in locating the steel plant are generally as follows:

a) proximity to sources of iron ore and reductants, in order to reduce raw material assembly costs. In the initial RP plant practically all materials may be imported, but for the future raw materials deposits would exert a locational pull.

b) an expanding market for steel, so as to reduce costs of product distribution. It is likely that for some years to come, the Manila area will

/ Fig. 23

Also see "Factors Affecting the Future Location of Iron- and Steelworks", Journal of the Iron and Steel Institute, June 1971; "Model relating to site selection for iron and steelworks", Stahl u. Eisen, 7 June 1973.

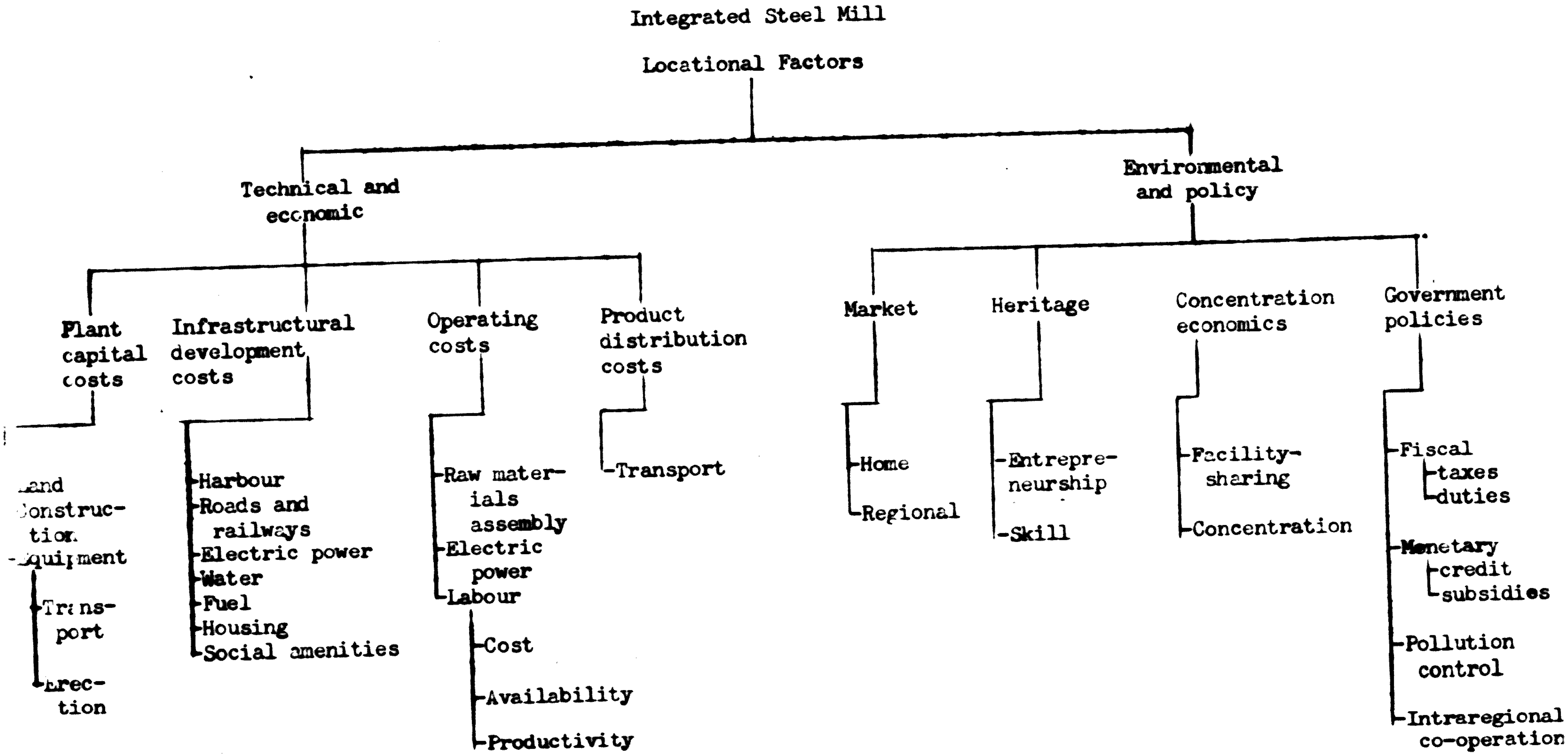


Figure 23: Factors affecting location of the steel plant.

/continue

continue to be the major market in spite of government policy to rapidly spread the effects of industrialisation.

c) adequate land with good subsoil conditions.

d) port facilities with depths to receive up to 300,000-ton carriers in future, for purposes of importing materials and exporting products.

e) availability of electric power at reasonable cost, together with an ensured water-supply.

f) availability of construction materials and services.

g) good infrastructural facilities, such as roads or tracks for internal distribution of products, technical training institutes, repair and maintenance shops.

Sites under consideration

278. A detailed location study is now underway which should provide the comparative cost and other data for the Government to take an informed decision.

279. The sites which are being given consideration are shown in Fig. 24. The search seems to have been narrowed down to sites along the Balayan Bay in south-west Luzon and along the Iligan and Macajalar bays in northern Mindanao. These were visited by the metallurgical adviser.

280. The cost of constructing the plant proper as well as essential infra-structural facilities requires proper engineering estimates, which will hopefully be forthcoming. Sub-soil conditions and availability of construction materials (cement, sand, aggregate, etc) could affect construction costs as well as the duration of the construction period.

/Figure 24

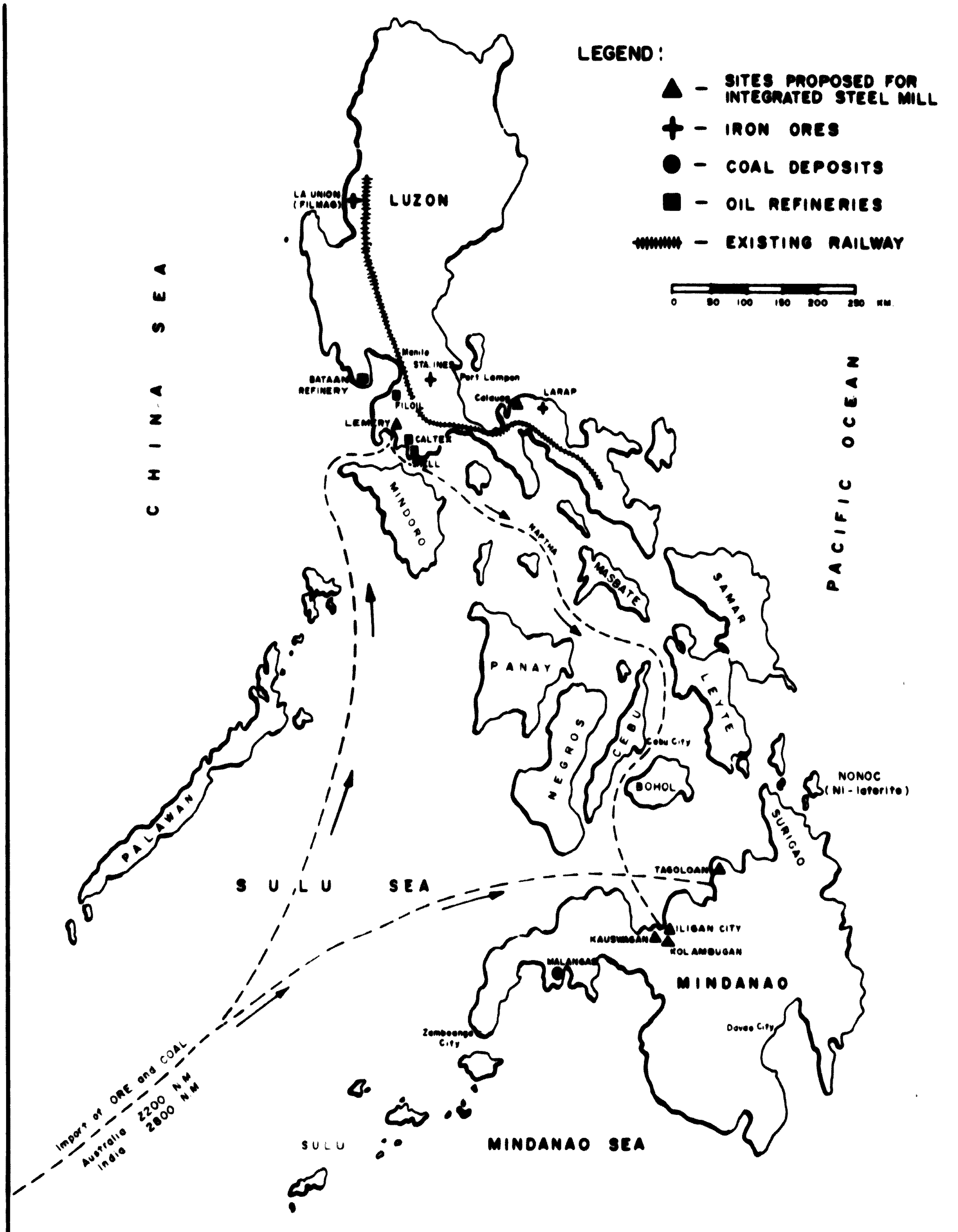


FIG. 24 RAW MATERIALS AND LOCATIONS FOR PROPOSED STEEL MILLS IN THE PHILIPPINES

Iligan not suitable

281. The land already owned by IISMI (including areas to the south of the national highway) would permit coke oven/blast furnace/BOF facilities of 1.0 to 2.0 million ton capacity to be installed quite readily. This would have advantages of better water and power availability as well as the investment in facilities (perhaps $8 to 10 million) already built-in for plant expansion. The component of fixed charges on this alone represents a saving of about $1 per ton at the 2-million ton stage.

282. However, as already noted, the limited land available at IISMI would not allow economic expansion much beyond this capacity. A larger plant of say 4 million tons at some other location would in the long run produce steel at lower costs (perhaps $5 to 6 lower, see Fig. 17).

283. Moreover, as discussed earlier, a semi-integrated plant could play a more effective -- and more immediate -- role at IISMI.

Tagloan vs Lemery sites

284. In Mindanao, the site examined at Tagloan, about 25 km north of Cagayan de Oro appears attractive (Fig. 25). Flat land is available between the national highway and the sea -- a width of average 2 km and length about 2 km. The effort should be to re-route the highway and secure at least 1,000 hectares, if this location is selected. The Tagloan river has good perenial water flow, reported to be 48 cu m per sec. Low-cost hydro-power would be available from the Agus river development.

285. Sites near Lemery have the advantage of proximity to the Manila market as well as to a future possible ore supply from Santa Inez. But the land available is narrow in width while power and water costs would be higher.

286. Assuming that construction costs and other factors at Lemery and at Tagloan would be about equal - which has yet to be established - we may, at this stage, consider only three factors which are more easily quantified, namely (i) power cost, (ii) indigenous materials assembly cost, and (iii) product distribution cost.

/Fig. 25

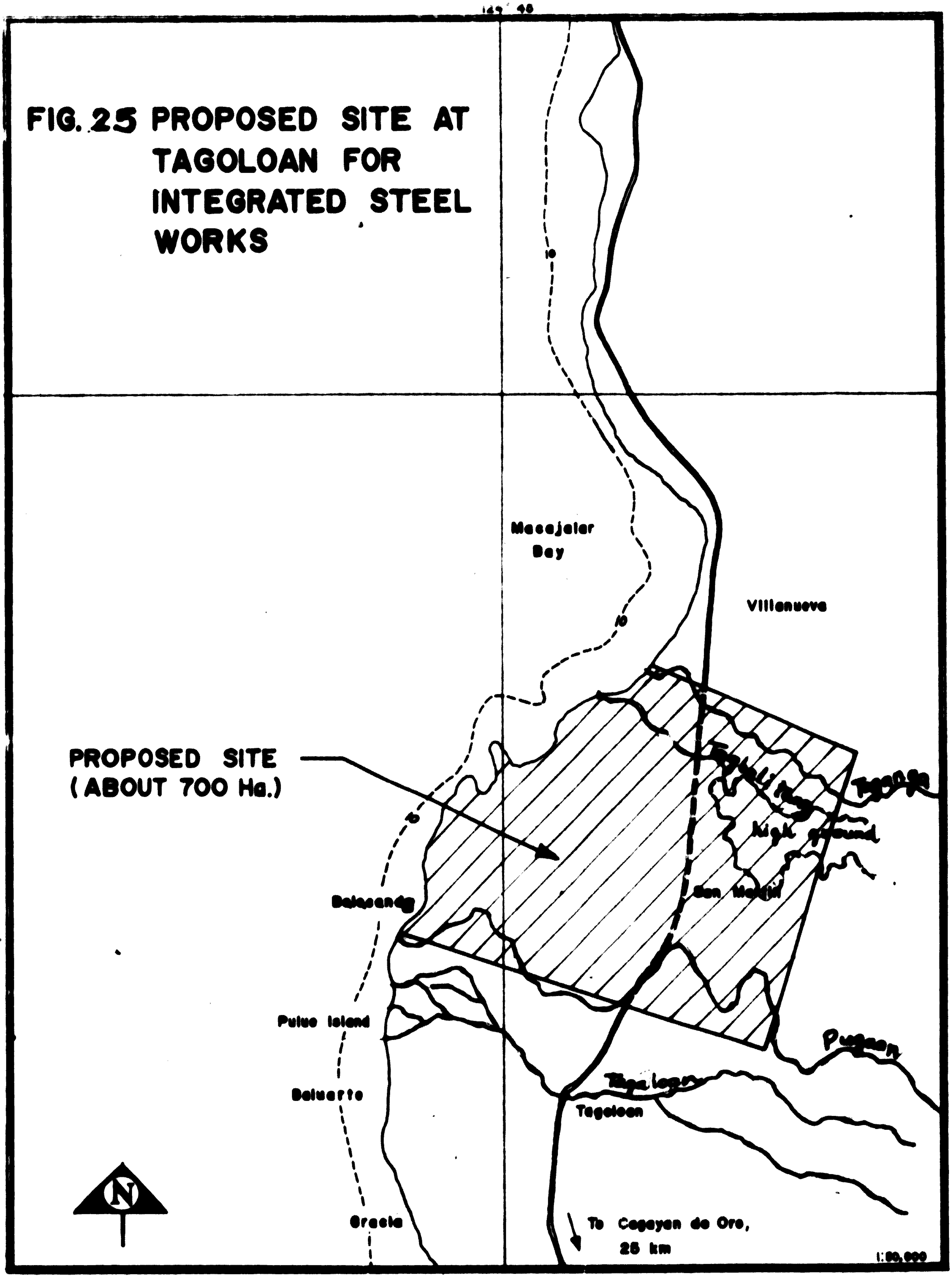


FIG. 25 PROPOSED SITE AT TAGOLOAN FOR INTEGRATED STEEL WORKS

Electric power cost

287. A comparison of power costs at the initial and expanded phases would be as in Table 44.

Table 44: Comparison of power costs

	Lemery		Tagloan	
	Power Cost/unit ($)	Annual Power cost (mill $)	Power Cost/unit ($)	Annual Power cost (mill $)
Phase I 400 x 10^6 kWh/yr (1.14 millt x 350 kWh/t)	0.014	5.6	0.007	2.8
Phase II 1,000 x 10^6 kWh/yr) (2.4 mill t x 420 kWh/t)	0.014	14.0	0.007	7.0

Power costs clearly favour a location in Mindanao.

Materials assembly

288. It may be assumed that while the initial plant would start on imported ore and coal, the expanded plant would utilize say 30% of total ore from the Santa Inez area, and 20% of coking coal from Malangas area. This of course requires detailed investigation and confirmation. Assembly costs are compared in Table 45.

Table 45: Comparison of indigenous materials assembly cost

Phase I: (1.14 million ton steel semis capacity)
As no indigenous iron ore or coal used, costs of imported materials same at Lemery and Tagloan.

Phase II: (2.4 million ton steel semis capacity)

Material	Possible source	Mode of transport Y	Distance	Freight (₱/t)	Annual freight cost (₱ mill)	Annual freight cost ($ mill)
To Lemery						
1,000,000 t ore	Sta. Inez	Rail (part to be linked)	125	20	20.00	3.00
360,000 t coal	Malangas	Boat	1000	23	8.23	1.24
			TOTAL (PHASE II)		28.23	4.24
To Tagloan						
1,000,000 t ore	Sta. Inez	Rail&boat	30+900	32	32.00	4.80
360,000 t ore	Malangas	Boat	670	19	6.84	1.03
			TOTAL (PHASE II)		38.84	5.83

Beyond 1982, the assembly costs of coal and ore favour Lemery, but only to a limited extent.

/Product

Production distribution

289. It is assumed -- quite arbitarily -- that 80 per cent of the steel products from this new mill would be consumed in Luzon (with Manila as focus) while 10 per cent each would be consumed in the central region (Cebu as focus) and in the southern region (with Davao as focus). On this basis product distribution cost is shown in Table 46.

Table 46: Product distribution cost

	Steel product	Destination	Mode of transport	Distance (km)	Freight (₱/t)	Annual freight cost (₱ mill)	Annual freight cost ($ mill)
	A. From Lemery						
	Phase I						
	776,000	Manila	Boat	100	10	7.76	1.16
	97,000	Cebu	Boat	600	18	1.75	0.27
	97,000	Davao	Boat	1410	29	2.81	0.42
Total	970,000					12.32	1.84
	Phase II						
	1,680,000	Manila	Boat	100	10	16.80	2.52
	210,000	Cebu	Boat	600	18	3.78	0.57
	210,000	Davao	Boat	1410	29	6.09	0.91
Total	2,100,000					26.67	4.00
	B. From Tagloan						
	Phase I						
	776,000	Manila	Boat	900	22	17.08	2.56
	97,000	Cebu	Boat	250	13	1.26	0.19
	97,000	Davao	Boat	1800	20	1.94	0.29
Total	970,000					20.28	3.04
	Phase II						
	1,680,000	Manila	Boat	900	22	36.96	5.55
	210,000	Cebu	Boat	250	13	2.73	0.41
	210,000	Davao	Boat	1800	20	4.20	0.63
Total	2,100,000					43.89	6.59

Again, in both initial and expanded phases, the product distribution costs are lower for a plant located in the Lemery area.

/Overall

Overall power and transport costs

290. The overall effect of transportation and power costs is summarised in Table 47.

Table 47: Overall annual costs (million $/year)

	Phase I		Phase II	
	Lemery	Tagloan	Lemery	Tagloan
Materials assembly	-	-	4.24	5.83
Product distribution	1.84	3.04	4.00	6.59
Electric power	5.60	2.80	14.00	7.00
Total	7.44	5.84	22.24	19.42

291. It is seen that the advantages of Lemery with respect to proximity to markets and materials are more than centralised by the lower annual power costs at Tagloan. However, the net advantage of Tagloan is only $ 1.6 million in Phase I and $ 2.82 million in Phase II -- that is, less than 1 per cent of the annual sales realisation of this plant.

Concentration economics

292. A steel plant has numerous backward and forward linkages, and depends for many of its inputs and services on the community in which it is located. These include foundries, refractories plants, structural fabrication and repair shops for its maintenance requirements, sharing of computer and technical research facilities between allied industries, technical education and training establishments.

293. There are also economies through inter-industry linkage. Large machine shops located near the proposed steel plant could be a source of steel scrap; a cement plant near the steelworks could utilize blast-furnace slag as a partial substitute for limestone; a petrochemical plant in the vicinity could supply reducing gas to a direct-reduction sponge-iron plant, and so on.

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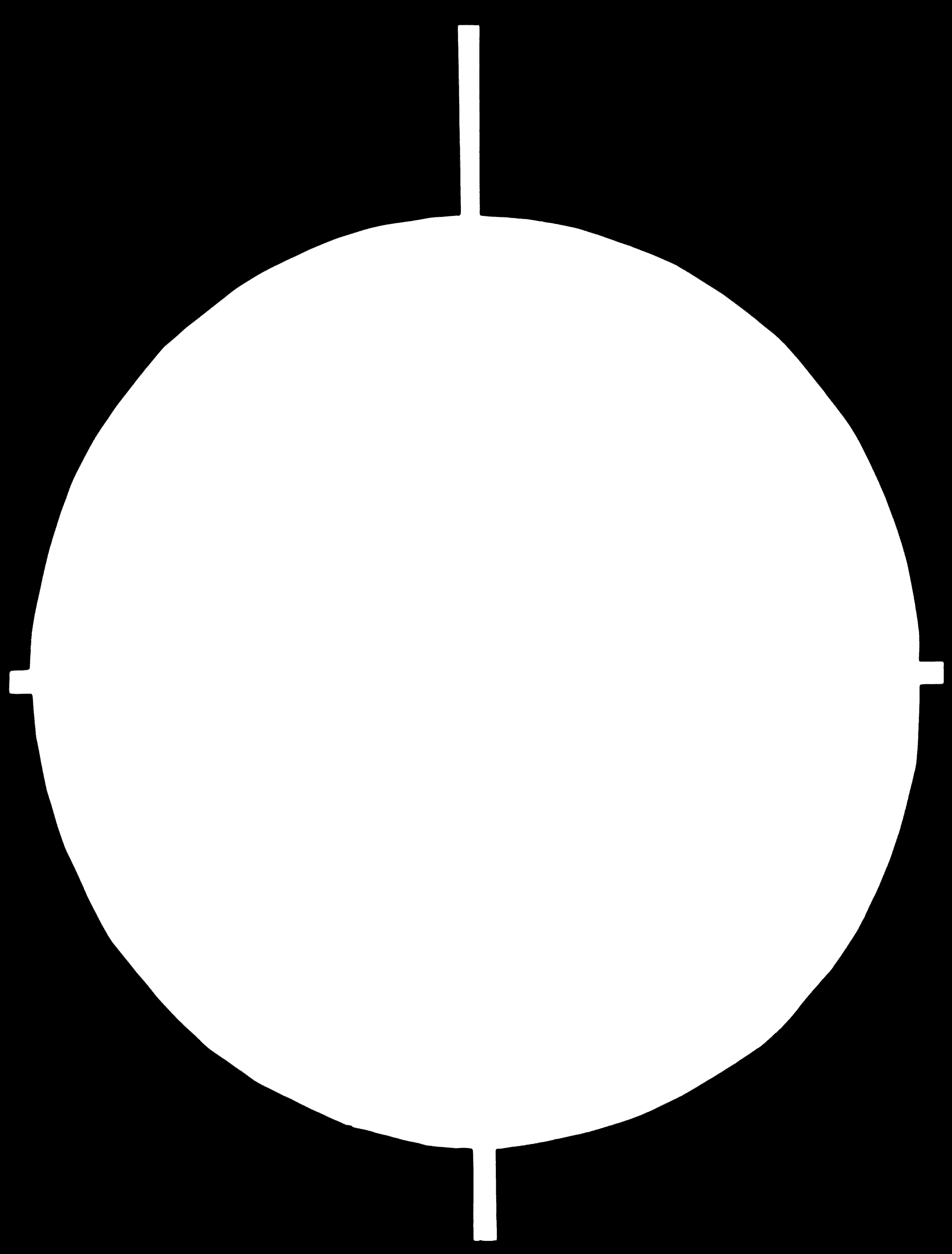

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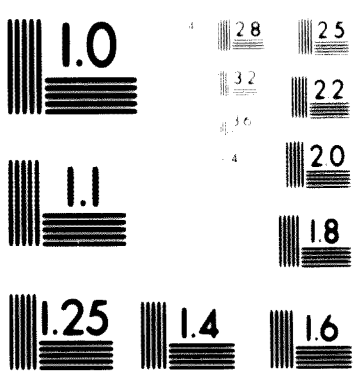

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294. Such localisation and urbanisation economics generally favour location near major industrial concentrations within a country, as evidenced by the concentration of industries around say, Manila, Bangkok and Kuala Lumpur.

Government policies

295. Government fiscal and monetary policies may differ from state to state. However, for a major national undertaking such as a new steelworks it may be assumed that such policies would be the same all over the country.

Environmental factors

296. The exploitation of natural resources as well as dust emission and effluent disposal at the steelworks are major polluters of the environment. An effective technology of pollution abatement is now being developed, but it is expensive.

297. Since 1951, the United States steel industry has spent as much as US$1,200 million on pollution control, and the operating cost of such control is now US$1.5 million/yr. In 1973, the Japanese Steel industry, for instance, expects to spend US$300 million on pollution control, or more than 10 per cent of its total investment.

298. As the steel industry in the Philippines is expanding, it has already started having adverse impact on ecology and the electric arc furnaces around Manila may now be forced to install fume-cleaning equipment. Where new plants are being planned, there is a temptation to postpone the introduction of pollution control owing to financial constraints, but any new steelworks would have to pay serious attention to and incur substantial costs for, pollution abatement.

299. Keeping in mind the above preliminary discussion, and based on detailed construction and production cost data for alternative locations, Government will have to take an early decision on the siting of the new integrated steelworks.

A P P E N D I C E S

APPENDIX I

PERSONS AND ORGANIZATIONS MET

Metals Industry Research and Development Center	Dr. Antonio V. Arizabal Mr. Julio Villamor Mrs. Beatriz Orinion Mr. Nestor Salanio Mr. Estefanio Gacad
Board of Investment	Mr. Tordesillas
National Science Development Board	Gen. Florencio A. Medina Miss Lydia Tansinsin Mr. Cordora
University of the Philippines, Mining & Metallurgy Department	Dr. Perfecto Guerrero Mr. Portugal
Bureau of Mines	Mr. Juanito Fernandez Mr. A. Filores
Bureau of Telecommunications	Mr. Pedro Villasenor
Department of National Defence	Col. Cavosora
Iligan Integrated Steel Mills, Inc.	Mr. E. Rodriguez Mr. F.M. Maxino Mr. R.Z. Gomez Mr. P.C. Benitez Mr. D.E. Lemster Capt. Tan-gan
National Water and Air Pollution Control Commission	Dr. R. M. Lesaca
Marcelo Steel Corp.	Mr. Jose Marcelo Jr.
Engineering Equipment	Mr. F. C. Payumo Mr. Coronel
Marsteel Corp.	Mr. Jose Martel
Elizalde Iron & Steel Corporation	Mr. Octavio Jose
Philippine Iron Mines	Mr. J.D. Cuyngan
Pellet Corporation of the Philippines	Mr. Motoi Sakaki
A. Soriano Y Cia.	Mr. Jose C. Quema
Filmag (Philippines)	Mr. I. O. Hidalgo Dr. F. P. Calderon Mr. E. Vera Mr. R. Rigor

/Atlas

Atlas Consolidated Mining & Development Corporation	Mr. R. B. Santos Mr. R. Hayag
Essochem Philippines	Mr. L. P. De Guzman
Esso Philippines	Mr. E. Verano
Caltex	Mr. P.L. Soriano
Petrolium Institute of the Philippines	Col. Javier
Nippon Steel Corporation	Mr. S. Uchida Mr. T. Watanabe Mr. T. Hojo
United Nations Industrial Development Organisation	Mr. J. Stepanek Dr. Mullik
United Nations Development Programme	Mr. T. M. Unwin Mr. G. Pihlgren

APPENDIX II

RESERVES OF IRON ORE IN THE PHILIPPINES

	Location	Operated by	Estimated reserves (M.T.)	Grade or analysis (% Fe)	Status
IRON ORE					
1. Agusan-Surigao del Sur	San Francisco-Hinatuan	Diwata Mining Corp	3,200	64.00	-
2. Albay	Batan, Acal, Rapu-rapu	San Romon Mining Co	17,500	43.33	Prospect
3. Bulacan	Camanching, San Ildefonso	Mrs. Villareal	2,000,000	55.52	Prospect
	Camanching, San Ildefonso	Bulacan Iron Mines	1,000,000	62.00	Prospect
	Camanching, San Ildefonso	Hizon, Santos and Tumutol	100,000	64.26	Prospect
4. Cagayan	Dawang, Camalaniugan	Elizalde Ind Company	1,222,552	51.00	Prospect
	Claveria	Claveria Iron Project	20,000	60.00	Prospect
5. Camarines Norte	Larap, Jose Panganiban	Phil. Iron Mines, Inc	45,084,943	25.80	Producing
	Capacuan, Jose Panganiban	Venida Inc	100,000	58.00	Prospect
	Calaburnay, Paracale	Agusan, Gold Mines, Inc	1,100,000	57.80	C.O. (1959)*
	Calaburnay, Paracale	United Mining Dev. Co	1,200	55.00	-
	Calaburnay, Paracale	San Felipe Iron Mines	5,000	-	-
	Calaburnay, Paracale	Gabun Paracale Mining Co	25,073	67.00	-
	Labo, Paracale	Maravini Consolidated Mines	1,000,000	57.00	C.O. (1960)*
	Matangue, Capalongan	Century Mines, Inc	1,171,620	-	-
	Matagdon, Labo	Carlos Cuevas Enterprises	215,300	62.27	-
6. Camarines Sur	Pantat, Tinambok	Yupegoz Mining Corp	1,649,300	50.32	Explored
	Lagonoy	Hercules Iron Mines, Inc	300,000	56.00	C.O. (1959)*
7. Ilocos Norte	Lamin, Piddig	Piddig Iron Deposits	1,250,000	60.00	Prospect
	Cabitaran, Nueva Era	Phil. Profiting Corp	102,600	57.56	Prospect
8. Iloilo	Nueva Valencia, Guimaras	J. Robles & Co.	1,800	51.75	Explored
9. Marinduque	Mogpog	Marindugue Iron Mines	187,300	58.01	C.O. (1959)*
	Maganan, Mogpog	Marindugue Iron Mines	100,000	50.37	"
	North Central Part	Jinapolan-Tumicab Prospect	25,000	-	-
10. Negros Occ.	Sipalay	Gabon-Paracale Mining Co.	44,192	39.59	Prospect
	Binalbagan	-	20,000	57.37	Prospect
11. Occ. Mindoro	Abralde Ilog	Lapao Iron Deposits	3,000,000	55.00	-
	Napabungan, Abra de Ilog	Hercules Consolidated	1,840,713	66.32	-
12. Rizal	Sta. Ines, Antipolo	Sta. Ines Steel & Mining Corp	29,586,740	57.06	Prospect
13. Tarlac	Burgos, Tarlac	Agro Mining Association	153,800	39.50	Prospect
	Bibiga, Mayantoc	P.D. Agro Enterprises	9,700	30.43	-
	Burgos, Tarlac	-	2,400	57.00	-

* C.O. = Ceased operation.

	Location	Operated by	Estimated reserves (M.T.)	Grade or analysis (% Fe)	Status
14. Western Samar	Bagacay, Kinabangan	Bagacay Copper Project (Marinduque Mining & Ind'l. Corp)	813,563	62.93	Under exploration*
15. Zamboanga del Sur	Bayog	Sibuguey Iron Prospect (Samar Mining Co)	2,852,000	49.80	C.O. (1970)
	Ramon Magsaysay	Surigao Consolidated Mining Co	5,900,000	60.00	Operating but not producing
	Aurora Midsalip	Buan Mining Corp	13,000	-	-
	Barrios of Lumponid, Lumangoy, Cumaaron, Midsalip	Pagadian Iron Mines	1,111,082	66.63	Explored
	Total and Average of Grade		104,590,268	41.90	

TITANIFEROUS MAGNETIZED SAND

	Location	Operated by	Estimated reserves (M.T.)	Grade or analysis (% Fe)	Status
1. Bataan	Morong	Long Beach Mining Corp	200,000	51.09	Producing
	Bagac	Long Beach Mining Corp	481,390	22.04	Being explored
2. Cagayan	Municipalities of Ballesteros	E.M. Ramos Development Corp	2,100,000	57.17	Geological
	Buguey, San Jose and Gonzaga	-	-	4.75	-
3. Cagayan, Ilogos Sur	-	-	5,000,000	60.00	-
4. Camarines Norte	Talisay-Vinzons Area	Woodson Brothers, Inc.	500,000	60.91	-
		Zen Mining Exploration Corp	1,400,000	60.00 6-9% TiO_2	Being explored by Filmag (Phils)
5. La Union	Aringay and Benang	-	2,509,000	55.00	-
	Caba	-	4,858,075	57.00	-
	Lingayen Gulf, Damortis	Anglo Phil. Oil & Mining Corp	2,031,400	60.11 8% TiO_2	Producing
		Lingayen Gulf Mining Corp	7,000,000	5-30% magnetic	Being contracted by Filmag
	Agoo & St. Tomas	Fortune Mining & Exnoration	1,820,400	56.04	-
	Bacnotan & Aringay	Filmag (Phils.), Inc)			
6. Ilocos Norte	Cabitaran, Nueva Era	Filmag (Phils.), Inc)	8,953,574 (blocked-out)	29.10	Non-producing
7. Ilocos Sur	Sta. Cruz, Sta. Lucia	Filmag (Phils.), Inc)			
	Vigan & Tagudin	-	-	-	-
8. Leyte	Abuyog & MacArthur	Phil. Mineral Sands & Co	5,131,000	19.91	-
	Bet. Abuyog & MacArthur	Phil. Mineral Sands & Co	917,730	57.39	-
	Tolosa	Inco Mining Corp	14,806,112	55.60	Producing
	Mayorga-Dulaglarea	Inco Mining Corp	1,594,383	8% TiO_2	-
	Dulag Area	Inco Mining Corp	5,273,859	-	-

* C.O. = Ceased operation.

	Location	Operated by	Estimated reserves (M.T.)	Grade or analysis (% Fe)	Status
9. Davao	Cateel	Filmag (Phils.), Inc	1,800,000	-	Prospect
	Davao Gulf	Filmag (Phils.), Inc	40,000	65.00	Prospect
10. Negros Occ.	West of Silay City	Mr. Alfredo Bustamante	138,400	59.00 4.13% TiO_2	-
	Calabruba	-	1,500,000	-	-
11. Negros Or.	Zamboanguita	Ever Mining Association	206,380	58.83 5.54% TiO_2	-
	Amlan-Tanjay	Ever Mining Association	109,375	59.59 8.81% TiO_2	-
	Southern Part	A.T. Escano Corp (positive	10,493,000)	60.65	-
12. Quezon	Mauban	-	1,142,000	53.55	-
	Mauban	-	378,308	56.04	Explored
	B. Paculao-Casiguran	Maravini Consolidated Mines	1,427,860	55.00	C.O. (1968)
13. Sorsogon	Magallanes	Rolando Tabueva & Associates	17,000	40.56 6.10% TiO_2	-
14. Sorsogon-Albay	-	-	210,000	-	-
15. Surigao Peninsula	-	-	2,879,000	11.67	-
16. South Cotabato	Saranggani Bay Beach	Liberty Mines, Inc	4,000,000	60.00 8.30% TiO_2	-
17. Zambales	Sabang, Sta. Cruz	Pd. Ieq. of Antonio Caguiat	22,467	w/chromite	Geological
	Total and Average of Grade		88,830,713	47.49	
LATERITE IRON ORE					
1. Camarines Norte & Quezon	Mt. Kadig	Horizon Mineral & Oil Corp	83,129,840	20.40	Geological, Explored
2. Eastern Samar	Hibacong, Borongan	G.Y. Ornopia & Associates	7,783,512	37.17	-
	Borongan	G.Y. Ornopia & Associates	4,595,610	43.30	-
3. Palaanan	Rio Tuba, Batarasa	Rio Tuba Nickel Mining Corp (positive	27,755,256 19,842,400)	45.00 w/15.38%Fe	Explored -
4. Surigao	Carrascal, Ludguran Island	Carrascal-Putlaw & Ass.	11,700,000	43.90	-
	-	Government Reservation	2,796,058,862	42.91	Under detailed exploration
	Total and Average of Grade		2,937,176,537	42.52	

	Location	Operated by	Estimated reserves (M.T.)	Grade or analysis (% Fe)	Status
ALUMINOUS LATERITE					
Surigao	Nonoc Island	Government Reservation	17,180,000	18.68% Al_2O_3 40.65% Fe 2.25% SiO_2	Under detailed exploration
	Bucas Grande Island	Government Reservation	242,196,400	21.53% Al_2O_3 41.65% Fe 2.74% SiO_2	Under detailed exploration
	Dinagat Island	Government Reservation	32,634,009	18.60% Al_2O_3 2.88% SiO_2	Under detailed exploration
	Total and Average of Grade		292,010,409	21.03% Al_2O_3 42.52% Fe	

/APPENDIX III

APPENDIX III

RESERVES OF KNOWN COAL DEPOSITS IN THE PHILIPPINES
(As of 31 December 1972)

Location	Estimated Reserve (tons)	Calorific value (B.T.U.)
Polillo Island, Quezon	2,295,000	10,060-12,790
Panganiban, Catanduanes	803,019	11,280-14,650
Batan Island, Albay	15,968,000	8,680-12,300
Gatbo, Sorsogon	112,000	10,269
Bulalacao, Mindoro Or.	7,236,000	8,390-12,040
Semirara Island, Antique	12,331,961	9,000 average
Buruanga, Aklan	---	---
Nabangig, Masbate	121,230	11,092-11,392
Calatrava-Taboso, Negros Occ.	3,398,000	8,760-12,680
Toledo-Danao, Cebu	25,679,000	9,870-13,800
Uling, Cebu	774,000	8,887,12,610
Argao, Cebu	8,220,000	12,340-14,000
Lingig, Surigao del Sur	4,582,000	9,450-14,260
Malangas, Zamboanga del Sur	8,261,492	12,270-15,220

APPENDIX IV

THE NEW INTEGRATED STEELWORKS OF
POHAND IRON & STEEL CO. LTD. REPUBLIC OF KOREA

The regional metallurgical adviser visited Po[illegible]g Iron & Steel Co. (POSCO) on 27-28 November 1972, in order to get a perspective on the potentials and problems of steel industry expansion in Korea which may be of interest to other developing countries.

POSCO's unique achievement

Of the three new integrated steelworks being built currently in the developing ECAFE countries, namely at Bokaro in India, Isfahan in Iran and Pohang in Korea, POSCO is unique in that this flat-products plant will cost about $300 per annual ton of steel capacity (with cost escalation of under 10 per cent on original budget) and will be fully constructed in a period of about three years.

The main events were as follows:

Dec.	1969 -	Preliminary engineering agreement with Japan group (JG) (Yawata, Fuji & Nippon Kokan)
April	1970 -	Consultancy agreement with BHP, Australia.
July	1970 -	Final engineering and consulting agreement with Japan group (JG).
Oct.	1970 -	Construction started on Hot Strip Mill & Plate Mill.
July	1972 -	Plate mill commissioned.
Oct.	1972 -	Strip mill commissioned.
Aug.	1973 -	Complete plant commissioned.

Plant facilities

The initial production facilities are as follows:

Coke ovens (68 oven battery) Nippon Otto.

Sinter plant, 130 sq. m hearth area (3,650 tons/day)

/One 1,660

One 1,660 cu m blast furnace (2,600 tons/day), Ishikawajima-Harima.

Two 100-ton LD vessels with OG system and 1,200 ton mixwr (about 1,030,000 t/yr crude steel).

Soaking pits, 3 x 4 holes.

Blooming/Slabbing mill, 1,190 x 2,900 mm with 2 x 3,200 kw motors, (initial output 890,000 t slab & 148,000 t bloom).

Strip mill - 60" semi-continuous, Mesta-Mitsubishi, (one scale breaker, reversing roughing mill, 6 finishing stands).

Plate mill - 132" wide Voest.

Billet mill - One reversing stand, (to be converted in expansion stage to structural mill).

Cold rolling mill will be added in the first expansion. POSCO is also installing a small blast furnace for foundry iron, in addition to the blast furnace for steelmaking iron.

POSCO will generate 80% of its own electric power needs. It has a small maintenance shop (cost $3 million), laboratories (cost $1 million), calcining plant, oxygen plant, etc.

Raw materials unloading (two - 1,000 t/h unloaders) and product loading facilities are provided at a dock built on reclaimed land. Initially 40,000-ton ships (and later 80,000 tonners) can be handled.

Product-mix

The initial production-mix is as follows:

HR sheet	220,000	tons/year
HR coil	183,000	"
Skelp	180,000	"
Plate	184,800	"
Billets	141,000	"
Total	908,000	tons/year

POSCO initially expects to use only 15-20 per cent of Korean iron ore, due to its limited availability, costs, high silica and sulphur contents. The balance ore (about 1.2 million tons) and all coking coal (0.8 million tons) will be imported.

/The coke rate

The coke rate is expected to be 520 kg with 30 kg auxiliary (tar) fuel. Blast furnace is designed for top pressure, 1,000°C average blast temperature and 80% fluxed sinter in burden.

With high cost imported raw materials POSCO expects to show some profit (after providing interest and depreciation charges) in about the second year of full operation. If realised, this would be a good achievement for which credit would be due to the efficiency of Korean personnel as well as to sound technical advise from their Japanese collaborators.

Even so, there is a need to rapidly expand capacity to 2.6 million tons in order to improve profitability and satisfy rising Korean steel demands.

<u>Consultancy arrangements</u>

From discussions it would appear that the projecting and engineering arrangements worked very well, resulting in a modern plant on schedule and at low cost.

Overall responsibility is of POSCO. Part of the financing is through Japanese reparations but there is no Japanese equity in the capital.

POSCO's contract with three Japanese steel producing companies (fee about $7 million) covered planning, evaluation of equipment bids, checking of manufacturers drawings, assistance in construction supervision and plant commissioning, and training.

In addition, POSCO had a contract with Broken Hill Proprietary Co. from April 1970 upto November 1971 for checking of the overall project plans prepared by the Japan Group.

Bulk of equipment and structural fabrication orders were placed in Japan and the equipment manufacturers also prepared the construction drawings and provided erection expert personnel. Total of about 400 Japanese were at POSCO including Japan Group personnel.

Local construction and erection was done completely by Korean general contractors and this was supervised by POSCO engineers (advised by Japan Group where required).

/Layout

Layout

The plant area covers 770 ha, with about 17 ha of initial covered area. 35 km of road and 18.5 km of railway tracks are provided.

The layout is typically Japanese, compact and efficient. Space has been provided for a total of four blast furnaces (plus foundry iron blast furnace) and two steelmelt shop complexes. Perhaps the arrangement is too compact, particularly at the raw materials storage area, which would make it difficult to expand beyond 7-8 million tons capacity.

A layout drawing is shown in Figure 22.

Plant expansion (1976)

It is planned to expand the plant to 2.6 million tons crude steel by 1976, with addition of the following:

1 - 2,200 cu m blast furnace;

1 - 100 ton LD vessel;

Requisite materials bedding, coke ovens and sintering facilities;

Continuous casting (for 1.5 million tons slab/bloom);

Plate mill modification (expansion of cooling bed, additional reheating furnace, etc.);

Conversion of billet mill to heavy structurals mill;

Cold mills, galvanizing plant.

The 1976 product-mix would be approximately as follows:

HR sheet	200,000	tons/year
HR coil	660,000	"
CR sheet	326,000	"
CR coil	100,000	"
Skelp	240,000	"
Plate	400,000	"
Galvanized sheet	80,000	"
H-beams	200,000	"
Total	2,206,000	tons/year

/Further expansion

<u>Further expansion possibilities</u>

By adding two 250-ton LD converters (with requisite iron-making and rolling mill facilities), POSCO's capacity could be expanded to 5 million tons crude steel by 1981. With a third 250 ton vessel, capacity could be expanded further to 7.5-8 million tons. As noted earlier, limited space for raw materials may present difficulties in future.

<u>Capital cost</u>

The initial 1 million plant is estimated to cost about $310 million (including $165 in foreign exchange). This gives a reasonable investment of about $300 per annual ton. Expansion to 2.6 million tons by 1976 is expected to cost another $300 million, which would reduce per-ton investment to about $230.

APPENDIX V

GASEOUS REDUCTANT PROCESSES

Direct reduction processes using gaseous reductants which have reached a stage of commercial utilization are briefly described below:

HyL PROCESS

This is a batch operation falling in the category of "fixed bed processes". Either lump or pellet may be charged in the reduction retorts in which the reduction is carried out by hot reformed natural gas, or other hydrocarbons. The first step in the HyL direct reduction process is the reforming of natural gas. Preheated steam-hydrocarbon mixture is passed into a reformer where, in presence of a nickel/ceramic catalyst, it is converted into hydrogen and carbon monoxide. Sulphur is removed from the feed stock prior to its entry into the reformer to prevent poisoning of the catalyst.

Hot reducing gas leaving the reformer passes through waste-heat boiler where the excess heat is recovered by converting water into steam. Sufficient steam is produced to meet the total requirement of the reforming process and also for the various drives which are steam turbine driven. The reformed gas (approximate composition: 74 per cent H_2, 13 per cent CO, 8 per cent CO_2 and 5 per cent CH_4) leaving the waste heat boiler, is cooled and dried in a quench tower and is sent to the reduction section of the plant. The sulphur in the gas should not exceed 5 grains per 1,000 cft.

The iron oxide-to-iron conversion is carried out in four identical fixed bed reactors. Each reactor has its own gas preheater and quench tower, and has 4-step processing operation, as follows:

(i) Removal of finished sponge iron and loading with fresh ore

(ii) Secondary reduction, in which the ore is heated and partially reduced by hot gases coming from another reactor

(iii) Primary reduction in which partially reduced ore (previously in the second stage) is further reduced by strong reducing gas.

(iv) Cooling in which hot sponge iron (from the primary stage) is cooled by contact with fresh reducing gas. This step completes the reduction and allows the controlled deposition of carbon which can be varied between 1 and 2 per cent.

The HyL process has found wide commercial application,

ESSO-FIOR PROCESS

The ESSO-FIOR fluidised direct reduction process has been developed by ESSO Research and Engineering. In this fluidised bed process, the charge materials are suspended in the reactor vessel by the flow of the heating and reducing gas. The material charged generally is in a fine form (from 200 mesh to 6 mesh). The gas flow velocity required will be quite different to maintain these different particle sizes in suspension during the reduction period. A particular reactor will be designed for a specific material size having the corresponding gas flow velocity required for the design size particle in suspension. The reducing gas is refined natural gas or any other suitable hydrocarbon. This process was abandoned some time ago but recent indications are that it is being actively promoted. The final product after briquetting is charged into electric arc furnace for steelmaking.

NU-IRON PROCESS

The Nu-iron process, developed by the US Steel Corporation, is also a fluidised bed process using reformed natural gasas reductant. Recent information indicates that the 1 million ton capacity plant now being operated by Orinoco Mining Company of Venezuela is a modification of the original process. In this process dried sized ore (-12 mm) is preheated to approximately 1600°F in a separate multistage ore heater. This is approximately 300°F higher than the reduction reaction temperature in order to supply the required endo-thermic heat for the reduction. The preheated ore is continously transferred to the first stage of the reduction reactor, where it is partially reduced at 1300°F and 15 to 25 psig by the hot off-gasses from the second stage. The partially reduced ore flows continuously to the second stage of the reducing gas. The 90 to 95 per cent reduced iron power is briquetted cooled and stored for processing into steel.

PUROFER PROCESS

The Purofer process is a fixed bed process in which the charge descends through shaft furnace. The reducing gas is a mixture of hydrogen and carbon monoxide kept at a temperature above the pyrophoric temperature of the reduction. This process has been developed only to pilot plant stage at Oberhausen, West Germany.

MIDREX PROCESS

The Midrex fixed bed process normally uses an oxide pellet charge which passes through a shaft type furnace. The mixture of hydrogen and carbon monoxide reducing gas is obtained by reforming natural gas and is used at a temperature above the pyrophoric range. This process was developed by the Midland Ross Corporation.

In this process the metallisation of oxide pellet is carried out in a shaft furnace. By means of high pressure blowers, hot reformed gas from the reforming furnace is forced counter-flow through the bed of pellets in the metallising shaft furnace. In the lower section of the furnace, the reduced sponge iron is cooled down to about 70°C. The inert circulating gas is passed through an heat exchanger for removal of its sensible heat.

Hot reformed gas passed through the bed of pellets is a mixture of hydrogen, carbon dioxide, carbon monoxide water vapour and nitrogen. The reducing gas after picking up oxygen from the oxidised pellets is tapped from the top of the furnaces and reused either in the reformer or for the other purposes.

A 400,000 net ton capacity plant is in operation since 1969 at Oregon Steel Co, Portland, USA. Plants of a similar capacity have been commissioned at Georgetown Steel, USA and Hamburger Stahlwerke, West Germany.

ARMCO PROCESS

The Armco process developed by Armco Steel Corporation, USA, is essentially a fixed bed process. The reducing gas is a mixture of hydrogen and carbon monoxide formed after reforming natural gas with cooled and dried shaft furnace top gas in alumina pebble stoves.

The oxide pellets, charged at the top of the furnace, get heated while descending in the furnace and reduced. They are then cooled to 70°C or less before discharge.

The furnace top gases are cooled and partially cleaned by water sprays. A small amount of top gas is bled and the remainder is compressed. Natural gas is added to the compressed recycle gas to obtain the desired CO_2/CH_4 ratio. A measured amount of the mixed gas enters the shaft furnace at the bottom to cool the pellets. The remainder is measured and flows to a three-way valve which proportions the amount fed to the pebble stove bottom for reforming and the amount by-passing the stoves for subsequent tempering of hot reformed gas leaving the stove dome. During reforming, the temperature in the stove falls from 1550°C to 1100°C at the top of the pebble bed and from 550°C to about 120°C at the bottom. Meanwhile gas and air burn directly in other stove dome to restore heat.

Based on the results of the experimental work, Armco has constructed at their Houston Works a direct reduction facility for the production of 1,000 tons per day iron.

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