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# REPORT ON IRON AND STEEL INDUSTRY IN THAILAND AND SCOPE OF TECHNICAL ASSISTANCE TO STUDY ITS PROSPECTS AND STRATEGY FOR EXPANSION BASED ON UNDP/UNIDO LARGE SCALE PROJECT 1/

by

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# Summary

## Iron and Steel Industry in Thailand

### General situation and current status

1. The present steelmaking capacity in Thailand is estimated at about 550,000 tonnes annually whilst the current annual crude steel output is about 494,000 tonnes yielding (at the yield ratio of 77%) the finished steel output annually of 380,000 tonnes comprising non-flat steel products (steel rods, bars, etc.). The total consumption, however, corresponds (non-flat steel products) to about 0.6 million tonnes annually at present; the difference is made up by imports of over 0.2 million tonnes of non-flat steel products annually at present. (Chapter II, paras 4, 5, 6).

2. In the case of flat steel products, the current consumption annually of about 465,000 tonnes is based wholly on imports (corresponding to crude steel equivalent of 603,750 tonnes at 77% yield ratio). (Chapter II, paras 8 to 10).

3. The total consumption of finished steel (flat and non-flat steel products) is currently estimated to be about 1.03 million tonnes annually (corresponding to crude steel equivalent of 1.3 million tonnes).

4. The estimates of future steel demands have been variously made (flat and non-flat steel products) to be around 1.3 million tonnes for 1975 comprising 0.7 million tonnes and 0.6 million

tonnes of non-flat and flat steel products respectively; the corresponding figures for 1980 are assessed to total 1.9 million tonnes (1.1 million and 0.8 million tonnes respectively of non-flat and flat steel products) and for 1986 to total 2.5 million tonnes (1.5 million and 1 million tonnes respectively of non-flat and flat steel products). To maintain the current steel capacity, steel scrap has to be heavily imported; in 1970 about 170,000 tonnes of steel scrap were imported[1/], whilst in 1972 this figure was over 230,000 tonnes. During 1973, 365,891 tonnes of steel scrap were imported at a cost of over 40 million US$. During the first two months of 1974,[2/] 61,507 tonnes of steel scrap were imported at a cost of 9.051 million US$. The total import bill of the steel products including steel scrap, flats and non-flats steel products is of the order of 250 million US$ for 1972 and exceeds 300 million US$ for 1973 in view of the steel price hike of steel products and scrap. During the first two months of 1974, the cost of steel imports approached 60 million US$ mark and for the whole of 1974, this figure is likely to touch 400 million US$. Thus on an average, in the preceding five years' period, over a billion US dollars represent the bill for steel imports into Thailand and this figure will further rise during 1975 - 1980 (Chapter III, paras 17-23).

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1/ At an average cost (CIF) of 109 US$ per tonne of steel scrap

2/ At an average cost (CIF) of 147.1 US$ per tonne of steel scrap.

5. Considered in the above context, the expansion of Thai iron and steel industry needs a critical study and appraisal and follow-up action on the basis of techno-economic utilisation of local raw materials for the iron and steel industry supplemented by their imports to meet the needs of expanding domestic steel markets and to off-set the increasing import bills of steel scrap and equally increasing import costs of imported steel and steel products. The corresponding strain on the prices levied for locally made steel products (non-flat) bars, rods, light sections is great; the steel prices of Thai made non-flat steel products are of the order of 300-350 US$ per tonne (in equivalent Baht) compared to an average of 150 US$ per tonne of Thai non-flat steel products (in equivalent Baht) during 1971-72, barely twenty-four months back.

Local raw materials

Current status and availability

6. Iron ore deposits in Thailand are widely scattered but most of high grade. These deposits contain possible reserves of 40 million tonnes with iron content ranging from 40-60%. Three main deposits are (a) Lop Buri - 7 million tonnes, used by the Siam Iron and Steel Co. (b) Kanchana Buri - 5 million tonnes and (c) Loei - 27 million tonnes located remotely in the north near the Mekong river and the boundary with Laos,

300 km away from Bangkok. There are no known deposits of high grade coal in Thailand but there are fair reserves of lignite of Tertiary age, some of which have properties of sub-bituminous coals. The principal lignite bearing sedimentary basins are at Li, Mae Mo, Mae Sot and Chiang in the north and Krabi in the south. The bulk of the lignite mined so far lies at Krabi which has a calorific value of about 11,000 BTU/lb. The use of these lignites as dried lignite or lignite char for metallurgical purposes, such as sponge iron production has not been investigated experimentally on Pilot Plant scale so far at all. (Chapter IV, paras 28 to 391).

Major problems

7. Major problems facing the iron and steel industry in Thailand are many and complex and pose important questions that need to be answered; some typical questions relate to the following:

8. a) Should Thai steel industry be fully integrated, i.e. starting from smelting of local iron ores (with or without their prior beneficiation and agglomeration) and/or imported iron ores/pellets and follow conventional process routes (blast furnace or electric smelting of pig iron + BOF steel-making) using imported metallurgical coal/coke in an integrated steel plant located at a coastal site in preference to an inland site? What would be its capital costs? What product mix should be produced? Should electric smelting of pig iron be undertaken?

What would be the electric power tariffs in years to come - it is high at present at 0.4 - 0.6 Baht/KwH. Does the integrated iron and steel plant need a deep coastal sea port or will a deep jetty/belt coveyer system do at an existing medium deep sea port such as at Sattahip or should a new deep sea port such as at Laem Chabang be put up about 14 km South of Siracha? What are the capital costs of doing so, i.e., of conventional integrated cycle of iron and steel production? A pertinent question would be - can Sattahip be used as a convenient civilian/medium deep sea port for industrial usages including import of raw materials for the integrated steel industry? What are the objections to its use as a civilian sea port in normal peace time and conversion to defence needs in case of a War, a practice normally followed in many countries. (Chapter VI, paras 45 to 57).

9. b) Can Thai lignites be used for sponge production using local iron ores after prior beneficiation/pelletization or using imported high grade heat-hardened iron oxide pellets? Pilot plant scale investigations and trials would be necessary to determine the technical feasibility of sponge production based on solid reductants (dried lignite or lignite char). It is well known that many of the solid-reductant based industrial sponge[1/] production plants in different countries have either failed or permanently closed down badly whilst one or two of them are now reportedly

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1/ Sponge with a high degree of metallization over 90% which is suitable for direct steelmaking in the electric arc furnace.

turning the conventional sponge production costs are, however, reported to not known nor is much precisely known about the cost of steel made directly from much highly metallised sponge in electric arc furnaces at the normal power costs. If one were to assess the technical feasibility of sponge production in Thailand based on the results of pilot plant scale investigations under laboratory conditions or limits, what would be the corresponding scaled up industrial scale techno-economic feasibility and costs (capital and recurring) as judged on acceptable criteria and reasonable plant capacities and economic aspects do need detailed examination. Another question would be - should Thailand import sponge made by the various sponge iron processes (HYL, Midrex, etc.), such as from a neighbouring country e.g., Indonesia[1] at reasonable price levels to substitute/supplement highly expensive imported steel scrap. Should Thailand import pellets for sponge production based e.g. on the HYL process and if so, at what costs? (Chapter V, paras 40 to 43).

ii. c) What should be the product mix of an integrated or a non-integrated steel plant - flat and non-flat steel products? If the flat steel products are to be produced what would be the economic size of the integrated iron and steel plant and of the mill - one million or 1.5 million tonnes of flat steel products? What are the market demands of flat steel products in the absence of a ship building industry and/or of automobile industry in Thailand which need cold steel coil/strip for auto-bodies and

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1/ Indonesia is reportedly setting up a Direct Reduction Sponge Plant based on a gaseous direct reduction process with an initial capacity of a million tonnes per year.

steel plates of varying lengths and widths for ship building and engineering industries. Or should the integrated steel plant produce both flat steel products and non-flat steel products (rods, sections, structurals, beams, medium sections, etc.) based e.g. on a universal blooming/slabbing rolling mill and a combination mill for steel plates and hot rolled steel coils, followed by a cold steel rolling mill for cold strip (coils) besides the structural/merchant section mills for non-flat steel products.

11. d) What would be the most optimum location for the new integrated steel plant? What would be the costs of transport of raw materials (cost per ton/mile) in case of an inland site? What would be the transport costs of supplying the Thai steel products to the domestic markets in Thailand? Optimum price levels will need to be determined and applied in practice as also the protective tariffs needed by the indigenous steel industry (customs duty on the imported steel products and/or subsidy for the export of Thai steel products). These questions need a detailed study and rational answers.(Chapter III, para. 4).

12. Capital investment needs of the new integrated steel industry would needd to be assessed both in terms of foreign exchange and local currency requirements. What about the merits of the existing steel industry's proposals which are based on reverse integration and installation of a cold strip mill followed later by a hot strip mill? What would be the related capital and in-built production costs? Protective tariffs and subsidies

will need to be worked out before such proposals can be acceptable. The examples and experiences inter alia of South Korea, Yugoslavia will need to be quoted and applied to the extent possible.

13. The above questions and problems will need to be examined through a detailed consultant's study including comprehensive investigations on pilot plant scale on Thai raw materials for sponge production based on solid reductants (dried lignite or lignite char). In effect the entire strategy of the planning and expansion of the Thai steel industry has to be formulated for the next decade in concrete terms which has to be realistically linked with (a) the existing home market demands and pattern and their future projections and (b) with possible exports. This strategy has to be linked on the one hand with potential uses of the natural resources and local Thai raw materials for the steel industry supplemented and/or substituted by imported raw materials. The interpolated cost effects of these factors have to be studied both on capital investment and plant operations including production costs of the steel products. (Chapter VI, paras. 45 - 57).

14. Alternatively, it will need examination how far and to what extent, the existing wholly scrap-based steel melting plants in Thailand can be strengthened through additional equipment/infra-structure facilities and expanded to the optimum extent techno-economically possible. Planning and time phasing

of these proposals will need to be rationally and judiciously outlined but not on any empirical and ad hoc basis that appear to have marked the growth of the Thai steel industry so far.

15. Regional solutions should also be examined based on bi- or multi-lateral co-operation, regional steel industry and trade possibilities. So far these factors have played a somewhat insignificant part in the growth of the steel industry in Thailand. To what extent can these factors be harnessed to the mutual benefits of the regional countries? These aspects will need to be studied at length through an International Consultant's study and report. (Chapter VII, paras 58 - 61).

16. Another important question relates to the production of high priced alloy and special steels in existing scrap melting electric arc furnaces in the country (that are imported at high foreign exchange costs) which could replace or at least supplement most profitably the relatively much lower priced common plain carbon and mild steels with almost the same inputs of scrap, electric and manpower besides the additions of requisite ferro-alloys. Where should the balance be struck in these areas which are most appropriate and applicable to the Thai steel industry? All these important questions need to be critically examined, clarified and decisions taken through a UN financial consultant's study and a detailed report. So far there have been a mushroom of ad-hoc studies empirically commissioned and business motivated and tailored to limited objectives and scope of work; however, there has been no single study and a comprehensive report

which aims at answering all the complex and inter-woven questions and parameters to enable the planners, economists and the industrialists to take judicious and well planned decisions and implement them on a systematic and time phased basis.

17. The questions of finances such as import tariffs, export subsidies, capital formation and of infrastructure facilities including inter alia transport, services (water, oil, gas, power) likewise need a careful study and rationale.

18. The iron and steel foundry industry (again dependent upon appropriate melting facilities) also requires adequate linkages with the iron and steel industry in the country.

19. The mineral exploration and proving such as of iron ores, coal (lignite resources) should be continuous features of an expanding economy and sights have to be focussed on a long term and well sustained basis.

Some of the specific problems to be studied by the International Consultants (Chapter VIII, paras 62 - 84).

20. a) Estimation of the demands for steel products on a yearly basis for the years 1975 - 1985 covering common grades of steels (flats, non-flats, structurals, light sections). This assessment could be based on the categories and types of steel rolling mills required such as the universal blooming/slabbing mill, combination mill,

structural mill, hot and cold continuous strip mill, etc.

21. b) Regional market needs have to be estimated for the steel products. Costs of transportation to feed the regional markets have to be broadly outlined.

22. c) Export possibilities based on mutually acceptable bilateral, multilateral and trade arrangements should be indicated.

23. d) Technological audit of the current steel production capacity should be made including plant and equipment under installation and those already ordered but awaiting receipt and/or installation. Cataloguing of the available plants and their equipment will need to be done with a view to their full capacity utilisation.

24. e) Technological audit should include the production levels currently achieved vis-a-vis the established steel capacity and delineation of the possible technical and non-technical reasons for under utilisation of the installed steel capacity, e.g., lack of raw materials, steel scrap, etc., depressed market conditions, plant imbalance, production costs and the pricing systems, etc. Remedies to achieve effectively the full utilisation of the installed capacity could be outlined on a pragmatic basis along with directions and possibilities of more efficient plant operations for achieving maximum productivity, e.g., can the existing rolling mills enable a more diversified range of steel rolled products?

25. f) Raw materials studies (local and imported) and their transport costs to the plant's premises including ocean freights. One of the main raw materials at present used viz the steel scrap (local as well imported) should be highlighted including its price levels (local currency and foreign exchange).

26. g) Studies of the services and their costs - including power, water, gas and oil. Their impact on steel production costs will need to be dealt with.

27. h) Review the present proposals for the expansion of the steel industry in Thailand put up by the public or private sectors. The consultants should offer their own solutions and plans therefor based on sound techno-economic rationale. Those steel products which cannot be economically produced in Thailand would enforce need imports; this aspect should be fully analysed as to what steel product mix would be beyond the range/capacity of even the expanded Thai steel industry and on what grounds.

28. i) In the case of the establishment of an integrated iron and steel plant in Thailand of an optimum capacity, the consultants will fully cover the following:

29. a) Scope of using local raw materials available such as Thai lignite deposits, iron ores to the extent techno-economically justified and the need of imported raw materials, e.g. high grade iron ore and pellets such as from Australia, India, required to

sustain the efficient operations of an integrated iron and steel plant in Thailand. The cost in foreign exchange of the import of requisite raw materials will need to be techno-economically justified.

30. b) Choice of technological processes for ironmaking and steel production including continuous casting of blooms or billets and slabs. Capital and production costs will be examined for each of the processes at different levels to justify the selection of the optimum process flowsheet. Data on material balance will be prepared for iron and steelmaking including effective utilisation of the by-products and for the individual steel rolling mills and finished shops.

31. c) Detailed report on the rolling mills to produce for example about 50-60% of the total steel output as flat products (hot and cold rolled coils, sheets, strip, skelp and steel plates); and the balance to roll structural product-mix including beams and medium sections, merchant mill light sections, Reebe bars and wire rods, etc. Alternative schemes of product-mix will be examined in relation to the economies of scale and techno-economic appraisal.

32. d) Study of the market requirements and their future projections upto 1980 and 1985 (including possible exports to regional countries) and their alignment with the integrated steel

plant's product-mix. The local and international price structures will be examined comprehensively to formulate inter alia requisite protective tariffs and subsidies, import bans and trade protection and Government incentives (tax rebate, etc.) that may be needed at least during the initial years of the steel plant's integrated operations.

33. e/ Most suitable location - the integrated steel plant will be examined including a medium deep sea coastal location to facilitate the import of bulk raw materials; the most optimal location will need to be techno-economically justified including "built-in-future flexibility" requirements.

34. f/ Financial projections for the integrated iron and steel plant will be prepared covering inter alia capital and investment costs including foreign exchange, cash flow analysis, operational and maintenance costs; mode of capital financing will also be recommended.

35. g/ General specifications of the steel plant equipment including auxiliaries and services (power, water, gas and air) will be drawn up.

36. h/ In preparing the above detailed report for the establishment of an integrated iron and steel plant in Thailand, previous technical feasibility reports prepared inter alia by UNIDO, IBRD, Krupp, Japanese and other steel survey missions will be taken fully into account.

## Conclusions

37. The above study and detailed report will be financed by UNDP/UNIDO under the Country Programme (IV) of Thailand and is estimated to cost between 150,000 to 200,000 US$. It should take six to eight months to be completed by a competent Technical Consultant's firm/organisation with UNIDO's technical support and backstopping. The report of this study will then be available to the IEPD and the Government for further follow-up action as appropriate.

## I. IRON AND STEEL INDUSTRY IN THAILAND

### A. Introduction

1. The growth of the iron and steel industry in Thailand during the last decade and its expansion has been the subject of considerable studies by UN Agencies, Asian Industrial Development Council, ESCAP and overseas steel interests and organisations. UNIDO took the initiative[1] in 1970 in studying the expansion of the Thai iron and steel industry and more specifically in outlining the complex problems confronting the steel industry as well as emphasizing the role and importance of the integrated iron and steel industry; in highlighting the latter, UNIDO sought to provide answers and solutions to the former through sponsoring a Technical Assistance programme which was welcomed by the Government bodies and its counterpart technical consultancy organisation, viz. the Applied Scientific Research Corporation of Thailand. UNDP reaction to UNIDO's technical assistance project was positive although it was linked subsequently to the question and problems of a deep sea port vis-a-vis the location of the integrated iron and steel plant in Thailand. A UNDP consultant[2] and Regional UNIDO Adviser[3] at ESCAP further endorsed the earlier UNIDO project[1] for implementing the Technical Assistance under the Special Industrial Services of UNDP/UNIDO through the

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1/ Mission report of Mr. R.R. Nijhawan, Senior Interregional Adviser, on the technical assistance to Thailand Iron and Steel Industry by UNIDO - August 1970.

2/ Mr. J. R. Miller's brief mission to Thailand - August 1971.

3/ The Scope of Technical Assistance for Development of the Thai Iron and Steel Industry - Advisory Service Report of Mr. R.D. Lalkaka - June 1972.

international technical consultancy services. Furthermore, US Koppers study of the regional steel industry supplemented by a Japanese AIDC steel study and finally a comprehensive study[1] and a report of the joint UNIDO/ECAFE steel industry mission fielded early in 1971 to the Mekong Delta riparian countries led to a series of chain reactions in the imperative need to expand the Thai iron and steel industry and plan it rationally on sound techno-economic lines instead of its bourgeoning on impirical and ad-hoc basis. The interest of the IBRD was aroused during 1974 which sponsored on request of the Government, the Industrial Sectoral Mission, the terms of reference[2] of which covered the Steel Sectoral Study; more specifically, the problems and study of the expansion of the Thai steel industry form the basic objectives of the steel sector study undertaken by Mr. B.R. Nijhawan as a member of the Industrial Sector IBRD Mission led by Mr. Jivat N. Thadani, IBRD, which has resulted in the detailed formulation of the "Terms of Reference" for a comprehensive Technical Consultancy Services Project, for implementation by UNIDO under Thailand's Country Programme and financing through the IPF of UNIDO.

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1/ Report of the UNIDO/ECAFE Iron and Steel Industry Survey Mission to the Four Countries (Thailand, Laos, The Khmer Republic, and the Republic of Viet-Nam) of the Lower Mekong Basin, led by Mr. B.R. Nijhawan, Senior Interregional Adviser, UNIDO - August 1971.

2/ The Terms of Reference are appended to the full Report of the Industrial Sectoral Mission of the IBRD.

It would be observed that UNIDO's initial concept of 1970 to promote such an international technical consultants' study for the expansion of Thai steel industry including inter alia the establishment of an integrated steel plant has withstood the test of numerous examinations and stipulations. It will not be possible to refer to all the numerous papers, some very recent and others of historical and general technical interests prepared by and for the Thai steel industry and linked with country's development plans. Although, the main essence of these studies has been the imperative need to rationally expand the Thai steel industry [illegible] techno-economic rationale, the studies themselves have been of a general conceptual character rather than aligned to specific issues and practical objectives; in most cases, these studies have covered the regional countries on an overall and bundled basis vis-a-vis their steel industry (including Thailand). In one case, the study covered the steel industry of the four riparian countries of the Lower Mekong Basin including Thailand. As such, the imperative need to undertake a detailed study in depth of the expansion of the Thai steel industry and its master plan became more acute. The IBRD mission and subsequent action to sponsor a comprehensive technical consultancy study relating specifically to the iron and steel industry in Thailand, are therefore, directed to meet these lacunae.

## II. CURRENT STATUS OF THE IRON AND STEEL INDUSTRY IN THAILAND

2. The current status of the iron and steel industry in Thailand has been variously interpreted. Corresponding to an average annual growth rate of 9% of GDP since 1958, the consumption of steel has increased by 15% per year. Providing employment to over 10,000 workers, Thai steel industry has saved the country substantial foreign exchange through import-substitution. Over 100 million US$ have been invested by Thai industrialists in equity partnership with the Japanese, UK and Indian investors; the Thai holding corresponds to about 70% of the capital investment. Despite the encouraging economic climate, only the two largest firms, G.S. Steel and TSCO have expressed periodically intentions to expand their capacities. There are many constraints to the expansion of the existing steel melting and rolling capacity in the country such as shortage of raw materials basically the steel scrap mostly imported and whose price has risen phenomenally during the last eighteen months, refractories, electrodes for electric arc furnaces but the one major basic and the linking factor is the lack of private Thai capital. To this effect, the Mission was repeatedly told that the Government will have to assist the private sector in capital formation through equity, loan or appropriate joint financial collaboration. The growth of the Thai steel industry has followed empirical and disjointed lines despite incessant

planning at various private levels and Government bodies (NESDB, ADBC, BOI). Despite these positive efforts and paths taken by the Government, an overall steel strategy and master plan for the growth of the Thai steel industry has so far not been prepared and the need for it is now recognised as most imperative. The following data outline the current status and capacity of the steel industry in Thailand:

a. There are only steelmaking plants are in operation which can be classified into six categories as follows:

| Type of production 1/ | Number of plants | Capacity (M/T) |
|---|---|---|
| Steel bars | 11 | [illegible] |
| Steel rails | 17 | [illegible] |
| Galvanised sheet | 3 | 200,000 |
| Galvanised wire | 4 | [illegible],000 |
| Galvanised pipe | 4 | 140,000 |
| Tin plate | 1 | 16,000 |

The total investment has been estimated at about 2,000 million Baht and direct employment extended to 10,000 workers. Steel industry in Thailand produces mostly non-flat bar products its present capacity is about 450,000 tonnes/annually based on scrap-based steel melting plants using electric arc melting furnaces and on six steel re-rolling mills.

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1/ Source: Ministry of Industry

4. The maximum annual rated steel production capacity to-date (1974) has been assessed at 550,000 tonnes of non-flat products mostly steel bars for R.C.C. works. However, the effective production has been nowhere near this figure due to various constraints such as shortage of raw materials basically the steel scrap which has largely to be imported to the extent of over 60% of its requirements. The production has been of the order of 330,000 to 365,000 tonnes a year of steel made in the electric furnaces whilst the re-rolling capacity has had to depend upon the varying of the internal and international trade for the supply of steel billets, steel scrap for direct re-rolling such as obtained from ship plates from hulls of the scrapped ships that are broken up for their scrap values. The following tables furnish the data concerning the steel production capacity in the country:

Table 1

Production Capacities of the Steel Mills

| Companies | Max. Capacity tonnes | Production tonnes | | |
|---|---|---|---|---|
| | | Electric Melting Furnace | Re-rolling | Total |
| U.S. Steel Co. | 140,000 | 3 x 20T 140,000 | - | 140,000 |
| Siam Iron and Steel Co. | 125,000 | 2 x 30T 97,000 | - | 97,000 |
| Bangkok Steel Co. | 70,000 | 1 x 3[illegible] 45,000 | 25,000 | 70,000 |
| Bangkok Iron and Steel Co. | 54,000 | 3 x 5T 42,000 | 12,000 | 54,000 |
| Thai-India Co. | 60,000 | 1 x 6T 14,000 | 16,000 | 30,000 |
| Six other Companies | 71,000 | - | 69,000 | 69,000 |
| Total | 550,000 | [illegible] | [illegible] | [illegible] |

5. The following Table provides the list of plants using flat products (galvanizers, tin plate) as well as producers of foundry iron and steel:

Table 2

Capacities of major steel production & processing facilities in Thailand

| Firm | Estimated capacity M.T./year | Type of product |
|---|---|---|
| Pig iron | | |
| [illegible] Steel Co. | 22,000 | Pig iron (for foundry) |
| Bars & light shapes | | |
| U.S. Steel Co. | 140,000 | Bars |
| Siam Iron & Steel Co. | 120,000 | Bars & light strls. |
| Bangkok Steel Co. | 70,000 | Bars |
| Bangkok Iron Steel Ind. | 84,000 | Bars |
| Union Metal | 25,000 | Light strls. |
| Thai Steel Industry | 3,000 | Bars |
| Thai-India Steel Co. | 60,000 | Bars |
| Others | 50,000 | Bars |
| Pipes | | |
| Thai Steel Pipe Industry | 60,000 | Pipes |
| Thai American Steel Work | 55,000 | Pipes |
| Boonsana Panichakarn Co. | 20,000 | Pipes |
| Cathedrion Co., Ltd. | 3,600* | Pipes |
| Bangkok Steel Pipe Co. | - | - |
| Thai Union Co. | 2,400* | - |
| Galvanizers | | |
| Bangkasi Thai Co. | 70,000 | Galvan sheet |
| Thailand Iron Works | 60,000 | Galvan sheet |
| Far East Iron Works | 24,000 | Galvan sheet |
| Tin-plate | | |
| Thai Tinplate Co. | 16,000 | Hot-dip plate |
| Expansion project | (55,000) | Electrolytic tinplate |
| Pipe-fittings | | |
| Thai Pipe Fittings | 120 | Steel fitting |
| Castings | | |
| Royal State Railway | 4,200 | Grey cast-iron |

* Under construction (not capacity)

6. Another major constraint to local steel industry's growth is the cost of electric power for electric arc steelmaking. From an earlier figure of 0.4 Baht per Kwh it has now reportedly risen to 0.6 Baht per Kwh i.e. from 20 mils to 30 mils which is indeed a high charge on the domestic steel producers.

7. The following Tables provide the basic data and statistics concerning the yearly steel production and imports/exports of steel to Thailand upto 19

20 Baht = 1 US$

Table 3

Quantity and Value of Steel Products Imported to Thailand
1960 - 1972

| | Flat Steel | | Non Flat Steel | | Total | |
|---|---|---|---|---|---|---|
| | Tonne | Bt. 1,000 | Tonne | Bt. 1,000 | Tonne | Bt. 1,000 |
| 1960 | 92,577 | 293,524 | 140,849 | 542,181 | 233,221 | 835,705 |
| 1961 | 117,425 | 469,366 | 162,647 | 538,133 | 280,272 | 1,007,499 |
| 1962 | 119,229 | 425,784 | 197,385 | 622,772 | 317,304 | 1,048,557 |
| 1963 | 125,812 | 415,929 | 235,800 | 757,630 | 361,612 | 1,173,559 |
| 1964 | 164,117 | 491,840 | 206,910 | 660,513 | 371,027 | 1,152,353 |
| 1965 | 152,416 | 490,298 | 282,257 | 931,308 | 434,673 | 1,521,606 |
| 1966 | 216,212 | 648,905 | 389,187 | 1,192,398 | 605,399 | 1,841,303 |
| 1967 | 267,442 | 824,202 | 493,926 | 1,398,320 | 691,368 | 2,222,522 |
| 1968 | 277,433 | 830,070 | 409,701 | 1,395,020 | 687,134 | 2,225,090 |
| 1969 | 338,122 | 1,075,674 | 328,640 | 1,222,305 | 666,762 | 2,297,979 |
| 1970 | 332,946 | 1,174,423 | 243,804 | 896,277 | 576,450 | 2,070,700 |
| 1971 | 268,684 | 1,212,600 | 237,798 | 1,092,000 | 506.482 | 2,304,600 |
| 1972 | 464,867 | 1,633,700 | 182,580 | 1,094,000 | 647,467 | 2,727,700 |

Source: Department of Custom

## Table 4

Consumption of Crude Steel Equivalent 1960 - 1972

| | A | | | | | B | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Consumption of Flat Steel | | | | | Consumption of Non-Flat Steel | | | | | Total A and B | | | | |
| | Import | Estimated Production | Export | Estimated local Consumption | Consumption per head | Import | Estimated Production | Export | Estimated local Consumption | Consumption per head | Import | Estimated Production | Export | Estimated local Consumption | Consumption per head |
| | Tonne | Tonne | Tonne | Tonne | kg/head | Tonne | Tonne | Tonne | Tonne | kg/head | Tonne | Tonne | Tonne | Tonne | kg/head |
| 1960 | 115,067 | - | - | 115,067 | 4.36 | 134,599 | 8,824 | - | 207,433 | 7.54 | 310,476 | 8,824 | - | 313,500 | 11.90 |
| 1961 | 152,500 | - | - | 152,500 | 5.56 | 211,490 | 8,824 | - | 220,314 | 8.03 | 343,993 | 8,824 | - | 373,314 | 13.59 |
| 1962 | 185,739 | - | - | 185,739 | 6.50 | 256,334 | 8,824 | - | 265,168 | 9.27 | 430,383 | 8,824 | - | 439,207 | 15.37 |
| 1963 | 203,392 | - | - | 203,392 | 6.90 | 306,234 | 8,824 | - | 315,058 | 10.50 | 489,626 | 8,824 | - | 498,450 | 16.60 |
| 1964 | 200,152 | - | - | 200,152 | 6.65 | 281,701 | 8,824 | - | 290,525 | 9.56 | 481,853 | 8,824 | - | 490,677 | 16.21 |
| 1965 | 187,343 | - | - | 187,343 | 6.38 | 366,668 | 8,824 | - | 375,492 | 12.10 | 554,011 | 8,824 | - | 563,745 | 18.48 |
| 1966 | 281,795 | - | - | 281,795 | 8.78 | 508,468 | 8,824 | - | 517,292 | 16.37 | 786,263 | 8,824 | - | 799,087 | 25.15 |
| 1967 | 347,327 | - | - | 347,327 | 10.53 | 550,653 | 47,412 | - | 597,965 | 18.12 | 897,980 | 47,412 | - | 945,392 | 28.65 |
| 1968 | 360,303 | - | - | 360,303 | 10.59 | 536,079 | 125,626 | - | 661,705 | 19.45 | 896,382 | 125,626 | - | 1,021,008 | 30.04 |
| 1969 | 439,119 | - | - | 439,119 | 12.50 | 426,866 | 191,682 | - | 618,548 | 17.62 | 865,985 | 191,682 | - | 1,057,667 | 30.12 |
| 1970 | 432,908 | - | - | 432,908 | 12.03 | 316,628 | 249,470 | 16,470 | 549,628 | 15.18 | 749,536 | 249,470 | 16,470 | 981,536 | 27.21 |
| 1971 | 348,940 | - | - | 348,940 | 9.33 | 308,862 | 384,000 | 20,235 | 672,627 | 17.99 | 657,802 | 384,000 | 20,235 | 1,021,567 | 27.32 |
| 1972 | 603,773 | - | - | 603,773 | 15.65 | 237,093 | 194,118 | 43,435 | 687,776 | 17.83 | 840,866 | 194,118 | 43,435 | 1,291,549 | 33.48 |

Source: - **From table 1**

- **Import** of flat and non-flat products in exposed crude steel equivalent by assuming 77% yield of steel product from crude steel

- **Production and Export** of non-flat products are exposed in crude steel equivalent assuming 65% yield of steel product from crude steel.

Table No. 5

Projection of Crude Steel Consumption (Based on estimated growth in per capita G.N.P. at rate of 2, 3, 4, 5% per year [illegible])

| | Projection of Flat Steel Consumption | | | | Projection of non-Flat Steel Consumption | | | | Projection of Total Consumption | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | At 2.1 growth rate Tonne | At 3.1 growth rate Tonne | At 4.1 growth rate Tonne | At 5.1 growth rate Tonne | At 2.1 growth rate Tonne | At 3.1 growth rate Tonne | At 4.1 growth rate Tonne | At 5.1 growth rate Tonne | At 2.1 growth rate Tonne | At 3.1 growth rate Tonne | At 4.1 growth rate Tonne | At 5.1 growth rate Tonne |
| 1973 | 523,800 | 533,600 | 542,900 | 551,900 | [illegible] | [illegible] | [illegible] | 813,900 | 1,301,600 | 1,353,000 | [illegible] | 1,365,400 |
| 1974 | 547,[illegible] | 586,700 | 596,400 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 1,381,400 | [illegible] | 1,[illegible] | 1,[illegible] |
| 1975 | 588,600 | 683,400 | 654,700 | [illegible] | [illegible] | 912,400 | 952,[illegible] | [illegible] | 1,465,700 | 1,[illegible] | 1,607,000 | 1,680,800 |
| 1976 | 689,900 | 643,000 | 717,[illegible] | 763,[illegible] | 923,700 | 797,500 | 1,036,900 | 1,096,[illegible] | [illegible] | [illegible] | 1,754,300 | 1,859,[illegible] |
| 1977 | 649,100 | 725,900 | 784,300 | 846,200 | 977,400 | 1,050,800 | 1,127,200 | 1,206,[illegible] | 1,546,500 | 1,776,[illegible] | [illegible] | 2,052,700 |
| 1978 | 730,500 | 782,200 | 857,500 | 936,500 | 1,034,000 | 1,126,700 | 1,224,200 | 1,328,[illegible] | 1,[illegible] | 1,908,900 | 2,[illegible] | 2,[illegible] |
| 1979 | 752,600 | 840,600 | 933,900 | 1,032,500 | 1,091,400 | 1,205,[illegible] | 1,325,700 | 1,453,[illegible] | 1,[illegible] | 2,044,700 | 2,[illegible] | 2,[illegible] |
| 1980 | 797,000 | 908,800 | 1,035,600 | 1,136,[illegible] | [illegible],651,600 | 1,288,200 | 1,434,400 | 1,590,700 | [illegible],948,500 | 2,190,800 | 2,450,000 | 2,727,100 |
| 1981 | 843,600 | 968,[illegible] | 1,103,200 | 1,248,800 | [illegible],214,900 | 1,376,400 | 1,550,900 | 1,735,700 | 2,[illegible],058,500 | 2,344,[illegible] | 2,654,100 | [illegible],988,000 |
| 1982 | 898,500 | 1,038,200 | 1,197,200 | 1,370,500 | 1,281,[illegible] | 1,[illegible],800 | 1,[illegible],500 | 1,899,700 | 2,1[illegible],900 | 2,508,[illegible] | [illegible],872,700 | 3,270,200 |
| 1983 | 944,000 | 1,112,400 | 1,297,900 | 1,508,100 | 1,364,800 | 1,568,900 | 1,809,000 | 2,073,[illegible] | [illegible],495,100 | 2,681,300 | 3,106,900 | 3,[illegible],300 |
| 1984 | 998,000 | 1,191,000 | 1,405,800 | 1,644,400 | [illegible],424,700 | 1,674,[illegible]00 | 1,951,900 | 2,260,900 | 2,422,200 | 2,865,000 | 3,357,600 | 3,904,900 |
| 1985 | 1,054,800 | 1,274,500 | 1,521,300 | 1,798,300 | 1,501,100 | 1,785,300 | 2,104,600 | 2,462,900 | 2,[illegible]5,900 | 3,059,900 | 3,625,900 | 4,261,600 |

Note: Computation is based on a straight line correlation between per capita consumption of crude steel and per capita G.N.P. at constant price

Table No. 6

THOUSAND

x Tonnes

| IMPORTS | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 |
|---|---|---|---|---|---|---|---|
| Coke | 3,623 | 4,209 | 5,991 | 10,270 | 9,368 | 9,783 | 17,438 | 14,726 |
| Iron ore and concentrates | 227 | 181 | 218 | 155 | 3 | 244 | | 23 |
| Pyrites residue | | - | | | | | | - |
| Manganese ore | | 56 | 593 | 366 | 256 | 370 | 314 | 424 |
| Scrap | 5,445 | 4,365 | 25,100 | 75,108 | 127,612 | 168,996 | 200,730 | 280,634 |
| Pig iron | 91 | 1,434 | 1,821 | 610 | 514 | 1,713 | 1,389 | 498 |
| Ferro-alloys | 1,016 | 1,858 | 2,332 | 3,483 | 3,499 | 3,129 | 4,902 | 3,922 |
| Spiegeleisen | | | | 0 | 124 | 993 | | - |
| Ferro-manganese | | | | | | | | - |
| Ingots | 139 | 265 | 3,478 | 2,[illegible] | 9,256 | 6,[illegible]78 | 35,96[illegible] | 57,85[illegible] |
| Heavy sections | 21,704 | 34,695 | 49,107 | 76,291 | 66,214 | 32,045 | 21,087 | 59,932 |
| Light sections | 162,677 | 193,397 | 238,790 | 221,877 | 143,211 | 74,564 | 67,336 | 39,403 |
| Heavy plates | ↓ | ↓ | ↓ | ↓ | ↓ | 42,089 | 18,545 | 16,286 |
| Medium plates | 118,583 | 158,705 | 207,445 | 178,068 | 225,214 | 30,295 | 34,582 | 1,659 |
| Sheets | ↑ | ↑ | ↑ | ↑ | ↑ | 148,562 | 130,046 | 292,[illegible]55 |
| Hoop and strip | 15,078 | 21,153 | 19,237 | 13,867 | 24,395 | 18,004 | 11,390 | 18,955 |
| Tinplate | 14,304 | 21,921 | 29,680 | 36,695 | 43,551 | 38,489 | 38,306 | 38,416 |
| Railway track material | 26,590 | 32,422 | 7,273 | 9,015 | 7,336 | 23,016 | 2,641 | 10,267 |
| Wire rods | 54 | 336 | 3,446 | 3,915 | 7,109 | 38,505 | 22,190 | 10,[illegible]23 |
| Wire | 20,253 | 27,421 | 27,917 | 23,525 | 18,973 | 28,411 | 38,678 | 11,[illegible]32 |
| Tubes and fittings | 21,236 | 36,255 | 42,499 | 74,035 | 68,514 | 60,941 | 53,795 | 46,95[illegible] |
| Wheels, tyres and axles | | | | | | | | |
| Steel castings | | | | | 188 | 14 | | |
| Steel forgings | | | | | ↓ | 21 | | |
| Total | 411,020 | 538,676 | 671,936 | 735,319 | 755,337 | 728,362 | 699,294 | 904,046 |
| Cast iron pipes | 1,065 | 4,302 | 1,102 | 1,222 | 881 | 1,218 | 3,090 | 1,519 |

## EXPORTS

x Tonnes

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Coke | - | - | - | - | - | - | - | - |
| Iron ore and concentrates | 720,303 | 719,543 | 495,576 | 402,196 | 496,840 | 52,335 | 4,500 | - |
| Pyrites residue | - | - | - | - | - | - | - | - |
| Manganese ore | 18,613 | 66,453 | 80,353 | 45,006 | 8,617 | 7,068 | 7,287 | 10,490 |
| Scrap | 3,276 | 205 | 0 | 0 | 89 | 0 | 0 | - |
| Pig iron | 130 | 0 | 0 | 1 | 0 | 800 | 304 | 3,225 |
| Ferro-alloys | - | - | - | - | - | - | - | - |
| Spiegeleisen | - | - | - | - | - | - | - | - |
| Ferro-manganese | - | - | - | - | - | - | - | - |
| Ingots and semis | | - | 0 | - | - | - | - | 3 |
| Heavy sections | - | 0 | 4 | 72 | - | - | - | - |
| Light sections | - | 2 | 43 | 210 | - | 264 | 700 | 9,662 |
| Heavy plates | - | - | - | - | - | - | - | - |
| Medium plates | 462 | 471 | 568 | 1,440 | 1,584 | - | - | - |
| Sheets | - | - | - | - | - | 401 | 384 | 642 |
| Hoop and strip | 0 | - | - | - | - | - | - | - |
| Tinplate | - | - | - | 452 | - | 1,167 | 56 | 128 |
| Railway track material | - | - | - | - | - | - | - | - |
| Wire rods | - | - | - | 2 | - | 250 | 121 | 354 |
| Wire | 0 | 2 | 4 | 7 | 1,216 | 0 | 0 | [illegible] |
| Tubes and fittings | - | 466 | 1,915 | 1,786 | 4,927 | 7,057 | 8,53[illegible] | 13,[illegible] |
| Wheels, tyres and axles | | | | - | | | | |
| Steel castings | - | - | - | 1 | - | | - | - |
| Steel forgings | - | - | - | 0 | - | - | | - |
| Total | 742,793 | 787,142 | 578,463 | 451,173 | 513,323 | 69,[illegible]92 | 21,865 | [illegible],[illegible]95 |
| Cast iron pipes | | | | 2 | - | 1,[illegible]3 | 1,[illegible]1 | [illegible]79 |

Source: Ministry of Economy and Department of Customs

General situation and current status

8. The present steelmaking capacity in Thailand is estimated at about 550,000 tonnes annually whilst the current annual crude steel output is about 494,000 tonnes yielding (at the yield ratio of 77%) the finished steel output annually of 380,000 tonnes comprising non-flat steel products (steel rods, bars, etc.). The total consumption, however, corresponds (non-flat steel products) to about 0.6 million tonnes annually at present, the difference is made up by imports of over 0.2 million tonnes of non-flat steel products annually at present.

9. In the case of flat steel products, the current consumption annually of about 465,000 tonnes is based wholly on imports (corresponding to crude steel equivalent of 603,750 tonnes at 77% yield ratio).

10. The total consumption of finished steel (flat and non-flat steel products) is currently estimated to be about 1.03 million tonnes annually (corresponding to crude steel equivalent of 1.3 million tonnes).

11. The estimates of future steel demands have been made by different agencies (flat and non-flat steel products) to be around 1.3 million tonnes for 1975 comprising 0.7 million tonnes and 0.6 million tonnes of non-flat and flat steel products respectively; the corresponding figures for 1980 are assessed to total 199 million tonnes (1.1 million and 0.8 million tonnes respectively of non-flat

and flat steel products) and for 1980 to total 2.5 million tonnes (1.5 million and 1 million tonnes respectively of non-flat and flat steel products). To maintain the current steel capacity, steel scrap has to be heavily imported; in 1970 about 170,000 tonnes of steel scrap were imported[1], whilst in 1972 this figure was over 280,000 tonnes. During 1973, 365,891 tonnes of steel scrap were imported at a cost of over 40 million US$. During the first two months of 1974[2], 61,507 tonnes of steel scrap were imported at a cost of 9.051 million US$. The total import bill of the steel products including steel scrap, flats and non-flats steel products is of the order of 250 million US$ for 1972 and exceeds 300 million US$ for 1973 in view of the steel price hike of steel products and scrap. During the first two months of 1974, the cost of steel imports approached 60 million US$ mark and for the whole of 1974, this figure is likely to touch 400 million US$. Thus on an average, in the preceding five years' period, over a billion US dollars represent the bill for steel imports into Thailand and this figure will further rise during ... s 1980.

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1/ At an average cost (CIF) of 108 US$ per tonne of steel scrap

2/ At an average cost (CIF) of 147.1 US$ per tonne of steel scrap.

12. The following data pertaining to 1973 are pertinent in studying the current situation and problems of the Thai steel industry. The steep rise in the imported steel scrap prices is shown below:

Table No. 7

Steel Scrap Prices

| | | | | |
|---|---|---|---|---|
| Average for | 1971 | - | 1583 Baht/tonne CIF | |
| " " | 1972 | - | 1420 " " " | |
| January | 1973 | - | 1836 " " " | |
| March | 1973 | - | 2013 " " " | |
| April | 1973 | - | 2028 " " " | |
| July | 1973 | - | 1908 " " " | |
| August | 1973 | - | 1924 " " " | |
| September | 1973 | - | 2157 " " " | |
| October | 1973 | - | 2169 " " " | |
| November | 1973 | - | 2943 " " " | |
| December | 1973 | - | 2721 " " " | - 136 US$/tonne CIF) |
| January/February | 1974 | - | 2942 " " " | - 147.1 US$ " |

Total steel scrap imports into Thailand

| | | | |
|---|---|---|---|
| | 1971 | - | 200,730 tonnes |
| | 1972 | - | 280,654 " |
| | 1973 | - | 365,981 " |
| January/Feb. | 1974 | - | 61,507 " |
| Total value of steel scrap imports in 1973 at an average of 2152 Baht/tonne i.e. about 108 US$/tonne CIF | | - | 787,624,197 Baht (39,381,210 US$ or say 40 million US$). |
| Total value of steel imports during Jan.and Feb.1974 | | - | 1,198,549,554 Baht -(about 60 Million U |
| " Feb.1974 | | - | 558,655,536 Baht -(about 28 million U |

13. There is some steel import every year under foreign aid which ranges annually upto the equivalent of maximum 250,000 US$ and is thus only of marginal value. The price of steel scrap is still rising steeply. In January and February 1974, 61,507 tonnes of steel scrap were imported at a cost of over nine million US$ at 147.1 US$/tonne CIF. In February 1974, 31,307 tonnes of steel scrap were imported at a cost of 83,063,[illegible]4 Bahts = 4.443 million US$ at 139.7US$ per tonne CIF. During 1972, total steel import bill amounted to the equivalent of [illegible] million US$ including steel scrap.

14. The prices of locally produced steel bars/rods are controlled by the Board of Investment to a maximum ceiling ex-factory; the retailers are allowed to retain a reasonable profit in fixing the retail price. The wholesale ex-factory prices of Thai steel non-flat products are shown below:

Table No.8

| Rods/bars | 1969 | 1970 | 1971 | Jan. 1973 | July 1973 | Sept. 1973 | Feb. 1974 |
|---|---|---|---|---|---|---|---|
| | | | Baht/tonne | | | | |
| 5.5 mm dia. rod | - | - | 3507 | 4147 | 4947 | 7000 | - |
| " " " coil | - | - | 3407 | 4047 | 4847 | 6900 | 7727 |
| 6 mm | 3230 | 3307 | 3307 | 3947 | 4747 | 6800 | 7430 |
| 9 mm | 3133 | 3208 | 3208 | 3843 | 4648 | 6700 | 7000 |
| 12 mm | 2842 | 2910 | 2910 | 3550 | 4350 | 6400 | 6700 |
| 15-18 mm | 2745 | 2810 | 2810 | 3450 | 4450 | 6200 | 6260 |

15. Thus the effects of the rise in the price of imported steel scrap has led to more than a 100% hike in the prices of the home produced steel bars/rods in the course of a single year. The consumer has had to pay in early 1974 the equivalent of about 390 US$/tonne for steel rods/bars of 5.5 mm dia; this price is almost double of what it was two to three years earlier. The Thai steel production adds the rising costs of imported steel scrap to his steel production costs (estimated to exceed 250US$/tonne currently) and passes it on to the consumer who has to pay for the common grades of steel rods/bars for R.C.C. building industry, a price which is 400% higher than what it was three to four years back. This then is literally the price one has to pay for not having an integrated steel industry in a developing country even though, it could well conform to the rigid yardsticks of acceptable techno-economic criteria.

16. Before we come to the study of an integrated iron and steel industry, let us see the forecasts of steel consumption in Thailand which were made some years back for the current year(s) ends by various bodies including UNIDO/ECAFE steel industry mission. It would be observed how remarkably realistic and true have these forecasts been in their projections as would be seen by the following:

## III. Current Steel Demands and Future Steel Market Projections

17. Projections made by the UNIDO/ECAFE[1] Steel Industry Survey Mission in August, 1971 concerning the forecast of future steel market pattern in Thailand by the Trend method are shown in Tables No. 8 and 9 and Figures No. 1, 2 and 3.

18. It would be observed that the actual steel consumption forecasts have been remarkably realistic upto almost 1975; it is believed that these will hold good equally for [illegible] and 1975.

19. The projections by the Trend method are based on the past trends of apparent consumption of steel in Thailand. Extrapolations were made for 1975 and 1980 after establishing the regression lines calculated by the least square method. As the historical data available are only for nine years, the extrapolation will be efficient enough for 1975. Application of the trend method to the projections for 1980 and 1985 was considered erroneous in view of the rather short series of historical data. So the calculations are made only for 1975 and for 1980 for the comparison with the results of calculation by the elasticity method. The results are as follows:

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1/ Report of the UNIDO/ECAFE Iron and Steel Industry Survey Mission to the Four Countries (Thailand, Laos, The Khmer Republic, and The Republic of Viet-Nam) of the Lower Mekong Basin, led by Mr. B.R. Nijhawan, Senior Interregional Adviser, UNIDO - August 1971.

Table No. 8

Forecast of steel consumption by the trend method

Unit: Metric ton and %

| Forecast of 1975 (1) | of which percentages of flat products (2) | of which percentages of non-flat products | Forecast of 1980 (1) |
|---|---|---|---|
| Thailand | | | |
| $y = 564.2 + 78.25x$ | | | |
| (1) 1,268,000 | | | 1,666,000 |
| $y = 37.09 + 0.285x$ | | | |
| (2) | 39.66 | 60.34 | |

20. The "trend" method was followed for the short-term forecast of steel consumption for 1975. As for the breakdown of two categories, non-flat products and flat products, the forecast for 1975 was made only by the trend method.

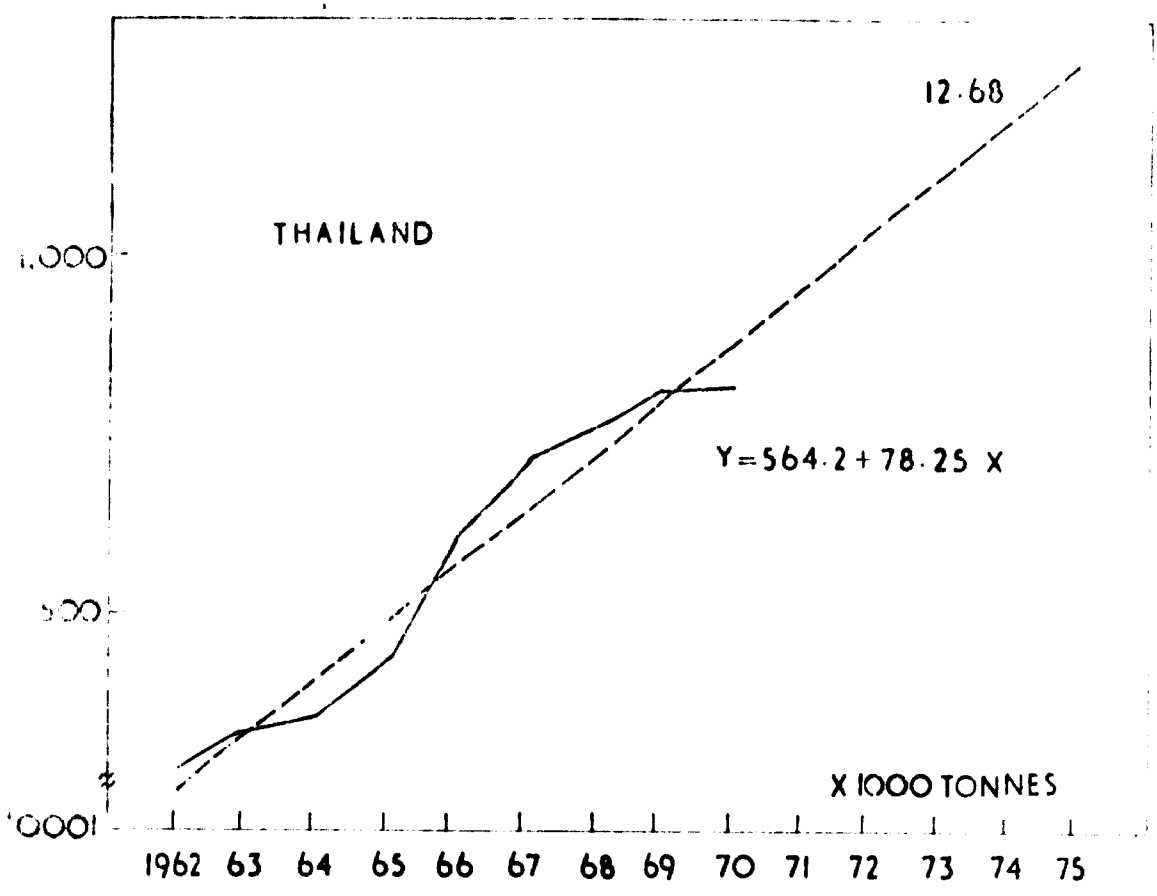
21. For the forecast of steel consumption for 1980 and 1985, the results of the steel intensity method were accepted because this method is considered more applicable for long-term projection in developing countries.

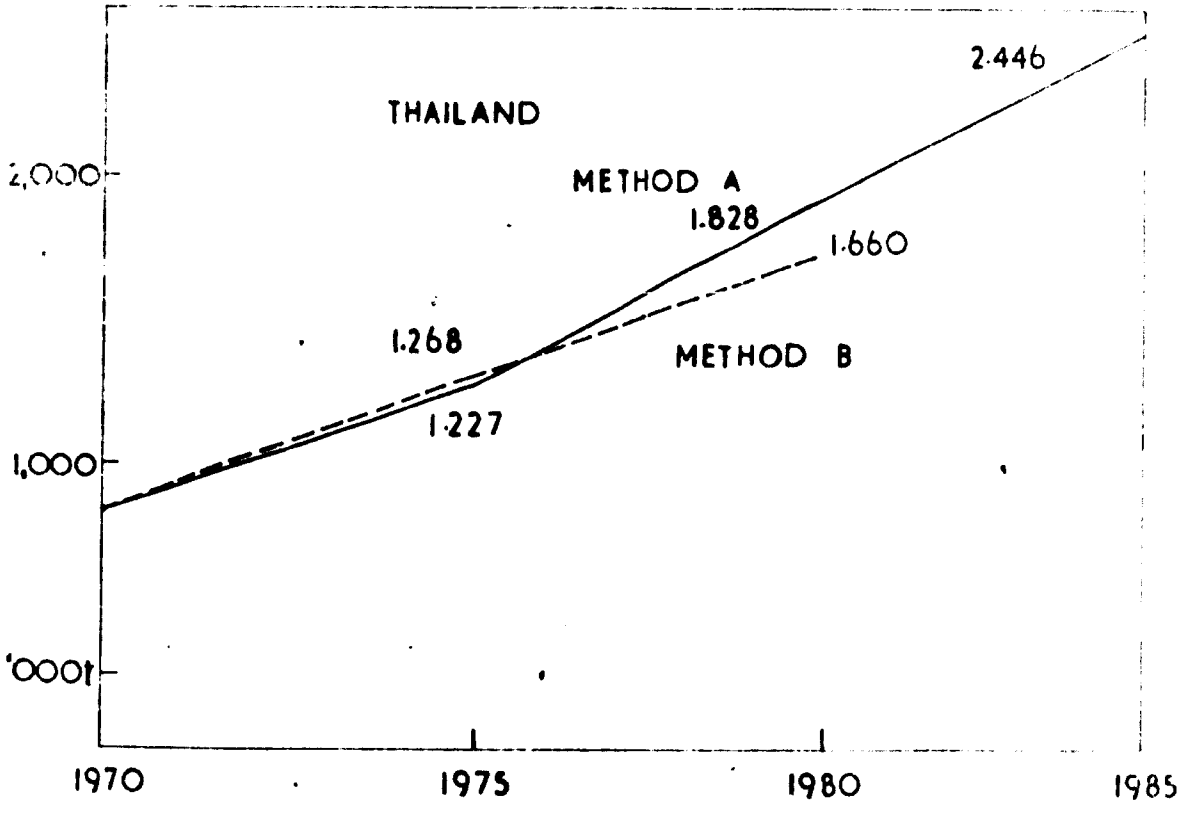
Table No. 9

Forecast of steel consumption (conclusion)

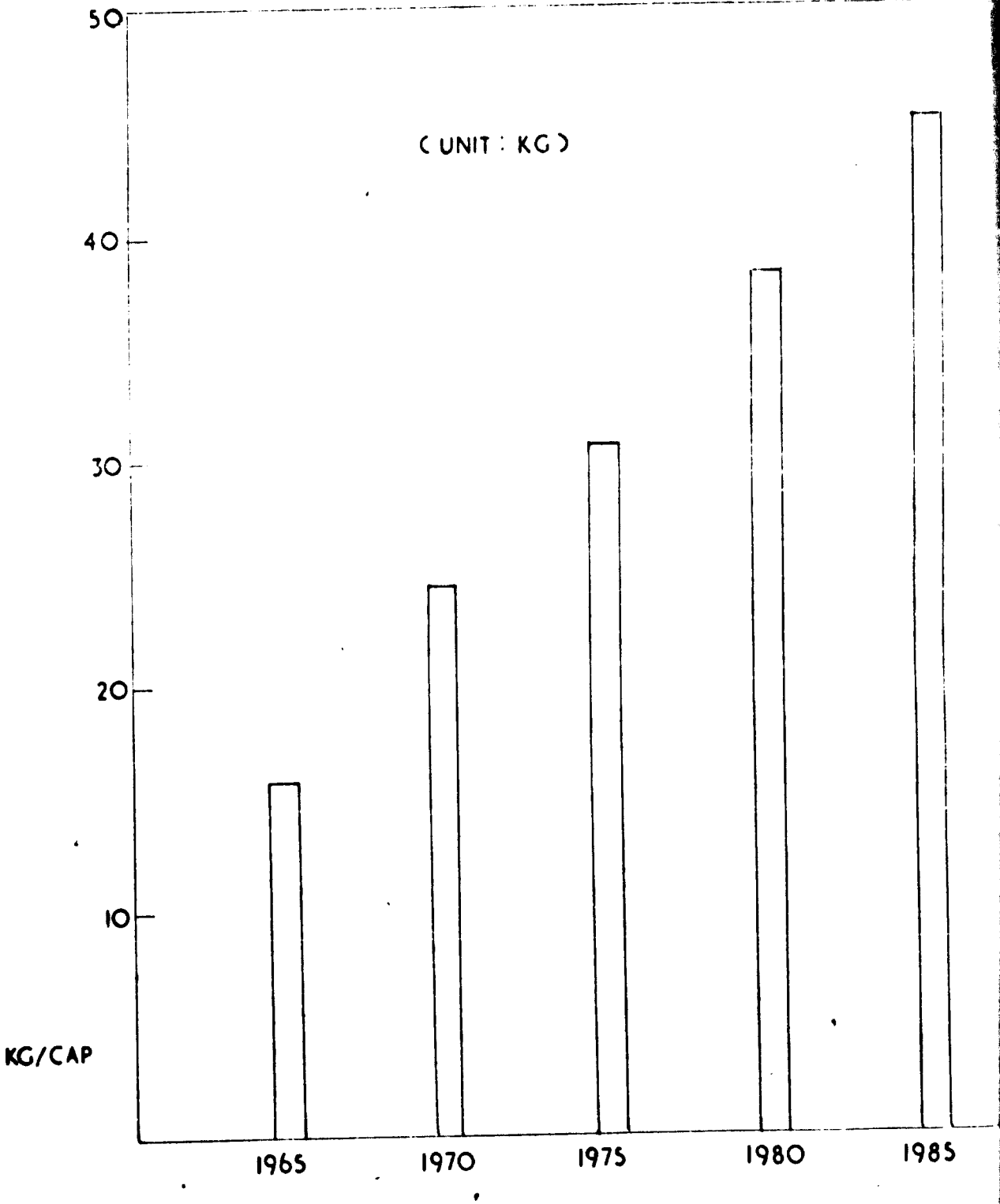
Unit: Thousand metric tons

| | 1975 | | | 1980 | 1985 |
|---|---|---|---|---|---|
| | Total | Flat Products | Non-flat Products | Total | Total |
| Thailand | 1,268.0 | 502.9 (39.66%) | 765.1 (60.34%) | 1,828.0 | 2,445.9 |

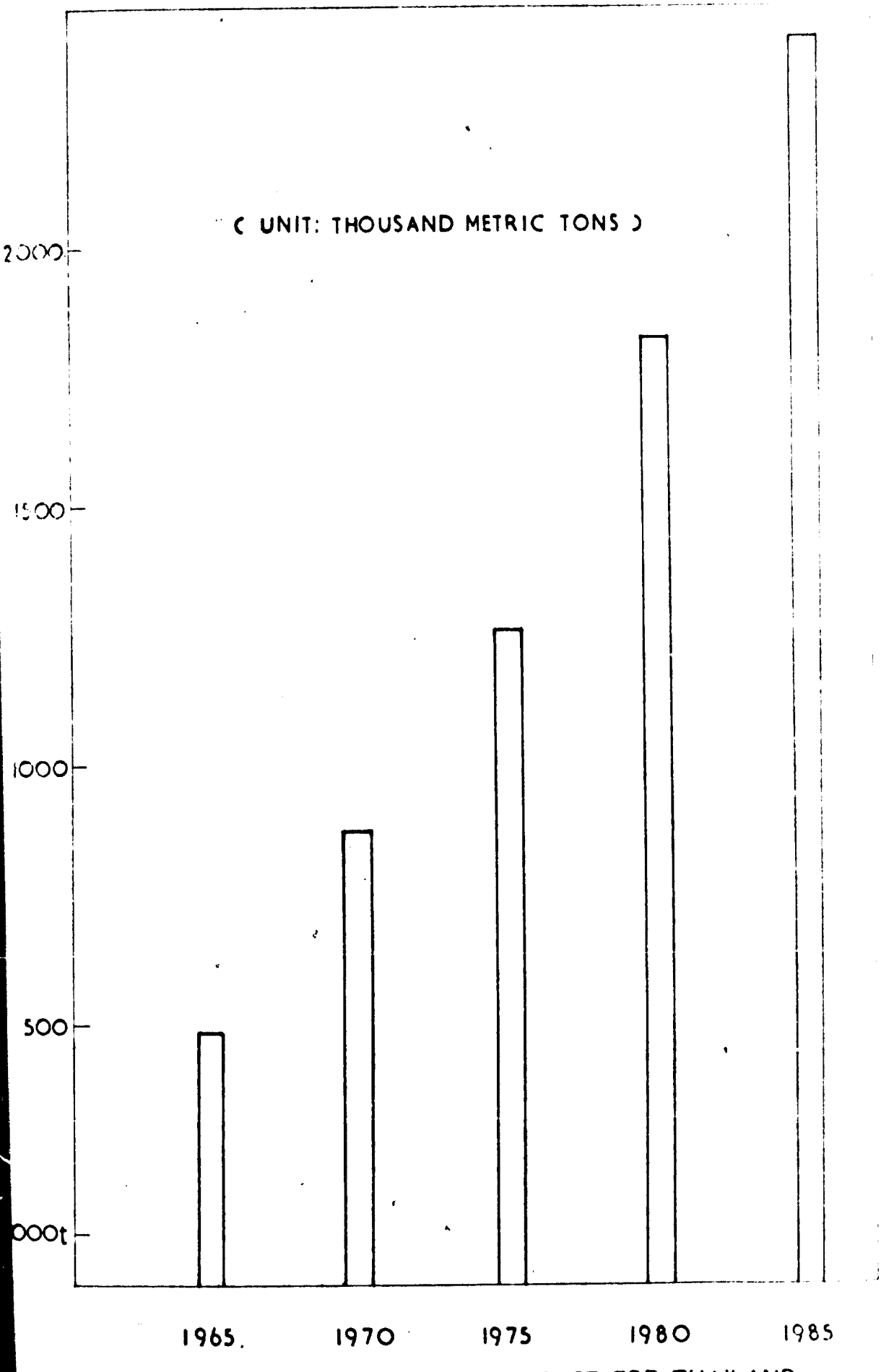



TRENDS OF AND PROSPECTS FOR STEEL CONSUMPTION BY THE TREND METHOD




PER CAPITA STEEL CONSUMPTION FORECAST FOR THAILAND

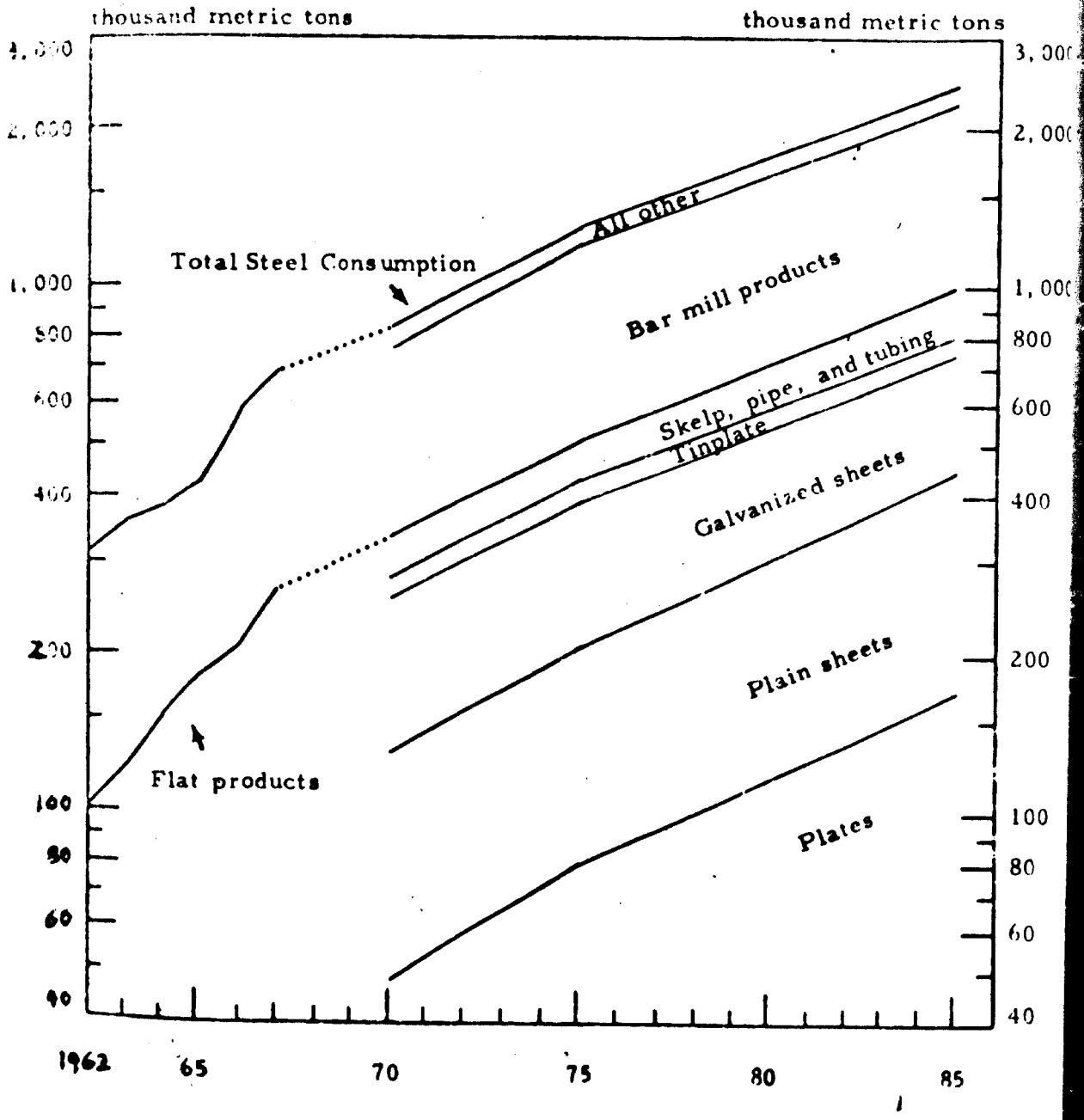



STEEL CONSUMPTION FORECAST FOR THAILAND

22. The estimates of steel demand made by US (Koppers) in 1968 are shown in the following figure No. 4:

Fig. No. 4

PROJECTED STEEL CONSUMPTION IN THAILAND



23. Estimates made for steel demands by 1985 by other bodies are also given herewith for comparison, (Tables No. 10, 11, Figs. No. 5, 6) the objective being to demonstrate clearly that by 1985, the demand and consumption in Thailand of finished steel (flat and non-flat products) would exceed 2.5 million tonnes. In the writer's view[1/], the consumption of finished non-flat and flat steel products by 1985 in Thailand would exceed 1.5 million and 1 million tonnes respectively; this is borne out by the accuracy of the forecasts made in early 1971 vis-a-vis actual consumption figures for 1974-75. The writer would venture to go a step further and emphasize that the country should gear itself and plan for somewhat higher steel capacity for 1985-88 corresponding to 2.9 million tonnes of finished annual steel production comprising flat and non-flat steel products; this calacity can only be achieved through the establishment of the integrated iron and steel plant at a suitable coastal site. In order to promote serious study and planning towards this end, the writer has prepared the schematic quantitative flowsheet, Fig. No. 6, entitled: "Integrated Iron and Steel Industry in Thailand based on imported raw materials (iron ores and coal) supplemented by local iron ores and fluxing materials".

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1/ Report of the UNIDO/ECAFE Iron and Steel Industry Survey Mission to the Four Countries (Thailand, Laos, The Khmer Republic, and The Republic of Viet-Nam) of the Lower Mekong Basin, led by Mr. B.R. Nijhawan, Senior Interregional Adviser, UNIDO - August 1971.

Table No. 10

ESTIMATED DEMAND OF STEEL PRODUCTS IN THE [illegible] 1/

UNIT: Tonnes

| Year | FLAT PRODUCTS | | | | LONG PRODUCTS | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Plate | HR Sheet/coil | CR Sheet/coil | TOTAL | Angle/section | Bar 6-25mm | Rod & its products | TOTAL | GRAND TOTAL |
| 1972 | 75,000 | 88,000 | 215,500 | 378,500 | 54,700 | 305,000 | 59,300 | 419,000 | 797,500 |
| 1973 | 82,500 | 95,800 | 240,600 | 418,900 | 58,500 | 320,000 | 69,900 | 448,400 | 867,300 |
| 1974 | 90,800 | 104,400 | 260,900 | 456,100 | 62,600 | 350,000 | 76,900 | 489,500 | 945,600 |
| 1975 | 99,800 | 113,800 | 274,700 | 488,300 | 67,000 | 385,000 | 84,600 | 536,600 | 1,024,900 |
| 1976 | 109,800 | 124,000 | 289,200 | 523,000 | 71,700 | 423,000 | 93,000 | 587,700 | 1,110,700 |
| 1977 | 120,800 | 135,100 | 304,700 | 560,600 | 76,700 | 465,000 | 102,400 | 644,100 | 1,204,700 |
| 1978 | 130,400 | 147,400 | 321,200 | 599,000 | 82,000 | 502,000 | 112,600 | 696,600 | 1,295,600 |
| 1979 | 140,900 | 160,600 | 338,700 | 640,200 | 87,800 | 542,000 | 123,800 | 753,600 | 1,393,800 |
| 1980 | 152,100 | 185,200 | 357,400 | 694,700 | 94,000 | 586,000 | 136,200 | 816,200 | 1,510,900 |
| 1981 | 164,300 | 202,100 | 377,300 | 743,700 | 100,500 | 633,000 | 149,800 | 883,300 | 1,627,000 |
| 1982 | 177,500 | 220,500 | 398,500 | 796,500 | 107,600 | 683,000 | 164,800 | 955,400 | 1,751,900 |
| 1983 | 191,700 | 240,700 | 421,000 | 853,400 | 115,100 | 738,000 | 181,300 | 1,034,400 | 1,887,800 |
| 1984 | 207,000 | 262,800 | 445,200 | 915,000 | 123,100 | 797,000 | 199,400 | 1,119,500 | 2,034,500 |
| 1985 | 223,600 | 287,000 | 471,000 | 981,600 | 131,800 | 861,000 | 219,400 | 1,212,200 | 2,193,800 |

1/ Paper on the Steel Industry Development in Thailand by Mr. Wasem Rahajiva, Director ISMIT presented at UNIDO's Third Interregional Symposium on Iron and Steel Industry, held in Brazil - October 1973.

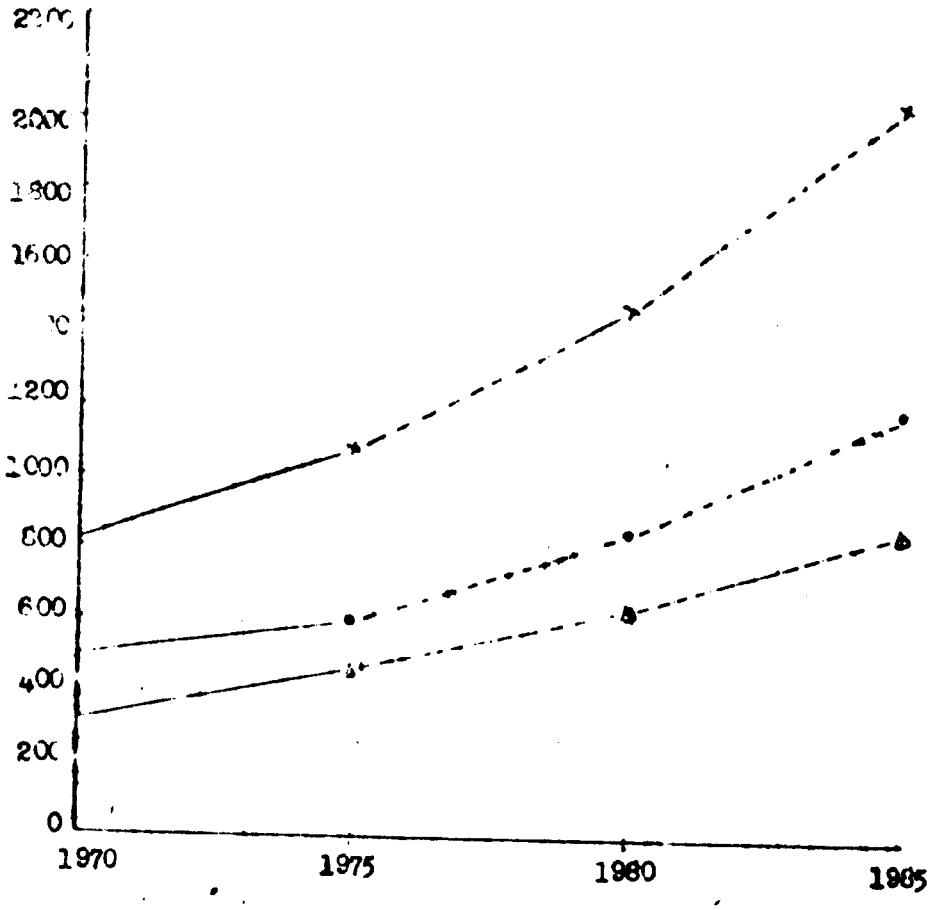
Table No. 11

Forecasts of Steel Demand in Thailand, 1975, 1980 and 1985
(1,000 tonnes finished steel)

| | 1975 | | | 1980 | | | 1985 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Flat | Others | Total | Flat | Others | Total | Flat | Others | Total |
| [illegible] 1967 | - | - | 1,233 | - | - | 1,784 | - | - | 2,491 |
| Japan/AIDC 1968 | 388 | 897 | 1,285 | 958 | 1,345 | 1,892 | 786 | 1,875 | 2,661 |
| UN Mapcore 1968 | 515 | 792 | 1,307 | 718 | 1,265 | 1,783 | 1,000 | 1,435 | 2,435 |
| AIDC 1969 | 606 | 740 | 1,346 | 845 | 1,061 | 1,906 | - | - | - |
| [illegible]/[illegible] (Aug.71) | 503 | 765 | 1,268 | - | - | 1,828 | - | - | 2,446 |
| Bitumi 1971 | 470 | 603 | 1,073 | 630 | 846 | 1,476 | 854 | 1,187 | 2,041 |
| [illegible] | - | - | 1,300 | - | - | 1,900 | - | - | - |
| Regional Advisor 1972 | - | - | - | 640 | 1,060 | 1,700 | 920 | 1,380 | 2,300 |
| [illegible] Steel Committee 1974 | 480 | 700 | 1,180 | 695 | 990 | 1,685 | 980 | 1,375 | 2,355 |
| Japan study for BOI 1974 | 488 | 537 | 1,025 | 695 | 816 | 1,511 | 982 | 1,212 | 2,194 |

Fig. 5

Forecast of steel demand (1,000 tons finished steel) for 1975, 1980, 1985 1/

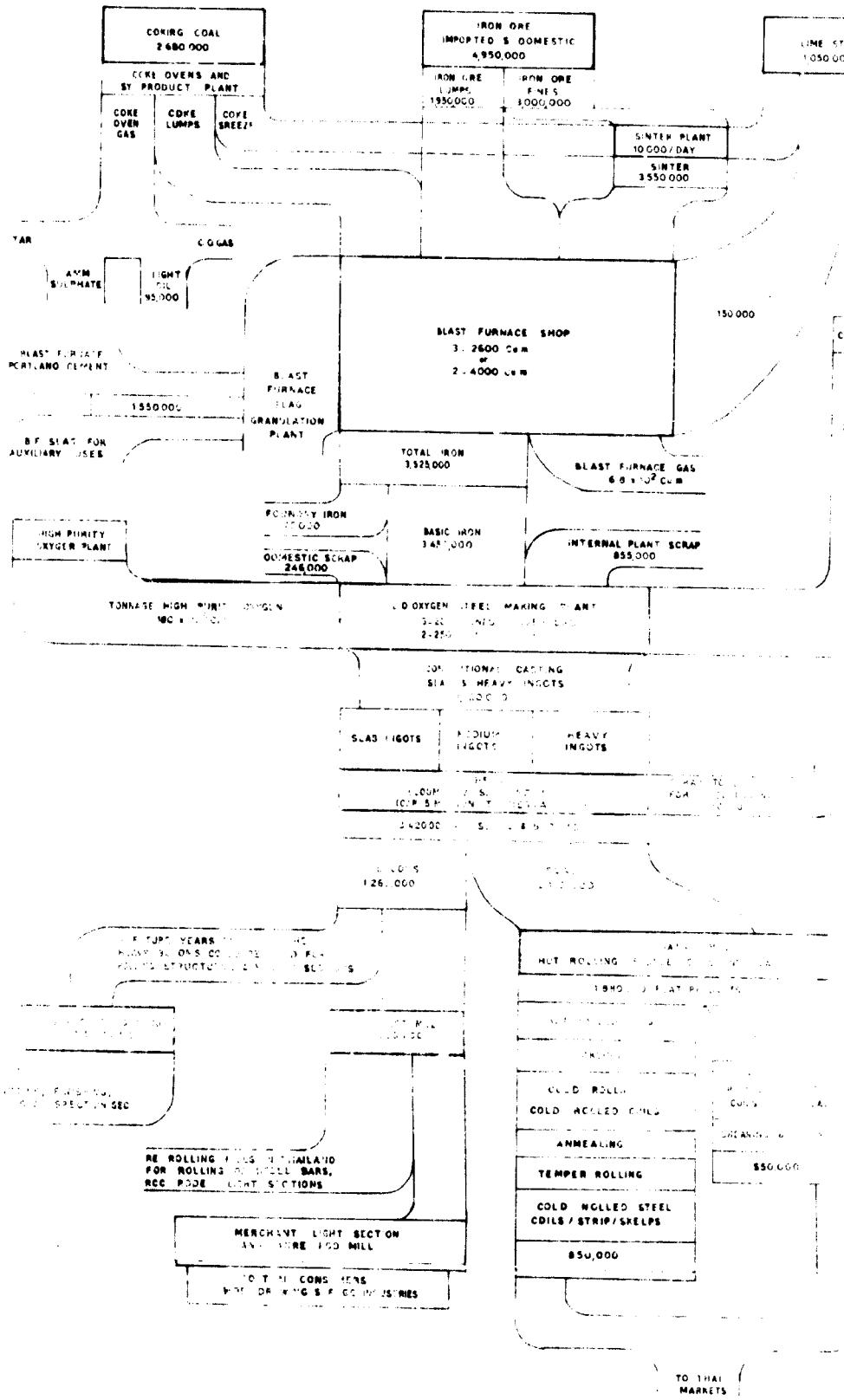



X = TOTAL CONSUMPTION

● = NON-FLAT PRODUCTS

Δ = FLAT PRODUCTS

1/ A report on the Iron and Steel Industry in Thailand
- P. Veerothai, Metallurgy Division, Department of Mineral Resources.




INTEGRATED IRON AND STEEL INDUSTRY IN THAILAND BASED ON IMPORTED RAW MATERIALS (IRON ORES + COAL) SUPPLEMENTED BY LOCAL IRON ORES AND FLUXING MATERIALS

FIG 6 SCHEMATIC QUANTITATIVE FLOW SHEET FOR THE INTEGRATED IRON AND STEEL WORKS AT A COASTAL LOCATION WITH AN ANNUAL CAPACITY OF FINISHED STEEL PRODUCTION BY 1985 E7 OF 2 5 MILLION TONNES (CORRESPONDING TO 3 5 MILLION TONNES OF CRUDE STEEL BASED ON AN OVERALL (IP D RATIO 75% FIN ..NED TO CRUDE STEEL) COMPRISING 1 7 MILLION TONNES OF FLAT STEEL PRODUCTS AND 1 2 MILLION TONNES OF NON-FLAT STEEL PRODUCTS, THE LATEN WILL BE SUPPLEMENTED BY ABOUT 0 5 MILLION TONNES ANNUAL CAPACITY OF NON-FLAT STEEL PRODUCTS CURRENTLY EXISTING TO GIVE A TOTAL 1 8 MILLION TONNES OF NON-FLAT STEEL PRODUCTS BY 1985 BE FORECASTS ARE REALISTICALLY BASED ON ACTUAL CONSUMPTION FIGURES DURING THE LAST DECADE

**Integrated Iron and Steel Industry in Thailand based on imported raw materials (iron ores and coal) supplemented by local iron ores and fluxing materials**

24. Schematic quantitative flowsheet for the Integrated Iron and Steel Works at a coastal location with an annual capacity of Finished Steel Production by 198[illegible] - 88 of 2.9 million tonnes (corresponding to 3.9 million tonnes of crude steel based on an overall yield ratio, 75% finished to crude steel) comprising 1.7 million tonnes of flat steel products and 1.2 million tonnes of non-flat steel products; the latter will be supplemented by about 0.6 million tonnes annual capacity of non-flat steel products currently existing to give a total 1.8 million tonnes of non-flat steel products by 1985-86. These forecasts are ambitiously yet realistically based on actual steel consumption figures during the last decade in Thailand.

25. Annexure I gives the steel consumption/production figures of Thailand 1962-1970 including their break-up; the figures for the more current years are given in the text of this report.

26. Selected economic Indications for Thailand from 1967 to 1974 are given in Annexure II, to provide the general background to steel industry's planned growth.

27. Annexure III gives the relationship between the Steel Industry and per capita GDP in selected Asian countries including Thailand for comparison purposes.

## IV. Raw Materials Resources of Thailand for the Steel Industry - The Case for an Integrated Iron and Steel Industry

28. The resources of raw materials for the iron and steel industry viz. iron ores, coals, fluxes are outlined in Annexure IV, from which it can be stated in a nut shell that resources of adequate (qualitatively and quantitatively) raw materials to support an integrated iron and steel industry of an annual capacity of even say 1.5 million tonnes, are not available in Thailand. The Thai iron ores are too low grade and widely dispersed to merit assembly at the site of the integrated steel plant; furthermore, their proved reserves are too meagre to merit complex and costly mineral beneficiation and agglomeration (pelletising) treatments; the latter on techno-economic grounds are not feasible.

29. The resources of a suitable fossil fuel and reductant likewise for the integrated steel industry do not exist in the country. Lignite deposits are widely scattered and some of the major lignite deposits have still to be opened up in the country. And, in any case, lignite is of little use for the operations of the integrated iron and steel industry. Even for solid reductant based direct reduction process to produce sponge iron, the proving of reserves, cost of lignite mining quantity and quality-wise and of commercial low temperature carbonisation of lignite have still to be investigated on pilot/industrial scale and techno-economically evaluated. The available data, except for Mae Moh lignite, are totally inadequate in many ways.

30. The case for the establishment in Thailand of an integrated iron and steel plant has, therefore, to be built on imported raw materials such as high grade iron ores/pellets and metallurgical grades of coking coal; fortunately the supplies of the former could be readily arranged from India and Australia and of the latter from Australia. Both India and Australia are supplying millions of tonnes of these essential raw materials to Japan along with Brazil and other countries to sustain the Japan's current 120 million tonnes annual steel output. Thailand lies on the route of such major supplies to Japan and could advantageously share them particularly when their demand for the Thai integrated steel industry would be less than even 5% of the Japanese imports. The prices of these raw materials exports to Japan vis-a-vis their quality (chemical and physical gradings) have been well established to enable Thai steel industry to accept them. At best Thailand could provide the indigenous supply of fluxing materials such as limestone, dolomite, fluorspar, etc. for the integrated steel industry and of manganese ore (if not of ferro-manganese at this stage).

31. These will be major topics for consultants to study and decide upon rat'-nally.

32. This brings us now and the Consultants before long to the supply of raw materials to a coastal site, not unministerily a deep sea port site which has been heatedly discussed during the last several years.

33. An integrated steel plant based chiefly on imported raw materials will need fair-sized ore carriers to transport large tonnages of ores, coal, etc. Much thought has already been given to a deep sea port in Thailand, one aim of which could be to service the integrated steel plant. Sattahip port could be considered for such a use with appropriate enlargement of its berthing facilities. After all a naval port ought not to deny its facilities for total national benefits and normal peace-time usages in the unlikely event of a major War in the area in which case a peace-time sea port is readily commandeered to war time requirements.

34. Another area Si-Racha 130 Km south of Bangkok has been considered for location of the steel industry. But it will not be suitable because the sea along the coast at Si Racha is so shallow that a region of 10 meter depth can only be reached 3-5 km from the sea shore. Coastal area southward from Laem Chabang about 15 Km sough of Si Racha may be more worthy of study where the coast is situated relatively near the deep sea of over 10 meter depth.

35. In this connexion, it is emphasised that the heavy cost of putting up a deep sea port should not be tagged on to the steel plant nor should the latter wait for the former's development. The report prepared by Daniel Mann Johnson and Mendenhall

(Contract No. AID/SA/IR-197 - Regional Development of the ports of Sattahip and Ba Hang and of Route 9) has shown that potentialities of Sattahip to serve as a deep sea port suitable for a coastal integrated steel plant. It merits closer study.

36. The question of imported raw materials for a national industry such as the iron and steel, very often raises a plethora of national feelings and interests and an issue is made of using indigenous raw materials, no matter how low grade and metallurgically unacceptable the latter could be. If these national feelings and aspirations are sufficiently scrutinized, the issue is decidedly made out that imported raw materials will entail foreign exchange expenditure whilst conveniently forgetting that Thailand incurs a truly massive foreign exchange bill approaching one billion US$ almost every five years to import steel for its steel hungry industries and consumers; this billion US$ could well double itself during the future half decades. And certainly this very heavy import bill could be used for establishing the integrated iron and steel industry in the country. What is needed is rational thinking, a dispassionate study and a driving leadership to take concrete and timely decisions such as the one which South Korea took years back to set up an integrated steel industry at Pohang despite objections from international financing agencies/organizations; this decision was timely since Pohang Steel Plant is reportedly one of the lowest in capital cost per annual ton capacity for flat steel products, of the order of 300 US$,

with cost escalation of less than 10% of the original figures. It was a wise and judicious decision for Pohang Steel Plant to import most of its iron ore requirements whilst continuing to export and earn foreign exchange on the export to Japan of its siliceous Yong-Yang iron ores. Pohang Steel Plant is reportedly going in for expansion from its present one million ton to 2.6 million ton annual capacity whilst also considering another integrated iron and steel plant - a prospect that is being welcomed by industrial enterpreneurs/financing agencies that had earlier opposed or were allergic to the original million ton integrated steel project at Pohang of South Korean Government.

37... This then is the basis for fresh study in Thailand and dynamic planning for the integrated steel industry which the country sorely needs. And such thinking and planning would be fully in line with the policies of international Financing Institutions which call for economic priorities and reasonable returns and which is stated to mean that each project should not only be sound and profitable business but should also benefit the country in some form, such as increasing national income, saving and/or earning foreign exchange, promoting import substitution, creating employment and skills in the developing country. An international Financing Agency is stated to support proposals that involve the transfer of technological, managerial and other skills for increasing productivity from the economically advanced to the developing countries.

38. There can be little dispute or doubt that the Thai integrated steel industry's projections effectively and pragmatically meet the above desiderata and objectives. To those who will still doubt the economic or technical wisdom of establishing the Thai integrated steel industry, the reply or the motive clearly is of vested business interests - internal and/or external. The last support for the Thai integrated steel project concerns the deep sea port in Thailand; Sattahip's deep waters and draft provide the ready answer.

39. In importing iron ores (high grade), Thailand will not serve as an exception but the rule; this is illustrated by the growth of trade in iron ore between selected countries for the years 1960 and 1972 - Table No.12.

**Table No. 12**

# Trade in iron ore between selected countries, 1960 and 1972

—Trade in iron ore between selected countries, 1960 and 1972 (*Percentages, except for total imports which are in thousand tons*)

| *Origin/Destination* | *Austria* | | *Belg.-Lux'bourg* | | *West Germany* | | *Italy* | | *Netherlands* | | *UK* | | *Czechoslovakia* | | *Poland* | | *USA* | | *Japan* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1960 | 1972 | 1960 | 1972 | 1960 | 1972 | 1960 | 1972 | 1960 | 1972 | 1960 | 1972 | 1960 | 1972 | 1960 | 1972 | 1960 | 1972 | 1960 | 1972 |
| Western Europe | 60.8 | 2.5 | 95.5 | 78.6 | 62.3 | 40.0 | 13.2 | — | 25.8 | 30.1 | 37.6 | 27.8 | 2.3 | .. | 13.1 | .. | 0.3 | .. | — | .. |
| *of which from:* France | — | — | 77.1 | 51.2 | 28.9 | 9.8 | — | — | — | — | 3.1 | — | — | .. | — | .. | — | .. | — | .. |
| Sweden | 15.3 | 2.4 | 18.2 | 27.4 | 24.6 | 21.4 | — | — | 21.6 | 15.4 | 26.8 | 21.3 | 2.3 | .. | 9.1 | .. | 0.3 | .. | — | .. |
| USSR | 23.8 | 21.4 | — | — | — | 0.9 | — | 8.4 | — | — | — | 6.9 | 69.5 | .. | 75.2 | .. | — | .. | — | .. |
| North America | — | — | — | — | 4.8 | 5.4 | — | 7.2 | 7.5 | 8.0 | 18.4 | 21.7 | — | .. | — | .. | 30.7 | .. | 12.8 | .. |
| *of which from* Canada | — | — | — | — | 4.8 | 5.4 | — | 7.2 | 7.5 | 8.0 | 18.4 | 21.7 | — | .. | — | .. | 30.7 | .. | 7.3 | .. |
| Latin America | 0.7 | 74.1 | — | 5.3 | 15.9 | 27.0 | 36.5 | 26.8 | 8.1 | 18.8 | 12.5 | 20.2 | 9.4 | .. | 4.8 | .. | 66.1 | .. | 8.5 | .. |
| *of which from* Brazil | 0.7 | 74.1 | — | 5.3 | 4.1 | 20.5 | 2.3 | 15.6 | 8.0 | 18.8 | 3.5 | 11.3 | 6.8 | .. | 4.8 | .. | 4.2 | .. | 2.4 | .. |
| Chile | — | — | — | — | 1.6 | — | — | — | — | — | — | — | 2.6 | .. | — | .. | 11.4 | .. | 1.7 | .. |
| Venezuela | — | — | — | — | 5.5 | 6.4 | 34.2 | 11.2 | 0.1 | — | 9.0 | 9.0 | — | .. | — | .. | 42.1 | .. | 0.2 | .. |
| Africa | 8.3 | — | — | 8.2 | 10.1 | 22.6 | 17.0 | 39.9 | 46.0 | 43.1 | 27.4 | 16.8 | — | .. | 3.9 | .. | 2.6 | .. | 2.0 | .. |
| *of which from* Algeria | 0.8 | — | — | — | 2.2 | — | 9.5 | — | 3.6 | — | 11.8 | — | — | .. | — | .. | — | .. | — | .. |
| Morocco | 0.3 | — | — | — | 1.7 | 0.3 | — | — | — | — | 4.6 | — | — | .. | — | .. | — | .. | 0.2 | .. |
| Sierra Leone | 1.2 | — | — | — | 1.1 | 1.5 | — | — | 16.0 | 11.7 | 4.1 | — | — | .. | — | .. | — | .. | — | .. |
| Liberia | — | — | — | 3.9 | 3.2 | 15.6 | — | 31.0 | 21.9 | 31.4 | 3.0 | 4.2 | — | .. | 0.5 | .. | 2.6 | .. | — | .. |
| Other West Africa | — | — | — | — | — | — | — | — | — | — | — | — | — | .. | — | .. | — | .. | — | .. |
| Far East | — | — | — | — | 6.8 | — | 6.1 | — | 11.2 | — | — | — | 9.8 | .. | 0.7 | .. | — | .. | 63.2 | .. |
| *of which from* India | — | — | — | — | 6.7 | — | 6.1 | — | 8.0 | — | — | — | 9.8 | .. | 0.7 | .. | — | .. | 16.8 | .. |
| Malaya | — | — | — | — | 0.1 | — | — | — | 3.2 | — | — | — | — | .. | — | .. | — | .. | 35.9 | .. |
| Philippines | — | — | — | — | — | — | — | — | — | — | — | — | — | .. | — | .. | — | .. | 2.1 | .. |
| Unallocated | 6.4 | 2.0 | 4.5 | 7.9 | 0.1 | 4.1 | 27.2 | 17.7 | 1.4 | — | 4.1 | 7.5 | 8.9 | | 2.3 | .. | 0.3 | .. | 13.5* | .. |
| Total imports (000 tons) | 1,612 | 1,504 | 20,600 | 28,078 | 33,454 | 40,670 | 2,621 | 13,308 | 2,312 | 5,655 | 18,302 | 17,351 | 7,211 | | 7,323 | .. | 35,138 | .. | 14,923 | .. |

*Source: The Steel Market in 1972—Economic Commission for Europe* *Mainly from Australia

V. Sponge Iron Production in Thailand

40. The subject of sponge iron production in Thailand through direct reduction based on solid reductant viz. Thai lignite or natural gas/naphtha has been cropping up for sometime now. Sponge iron production, should the question of the suitable Thai reductant be appropriately settled based on its technical success and economic viability, will not replace the need of the integrated steel industry in Thailand but may supplement it. The use of lignite (dried lignite or lignite char) for directly reduced sponge for steelmaking has received much economy of [illegible].

[illegible] commercial implementation on industrial scale must await the pilot plant scale investigations on Thai iron ores (after prior beneficiation and agglomeration) and Thai lignites (dried or as char), whose results must establish (a) technical success of the technology in terms of (i) trouble free and continuous operations over reasonable periods, (ii) quality of the sponge and its uniformity for continuous steelmaking and (iii) attainment of rated capacity and economic productivity and (b) acceptable production costs of the sponge produced and of the steel made from the latter.[1] The recent reported position that the New Zealand Steel Plant has now turned the corner where lignite is used for sponge production is countered by some in referring to lignite based sponge plant in Yugoslavia at Skopje in having been scrapped soon after its operations.

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[1] [illegible] project [illegible] programme.

to directly reducing imported high grade iron ores/pellets to produce acceptable sponge and the same may hold good for beneficiated/ agglomerated Thai iron ores. However, the detailed pilot plant scale test investigations and their positive results must satisfy the above criteria on techno-economic parameters before venturing on setting up an industrial sponge plant.[1/] It has been reported that the New Zealand directly reduced sponge/scrap electric arc furnace melt consumes 900-950 Kwh per ton of steel made is hardly likely to boost the Thai lignite based sponge project considering that 1000 Kwh in Thai is currently supplied reportedly at 0.6 Baht [illegible] to electric furnace steel makers. The question of imported naphtha for sponge production in Thailand also merits further study subject of course, to the stipulation that long term firm contracts for naphtha supplies are available and concluded well in advance. Even allowing for the increase in naphtha prices to over 300% of its earlier price a year back, its use for sponge production with high degree of metallisation may on investigation be economic and compete well with imported steel scrap prices per tonne that have crossed the 140 US$ mark early in 1974 and may rise to 150-200 US$ CIF early in 1975. To merit further study sponge production cost estimate has been outlined herewith based on the current escalated naphtha prices. After all acceptable sponge has to replace steel scrap as the melting stock for the electric arc furnace and the relative prices of the two for steelmaking should give the final reply about their choice.

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1/ At this stage, there are no techno-economic data available to justify the establishment of a Sponge Plant based on Thai lignite (dried or as char) and local and/or imported iron ores/pellets. Even the Thai lignite resources have yet to be fully proved both quantitatively and qualitatively vis-a-vis sponge production. In so far as sponge production based on natural gas is concerned, it may well be that Thai steel industry imports its sponge requirements from the sponge plants based on natural gas that are under establishment in the Persian Gulf countries or Indonesia. Thai natural gas resources have yet to be established and proved.

Table No.13

## ESTIMATED OPERATING COSTS to reflect current Light Naphta prices 1/

165,000 Annual Metric Tons Fe in Sponge Iron
Metallization - 85%

| | Unit Cost U.S. $ | Unit Consumption Metric Ton Iron | Annual Cost U.S. $ | Cost U.S. $ Metric Ton Iron |
|---|---|---|---|---|
| 1. Lump Ore, Sized +1/2" -2" 280,000 Annual Metric Tons 62% Fe | $ 12.0/Metric Ton C.I.F. ($0.193/Metric Ton Iron Unit) | 1.7 Tons | $ 3,336,000 | $ 20.2 |
| 2. HyL Reduction | | | | |
| Light Naphtha | $11.0/BBL | 5.0 BBLS | $ 9,075,000 | $55,000 |
| Electric Power | 0.01/KWH | 20 KWH | 33,000 | 0.200 |
| Water | 0.10/1000 Gals. | 2,140 Gals | 36,300 | 0.220 |
| Chemicals, Catalysts & Misc. | | | 41,250 | 0.250 |
| Maintenance-Matl. & Labor | | | 412,500 | 2.500 |
| Operating Labor | 0.625/Manhour | 108,000 Manhours | 67,500 | 0.409 |
| Operating Supervision | 1.25/Manhour | 11,000 Manhours | 13,750 | 0.083 |
| General Overhead 100% | Labor & Supervision | | 81,250 | 0.492 |
| Total HyL Reduction | | | $9,800,550 | $57,154 |
| 3. Grand Total | | | $13,136,550 | $77,354 |

Not Included - Depreciation, Taxes & Insurance, Royalty, Cost of Sales and Overhead.

4. Estimated Annual Consumptions

| | |
|---|---|
| Lump Iron Ore (sized +1/2" -2") (Includes a 5% fines loss allowance) | 280,000 Metric Tons |
| Light Naphtha | 825,000 BBLS. |
| Electric Power | 3,300,000 KWH |
| Water | 353 x $10^6$ U.S. Gals. |

5. BBL = Barrel = 42 Gallons
Gals = Gallons

1/ Compiled from the technical literature by the writer

## ESTIMATED OPERATING COSTS

198,000 Annual Metric Tons Fe in Reduced Pellets
Metallization - 85%

| | Unit Cost U.S. $ | Unit Consumption Metric Ton Iron | Annual Cost U.S. $ | Cost U.S. $ Metric Ton Iron |
|---|---|---|---|---|
| 1. Iron Oxide Pellets, Sized +3/8"-5/8" 315,000 Annual Metric Tons 66% Fe | $16.0 /Metric Ton | 1.54 Tons | $5,040,000 | $25.4 |
| | ($0.242 /Metric Ton Iron Unit) | | | |
| 2. HyL Reduction | | | | |
| Light Naphtha | $11.0/BBL | 4.2 BBLS | $9,[illegible],600 | $46.200 |
| Electric Power | 0.01/KWH | 16.8 KWH | [illegible],200 | 0.168 |
| Water | 0.10/1000 Gals. | 1,790 Gals | 35,400 | 0.179 |
| Chemicals, Catalysts & Misc. | | | [illegible],500 | 0.210 |
| Maintenance-Mat'l.&Labor | | | [illegible],800 | 2.100 |
| Operating Labor | 0.62[illegible]/Manhour | 10[illegible],000 Manhours | [illegible],500 | 0.341 |
| Operating Supervision | 1.25/Manhour | [illegible],000 Manhours | [illegible],750 | 0.069 |
| General Overhead 100% | Labor & Supervision | | [illegible],[illegible] | 0.410 |
| Total HyL Reduction | | | $9,[illegible],000 | $49.077 |
| 3. Grand Total | | | $14,876,000 | $75.077 |

Not Included - Depreciation, Taxes & Insurance, Royalty, Cost of Sales and Overhead.

4. Estimated Annual Consumptions

| | |
|---|---|
| Oxide Pellets (sized +1/2"-2") (Includes a 5% fines loss allowance) | 315,000 Metric Tons |
| Light Naphtha | 832,000 BBLS |
| Electric Power | 3,326,000 KWH |
| Water | 354 x $10^6$ U.S. Gals. |

5. BBL = Barrel = 42 Gallons
Gals = Gallons

41. The steel scrap imported into Thailand now costs over 14[illegible] US$/tonne CIF. Heavy scrap in the country, if available, is quoted at the equivalent of 80-100 US$/tonne in the "as is and where is" condition; its processing, transport and delivery will add another 10-20US$/tonne.

42. The production cost estimate of sponge production based on escalated naphtha prices of US$11 per barrell (compared to its earlier price of 2.25 to 3.0 US$ per barrell), works out around 75 to 77 US$/tonne; to this if the normal overhead costs, depreciation and interest on fixed and working capital are added, its overall price may be around 90 US$/tonne or in any case less than 100 US$/tonne which is well below the imported steel scrap prices and matches the local scrap prices.

43. Adjudged realistically, the industrial production of sponge iron in Thailand involves many variables and quite a few uncertainties albeit not regarded by some as insurmountable. In any case, it will not lead to the goal of establishing an integrated steel industry in the country; at best it may only supplement the current steel melting capacity in Thailand. As such, it is strongly felt that the emphasis should be on the establishment of an integrated steel industry based on imported raw materials in the country; this objective and the location per se will need the concerted attention of the international consultants.

44. Annexure V gives the list of pre-reduction and direct reduction plants in the world using solid reductants whilst Annexure VI gives the latest global picture of sponge plants based on gas and solid reductants that are operating and others that are in different stages of feasibility, negotiations, planning and implementation; it is possible that some of them will be dropped and not installed.

## VI. Thai Steel Industry - Gaps, Problems (Short Term and Long Range) and their possible solutions

45. It is not for the first time that the gaps, short term and long range problems facing the Thai steel industry and its expansion are being outlined and their possible solutions referred to. This has been attempted earlier at different forums and platforms. However, nothing has resulted thereby except painless repetition of the issues. It is for the first time that the IBRD has stepped in to study the issues and focus attention on possible solutions facing the Thai steel industry. Some of the issues and problems that require answers are:

46. a) Should Thai steel industry be fully integrated, i.e. starting from smelting of local iron ores (with or without their prior beneficiation and agglomeration) and/or imported iron ores/pellets and follow conventional process routes (blast furnace or electric smelting of pig iron + BOF steelmaking) using imported metallurgical coal/coke in an integrated steel plant located at a coastal site in preference to an inland site? What would be its capital costs? What product mix should be produced? Should electric smelting of pig iron be undertaken? What would be the electric power tariffs in years to come - it is high at present at 0.4-0.6 Baht/KwH. Does the integrated iron and steel plant need a deep coastal sea port or will a deep jetty/belt conveyer system do at an existing medium deep sea port such as at Sattahip or should a new deep sea port such as at Laem Chabang be put up about 14 km

South of S cha? What are the capital costs of doing so, i.e., of conventional integrated cycle of iron and steel production? A pertinent question would be - can Sattahip be used as a convenient civilian sea port for industrial usages including import of raw materials for the integrated steel industry? What are the objections to its use as a civilian sea port in normal peace time and conversion to defence needs in case of a War, a practice normally followed in many countries.

47. b) Can Thai lignites be used for sponge production using local iron ores after prior beneficiation/pelletization or using imported high grade heat-hardened iron oxide pellets? Pilot plant scale investigations and trials would be necessary to determine the technical feasibility of sponge production based on solid reductants (dried lignite or lignite char). It is well known that many of the solid-reductant based industrial sponge[1/] production plants in different countries have either failed or permanently closed down badly whilst one or two of them are now reportedly turning the corner; their sponge production costs are, however, reportedly not known nor is much precisely known about the cost of steel made directly from such highly metallized sponge in electric arc furnaces at the normal power costs. If one were to accept the technical feasibility of sponge production in

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1/ Sponge with a high degree of metallization over 90% which is suitable for direct steelmaking in the electric arc furnace.

Thailand based on the results of pilot plant scale investigations using Thai iron ores and lignite, what would be the corresponding scaled up industrial scale techno-economic feasibility and costs (capital and operational) adjudged on acceptable criteria and rationale. These problems and important aspects do need detailed examination. Another question would be - should Thailand import sponge made by the gaseous sponge iron processes (HYL, Midrex, etc.), such as from a neighbouring country e.g., Indonesia at reasonable price levels to substitute/supplement highly expensive imported steel scrap. Should Thailand import naphtha for sponge production based e.g. on the HYL process and if so, at what costs?

48. c) What should be the product mix of an integrated or a non-integrated steel plant - flat and non-flat steel products? If the flat steel products are to be produced what would be the acceptable size of the integrated iron and steel plant and of the mill - one million or 1.5 million tonnes of flat steel products? What are the market demands of flat steel products in the absence of a ship building industry and/or of automobile industry in Thailand which need cold steel coil/strip for auto-bodies and steel plates of varying lengths and widths for ship building and engineering industries. Or should the integrated steel plant produce both flat steel products and non-flat steel products (rods, sections, structurals, beams, medium sections, etc.) based e.g. on a universal blooming/slabbing rolling mill and a combination mill for steel plates and hot rolled steel coils, followed by a cold steel rolling mill for cold strip (coils)

besides the structural/merchant section mills for non-flat steel products.

49. d) What would be the most optimum location for the new integrated steel plant? What would be the costs of transport of raw materials (cost per ton/mile) in case of an inland site? What would be the transport costs of supplying the Thai steel products to the domestic markets in Thailand? Optimum price levels will need to be determined and applied in practice as also the protective tariffs needed by the indigenous steel industry (customs duty on the imported steel products and/or subsidy for the export of Thai steel products). These questions need a detailed study and rational answers.

50. Capital investment needs of the new integrated steel industry would need to be assessed both in terms of foreign exchange and local currency requirements. What about the merits of the existing steel industry's proposals which are based on reverse integration and installation of a cold strip mill followed later by a hot strip mill? What would be the rubbted capital and in-built production costs? Protective tariffs and subsidies will need to be worked before such proposals can be acceptable. The examples and experiences inter alia of South Korea, Yugoslavia will need to be quoted and applied to the extent possible.

51. The above questions and problems will need to be examined through a detailed [illegible] study involving comprehensive investigations on pilot plant scale on Thai raw materials for iron production based on solid reductants (direct reduction or blast furnace). In effect the entire [illegible] the planning and operation of the Thai steel industry [illegible] for the next decade in concrete terms [illegible] effectively linked with (a) the existing [illegible] and pattern and their future development and (b) with world resources. The strategy has to be based on the optimum use of the natural resources and local Thai raw materials for the steel industry supplemented and/or substituted by imported raw materials. The interrelated cost effects of these factors have to be studied both on capital investment and plant operations including production costs of the steel products.

52. Alternatively, it will need examination how far and to what extent, the existing wholly scrap-based steel melting plants in Thailand can be strengthened through additional equipment/infra-structure facilities and expanded to the optimum extent techno-economically possible. Planning and timing of these proposals will need to be rationally and judiciously outlined but not on any empirical and ad hoc basis that appear to have marked the growth of the Thai steel industry so far.

53. Regional solutions should also be examined based on bi- or multi-lateral co-operation, regional steel industry and trade possibilities. So far these factors have played a somewhat insignificant part in the growth of the steel industry in Thailand. To what extent can these factors be harnessed to mutual the benefits of the regional countries? These aspects will need to be studied at length through an International Consultant's study and report.

54. Another important question relates to the production of high priced alloy and special steels in existing scrap melting electric arc furnaces in the country (that are imported at high foreign exchange costs) which could replace or at least supplement most profitably the relatively much lower priced common plain carbon and mild steels with almost the same inputs of scrap, electric and manpower besides the additions of requisite ferro-alloys. Where should the balance be struck in these areas which are most appropriate and applicable to the Thai steel industry? All these important questions need to be critically examined, clarified and decisions taken through a UN financial consultant's study and a detailed report. So far there have been a mushroom of ad-hoc studies empirically commissioned and business wise completed tailored to limited objectives and scope of work; however, there has been no single study and a comprehensive report

which aims at answering all the complex and inter-woven questions and parameters to enable the planners, economists and the industrialists to take judicious and well planned decisions and implement them on a systematic and time phased basis.

55. The questions of . . subsidies, capital formation and of infrastructure facilities including inter alia transport, services (water, oil, gas, power) likewise need a careful study and rationale.

56. The iron and steel foundry industry (again dependent upon appropriate melting facilities (also requires adequate linkages with the iron and steel industry in the country.

57. The mineral exploration and proving such as of iron ores, coal (lignite resources) should be continuous features of an expanding economy and sights have to be focussed on a long term and well sustained basis.

## VII. Regional Steel Industry

58. Regional industrial projects in developing countries have been discussed and promoted on paper relatively far more than any tangible action taken on their practical realisation. Regional steel industry projects have been no exception to this general rule; the subject is as complex as its objectives are desirable. Some imply a regional project to denote certain mandatory trade obligations and/or connote by implication undefined restrictions on free trade. Such (mis)understandings are not justified. Regional steel projects in developing countries should be welcome; these have a good measure of in-built flexibility if the quality, quantity and the selling prices of steel are mutually satisfactory. Regional trade could be regarded as the equivalent of a preferred normal trade system between the regional countries that will ensure profitable mutual trade flow. Regional steel projects ought not to be confused with regional trade like that obtaining among the European common market countries or the LAFTA (Latin American Free Trade Association) Latin American countries.

59. The UNIDO/ECAFE[1/] iron and steel industry survey mission to the Lower Mekong Basin countries focussed attention on the subject and highlighted potential regional steel industry projects; this mission was followed up by ECAFE Regional Steel Billet Mission (1973)[2/]

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1/ Report of the UNIDO/ECAFE Iron and Steel Industry Survey Mission to the Four Countries (Thailand, Laos, The Khmer Republic, The Republic of Viet-Nam) of the Lower Mekong Basin - August 1971, led by Mr. B.F. Nijhawan, Senior Interregional Adviser, UNIDO.

2/ ECAFE Document AIDC(8)/10, 2 January 1973 - Regional Steel Billet Plant - Report of the Expert Team on Regional Co-operation for Steel Billet Production.

but practically nothing has come out of them so far except in fructuous discussions and this situation is not likely to change perceptibly in the reasonable future.

60. The Regional Steel Billet Project centered around a central location for the production of steel billets for distribution to some of the regional countries of ECAFE (now ESCAP) including Thailand based on an investment of US$ 42 million (estimated in 1971) for the production of steel billets continuously cast into 150-180 mm blooms that would be rolled to 65x125 mm size billets.

61. Likewise, a regional cold rolling flat product steel mill was mooted. The Asian Industrial Survey for Regional Co-operation issued its Study Report No. 10 (November 1972) covering the proposal for Regional Co-operation in the field of steel production, i.e. emphasising support to the two regional steel projects referred to above. However, nothing tangible has so far resulted nor is expected to emerge out of these deliberations in the reasonable future.

## VIII. Terms of Reference for an International Consultant's Study of the Expansion of the Thai Iron and Steel Industry

1. Steelmaking capacity in Thailand in 1974 is reported at about 550,000 metric tonnes per year of bars and light structurals, based on imported scrap, processed in electric furnaces. There are eleven firms in the industry altogether, of which only six are considered as major producers, with capacities in the range of 25,000 to 130,000 tonnes per year. The other five are small plants with a total capacity of only about 50,000 tonnes. One company (Siam Iron and Steel) also produces about 20,000 tonnes per year of pig iron for domestic foundries. There are also six manufacturers of steel pipes, three producers of galvanized sheet, and one tinplate producer in Thailand, who depend entirely on imported flat rolled products. Their total capacity is for about 375,000 tonnes of products. Thailand is reported to have imported 556,171 tons of steel products in 1974. Although this represents a 6.9% fall on the previous year in tonnage terms, higher prices meant a 35.5% rise in value. Significant quantity increase were recorded for certain items; however, steel rods imports rose 105% and bars were up 83.8%, to 44.827 tons. The overall drop in import value primarily reflected a 27.9% fall in prices and a 13.8% fall in steel sheets requirements.

2. Actual production of non-flat rolled steel products in Thailand in 1974 is estimated at 380,000 tonnes, equivalent to about 495,000 tonnes of crude steel (based on a 77 per cent yield ratio). This fulfils only about two-thirds of the countries demand, which is placed at about 600,000 tonnes of products. The difference - 220,000 tonnes - is being met by imports. The total consumption of non-flat products thus represents a demand for about 780,000 tonnes of crude steel.

3. In the case of flat steel products, current consumption is about 465,000 tonnes, based wholly on imports. This is equivalent to about 665,000 tonnes of crude steel (based on a 70 per cent yield ratio).

4. The total consumption of finished steel (flat and non-flat) is thus about 1.06 million tonnes, corresponding to about 1.45 million tonnes

of crude steel.

7. Demand projections for future years have been made by various agencies and as may be easily predicted, have varied substantially from one another, depending on the assumptions made regarding growth of specific sectors. The most conservative projection would place demand in 1980 at about 2 million tonnes crude steel equivalent, rising to about 2.5 million tonnes crude steel equivalent by 1985. These totals may be apportioned in the ratio of 40:60 for flat and non-flat products respectively and we get the conclusion that (i) there will be a need for 1.5 million tonnes of crude steel for production of non-flat rolled products in 1985, compared with the current capacity for 0.55 million tonnes, and (ii) for flat rolled products, there will be a market demand for over 0.7 million tonnes of crude steel against an estimated consumption of 0.46 million tonnes in 1978. The growth rates for demand envisaged in these figures are around 6 percent per annum for non-flat products and about 4 percent per annum for flat rolled products; and the average rate of growth works out to a little over 5 percent per annum. Other estimates, which are based on somewhat more optimistic assumptions regarding growth of the Thai economy and steel consuming sectors, estimate the demand for steel, expressed in crude steel, at about 2.5 - 2.7 million tonnes by 1980 and in the range of 3.6 - 4.2 million tonnes by 1985. Dividing these overall projections into two major parts, for flat and non-flat products respectively, we get the following projections.

| Projected Demand for Steel: (in million tonnes) | 1980 | 1985 |
|---|---|---|
| Total - expressed in Crude Steel equivalent | 2.5 - 2.7 | 3.6 - 4.2 |
| Flat rolled Products (including pipe) | (0.70 - 0.76) | (0.98 - 1.68) |
| Non flat Products (including alloy-steel) | (1.15 - 1.23) | (1.69 - 2.07) |

These are rather rough projections, based on relations of steel consumption, GDP growth and population growth during the past decade, and assumptions regarding future growth rates. There will be need for further refinement of these figures, for purposes of planning a detailed strategy for development of the iron and steel industry in Thailand; but they serve a useful purpose in so far as they indicate the dimensions of the problems involved. In respect of non-flat products, for which capacity exists at present to the extent of about 550,000 tonnes per year (finished product) there will be need for at least about 1.1 million tonnes per year by 1985; and the demand could possibly be as high as 1.9 million tonnes. For flat rolled products, similarly, the demand is likely to be at least about 0.7 million tonnes, and could be as high as 1.2 million tonnes, by 1985; and existing capacity is for secondary operations only, dependent on imports of plate, sheet, coil, etc.

5. The Government as well as some private interests, particularly the larger companies presently involved in steel production and processing, have been anxious, for the past several years, to develop a rational and efficient strategy for the iron and steel industry in Thailand. Some studies have been made, under auspices of UNIDO, ESCAP, and other international agencies, as well as by steel industry interests (e.g. U.S. Koppers) in recent years; but the Government felt the need for a more detailed study at this stage, with the object of providing guidance for policy as well as specific decisions required to develop the iron and steel industry speedily and efficiently. Funds for the study would be provided by UNDP; and the Bank mission was asked to advise on the terms of reference for the study. The mission's review of facts is, therefore, very brief by design; and it is intended only to provide the background for the terms of reference proposed.

[illegible] The existing producers of steel bars and light structurals in Thailand depend largely on the import of steel scrap, and to a lesser extent, on imports of ingots and billets, for their raw material [illegible]. In 1967 the country imported about 300,000 tonnes of steel scrap, and for 1968 suggests a higher figure. As the cost of scrap on international markets has risen rapidly in recent years, in response to the rapidly increasing demand for many countries, including the major steel producing countries, serious questions naturally arise about the advisability of Thailand continuing to rely on imports of scrap for its needs of non-flat products in the future. In the past decade, countries like Korea, Taiwan, the Philippines and Malaysia imported much larger quantities of scrap steel than Thailand does presently; but looking to 1985, Thailand has to consider these countries themselves, as its demand would begin to approach the volume at which integrated steel plants, starting with iron ore, become feasible.

3. In considering economically feasible choices, Thailand would have a natural desire to use such domestic resources as may be available at reasonable cost. Known iron ore deposits of suitable quality [illegible] have been estimated at about 40 million tonnes, of which about 27 million tonnes are reported to be located at Loei, in the northern part of the country; only about 7 million tonnes are estimated at Lopburi, where mining operations are presently undertaken for the Siam Iron and Steel Co. [illegible]. It is likely that the logical choice for an integrated steel works would not be significantly affected by these small deposits. The exploitation of the domestic iron ore reserves may depend on the cost of transport to a possible location at which all the requirements for a modern steel plant can be efficiently assembled, in order to produce steel at internationally

competitive cost. Alternatively, the domestic iron ore may be usable in smaller pig or sponge iron production facilities, if suitable fuel at viable cost can be found, near the iron ore deposits.

9. Thailand does not have any reported coal deposits for metallurgical industry. Lignite reserves have been estimated at about 235 million tonnes; but all the presently exploited reserves are committed for power generation. If more lignite can be mined economically, it may be possible to use it in small low-shaft blast furnaces for pig iron production.

10. It appears, therefore, that for the major raw materials needed for steel production, Thailand will have to depend on imports. In this context, a seaside location would, prima facie, appear advantageous. Actual site selection will, however, need detailed consideration of a large number of physical and cost factors.

11. The Bank mission has attempted to discuss all major questions related to future expansion of the steel industry with the relevant agencies in Government and private enterprise interests; and all the points emerging therefrom have been kept in-view in the draft terms of reference prepared for a detailed study, which follow:

12. Terms of Reference for a study of the prospects and strategy for expansion of the Iron and Steel Industry:

(i) To assess the demand for steel products for the years 1975-85, covering the principal common grades of steel, e.g., non-flat products, structurals, light sections; flat-rolled products, plate, hot coils, cold mill products, etc. This assessment should serve to determine the

[illegible] and capacities of steel rolling mills required, such as [illegible], medium mill, structural mill, hot and cold rolling [illegible] mills. The demand projections should take account of [illegible] growth of GDP, population, growing intensity of [illegible] with phases of development, etc., as well as micro-economic data [illegible] consuming industries, prices, etc.

(iii) To assess the current steel production capacity of the [illegible] existing plant and equipment under installation and/or ordered by existing firms. This assessment should include a technological audit of [illegible] utilization, best actual output attained, and major reasons for under-utilization of capacities.

(iv) To determine the real viable installed capacities of the [illegible] and appropriate measures for their effective utilization.

(v) To review the sources and prices of the principal raw materials used, and determine the trends of costs during the past 3-5 years. This review will include imported steel scrap, domestic scrap, ingots and billets, as well as power, water and fuel.

(vi) To evaluate the proposals presently available (in the Board of Investments and with the leading manufacturers) for expansion of the iron and steel industry in Thailand, and determine which, if any, are likely to yield steel products at internationally competitive prices, taking account of c.i.f. landed cost of imports from the leading export markets, e.g., Japan.

(vii) If the result of the evaluation envisaged above is negative entirely or positive for some steel products and negative for others, the Consultant will proceed, in respect of the principal products for which no economically viable project proposal is presently available, to develop and offer recommendations, based on specific techno-economic data, for the production/supply of the principal categories of iron and steel products for which the projected

demand in the period 1980-85 would be in excess of the presently installed viable capacities of the industry, as assessed in pursuance of paras. (i), (ii) and (iii) above. The Consultant should, in the process of developing recommendations, review the alternative strategies that may be available in respect of technical processes and plant sizes, keeping in view the demands projected for 1985, and with due regard to the needs of the existing industry. The question of supply of raw materials for the existing electric furnaces, and the implications of manufacturing sponge irons will be considered.

(vii) To determine the appropriate capacities for the principal sections of the Plant(s), the processes to be employed, and the starting principal raw materials required.

(viii) To examine specifically the scope for using available domestic raw materials, such as iron ore, lignite, etc.; and to the extent that imports would be necessary, identify likely sources of supply , and estimate the quantities needed, and c.i.f. landed costs.

(ix) To recommend the appropriate technological processes for iron making and steel production, including casting of blooms or billets and slabs. The recommendations will be supported by rough estimates of capital and production costs for the available alternatives, as well as technical data on materials balance and generation/utilization of by-products.

(x) For the process route and plant equipment selected, develop specifications in sufficient detail to enable the preparation of estimates of capital costs, to enable the Government to make judicious choices.

(xi) As the product mix which is required to be produced will have a significant impact on the choice of rolling mills, and hence influence capital and production costs, the Consultant will, keeping in view the volume of demand projected (for the period 1980-85) for various product

[illegible], recommend the appropriate product mix to be aimed for, with the objective of optimising the capital and production costs. Alternative product-mixes will be examined in relation to the available techno-economic choices.

(xiii) A short list of possible locations for the proposed steel plant will be examined (including suitable coastal locations, to facilitate the import of basic raw materials), and the major cost implications of available alternatives will be assessed, taking account of the needs for infrastructure, rail and road facilities, water and power supply, town and housing requirements, [illegible] and a suitable location chosen.

(xiv) Financial projections for the proposed plant will be prepared, showing inter-alia the investment costs (showing separately the foreign exchange and domestic currency requirements), operational and maintenance costs, possible modes of capital financing, cash flow projections, estimates of break-even point, and the internal rate of return.

(xv) To the extent that financial costs and revenues (referred to in para. (xiii) above do not reflect appropriately the economic costs and benefits, the differences will be estimated and analysed with a view to providing relevant information for appropriate choices.

(xvi) It is envisaged that this study should be completed in about six months time; it may involve about 30-35 man-months of experts' time.

(xvii) The consultants would need two or three competent counterpart officers, to be provided by the DOI or some other Government agency, to help in the collection and analysis of relevant data within Thailand. At least one of these supporting officers should be familiar with the market for steel products in Thailand, and would help the consultants in their assessment of demand; another should have knowledge of the existing manufacturers of iron and steel products.

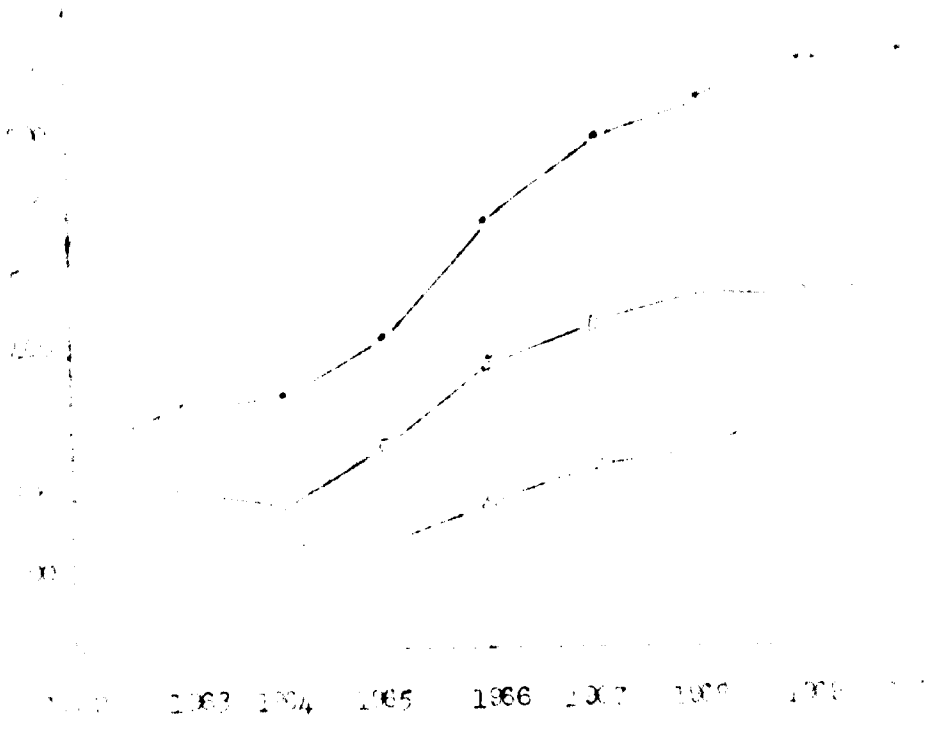
ANNEXURE I

## Steel Consumption/Production Figures of Thailand for 1962-70

1. The iron and steel industry in Thailand was started in 1942 with pig iron production in a small charcoal blast furnace and a re-rolling mill began operation in 1962. The present products are in the form of bars and rods for constructional uses produced in scrap based electric arc furnaces. Fig. 1 shows the steel demand by product groups for the years 1962-1970. Consumption of flat products is quite high due to the requirements of cold-rolled sheets for galvanizing and tinning. Almost 80 per cent of steel consumption is in construction activities comprising mostly RCC steel bars and rods.

2. Fig. 2 also shows the steel imports which have declined in recent years due to the Government's policy of banning imports of some steel products and imposing duties on others.

3. The different forecasts of steel demand in 1975, 1980 and 1985 have been made by various organizations, missions and experts on iron and steel. The latest forecasts of finished steel are 1.7 and 2.3 million tons for 1980 and 1985 respectively. The market for special and alloy steels in Thailand is expected to be 70,000 tonnes in 1980 mostly comprising low alloy constructional steels, besides small tonnages of nickel-chrome and ferritic stainless and tool steels. It is estimated that about 100,000 tonnes of foundry pig iron would be required by 1980.




C = TOTAL CONSUMPTION

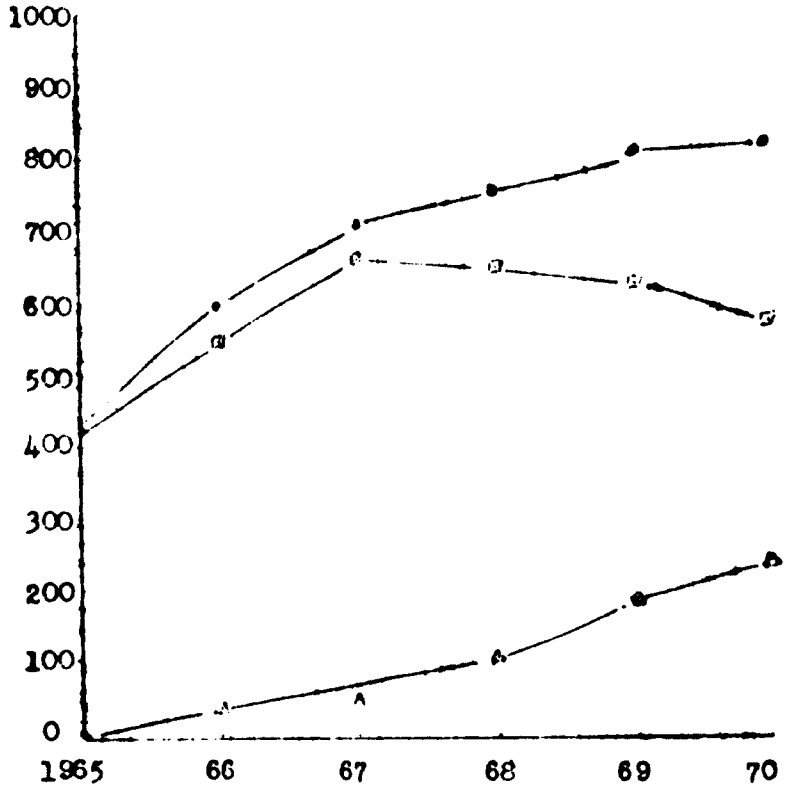
= TOTAL PRODUCTS

= TOTAL PRODUCTS

[illegible] total products excluding the stock [illegible]

Fig. 2 Steel consumption by Import; 1965 - 1970

(in 1,000 metric tons)




● = TOTAL CONSUMPTION

□ = IMPORT

Δ = PRODUCTION

Note Export of each year was less than 5,000 tons.

ANNEX II

## Selected economic indications Thailand from 1967-1974

Economic Indicators

1. Gross National Product in 1971 amounted to 144,560 million baht, an increase of 8,611 million baht over the 1970 figure of 135,949 or at a rate of 6.3 per cent.

Table 1. shows GDP, GNP, National Income and Per capita GNP (1967 - 1971).

(Millions of baht)

| Year | 1967 | 1968 | 1969 | 1970 | 1971 |
|---|---|---|---|---|---|
| Gross domestic product (GDP) | 108,294 | 116,774 | 128,566 | 135,949 | 144,560 |
| Gross national product (GNP) | 108,462 | 117,046 | 128,792 | 136,328 | 144,590 |
| National income | 89,594 | 95,345 | 104,581 | 110,598 | 117,175 |
| Per capita GNP (Baht) | 3,171 | 3,311 | 3,527 | 3,614 | 3,718 |

Income per capita in 1971 rose to 3,718 baht, an increase of 104 baht over the 1970 figure.

Table 2. shows major percentage distributions of GDP by industrial origin.

| Industrial origin | 1967 | 1968 | 1969 | 1970 | 1971 |
|---|---|---|---|---|---|
| Agriculture | 32.0 | 31.4 | 31.7 | 28.6 | 28.6 |
| Wholesale and retail trade | 17.5 | 17.3 | 17.4 | 18.9 | 18.2 |
| Manufacturing | 15.4 | 15.3 | 15.4 | 16.0 | 16.3 |
| Services | 9.7 | 10.1 | 10.1 | 10.4 | 10.6 |
| All others | 25.4 | 25.9 | 25.4 | 26.1 | 26.3 |
| Gross domestic product (GDP) | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

2. In 1971 the share of GDP coming from agriculture was 28.6 per cent the same percentage as of 1970. Agriculture still amounted to about one-third of total GDP.

Manufacturing sector ranks third of GDP and gains further importance each year. During 1967 - 1971, manufacturing growth rates were 19.8, 7.1, 11.0, 10.0, 8.5 percent, in 1967, 1968, 1969, 1970 and 1971 respectively.

In addition to the income approach and the product approach, the structure of the economy can be described in terms of the expenditure approach (see Table 3).

Table 3. Domestic Product

(Millions of baht)

| | 1967 | 1968 | 1969 | 1970 | 1971 |
|---|---|---|---|---|---|
| Net domestic product at factor cost | 89,426 | 95,073 | 104,355 | 110,219 | 117,145 |
| Provisions for domestic fixed capital consumption | 6,313 | 7,543 | 9,881 | 10,193 | 11,343 |
| Indirect taxes | 12,555 | 14,158 | 15,330 | 15,537 | 16,072 |
| Gross domestic product at market prices | 108,294 | 116,774 | 128,566 | 135,949 | 144,560 |
| Private consumption expenditure | 75,231 | 80,883 | 86,415 | 92,008 | 98,917 |
| General government consumption expenditure | 10,360 | 12,736 | 14,058 | 15,589 | 17,329 |
| Gross domestic fixed capital formation | 24,927 | 24,477 | 30,774 | 31,824 | 31,552 |
| Increase in stocks | 758 | 1,958 | 3,700 | 3,166 | 1,961 |
| Export of goods and services | 21,300 | 21,425 | 22,729 | 22,720 | 25,055 |
| Less: Import of goods and services | 23,704 | 26,159 | 27,937 | 29,316 | 29,735 |
| Statistical discrepancy | - 578 | -1,546 | -1,163 | - 42 | +1,571 |
| Expenditure on Gross domestic product | 108,294 | 116,774 | 128,566 | 135,949 | 144,560 |

About two-thirds of total spending was devoted to private consumption, but one-fourth to capital formations, both private and public, the remainder (about 9 per cent) constituted general government consumption expenditure. The amount of goods and services exported as compared to the Gross Domestic Product ( a ratio of about 19 - 20 per cent) has increased only a little, but in absolute terms, exports increased from 22,720 million baht to 25,055 million baht in 1971. Even so, imported goods and services still exceed those exported, particularly because demand for capital goods to increase production capacity in the country remains high. In 1971, imports (excluding military goods) arounted to baht 29,735 million, a rise of 419 million or about 2 per cent over that of 1970.

THAILAND: SELECTED ECONOMIC INDICATORS

*(in million baht)*

| *Indicator* | *1972* | *1973[b]* | *1974[b]* | *Percentage change over previous year* | | |
|---|---|---|---|---|---|---|
| | | | | *1972* | *1973* | *1974* |
| Total expenditure on GDP at current prices | 156,542[a] | 184 16 | 204,617 | 8.3 | 17.6 | 11.1 |
| Of which: | | | | | | |
| Private gross fixed capital formation | 21,653 | 24,468 | 28,872 | 4.8 | 13.0 | 18.0 |
| Government gross fixed capital formation | 10,810 | 12,600 | 14,950 | −0.8 | 16.5 | 18.7 |
| GDP (1962 constant prices) | 132,336[a] | 144,246 | 153,320 | 4.0 | 9.0 | 6.3 |
| Of which | | | | | | |
| Agriculture | 36,229 | 39,908 | 42,100 | −5.0 | 10.2 | 5.5 |
| Manufacturing | 25,109 | 27,871 | 30,100 | 11.0 | 11.0 | 8.0 |
| Construction | 7,204 | 7,636 | 8,100 | 4.0 | 6.0 | 6.0 |
| Exports of goods and services | 32,539[c] | 42,710 | 47,650 | 22.9 | 31.3 | 11.6 |
| Imports of goods and services | 35,375[c] | 44,855 | 53,200 | 13.6 | 26.8 | 18.6 |
| Balance of payments on current account (not including transfers) | −2,846[c] | −2,145 | −5,550 | — | — | . . |
| Basic balance of payments | 3,991[c] | 1,806 | — | — | — | . . |
| Change in money supply (including time deposits) | 12,891[c] | 15,200 | 13,000 | 24.0 | 22.8 | 16.0 |
| Consumer price index[d] (1964-65 = 100) | 119.5[c] | 137.4 | 151.1 | 4.8 | 15.0 | 10.0 |
| International reserves (million $US) | 819.8[e] | 993.6[e] | 1,096.1[f] | 3.6 | 21.2 | — |

Source: Data on GDP are from the Department of Business Economics, Ministry of Commerce. Data on financial variables are from the Bank of Thailand. Estimates and forecasts are projected.

[a] Estimate.
[b] Forecast.
[c] Actual.
[d] Average for the year.
[e] January of year.
[f] October 1973.

ANNEXURE III

Relationship between steel intensity and per capita cost in selected Asian countries

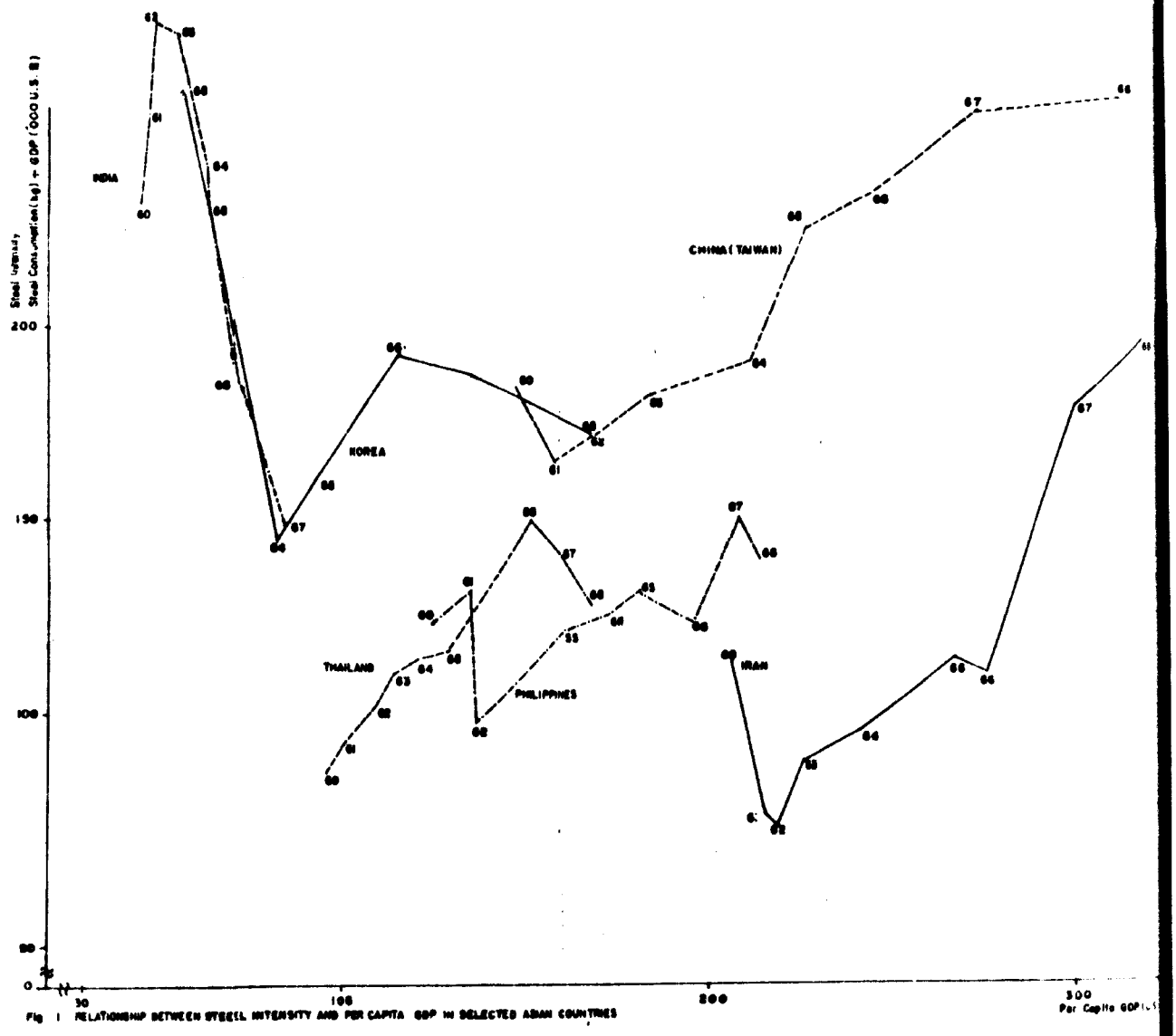



Fig 1 RELATIONSHIP BETWEEN STEEL INTENSITY AND PER CAPITA GDP IN SELECTED ASIAN COUNTRIES

## Raw Materials Resources for the Iron and Steel Industry in Thailand

### General situation

1. Table 1 shows major raw material reserves needed by iron and steel industry. Iron ore deposits are widely scattered and not high grade. Deposits contain possible reserves of about 40 Million tonnes with Fe content 40 - 60 percent. Three main areas of deposits are:

2. a) Lop buri with 7 million tonnes of estimated reserve;

3. b) Kanchana buri (5 million tonnes) and

4. c) Loei (27 million tonnes).

5. At present Lopburi deposits are the only ones which have been actively exploiting supply to SISCO charcoal blast furnaces. Largest reserve deposits are in the Loei area located rather remotely in the north relatively near the Mekong River and the boundary with Laos, some 800 km from Bangkok. Most of manganese ore deposits are in the far northern areas of Thailand, requiring long routes to reach destinations. Other primary raw materials come from flux materials - dolomite and fluorspar.

6. Coal reserves donot exist in Thailand; lignite reserves are estimated at 235 million tonnes. Iron ore mining rose to 0.75 million tonnes in 1965 which dropped to 543,180 tonnes in 1967 which were almost wholly exported, based on Nakhon Sri Thamarat deposit which is now exhausted. Thai iron ore production dropped to 41,591 tonnes in 1971. During 1973, it was about 36,300 tonnes used exclusively for SISCO's charcoal blast furnaces for iron production of foundry grades.

Table 1 - Major Raw Material Reserves

| Location | Potential Reserve | Production | Years of Production | Grade | Remarks |
|---|---|---|---|---|---|
| Iron Ore | | | | | |
| Loei | 27,000,000 | - | - | Fe 54-67 % | Not producing |
| Lopburi | 7,000,000 | 170,244 | 1958 - 69 | Fe 44-55 % | Producing |
| Chachoengsao | 6,200,000 | - | - | Fe 50-60 % | Under exploration |
| Kanchanaburi | 5,000,000 | - | - | - | Low grade, not producing |
| Limestone | | | | | |
| Songkla | over 500,000 | 128,768 | 1965 - 69 | | Not producing |
| Lampun | over 200,000 | 50,280 | 1963 - 69 | | Producing |
| Chiang - rai | over 200,000 | - | - | | Not producing |
| Dolomite | | | | MgO CaO $SiO_2$ | |
| Kanchanaburi | over 200,000 | - | - | 20.8 31.9 0.12 | Producing |
| Koh Sichang, Chonburi | 5,700 | - | - | 20.5 31.6 1.1 | Not producing |
| Flourite | | | | $CaF_2$ | |
| Lamphun | over 5,000,000 | 626,190 | 1962 - 69 | 75 - 85 % | Main producing area |
| Ratburi | 1,000,000 | 81,440 | 1960 - 64 | 75 - 85 % | Producing |
| Petchburi | 1,000,000 | 53,320 | 1965 - 69 | - | Producing |
| Kanchanaburi | 3,500,000 | - | - | - | Not producing |
| Lignite | | | | | |
| Lampang | 120,000,000 | 1,255,589 | 1958 - 69 | 4,000 Kcal/Kg | Producing |
| Krabi | 100,000,000 | 933,603 | 1964 - 69 | 4300 Kcal/Kg | Producing |
| Lampun | 15,000,000 | - | - | 6000 Kcal/Kg | Produce in near future |

1. The accompanying map shows the iron ore and lignite deposits in Thailand.

Iron ore deposits

2. Iron ore deposits are reported to occur in a large number of areas. The aivailable information 1/ regarding reserves and grades of ore occurring in different deposits are as follows:

| | Reserves '000 tons | Grade % Fe |
|---|---|---|
| Chiang Mai | 1,000 | 69.3 |
| Phrae | 50 | 71.8 |
| Kamphaeng Phet | 157.5 | n.a. |
| Loei | 27,200 | 52.0 |
| Nakhon Sawan | 37 | 50 |
| Lop Buri | 7,000 | 48.4-66.4 |
| Kanchanaburi | 5,000 | 34.0-42.0 |
| Prachin Buri | 21,620 | 15.0-40.0 |
| Chachoengsao | 5,000 | 25.0-35.0 |
| Chon Buri | 55 | 52.9-68.3 |
| Surat Thani | 50.1 | 49.1-57.6 |
| Nakhon Si Thamarat | 2,000 | 60.0 |
| Satun | 18,000 | 28.0 |
| Yala | 54 | 25.24-39.4 |
| | 84,956 | |

1/ Source: Mineral Resource Gazette


IRON ORE AND LIGNITE DEPOSITS IN THAILAND

Nakhon Si Thamarat

3. The main iron ore deposit so far exploited in Thailand is located at Nakhon Si Thamarat in the south. The annual output has been of the order of 0.5 to 0.75 million tons until recently and the iron ore contains an average of 45 % of iron, most of which has been exported to Japan. The original reserves of iron ore at Nakhon Si Thamarat were estimated at about 2 million tons. This mine is now totally exhausted and so there is now no production or export of iron ore.

Lop Buri

4. The iron ores of Lop Buri, namely in the Ban Hua Wai and Khok Samrong regions, occur as small lenticular hematite ore bodies with some magnetite. The mineralization of contact-metasomatic type near the margin of diorite intruded into limestone. The Ban Hua deposit has been worked for some years by the Eastern Mining Development Co.; however, since 1966 there has been virtually no production. The Khok Samrong deposit is being worked as open cast mine by Siam Cement Co., and the ore is used in its blast furnace in Tha Luang plant near Saraburi.

Nong Bon

5. There are a number of small iron ore deposits in an area about 40 km south-east of Chachoengsao, a town in the eastern region. Apart from the Nong Bon deposit others are practically of economic importance. The major minerals of Nong Bon deposit ore hematite, magnetite, limonite and some pyrites occurring in sedimentary beds (or metamorphic segregations) in a series of amphibolites and mica chists of Pre-Cambrian age. Three beds, averaging 1.5 to 5 m thick, have been identified. The ore is classified into types - oxidized and unoxidized. The oxidized ore, containing mainly magnetite and hematite, analyses 57.4 % Fe, 0.4% Mn, 6.6% $SiO_2$, 4.9% $Ai_2O_3$, 0.02% S and 0.07% P. The unoxidized ore, containing magnetite with pyrite, averages 57.9% Fe, 0.4% Ma, 8.4% $SiO_2$, 3.5% $AiO_3$, 3.66% S and 0.11% P.

Loei

6. There are seventeen iron ore prospects in Loei province. Of these, four measure over 150 m horizontally. These are Phu Lek, Phu Yang, Phu Hia and Phu Ang. The Phu Yang deposit is a bedded replacement within a roof pendant of a granodiorite stock in a series of metamorphosed sedimentary and volcanic rocks. The iron mineralization at the surface is hematite-magnetite having 1.5 million tons of proved and probable reserves with an average iron content of 62.4 per cent. The lower magnetite-pyrite zone has 9.25 million tons of proved and probable reserves having an average iron content in magnetite of 45.9 per cent. Possible reserves are 3.5 million tons.

7. On the top of a hill called Phu Hia there are two outcrops of high-grade magnetite ore 250 metres apart. These are the surface expression of dipping tabular magnetite zones. Massive magnetite also occurs as boulders on the hill slopes. Igneous rocks are not exposed on the surface, but granodiorite was encountered in drill-holes. They are near the Phu Yang iron deposit and can therefore be considered part of the Phu Yang iron district.

8. Phu Lek lies at the contact of a granodiorite intrusion extending to the south and east of the deposit. The surface expression of the Phu Lek deposit consists of patches of hematite-magnetite boulders exposed along a strike length of 900 metres. Trenching and drilling showed the presence of a northwest-dipping zone of iron mineralization 6.7 m thick. Proved and probable reserves are estimated to be 400,000 tons. The lower slopes of the hill will be covered by water after the construction of the proposed Pa Mong dam, and the prospect will be on a small island.

9. The iron deposit at Phu Ang consists of a surface cover of hematite-magnetite boulders and outcrops underlain by a series of overlapping lenses of iron minerals alternating with layers of sedimentary rocks. The lenses have a thickness of 2 to 18 metres. They are composed of hematite, magnetite, martite, and goethite in the weathered oxidized zone and of magnetite with pyrite in the unoxidized zone below a depth of 50 metres. At Phu Ang there is a total of 11.0 million tons of ore containing an average of 53.9 per cent iron as oxides, and 2.1 per cent as pyrite. Of this total, 10.9 million tons are proved or probable, and the remaining 100,000 tons are possible reserves.

10. The proven plus probable reserves consist of 7.6 million tons of oxidized ore plus 3.3 million tons of unoxidized ore. The oxidized ore, most of which lies within 50 m of the surface, contains an average of 58.6 per cent iron as oxides and 0.1 per cent as pyrite. The unoxidized ore, all of which lies more than 50 m below the surface, contains an average of 43.0 per cent iron as oxides and 6.7 per cent as pyrite.

11. Iron ore mining in Thailand reached a peak of 750,000 tons in 1965, and then declined steadily until it was only about 36,000 tons in 1973. The largest output used to be in the Nakhon Si Thamarat area of southern Thailand, entirely for export to Japan, but mining has stopped there since 1969.

12. At present only 50,000 sq km of Thailand's land area (or about 10 per cent of the country) have been covered by airborne surveys. This has revealed some deposits, such as the iron ores in Loei, Nakhon Sawan, Prachinburi and Chachoengsao. At present prospecting is being done only sporadically by companies such as SISCO and G.S. Steel, based on local reports followed by ground checks.

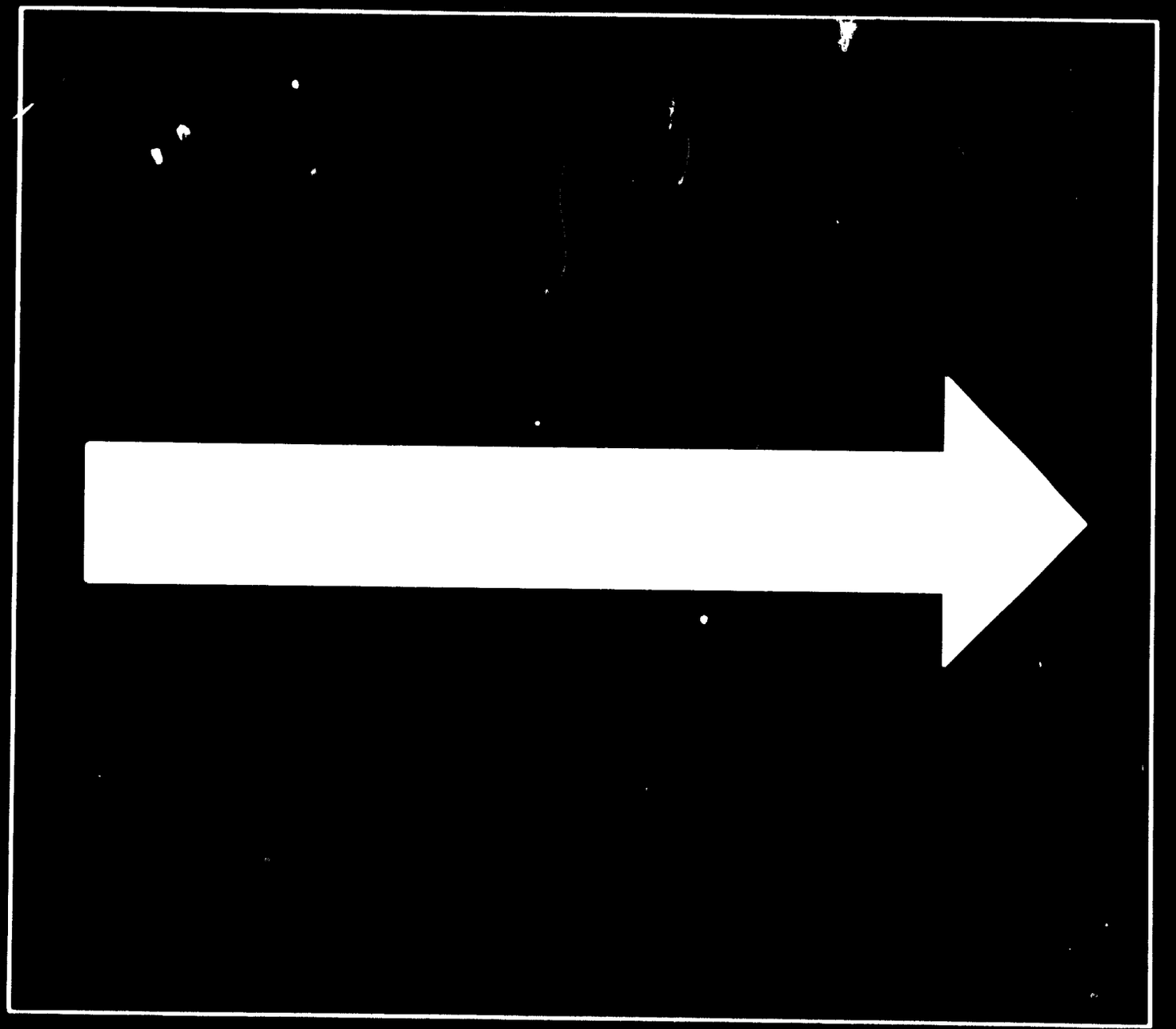
13. The accompanying table shows the Thai iron ore production figures up to 1973.

THAI 2

TABLE 2

IRON ORE PRODUCTION, CONSUMPTION AND EXPORT
(Source: Statistics of the Department of Mineral Resources)

| | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|---|---|---|---|---|
| A. PRODUCTION | | | | | | | | | | |
| Southern Region | | | | | | | | | | |
| Nakhon Sri Thammarat | 176,125 | 737,396 | 674,042 | 536,179 | 465,760 | 450,750 | -- | -- | -- | -- |
| Surat Thani | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Central Region | | | | | | | | | | |
| Chon Buri | -- | -- | -- | -- | -- | -- | -- | 9,990 | 3,140 | -- |
| Lop Buri | 8,118 | 9,069 | 15,968 | 12,706 | 33,570 | 21,605 | 19,719 | 30,020 | 23,274 | 35,661 |
| Northern Region | | | | | | | | | | |
| Nakhon Sawan | 6,712 | 4,009 | 1,690 | 295 | 176 | 4,838 | 2,804 | 1,581 | 1,404 | 648 |
| Total Production | 190,955 | 750,474 | 691,700 | 549,180 | 499,506 | 477,393 | 22,523 | 41,591 | 27,818 | 36,309 |
| Value (Million baht) | 31.5 | 126.5 | 110.7 | 87.9 | 79.9 | 76.4 | 3.6 | 6.7 | 4.4 | 11.3 |
| B. EXPORTS | | | | | | | | | | |
| Countries of Destination | | | | | | | | | | |
| Japan | 110,641 | 723,405 | 717,834 | 530,545 | 402,196 | 492,645 | 4,000 | 4,500 | -- | -- |
| South Korea | -- | -- | -- | -- | -- | -- | 1 | -- | -- | -- |
| Total Exports | 110,641 | 723,405 | 717,834 | 530,545 | 402,196 | 492,645 | 4,001 | 4,500 | -- | -- |
| Value (Million baht) | 18.8 | 123.0 | 114.9 | 84.9 | 64.4 | 78.8 | 0.6 | 0.7 | -- | -- |
| C. DOMESTIC CONSUMPTION | | | | | | | | | | |
| For Foundry Foundry | 8,118 | 9,069 | 15,968 | 10,335 | 32,745 | 24,581 | 15,000 | 19,840 | 26,264 | 46,441 |
| Value (Million baht) | 0.4 | 0.5 | 0.9 | 0.6 | 1.8 | 1.3 | 1.1 | 3.2 | 4.2 | 7.4 |



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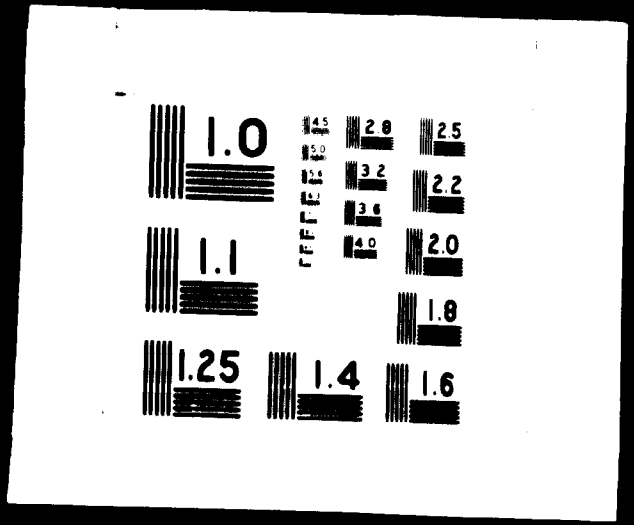


LIGNITE

14. There are no known deposits of high-rank coal in Thailand, but there are fair reserves of lignite of Tertiary age, some of which have properties of sub-bituminous coals. The principal lignite-bearing sedimentary basins are at Li, Mae Mo, Mae Sot and Fang in the north and Krabi in the south. Of these, Li, Mae Mo and Krabi have good minable seams. Lignite output during 1962 to 1973 is shown in table 1. The bulk has been raised at Krabi while all three mines now have major expansions planned because rising of prices have improved the relative viability of local lignite for power generation and even steam locomotives. The average properties of typical samples are shown in the accompanying table.

**Table 1** LIGNITE PRODUCTION AND CONSUMPTION

| | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|---|---|---|---|---|
| A. PRODUCTION | | | | | | | | | | |
| Southern Region | | | | | | | | | | |
| Krabi | 13,367 | 77,728 | 112,530 | 196,125 | 210,913 | 222,945 | 245,998 | 292,269 | 252,958 | 239,094 |
| Northern Region | | | | | | | | | | |
| Lampang | 90,267 | 47,236 | 58,603 | 139,169 | 94,423 | 124,866 | 147,047 | 151,395 | 90,943 | 118,106 |
| Lamphun | -- | -- | -- | -- | -- | -- | 6,827 | 1,418 | 1,585 | 3,815 |
| Total Production | 103,634 | 124,964 | 171,133 | 335,294 | 305,336 | 347,811 | 399,872 | 445,082 | 345,486 | 361,015 |
| Value (Million baht) | 8.3 | 10.0 | 13.7 | 26.8 | 24.4 | 27.8 | 32.2 | 35.6 | 27.6 | 44.9 |
| B. DOMESTIC CONSUMPTION | 89,366 | 138,331 | 171,132 | 313,451 | 301,548 | 335,975 | 372,717 | 336,756 | 321,390 | 364,915 |
| Value (Million baht) | 7.1 | 11.1 | 13.7 | 25.1 | 24.1 | 26.9 | 29.8 | 26.9 | 25.7 | 29.2 |

Source: Department of Mineral Resources

Table 4 PROPERTIES OF LIGNITE AT KRABI, MAE MOH AND LI

| Analysis | Krabi | Mae Moh | Li |
|---|---|---|---|
| **A. Analyses** | | | |
| Moisture, % | 30.3 | 35.9 | 28.0 |
| Dry basis, % | | | |
| Ash | 8.5 | 12.4 | 3.7 |
| Volatile matter | 46.5 | 44.5 | 45.9 |
| Fixed carbon (diff.) | 45.0 | 43.1 | 50.4 |
| D.a.f. basis, % | | | |
| Volatile matter | 50.8 | 50.8 | 47.7 |
| Fixed carbon (diff.) | 49.2 | 49.2 | 52.3 |
| Carbon | 70.7 | 72.1 | 75.2 |
| Hydrogen | 4.5 | 4.5 | 5.0 |
| Nitrogen | 1.7 | 2.6 | 0.7 |
| Sulphur | 4.1 | 2.0 | 0.6 |
| Oxygen (diff.) | 19.0 | 18.8 | 18.6 |
| Calorific value, Btu/lb | 11,850 | 12,040 | 12,810 |
| **B. Forms of sulphur, dry ash-free** | | | |
| Total sulphur | 4.1 | 2.0 | 0.60 |
| Sulphate sulphur | 0.20 | 0.11 | 0.15 |
| Pyritic sulphur | 1.68 | 0.69 | 0.06 |
| Organic sulphur (diff.) | 2.22 | 1.20 | 0.39 |
| **C. Analysis of ash, weight, %** | | | |
| $SiO_2$ | 5.95 | 9.36 | 28.72 |
| $Al_2O_3$ | 10.49 | 7.61 | 19.54 |
| $Fe_2O_3$ | 32.60 | 10.05 | 18.17 |
| $TiO_2$ | 0.17 | 0.14 | 0.50 |
| CaO | 10.63 | 29.59 | 11.48 |
| MgO | 9.47 | 8.89 | 3.04 |
| $Na_2O$ | 3.44 | 0.44 | 4.13 |
| $K_2O$ | 0.51 | 0.29 | |
| $P_2O_5$ | 0.39 | 0.60 | 1.09 |
| $SO_3$ | 27.20 | 30.86 | 13.28 |

Source: S. Rachdamrong, Department of Mineral Resources, Thailand: "Fundamental Properties and Utilization Potential of Thailand Lignites".

15. Low temperature carbonisation laboratory bench scale tests on Li lignite made by Krupp in 1966 gave the following results:

| | |
|---|---|
| Char yield | 95.7 % (dry basis) |
| Volatile matter | 4.3 |
| Moisture | 0.9 |
| Ash | 8.6 |
| Fixed carbon | 86.2 |

16. Similar laboratory scale tests have also been conducted by the Central Fuel Research Institute, India, and by Eastern Associated Coal Operation, USA. The general conclusion was that Li lignite low temperature carbonized briquettes could be used for low-strength applications such as in small/ low-shaft blast furnaces, etc.

ANNEXURE V

List of pre-reduction and direct reduction plants in the World using solid reductants

It is advisable to clearly demarcate and understand the differences between a highly metallized product (sponge) for direct steel-making in the electric arc steel melting furnace and partly metallized product for iron making in an electric sub-merged arc iron smelting furnace; the two products are different from one another chiefly in respect of the degree of metallization and the end-products they directly produce, viz. steel and pig iron respectively. This distinction is to be clearly understood in view of the anomalous claims made in respect of their successes and failures vis-a-vis the metallization technology. Direct reduction represents almost the complete solid state reduction of the oxides of iron in the ore; the directly reduced sponge iron is suitable for charging to a steel making furnace for melting and refining to steel. The pre-reduction is the partial reduction of iron ore in the solid state; the pre-reduced sponge is suitable inter alia for ironmaking.

PRE-REDUCTION ROTARY KILN PLANTS FOR ELECTRIC SMELTING FURNACES TO PRODUCE PIG IRON 1/

## Table I

| Iron-production process, plant and location | Larco Nickel Co. (LARCO) Salonica Highway, Greece | Kawasaki Akaiwa Iron and Steel Co. Japan | Interamerican-Udy (Trans Steel Rent Matanzas Venezuela | Elkem Rjukan-i-Zelesarnice Skopje Yugoslavia | Highveld/Elkem Highveld Steel and Vanadium Corpn., Witbank South Africa (DorrOliver kilns made to ELKEM designs) | SL/RN Inchon Iron and Steel Co. Seoul South Korea | Eskdale New Caledonia Nouméa Plant of Société de Nickel |
|---|---|---|---|---|---|---|---|
| Plant capacity, t/year: Hot metal | Pre-reduced charge | 40,000 | 120,000 | 540,000 | 480,000 | 175,000 | 200,000 tons of ferro-nickel/year to contain 30,000 tons of nickel (1973) |
| Production equipment: Rotary kiln - Nos. | Pre-reduction of lateritic ore 2 operating and 1 more to start in 1973 | One | One | Six | Five | One | Further expansion plans to produce 45,000 t/y of nickel contained in ferro nickel |
| - Size | 90 m x 4.2 m dia. 60 m x 4.2 m dia. | 4.50 m dia. x 75 m | 3.35 m dia. x 107 m | 4.15 m dia. x 95 m | 4 m dia. x 60 m | 4 m dia. x 6 m with preheating grate | 6 old rotary kilns 3 new rotary kilns 45 m x [illegible] m. For production, drying and some preheating at 900°C - below the gauge at which sintered ore rings form |
| Smelting - Nos. | 4 electric smelting furnaces | One | One | 3 and 2 | Four | One | Hot blend is sent to 4 old (11mVA) and 2 New (33 mV each) electric smelting furnaces |
| - Capacity: | 25 mVA to produce ferro-nickel (15% Ni) and slag(30% Fe) which is discarded 2 oxygen converters (15 t cap. each) to produce FeNi (26-32% Ni) and slag containing 6% Fe currently discarded but planned to yield iron in future. | 14 mVA | 33mVA | 33 mVA and 43 mVA | 33 mVA | 28 mVA | |
| Raw materials: Iron ore - Quality | Lateritic nickeliferous iron ore Larima(%)/Rubois(%) Fe 33.0 34.0 Ni 1.45 1.20 $Cr_2O_3$ 2.50 3.20 CO 0.07 0.06 | Beneficiated iron sand Fe - 57% $TiO_2$-12% | Fines concentrate Fe - 50-59% | Lumpupgraded ore (chamosite) Fe - 40-48% $SiO_2$ - 16-17% $Al_2O_3$ - 8-9% | Lump ore Fe - 55% $V_2O_5$ - 1.6% $TiO_2$ - 13% | Lump ore and pellets Fe - 49-56% | Garnierite ore containing iron and nickel oxide Total consumption in 2.5 million t/y |
| -Size range: | N.A. | N.A. | -10 mm | 10 - 40 mm | N.A. | 8 - 20 mm | 0 - 20 mm |
| Reductant: - Quality | -Coke reportedly - plans to use lignite from Ptolemais | Natural coke F.C. - 71% VM - 9% Ash - 21% | Low grade coal F.C. -40% VM - 44% Ash - 15% | Dry lignite and 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% | coke with oil-firing (for heating) |
| - Size range: | | - 15 mm | Fines | 20-60 mm | - | Fines | |
| Product and usage | - Pre-reduced hot charge (900°C) FeNi and Fe-enriched slag - steel billets | Pre-reduced cold charged | Pre-reduced hot charged | Upto 35% reduction, hot charged | 35% pre-reduction, hot charged | 70% pre-reduction, cold charged | Predried, preheated and somewhat prereduced charge |
| Start up | 1965 | 1961 | 1963 permanently closed down since last 7 years | 1964 pre-reduction kilns shut down since 1971 permanently | 1968 | 1969-70 pre-reduction and steel-making shut down since 1971 permanently as reported | In the sixties, the plant started and in 1969 major expansion took place |

1/ Compiled by the writer.

SPONGE IRON PLANTS BASED ON SOLID REDUCTANTS/ROTARY KILN OPERATIONS

Table 2 1/

| PROCESS | KILN PROCESSES SL/RN | SL/RN | KRUPP | SL/RN | BATCH PROCESSES HOGANAVES | KOHEVERRIA | DELVA PROCESS |
|---|---|---|---|---|---|---|---|
| Plant and location | New Zealand Steel Ltd, Glenbrook, New Zealand | Falconbridge Nickel Mines Ltd., Sudbury Canada | Dunswart Iron and Steel Works Beneni, South Africa | Aces Pines Piratini S.A. Charqueadas, Brazil | Hoeganaes, Sweden, Oxelosund, Sweden Riverton, USA | Patricio Echeverria S.A. Legazpia Spain | Siderurgica Nonfalcone (SIRO), Italy |
| Capacity t/y of sponge | 150,000 | 300,000 | 150,000 | 65,000 | 130,000 (total) | 20,000 | 30,000 |
| Production equipment | One kiln 4 m ϕ 75 m | One kiln 5 m ϕ 50 m with pre-heating grate | One kiln 4.6 m ϕ 74 m | One kiln 3.6 m ϕ 50 m | Silicon carbide saggers | 40 Nos of alloy steel retorts | 8 Nos of silicon carbide lined vessels |
| Raw materials Iron ore - quality | Iron sand green pellets/concentrate Fe - 61% $SiO_2$ - 1.1% $Al_2O_3$ - 2.8% $TiO_2$ - 8.3% | 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. |
| Reductant | Brown coal(dry) F.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. - 38.5% VM - 26.5% Ash - 35% 1-25 mm size | Coke breeze Producer gas | Anthracite coal V.M. - 8.2% Ash - 2[illegible]% F.C. - 82.5% S - 1.1% Producer gas | Low grade coal Propane |
| Start-up | 1970 operating far below rated capacity as reported | 1971 now closed down | Early 1973 | Mid 1973 | 1911 | 1958 reportedly closed since 1965 | 1972 |

1/ Compiled by the writer

## List of World Direct Reduction Plants Based on Gas and Solid Reductants 1/

1. Commercial interest in direct reduction has quickened recently, due to a combination of factors. The technology has reached a stage where there is ample evidence that a number of processes are now both economic and technically efficient. In addition, direct reduction seems eminently suitable for use in the energy-rich developing countries such as the oil producers which possess natural gas deposits. These nations now also command the funds to develop large-scale industries, and appear to be willing to take the plunge with a relatively new iron-making technology.

2. In the industrialized countries direct reduction has played a necessarily more muted role, given the existence of established iron and steelmaking. The proposed BSC plant at Hunterston and the Spanish projects for example, are primarily aimed at covering actual or predicted scrap deficits. It remains to be seen whether the Spanish plants, if approved, can operate economically given the necessarily higher cost of imported natural gas on which they will have to run.

3. It can be expected that merchant direct reduction plants will be of growing importance and that traditional iron ore exporters may prefer to build such plants to add value to their exports. The effect this development has on the untreated iron ore and scrap markets may be considerable.

| Country, Company | Location | Process | Capacity (tpy) | Start-up date | Status |
|---|---|---|---|---|---|
| ABU DHABI | | | | | |
| Government/ Kawasaki Steel | | Midrex | 1,000,000 | 1978-9 | agreed in principle |
| ARGENTINA | | | | | |
| Dalmine Siderca | Campana | Midrex | 330,000 | 1976 | |
| BANGLADESH | | HyL | | | under feasibility stage |
| BOLIVIA | | | | | |
| Sidersa | Mutún | | | | envisaged |
| BRAZIL | | | | | |
| Aços Finos Piratini | Charqueadas | SLRN | 60,000 | 1973 | operating |
| | | SLRN | 250,000 | 1976 | planned |
| Construtora Jose Mendes Jr. | Juis de Fora | | | | envisaged |

1/ Based on the list published in September 1974 by Metal Bulletin Monthly and modified/updated to present the latest data up to November 1974 by the writer.

| Country, Company | Location | Process | Capacity (tpy) | Start-up date | Status |
|---|---|---|---|---|---|
| BRAZIL (cont'd) | | | | | |
| Cesigua | Santa Cruz | Purofer | 300,000 | 1976 | |
| | | | 300,000 | 1978 | |
| F-El Kerf SA | São José dos Campos | Midrex | 400,000 | 1978 | planned |
| Usiba | Bahia | HyL | 165,000 | 1974 | operating |
| CANADA | | | | | |
| Falconbridge Nickel Mines | Sudbury | SLRN | 300,000 | 1971 | closed down 1972 |
| Sidbec-Dosco | Contrecoeur | Midrex | 450,000 | 1973 | operating |
| | | Midrex | 600,000 | 1976 | plant ordered |
| Stelco | Griffith Mine, Ontario | SLRN | 545,000 | 1975 | plant ordered |
| EGYPT | | | | | |
| Government in joint co. | Dekhelia | Midrex | 1,600,000 | 1977 | agreed in principle |
| | | Midrex | 3,400,000 | 1982 | envisaged |
| FRANCE | Toulouse | Novalfer | 18,000 | 1965 | pilot plant |
| GREECE | Kabella | HyL | 500,000 | | under negotiation |
| WEST GERMANY | | | | | |
| August Thyssen Hütte | Oberhausen | Purofer | 300,000 | 1972 | pilot plant |
| Hamburger Stahlwerke | Hamburg | Midrex | 400,000 | 1971 | operating |
| INDIA | Gujrat | HyL | 500,000 | | feasibility stage |
| | Andhra Pradesh | Rotary kiln | 30,000 | 1975 | pilot plant (UNIDO Project) |
| INDONESIA | | | | | |
| PT Krakatau Ferrostaal | Anyer-Ler | HyL | 1,000,000 | 1976 | plant ordered |
| IRAN | | | | | |
| National Iranian Steel Industries | Ahwaz | Purofer | 330,000 | 1975-6 | |
| | Ahwaz | Midrex | 1,200,000 | 1976 | under construction |
| | Isfahan | HyL | 1,000,000 | 1976 | plant ordered |
| | Bandar Abbas | Midrex | 2,000,000-3,000,000 | | agreed in principle |
| IRAQ | Khor Al Zubair | HyL | 1,150,000 | | agreement signed October 1974 |
| ITALY | | | | | |
| Siderurgica Manfalcone | Manfalcone | Kinglor Meter | 30,000 | 1973 | pilot plant |
| JAPAN | | | | | |
| Chiba | | | 250,000 | | partial reduction |
| NKK | Fukuyama | SLRN | 500,000 | 1974 | |
| Hitachi Metals Ltd. | Tokyo | Wiberg-Söderfors | | | |
| Kawasaki Steel | Mizushima | | | | rotary kiln: operating |
| Nippon Steel Corp. | Hirohata | (NSC process) | | end 74 | planned for commercial operat. |

| Country, Company | Location | Process | Capacity (tpy) | Start-up date | Status |
|---|---|---|---|---|---|
| KUWAIT | | | | | |
| Kuwait Iron and Steel Co. | Shuaiba | | 400,000 | | at tender stage |
| MEXICO | | | | | |
| Hylsa | Monterrey | HyL | 85,000 | 1957 | operating |
| | | HyL | 185,000 | 1960 | operating |
| | | HyL | 365,000 | 1974 | operating |
| Hylsa de Mexico SA | Puebla | HyL | 850,000 | 1970 | operating |
| Siderurgica Tamsa | Vera Cruz | HyL | 170,000 | 1967 | operating |
| NEW ZEALAND | | | | | |
| New Zealand Steel | Glenbrook | SLRN | 150,000 | 1970 | operating at reduced capacity; serious troubles encountered in plant operations |
| PERU | | | | | |
| Siderperu | --- | details are not available | --- | | Re-use of 3 cement kilns planned |
| QATAR | | | | | |
| Government in joint venture | | | 350,000 | 1977 | agreed in principle |
| SAUDI ARABIA | | | | | |
| Petromin in joint venture | | | 3,500,000 | | agreed in principle |
| SOUTH AFRICA | | | | | |
| Dunswart Iron and Steel | Dunswart | Krupp-Renn | 150,000 | 1972 | operating |
| Highveld Steel and Vanadium | Witbank | Lurgi/Rhenn | 440,000 | 1968/72 | partial reduction |
| | | Lurgi/Rhenn | 250,000 | 1974 | partial reduction |
| SOUTH KOREA | | | | | |
| Inchon Steelworks | Inchon | SLRN | 150,000 | 1970 | partial reduction; closed down 1971 |
| SPAIN | | | | | |
| Promesa | Port de Llobregat Barcelona | | 500,000 | | subject to government approval |
| Promesa | Bilbao | | 800,000 | | subject to government approval |
| Prodemesa | Barcelona | | 300,000 | | subject to government approval |
| Siderurgica de Gibraltar | Algeciras | Midrex | 400,000 | | subject to government approval |
| SWEDEN | | | | | |
| Gränges Steel | Oxelosund | Hoganas | 40,000 | | |
| Hoganas AB | Hoganas | Hoganas | 130,000 | 1911 | Fer iron powder production |
| Sandvik AB | Sandvik | | 60,000 | | |
| SKF Steel Div. | Hofors | | 30,000 | | |

| Country, Company | Location | Process | Capacity (tpy) | Start-up date | Status |
|---|---|---|---|---|---|
| TAIWAN | | | | | |
| Tung Ang Iron Works in joint co. | | | 1,000,000 | | |
| THAILAND | | | | | |
| C.S. Steel | Kaohsiung | Midrex | 420,000 | | planned |
| TRINIDAD | | | | | |
| Government in joint co. | | Midrex | 600,000 | | agreed in principle |
| TUNISIA | | | | | |
| Government in joint co. | Gabes | Midrex | 1,000,000 | 1976 | agreed in principle |
| TURKEY | | | | | |
| Eras | Ismir | | 250,000 | 1976 | planned |
| UK | | | | | |
| Ferrofeed Ltd. | Hunterston | | 000,000 | 1977 | agreed in principle |
| BSC | Hunterston | Midrex | 400,000 | 1977 | envisaged |
| USA | | | | | |
| Armco Steel | Houston | Armco | 350,000 | 1973 | operating |
| Georgetown Steel Corp. | Georgetown | Midrex | 400,000 | 1971 | operating |
| Georgetown Texas Steel Corp. | Beaumont or Georgetown | Midrex | 400,000 | | planned |
| Hecla Mining | Casa Grande | SLRM | 95,000 | 1975 | plant ordered |
| Niagara Metal | | (Allis-Chalmers) | 300,000 | 5 | semi-commercial operation (rotary kiln) |
| Oregon Steel Mills | Portland, Ore. | Midrex | 2x 150,000 | 1969 | operating |
| Republic Steel | Arizona | | 400,000 | | at feasibility stage |
| USSR | | | | | |
| National Steel Ind. | Kursk | Midrex | 2.4 m. | 1978 | 1st stage agreed in principle |
| | | Midrex | 2.4 m. | | 2nd stage |
| | Stariy Oskol | | | | under construction |
| VENEZUELA | | | | | |
| Acaria Electrica del Caroni | Matenzas | | 500,000 | | at feasibility stage |
| Fior de Venezuela | Cuyuna | Fior | 400,000 | 1975 | plant ordered |
| rine e Mining | Puerto Ordaz | HIB | 1,000,000 | 1973 | partial reduction (initially), operat. |
| Sidor | Matenzas | Midrex | 400,000 | 1976 | plant ordered |
| Sider | Puerto Ordaz | HyL | 365,000 | 1976 | plant ordered |
| YUGOSLAVIA | | | | | |
| Rudni i-i-Selezara, Skopje | Skopje | Elkem | 500,000 | | partial reduction: closed 1971 |
| ZAMBIA | | | | | |
| Tika Ltd. | Lusaka | HyL | 250,000 | 1976 | plant ordered |

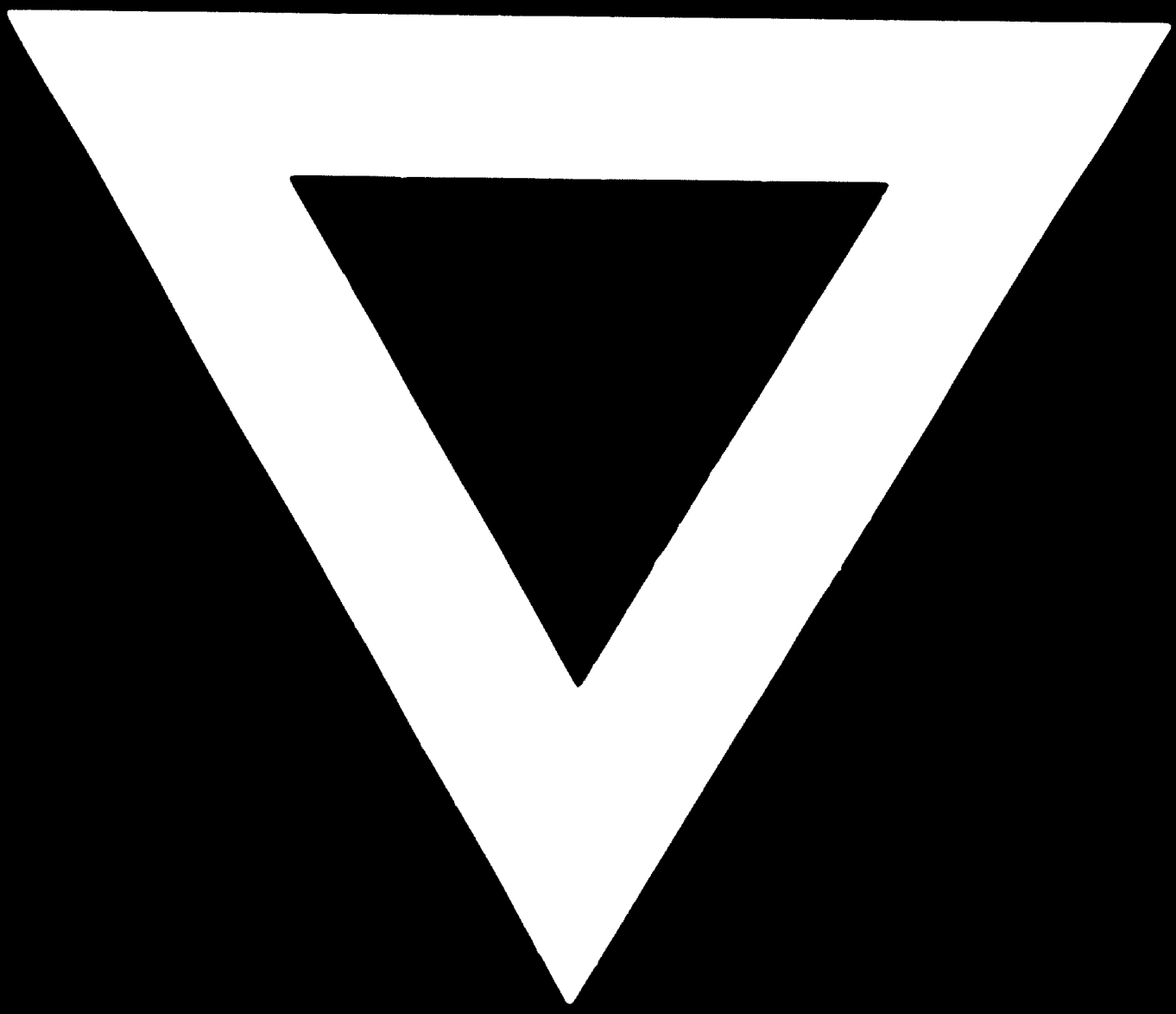
## OPERATING HyL PLANTS

| COMPANY | LOCATION | START-UP | PRODUCTION METRIC TONS OF PRODUCT PER YEAR |
|---|---|---|---|
| FESA I | Monterrey, Mexico | 1957 | 95,000 |
| FESA II | Monterrey, Mexico | 1960 | 260,000 |
| TAMSA | Veracruz, Mexico | 1967 | 220,000 |
| HyLSAMEX I | Puebla, Mexico | 1969 | 315,000 |
| USIBA | Bahia, Brazil | 1974 | 225,000 |
| FESA III | Monterrey, Mexico | 1974 | 420,000 |
| | | Sub-total | 1,535,000 |

## CONTRACTED HyL PLANTS

| | | | |
|---|---|---|---|
| SIDOR | Guayana, Venezuela | 1975 | 360,000 |
| HyLSAMEX II | Puebla, Mexico | 1976 | 630,000 |
| Krakatau-Ferrosteal | Kota Java, Indonesia | 1976 | 2,300,000 |
| TIKA, Ltd. | Solwezi, Zambia | 1977 | 250,000 |
| NISIC | Ahwaz, Iran | 1977 | 1,000,000 |
| Ministry of Industry | Khor Al Zubair, Iraq | 1977 | 550,000 |
| Ministry of Industry | Khor Al Zubair, Iraq | 1977 | 935,000 |
| | | Sub-total | 6,025,000 |
| | | TOTAL | 7,560,000 |

Annual ratings based on 330 days/year.



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