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PROBLEMS AND OPPORTUNITIES IN THE WORLD'S IRON AND STEEL INDUSTRY1/

Informal background paper
for reference in operational activities.

prepared by
the Secretariat of UNIDO

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Contents

EXPLANATORY NOTES

For the purposes of this paper the following **definitions and abbreviations were used:**

Dd.C. (developed countries): Eastern and Western European countries (including Turkey) Canada, U.S.A., Australia, New Zealand, Japan and South Africa.

Dg.C. (developing countries): Countries other than Dd.C. defined above. They were classified into following regional groups when convenient:

- S.S. Africa : Sub-Sahelian Africa
- Arab : Arab countries
- L. America : Central and South America
- S. Asia : South Asia (Afghanistan, Bangladesh, Buthan, India, Iran, Nepal, Pakistan, Sri Lanka)
- S.E. Asia : South East Asia (Brunei, Burma, Cambodia, Indonesia, Laos, Malaysia, Philippines, Singapore, Thailand, Vietnam)
- E. Asia : East Asia (China, Korea DPR, Korea R, Mongolia)

Reference to "dollars" ($) indicates United States dollars, unless otherwise stated.

Reference to "tons" (t) indicates metric tons. "Mt" indicates millions of tons.

The term "billion" (b) is used to signify a thousand million.

Unless otherwise specified, all figures of steel production and consumption refer to raw steel (ingots) equivalent.

Unless otherwise specified, statistical data were taken from:

1) United Nations Statistical Yearbook, 197[illegible]
2) Various issues of United Nations Monthly Bulletin of Statistics
3) UNCTAD Handbook of International Trade and Development Statistics, 1976

FOREWORD

UNIDO's activities in the iron and steel sector have covered a wide spectrum: technical assistance; organization of symposia, seminars and workshops; preparation of special studies with analysis and forecasts related to the sector as a whole or to some of its particular aspects.

Technical assistance comprised some 100 individual projects in some 40 countries, in the period 1968 - 1976. Three Interregional Symposia, with world wide scope were organized: Prague - Geneva (1963), Moscow (1968) and Brasilia (1973). A large number of documents have been prepared and distributed. The Appendix contains further information on these points.

Through these activities UNIDO has made a substantial contribution to the identification of problems and opportunities in the iron and steel sector. This paper reflects some relevant facts and analyses arising from experience gathered so far in the Metallurgical Industries Section of the Industrial Operations Division (previously, Industrial Technology Division). It is intended as an informal background paper for reference by UNIDO officers and experts, in operational activities.

1. THE WORLD's IRON AND STEEL INDUSTRY: THE NEED FOR AN ASSESSMENT

Since steel is the main material of construction in a modern economy and since the Dg.C. have such large needs and capabilities in the I.S. sector it is necessary to consider the present situation and perspectives for expansion of the world I.S. industry in the light of the new economic and political realities and, on this basis, to promote international co-operation to ensure that such expansion takes place expeditiously, effectively and equitably.

For the community of Dg.C. the expansion of the I.S. industry is an economic imperative, mainly to satisfy their own demand. For Dd.C. particularly attractive opportunities exist for co-operation with Dg.C. for the establishment of new capacity or for trade. It will be also necessary for them to develop and/or to secure the raw materials supplies needed for the smooth expansion of their own capacity.

1.1 THE IRON AND STEEL INDUSTRY: ITS SIGNIFICANCE FOR THE WORLD ECONOMY

The significance of the I.S. industry for the world economy is indicated by the following facts:

(a) It produces the most essential material needed in a modern economy at a relatively low cost.

The products of the I.S. industry in the form of plate, sheet, bars, rods, wire, heavy and light sections, tubing, etc., are essential for, among other uses: production of industrial equipment, industrial buildings and installations; power, transportation, communications and water distribution networks; housing; durable consumers' goods. Some of its by-products are also important for the operation of subsidiary industries, e.g.: pig iron, which is needed for cast iron foundries; coke by-products, used in the chemical industry; slag, used for production of cement, glass wool and aggregate materials. The strength and ease of fabrication of steel, combined with its low cost make it the most essential of all materials used in modern industry. Total world production reached 695 Mt of ingot in 1973. In spite of price fluctuations, specially in the period 1973 - 76, steel continues to be cheaper than any other metal and, if its strength and durability are taken into account, cheaper than most other construction materials.

(b) The value of its production in a dynamic economy is a significant part of the GNP.

The gross value of the products and by-products of the I.S. industry corresponds to at least 2-5 per cent of the GNP in an industrialized economy but may reach 6-8 per cent in countries where the GNP is growing at a high rate and where the production of steel is keeping pace with needs. If one considers the indirect impact of steel production on the basis of the gross value of all products and structures made from steel, the corresponding percentage of GNP might reach values of the order of 20 per cent.

(c) Its operation involves transportation and handling of very large tonnages of raw materials and products.

The sheer weight of materials and products that have to be handled and transported for the operation of the world steel industry is huge and makes it highly dependent on infrastructure. About 3 tons of ore, coking coal, outside scrap, oil and fluxes are needed to produce one ton of steel. The marketable output can be estimated at roughly one ton per ton of steel ingot produced. Accordingly, for a country producing 100 Mt of steel per year it is necessary to secure a yearly input of some 300 Mt of raw materials and an outlet for some 100 Mt of products, by-products and other materials.

(d) It is a capital-intensive industry, requiring heavy investments for its establishment and operation.

The I.S. industry is notably capital-intensive, with a specific requirement of $600 - 1200 1/ for each ton per year of new steel ingot production capacity. In addition, in certain cases, particularly in Dg.C. substantial infrastructure investment has to be made. Accordingly, the establishment in a Dg.C. of an integrated I.S. plant with a capacity of one million tons per year (of ingots) will require an investment of the order of $ 1 billion. Additional investment "up-stream", i.e. for supply of the necessary inputs, and "down-stream", i.e. for processing of steel into manufactured products, will also have to be taken into account and may amount to investments of the same order of magnitude. A large portion of the capital invested in I.S. installations (some 50-70%) corresponds to heavy industrial equipment and heavy industrial construction. The I.S. industry is, thus, a large buyer of heavy capital goods.

(e) It depends greatly on know-how and technology of a multidisciplinary character.

In an industry handling very large amounts of materials and products in large installations and delivering relatively cheap products to the national and international market, know-how and technology are decisive particularly to ensure productivity and quality. A constantly changing pattern of sources, characteristics and prices of raw materials; changing conditions and requirements regarding the ecological impact of large industrial installations; new developments regarding the sources and costs of labour and capital; a changing market picture; all these have made technological development an imperative for continued growth of an efficient I.S. industry. Specially significant changes in the technologies of processes and products have taken place in the last two decades with prospects of further radical changes taking place in the next two.

(f) A large share of international trade is directly related to the operation of the I.S. industry.

The international trade in iron ore, pellets, coking coal, semi-finished and finished steel products involves exchanges of about 700 Mt per year of materials and products worth about $ 60 billion. Exports or imports of raw materials and products of the I.S. industry represent important sources of income or, on the other hand, serious drains to the balance of payments of Dd.C. and Dg.C.

1/ Depending on size, technology, location and infrastructure, and relationship to previously existing plants and to other related industries.

(g) <u>It generates or activates "up-stream" and, specially "down-stream" industries of great economic impact.</u>

The I.S. industry, being a heavy consumer of raw materials, refractories, rolling mill rolls (cast or forged), special heavy equipment and components, ferro-alloys, special additives, tin (for tin plate), lubricants, etc., is dependent on the operation of important "up-stream" industries.

On the other hand, the ready availability of its output is the basis for a diversity of "down-stream" industries producing: heavy equipment; agricultural machinery; structures (buildings, bridges, etc.); ships; automobiles; tractors; industrial and civil construction hardware; metal furniture; household appliances and utensils; tools; etc.

(h) <u>It is a large scale consumer of energy.</u>

The I.S. industry uses about 12% of the total world's energy requirements, in terms of coal, hydrocarbons and electric power. It must be notsd, however, that over one third of the total "fuel" requirements is not used for its energy value but rather as a "reductant" or "chemical" needed to react with oxides in the ores, so as to obtain metallic iron (mainly as "pig iron", which is iron containing carbon, silicon and manganese in solution, besides impurities). Accordingly, the "energy problem" of the I.S. industry is a peculiar one and requires special treatment.

1.2. THE IRON AND STEEL INDUSTRY: A SIMPLIFIED GLOBAL PICTURE

The massive materials flow related to the I.S. industry is concisely presented in <u>Figure 1</u> which refers to 1973 1/. The overall figures of <u>Table I</u> are a further measure of the I.S. industry's size. The following main features of the industry should be noted, for 1973:

(a) The production of raw steel reached 695 Mt and that of finished products 556 Mt.

(b) The total direct raw materials input amounted to about 1700 Mt; some 600 Mt of products were transported to markets.

(c) The total worth of all products and by-products of the industry in 1973 can be estimated at about $ 130 billion.

(d) The value of inputs reached $ 60 billion. Thus, the added value in this industry was $ 70 billion which corresponds to $ 100 per ton of crude steel.

(e) Developing countries with 70 per cent of the world's population, contributed about 29 per cent of world iron ore (or 36% in terms of iron content) but produced only 8 per cent of the world raw steel while consuming about 14 per cent of world steel products.

(f) Another point to be noted is that the pig iron quantities involved are huge and indicate that any process designed to replace the conventional blast furnace in the reduction of ore to metal must be capable of operation on a very large scale.

1/ 1973 is considered, in this paper, on an ad hoc basis, the "last normal year before 1976". Production was: World = 695; Dg.C. = 55; Dd.C. = 640 Mt

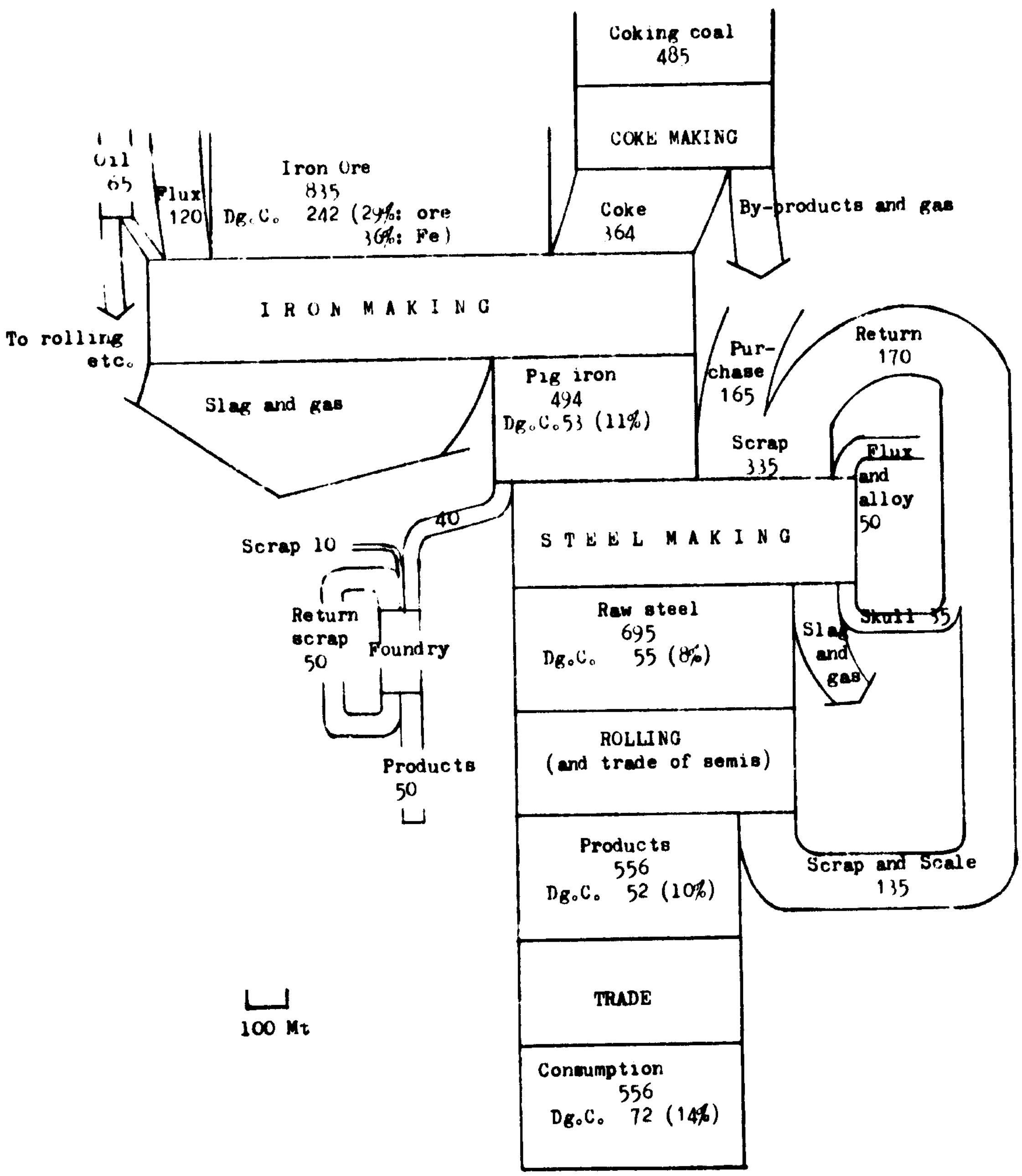


Fig. 1 The iron and steel industry - global flow chart in 1973 (unit Mt) - partly data, partly rough estimates

TABLE I

Main inputs, intermediate products and final products of world I.S. industry (1973) 3/

	INPUTS		INTERMED PRODUCTS	FINAL PRODS		UNIT VALUE
	Mt	Value M US$	Mt	Mt	M US$	US$/t
Iron ore	835	12.500				15
(Pig iron)			494			
Coking coal	485	26.700				55
(Coke)			364			
Oil	65	2.000				30
Fluxes	140	2.100				15
Scrap	165 1/	8.250	170 2/			50
Other consumables	30	9.000				300
(Steel ingots)			695			
Steel products				556	122.300	220
Other				50	7.500	150
TOTALS	1720	60.550	1723	606	129.800	

1/ Purchased scrap

2/ Internal process scrap

3/ DATA plus rough estimates

(g) The requirements for coking coal have also reached volumes which create special problems, considering the very uneven distribution of economic deposits. Unlike iron ore, good coals are available only in relatively few locations in the world and must be imported by most Dg.C.

1.3. THE IRON AND STEEL INDUSTRY: ITS IMPACT ON DEVELOPMENT OF ECONOMY AND INDUSTRY

There is a direct relationship between industrial development and steel production, as shown by the following facts:

(a) Historically, industrial development has been directly dependent on I.S. production. The strongest industrialized economies are found in countries with the largest steel industries: USA, USSR, Japan, Germany, UK, France, Italy. The efforts to develop the steel industry in those countries are well known and were founded on deliberate planning of on imperative need.

(b) The "take off" stage of economic development is characterized by an accelerated increase in steel consumption per capita. This fact is clearly illustrated by the "steel intensity curve", shown in Figure 2. The curve, calculated by IISI, shows that as GNP/per capita increases to about $ 1000 (at 1963 value) the ratio of apparent steel consumption in kg per dollar of GNP increases markedly, meaning that economic growth becomes increasingly dependent on steel. The "steel intensity curve" is one way of expressing the fact that the very early stages of development (least developed countries)are characterized by small need for steel but as development accelerates so do the steel requirements. On the other extreme, in very advanced "post industrial" societies the relative importance of steel declines and reaches almost stable level (in terms of steel consumption per capita) since the economy grows then mainly through other more complex industries and services.

(c) Figure 3 shows some basic indices such as population, steel production, stsel imports, GDP, industrial production and ratio of industrial production to GDP as functions of per capita steel consumption. This Figure was prepared by classifying countries into 7 groups according to their 1973 per capita steel consumption, then adding up the data and calculating per capita indices for each group. Figure 3 provides chsracteristic data and indices for groups of countries with different steel consumption levels. The following can be noted:

(i) There are two clearly separated groups of countries: Dg.C., whose population is distributed at consumption levels below 100 kg/capita, and Dd.C. whose population is characteristically concentrated between the 400 - 800 kg/capita levels.

(ii) Steel production of the group of countries consuming less than 100 kg/capita is extrsmely low and about 35 % of their consumption is dependent on imports from the group of countries with 400 kg/capita consumption and above.

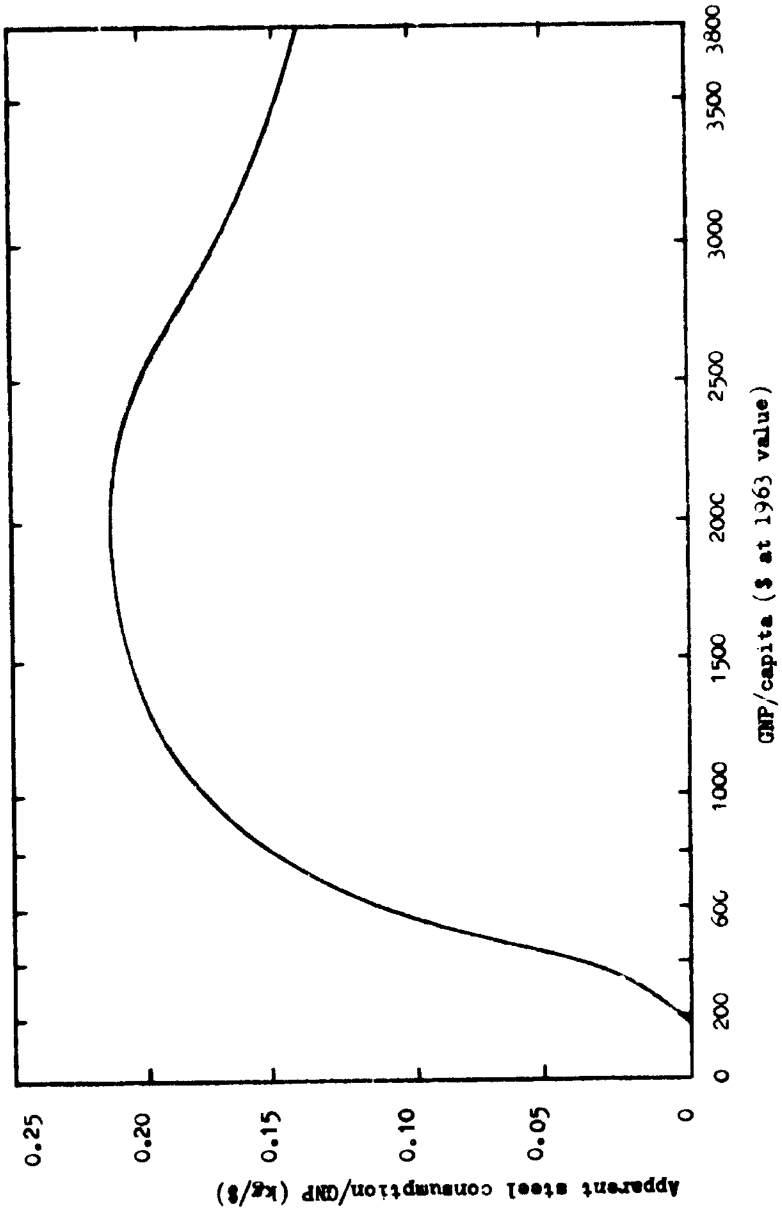


Fig. 2 Steel intensity curve (Data source: IISI Projections 85)

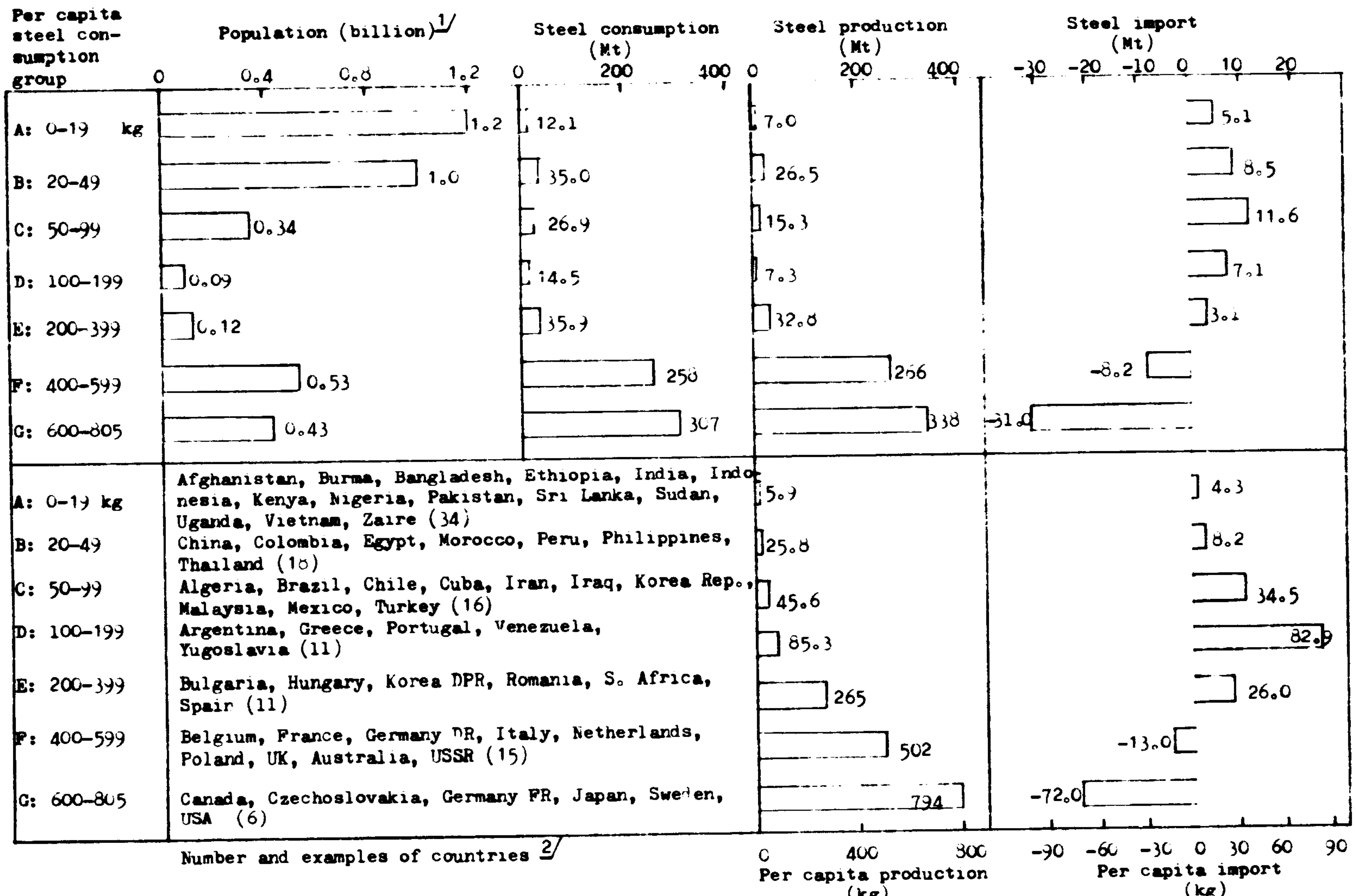


Fig. 3 Some basic indices by per capita steel consumption classification (at 1973)

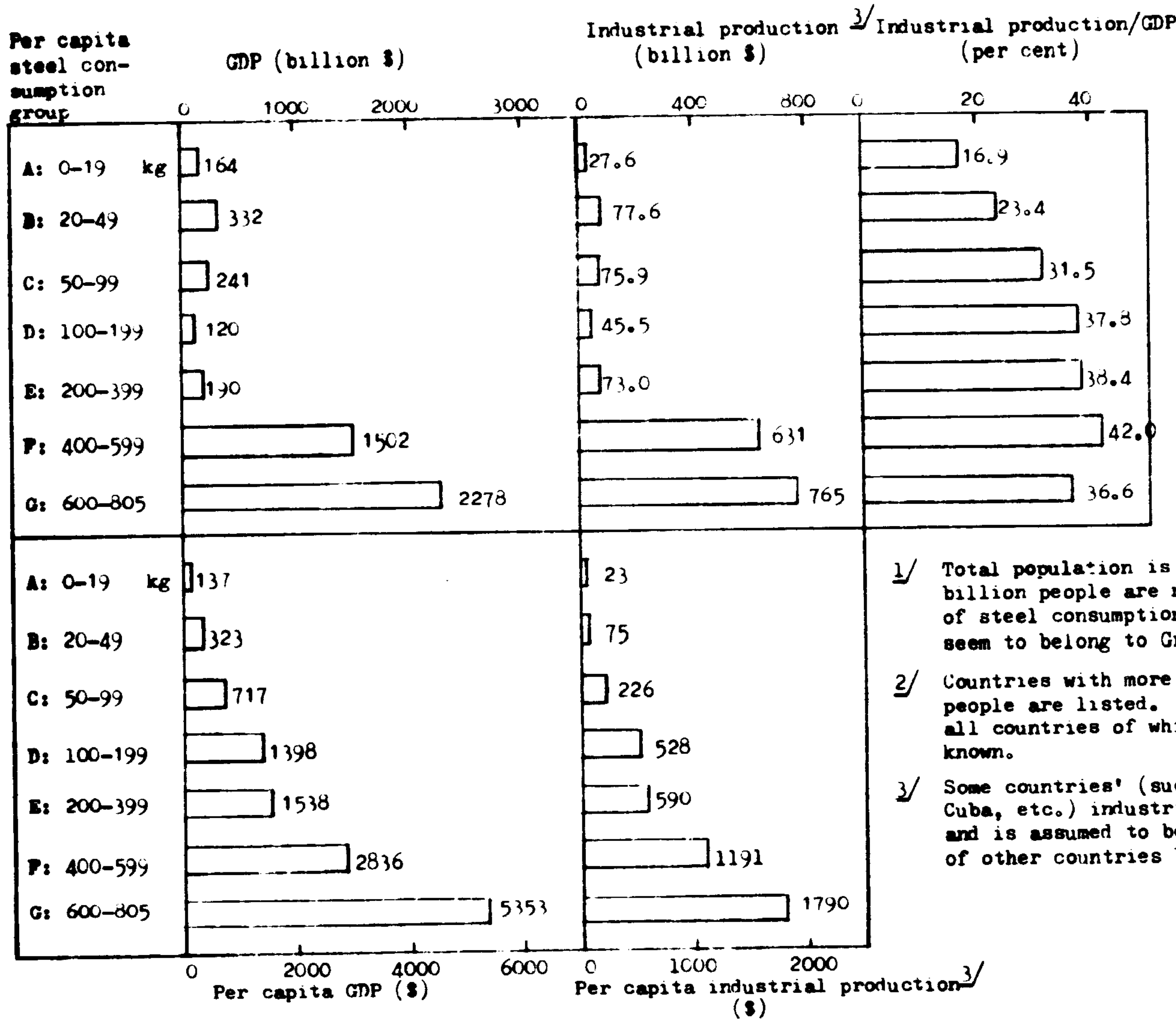


Fig. 3 continuation

1/ Total population is 3.71 billion. Some 0.1 billion people are not counted because of lack of steel consumption figures. Most of them seem to belong to Group A.

2/ Countries with more than round 10 million people are listed. Number of countries includes all countries of which steel consumption is known.

3/ Some countries' (such as China, Korea DPR, Cuba, etc.) industrial production is not known and is assumed to be the same with the average of other countries belonging to the same group.

(iii) GDP per capita increases with steel consumption from $ 140, for the 10 kg/capita group, to more than $ 5000, for the 600 - 800 kg/capita group.

(iv) Industrial production per capita is only $ 23 for the 10 kg/capita group but increases by 10 times, for the 50 - 100 kg/capita group, which is also very low as compared to $ 1200 - 1800, for the 400 - 800 kg/capita group.

(v) The ratio of industrial output to GDP, which is one of the measures of industrialization, is characteristioally low for lower consumption groups and reaches the level of industrialized countries after steel consumption increases to more than 100 kg.

(d) A close relationship between steel consumption and industrial production is further shown in Figure 4. Although considerable scattering is observed, the graph shows unmistakably that steel is essential for industrial development. Turning from consumption to production of steel, it is seen from Figure 5 that most developing countries are not producing steel in the amount needed for their existing industrial production. Although there are difficulties to initiate suoh capital intensive industry as the steel industry in Dg.C., it is clear that industrialization of developing countries requires the overcoming of those difficulties.

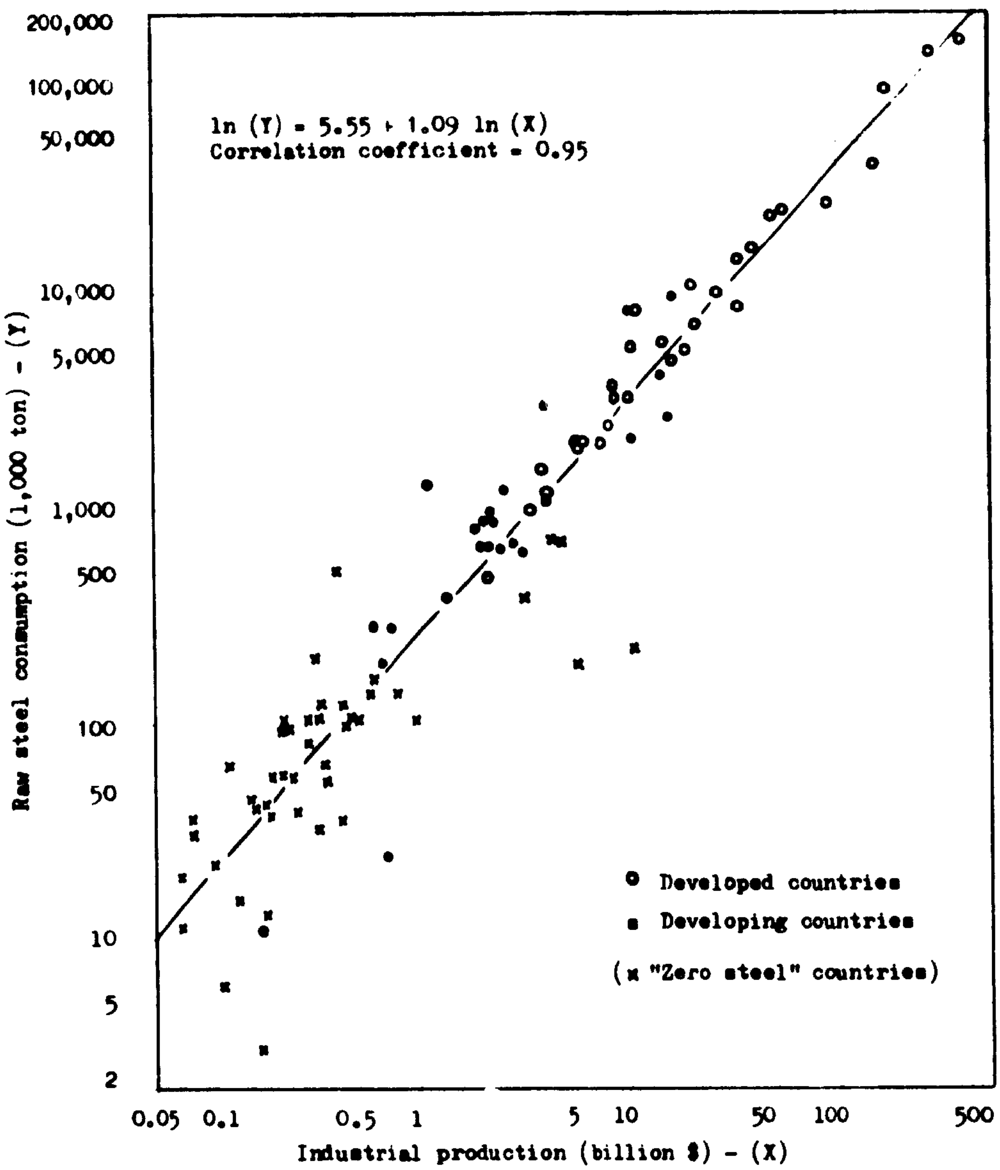


Fig. 4 Relationship between steel consumption and industrial production (in 1973)

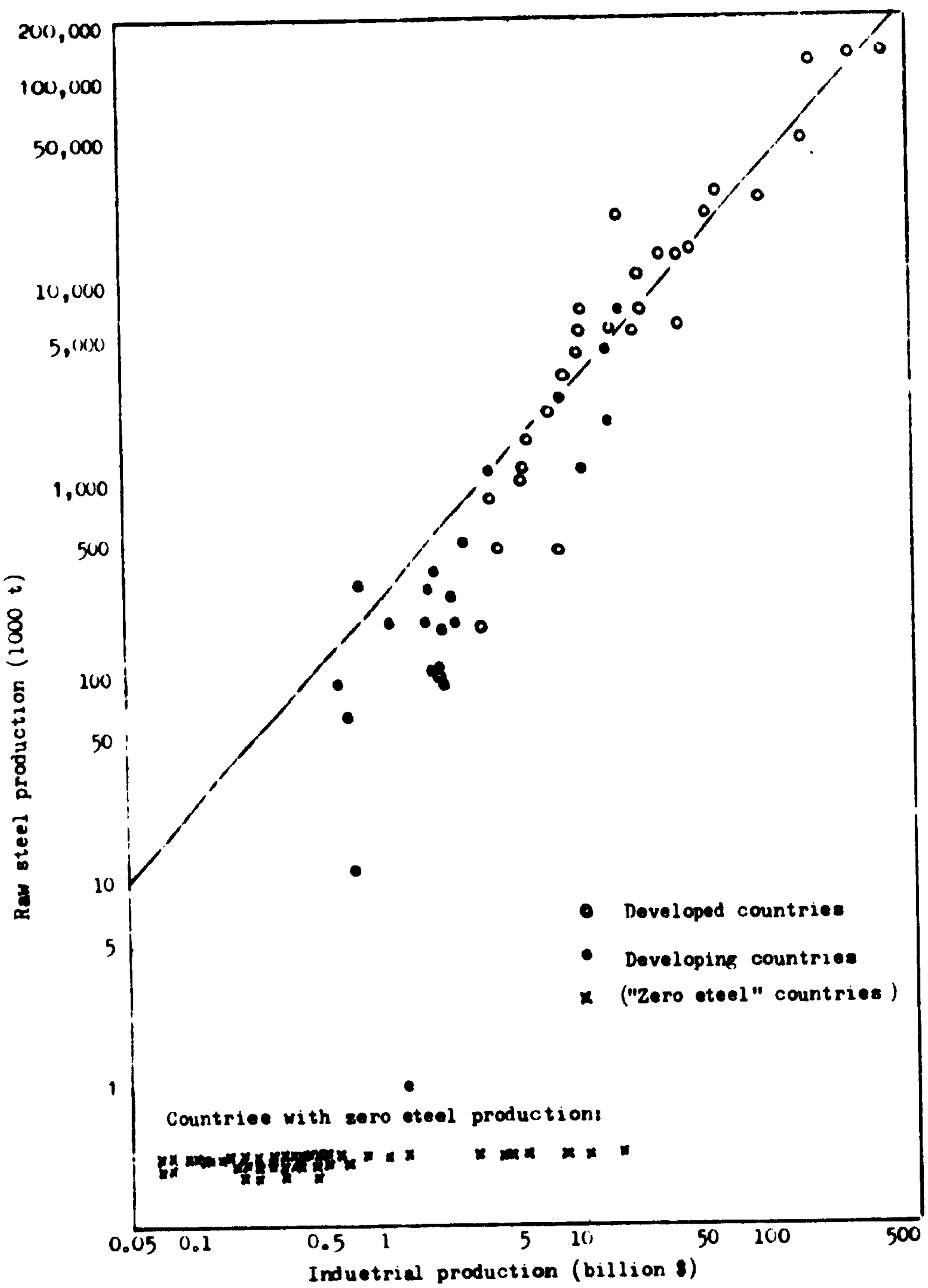


Fig. 5 Relationship between steel production and industrial production (in 1973)

Note: The line is the one for the relationship between steel consumption and industrial production (Fig. 4)

2. PRESENT SITUATION OF THE WORLD IRON AND STEEL INDUSTRY

2.1. EVOLUTION AND GROWTH RATES OF THE IRON AND STEEL INDUSTRY IN THE RECENT PAST

The world I.S. industry has grown steadily over the last quarter of a century and has supplied essential low cost materials to the world market. This growth was supported by a remarkable technological development in every aspect of steel production. Since there are many articles and papers on the recent development of technology in this sector, no revision of this area is attempted here and only some statistical production and consumption aspects are presented, to outline the broad features of the growth of the sector.

Figure 6 presents in graphical form the evolution of the world's steel production since 1948 and the shares of Dd and Dg.C. It also indicates growth rates[1] for various periods. It is seen, for example, that the growth of the industry in the period 1966-1975 was: 4.3% for the world and 9.[illegible]% for Dg.C. In the same period the share of Dg.C. grew from 7.1% to 10.5%. This last figure (10.5%) is unusually high because of the sudden drop in world production in 1975. Under "normal" conditions the share of Dg.C., in 1975 would have been about 9.5%.

Figure 7 illustrates another aspect of the evolution of the industry in Dg.C. It shows that although production increased appreciably, the "degree of self-sufficiency" remained practically the same (for Dg.C.).

Figure 8 shows the evolution of iron ore production. It is seen that the share of Dg.C. is increasing and that it is quite substantial in terms of tonnage. In 1973, in a world total of 490 Mt, the tonnage produced by Dg.C. reached 180 Mt and their share was 36%[2].

2.2. SELECTED BASIC DATA ON THE WORLD'S IRON AND STEEL INDUSTRY

A selection of basic statistical data on the world's iron and steel industry at 1973 is presented below.

(a) Present production and consumption of steel in regions and countries

Table II provides selected data on production and consumption of steel in various regions. Details by country and region are found in Annex Table 1. It also provides information on net trade, by comparison of the figures for production and consumption. The production and consumption per capita are also indicated.

(b) Production of "new iron"[3] in Dg. C.

To make steel it is necessary to have metallic iron, in one form or another, to start with. The world's steel production is based on the use of "new iron" (pig iron and "reduced iron"[4]) and scrap.

1/ All the growth rates were calculated by regression analysis assuming a constant rate of growth in the period concerned.

2/ All figures in terms of iron contained in ore.

3/ The expression "new iron" is used to cover all products of the reduction of iron ore.

4/ In this paper we will frequently use the expression "reduced iron" to cover all forms of solid iron-rich products obtained by "direct reduction".

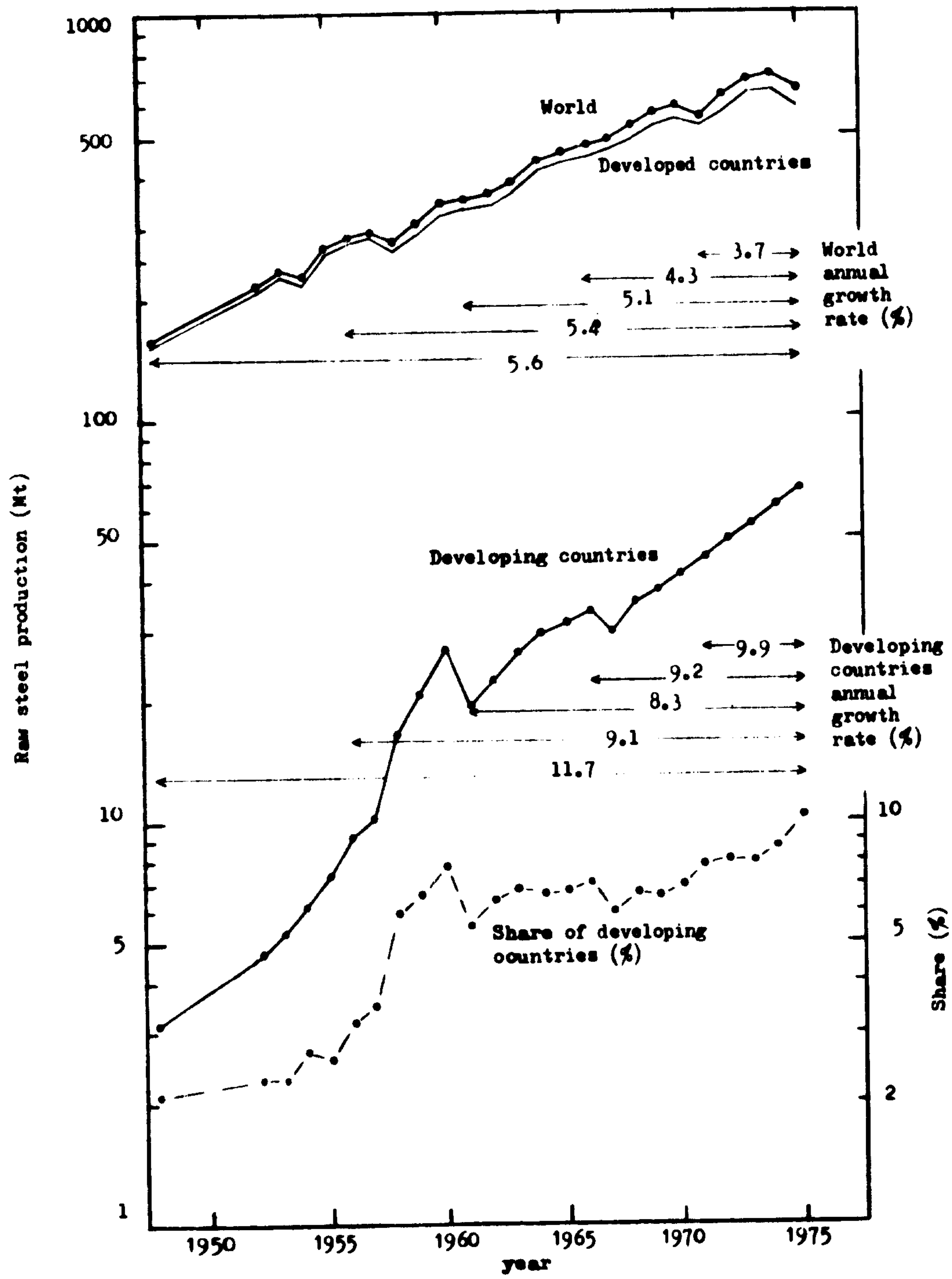


Fig. 6 Recent evolution of raw steel production

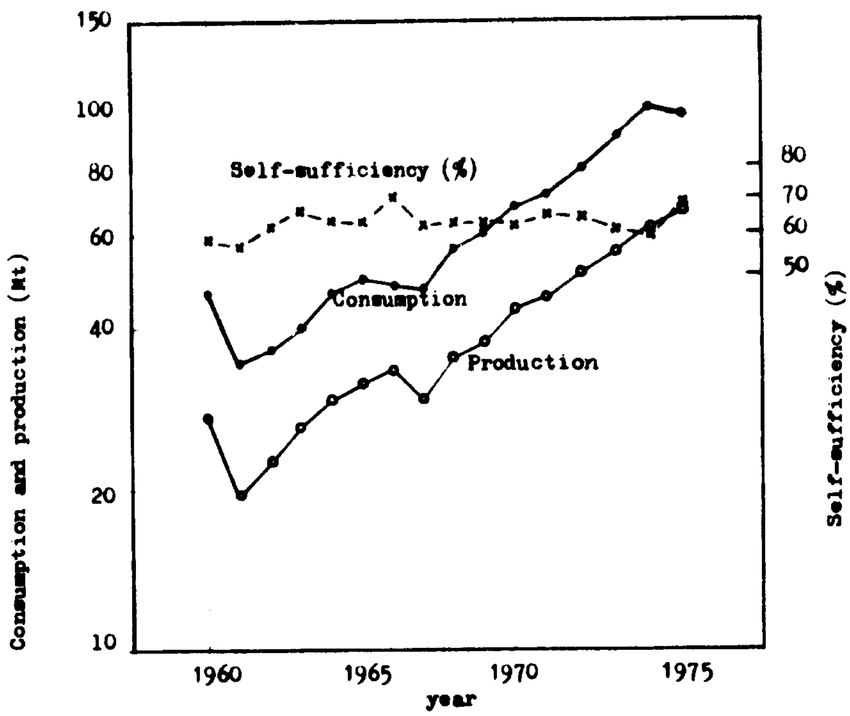


Fig. 7 Self-sufficiency of steel supply in developing countries - Production compared to consumption

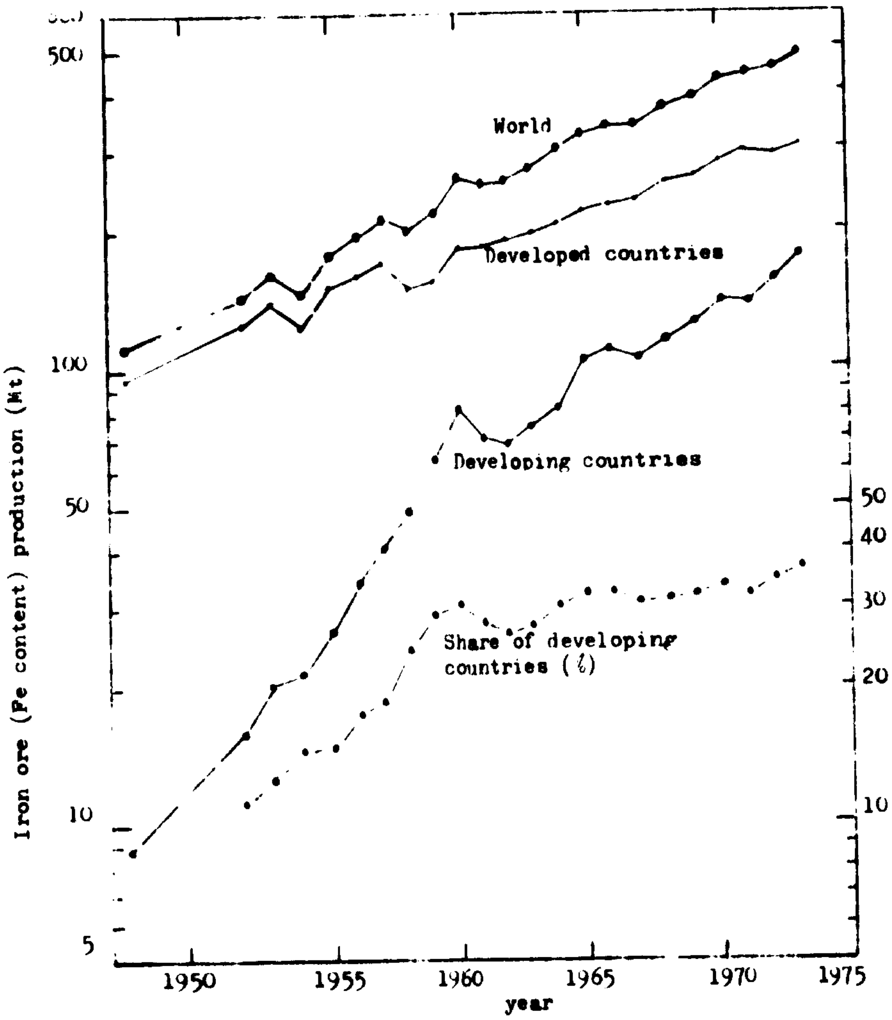


Fig. 8 Recent evolution of iron ore production (Fe content)

TABLE II

Production and Consumption of Steel by Regions[1/]

Region	Population		Crude Steel Production		Crude Steel Consumption		Per capita (kg)	
	Million	%	Mt	%	Mt	%	Prod.	Consump
Developing	2,668	69.8	55.3	8.0	86.3	12.5	20.7	32.3
S.S.Africa	263.1	6.9	0.42	0.1	2.40	0.3	1.6	9.1
Arab	133.6	3.5	0.65	0.1	5.65	0.8	4.9	42.3
L.America	302.3	7.9	16.40	2.4	24.50	3.6	54.3	81.0
S.Asia	788.8	20.6	7.65	1.1	11.44	1.7	9.7	14.5
S.E.Asia	301.2	7.9	0.87	0.1	5.40	0.8	2.9	17.9
E.Asia	867.8	22.7	29.44	4.2	36.87	5.3	33.9	42.5
Developed	1,137	29.8	639.5	92.0	603.7	87.5	562	531
W.Europe	399.1	10.4	178.10	25.6	161.90	23.5	446	406
E.Europe	356.9	9.3	178.30	25.7	177.20	25.7	500	496
N.America	232.5	6.1	150.20	21.6	163.75	23.7	646	704
Oceania	16.1	0.4	7.89	1.1	8.02	1.2	490	498
Japan	108.4	2.8	119.32	17.2	87.18	12.6	1,101	805
S.Africa	23.7	0.6	5.72	0.8	5.64	0.8	241	237
World	3,820		695		690		182	181

1/ For detail by countries see ANNEX Table

Table III presents selected data and estimates on production of "new iron" in Dg.C. and Dd.C., as well as the estimated consumption of scrap.

It is seen that the industry still depends almost totally on pig iron for the required yearly input of "new iron" although dependence on "reduced iron" may rapidly increase in future. "New iron" contributes with about 60% of the iron input for world raw steel production. For Dg.C. the percentage of "new iron" as iron input for raw steel production may be as high as 80%.

(c) Reserves and production of main raw materials

Table IV presents selected data on iron ore, coking coal and hydro-carbon reserves and production. Details by countries and regions are shown in Annex Table 1, attached.

Regarding iron ores, the situation is quite favourable to Dg.C. in terms of high quality ore, reserves and production.

The coking coal reserves of Dg.C. are very limited. Their volume, quality and economics are generally insufficient or unfavourable. Non-coking coal reserves are much larger but these coals have, so far, found very limited application in the I.S. industry. They have, however, a good potential for greater use in the future.

Despite the intense and concerted efforts taken to cut down coke consumption for iron production during the last decades (Figure 9) through technological improvement and innovation requirements of coking coal are creating special problems to the steel industry. The problem arises because the total world reserves of coking coal are limited as against the total world reserves of coal and 90% of the coking coal reserves exist in relatively few locations of the world, mainly in Dd.C. Developing countries other than China account only for some 2.3% of the total world reserves, as shown in Table IV.

To help offset the dependence on coking coal intensive efforts are being made towards the fuller use of non-coking coals: (i) as a reductant, in direct reduction processes, (ii) as "formed coke" in blast furnace iron making and (iii) through coal washing and blending of semi, non-coking and coking coals for iron smelting. The potential of charcoal as a reductant is also the object of attention in Dg.C. since this renewable resource can be the basis of sizeable iron and steel production as in the case of Brazil (over 3 Mt/yr).

Another important input (see Figure 1) is scrap. However, no data on scrap are included here because they are difficult to obtain for Dg.C. Most of the scrap used in the I.S. industry comes from two sources: internal scrap (generated in I.S. plants in normal operations) and obsolescence scrap. The first type is a direct function of plant production. The second type is characteristic of highly industrialized countries and is only available in very limited quantities in Dg. C., but it can be used for starting a small steel industry, if it is available on a regular basis. Imports of scrap are sometimes possible but are uncertain in price and availability. In the last three years scrap prices fluctuated widely in international and in local markets.

TABLE III

Production of "New Iron" in 1973[1/] (Mt)

	Dd.C.	Dg.C.
Pig iron	440	52
Coke	(440)	(48)
Charcoal	(0.1)	(3.8)
"Reduced iron"	2	1
Total "new iron"	442	53
Total consumption of scrap	320	15

1/ Data and estimates

TABLE IV

Production and Resources of Raw Materials by Regions 2/ (in 1973)

Region	Iron Ore (Mt)		Coal (Mt)		Coking coal (Mt)	Crude Petroleum (Mt)		Natural Gas (1,000 [illegible])	
	Prod. (Fe)	Resource (Ore)	Prod.	Resource	Resource	Prod.	Reserve	Prod.	Reserve
Quantity									
Developing	176	196,000	573	1,148,000	245,000	1,740	59,000	113	28,500
S.S.Africa 1/	37.2	22,600	5	14,500	1,000	120	2,950	0.4	1,750
Arab C.	2.6	4,780	1	140	0	921	38,400	29.6	11,900
L.America	68.6	99,000	12	35,600	6,000	265	4,050	47.0	2,300
S.Asia	22.5	31,000	80	83,100	14,200	300	9,430	27.7	11,300
S.E.Asia	1.7	5,080	3	1,600	500	83	2,120	5.5	1.070
E.Asia	43.7	33,150	472	1,013,000	223,300	50	2,030	2.8	165
Developed	315	586,000	1,633	7,002,000	683,000	1,030	15,300	1,163	41,900
W.Europe	54.8	31,900	289	402,500	136,500	23	2,390	145	4,670
E.Europe	121.1	306,000	657	4,052,000	244,500	448	6,700	283	20,100
N.America	83.9	225,800	547	2,383,000	273,000	540	6,020	728	16,100
Oceania	47.2	16,700	55	112,500	6,000	17	230	4	990
Japan	0.6	1,500	22	7,400	4,000	1	4	3	15
S.Africa	6.9	4,200	62	44,300	19,000	-	-	-	-
World	491	782,000	2,206	8,150,000	928,000	2,770	74,300	1,276	70,400
Percentage									
Developing	35.8	25.0	26.0	14.1	26.4	62.8	79.4	8.9	40.5
S.S.Africa	7.6	2.9	0.2	0.2	0.1	4.3	4.0	0.0	2.5
Arab C.	0.5	0.6	0.0	0.0	0.0	33.2	51.7	2.3	16.9
L.America	14.0	12.7	0.5	0.4	0.6	9.6	5.5	3.7	3.3
S.Asia	4.6	4.0	3.6	1.0	1.5	10.8	12.7	2.2	16.1
S.E.Asia	0.3	0.6	0.1	0.0	0.1	3.0	2.9	0.4	1.5
E.Asia	8.9	4.2	21.4	12.4	24.1	1.8	2.7	2.2	0.2
Developed	64.2	74.9	74.0	85.9	73.6	37.1	20.6	91.1	59.5
W.Europe	11.1	4.1	13.1	4.9	14.7	0.8	3.2	11.4	6.6
E.Europe	24.7	39.1	29.8	49.7	26.3	16.2	9.0	22.1	28.6
N.America	17.1	28.9	24.8	29.2	29.4	19.5	8.1	57.1	22.9
Oceania	9.6	2.1	2.5	1.4	0.6	0.6	0.3	0.3	1.4
Japan	0.1	0.2	1.0	0.1	0.4	0.0	0.0	0.2	0.0
S.Africa	1.4	0.5	2.8	0.5	2.0	0.0	0.0	0.0	0.0

1/ Sub-Sahelian Africa

2/ For details by countries and notes to the Table see Annex Table 1.

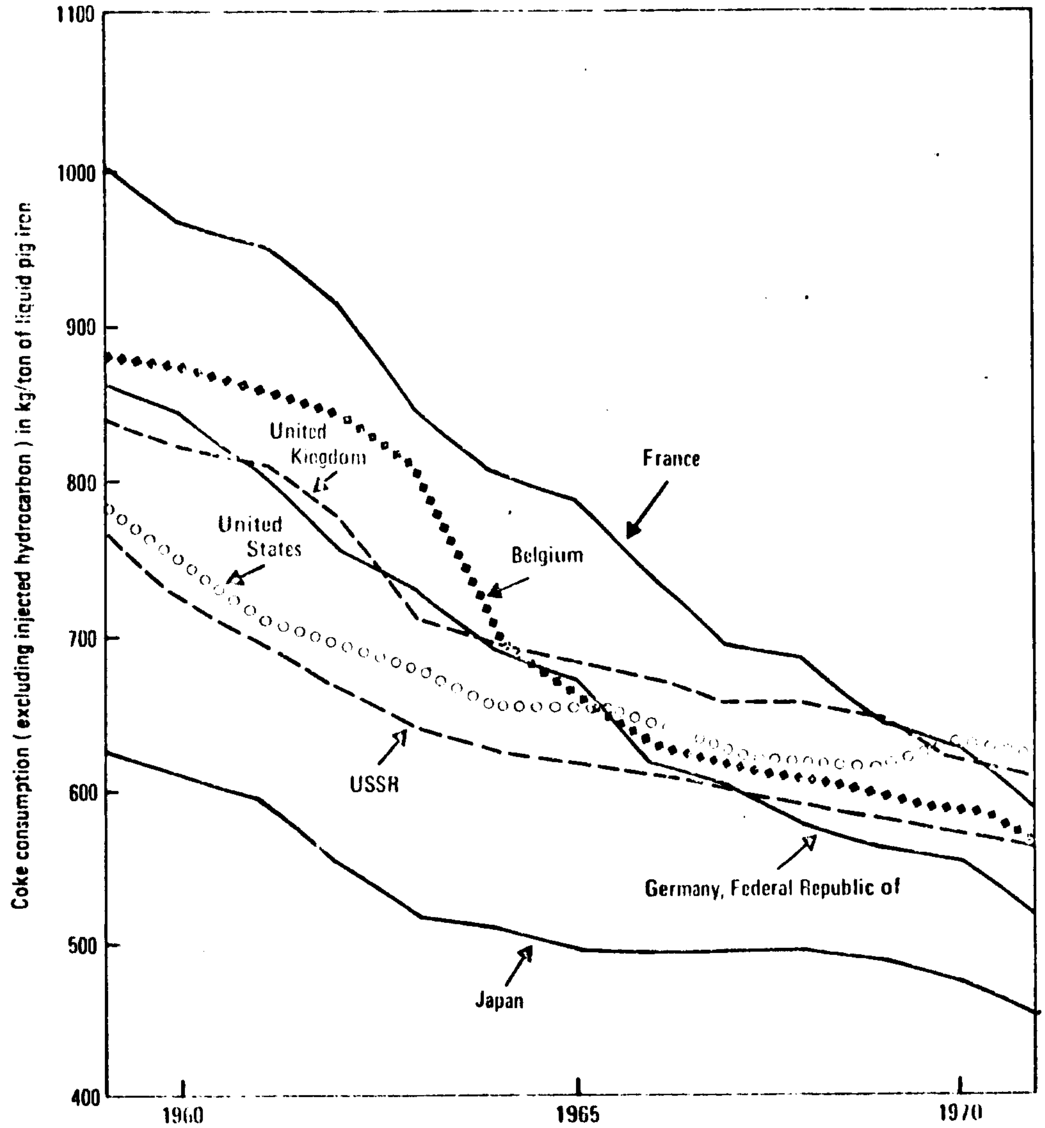


Fig. 9 Blast furnace coke consumption in the principal steelmaking countries, 1960 - 1970 (excluding injected hydrocarbon)

Data source: ECE/STEEL/12, page 47

2.3. GEOGRAPHIC DISTRIBUTION OF STEEL PRODUCTION

As already indicated (Figure 8) Dg.C supply some 36% of the world's "new iron", in terms of iron content, but produce only some 8% of world steel (1973). In other words: 2.7 billion people (70% of world population) produce only 8% of world steel, while the other 1.1 billion people in Dd.C. (30% world population) produced about 92% of the world steel in 1973.

The above two points alone indicate a striking disparity between Dd. and Dg.C. in the I.S. sector. The large difference between Dd. and Dg.C. in this respect is generally reflected in other indices of production, consumption and standard of living.

Figure 10 indicates in more detail the distribution of steel production in Dg.C. in different regions and sub-regions. It also indicates the corresponding degrees of self-sufficiency. It is seen that Dg.C. in all regions have a steel deficit and have to rely on imports. This is particularly marked in S.S. Africa 1/ in the Arab Community and in S.E. Asia. The wide difference in the degree of self-sufficiency, in steel, among the regions is quite marked.

Steel production is quite unequally distributed among the countries: 20 countries produce 95% of world steel. Nine countries alone produce 80% of the total. An even more striking difference exists among individual countries. Production varies from zero tons/country and zero kg/capita up to about 140 million tons/country and 2,060 kg/capita as seen in Annex Table 1 attached.

Practically all Dd.C. have integrated or semi-integrated steel making facilities. Among Dg.C. only 15 have integrated I.S. plants, most of them quite small, with another 30 having very small steel making facilities based on scrap melting. Many of the latter are now paralyzed or operating irregularly.

The per capita production by regions was indicated in Table II. It can be seen that South Asia, S.E. Asia and S.S. Africa 1/ show very low per capita production and consumption figures. The situation is particularly critical in S.S. Africa, which only produces 1.6 kg of steel, per inhabitant, per year. On the other hand, Latin America as a whole seems to be in the "take off" stage to industrialization and already has an important and flourishing steel industry.

As indicated above, whereas in certain developing countries production and consumption have attained good levels (in total tonnage, per capita values and growth rates) in most of them the I.S. industry is non-existent. These countries constitute a special group ("zero steel countries") meriting special attention and assistance to enable them to make a start at iron and/or steel production, for rolled products or castings, even if only in very small integrated or non-integrated plants. Such plants, as demonstrated in Dd. and certain Dg.C. can be technologically and economically viable.

1/ Sub-Sahelian Africa

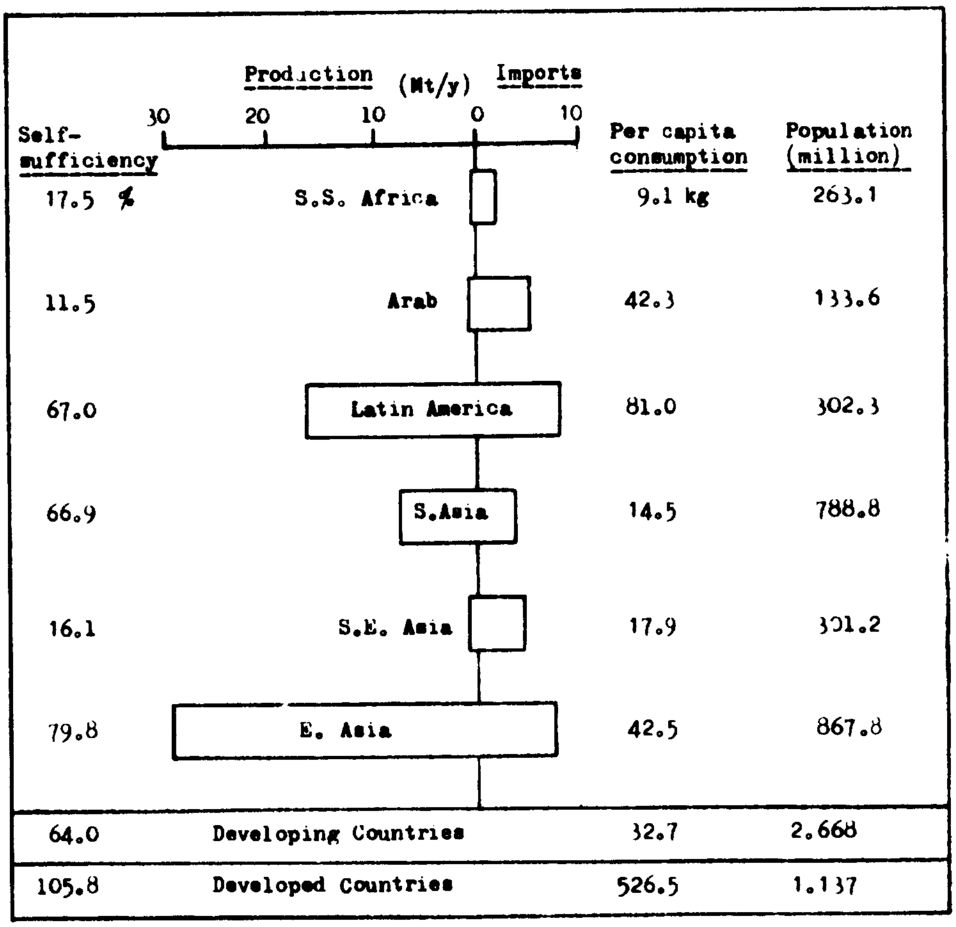


Fig. 10 Production and import of steel by regions (in 1973)

2.4. SOME OBSERVATIONS ON TRADE

The world trade in steel rose from 60 Mt in 1965 to about 90 Mt in 1970, 97 Mt in 1972, and an estimated 110 Mt in 1973. Figure 11 shows the situation regarding imports of steel by Dg.C. It is noted that, since 1965, the tonnage imported has grown approximately linearly, but the total cost of imports have grown much more rapidly due to the severe price increase. In 1974 the total tonnage imported reached 40 Mt at a total cost of $12 billion. Such imports of steel by Dg.C. place a heavy burden on their already limited resources of foreign exchange.

Another serious problem is related to the extreme price fluctuations in recent years. Thus, the price of reinforcing bars climbed steadily from $100 per ton in January 1972 to $122 per ton a year later. By January 1974, the price more than doubled to $280 per ton and reached $320 per ton in April 1974, although it has fallen again since then. The fluctuations in steel prices, uncertain deliveries and rising freight costs have created serious problems for the Dg.C. in meeting their growing steel requirements.

On the other hand, Dg.C., are heavy exporters of iron ore. As shown in Figure 12 S.S. Africa, Latin America and South Asia are large scale exporters. The Arab countries and S.E. Asia show very little production, consumption and export.

Iron ore trade was about 265 Mt in 1970, 330 Mt in 1972 and 350 Mt in 1973. The share of Dg.C. was about 130 Mt in 1970, 150 Mt in 1972, and 170 Mt in 1973; or 49%, 45% and 48% respectively, in iron ore trade.

Prices of raw materials have been quite stable in recent years, as compared to the prices of steel products and scrap, as shown in Figure 13. However, the trends in prices of raw materials in very recent years indicate considerable increases and are of great concern to the future development of the steel industry.

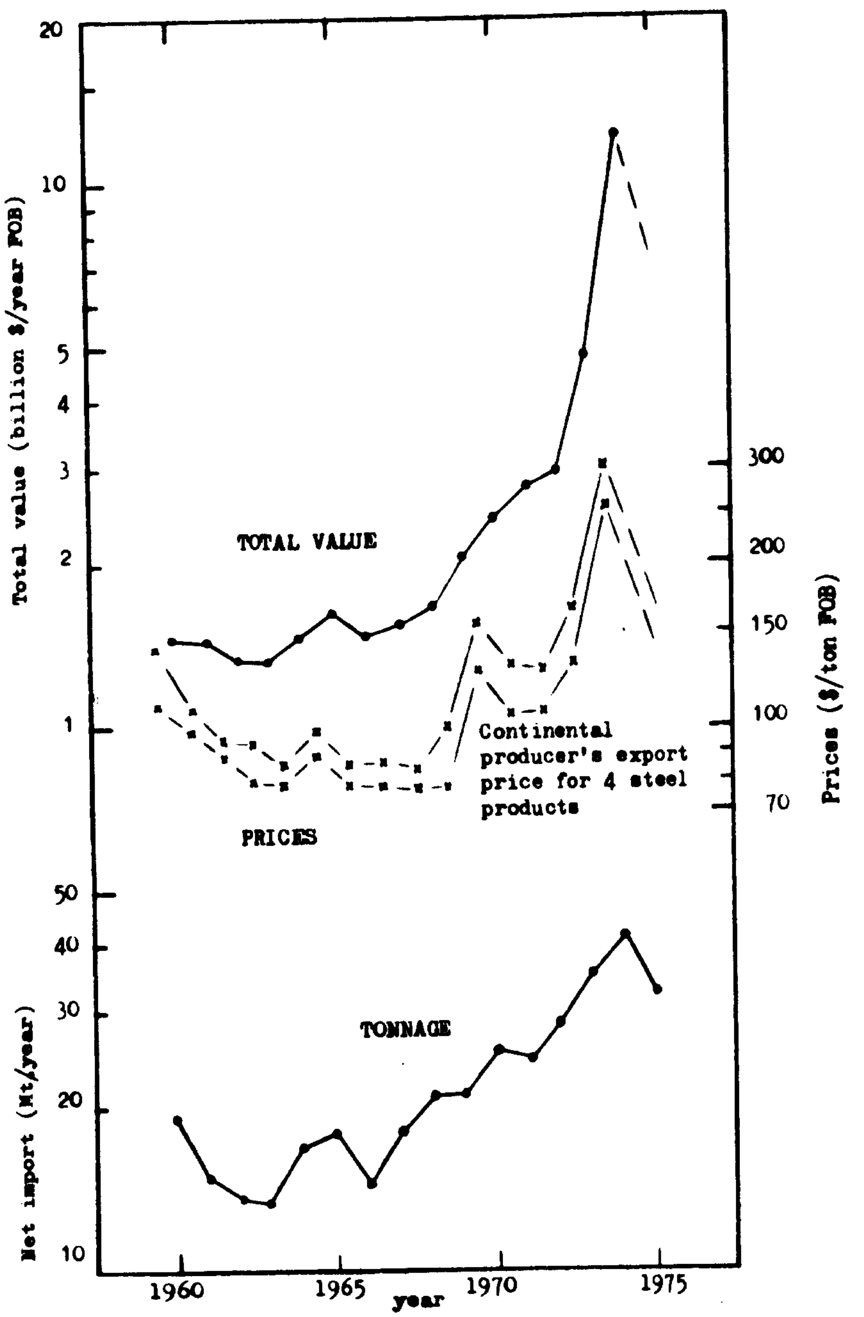


Fig. 11 Net import of steel by Dg.C. from Dd.C.
Price data source: OECD, The Iron and Steel Industry in 1973 and Trends in 1974

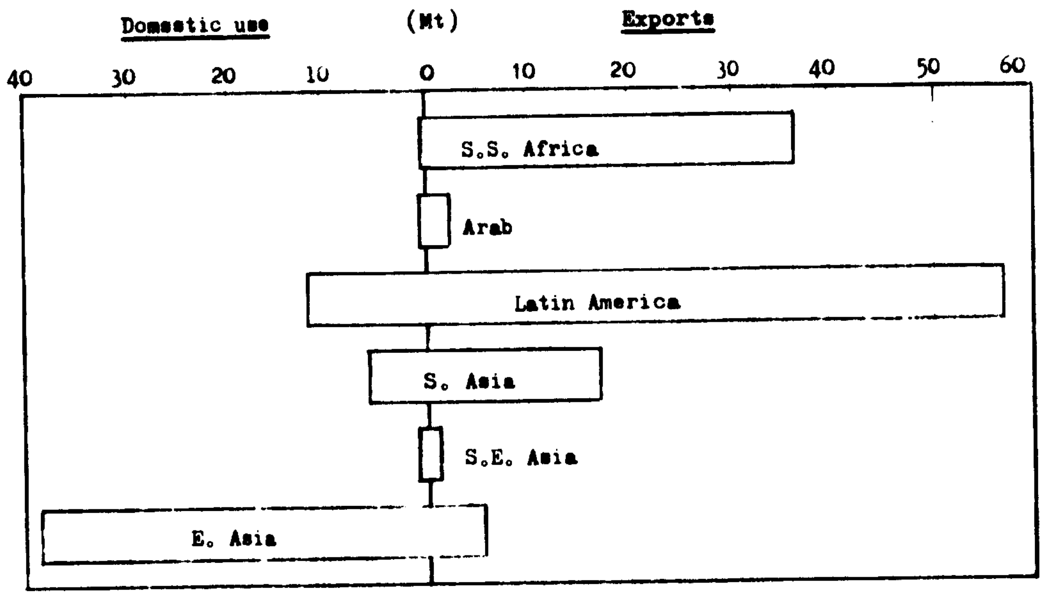


Fig. 12 Local consumption vs export of iron ore - Dg.C. in 1973

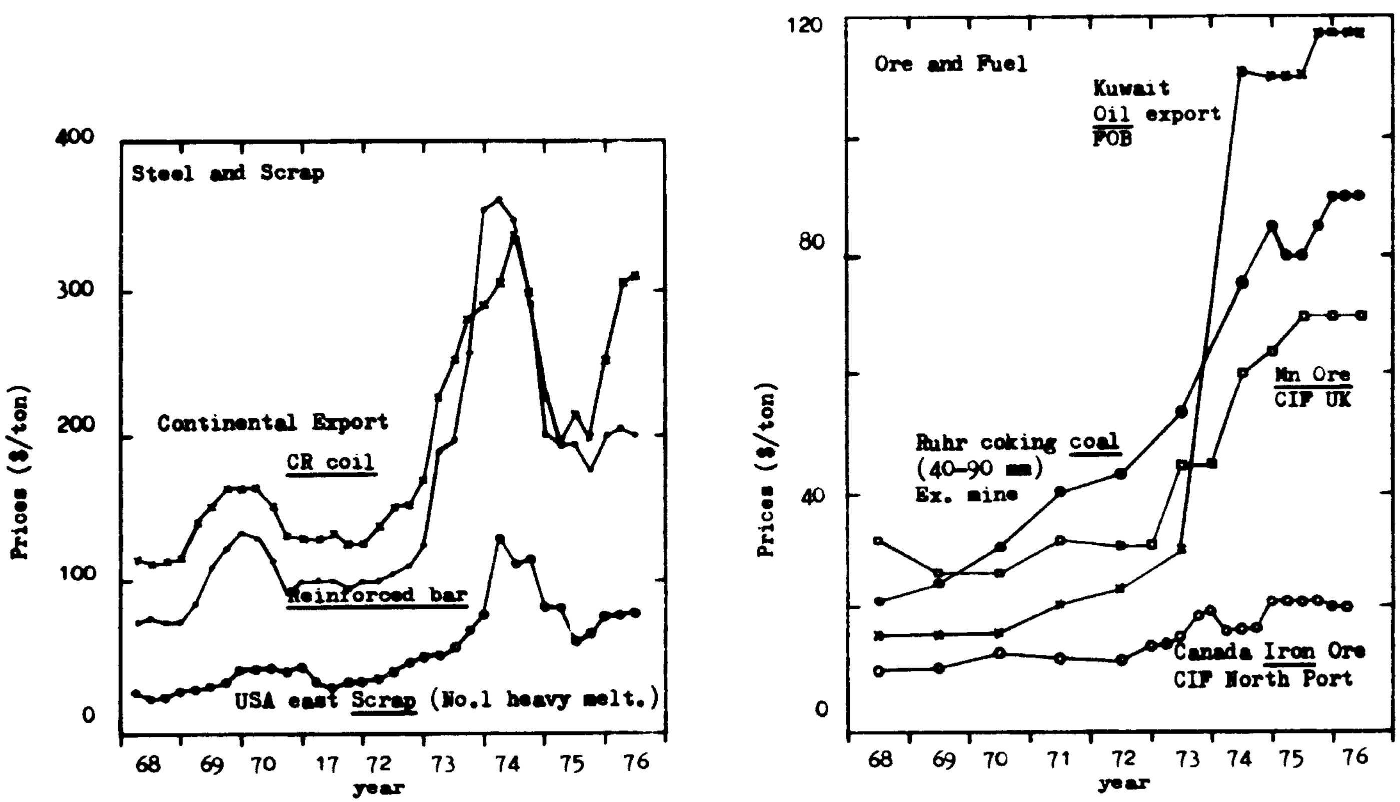


Fig. 13 Price fluctuation of steel, scrap, ore and fuel in recent past.

Data sources: Various issues of Metal Bulletin and Monthly Commodity Price Bulletin, and Metal Bulletin Handbook (1974)

3. THE FUTURE: PROJECTIONS, FORECASTS AND TARGETS

In the light of the present situation of the world's I.S. industry it is clear that further expansion of the sector in both Dd. and Dg.C. will be necessary. Many studies and forecasts have been and are being made on the long term expansion of the world's I.S. industry. Most of them, however, do not take fully into account the problems and opportunities of Dg.C. To identify the order of magnitude of the expansion of the I.S. industry in Dg.C. and to assess the resulting implications it is necessary to consider possible projections and scenarios, for the short and medium term, for Dd. and Dg.C. This is done below, in a preliminary and tentative way.

For clarity, one should note that it is convenient to distinguish various types of projections:

- extrapolations: direct extension of past data to the future;
- trends: changes noticed in the recent past and foreseeable for the immediate future, affecting future projections;
- forecasts: predictions of actual performance or evolution based on careful analysis of present information and data;
- targets: quantitative objectives for planning and action, established on the basis of careful evaluation of present and future needs and capabilities.

3.1. SIMPLE EXTRAPOLATION OF PRODUCTION AND CONSUMPTION DATA

Figure 14 shows data for production and consumption of steel (for the world and Dg.C.) as well as simple extrapolations obtained by regression analysis, assuming that constant rates prevail for the entire period considered. **The figure was drawn on the basis of selected calculated data tabulated in Table V.**

One should note that the simple extrapolation based on regression analysis gives a wide range of projected values, in spite of the rather high correlation coefficients observed, if different base periods are considered. Even so, however, the projections are useful to indicate the broad possibilities and magnitudes to be considered on the basis of past performance.

3.2. ANALYSIS AND PROJECTIONS OF CONSUMPTION BASED ON STEEL INTENSITY CONSIDERATIONS

Detailed analysis of apparent steel consumption of 16 selected countries were carried out by IISI 1/ and used as a basis for projection of world steel production. Unfortunately, the analysis covered only the period up to 1985 and significant scattering was observed for consumption growth of developing countries. It is understood that IISI is now re-examining their projections in the light of the recent economic recession.

Since in view of the Lima Declaration and Plan of Action UNIDO is particularly interested in the potential for expansion of the I.S. industry of Dd. and Dg.C. until the year 2000, detailed analysis of steel consumption data was carried out using an approach related to the "steel intensity" concept. To start with, Figure 15 was prepared, based on a

1/ IISI: Projection 85, 1972

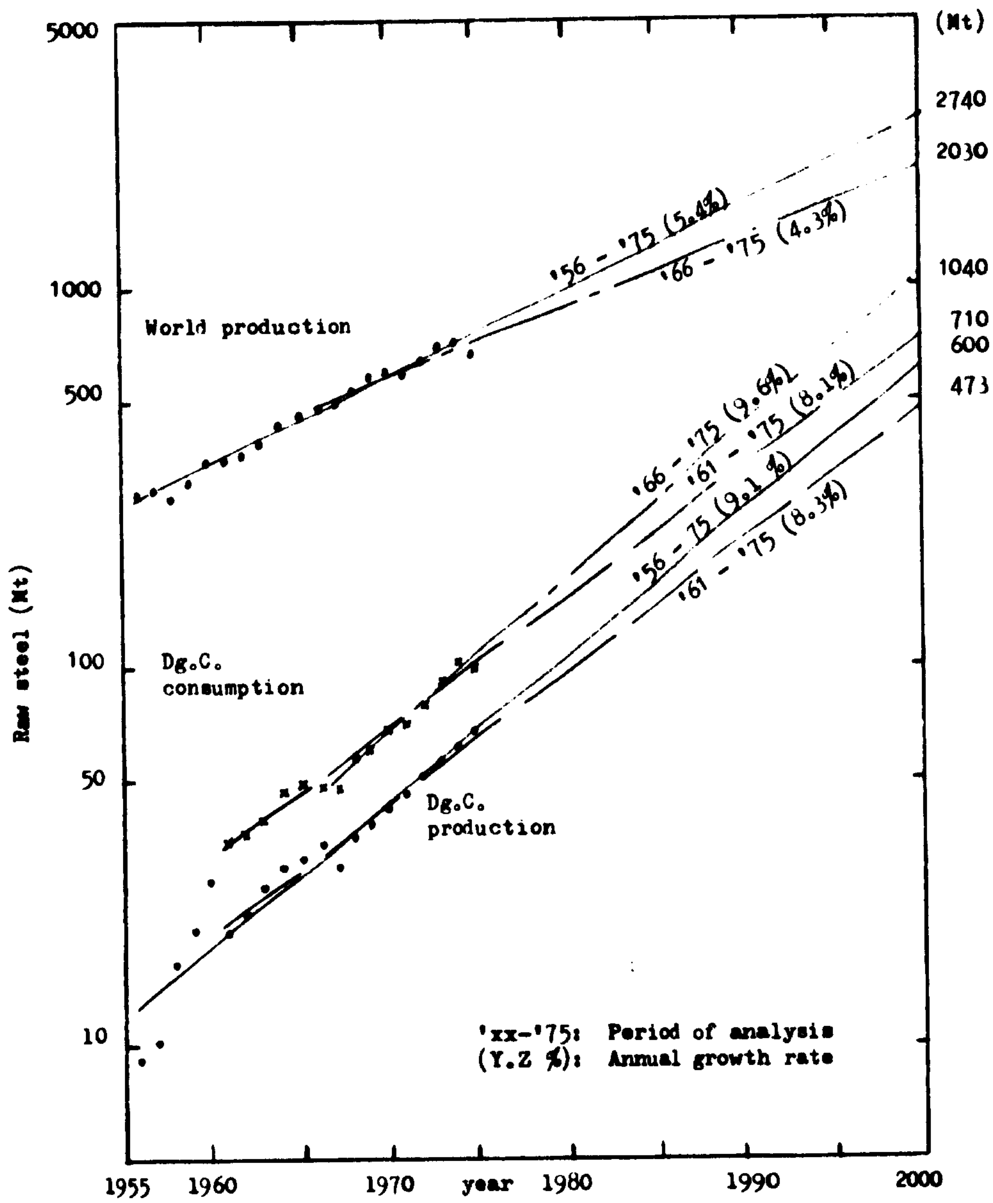


Fig. 14 Constant rate projections based upon the regression analysis of the past data

TABLE V

Selected data based on extrapolations at constant rate 1/

	Period of analysis	Annual growth rate	Correlation coefficient	Extrapolation (Mt)	
				1985	2000
World production and consumption 2/	66 - 75	4.29	0.94	1,080	2,030
	61 - 75	5.13	0.98	1,210	2,550
	56 - 75	5.38	0.99	1,250	2,740
Dg.C. production	66 - 75	9.16	0.98	158	589
	61 - 75	8.30	0.98	143	473
	56 - 75	9.13	0.96	163	603
Dg.C. consumption	66 - 75	9.61	0.99	263	1,040
	61 - 75	8.13	0.99	220	710

1/ On the basis of standard linear regression analysis over periods indicated in first column.

2/ It is assumed that production equals consumption.

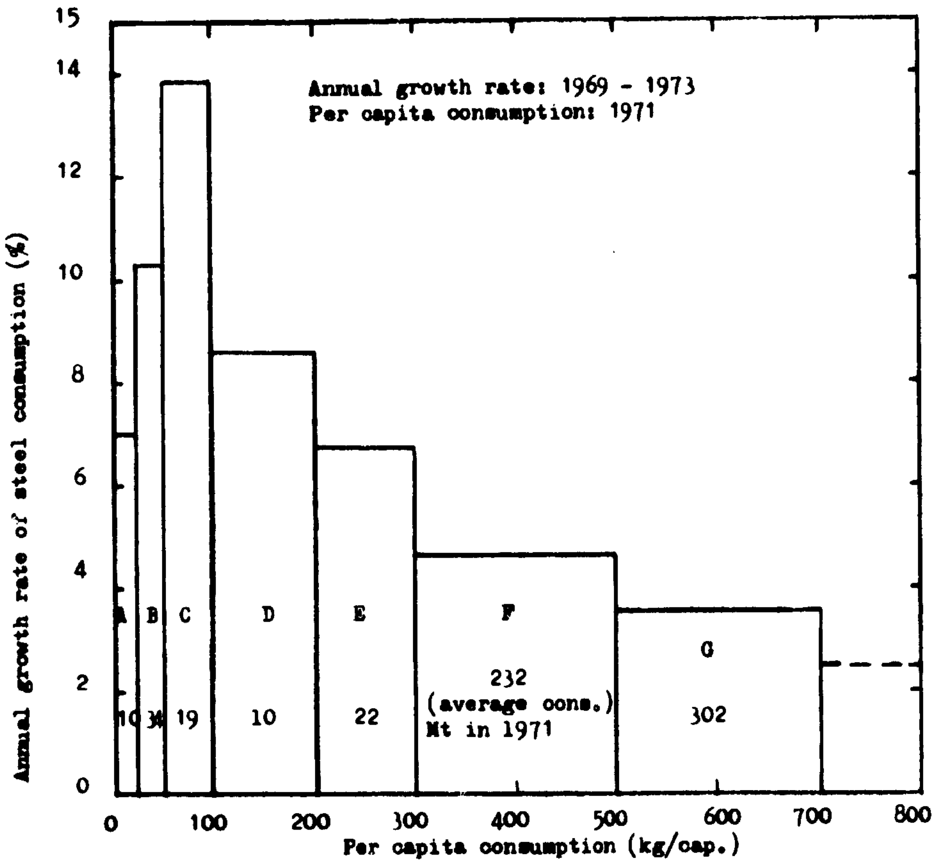


Fig. 15 Average growth rate of steel consumption by per capita consumption classification

classification of Dg.C. and Dd.C. according to their per capita consumption.

Figure 15 was prepared as follows: actual data for yearly rate of growth of consumption in the period 1969 - 1973 were plotted as a function of consumption per capita. For this purpose, and to have better statistical significance, all the Dg. and Dd.C. of which steel consumption figures are known were divided into various groups, according to levels of per capita consumption in 1971 (mid-year in the period 1969 - 1973).

It can be seen that the growth rate of steel consumption (loosely, one might speak of "steel hunger") increases at first and then decreases. Dd.C., characteristically, have lower steel consumption growth rates since they have already reached high levels of consumption per capita (which is higher than 300 kg/capita, for most of them). On the other hand, the least developed countries with practically no industry, have a lower rate of growth of steel demand (lower "hunger of steel"). The highest rates of growth of demand are observed in the Dg.C. with per capita consumptions between 50-100 kg. These are Dg.C. reaching the "take off" stage (Brazil, Mexico, etc.).

It should be expected, thus, that until 2000 a Dg.C. would gradually move (for example) from class A to class B, and then to class C. Another may move from class B to C and D, etc. In other words, it can be expected that in the next 25 years the growth of steel consumption in Dg.C., as a whole, will not follow a constant rate but will show a variable rate, (or "moving rate") which will be a composite of the varying rates of all Dg.C. (now mainly in classes A, B and C).

The above considerations are directly related to and consistent with the "steel intensity curve" (Figure 2).

On the basis of the considerations made above, the overall growth of consumption can be calculated with minor adjustments for population growth. However, it is to be noted that years 1969 to 1973 can be considered as "good years" for the steel industries of developing countries compared to previous five years or so, as seen in Figure 6.

On the other hand, developed countries have suffered quite a setback from the last half of 1974 until the present and trends in their steel consumption growth in future years might be considerably lower than those for the period of 1969 to 1973. Therefore, there is the possibility that the growth rates shown in Figure 15 cannot be maintained for the future. Accordingly, two growth rate levels were assumed: a "moderate" growth rate 25% smaller for each group represented in Figure 15; and a "high" growth rate corresponding to the data shown in Figure 15.

Assuming these two levels of growth rates of consumption, the projections of consumption shown in Figure 16 were obtained. The lines shown in the graph are not straight lines but curves, since they correspond to variable overall growth rates in the period.

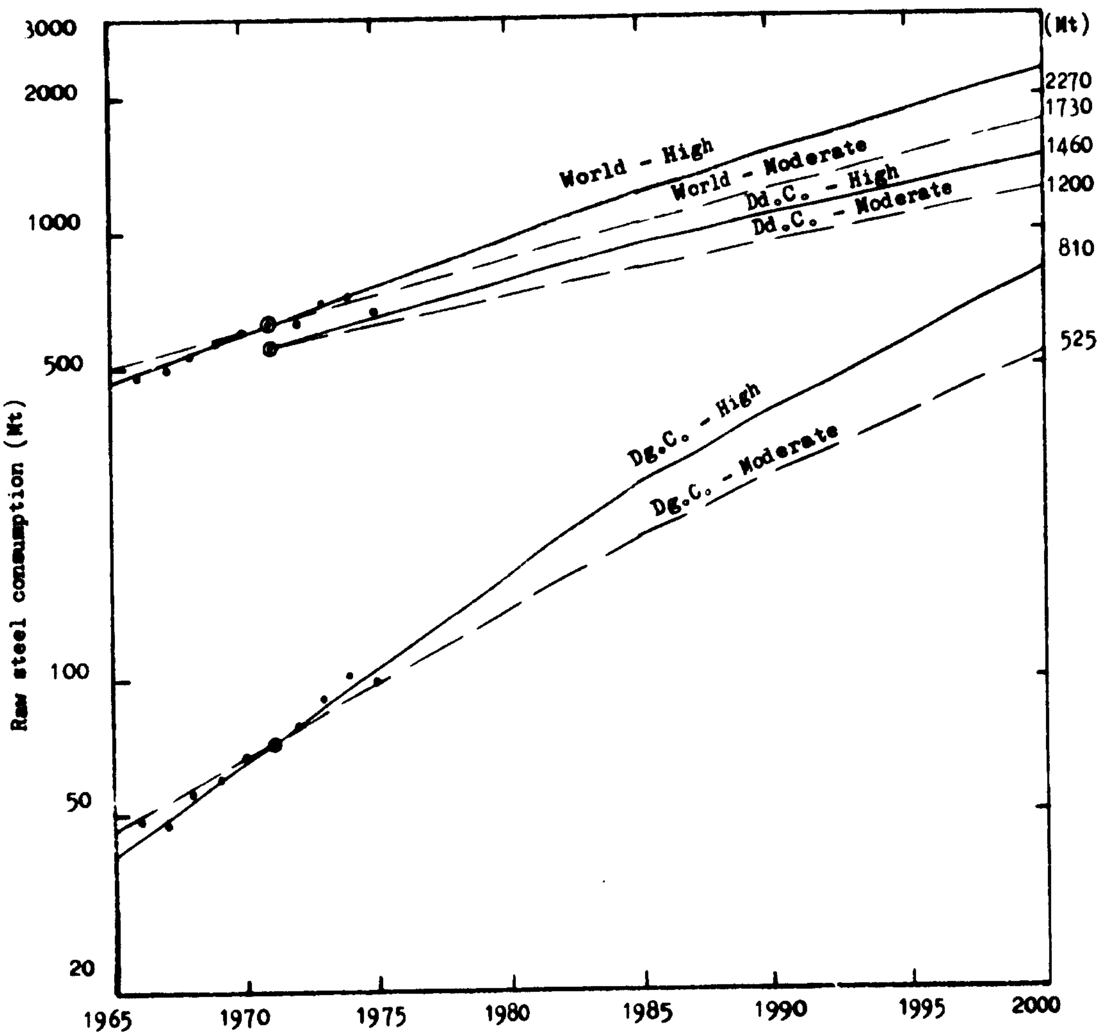


Fig. 16 Steel consumption projection based on "moving rate" analysis

A summary of the results of this consumption growth analysis is presented below, with the lower figures corresponding to the "moderate" hypothesis for growth.

TABLE VI STEEL CONSUMPTION PROJECTION BASED ON "MOVING RATE" ANALYSIS (Mt)

	1985	2000
Dg.C.	210 - 270	525 - 810
Dd.C.	830 - 940	1200 -1460
World	1040 ~ 1210	1730 -2270

The above projections seem to be much better founded in comparison to simple extraporation, but still lead to quite a wide range in the final projections for the year 2000.

3.3. ANALYSIS BASED ON INDUSTRIAL PRODUCTION GROWTH

It has been already shown in Figure 4 that the steel consumption is a linear function of industrial production. Thus, if one assumes a future growth rate of industrial production, it is possible to forecast the corresponding steel consumption. Figure 17 again shows the relationship between steel consumption and industrial production, for a larger range of the variables. In the graph of Figure 17 the aggregate steel consumption was plotted as a function of the aggregate **industrial production,** for each steel consumption group (see Figure 3). The values for the entire group of Dg.C. (all taken together and for the world are also indicated. **A good linear correlation is obtained, showing the interdependence between industrial and steel production.**

It can be argued that developing countries as a whole will actually increase their steel and industrial productions along the line shown in Figure 17, in the future, since: (a) the line is the same that developed countries have followed in the past; and,(b) there seems to be no reason to assume a drastic change in the dependence of industrial production on steel consumption within coming 25 years, for Dg.C. However, the same cannot be said for the developed countries because their dependence on steel is highly likely to decrease, as already observed in some of the most developed countries.

Therefore, groups G and F which consume 600 - 800 kg and 400 - 600 kg steel per capita respectively, may depart from the line in such manner that industrial production increases with lower growth of steel consumption. Thus the projected line, in the future, may bend considerably, as shown in the arbitrarily drawn broken line in Figure 17. It should be noted that the point for "world 1973" (namely $ 1,700 billion industrial production and 690 Mt steel consumption) also falls very well on the straight line.

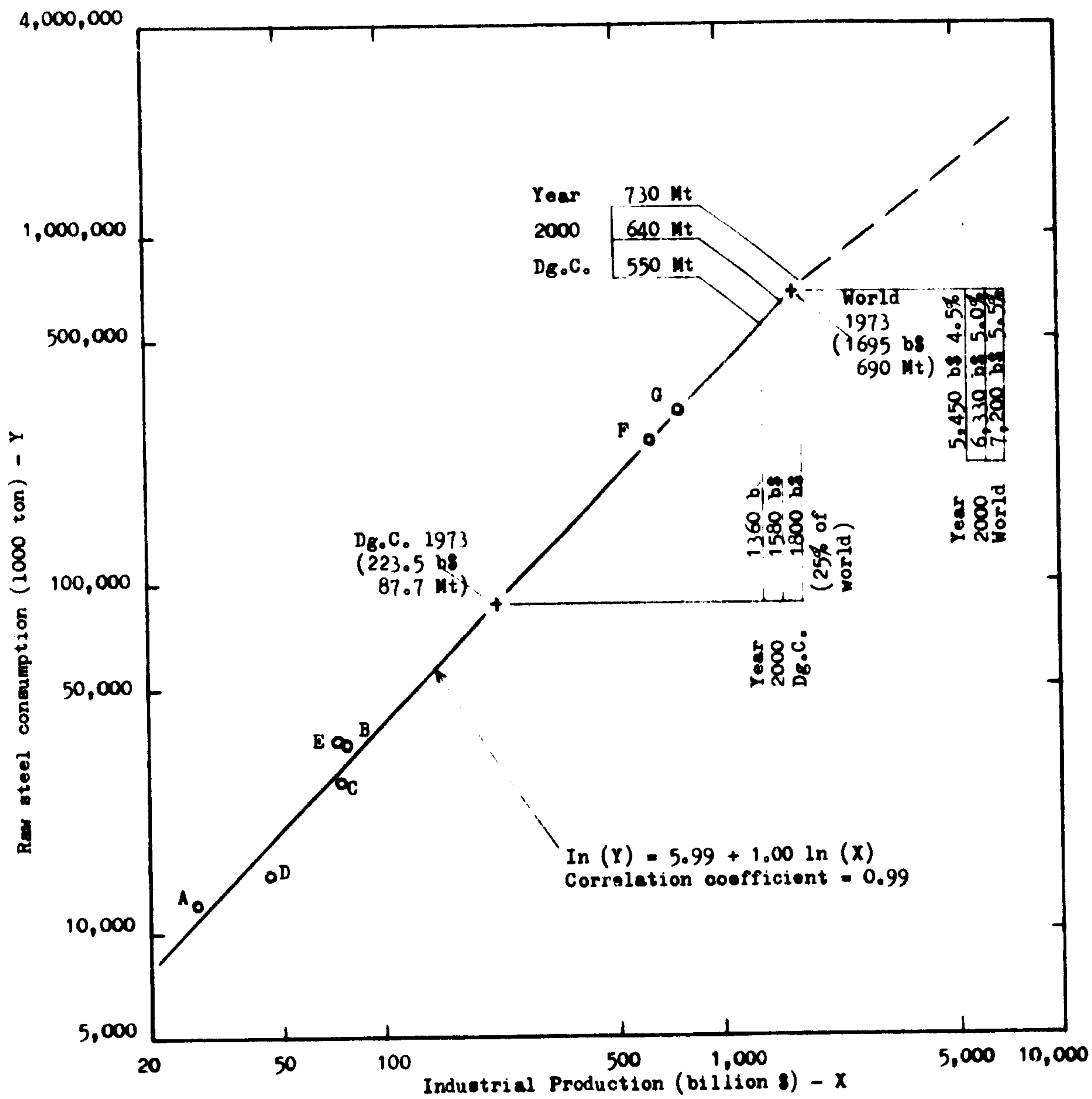


Fig.17 Estimates of steel consumption of Dg.C. from industrial production growth analysis

World industrial production rose at a steady annual rate of 7% during the 17 years from 1958 to 1975. It is, however, anticipated that the rate of growth during the remainder of the current century will fall considerably. As an exercise, the growth rates of 4.5, 5.0 and 5.5% were assumed for the world industrial production, in the next 25 years. This assumption leads to the following results:

TABLE VII PROJECTED GROWTHS OF INDUSTRIAL PRODUCTION AND OF STEEL CONSUMPTION - YEAR 2000

Assumed Growth Rate of World Ind. Production	World Ind. Production in 2000 1/	Target for Dg.C. 2/ Ind. Prod.	Steel Consumption of Dg.C. 3/	Growth Rate of Dg.C.'s Ind. Prod.
4.5%	$ 5,450 billion	$ 1,360 billion	550 Mt	7.0%
5.0	6,330	1,580	640	7.5
5.5	7,200	1,800	730	8.0

1/ Base year = 1973 ($ 1,695 billion)
2/ 25% of the world in accordance with the Lima Target
3/ Graphically obtained estimate based on Figure 17.

The above mentioned analysis shows that steel consumption of Dg.C. must reach 550 - 730 Mt by the year of 2000 in order to attain the Lima Target, subject to the assumptions made for the world industrial production growth rates.

3.4. INFORMAL ESTIMATES OF PRODUCTION

It should be noted that informal forecasts by various sources, on the basis of judicious consideration, also vary from 1500 Mt to 2000 Mt for world production by the year 2000. The data shown below are illustrative of such projections.

TABLE VIII **INFORMAL FORECASTS**

Data Source	World Production (Mt)		Share of Dg.C. 2/
	1985	2000	2000
IISI Projection 85, 1972	1,140	(1,950) 1/	590
J. Miller	1,090	1,550	470
UNIDO Working Group, November 1975	1,040	1,750	530

1/ Simple extrapolation from IISI figure, at constant rate.
2/ Assuming Dg.C. will have a 30% share in world I.S. production (rounded).

The last column of Table VIII was calculated on the basis of a 30% share for Dg.C. in the steel sector, in the year 2000. This assumption corresponds to the feeling of various experts from Dg.C. that if the overall share of industrial production has to be 25% (Lima Target), Dg.C. must exceed this share in certain sectors where they have favourable conditions and resources, so as to balance other sectors in which the 25% share would be difficult to attain (aero-space, electronics, etc.).

3.5. BASIC CONSUMPTION PROJECTIONS AND PRODUCTION TARGETS

On the basis of the previous analyses and forecasts one might, as a working hypothesis, arbitrarily choose two levels of world consumption in the year 2000: an "optimistic" and a "moderate" one. They are suggested below, together with the possible ranges for Dg.C.

	World Consumption	Dg.C. Consumption
High forecast	2000 Mt	700-800 Mt
Moderate forecast	1750 Mt	500-550 Mt

The high forecast is mainly based on the higher estimates of world production by various sources and on a rather high consumption growth rate for Dg.C. (see previous sections). On the other hand, the moderate forecast is mainly based on the middle value estimates of world production, by various sources, and a moderate growth rate of Dg.C. consumption.

To select a consumption projection as a basis for setting production targets for the year 2000 it would be necessary to carry out further detailed techno-economic studies. However, in a first attempt to quantify production targets and to identify the corresponding implications, the moderate forecast is tentatively selected, for the following reasons:

(i) The recession experienced in the very recent years was the most serious one after the war and the steel industry was very much affected, even more than most other industries. Full economic recovery may take a few years. Certain expansion plans were shelved, others are being revised or delayed. Besides, normal structural changes in the world economy, ecological problems and huge raw material and energy requirements will pose special problems for the growth of the world steel industry.

(ii) The high rate of steel consumption growth by Dg.C., namely 8.1 to 9.6%/year for the last 10 to 15 years may decrease when the total quantity of steel consumed increases and imports become more costly. The supply of low priced steel from Dd.C. before the economic crisis played an important part for the steady development of consumption by Dg.C. It is likely that world steel prices will be generally higher, from now on, affecting imports and consumption of steel by Dg.C. in the short and medium term.

(iii) Production of steel in Dg.C. also has grown at a steady rate (8.3 to 9.2%/year), and if it continues at such a rate it will reach 470 to 600 Mt in 2000. It seems difficult for Dg.C. to exceed the past rate of growth appreciably, in view of the heavy requirements related to development of inputs and infrastructure.

(iv) The steel consumption forecast of Dg.C. (500 to 550 Mt for the year 2000) implies industrial production growth of about 7%/year (as seen in **Table VII**). The figure of 7% growth rate corresponds to the observed Dg.C.'s growth rate of the last 10 to 17 years. Since appreciable slow down of industrial production of the world is anticipated (from 7%/year growth rate to 4.5 - 5.5%/year) it seems reasonable to assume that the Dg.C. will not exceed the overall 7% growth rate in the next 25 years.

(v) On the other hand the high projection for Dg.C. steel consumption (700 - 800 Mt in 2000) would imply a high import of some 150 - 200 Mt if the production of Dg.C. grows at the present rate. This would represent a very heavy burden in the balance of trade of Dg.C.

The adoption of the moderate forecast of consumption is also consistent with the following considerations:

(a) Considerations based on the Lima Target for industrial output - Since the Lima target for overall industrial output of Dg.C. is 25% and since there are sectors of industry where Dg.C. will encounter serious problems in meeting the target (aero-space, electronic industry, nuclear energy generation equipment, etc.) it is necessary that in other sectors Dg.C. do considerably better than reach a 25% share. It is here assumed that the 25% value can more easily be exceeded in the "conventional basic industries" sectors: steel, fertilizers, petrochemicals, etc. The consensus of many Dg.C. experts seems to be that a share of at least 30% of steel production must be reached by Dg.C. by the year 2000. On the basis of the forecast of 1750 Mt for world production, one would thus arrive at the value of 530 Mt for Dg.C., in 2000.

(b) Per capita considerations - If one considers that an average "ad hoc" GNP goal of $ 750/capita/year (at 1963 value) by the year 2000 would be a minimum one, it can be seen from the "steel intensity" curve (Figure 2) that the corresponding apparent steel consumption would be approximately 110 kg/capita. If the world, Dg.C. and Dd.C. populations, by 2000, are assumed to reach 6.1 billion, 4.6 billion and 1.5 billion people respectively, it is seen that a consumption target of 110 kg/capita would lead to a figure of 510 Mt, by 2000, for Dg.C.

(c) Self sufficiency considerations - As repeatedly mentioned, imports of steel by Dg.C. are a heavy burden for their limited foreign currency resources and achievement of a large degree of self sufficiency should be a major target of Dg.C. as a group. Under the "moderate" forecast, steel consumption of Dg.C. will reach 500 - 550 Mt in 2000 year and this can be produced within Dg.C., if the present rate of production growth of Dg.C. can be maintained constant until the end of this century, which seems a reasonable assumption.

Thus, as a "basic projection" for reference in discussions and planning one can assume, tentatively and arbitrarily, the basic targets for steel production in the year 2000 indicated in Table IX. It is emphasized that the figures shown are no more than suggestions for reference and discussion. The figures can, nevertheless, be considered as a minimum desirable target and can serve as a basis to identify the order of magnitude of the problems and opportunities facing Dd. and Dg.C.

It is interesting to note that some Dg.C. have already reached production or consumption figures close to 100 kg/capita. Examples (in kg/capita):

Consumption:	Saudi Arabia (96kg),	Brazil (94)
	Mexico (95)	Korea, R (91)
	Portugal (138)	Ireland (155)
Production:	Mexico (86)	Venezuela (103)
	Singapore (91)	Greece (92)
	Yugoslavia (128)	

TABLE IX "BASIC PROJECTION" FOR THE YEAR 2000 (RAW STEEL BASE)

Forecast, world production	1750 Mt/yr
Targets for Dg.C.:	
- production	530 Mt/yr
- share of production	30 %
- per capita production	115 kg/yr
- self sufficiency	100 %
- GDP/capita (at 1973 value)1/	$1000/yr
- Industrial output/capita (at 1973 value)	$350/yr
- ratio industrial output to GDP	35 %

1/ Estimated from the data shown in Figure 3

4. IMPLICATIONS, PROBLEMS AND OPPORTUNITIES

A detailed and careful analysis of the implications, problems and opportunities arising from the facts and projections considered in the previous sections would be essential for guidance in planning and decision, by governments and organizations.

In this section no more than a preliminary and limited assessment is attempted, together with some conclusions and suggestions.

It is useful to recapitulate briefly the main facts and projections previously considered and this is done below.

a) THE MAIN FACTS:

i) The imbalance in world I.S. production

In 1973, Dg.C., with 70% (2.7 billion people) of world population produced only about 8% of world steel (55 Mt). Dd.C., with 30% of world population (1.1 billion) produced 92% of world steel (640 Mt). This corresponded to 21 kg/capita and 562 kg/capita, respectively, for Dg. and Dd.C.

This enormous disparity is directly related to, and representative of, the huge gap in economic development between the two groups of countries.

ii) The imbalance in world trade of iron and steel products - Dg.C. are net importers of over 30 Mt of steel per year, which costs them over $10 billion (including freight, insurance, etc.). This corresponds to about one third of their steel requirements. If one excludes China, the largest producer among developing countries, the imports of steel are roughly one half of the requirements of all other Dg.C. together, As a consequence, Dg.C. suffer a heavy drain of foreign exchange to import a basic material which they could produce locally. The ten billion dollars spent annually on steel imports could very well be used to cover other much needed imports, from food to capital goods.

iii) The imbalance in the production and trade of capital goods for the I.S. sector- Dg.C. are today almost fully dependent on Dd.C. for the supply of the specialized equipment and heavy structures needed for construction of I.S. plants. Although China and India have attained a high degree of self-sufficiency, all other Dg.C. depend on supplies of Dd.C. for 70 -100% of the "hardware" needed for the establishment or expansion of the steel sector.

iv) The imbalance in the availability of specialized "know-how" and technology - Dg.C. are almost totally dependent on Dd.C. for the know-how and technology required for planning, engineering and construction of iron and steel plants. This dependence could be measured in terms of the outlays for technical services (feasibility studies, sectoral planning, engineering and design, start-up and construction) but no specific statistics exist for this specialized "soft ware" trade. However, it can be estimated that it amounts to about 5 - 8% of total investment in the sector.

v) Unequal distribution and limited availability of essential raw materials - Good quality iron ore, coking coal and hydrocarbons are distributed rather unevenly in the world, with Dg.C. having an advantage regarding high quality iron ore and Dd.C. having an advantage regarding good quality coking coal. Dg.C. now supply 36% of the world requirements in "new iron" (contained in ore).

vi) Unequality in the availability of financial resources for I.S. development - With the exception of a few Dg.C. which have their own adequate means to finance their I.S. industry expansion, most Dg.C. have to rely on financing from external sources to cover a large and even predominant share of the huge investments required for the I.S. sector.

vii) The inexistence of any steel production in the majority of Dg.C. - Of a total of over 110 Dg.C. only about 45 have established steel production installations. Most of these are small scale and many are non-integrated facilities (based on scrap melting). Only 15 Dg.C. have facilities in operation for the reduction of iron ores and production of primary iron (pig iron or sponge iron). Thus, most Dg.C. belong to the group of non-producers ("zero steel countries").

b) THE BASIC FORECASTS AND TARGETS

i) The world I.S. production (and consumption) will likely grow by one billion tons until the year 2000 - A "moderate" forecast indicates that the world's I.S. consumption may reach some 1750 Mt by the year 2000.

ii) The Dg.C. iron and steel consumption should reach some 500 - 550 Mt by the year 2000 - A "moderate" forecast for the consumption of I.S. products in Dg.C. indicates that their minimum requirements would be 500 - 550 Mt/yr by 2000. Assuming a balanced I.S. trade (zero net exports - imports) with Dd.C., this would require production of the corresponding amount of steel (500 - 550 Mt) in Dg.C.

iii) The expansion of the world's I.S. production, between now and 2000, will be divided almost equally between Dd. and Dg.C. The increment of capacity should be, roughly, 500 - 550 Mt for each of the two groups. The situation is illustrated very schematically in Figure 18.

The facts summarized above in a) are indicative of an unsatisfactory situation existing at present. The facts, forecasts and targets suggested above are indicative of the extraordinary magnitude of the problems and opportunities that Dg. and Dd.C. will face in the expansion of their I.S. industry in the next quarter of a century.

Thus, for instance, to increase the installed capacity of Dg.C. by some 510 Mt until 2000 (this increase in capacity being the very minimum which could ensure an increase in production of some 470 Mt), Dg.C. would have to install 102 plants of 5 Mt capacity each, until 2000. Comparing these figures with the present situation of Dg.C., namely about 30 complexes of which capacity are 0.1 - 3 Mt in 15 countries, the magnitude of the efforts

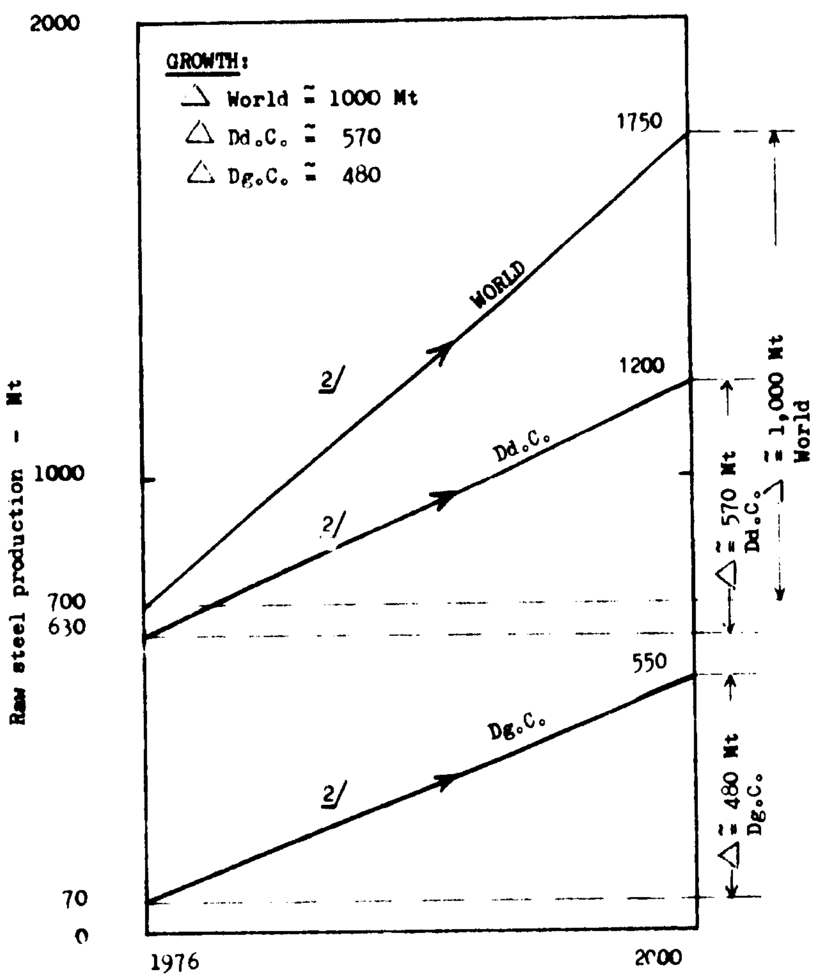


Fig. 18 Schematic comparison of the shares and growth of production in Dd.C. and Dg.C. (1976 - 2000) 1/

1/ The figures have been estimated and/or rounded and the graph is meant only as a simplified presentation of the order of magnitude of the growth of production from now to the year 2000.

2/ The inclined lines do not represent the evolution of production in intermediate years.

required become apparent.

On the other hand, a similar increase of capacity in Dd.C., will meet with no less problems, although some of these may be of quite a different nature than those encountered by Dg.C.

The necessary and probable growth of the world's I.S. industry in the next 25 years can be concisely stated as follows: Installation of about 1 billion tons of additional capacity, requiring a direct investment of over US$ 1 trillion[1/], the growth being about evenly split between Dd. and Dg.C.

A more detailed picture of the implications of the facts and forecasts previously presented can be found in Table X. The Table includes assumed "scenarios" for 1980, 1985 and 2000. It is emphasized here that the estimates presented are based on some uncertain assumptions and should be considered merely as a semi-quantitative basis for reference and discussion. The Table does convey, however, a broad view of the possible profiles of the I.S. industry at different points in time, in terms of a number of significant parameters.

In the sections below some of the implications of the targets and "scenarios" suggested before will be briefly considered.

4.1 RAW MATERIALS

Considering the huge quantities involved and the limited number of sources the supply of raw materials for the world's I.S. industry will become a critical one in the next 25 years. Mining, beneficiation installations and transportation (specially ports and shipping) will have to be developed to an unprecedented scale.

a) Iron ore

World consumption of iron ore may reach 1900 Mt by 2000, more than two times the present mining capacity. Since development of new large scale ore mines takes five to ten years and requires large investments for infrastructure, mine equipment and installations for ore processing, it is clear that this problem alone would merit close study and co-operation at the international level. It is likely that the dependence of the world I.S. industry on Dg.C. for iron ore supplies will increase due to the definite trend towards use of high grade ore, sinter, or pellets. Traditional sources of low grade iron ore are playing an increasingly secondary role in view of either exhaustion or higher costs of production associated with the use of such ores. The fast development of large scale transoceanic ore shipping in the recent past has given Dd.C. access to new sources of better iron ores, while providing Dg.C. with a new source of revenue.

The trends, in respect to iron ore, could be summarized as follows:

- Higher grade ores;
- Increasing use of beneficiated ore, specially pellets;

1/ This has been informally referred to as "the trillion dollar question"

TABLE X

Scenarios of world iron and steel industry up to the year 2000

(data and estimates based on "basic projection")

Item	1973 World Mt	1973 Dg.C. Mt	1973 Dg.C. %	1980 World Mt	1980 Dg.C. Mt	1980 Dg.C. %	1985 World Mt	1985 Dg.C. Mt	1985 Dg.C. %	2000 World Mt	2000 Dg.C. Mt	2000 Dg.C. %	Assumptions
1. Iron ore (beneficiated) production - Net export Dg.C. to Dd.C.	835	242 +153	29	1007	342 +144	34	1205	446 +220	37	1888	944 +24[illegible]	50	'73 '80 '85 2000 Ore/New iron 1.69 1.65 1.65 1.60 Dg.C. production share (%) 29 34 37 50
2. Coking coal production - Net export Dg.C. to Dd.C.	465	26 -26	5	488	37 -37	8	504	47 -47	9	440	75 -75	17	Coke/coking coal = 0.75 Use of non coking coal: '80=5%; '85=10%; 2000=25% 50% of Dg.C. consumption is to be imported from Dd.C.
3. Coke production	304	39	11	385	56	15	420	78	19	440	150	34	Coke ratio '73 '80 '85 2000 World/Dd .70/.75 .65/.70 .60/.65 .45/.50
4. Oil and natural gas consumption in the iron and steel industry	65	5	8	88	10	11	105	15	14	193	50	30	Oil and natural gas/raw steel (weight ratio) '73 = 0.09; '85 = 0.1; 2000 = 1.1
5. New iron production of which by DR 1/	494 2	53 1	11	610 17	90 7	15 40	730 34	137 17	19 50	1180 200	435 137	37 70	Per cent of DR 1/ for new capacity '73/'85 '86/2000 Dg.C. 20 40 Dd.C. 10 20
6. Scrap (inplant and purchase consumption	335	15	4	430	30	7	505	45	9	645	186	20	World scrap/raw steel = 0.48 Dg.C. '73 = 0.27; '85 = 0.3; 2000 = 0.35
7. Raw steel production - Net export Dg.C. to Dd.C.	695	55 -35	8	884	100 -45	11	1050	151 -60	14	1750	530 0	30	
8. Finished steel production	556	52	9	725	93	13	866	139	16	1496	450	30	Finished steel/raw steel = 0.8 ('73) - 0.85 (2000) 30% of import by Dg.C. are semis
9. Per capita steel production - Dd.C. (kg)	182	21 (562)		206	33 (637)		224	45 (692)		290	116 (820)		In terms of raw steel
10. Per capita steel consumption - Dd.C. (kg)	181	32 (531)		206	47 (601)		224	62 (645)		290	116 (820)		
11. Population (billion) - Dd.C.	3.82	2.67 (1.15)	70	4.30	3.07 (1.23)	71	4.69	3.39 (1.30)	72	6.06	4.56 (1.50)	75	Annual growth rate Dg.C. = 2%; Dd.C. = 1 %

1/ Should really talk in terms of non-coking coal BF process.

- Increasing share of Dg.C. in the international market;
- Increasing reliance on large scale transoceanic shipping and specialized ore-ports;
- Increasing control of Dg.C. over their own ore production;
- Increaseing efforts for local processing, for greater value added, towards export of pellets, pre-reduced ore (including "sponge iron "), "semis" (billets, slabs, blooms), etc.

The magnitude of the task of expanding iron ore production to the levels indicated before can be gauged by the following estimates:

- It will be necessary to develop the equivalent of 50 new mines producing 20 Mt/yr each.
- Transoceanic transportation may involve, by 2000, the equivalent of 1000 ships with 100,000 t capacity each.

b) Reductants

It is more appropriate, when discussing the problems of the world's I.S. industry to talk in terms of the supply of "reductants" rather than in terms of "energy". This is due to the fact that the basic first step essential for the operation and expansion of the I.S. industry is the reduction of iron oxides, an operation which depends on their reaction with reducing agents. These, in one form or another, pure or in mixtures, are: carbon, carbon monoxide and hydrogen. While the problem of energy supply can be solved by other means (hydroelectric generation, nuclear power, solar energy, etc.) there is no substitute for C, CO or H_2 in the reduction of iron oxides.

Of course, for reduction, steelmaking and rolling energy (as heat or electricity) is also necessary, and renewed efforts to decrease energy requirements of I.S. plants must be made , but the crucial problem remains the one of the "reductants" or reducing agents.

The main reducing agent used in the I.S. industry today is, by far, coke, produced from mixtures of coking coals. The tight supply and increasing price of coking coal will likely continue in the future because the reserves are mainly located in Dd.C. and the difficulty in expanding mining. Thus, the critical problem for the I.S. industry, epecially in Dg.C., is to decrease the dependence on coke (and on the blast furnace) and/or develop the use of non-coking coals, liquid hydrocarbons, natural gas and, when feasible, charcoal. The possible competitors to the coke operated blast furnace are the so called "direct reduction"1/ processes and the charcoal operated blast furnace.

Accordingly, the main trend of the efforts to decrease the dependence on coke has relied and will continue to rely mainly on the following measures:

1/ The abbreviation "D.R." is frewuently used.

i) Reduce coke consumption in conventional blast furnaces, through: careful control of the operation; charge preparation; use of high grade ores (or sinter, or pellets); injection of carbon rich solids, hydrocarbons and oxygen at tuyere level; increase the use of non-coking coals in the production of coal (mixed with coking coals).

ii) Develop and/or apply appropriate D.R. processes, according to local conditions, raw materials and reductants available (hydrocarbons or non-coking coals).

iii) Where possible, use charcoal operated blast furnaces.

4.2 SITE FACILITIES, INFRASTRUCTURE AND COMPREHENSIVE PLANNING FOR I.S. INSTALLATIONS

The very large new capacity to be installed until 2000 in Dd. and Dg. C. will face serious difficulties regarding site facilities (extensive, more or less flat areas with good soil-mechanics characteristics; abundant water; proximity or easy communication with deep water ports; distant from touristic or urban areas). The very fact of their lack of industrial development plus their much larger area, as a group, place Dg.C. in a favourable position in this respect.

Industrial saturation has led to unacceptable pollution levels in some areas of Dd.C., limiting the possibilities for establishment of new iron and steel capacity. The cost of anti-pollution equipment, which might be very high in strictly controlled industrialized or urban areas, might be much lower in developing countries where areas exist which can tolerate higher levels of pollution of the "non-destructive" type (non-toxic dust or fumes for example) far from urban areas. The cost of land is also generally much lower in Dg. than Dd.C. Water resources, increasingly scarce in Dd. C. may also dictate establishment of new capacities in Dg.C. Uncongested port facilities can also be found in Dg.C. near large ore deposits and mines.

On the other hand, lower costs related to infrastructure, ready availability of skilled personnel and proximity to their own markets may favour location of new I.S. plants in Dd.C. to attend to their own demand. However, the time is now past when this was practically the only viable option. Location of large scale I.S. plants in Dg.C. to supply the international market (with semi or finished products) is now a distinct practical possibility and is being increasingly considered.

As previously indicated, the transportation problem is a basic and serious one. Thus, by 2000, transportation of raw materials and products outside steel plants may reach the magnitude of 5 billion tons per year, for the world. Expansion of economic large tonnage transportation, particularly of transoceanic transport, will be an imperative. On the other hand, regional co-operation in sharing raw materials and products should be accelerated in order to decrease unnecessary long distance transportation as far as possible.

In planning new I.S. plants it is specially important to take into account their relation to their surroundings, not only in terms of infrastructure but also in terms of other related "up stream" suppliers and "down stream" industries (consuming steel or by-products of I.S. operations). Figure 19 schematically illustrates the relation of a steel-works with the required infrastructure and with other related industries. Most of the new capacity in developing countries is to be established in "green" sites where most of these requirements are frequently non-existant and this may add appreciably to initial investment. The Figure shows, among other, the connexions with "up-stream industries" such as: ferro-alloy, refractory, heavy foundry, heavy equipment, machinery, etc. It indicates the requirements of back up electric power, water and operating personnel. The typical main "down stream" industries are also indicated. Without a sound and dynamic growth of upstream and down-stream industries, the steel industry cannot operate satisfactorily.

The inter-connexion with other industries, the large investments required and the impact on the physical, economic and social environment frequently demand that new I.S. plants be planned in the context of a comprehensive industrial and economic development plan. This is particularly true in the case of Dg.C. in view of the larger relative impact and implications of initiatives in the I.S. sector. Overall national planning, with careful evaluation of goals, resources, methodology and timing is frequently essential.

Experience shows that I.S. production, even at a small scale, can be a potent activator of the local economy but it also shows that it can become a burden if its setting up and implications are not carefully evaluated beforehand and duly taken into account. Optimization of needs and capabilities can go even further if carried out regionally and internationally, as the experience of the European Iron and Steel Community indicated. Regional co-operation would seem to be a necessity for greater viability of the I.S. sector in Dg.C.

4.3. ALTERNATIVES AS TO SCALE AND PROCESS TECHNOLOGY

The I.S. plants now in successful operation in Dd. and Dg. C., for production of plain carbon steels, cover a wide spectrum in regard to scale and processes used. A diversity of raw materials and products (and by-products) are processed or produced, in a variety of equipment, at levels reaching over 10 Mt/yr or as low as 20,000 t/yr.

The spectrum of possibilities in use covers, for example:

- Iron ores: low grade oolithic ores with iron as low as 26 - 28 % and high phosphorus; hematites with over 60 % iron; taconites and itabirites needing ore dressing; etc.
- Iron containing materials for reduction to iron: screened ores; sinter; pellets.
- High iron content materials for steel making: scrap; pre-reduced ores; sponge iron; pig iron (liquid or solid).
- Reductants: coke; non-coking coals; charcoal; hydrocarbones (liquid or gaseous); hydrogen (for special iron powder production).
- Reduction furnaces: coke B.F.; charcoal B.F.; electric reduction furnace; rotary kilns of various types; vertical retorts of various types; fluidised bed units.

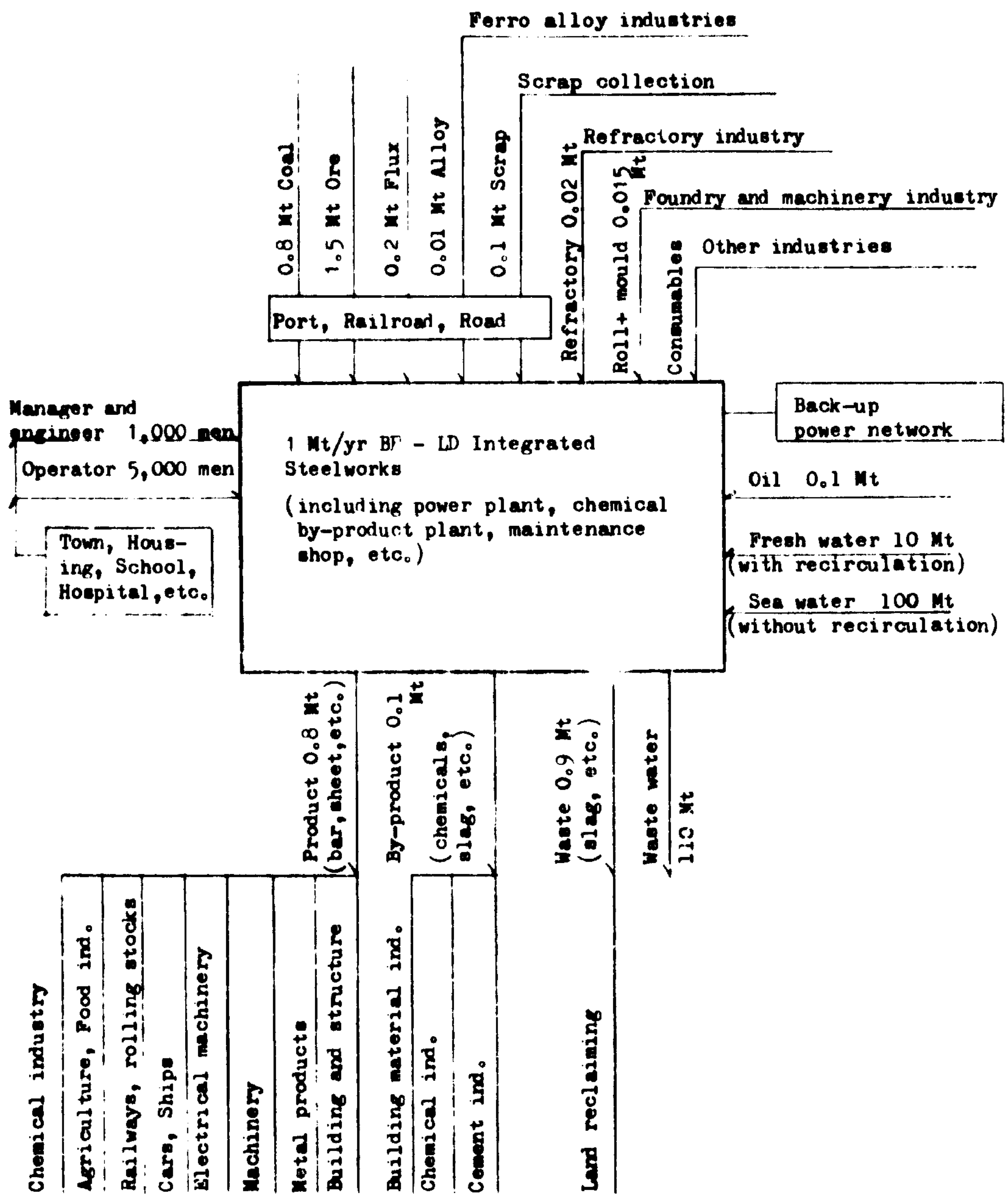


Fig. 19 Steel industry, infra-structure and related industries

- Steel making furnaces: oxygen converter; open hearth; electric arc furnace; induction furnace; Thomas and Bessemer converters; special type furnaces.
- Ingotting: conventional top and bottom-fed ingot molds; continuous casting (various types).
- Rolling: a wide variety of equipment is available to roll all types of plate, sheet, sections, bars, rod and tube products. They vary widely in size, degree of automation, principle of operation, output, etc.

The selection of process and equipment best fitted to local conditions (such as raw materials availability, reductants, energy, market situation, infrastructure, related industries, economic situation, etc.) is of vital importance for the success of newly installed steelworks. Table XI indicates various alternative routes which are in actual use today. It also indicates the normal ranges for capacity, number of employees, required construction period and cost. These figures change quite widely depending on local conditions and should be treated as only a rough indication of the scope of applicability of the various process routes.

The Table is self explanatory but the following points seem to be worthy of attention:

- There is a wide variety of processes, equipment and scale of operations to choose from.
- Small semi-integrated (steelmaking plus rolling) plants can be operated on the basis of scrap at scales as low as 20,000 t/yr.
- Pig iron can be produced at scales as low as 5,000 t/yr (for foundries).
- Small integrated plants based on the charcoal BF can be very successfully operated at scales as low as 100,000 t/yr (and even lower, under special conditions).
- Certain D.R. processes can be the basis for fully integrated plants (ore to product) at scales as low as 100 -150,000 t/yr. Production of sponge for sale is also an interesting option for certain Dg.C.
- In certain cases production is carried out only to the semi-product stage (slab, bloom, billet) which is then shipped for processing elsewhere in the country or exported. Certain Dg.C. seem to have good possibilities in this connexion.

It should be noted that for some of the process route options outlined in Table XI certain Dg.C. are in a position to assist other Dg. C. better than Dd.C. would be able to. This is particularly true for certain D.R. processes and for charcoal based I.S. production.

4.4. KNOW-HOW, TECHNOLOGY AND PERSONNEL

Know-how and technology may make the difference between success and failure in the expansion of such a capital intensive sector as iron and steel. Although the basic science and technologies used today in the I.S. industry have been essentially available for a long

Table XI

Technological alternatives

Type		Material ——— Process ——— Product	Application	Capacity of works (1000t/y)	Number of employees (persons)	Period of construct. (years)	Capital investment (million $)
				very	rough	estim	ates
I	a1 a2 a3	Billet ——— Bar/Section mill ——— Bars, light sections Cold coil/sheet - Coating line ——— Galvanised sheets, tin plates Hot coil ——— Tube/pipe machine ——— Tubes, pipes	Countries with very low steel consumption and without any significant raw materials. Material supplying countries often supply finance and technology.	30 (10/100)	200	2	5
I	b1 b2 b3	Hot coil ——— Cold rolling mill — Coating line ——— Flats Bloom ——— Billet/Bar/Section mill ——— Non-flats Slab ——— Hot rolling mill — Cold rolling mill — Coating line — Flats	There are very few countries using those types today, but may become very important for regional and sub-regional co-operation in connexion with types IV, b1, b3	500 (100/ 1,000)	1,200	2-3	75
II		Scrap / Sponge iron / Cold pig — EF — [Ingot / CC] ——— Rolling mill ——— Mainly non-flats	Most common in developing countries. Availability of scrap at reasonable prices is most important. World wide spread of DR pellets may greatly contribute to the development of this type.	100 (20/400)	800	2	25
III	a	Charcoal / Ore — Charcoal BF ——— Foundry pig iron	Highly recommended for those countries which have forest resources and are going to initiate steel industries.	10 (5/40)	50	2	1
III	b	Charcoal / Ore — Charcoal BF ——— LD ——— [Ingot / CC] ——— Rolling mill ——— Mainly non-flats	Countries with forest resources may become self-sufficient in steel utilising this type with relatively low investment	200 (150/ 400)	2,000	2-3	100
III	c	Non-coking coal / Ore — Electric reduct. furnace — LD — [Ingot / CC] ——— Rolling mill ——— Non-flats and flats	Countries with abundant electricity with low cost but good coking coal may advantageously employ this type	200 (150/ 1,000)	2,000	2-3	100
IV	a1	Coke / Ore — BF ——— LD ——— [Ingot / CC] ——— Rolling mill ——— Non-flats and flats	Applicable for countries with large market and relatively high level of industrialisation	1,000 (300/ 10,000)	6,000	5-6	800
IV	a2	Gas (or coal) / High grade ore — DR ——— EF ——— [Ingot / CC] ——— Rolling mill ——— Non-flats and flats	Gas rich countries are most advantageous. Flexibility in scale of works is also advantageous for developing countries	500 (150/ 1,500)	3,000	3-4	250
IV	b1	Coke / Ore — BF ——— LD ——— CC ——— Slabs, Blooms, Billets	Ore rich countries may have this type with long range export agreements of semis.	2,000 (2,000/ 10,000)	4,000	5-6	1,200
IV	b2	Gas (or coal) / High grade ore — DR ——— DR pellets	Gas rich countries may contribute the development of type II in many developing countries by stable supply of pellets	1,000 (1,000/ 5,000)	1,500	3-4	150
IV	b3	Gas (or coal) / High grade ore — DR ——— EF ——— CC ——— Slabs, Blooms, Billets	Gas rich countries may have this type with long range export agreements of semis	1,000 (1,000/ 3,000)	2,500	4-5	400

time, the sector is very sensitive to small improvements obtained through long term research and development, or through slow accumulation of operating experience.[1]

The main critical areas where know-how is essential in the I.S. industry are: overall planning and feasibility evaluation; plant design and engineering; equipment design and manufacture; plant construction; process and product development and control; management of operations.

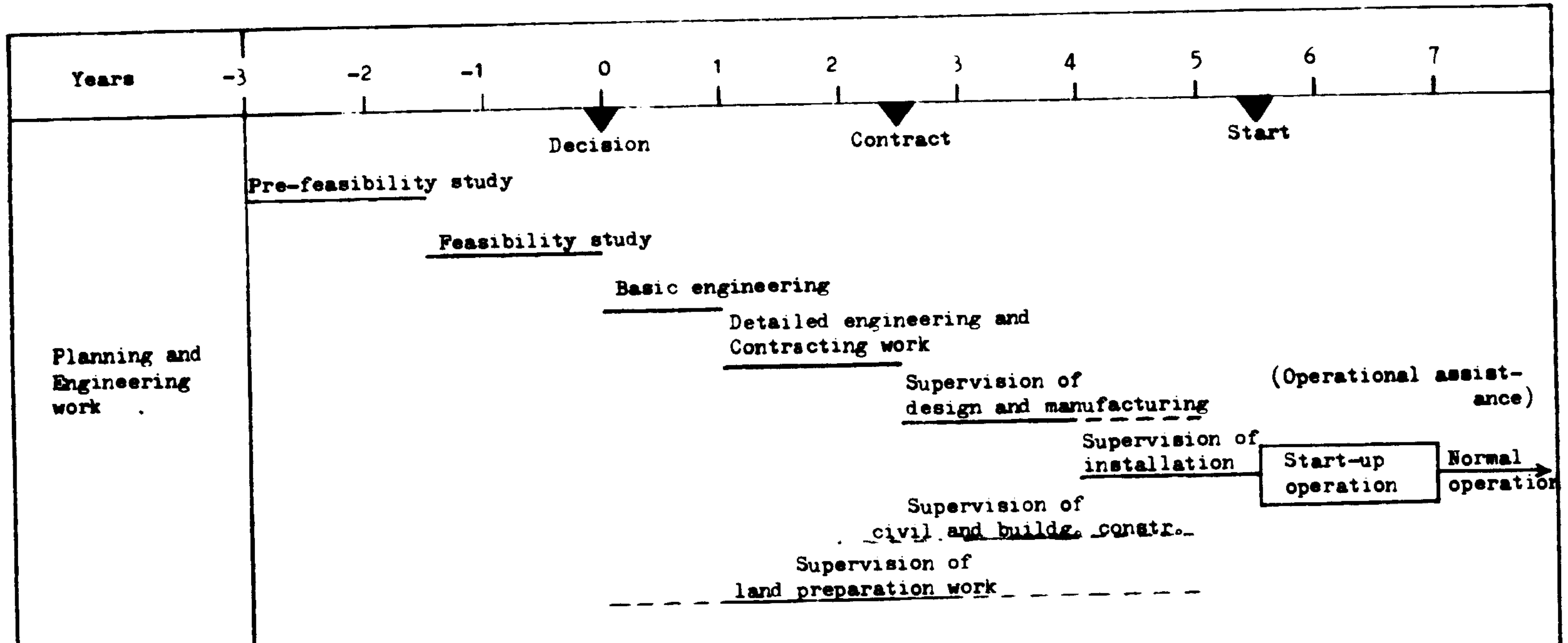
In all of the above areas Dd.C. have today a decided advantage and the expansion of the world's I.S. industry will depend, to a great extent, on their collaboration with Dg.C. in know-how and technology arrangements.

Figure 20 illustrates the many steps required between planning and operation along with a rough estimate of man-power requirements for the construction of large-scale integrated steelworks. Selection of the best site, most appropriate design of plant, most economic purchase of equipment and structures, shortening of construction period and shortest possible start-up period are the main criteria for the planning and engineering of new steelworks.

As indicated in the Figure, establishment of a steelworks takes a long time and requires a large number of trained personnel. Only long experience and accumulation of know-how and technology can develop the planning and engineering capability needed.

At present in the iron and steel sector, Dg.C. are almost totally dependent on Dd. C. for the know-how and technology required for sectional planning; plant design, engineering and construction; plant operations and management; process and product engineering. This dependence could be measured in terms of the outlays for technical services (feasibility studies, sectoral planning, engineering and design, start-up and construction) but no statistics exist for this specific "soft ware" trade. However, it can be estimated that it amounts to about 5 - 8 % of total investment in the sector. On the basis of the growth projected for the I.S. sector of Dg.C. some 95 Mt will have to be established in the decade 1976 - 1985, involving an investment of the order of 85 billion US$. This would correspond to about 5 billion US$ of technical services required by Dg.C. Since some of the Dg.C. have a substantial capability in this broad area (China, India, Brazil, Mexico, Argentina, etc.) it could be roughly estimated that 80 % of the amount mentioned will have to be spent abroad, i.e. 4 billion US$ in the decade. Apart from the fact that the outlays in foreign currency for specialised services imported from Dd.C. will be substantial in themselves, there is a more important consideration to be kept in mind: the decisions made or implied in the preparation of feasibility studies or in the engineering of new plant installations have a direct bearing on Dg.C. and to a large extent control the choice of process and equipment.

1/ The I.S. industry has never had a technological breakthrough comparable to that of the transistor, for example. The oxygen converter, which revolutionised the economics of the industry, had been proposed one century ago by Bessemer.



	-3 to -2	-1	0 to 1	1 to 2	2 to 4	4 to 5	6 to 7
No. of Engineers and Management staff	20 - 100	50 - 150	100 - 300	200 - 500	300 - 700	500 - 1,000	1,000 - 1,500
No. of land prep. workers	-	-	-	500 - 1,000	500 - 1,000	-	-
No. of construct. workers	-	-	-	-	5,000	5,000 - 10,000	-
No. of operators	-	-	-	-	(100 - 1,000)	(2,000-5,000)	5,000 - 10,000

Fig. 20 Engineering work and manpower requirement for the construction of 1 - 2 Mt/yr integrated steelworks (rough estimates)

Thus Dg.C. frequently find themselves burdened with solutions and industrial installations which are not really the best suited to their conditions and needs. Furthermore, the dependence on imported know-how restricts the development of local capability, specially regarding technical services and capital goods production.

Besides the purchase of explicit know-how (technical services mentioned above) Dg.C. also are importers of large amounts of implicit know-how, i.e. the know-how "built into" the equipment they buy abroad for their I.S. plant installations. It can be roughly estimated that 20 % of the cost of the plant equipment purchased abroad corresponds to payments for know-how (designers, mechanical engineers, skilled technicians and workers etc.). Thus, the true cost of know-how, both in terms of total requirements and in terms of imported know-how, would be much higher than the figures quoted for technical services alone.

It is imperative for Dg.C., as a community, or individually, to develop to a maximum extent possible, their local capability for planning, engine ring, design, construction and start-up of new I.S. capacities. This will require: establishment of local consulting and engineering firms or organisations, private or under government sponsorship. A variety of such firms would be needed in the larger Dg.C., with a certain degree of specialization in the various types of services required. In the smaller Dg.C. or in those Dg.C. where industrialisation is taking the first steps possibly a government organization could be put in charge of development of local sources of know-how in the I.S. sector. It should be emphasized that know-how is needed even to evaluate, select and purchase know-how from abroad. It is also essential to have a local capability to evaluate and reach decision regarding planning and investment. Apart from incentives and support which Dg.C. governments may wish to extend to stimulate the establishment of specialized technical services, it is clear that there is ample room for constructive international cooperation in this area.

Dg.C. should lay special stress on the development of local know-how capability, beginning with the civil works, then tackling auxiliary facilities and finally planning and engineering the main plant. Steelworks always require modernisation and plant operators are easily adapted for modernisation planning. Some of the developing countries already ask foreign engineering companies to use domestic engineering capability as much as possible so as to transfer know-how and technology to local personnel. Construction of steelworks by "turn-key" contacts with foreign enterprises sometimes results in serious operating difficulties. The maximum use of domestic human resources and capability, from the stage of planning and engineering is the key factor for successful operation.

Some of the steelworks of Dg.C. are producing today at only a part of their capacity, inspite of high demand for I.S. products in the local market. In most such cases the lack of a sufficient number of trained managerial and technical personnel is the main reason for this. Since, in a capital intensive industry such as the steel industry, low utilisation of equipment is the main cause for increased costs, training of managerial and technical personnel is essential.

The number of personnel directly required for operation varies largely with location and plant size. For the developing countries the number may reach 6,000 to 10,000 men for a 1 Mt/yr. integrated works, with a productivity of the order of 100 - 170 t/man yr, which is low. For a production of 530 Mt in 2,000 some 3 to 5 mill. workers would be necessary, on this basis, of which some 20 % (equal to 0.6 to 1 million) are to be well trained management and technical personnel and another 30 % should be at least skilled workers. The figures are indicative of the order of magnitude of the problems to be encountered.

It should be noted that it is necessary to train a considerable part of workers well before the start-up of the works and even for a long time after that. Educational and training facilities are of highest importance for a smooth operation and must be a permanent feature of plant activities.

Particular attention is needed for the training of maintenance workers and for establishment of a maintenance system which is best fitted to the particular local conditions. A stop in operation of a certain plant department within an integrated works means in many cases a stop of the works as a whole. Without the back-up of a well established maintenance system it is impossible to maintain production at a steady and efficient pace.

In the ultimate analysis the critical factor for successful establishment and operation of I.S. plants is the availability of local personnel of the highest caliber. The development of full local capability for planning, engineering, construction and operation is directly related to education and training, requiring and justifying a special effort at the national and international levels.

4.5 CAPITAL GOODS

Dg.C. are today almost fully dependent on Dd.C. for the supply of the specialized equipment and heavy structures needed for construction of I.S. plants. Although China and India have attained a high degree of self-sufficiency, all other Dg.C. depend on supplies of Dd.C. for 70 - 100 % of the "hardware" needed for the expansion of the steel sector.

Dg.C. will constitute, in the next 25 years, a market for capital goods (equipment and structures) of roughly the same size as the market for the same goods in all Dd.C. In any case, the capacity to be installed in Dg.C. in the decade from 1975 to 1985 alone will be of the order of 95 Mt which represent a market for capital goods equivalent to 2 - 4 times the total capacity installed in the largest producers of Western Europe, for example. This large new market for capital goods certainly justifies the expansion or the establishment of facilities for production of such goods in the developing countries themselves.

The objectives would be justifiable in terms of: savings in foreign exchange; greater degree of self-sufficiency and self-reliance; acquisition of critical technological capabilities; possibilities of designing and building equipment to the specifications appropriate to local conditions; creation of specialized jobs and opportunities for advancement for local workers.

It is recognized that the production of capital goods requires highly skilled management and technical personnel. However, on one hand, there is no reason to believe that this is not possible to achieve in Dg.C. and, on the other hand, there is really no alternative since Dg.C. would be unable to expand their I.S. industry in accordance with the Lima target unless they have their own sources of heavy capital goods to cover at least 70 - 80% of their overall needs. Since various other sectors of the industry and infrastructure also requires heavy capital goods, it is certain that the market in Dg.C. as a whole, more than justifies further installation of local production capacity.

The steel industry is the largest consumer of capital goods. In order to construct a 1 Mt/yr steel works some 0.2 Mt of equipment and heavy structurals have to be used. This means that in order to reach the target previously suggested for developing countries, roughly 100 Mt of heavy capital goods equipped with sophisticated instrumentation will have to be supplied within 25 years. If the requirements for modernization and maintenance of steel plants are taken into account, the figure will increase considerably. Since capital goods are very expensive and the world production capacity limited, the creation of new capacity to produce heavy equipment and structurals locally is of great importance for Dg.C. Without the creation of such capability, the dependence of Dg.C. on Dd.C. may reach levels which will become a burden for both sides.

In this connexion, it is worth to mention that some developing countries are applying the following measures to promote domestic capital goods production capacity:

(i) Promoting the establishment of companies for local production of capital goods under joint venture arrangements;

(ii) Requiring foreign suppliers to use a certain percentage of domestic capital goods even if these are considerably more expensive than imported goods;

Table XII includes estimates of the expenditures of Dg.C. for capital goods, in the period 1976 - 2000, yearly and by quinquennia. The figures are only meant, again, to provide a basis for discussion of the order of magnitude of problems to be faced and of the corresponding action required. The estimate adds up to $265 billion in the 25 years period, corresponding to about 100 Mt of heavy "custom built" capital goods and structures.

The considerations above clearly point out another fruitful area for international co-operation.

4.6 FINANCING

With the exception of a few Dg.C. which have their own adequate means to finance their I.S. industry expansion, most Dg.C. will have to rely on financing from external sources to cover a large and even predominant share of the huge investments required in the periods from now to the year 2000. Reference is made to Table XII which indicates a preliminary estimate of new capacity to be added yearly or by quinquennia. In the decade 1976 - 1985 some 95 Mt will have to come "on stream", meaning that it must be built and put into full operation. It should be remembered that in the same decade further investment will have to be made into installations which will not yet be productive in the decade. Accordingly, it

TABLE XII

Capacity Increasee, Investment and Equipment Requirements 4/

(Rough estimates)

Year	Product-ion (Mt)	Capacity (Mt)			Invest.(billion $) 2/4/		Equipm.a.structure (billion $) 3/4/	
		Annual 1/	Increase		Requirement		Requirement	
			Quin.	Yearly	Quin.	Yearly	Quin.	Yearly
1973	55.6							
76	71.4	84.0		7		6		3
77	77.6	91.3		7		7		4
78	84.4	99.3	40	8	36	7	20	4
79	91.7	107.9		9		8		4
1980	99.7	117.3		9		8		5
81	108.4	123.8		9		8		5
82	117.8	134.6		9		9		5
83	128.0	146.3	56	12	50	10	28	5
84	139.2	159.1		13		11		6
1985	151.3	172.9		13		12		7
86	164.5	188.0		15		15		9
87	178.8	204.3		16		16		9
88	194.3	222.1	89	18	85	17	47	9
89	211.2	241.4		19		18		10
1990	229.6	262.4		19		19		10
91	249.6	277.3		19		20		10
92	271.3	301.4		22		21		12
93	294.9	327.7	125	25	119	24	65	13
94	320.5	356.1		28		26		14
1995	348.4	387.1		31		29		16
96	378.8	420.9		33		32		18
97	411.7	457.4		36		34		19
98	447.5	497.2	200	40	190	38	105	21
99	486.5	540.6		44		42		23
2000	528.8	587.6		47		45		24
	TOTAL	510			480		265	

1/ Operation ratio 1976 - 1980: 85 %
1981 - 1990: 87.5 %
1991 - 2000: 90 %

2/ Total investment New inetallation: $1,000 ton
Expansion: $600/ton
1976 - 1985: New installation 75 % = $900/ton
1985 - 2000: New installation 85 % = $950/ton

3/ Equipment and heavy structure: 55 % of total investment

4/ The figures for a given period correspond strictly to the requirements for the actual increase in production in the period considered. No provision has been made for modernization, maintenance and construction of capacity to come on stream in the following period.

will be necessary to secure financing to cover most of the new capacity to be installed and operated in the decade (it is considered that a part of this has already been secured) plus the financing of capacity which will still be under construction by 1985. If we consider only the capacity to be installed and operated the requirement will be of the order of $86 billion. Of this total figure a good share will be, of course, in national currency, to be spent locally. This share could be of the order of 50% for the Dg.C. as a whole, taking into consideration that a number of these countries can secure locally part of the necessary services, materials of construction and equipment. Of the part of the investment which will have to be financed in foreign currency some Dg.C. can count on their balance of trade surpluses. It is not easy, without further analysis, to arrive at the remaining share to be financed by the Dd.C. but it could be as high as 20% of overall investment requirements (or some $17 billion), or about 45% of overall goods and services to be purchased abroad in the period ($17 billion out of a total of $39 billion).

Table XIII presents a rough estimate of needs and capabilities in financing the expansion of Dg.C. I.S. industry in the future. It is merely illustrative and intended to indicate orders of magnitude only.

One important problem related to the huge investements required is the matter of "profitability" of the industry. In order to ensure its growth the industry must make profits to justify the investements for further development. On the other hand, the steel industry is responsible for the stable supply of basic products to the market, at a low price. Large fluctuations in price of such essential materials as took place in recent years should be avoided. Furthermore, the steel industry of Dg.C. is "weak" as compared to the giant modern complexes in the developed countries. Because of smaller scale of plants and lower utilization ratio of equipment this weakness is likely to continue for some time except for some plants which are exceptionally well located. Efforts should be made to determine the appropriate conditions under which the I.S. industries of Dg.C. may have its viability and profitability ensured.

4.7. TRADE ASPECTS

The present picture regarding trade, on the basis of a preliminary analysis has been presented before (See Section 2.4).

The implications regarding the future of trade related to the I.S. Sector would require a detailed analysis which cannot be undertaken here. Studies by UNCTAD are under way and will likely become available in the near future.

However, for a rough idea of the magnitudes involved, the concise picture presented in Figure 21 could be useful. Using the basic projections of Section 3.5, the Figure summarizes the overall net trade for the whole period 1976 - 2000. The possible accumulated values of net trade for steel, iron ore, coking coal, hydrocarbons, equipment and engineering are indicated.

Table XIII Foreign currency and external finance requirements by Dg.C.[1/]

Item	Group [2/]	Arab Countries		Advanced Dg.C. (Argentina, Mexico, Brazil, India, etc.)		Centrally planned Dg.C. (China, Korea DPR, Cuba, etc.)		Other countries		Total	
	Period	76/85	86/2000	76/85	86/2000	76/85	86/2000	76/85	86/2000	75/85	76/2000
I Production increase (Mt)		12	47	40	145	25	110	5	80	81	382
II Capacity increase [3/] (Mt)		14	51	47	157	29	119	6	87	95	414
III Investment total (b$)		13	48.5	42	149	26	113	5.5	83	86	394
Engineering [4/]	(6%)	1	3	2.5	9	1.5	7	0.5	5	5	24
Equipm. and structurals	(55%)	7	26.5	23.5	82	14	62	3	46	47	217
Civil and electr.	(29%)	4	14	12	43	7.5	33	1.5	24	25	114
Others [5/]	(10%)	1	5	4	15	3	11	0.5	8	8.5	39
IV External dependence (%)											
Engineering		95	80	80	50	30	10	95	80		
Equipm. and structurals		95	70	70	30	30	10	95	70		
Civil and electr.		70	50	20	0	C	0	70	50		
V Purchase from abroad (b$) (foreign currency requirement) [6/]		2	28.5	21	29	4.5	7	4	48	38.5	112.5
Engineering		1	2.5	2	4.5	0.5	1	0.5	4	4	12
Equipm. and structurals		7	19	16.5	24.5	4	6	3.0	32	30.5	81.5
Civil and electr.		1	7	2.5	0	0	0	0.5	12	4	19
VI Dependence for finance by Dd.C. for purchase from abroad (%)		0	0	60	40	10	10	80	60		
VII Finance requirement from Dd.C. for purchase from abroad (b$) [7/]		0	0	13	12	0.5	0.5	3	29	16.5	41.5

1/ Based on uncertain assumptions, thus the table should be treated as an indicative one.
2/ Very rough grouping according to characteristics of countries.
3/ See note of Table XII, do not include capacity replacement.
4/ Include frim pre-feasibility study to plant operation know-how.
5/ Working capital and pre-operational expenses.
6/ Calculated multiplying each component of item III by corresponding component of item IV.
7/ Calculated multiplying item V by item VI. Some countries may require external finance on domestic expenditure, but this is not considered here.

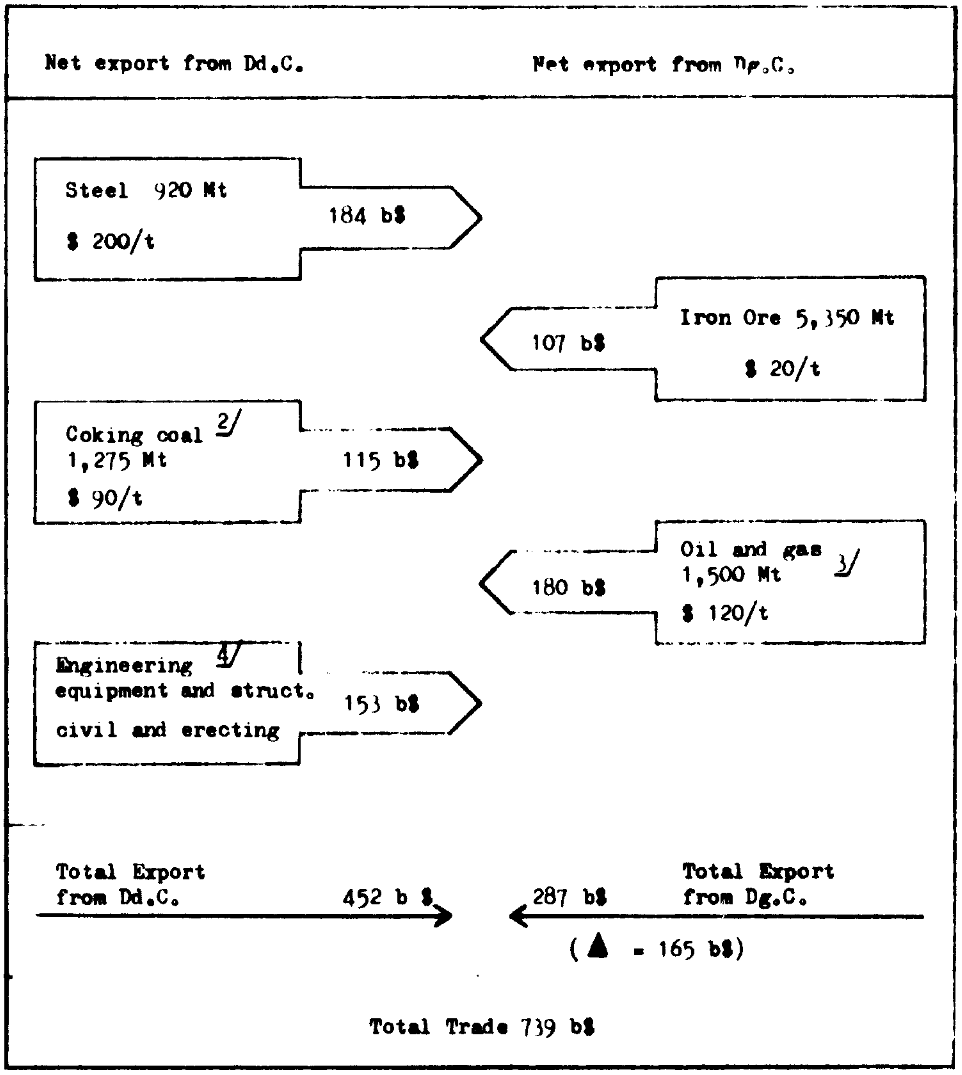


Fig. 21 Trade directly related to steel industry between Dd.C. and Dg.C. (1976 - 2,000 accumulated) 1/

1/ Based on estimates of Table X "Scenario" and current (1976 unit price. Very rough estimate to indicate magnitude of trade.

2/ Assumed 50 % of Dg.C. consumption is to be imported from Dd.C.

3/ Assumed consumption of 100 kg/t-steel and 60 % of Dd.C. consumption is to be imported from Dg.C.

4/ Refer to Table XII

ANNEX Table 1

Some basic statistics related to the iron and steel industries by region and country (1973)

Notes:

1. All the production and consumption figures refer to that of 1973 and * indicate that the figures are not known but the presence is apparent or highly possible.
2. Iron ore production figures are given in terms of Fe content.
3. Iron ore resource figures are given in terms of ore and data is taken from "Survey of world iron ore resources: Occurrence and Appraisal" published in 1970 by UN.
4. Iron ore resource, coal resource and coking coal resource are the sum of measured and exploitable reserve and inferred or potential resources.
5. On the other hand oil reserve and natural gas reserve are measured and exploitable reserves.
6. Data source of coking coal resource is "Metallurgical coal in the seventies" by W.Bellano, IISI conf., Paris, 1970. Some adjustment to allocate to countries and regions are made.
7. Other data are taken from the sources identified in explanatory notes.
8. Natural gas production does not include "flared" one.
9. Abbreviations used:
   Prod. = Production, Cons. = Consumption, Res. = Reserves and Resources
10. "Prod.1/" indicates iron contained
    "Res.2/" indicates coking coal only

ANNEX Table 1.1

COUNTRY or REGION	Population (mill.)	GDP per capita (US$)	Crude Steel (Mt) Prod.	Crude Steel (Mt) Cons.	Crude Steel p. capita (kg) Prod.	Crude Steel p. capita (kg) Cons.	Iron Ore (Mt) Prod.[1]	Iron Ore (Mt) Res.	Coal (Mt) Prod.	Coal (Mt) Res.	Coal (Mt) Res.[2]	Oil (Mt) Prod.	Oil (Mt) Res.	Natural Gas (1000 M^3) Prod.	Natural Gas (1000 M^3) Res.
S.S. AFRICA															
1 Angola	6.06	495	*	0.123	*	20	3.8	1,339	—	—	—	8.2	185	0	41
2 Benin	2.91	133	—	—	—	—	—	210	—	—	—	—	—	—	—
3 Burundi	3.60	93	—	0.015	—	4	—	—	—	—	—	—	—	—	—
4 Central African R.	1.71	185	—	—	—	—	—	—	—	—	—	—	—	—	—
5 Chad	3.87	87	—	—	—	—	—	—	—	—	—	—	—	—	—
6 Congo	1.00	477	—	0.044	—	44	—	5,200	—	—	—	2.1	100	0.016	142
7 Ethiopia	26.08	92	*	0.057	*	2	—	27	—	—	—	—	—	—	—
8 Gabon	0.52	1063	—	0.081	—	156	—	1,116	—	—	—	7.6	172	0.040	187
9 Ghana	9.36	296	*	0.053	*	6	—	405	—	—	—	—	—	—	—
10 Guinea	4.21	113	—	0.006	—	1	—	1,554	—	—	—	—	—	—	—
11 Ivory Coast	4.64	553	—	0.120	—	26	—	2,400	—	—	—	—	—	—	—
12 Kenya	12.43	184	*	0.200	*	16	—	27	—	—	—	—	—	—	—
13 Liberia	1.66	288	—	0.037	—	22	23.5	713	—	—	—	—	—	—	—
14 Madagascar	7.23	179	—	0.042	—	6	—	251	—	60	—	—	—	—	—
15 Malawi	4.79	110	—	0.019	—	4	—	—	—	38	—	—	—	—	—
16 Mali	5.38	60	—	—	—	—	—	69	—	—	—	—	—	—	—
17 Mauritania	1.26	260	—	—	—	—	6.8	465	—	—	—	—	—	—	—
18 Mauritius	0.88	411	—	—	—	—	—	—	—	—	—	—	—	—	—
19 Mozambique	8.82	374	—	0.036	—	4	—	509	0.39	700	*	—	—	—	—
20 Niger	4.30	111	—	—	—	—	—	680	—	—	—	—	—	—	—
21 Nigeria	59.61	227	*	0.710	*	12	—	266	0.33	359	—	101.8	2.415	0.303	1.370
22 Rwanda	3.98	83	—	0.015	—	4	—	—	—	—	—	—	—	0.001	*
23 Senegal	4.23	266	—	0.057	—	13	—	100	—	—	—	—	—	—	—
24 Sierra Leone	2.67	207	—	0.015	—	6	1.4	200	—	—	—	—	—	—	—
25 Somalia	3.00	118	—	—	—	—	—	170	—	—	—	—	—	—	—
26 S. Rhodesia	5.90	385	0.300	0.280	51	47	0.3	3,738	3.06	6,613	*	—	—	—	—
27 Swaziland	0.46	309	—	—	—	—	1.4	233	0.14	5,022	*	—	—	—	—
28 Togo	2.11	196	—	0.011	—	5	—	642	—	—	—	—	—	—	—
29 Uganda	10.81	154	*	0.011	*	1	—	98	—	—	—	—	—	—	—
30 Upper Volta	5.74	84	—	—	—	—	—	50	—	—	—	—	—	—	—
31 U.R. Cameroon	6.17	303	—	—	—	—	—	120	—	—	—	—	—	—	—
32 U.R. Tanzania	14.38	127	—	0.096	—	7	—	121	0.003	370	—	—	—	—	—
33 Zaire	23.56	136	—	0.138	—	6	—	—	0.115	720	—	—	—	—	—
34 Zambia	4.63	444	—	0.126	—	27	—	346	0.94	154	—	—	—	—	—
35 Others	5.09	—	—	—	—	—	—	1,600	0.02	506	—	—	—	—	—
Total	263.1	~250	0.415	2.40	1.6	9.1	37.2	22,600	5.1	14,500	1,000	120	2,950	0.36	1.750

ANNEX Table 1.2

COUNTRY or REGION	Population (mill.)	GDP per capita (US$)	Crude Steel (Mt) Prod.	Crude Steel (Mt) Cons.	Crude Steel per capita (kg) Prod.	Crude Steel per capita (kg) Cons.	Iron Ore (Mt) Prod.1/	Iron Ore (Mt) Res.	Coal (Mt) Prod.	Coal (Mt) Res.	Coal (Mt) Res.2/	Oil (Mt) Prod.	Oil (Mt) Res.	Natural Gas (1000 K^3) Prod.	Natural Gas (1000 K^3) Res.
ARAB COUNTRIES															
1 Algeria	15.77	457	0.186	0.834	12	53	1.7	1,521	0.02	20	—	[illegible]	1,272	4.7	[illegible]
2 Bahrain	0.23	935	—	0.054	—	235	—	—	—	—	—	3.4	[illegible]	0.23	54
3 Egypt	35.62	251	0.290	0.797	8	22	0.3	433	0	25	—	8.5	[illegible]	[illegible]	[illegible]
4 Iraq	10.41	645	*	0.624	*	60	—	—	—	—	—	[illegible]	[illegible]	1.2	[illegible]
5 Jordan	2.54	317	*	[illegible]	*	25	—	—	—	—	—	—	—	—	—
6 Kuwait	0.88	8058	—	0.189	—	215	—	—	—	—	—	138.7	[illegible]	5.3	1,112
7 Lebanon	3.06	894	*	0.514	*	168	—	—	—	—	—	—	—	—	—
8 Libyan Arab R.	2.16	3396	*	0.693	*	321	—	2,076	—	—	—	104.9	[illegible]	10.9	814
9 Morocco	16.31	306	0.001	0.390	*	24	0.2	149	0.57	96	—	0.04	0	0.07	1
10 Oman	0.72	492	—	—	—	—	—	—	—	—	—	14.5	454	0	71
11 Qatar	0.09	5938	—	—	—	—	—	—	—	—	—	27.6	715	1.6	[illegible]
12 Saudi Arab R.	8.44	1299	—	0.810	—	96	—	403	—	—	—	364.3	13,157	3.2	[illegible]
13 Sudan	16.90	154	—	0.125	—	7	*	61	—	—	—	—	—	—	—
14 Syrian Arab R.	6.89	357	*	0.219	*	32	—	—	—	—	—	5.5	[illegible]	[illegible]	35
15 Tunisia	5.51	451	0.136	[illegible]	25	52	0.4	75				3.7	54	[illegible]	41
16 U.Arab Emirates	0.21	6736	—	—	—	—	—	—	—	—	—	74.1	2,739	2.0	[illegible]
17 Yemen	6.29	129	—	—	—	—	—	—	—	—	—	—	—	—	—
18 Yemen D.	1.56	110	—	—	—	—		—	—	—	—	—	—	—	—
19 Neutral zone												26.5	1,423	—	1,472
Total	133.6		0.650	5.650	4.9	42.3	2.6	4,780	[illegible]	140	—	921	[illegible]	29.6	[illegible]

ANNEX Table 1.3

COUNTRY or REGION	Population (mill.)	GDP per capita (US$)	Crude Steel (Mt) Prod.	Crude Steel (Mt) Cons.	Crude Steel per capita (kg) Prod.	Crude Steel per capita (kg) Cons.	Iron Ore (Mt) Prod.1/	Iron Ore (Mt) Res.	Coal (Mt) Prod.	Coal (Mt) Res.	Coal (Mt) Res.2/	Oil (Mt) Prod.	Oil (Mt) Res.	Natural Gas (1000 M³) Prod.	Natural Gas (1000 M³) Res.
LATIN AMERICA															
1 Argentina	24.29	1229	1.995	4.123	82	170	0.1	392	0.45	555	*	21.5	[illegible]	[illegible]	192
2 Bolivia	5.33	201	—	0.133	—	6	—	42,268	—	—	—	2.2	28	2	[illegible]
3 Brazil	101.43	765	7.150	9.519	70	94	39.4	40,214	2.3	[illegible]	*	8.3	101	1.2	27
4 Chile	10.23	696	0.508	0.660	50	65	5.8	1,872	1.4	3,945	*	1.5	[illegible]	4.1	[illegible]
5 Columbia	23.21	516	0.266	0.664	11	28	0.4	772	3.3	[illegible]	[illegible]	4.5	222	1.7	24
6 Costa Rica	1.87	798	*	0.103	*	55	—	—	—	—	—	—	—	—	—
7 Cuba	9.92	540	0.220	0.510	25	57	*	5,115	—	—	—	0.14	*	—	—
8 Dominican R	4.43	529	—	0.101	—	23	—	43	—	—	—	—	—	—	—
9 Ecuador	6.93	392	—	0.135	—	20	—	—	—	—	—	10.7	823	[illegible]	117
10 El Salvador	3.86	333	*	0.055	*	14	—	—	—	—	—	—	—	—	—
11 Guatemala	5.54	468	*	0.098	*	18	—	—	—	—	—	—	—	—	—
12 Guyana	0.76	397	—	—	—	—	—	1,019	—	—	—	—	—	—	—
13 Haiti	4.44	133	—	0.036	—	8	—	—	—	—	—	—	—	—	—
14 Honduras	2.78	323	*	0.041	*	15	—	8	—	1	—	—	—	—	—
15 Jamaica	1.98	871	—	0.119	—	60	—	—	—	—	—	—	—	—	—
16 Mexico	54.30	914	4.652	5.161	86	95	3.1	623	4.2	12,000	*	23.3	[illegible]	18.7	[illegible]
17 Nicaragua	2.02	555	*	0.097	*	48	—	8	—	—	—	—	—	—	—
18 Panama	1.57	938	—	0.079	—	50	—	—	—	—	—	—	—	—	—
19 Paraguay	2.67	373	—	0.003	—	1	—	410	—	—	—	—	—	—	—
20 Peru	14.91	617	0.360	0.645	24	43	5.6	2,127	0.09	2,334	*	3.5	74	[illegible]	72
21 Puerto Rico	2.95	2693	—	—	—	—	—	142	—	—	—	—	—	—	—
22 Surinam	0.43	909	—	—	—	—	—	[illegible]	—	—	—	—	—	—	—
23 Trinidad Tobago	1.06	1145	—	0.162	—	153	—	—	—	—	—	8.6	71	1.5	[illegible]
24 Uruguay	2.99	472	0.012	0.024	4	8	—	131	—	—	—	—	—	—	—
25 Venezuela	11.29	1579	1.162	2.081	103	184	14.2	2,097	0.05	845	*	176.1	1,978	11.3	1,136
26 Others	2.31	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Total	302.3	~790	16.40	24.50	54.3	81.0	68.6	94,000	11.9	35,650	6,000	245.3	4,050	47.0	2,360

ANNEX Table 1.4

COUNTRY or REGION	Population (mill.)	GDP per capita (US$)	Crude Steel (Mt) Prod.	Crude Steel (Mt) Cons.	Crude Steel per capita (kg) Prod.	Crude Steel per capita (kg) Cons.	Iron Ore (Mt) Prod.1/	Iron Ore (Mt) Res.	Coal (Mt) Prod.	Coal (Mt) Res.	Coal (Mt) Res.2/	Oil (Mt) Prod.	Oil (Mt) Res.	Natural Gas (1000 M³) Prod.	Natural Gas (1000 M³) Res.
SOUTH ASIA															
1 Afghanistan	18.29	81	—	0.019	—	1	—	1,100	0.1	85	—	—	—	2.7	*
2 Bangladesh	73.21	100	0.068	0.157	1	3	—	*	*	1471	*	—	—	—	—
3 Bhutan	0.89	60	—	—	—	—	—	—	—	—	—	—	—	—	—
4 India	574.42	113	6.915	8.232	12	14	22.2	29,052	77.1	80,953	14,000	7.2	118	0.63	70
5 Iran	31.30	[illegible]	0.650	2.568	21	82	0.3	249	1.1	355	—	212.8	9,359	19.9	10,760
6 Nepal	12.07	91	—	—	—	—	—	15	—	—	—	—	—	—	—
7 Pakistan	66.23	123	*	0.357	*	6	*	558	1.2	190	—	0.41	4	4.1	457
8 Sri Lanka	13.25	203	—	0.014	—	5	—	72	—	—	—	—	—	—	—
	788.8		7.65	11.44	9.7	14.5	22.5	31,000	80	83,100	[illegible]	300	9,430	27.7	11,200
SOUTH EAST ASIA															
1 Brunei	0.15	1640	—	—	0	—	—	—	—	—	—	11.1	294	*6.5	456
2 Burma	29.56	82	0.040	0.031	1	1	*	198	0.02	21	—	0.37	6	*0.02	3
3 Cambodia	7.67	81	—	0.022	0	3	—	2	—	—	—	—	—	—	—
4 Indonesia	134.60	171	0.080	1.050	1	9	—	572	0.15	573	*	68.1	1,508	5.0	223
5 Laos	3.18	100	—	0.001	0	0	—	1,000	—	—	—	—	—	—	—
6 Malaysia	11.31	662	0.190	0.665	17	59	0.3	97	—	—	—	4.3	261	0	323
7 Philippines	40.12	257	*	1.206	*	30	1.4	3,073	0.04	*	—	—	—	—	—
8 Singapore	2.19	1913	0.200	1.229	91	561	—	—	—	—	—	—	—	—	—
9 Thailand	39.79	228	0.320	0.913	8	24	*	54	—	—	—	0.01	*	—	—
10 Vietnam	42.65	135	*	0.205	*	5	*	63	3.0	1,000	*	—	—	—	—
	301.2		0.87	5.20	2.9	17.9	1.7	5,070	3.2	1,600	500	83	2,120	5.5	1,070
EAST ASIA															
1 China	933.44	270	28,650	30,810	31	38	39.1	30,640	428.0	1,011,000	223,000	50.0	2,026	2.8	165
2 Korea R	32.51	[illegible]	1,157	[illegible]	25	91	0.2	74	13.6	1,450	*	—	—	—	—
3 Korea DPR	15.64	[illegible]	[illegible]	3,053	175	203	4.9	2,912	30.0	*	—	—	—	—	—
4 Mongolia	1.36	550	—	—	0	—	—	*	0.1	*	—	—	—	—	—
	867.8		29.41	33.97	33.9	42.5	43.7	33,150	472	1,013,000	223,000	50	2,030	2.8	165
OTHERS															
1 Cyprus	0.66	—	—	—	0	—	—	—	—	—	—	—	—	—	—
2 Israel	3.18	—	0.120	0.876	32	279	—	19	—	—	—	5.6	0	0.05	1
3 Oceania	4.20	—	—	—	0	—	—	16	0	15	—	—	—	—	—
4 Others	3.06	—	—	—	0	—	*	—	—	—	—	—	—	—	—
	11.1		0.12	1.00	1.1	90	—	110	—	20	—	6	—	—	—

ANNEX Table 1.5

COUNTRY or REGION	Population (mill.)	GDP per capita (US$)	Crude Steel (Mt) Prod.	Crude Steel (Mt) Cons.	Crude Steel per capita (kg) Prod.	Crude Steel per capita (kg) Cons.	Iron Ore (Mt) Prod.1/	Iron Ore (Mt) Res.	Coal (Mt) Prod.	Coal (Mt) Res.	Coal (Mt) Res.2/	Oil (Mt) Prod.	Oil (Mt) Res.	Natural Gas (1000 M3) Prod.	Natural Gas (1000 M3) Res.
W. EUROPE															
1 Austria	7.53	3,617	4.238	3.251	563	432	1.4	320	0	4	—	2.0	25	2.3	14
2 Belgium-Luxemburg	10.09		20.837	4.736	2,063	475	1.2	635	8.8	253	—			0.06	*
3 Denmark	5.02	5,523	0.449	2.329	89	464	0		0	2	—	0.07	33	0	17
4 Finland	4.67	3,742	1.615	1.987	346	425	0.6	230	—	—	—	—	—	—	—
5 France	52.3	4,755	25.264	25.827	485	495	15.7	10.125	26.4	1,380	4,000	1.3	12	7.5	180
6 Germany FR	61.97	5,614	49.521	40.411	799	652	1.6	4,376	103.0	230,304	[illegible]	6.6	75	19.3	326
7 Greece	8.97	1,788	0.825	1.535	92	172	0.8	160	—	—	—	—	—	—	—
8 Iceland	0.21	4,575	—	0.039	—	186	—	—	—	—	—	—	—	—	—
9 Ireland	3.03	2,132	0.110	0.471	36	155	—	—	0.06	48	—	—	—	—	—
10 Italy	54.91	2,525	20.995	22.561	382	411	0.2	43	0.01	1	—	1.0	35	15.3	145
11 Netherland	13.44	4,003	5.625	5.300	416	378	—	—	1.7	3,705	*	1.5	39	[illegible]	[illegible]
12 Norway	3.96	4,922	0.962	1.957	243	454	2.5	2,010	0.42	152	—	1.6	605	0	510
13 Portugal	8.56	1,247	0.457	1.188	54	132	0	319	0.22	5	—	—	—	—	—
14 Spain	34.86	2,033	[illegible]	10.947	301	314	3.5	2,765	9.9	2,370	*	0.90	10	[illegible]	12
15 Sweden	8.14	6,133	5.651	5.954	694	725	22.1	3,370	0	90	—	—	—	—	—
16 Switzerland	6.43	6,194	0.558	3.106	91	411	0	80	—	—	—	—	—	—	—
17 Turkey	37.93	555	1.163	[illegible]	31	50	1.5	403	4.6	1,291	*	3.6	20	0	3
18 UK	55.93	3,119	26.649	[illegible]	476	442	1.9	5,437	132.2	162,514	56,000	0.09	1,410	29.7	[illegible]
19 Yugoslavia	20.96	991	2.676	3.630	[illegible]	173	1.8	1,655	0.58	104	—	3.3	45	1.3	42
20 Others	0.36	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	399.1		178.10	[illegible]	446	406	[illegible]	31,130	293.9	402,500	136,500	22.5	2,390	145.4	4,670
N. AMERICA															
1 Canada	22.13	5,007	13.386	[illegible]	605	640	[illegible]	120,017	16.8	[illegible]	17,000	85.5	1,247	[illegible]	[illegible]
2 USA	210.40	6,267	[illegible]	141.595	[illegible]	711	53.2	[illegible]	530.1	2,285,763	[illegible]	451.2	4,772	[illegible]	[illegible]
	232.53		150.20	163.75	646	704	83.9	[illegible]	547	[illegible]	[illegible]	540	6,020	720	16,100
OCEANIA															
1 Australia	13.13	[illegible]	7.699	7.057	586	537	47.2	[illegible]	54.6	[illegible]	[illegible]	16.6	214	[illegible]	[illegible]
2 New Zealand	2.96	3,955	0.190	[illegible]	64	326	0	[illegible]	0.42	[illegible]	—	0.16	16	[illegible]	[illegible]
	16.10		7.59	8.02	[illegible]	[illegible]	47.2	[illegible]	55.0	112,500	6,000	[illegible]	230	4.0	[illegible]
JAPAN	[illegible]	[illegible]	[illegible]	57.13	1,101	[illegible]	[illegible]	1,510	22.4	7,443	[illegible]	0.7	4	2.4	15
SOUTH AFRICA	25.72	1,142	[illegible]	[illegible]	241	237	6.9	[illegible]	62.4	24,339	19,000	—	—	—	—

ANNEX Table 1.6

COUNTRY or REGION	Population (mill.)	GDP per capita (US$)	Crude Steel (Mt) Prod.	Crude Steel (Mt) Cons.	Crude Steel per capita (kg) Prod.	Crude Steel per capita (kg) Cons.	Iron Ore (Mt) Prod.1/	Iron Ore (Mt) Res.	Coal (Mt) Prod.	Coal (Mt) Res.	Coal (Mt) Res.2/	Oil (Mt) Prod.	Oil (Mt) Res.	Natural Gas (1000 M^3) Prod.	Natural Gas (1000 M^3) Res.
E. EUROPE															
1 Albania	2.37	[illegible]	—	120	—	51	—	—	—	—	—	2.1	11	[illegible]	7
2 Bulgaria	8.72	1,590	2.246	[illegible]	261	232	0.4	263	0.35	34	—	0.19	3	0.22	14
3 Czechoslovakia	14.56	[illegible]	[illegible]	[illegible]	908	689	0.5	560	27.8	11,573	2,000	0.17	3	1.0	14
4 Germany DR	16.79	3,000	[illegible]	8.439	347	4?7	0	10	0.75	[illegible]	—	—	—	7.0	16
5 Hungary	10.43	1,750	3.327	[illegible]	319	313	0.2	150	3.4	[illegible]	*	2.0	31	4.8	115
6 Poland	33.36	2,090	14.000	[illegible]	420	475	0.4	572	156.6	45,741	22,000	0.31	6	6.0	1,3?3
7 Rumania	20.83	890	8.161	8.163	372	392	0.9	103	7.2	590	*	14.3	158	27.4	[illegible]
8 USSR	249.75	2,030	131.481	129.369	526	518	118.2	304,301	461.2	3,9??,357	220,000	429.0	6,464	23?.3	18,4??
Total	35?.9		179.35	177.2	500	216	121.1	306,000	657	4,052,0??	2?4,500	448	[illegible]	233	20,100
SUMMARY															
Developing	2,1?5		55.3	8?.3	20.7	32.3	176.3	176,000	573	1,149,??0	245,000	1,2?0	[illegible]	[illegible]	[illegible]
S.S. Africa	2??.1		0.415	2.40	1.6	9.1	37.2	22,600	5.1	14,520	1,000	120	2,9?0	0.36	1,750
Arab	133.6		0.640	5.65	4.9	42.3	2.6	4,750	0.6	140	0	421	39,400	29.6	11,900
L. America	302.3		16.40	24.5	54.3	81.0	68.6	99,000	11.8	35,600	6,000	265	4,050	47.0	2,360
S. Asia	[illegible]		7.65	11.4	9.7	14.5	22.5	31,000	80.0	83,100	14,200	300	9,430	27.7	11,3??
S.E. Asia	??1.2		0.87	5.40	2.9	17.9	1.7	[illegible]	3.2	1,600	500	23	2,120	5.5	1,070
E. Asia	967.8		29.44	36.9	33.9	42.5	43.7	33,150	472	1,013,000	223,300	50	2,030	2.8	165
Developed	1,137		639.5	603.7	562	531	314.5	59?,000	1,633	7,0??,000	683,???	1,030	15,300	1,163	41,9??
W. Europe	???.1		178.10	161.9	436	40?	54.8	31,??0	289	4?2,9?0	134,500	23	2,370	145.4	4,690
N. America	232.5		150.20	163.8	646	704	83.9	25,??0	[illegible]	2,323,000	293,000	540	6,020	7?9	16,150
Oceania	16.1		7.89	8.0	490	498	47.2	16,720	55.0	112,500	6,000	17	230	4.0	990
Japan	108.4		119.32	87.2	1,101	805	0.6	1,510	22.4	7,443	4,000	1	4	2.9	15
South Africa	23.7		5.72	5.6	241	237	6.9	4,220	62.4	41,339	19,000	—	—	—	—
E. Europe	355.9		178.35	177.2	500	496	121.1	306,000	657	4,052,000	244,500	448	6,700	233	20,100
World	3,920		695	690	182	131	491	762,000	2,206	8,150,000	928,000	2,770	[illegible]	1,376	70,??0

APPENDIX

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

INDUSTRIAL OPERATIONS DIVISION - METALLURGICAL INDUSTRIES SECTION

LIST OF MAIN PROJECTS, MEETINGS AND DOCUMENTS

1. Technical Assistance Projects
2. Special Studies and Documents
3. Symposia, Seminars and Workshops
4. Papers

1. TECHNICAL ASSISTANCE PROJECTS

Europe and the Middle East

Country	Project
Greece	- Expert assistance to Greek iron and steel industry.
Hungary	- Introduction of modern maintenance system for the Danube Iron and Steel Works.
Iraq	- Merchant steel rolling expert.
	- Electric steel making expert.
	- Steel market survey, demand and projections expert.
	- Evaluation of offers for the establishment of semi-integrated steel plants and preparation of a feasibility study for the production of sponge iron.
Jordan	- Assistance to steel rolling mill industry.
Kuwait	- Evaluation of proposals for feasibility study for iron and steel industrial development.
Romania	- Expert on quality control of steel products.
Syrian Arab Republic	- Assistance in the utilization of steel scrap for local production.
	- Assistance to the Barada Company in treatment of special steels.
	- Iron and Steel industry planning.
	- Advice on installation and operation of steel rolling mill.
	- Iron and steel industry adviser.
Turkey	- Expert assistance in planning of a ferro-chromium project and advise on plant operations.
	- Establishment of the Marmara Scientific and Industrial Research Institute.
Yugoslavia	- Assistance to Metallurgical Institute "Hasan Brkic", Zenica, in mastering modern technologies in the iron and steel industry, covering specialized expertise such as: iron ore beneficiation and agglomeration expert;

Country	Project
Yugoslavia (continued)	Expert in vacuum spectroscopic and X-ray fluorescence analysis of minerals, iron and steel;
	Expert in electron microscopy;
	Steel ingot reheating and soaking expert;
	Open hearth steelmaking expert;
	Steel vacuum degassing expert;
	Roll pass design expert;
	Roll pass design expert (commissioning new sections)
	Stainless steel rolling expert;
	Expert in automation of steel production in LD oxygen converters.
Africa	
Arab Republic of Egypt	- Establishment of the Central Metallurgical Research and Development Institute.
	- Application of modern data system to the metallurgical industry.
	- Assistance to the Iron and Steel Company, Helwan, covering:
	Quality control of rolled steel products;
	Quality control of longitudinal and spiral welded steel pipe;
	Expert in the production of steel rolls;
	Expert in the production and rolling of special steels;
	- Pilot plant scale investigations and trials on beneficiation, pre-reduction and electric smelter of the Aswan iron ore.
	- Pilot plant scale tests on Bahariya iron ore for the production of sponge iron.
	- Preparation of techno-economic feasibility report for the Iron and Steel Company (Helwan).
Ghana	- Preparation of rehabilitation programme for the steel plant of the Ghana Industrial Holding Corporation.
Liberia	- Assistance to iron and steel industry development.
Libya	- Evaluation of feasibility reports on the establishment of the iron and steel industry.
Madagascar	- Pre-feasibility study for the creation of a small steel plant.
Maghreb	- Pre-investment study for production of special steels.
Mali	- Pre-feasibility study of the iron and steel industry.
	- Evaluation of technical report for establishing a re-rolling mill.

Country	Project
Mauritania	- Pre-feasibility study of an iron and steel industry.
Mauritius	- Steel production adviser.
Morocco	- Iron ore pelletizing and marketing expert.
Togo	- Pre-feasibility report for the establishment of a re-rolling mill.
Uganda	- Assistance to Uganda steel industry and metal products.
Upper Volta	- Feasibility study for establishing a steel bar, rod and light section rolling mill.
Regional	- Assistance to Industrial Development Centre of Arab States related to production of special steels and ferro-alloys.
	- Assistance for the development of Fe ore resources.
Latin America	
Argentina	- Assistance to the steel based industries.
	- Steel products marketing adviser.
	- Steel industry adviser (rolling).
	- Expert in subsidiary industries in an integrated iron and steel plant.
Brasil	- Standardization and industrial quality in the iron and steel industry.
	- Study of the possibilities for the development of metallurgical industries in the State of Bahia.
	- Long range study on technological innovation and its implications for long-range planning of the iron and steel industry.
	- Technical assistance to the iron and steel industry (Preparation of a Master Plan).
Chile	- Expert on quality control of rolled steel plants.
	- Assistance to the Compania de Acero del Pacifico.
Colombia	- Long range study on the development of the iron and steel industry of the country.
Cuba	- Lecture course in the theory and practice of hot and cold rolling for engineers.
	- Courses for engineers in physical metallurgy and steel-making.
Mexico	- Iron and steel industry adviser.
	- Iron and steel documentation expert.
	- Iron and Steel Research Centre of Mexico.

Country	Project
Peru	- Expert in the assessment of tenders for an electrolytic tinning line.
	- Industrial cost accountant in the iron and steel industry.
	- Expert in quality control of steel products.
	- Flat product rolling mill expert.
	- Assistance to SIDERPERU (Expertise in steelmaking and rolling).
	- Expertise in planning and training in the steel sector for INDUPERU.
	- Long range pre-investment study on the iron and steel industry development.
Uruguay	- Laboratory-scale determination of the techno-economic characteristics of Valentine iron ore deposits.
	- Techno-economic feasibility for the establishment of a direct reduction mini plant.
Venezuela	- Adviser on planning and development of the iron and steel industry.
<u>Asia and the Far East</u>	
Burma	- Study on the establishment of iron and steel industry using local raw materials.
India	- Establishment and operation of a Central Creep Testing Research facility at the National Metallurgical Laboratory.
	- Establishment of a pilot and demonstration plant for the production of sponge iron using non-coking coal in Andhra Pradesh.
	- Assistance in the establishment of a sponge iron plant in Orissa.
	- Tests on iron ore deposits from Goa and Mysore for the production of sponge iron.
	- Pilot plant scale investigations on vanadiferous magnetites for the production of ferro-vanadium.
	- Consultancy on ferro-vanadium production.
	- Establishment of a Welding Research Institute.
Indonesia	- Assistance to the Tjilegon Steel Plant.
Iran	- Pilot plant scale tests on direct reduction of iron ore by HYL process for the production of sponge iron.
	- Feasibility study on special steels and ferro alloys.
Pakistan	- Iron and steel industry adviser.
Philippines	- Steel industry adviser.

Country	Project
South Korea	- Technical assistance for the feasibility of the establishment of an integrated iron and steel plant in South Korea.
Thailand	- Expert in the quality control of hot-dipped tinplate production.
	- Assistance in the establishment of an integrated iron and steel industry.
Regional	- Steel standardization expert for South East Asian Iron and Steel Institute.
	- Regional adviser on tranfer of technology at ESCAP (assistance to iron and steel industry in Philippines, Thailand, South Korea, Singapore, Malaysia, etc.).

2. SPECIAL STUDIES AND DOCUMENTS

1969

UNIDO Monograph No.5 Industrialization of Developing Countries Problems and Prospects: Iron and Steel Industry	ID/40/5 Sales Publication: E.69.II.B.39 Vol. 5 New York, 1969

1974/75

Updated UNIDO Monograph on the Iron and Steel Industry	1 copy available in UNIDO library
Promotion of Technical Co-operation Among Developing Countries in the Iron and Steel Industry	1 copy available in UNIDO library

1975

The Iron and Steel Industry in Developing Countries - A preliminary case study of the present situation, prospects for development and international co-operation (Paper prepared by the Secretariat for the Second General Conference of UNIDO)	ID/B/C.3/35/Rev.1/Add.1 and Appendix

3. SYMPOSIA, SEMINARS AND WORKSHOPS

	Documentation 1/
1963 First Interregional Symposium on the Iron and Steel Industry, Prague/Geneva 11-26 November 1963, organized by CID (UNIDO's predecessor organization)	Proceedings on Symposium 64 working papers (see item 4) 1 photocopy available at IOD/Metallurgical Industries Section
1968 Second Interregional Symposium on the Iron and Steel Industry Moscow, 19 September - 9 October 1968	Report of Symposium ID/24, Sales No. E.69.II.B.36 New York, 1969 75 working papers (see item 4)
1970 Seminar on Tinplate Production (Report published in 1971) Santiago, 9 - 13 November 1970	Report of Seminar ID/WG.73/17 14 working papers (see item 4)
1972 Preparatory Meeting for Preparation of Third Interregional Iron and Steel Symposium, March, Vienna	
1973 Third Interregional Symposium on the Iron and Steel Industry Brasilia, 14 - 21 October 1973	Report of Symposium ID/139, Sales No. E.74.II.B.15 New York, 1974 117 working papers (see item 4)
1975 Follow-up of Third Interregional Symposium on the Iron and Steel Industry Vienna, 24 - 27 November 1975	Short Descriptive Report, February 1976 Summary of conclusions and recommendations by experts, December 1975 Summary Report February 1976

1/ Please note that most of the papers presented to Seminars and Symposia are out of stock by now. The Proceedings on the 1st Iron and Steel Symposium and the Report on the Seminar on Tinplate Production are also no longer available.

4. PAPERS

(a) PAPERS PRESENTED TO THE FIRST INTERREGIONAL IRON AND STEEL SYMPOSIUM - PRAGUE/GENEVA, 11 - 26 NOVEMBER 1963

COMM 1	Statement by Commissioner Abdel-Rahman
SECT 1	The modern iron and steel industry, by Centre for Industrial Development
SECT 2	Raw materials and their preparation, prepared for Economic Commission for Europe
3	Problems arising from the establishment and development of the iron and steel industry in developing countries, by the U.N. Economic Commission for Europe
ECA 1	Raw materials in Africa for iron and steel manufacturing, by the U.N. Economic Commission for Africa
ECAFE 1	Availability of raw materials for iron and steel making in the ECAFE Region, by the U.N. Economic Commission for Asia and the Far East
ECE 1	Trends in production and consumption of iron and steel making raw materials in Europe and the United States, by the U.N. Economic Commission for Europe
ECLA 1	Steel making raw materials in Latin America, general situation, by U.N. Economic Commission for Latin America
ECA 2	The iron and steel industry in Africa
ECAFE 2	Review of the iron and steel industry in the ECAFE Region, by U.N. Economic Commission for Asia and the Far East
ECE 2	Present and future trends of production and consumption of pig iron and crude steel in Europe and the United States
ECLA 2	The iron and steel industry of Latin America, by U.N. Economic Commission for Latin America
A. 1	Exploration of the small iron ore deposit, by J. Caorsi (Uruguay) and G. Bossi (Uruguay)
2	Ore exploration and exploitation - intermediate scale, by R. Wasmuht and R. Tschoepke (Fed. Rep. of Germany)
3	Ore exploration and exploitation on a large scale, by H. Rone (USA)
4	Standard methods of beneficiation and concentration - blending, separating, sizing and agglomeration, by M. Nakatsuyama (Japan)
5	Pelletizing, by J.E. Astier (France)

A. 6 Krupp-Renn experience in Czechoslovakia, by J. Mach (Czechoslovakia) and B. Verner (Czechoslovakia)

7 Sintering - a general review, by H. Lehmkuhler (Federal Republic of Germany)

8 The production of high quality sinter, by J.E. Greenawalt (USA)

9 Sintering practice on a large scale, by A. Rudkov (USSR)

10 Sintering practice in continuous strand plants, by G. Brandes and L.R. Choudhary (Federal Republic of Germany)

11 Sintering practice - operating results, by P. Maertens (Belgium)

12 Small steel plants - their influence on developing countries, by M.N. Dastur (India)

13 The Canadian steel industry - a pattern of growth, by W.K. Buck (Canada) and R. B. Elver (Canada)

14 Growth pattern of the iron and steel industry in India's economic development, by B.R. Nijhawan (India)

15 Problems of steel plant expansion, by W. Musialek (Poland)

16 Economic considerations for steel plants in developing countries, by W.T. Hogan (U.S.A.)

17 The use of non-coking coals for iron-making operations, by R. Loison (France)

18 Substitutes for coking coals in the blast furnace, by M. Fine, J. de Carlo and E. Sheridan (U.S.A.)

19 Substitutes for coking coals in iron ore reduction, by H.R. Brown (Australia) and W.R. Hesp (Australia)

20 Electric energy requirements for steel plants, by H.W. Lownie, Jr. and R.E. Presnell (U.S.A.)

21 Electric pig iron smelting, by H. Rekar and J. Staro (Yugoslavia)

22 Electric steel melting, by S. Scotti (Italy) and F. Grossi (Argentina)

23 Electric furnace steel production in Peru, by E. Palacio (Peru)

24 Iron ore exploration and exploitation on a large scale - Liberia, by A. Momolu Massaquoi (Liberia)

25 Progress in electric smelting furnaces, by F.C. Collin (Norway)

B. 1 Technical progress in the production of pig iron in blast furnaces, by V.G. Voskobojnikov (USSR)

2 Charcoal blast furnace operations, by A. Constantine (Australia)

3 General review of direct reduction processes, by F.M. Wiberg

4 Comparative evaluation of direct reduction processes, by H. Poblete (Chile)

5 The SL direct reduction process, by D.J. Haine (Canada)

6 The HyL process, by J. Cclada (Mexico) and J. Skelly (USA)

7 The echeverria ore reduction process, by G. Cedarvall (Switzerland)

8 The Strategic-Udy process, by K. Sandbach (USA)

*)

10 Comparison of steel making processes, by the U.N. Economic Commission for Europe

11 Open hearth steel making with oxygen, by M. Trotta (Italy) and B. Sommacal (Italy)

12 Oxygen-lime steelmaking practices, by B. Trentini (France)

13 Problems of quality in steel production, by J. Pearson (United Kingdom)

14 Steel standards and standardization on country-wide basis, by B.S. Krishnamachar (India)

15 Steel standards and regional standardization, by F. Aguirre (Chile) and A. Gomez (Chile)

16 Continuous casting - developments and current installations, by I.M.D. Halliday (United Kingdom)

17 Continuous casting - present and future prospects, by E.I. Astrov (USSR)

18 The continuous casting of round sections, by B. Tarmann (Austria) and W. Poppmeier (Austria)

19 Technical and economic feasibility planning for a small iron and steel plant, by I.D. Dick (New Zealand) and T. Marshall (New Zealand)

20 Project planning and construction - intermediate scale, by M. Perez (Chile)

21 Project planning and construction - large scale, by M. Gonni (Italy)

22 Problems involved in development of a steel plant, by M. Allard (France)

*) No paper appeared as B.9

B.23	Regional integration of the steel industry in Latin America, by F. Aguirre (Chile)
24	Training of engineers and operatore for new eteel operations in developing countries, by J.A. Berger (USA)
25	The Purofer direct reduction proceee, by Ludwig Von Bogdandy (Federal Republic of Germany)
26	The Kaldo procees, by F. Johaneeon(Sweden)
27	The iron and steel induetry of Southern Rhodesia, by W. Welle (Southern Rhodeeia)
28	The use of charcoal in blaet furnace operation, by Food and Agriculture Organization of U.N.

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64.II.B.7	Proceedings of the Inter-Regional Symposium on the Application of Modern Technical Praotices in the Iron and Steel Industry to Developing Countries. Prague - Geneva, November, 1963.

(b) **PAPERS PREPARED FOR SECOND INTERREGIONAL SYMPOSIUM ON THE IRON AND STEEL INDUSTRY - MOSCOW, 1968**

ID/WG.14/1	The Liège experimental furnace	A. Poos Belgium
ID/WG.14/2	The effect of regional co-operation on the development of the iron and steel industry under the Economic Mutual Assistance Board	K. Plishtil A. Penkovsky L. Makh I. Shibaev EMAB
ID/WG.14/3	Economic conditions regulating the growth of Latin American steel production	A. Gomez Chile
ID/WG.14/4	Ironmaking plant of Chiba Works - its construction and rationalization	T. Nagai Japan
ID/WG.14/7	Processing of metallurgical slags at iron and steel plants	S. Klemantaski United Kingdom
ID/WG.14/8	Present status and future of the iron and steel industry of African countries	ECA secretariat
ID/WG.14/9	Present status and future of the iron and steel industry of the Asian countries	ECAFE secretariat
ID/WG.14/10	Continuous steelmaking	M. W. Thring United Kingdom
ID/WG.14/11	Water supply, re-use and disposal at an integrated iron and steel works in Great Britain	G. W. Cook United Kingdom
ID/WG.14/12	Forecasting iron and steel demand in developing countries	ECA secretariat
ID/WG.14/13	Possibilities of developing an iron and steel industry with other than fully integrated plants	R. Tietig, Jr. United Kingdom
ID/WG.14/14	Control of strip tension in electrolytic tinning lines	K. T. Lawson United Kingdom
ID/WG.14/15	Research for the iron and steel industry in developing countries, possibilities for regional co-operation	L. C. Correa da Silva Brazil
ID/WG.14/16	Economic advantages of the creation of iron and steel plants for small countries on a regional basis	ECA secretariat

ID/WG.14/17	Requirements of manpower and qualified staff in the creation of the iron and steel industry and training of personnel	O. Malukha Czechoslovakia
ID/WG.14/18	Pre-investment information for designing iron and steel plants in the developing countries	J. Hlavacek Czechoslovakia
ID/WG.14/19	SL/RN direct reduction process for the production of sponge iron and its melting to steel	H. Garbe W. Janke Federal Republic of Germany
ID/WG.14/20	World production, trade and prices of iron and steel	ECE secretariat
ID/WG.14/21	Availability of iron ore resources for iron and steelmaking	ECE secretariat
ID/WG.14/22	Application of low-shaft furnace for ironmaking with sub-standard raw materials	A. B. Chatterjea B. R. Nijhawan India
ID/WG.14/24	Electric arc furnace steelmaking for developing countries	T. V. S. Ratnam R. D. Lalkaka India
ID/WG.14/25	The IRSID continuous steelmaking process	P. Vayssiere J. Rouanet A. Berthet C. Roederer B. Trentini France
ID/WG.14/26	Injection of light petroleum naphtha into iron smelting furnace	A. B. Chatterjea B. R. Nijhawan India
ID/WG.14/27	Energetics of iron and steel works, evolution and application to developing countries	J. Astier P. Dancoisne France
ID/WG.14/28	Automation in the iron and steel industry	ECE secretariat
ID/WG.14/29	Factors affecting steel demand and its product pattern in developing countries	ECE secretariat
ID/WG.14/30	Demand for steel and prospects for regional co-operation in South-east Asia	Nippon Kokan K. K. Japan
ID/WG.14/31	The supply of steel in developing countries	ECE secretariat
ID/WG.14/32	Assistance of the advanced countries to develop the iron and steel industries in developing countries	M. N. Dastur India
ID/WG.14/33	Standardization of steel and steel products to facilitate co-ordination of national, interregional and international specifications and to promote trade among different countries	B. S. Krishnamachar India

ID/WG.14/34	Modern design of blast furnace	M. Iimori T. Tsutsumi Japan
ID/WG.14/35	New equipment for oxygen steelmaking plant	G. Urban H. Schirmer Federal Republic of Germany
ID/WG.14/36	Modern equipment for the rolling of steel	M. G. Sendzimir United States
ID/WG.14/37	Economic analysis as an instrument of the management system in metallurgical production	O. Fiala Czechoslovakia
ID/WG.14/38	Modern techno-economic indices and ways of their attainment in blast furnaces, steelmaking and rolling mills	W. H. Mieth Federal Republic of Germany
ID/WG.14/39	Efficiency of mechanization and automation in the iron and steel industry. Economic aspects of computer control of the oxygen steelmaking process	ECE secretariat
ID/WG.14/40	Experience and economic profit of continuous casting in steel plant	Y. Kawamoto Japan
ID/WG.14/41	Conversion of open-hearth shops into basic oxygen furnace shops at Fuji Iron and Steel Co. Ltd.	S. Toyoda H. Nakajima M. Maeda E. Hirao K. Nakajima Japan
ID/WG.14/42	Present status and future of the iron and steel industry of the Latin American countries	ECLA secretariat
ID/WG.14/43	Economies of scale in the steel industry	ECLA secretariat
ID/WG.14/44	Export-import Bank and its relationship in the development of an iron and steel industry	A. C. Cass United States
ID/WG.14/45	New development in the sector of tube manufacturing	J. Mietzner Federal Republic of Germany
ID/WG.14/46	Steel plant location: A guide for the developing countries	E. T. Culver J. Pearce United States
ID/WG.14/47	The financing of the iron and steel industry in a developing country: the case of Spain	L. Guereca Spain
ID/WG.14/48	Determination of the optimum capacity of the fully integrated iron and steel plant and its parts	H. R. Mills B. S. Soan United Kingdom

ID/WG.14/49	Experiences and advantages in employing preheated cold charge in electric furnaces and their influence on new electric steel plant layout	F. Grossi et al. Italy
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ID/WG.14/53	Waste gas cleaning systems for large capacity basic oxygen furnace plant	A. D. Rowe H. K. Jaworski B. A. Bassett United Kingdom
ID/WG.14/54	The value of the technical press in the development of a steel industry and its technology	R. L. Deily United States
ID/WG.14/55	Collection and processing of iron and steel scrap for iron and steel industry	K. N. P. Rao India
ID/WG.14/56	Is Latin American steel expensive?	A. Gomez Chile
ID/WG.14/57	Development plan for the iron and steel industry in Argentina	F. E. Aldinio Argentina
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ID/WG.14/63	Economics on transporting of raw materials in large bulk carriers	W. T. Hogan United States
ID/WG.14/64	Equipment for the continuous casting of steel for the needs of small-scale works	I. Mydlarz Poland
ID/WG.14/65	Modern light and medium rolling mills for the production of sections for a varied market	A. Mularz Poland
ID/WG.14/66	Review of the activities of the United Nations in the iron and steel industry in developing countries	UNIDO secretariat

ID/WG.14/69	Interrelation between iron and steel industry and industries of consumers of its products	I. M. Denisenko
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ID/WG.14/78	The most essential metal production for developing countries	V. M. Tsitver
ID/WG.14/79	Ways of development of iron and steel industry in developing countries	P. A. Shiryayev
ID/WG.14/80	Technical assistance of the USSR in establishment and progress of ferrous metallurgy in developing countries: its main principles and arrangements, long-term credits and their repayment	M. I. Syrjakov
ID/WG.14/81	Modern designs of blast furnaces	A. E. Suhkorukov

(c) **PAPERS PRESENTED TO THE SEMINAR ON TINPLATE PRODUCTION - SANTIAGO, NOVEMBER 1970**

ID/WG.73/1	Tinplate production in Mexico by José Castaldi Yuriche, Mexico
ID/WG.73/2	Application of other than tin material used for coating of steel in packaging by Gerd Habenicht, Federal Rep. of Germany
ID/WG.73/3	Development of tinplate manufacturing in Japan by Hidejiro Asano, Japan
ID/WG.73/4	Tinplate quality control in Brazil by Pedro Silva, Brazil
ID/WG.73/5	Quality control problems in the production of tinplate in developing countries: hot-dipped by Kripal Singh, India
ID/WG.73/6	Perspectives for tinplate production and consumption in developing countries (1970-1980) by William Robertson, United Kingdom
ID/WG.73/7	Selection, installation, starting up and operation of the electrolytic tinning line at "Laminación de Bandas en Frio" (LBF, Spain)
ID/WG.73/8	The electrolytic tinning line of the Empresa Nacional Siderúrgica, S.A., Spain by Julio Bou Mon, Spain
ID/WG.73/9	Tinplate market and marketing in Chile by Danilo Vucetich, Chile
ID/WG.73/10	Planning, installation, start-up and operation of tinplate lines in Brazil by João Batista Araújo, Brazil
ID/WG.73/11	Application of tinplate as packaging material by A.R. Männicke, Federal Rep. of Germany
ID/WG.73/12	Application of hot-dipped and electrolytic tinplate in packaging by the UNIDO Secretariat
ID/WG.73/15	Production of tinplate in Rourkela steel plant of Hindustan Steel Limited, India by Atmaram Bajekal, India
ID/WG.73/16	The evolution of tinplate technology by M. Verdé-Delisle, France

(d) **PAPERS PREPARED FOR THE THIRD INTERREGIONAL SYMPOSIUM ON THE IRON AND STEEL INDUSTRY - BRASILIA, 1973**

Symbol	Title
ID/WG.146/1	Programme
ID/WG.146/2/ Rev. 2	List of participants
ID/WG.146/3	Direct reduction of iron ore: technical and economic aspects Economic Commission for Europe
ID/WG.146/4	Developments in ironmaking practice J. M. Ridgion
ID/WG.146/5	Mini-mills for developing countries C. W. Chua
ID/WG.146/6	Participation of developing countries in the world iron-ore market P. M. Bohomoletz
ID/WG.146/7	State planning of iron and steel product consumption demand K. Kémeny and I. Berendik
ID/WG.146/8	The No.4 pickle line at BSC Ebbw Vale Works K. T. Lawson
ID/WG.146/9	Activities for personnel training and determination of manpower requirements at Chiba Works T. Kadooka
ID/WG.146/10	Production of self-fluxing pellets and their blast-furnace performance K. Taguchi
ID/WG.146/11	Automation and computer control of hot and cold strip mills T. Okamoto and Y. Misaka
ID/WG.146/12	Some developments in top-blown BOF equipment I. Hamabe, S. Yamazaki, J. Tsunoda, S. Yamada and K. Yanagida
ID/WG.146/13	Developments in coking technology M. Takemoto, K. Sugasawa and Y. Otake
ID/WG.146/14	The use of linear programming in the optimization of coal blends A. Falco, P. E. dos Santos, M. R. F. Monteiro, O. L. Filho and R. P. Gouveia
ID/WG.146/15	Assistance by metallurgical research instituees to developing countries J. E. Astier

Symbol	Title
ID/WG.146/16	Techno-economic comparison of typical wire-rod mills: the experience of Kobe Steel O. Miki and T. Ohnishi
ID/WG.146/17	Developing a steel industry Wean United Incorporated
ID/WG.146/18	Changes in ironmaking technology in relation to the availability of coking coals E. W. Voice and J. M. Ridgion
ID/WG.146/19	Planning and promotion of the use of steel Chilean Iron and Steel Institute
ID/WG.146/20	Assistance by Nippon Steel to developing countries in establishing their own iron and steel industries S. Maehara
ID/WG.146/21	Development in electric steelmaking J. E. Astier and J. Antoine
ID/WG.146/22	Plant location and cost aspects of integrated steel plants in developing countries M. Sato
ID/WG.146/23	Factors affecting the location of iron and steel works at coastal sites G. Suzuki and M. Saito
ID/WG.146/24	Methods of financing iron and steel industries in developing countries K. Miyagi
ID/WG.146/25	Developments in blast-furnace practice and design T. Hasegawa and T. Satoh
ID/WG.146/26	The activities of CESSID J. Szczeniowski
ID/WG.146/27	Computerized integrated production control systems I. Nagasawa and T. Kobayashi
ID/WG.146/28	Participation of developing countries in the world steel market G. Andrejević
ID/WG.146/29	Economic, financial and technological considerations in the choice of mini steel plant technology by developing countries M. L. Shrikant
ID/WG.146/30	Co-operation between member countries of CMEA and the activities of the Standing Commission on Iron and Steel Council for Mutual Economic Assistance
ID/WG.146/31	Co-operative metallurgical research: the Centre de Recherches Métallurgiques P. M. Coheur and A. Decker
ID/WG.146/32	Stage-wise expansion programme of a steel strip mill S. Nomura and H. Watanabe
ID/WG.146/33	Diversification of energy sources for the blast furnace: the double injection process P. M. Coheur and A. Decker

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ID/WG.146/34	The direct and indirect effects of an iron and steel industry as a supplier and consumer on the over-all economy M. N. Dastur and Company Private Limited
ID/WG.146/35	Steel: the evaluation of feasibility studies M. N. Dastur
ID/WG.146/36	Survey of the development of the Spanish iron and steel industry J. J. Alzugaray
ID/WG.146/37	Development of personnel training for the start-up of Propulsora Siderurgica M. A. Punte and L. Iperti
ID/WG.146/38	Oxygen steelmaking in bottom-blown converters P. Nilles and M. Boudin
ID/WG.146/39	Developments in the iron and steel industry in the ECAFE region Economic Commission for Asia and the Far East
ID/WG.146/40	Changing technology in the light of coking coal availability M. Conti and R. Sacerdote
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ID/WG.146/43	Pre-investment studies and the role of technical consultancies in the establishment of iron and steel industries, particularly in a developing country V. M. G. Raman and K. C. Mohan
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ID/WG.146/50	Steel plant design and engineering organizations: the Indian experience M. N. Dastur and Company Private Limited
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ID/WG.146/54	The establishment and development of the Bulgarian iron and steel industry V. E. Iliev
ID/WG.146/55	Establishment of iron and steel industries in the Arab countries to suit local conditions S. Y. Ezz
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ID/WG.146/68	Choice of heavy blooming mill versus continuous casting: technical and economic comparison B. Misebach and J. Th. Waemuht
ID/WG.146/69	Changing technology in the light of the availability of natural gas A. Chaker

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ID/WG.146/73	Progress in blast-furnace production in the USSR Z. I. Nekrasov
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ID/WG.146/93	The development of the Brazilian iron and etsel industry CONSIDER
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ID/WG.146/100	Assistance by the United Nations to the iron and steel industries of the developing countries United Nations Industrial Development Organization
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ID/WG.146/102	Changing features of the world iron and stoel industry S. Tabata
ID/WG.146/103	Follow-up report on the UNIDO Workshop on the Creation and Transfer of Metallurgical Know-How, held at the National Metallurgical Laboratory, Jamshedpur, India, 7-11 December 1971 United Nations Industrial Development Organization
ID/WG.146/104	Mini-steel mills and their importance for steel production in developing countries D. Ksinsik
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