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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

THE WORLD
IRON AND STEEL INDUSTRY*

(Second study)

PREPARED BY THE

SECTORAL STUDIES SECTION,
INTERNATIONAL CENTRE FOR INDUSTRIAL STUDIES

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id. 78-8141

The Summary

1. The main objective of the second ICIS study of the world-wide iron and steel industry is to analyse the changes that have taken place in this industry since the Joint Consultation Meeting on the Iron and Steel Industry, held in February 1977.

2. The re-evaluation of the situation involves: a) the iron and steel crisis in the industrialized market economy countries, as well as the crisis in long-term forecasting, b) the existing differentiations within the iron and steel industry in the developing countries and their structural weaknesses as compared with those of the industrialised countries, and c) sectoral negotiations and possible co-operation.

3. In view of the importance of the re-evaluated issues, such important questions as "the iron and steel industry and the consumption of energy" and "the iron and steel industry and the environment" are discussed in an annex. The main body of the study focusses on the major points for discussion at the second consultation meeting on iron and steel to take place in January 1979, and for which this study is intended.

4. The study analyzes the evolution of iron and steel production during recent years, and establishes that the present recession in the developed market economy countries can no longer be explained by the familiar "steel cycle," but by structural transformations.

5. The study compares the forecasts with effective production, and points out a persistent lag between the two. The 1976 economic context was marked by a long growth period, explaining the persevering optimism in the forecasts that contradicted subsequent events in the industry. It is within this new context of crisis in the iron and steel industry that the situation should now be reassessed.

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(Second study)

Corrigendum

Page 63, line 20

Delete South Africa, Rhodesia,

Page 109

Delete lines 8 and 9

Page 128

Paragraph 239, line 4 should read industry. Neither Japan nor the Republic of Korea have major resources

Paragraph 240, line 5: delete and Taiwan

Page 130, paragraph 242, line 15

Delete and Taiwan

Page 143

Line 28 should read as India, Brazil, Argentina and the Republic of Korea

Page 163, line 11

Delete (see Annex V.)

id.78-8488

6. The transformations in the world iron and steel industry are the result of a crisis in forecasting and forecasting methods. These forecasting methods are reviewed and the conclusion that is reached is that the methods used so far, particularly those based on the "steel intensity curve", were oversimplifications of what were in actual fact more complex realities. These methods enabled acceptable results only as long as the economy was in a strong growth period; in a period of depression these methods are not valid. The study shows that these methods did not accommodate actual conditions in developing countries. Therefore, it is essential to devise new forecasting methods. The study raises questions concerning the problems involved in the substitution of metals, the cycle of the so-called durable consumer goods, the choice of priority economic sectors to be studied in developing countries in order to meet the demand for iron and steel products, and the future peaks in the steel intensity curve. Suggestions are made to link more forecasts with fixed-capital formation, the evolution of per capita national steel stock and the interactions between the demand for steel and the supply.

7. A more prospective approach is necessary, but it is not the real problem. The projects of the actors that can be put into action and exert an influence on the future reality must be incorporated into this analysis. There is not one but several future realities that are possible, namely, "trend futures," "possible futures," "normative futures," and "probable futures."

The medium-term future reality can be anticipated on the basis of investment projects. It is from the confrontation between the various actors and their strategies that one or another of the future realities will take place. The consultations on the strategies of the actors is, therefore, a first element in the prospectus for the sector. The methodology begins by analysing the structure of the sector and its environment, and then incorporating the dynamics of the strategies of the actors.

8. The study then reviews the various groups of actors in the centrally planned and market economy countries. In connection with the latter, the study shows the influence of the Japanese development model and the new role of non-integrated producers.

The evolution of the iron and steel industry's redeployment movement from developed market economies to the developing countries, and from the broad initial projects to the present slowdown, is analysed. An inventory of the abandoned investment projects in developing countries is provided.

The economic crisis, the evolution of investment costs and the shrinking of markets seem to provoke notable changes in the iron and steel strategies in the industrialized market economy countries. Therefore, in order to increase competition, it is more a question of national restructuring and productivity than of redeployment.

9. The structure of iron and steel production in developing countries reveals important differences among the countries. Four categories of countries can be drawn according to their period of entry into this industry. At the moment, more than 40 countries have neither installations nor, it seems, concrete projects. Africa is the most deprived.

A more realistic analysis of the iron and steel industry in developing countries relativises the frequently expressed fear of new producers in the world market. The developing countries that have the necessary bases to permit them to launch massive exporting policies are scarce.

This study observes that the iron and steel industry in developing countries is differentiated, and most of them manufacture only long products. At the moment, the developing countries are largely excluded from the production of flat products and fine alloy steel, which are significant for the production of equipment goods and durable consumer goods.

The criteris of access to the iron and steel industry is the object of a critical review. The study points out the important role of the iron and steel industry in the construction of integrated national industrial systems and the possibilities for more autonomous strategies without exluding active international trading.

10. The study deals with a few key problems that are facing the developing countries and that are important in defining and implementing long-term strategies: new possibilities and routes in the area of processing and size of installations, and obstacles to entry into the sector, particularly the problems of cost and financing.

11. The study deals with the problems of inputs, i.e., iron ore and reducing agents, in the iron and steel industry. It points out that the structural dependency of the developing countries on coking coal can be decreased by using other reducing agents such as non-coking coal and wood charcoal. However, these possibilities are limited. The development of direct reduction processes presents more potentiality.

The study discusses the situation with respect to the direct reduction processes in developing countries. It notes the difficult progress of direct reduction capacities. At present, the decrease in the price of scrap impairs the growth of direct reduction capacities. The study underlines the prospects opened by the use of natural gas and solid reducing agents. It answers the question, "Is direct reduction only a marginal innovation?" by showing the flexibility gained by using direct reduction processes in terms of usable ores, reducing agents and size of installations. However, in order for direct reduction processes to become universally acceptable and capable of functioning in a wide variety of contexts, the problems of transportation (oxidation), sizes and modules of the sponge iron must be resolved. The direct reduction processes are controlled by large iron and steel companies and developed market economy countries.

The study suggests setting up research and development capacities in the developing countries, making it possible to speed up the adaptation of the processes to a variety of contexts.

12. The matter of scale economies seems to be questioned again in the iron and steel industry. The dominant norm of the development in the industry during the last period was to increase the size of installations. The study relates the historical phases of this evolution. The "scaling-up" movement has permitted gains in productivity, capital and exploitation costs. These gains are tempered by inconveniences that are now appearing. The economic stakes have revealed the vulnerability of large production units. The delays in initiating operations, the increase in production and the difficulty in controlling the management of large complexes threaten the advantages to be drawn from scale economies. This is the case in the developing countries where the time necessary for constructing iron and steel units is often appreciably longer than in the developed countries, entailing heavy financial charges. The increase in the scale of production also causes serious collective organizational problems for work in the developing countries and necessitates rethinking the problems of training in relationship to the size of the production units.

The experiments of numerous countries permit formulating these problems in new terms. Numerous realizations indicate that the dominant tendency until then seems reversable. The scaling-down movement opens new possibilities, particularly for the developing countries. These possibilities seem to be confined to long products, but the potentialities do not exclude flat products.

These prospects could provoke changes in the structure of the world iron and steel industry. In the study these prospects are linked with those affecting the promotion of equipment goods manufacture and national study and implementation capacities in the developing countries in order to incorporate the new iron and steel industries both "upstream" and "downstream".

13. The financing hypotheses established in the first UNIDO world-wide study on the iron and steel industry are the object of a reassessment. The assessments of capital costs are now substantially higher.

The real or estimated costs of iron and steel installations in different parts of the world show great discrepancies in the case of expansion or modernization of operations, or in the case of entirely new units. In general — with the exception of certain developing countries in Far East Asia -- the investment costs are much higher in the developing countries than in the developed countries. Contradictory tendencies appear. The engineering companies and the manufacturers of equipment goods are, on the one hand, interested in opening markets in developing countries at reasonable prices and, on the other hand, are tempted to compensate for a relative reduction in their activities by raising prices. Raising capital costs have important consequences in terms of production costs and the slowing down of investment in the developing countries. The weaknesses in indigenous capital resources increases capital costs. The financing of equipment acquisitions can contradict the promotion of national industries for the production of equipment goods and national engineering capacities. In fact, the key problem of financing seems to be finding a solution as other development problems in the iron and steel industry in developing countries provoke causality links. The study suggests that there is not a financing problem per se, but that it occupies a central position in the elements that interact and that constitute the data of the complex negotiations.

14. International co-operation cannot help being affected by the evolution and prospects of the world iron and steel industry. It is, therefore, important to recover the significance of the objectives for the development of the iron and steel industry until the year 2000 that were accepted at the Lima Conference, and expressed afterwards during the course of the first consultation meeting. Increasing the share of developing countries up to 25-30 per cent of the world iron and steel production is not a simple quantitative objective. Such a distribution implies a modification of the structure of the world iron and steel industry. In practice it depends on the development of new processes and routes, the reorientation of research and greater autonomy in choices, certain displacement of decision centres, etc. The present crisis, far from leading to a postponement of the Lima objectives, is an invitation to underline its prospective significance.

Moreover, the iron and steel crisis and the protection measures it generates constitute a menace to the structure built on the principles of free trade. That is why the idea in favour of the organisation of major negotiations on the future of the world iron and steel industry is gaining support. Retaining this prospect, the study gathers materials which are capable of forming a preparatory dossier for possible world iron and steel negotiations. These materials concern the role of the state in national iron and steel industries, the evolution of contractural forms of industrial arrangements, the impossibility to dissociate components for negotiations. In the same spirit, it reviews the availability of factors and partners. The driving factors are not only the principal natural resources, but also those related to technological capacities and equipment goods, management, markets and financing.

15. From these analyses result new tasks for UNIDO. These tasks are a function of the objectives that must be clearly reformulated in the next context. The proposed objectives are: the organisation of the iron and steel sector at world level by a combination of regulations and information, and the production of at least 25 per cent of the world iron and steel output by the year 2000 in developing countries.

A re-evaluation of these prospects would take place through the scenario methods. The study suggests as a first step that the sector be considered as a "system" in which the variable interact. It proposes to describe possible futures, taking into consideration the strategies of the actors, th technological tendencies and the forecasts of demand. The configuration of possible conflicts and co-operation would then be derived from these prospects. This co-operation implies informed partners and that the information to be gathered will be of a varied nature.

The knowledge of the variables in the iron and steel "systems" and the combination of their inter-relations necessitates a more systematic study programme. A suggested initial inventory of the necessary information and studies is given in Annex II. The information to be gathered is indispensable both to improve the long-term forecasts and to prepare global negotiations on the structure of this industry. A second category of information concerns investment projects and the intentions of the partners. In this area UNIDO, through consultations and opinion-exchange channels, has begun to play the role of an international forum, revealing the strategies and the ensuing scenarios. This role can be reinforced by the organisation of a logistical base of information that is constantly kept up to date on the projects and strategies of the actors. Finally, a third category of information of an operational nature concerns "tactical" information to increase productivity and improve the "strategic" performances, as well as information intended to select technological manufacturing steps to enable the developing countries to enter the iron and steel industry. The study suggests the main lines of an information policy in this field that, in accordance with the mandate received by UNIDO, is the initial objective to be realized, along with the establishment of a technological information bank.

The realization of studies, the gathering of information and the preparation of complex negotiations require major international collaboration. The complexity of these negotiations, resulting from the importance of its components, is discussed with a concrete example in Annex I.

Finally, Annex IV contains elements intended for those at the national level who are responsible for problems of energy. These problems should later be incorporated with those of the iron and steel industry environment as important components for alternative scenarios for the world iron and steel industry.

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Acknowledgements

The Sectoral Studies Section of the International Centre for Industrial Studies gratefully acknowledges the assistance and cooperation of a number of international organizations and of private persons. We have included in this study a considerable amount of information contributed by international organizations, in particular the Economic Commission for Europe (ECE), Geneva and the International Iron and Steel Institute (IISI), Brussels.

The International Centre for Industrial Studies is deeply grateful to Mr. Pierre Judet, Institute for Economic Research and Planning of the Grenoble University of Social Sciences for his participation in the writing of various sections of this study, and to Mr R.U. Ayres for his contributions in the field of forecasting.

INTRODUCTION

CHANGES IN THE IRON AND STEEL INDUSTRY SINCE THE FIRST UNIDO CONSULTATION[1]

1. The world-wide study on the iron and steel industry, 1975-2000, prepared by the International Centre for Industrial Studies in 1976 proposed, within the framework of the Lima Declaration and the Plan for Action, to "give a concrete content to the process of industrialisation of the developing countries". This study was produced on the occasion of the first Consultation Meeting on the Iron and Steel Industry held in February 1977.

2. Since 1976, however, the changes which have taken place in the iron and steel industry and which affect trading, the prospects for location and the problems of financing, have led the International Centre for Industrial Studies to propose a new examination, extending the work carried out in 1976.

This study has been prepared within the framework of the second sectoral consultation.

3. It is not a question, in this second study, of re-examining the basic data supplied by the first, but of analysing the changes which have taken place so as to be able to know to what extent these changes are capable of affecting those perspectives previously traced out.

These changes are important, and it would not be realistic to fail to take them into account.

It was in fact during the second half of 1977 that authoritative voices were heard confirming that the recession in iron and steel production, which had been noted in a large number of countries, arose not from the familiar cyclic economic situation but rather from a structural phenomenon involving in-depth transformations, putting in doubt the various instruments forged, during a long period of continuous growth, for the purpose of measuring and forecasting developments in the branch.

(1) This study is greatly indebted to the cooperation of M. Pierre Judet of the Institut de Recherche Economique et de Planification of the Université des Sciences Sociales, Grenobles.

These new analyses suggest that we were entering a period where the regularity of trends and the firmness of forecasts was giving way to a situation marked by uncertainty: uncertainty on forecasts, doubt concerning the methods used up to the present time and fluidity in the strategies of actors confronted with the possible necessity of "agonising re-appraisals".

The crisis in the structure of the iron and steel industry affects the various groups of countries, and sometimes each of the countries within the group, in a different way. The iron and steel industry, a basic industry, is a national one where States are heavily involved either directly or indirectly, not only in the centrally planned economy countries but also in the developing and in the market economy countries. Each national iron and steel industry, even if it proposes as a matter of priority to satisfy its domestic requirements, is increasingly implicated at the level of techniques, supplies and financing in a world development of the branch which must be appreciated both in its global aspects and also in its highly differentiated aspects.

4. These considerations have led the International Centre for Industrial Studies of UNIDO to carry out a re-evaluation of the situation and the problems.

This re-evaluation involves three levels:

- An appreciation of the existing situation, the iron and steel crisis and that of long-term forecasting and developments in the strategies of the principal actors - inasfar as these are identifiable;
- An analysis of existing differentiations within the iron and steel industries of the developing countries and their structural weaknesses as compared with those of the industrialised countries. As far as the creation and future development of the iron and steel industries in the developing countries is concerned the importance and the potentiality of new technological routes has been emphasised, even more strongly than in the past. Although it is not a panacea special attention has been given to direct reduction processes. The same applies to the reversal of the trend concerning the size of production units. The accent placed on these new possibilities has led, simultaneously, to presenting a rebalanced view of the incidence of projects in the developing countries on the world iron and steel situation, projects which the crisis had undoubtedly

exaggeratedly dramatised in the opinion of certain parts of the Western iron and steel industry, together with fears which have to be relativised. Projects, which today appear to be somewhat compromised by the withdrawals of shareholdings which have been announced and by the growing financing requirements due to the increasing cost of equipment;

- Sectoral negotiations and possible cooperations.

5. The iron and steel crisis, the size of the restructuring undertaken in the majority of the industrialised countries with a market economy, the announced shutting-down of part of the production capacity within the European Economic Community are circumstances which, objectively, should not favour aid from these countries towards facilitating the creation of new production capacities in the developing countries.

The question may therefore be asked now(2), and beyond any matter of good intentions, as to the real and possible content in the coming years of cooperation in the iron and steel sector in favour of the developing countries.

But the crisis makes this a matter of necessity, leading to regulation of the sector and to negotiation which is more global than partial, particularly in relation to customs tariffs.

6. On this difficult terrain, but one of primary interest, ICIS has attempted an initial clearing of the ground relative to the context, together with the content of the negotiation. The analysis will proceed from agreements already concluded, or from the trends which can already be seen. A statement of the interdependence of the factors in the iron and steel industry considered as a "system" leads to the search for a method capable of linking the negotiation of global issues with special issues.

7. The importance of the re-evaluated issues has appeared to be such that it has led to relegating to an annex important questions such as "the iron and steel industry and the consumption of energy" and "the iron and steel industry and the environment". The solution adopted has been to put forward factors valuable for decision-makers in the developing countries. When more certain long-term prospects of the iron and steel industry are possible the balance

(2) This report was completed in September 1978.

of effects on energy consumption can be examined. However these choices arise from more general options. It is these options which have been retained as the centre of this document.

8. In order to carry out this re-evaluation ICIS finds itself facing the following dilemma: either to retain the positions officially expressed by countries, and in this way to limit the analysis significantly, or to use non-official information - sometimes difficult to check - but in this way giving the document a style which reflects the positions of the decision-makers and the national directors of the iron and steel industries.

The choice was made in favour of this latter solution. If the report therefore differs to some extent from the normal style of these documents the International Centre for Industrial Studies of UNIDO hopes that it will nevertheless leave nothing to be desired in terms of objectivity and will, possibly, gain in realism.

I. RE-EVALUATION OF THE SITUATION AND THE PROSPECTS OF THE WORLD IRON AND STEEL INDUSTRY

A. THE SITUATION SINCE 1977

9. In 1977, for the fourth consecutive year, the results of the world iron and steel industry were bad.

Production was 674.3 million tonnes(3) instead of 676.3 million tonnes in 1976 and 707.9 million tonnes in 1974. The fall in production in the market economy developed countries, 394.2 million tonnes in 1977 instead of 411.1 million tonnes in 1976, was balanced by the increase in the production in the planned economy countries: 204.2 million tonnes in 1977 as against 199.0 million tonnes in 1976, together with that in the developing countries: 75.9 million tonnes in 1977 as against 66.2 million tonnes in 1976.

10. After more than 40 months any explanation of this by the "steel cycle" has lost its validity; transformations were taking place which according to many authoritative statements seem to affect the very structures of the industry itself.

11. It is within this context that it is necessary to examine:

- the medium and long-term projections of the demand and production of steel;
- the function of the various actors and the development of their strategies.

B. THE MEDIUM AND LONG-TERM PROJECTIONS

1. THE PROJECTIONS OF THE WORLD STUDY ON THE IRON AND STEEL INDUSTRY, WITHIN THE 1976 CONTEXT

12. The world study of the iron and steel industry carried out by the International Centre for Industrial Studies of UNIDO contains forecasts for the world demand and production of steel for 1985 and for the year 2000; these were overall forecasts, but they were also forecasts broken down between the

(3) On the basis of the statistics contained in the publications of the ECE

- in the USA : 113.1 million tonnes instead of 116.3
- in Germany : 38.9 million tonnes instead of 42.4
- in France : 22.1 million tonnes instead of 23.2.

principal groups of countries and, in particular, between the developed countries and the developing countries. These forecasts, which were the subject of in-depth work, were set out in Chapter II entitled "World Steel Production and Consumption to the year 2000".(4)

13. These forecasts were as follows:

	(millions of tonnes) 1985	2000
Consumption	1,069	1,665 to 1,925
including: developing countries	170	395 to 655
Production	1,069	1,665 to 1,925
including: developing countries	125	378 to 487

14. These forecasts were based on a continuation of the rate of increase in the consumption and production of steel; some slowing down in the developed countries(5) being balanced by a very sustained rate of growth in the developing countries(6). These forecasts were optimistic as compared with the recent development of world production of steel which, after having increased from 630 million tonnes in 1972 to 708 million tonnes in 1974(7), fell to 646 million tonnes in 1975, below the level of 1973.

15. These forecasts were made in 1976 in a context to which it is of value to return.

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(4) From page 28 to page 111, out of a total of 214 pages.

(5) Rate of growth	Consumption	Production	
1975-1985 (expected)	3.0	2.8	UNIDO
1985-2000 (hypotheses)	1.5 to 2.5	1.5 to 2.6	World-wide study op. cit. p. 35
(6) 1975-1985	7.8	12.0	
	5.8 to 9.4	7.7 to 9.4	op. cit. p. 37

(7) IISI figures

The 1976 context

This period was marked by the imprint of a long period of growth which had never been really questioned by the down-turn in the economic situation which took place at the end of 1974 and particularly in 1975.

A long period of growth

16. Since the beginning of the fifties the iron and steel world had become accustomed to a steady average rate of growth in the consumption and production of steel: nearly 5% per year between 1955 and 1974, 6.2% from 1960 to 1965, 5.3% from 1966 to 1970 and 5.8% from 1960 to 1970. The steel economic cycles, covering a period of about 40 months, showed variations oscillating around this sustained trend.

The Conference of the International Iron and Steel Institute (IISI) held in October 1974(8) showed the confidence of those in the iron and steel industry in a continuation of this growth: the Conference forecast that the year 1975 would show an increase in iron and steel production of 4.2% as compared with 1974, or 740 million tonnes instead of 720 million(9). According to the specialists the difficulties which would probably be encountered during 1975 would be not so much a reduction in the demand as insufficient production capacities, aggravated by shortages of coking coal(10).

The IISI therefore had no reason to modify the forecasts which it had drawn up three years previously and which forecast a production of 1,144 million tonnes of steel(12) for 1985(11), corresponding to an increase of more than 80% as compared with 1972(13) and an annual rate of growth of about 5%.

Continuing optimism

17. The fall in the world production of steel was extremely sudden in 1975, the reduction in production corresponding to approximately the whole of the world production in 1910.

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(8) Annual Conference of the IISI, Munich, 14-16 October 1974, Report of proceedings

(9) Instead of the 720 million tonnes forecast by the previous Annual Conference in October 1973.

(10) IISI, 1974, Report of proceedings, page 19.

(11) Projection 85, International Iron and Steel Institute, Brussels 1972

(12) as crude steel equivalent.

(13) 630 million tonnes in 1972.

18. However the habits of steady and sustained growth were so profoundly ingrained that the estimates and forecasts made in 1976 for the period 1980-1985 extended from very moderate pessimism to marked optimism; this is shown by the following examples:

a) A study by the Bank of America on the world steel industry stated[14] that it:

- "foresees only slight increases in capacity in the next five years as a result of a slow growth in demand and the rising cost of expansion ......"

- "the most significant growth is expected to come from the developing countries"

- "the growth in consumption is now slowing down, including in Japan ...... by 1980 the developed countries will probably be consuming 57% of the world total compared with 60% now ....."

- "the international steel trade is expected to show a much slower development than in the last twenty years ......"

b) By contrast a study of the Japanese iron and steel industry[15] forecast, both for 1980 and for 1985, a deficit in the world supply of steel as compared with the world demand:

- 1980	Demand	:	918.2 million tonnes
	Supply	:	774 million tonnes
	Deficit	:	45.2 million tonnes
- 1985	Demand	:	1,900 million tonnes
	Supply	:	958 million tonnes
	Deficit	:	51 million tonnes

(14) Bank of America - Metal Bulletin of 13 July 1976.

(15) Japan Consulting Institute - reproduced in Actualités Industrielles Lorraines - June 1976, Vol. IV. One may, however, note that the evaluation of the demand in 1985 (1 million tonnes) was considerably lower than the IISI projection for the same year (1,144,000 tonnes).

The Japanese study indicated that the deficit would, in particular, be felt in some of the major importing regions:

Table 1 - Major importing regions

	(millions tonnes)	
	1980	1985
USA	13.7	16.6
ASIA	22.0	27.6
MIDDLE EAST	9.8	10.0
LATIN AMERICA	9.1	8.9

The EEC and Japan would remain major exporters.

c) The view of W.T. Hogan, a specialist on the American iron and steel industry, was on the same lines as the Japanese study. Hogan forecast that the production capacities of the Western iron and steel industries would be inadequate to ensure their development in 1980[16].

d) The President of US STEEL affirmed, for his part, that a steel shortage was to be expected from the end of 1976 or, in any event in 1977[17].

19. This prolonged optimism was also based on the announcement of an extensive "redeployment" of the iron and steel industry towards areas better provided with energy, minerals and capital and away from those European (North Europe) or Japanese sites which were either saturated or threatened by pollution[18]. Under these conditions it is understandable that the survey carried out in 1976 by the EEC on "Investments in the coal and steel industries" confirms that "the unfavourable economic situation in 1975 has not prevented companies, with a few exceptions, from carrying out the investment programmes which were in hand or already decided on"[19]. One can also understand the persistence of the optimism in an article, which appeared in May 1976, entitled "On the brink of recovery", where the author, after having referred to the "normal steel cycle extending over a period of four years" stated that "as the worst of the recession passes .... 1976 is showing the same rhythm of recovery

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(16) MOCI, 11 October 1976

(17) Financial Times of 4 May 1976

(18) This was also the period when the problem of "recycling petrodollars" arose.

(19) Le Nouveau Journal, 4 September 1976.

as 1972 after the disaster of 1971 ...... it is beginning to look as if the next really good year steel will be peaking in 1978."[20]

20. These reminders are not just anecdotal. Their inclusion in this report is necessary if we are to understand how and why the forecasts were so contradicted by the facts. Within this context it should be pointed out that the UNIDO forecast of consumption and production in the iron and steel industry for 1985 and for 1990 showed a certain degree of prudence in 1976, since they were considerably below the IISI forecast: 1,069 million tonnes instead of the 1,144 million tonnes forecast by IISI. The prolonged optimism which was still being shown in 1976 therefore made it very difficult to appreciate the situation, not just as a simple economic and cyclical movement, but as an in-depth and structural transformation of the factors in the world iron and steel industry.

2. THE NEW CONTEXT OF 1977-1978: THE "CRISIS"

From "cycle" to "crisis"

21. The prolongation of the recession in the iron and steel industry in many countries during 1977 caused a modification of these reactions. The facts finished any hopes of continuing optimism.

- IISI estimates	
of the 1976 production (in October 1976)[21]	: 693 million tonnes
effective 1976 production	: 676 million tonnes
- IISI estimates	
of the 1977 production (in October 1977)	: 695 million tonnes
effective 1977 production	: 673 million tonnes
- IISI estimates	
of the 1978 production (in October 1977)	: 733 million tonnes
effective 1978 production	: very probably lower

(20) "On the brink of recovery" - Financial Times of 8 May 1976

(21) as crude steel.

The annual IISI Conference held at Rome in October 1977 showed this change very clearly. The report presented by the Secretary General explained that the various indicators which were available were not of the kind to give much comfort and that, whilst the recession had principally affected the market economy developed countries, the developing countries were not completely spared, in particular Latin America[22]. He drew the conclusion from this that "the present period of lower demand for steel has brought in its wake increased competition on the international level, lower prices and what is generally described as the steel "crisis". According to many articles and analyses in the business and financial press this crisis is a world-wide phenomenon. And it is, of course, true that the general economic slow-down is global in scope and that capital goods investment activity is much reduced everywhere."[23]

The crisis and new projections

22. Whereas the IISI admitted in October 1976 that it was probably necessary to reduce the 1985 forecasts by the equivalent of one year of growth a study carried out on behalf of the American iron and steel industry had already put forward, in May 1977, the following opinion: "today it appears to us that a two-year lag is not unlikely, for a 1977-81 per annum expansion rate of only 2.8%."[24]

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(22) Developing countries - Apparent steel consumption

1974 = 100

	1975	1976	1977 (est.)	
- Latin America	97	86	96	Annual report of the Secretary General Mr. Charles Baker, 11th IISI Annual Conference, Rome, 10-12 October, 1977
- Asia (excluding Japan, China and Dem. People's Rep.of Korea)	99	111	117	
- Africa (except South Africa)	112	114	121	
- Middle East	109	118	133	
Total	101	101	111	

(23) Baker Annual Report, op. cit.

(24) "Steeling against inflation" - Mitchell, Hutchins, Inc., May 1977

The Eleventh IISI Conference drew the conclusion of this development by proceeding to a re-evaluation of the new production capacities installed or projected between 1974 and 1985. Whereas the Eighth Annual Conference in Munich(25) had estimated the net capacities to be installed between 1974 and 1985(26) in the market economy countries and in the developing countries as 240 million tonnes of crude steel, these forecasts were reduced "after a very careful examination of all the projects" to 142 million tonnes, divided up as follows:

Table 2 - Additional iron and steel capacities, by regions, between 1974 and 1985(27)

(millions tonnes)

	1974 estimates (Munich)	1977 estimates (Rome)			
		Total	% Reduction	Installed capacity 1974-1977	Capacity to be installed in 1978-1985
EEC	41.3	23.6	43	14.5	9.1
Other Western European countries	26.7	14.1	47	9.2	4.9
North America	28.5	13.0	54	3.9	9.1
Latin America	37.2	30.7	18	13.3	17.4
Africa	12.3	5.4	56	3.8	1.6
Middle East	23.8	9.5	60	2.8	6.7
Far East*)	67.9	43.9	35	17.0	26.9
Oceania	2.3	1.8	22	-	1.8
Total	240.0	142.0	41	64.5	77.5

*) China and Democratic People's Republic of Korea are not included.

23. These estimates were not exaggeratedly pessimistic; on the contrary the information available since October 1977 seemed to indicate that they were realistic:

(25) In October 1974

(26) New installed capacities - declassified capacities

(27) 11th IISI Annual Conference, Rome, 10-12 October 1977. Annual report of the Secretary General, Mr. Charles Baker

a) Certain iron and steel specialists who had, in 1976, envisaged steel shortages in the eighties, radically revised their forecasts at the end of 1977, remarking[28]:

- That the projections relating to the iron and steel industry and derived from the Lima objective were very ambitious in the light of the technical and financial obstacles to be overcome ....
- That it is very hazardous to make forecasts for the year 2000 and that it is better to retain an intermediate horizon, 1985 or 1990 .....
- That a consensus is appearing on the fact that world iron and steel production in 1980 will reach (and exceed) the record production of 1974.
- That it is doubtful if the iron and steel production capacity of the developing countries can reach the objective of 150 million tonnes in 1985, but that probably the new installed capacity in the developing countries will not exceed 55 million tonnes.
- That the financial problem is an enormous one, the more so since iron and steel projects are not the only ones to come into competition for these rare resources.

b) Various projections relating to the world demand for steel are convergent, inasfar as they propose reduced evaluations as compared with the old projections (see Table 3).

24. All this leads to the essential question put by experts and observers in the iron and steel industry: "Is the iron and steel world in the process of changing ?"[29]

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(28) W.T. Hogan, "Future Plans in the Third World". Iron and Steel Engineer - November 1977, pages 25 to 37

(29) "The changing world steel industry" is, for example, the title of an article published in the SEAISI review, January 1977, pages 3 to 18.

Table 3

	Projections of the steel demand in 1985 (millions of tonnes)
IISI (1972)	1,144
UNIDO (1976)	1,069
General Electric (1977)[30]	968 (no projections possible beyond 10 years)
General Electric (1978)[31]	949
Ayres Model II (1978)[32]	890 to 1,008
AISI (1978)[33]	Forecasts, for 1985, a demand which is 85 million tonnes lower than the available capacity.

The significance of what is termed the crisis

25. The crisis has today become the central subject of commentaries and analyses relating to the development of the world iron and steel industry. Comments and analyses have a tendency to enlarge on the dramatic character of the phenomenon, in respect of which one must not overlook either the complexity or the contradictory aspects.

26. The iron and steel industry in the **centrally planned economy countries continues, in practice, to develop; this applies also to the developing countries.** In the United States the recovery appears to have been effective during the first months of 1978, whilst the situation continues to deteriorate in the European Economic Community to the point where a drastic reduction of production capacity between now and 1985 is being envisaged[34a].

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(30) Reply from General Electric to the UNIDO enquiry, October 1977.

(31) Prospective study by General Electric, 1978.

(32) Report by R.U. Ayres to the International Centre for Industrial Studies, UNIDO, May 1978.

(33) Metal Bulletin, 30 June 1978

(34a) On the crisis of the iron and steel industry in the Community see the book by Patrick Bonazza "The European Iron and Steel Industry in Crisis" - European Information Office - June 1978.

27. At all events the world iron and steel industry is affected, inasfar as a regular and widespread growth has given place to national or continental changes which were diverse and abrupt. This development has provoked considerable unease, the more so since the "causes of this recession, of these abrupt changes, are still obscure"[34b], and that the statistical or other tools available at the present time do not make it possible to answer the new questions which are posed.

Certain specialists have stated, since 1976, that it was no longer possible, because of the transformation of the world iron and steel industry, to make very long term projections (the year 2000), but that it was necessary to be satisfied with projections of less than 10 years and by regions: the reference bases had collapsed, and the statistical tools were no longer suitable[35].

In 1978, although they took note of the fact that the past could no longer be used in the iron and steel industry as a basis for forecasts on the future, specialists ceased to have any confidence in the regression equations explaining the levels of production in the past and the total capital investments. Changes have been so profound in some of the independent variables that it was now simply a matter of good sense to consider that such statistical relationships on the basis of past data no longer had any significance for the future[36]. IISI had in fact already carried out, some months previously, a revision of the 1985 projections published in 1972, together with an extension to the year 1990. The Secretary General of the Institute stated that the results of this work were not yet available, inasfar as the present situation

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(34b) "The current steel crisis and future growth" by C.B. Baker, Secretary General of the IISI. Concast speech, 9 March 1978. Mr. Baker posed the question: "Are we experiencing a crisis of the free market economy system, rooted in long-term structural changes which will lead to permanently reduced rates of economic development or even zero-growth ? ...... The evidence, statistical and other, is not sufficiently complete to permit a clear distinction between the ordinary, familiar features of recession and the long-term and possibly structural elements which may have come to stay .....".

(35) Raveson, Manager of Economic Planning of Research, Worldwide General Motors Overseas Operations - Metal Bulletin of 8 April 1976.

(36) General Electric - 1978 projections.

provided a base which was completely unsuited for carrying out long-term projections, the available analytical tools making it impossible to take into account the impact of structural transformations(37). It does not seem therefore that IISI will publish new global forecasts for 1985 or for 1990 in the near future.

28. The transformations of the world iron and steel industry are also shown by a forecasting crisis which is explained both by the disappearance of an adequate base and also by the non-availability of statistical or other tools suited to this new situation.

The forecasting crisis is also the result of a crisis in forecasting methods.

29. The difficulties in forecasting are not specific to the iron and steel industries. Most sectors are in the same position. The difficulties are accentuated when the sectors are particularly sensitive to macro-economic variables. Forecasting their long-term development seems highly uncertain today(38). Sectoral expertise, which generally effectively dominates internal variables, is at the present time disarmed by external uncertainties and their repercussions on the sectors. Technological forecasting is therefore affected, particularly in those sectors where technological progress is largely exogenous to the sector (39, 40).

In the case of the iron and steel industry the uncertainty in regard to its economic environment is accompanied by problems concerned with the operation of its internal mechanisms.

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(37) Ch. Baker "The current steel crisis and future growth" - March 1978.

(38) See: World Economic Survey 1977 - E/1978/70. 26 May 1978 - Economic and Social Council - United Nations.

(39) Professor Gerhard Mensch writes: "specialists on economic policy are obsolete as soon as one asks them for accurate information on specific and concrete prospects by branches ..... The experts know, as does also any layman, that technologies and the models of future applications must economise on energy, control the environment, serve men, etc., but nothing more precise". Gerhard Mensch - Das Technologische Pakt, Fischer Taschenbuch Verlag - 1977.

(40) An important part of the technological innovations used by the iron and steel industry is exogenous to it. See the book by Robert Emile Miller, University of Quebec and Massachusetts Institute of Technology - Company and innovation - a comparative study of eleven European and American iron and steel companies: Presses Universitaires de Grenoble, 1975.

3. THE PROBLEM OF FORECASTING METHODS

The reference method

30. Numerous methods were used to make long-term projections of the world demand - regional or national - for steel. In fact these various methods were all based, with variations, on a basic method, the most sophisticated version of which was developed by the IISI on the occasion of the publication of the 1985 projections[41]. A similar method had been used by the ECE for its 1976 forecasts[42] and also for the UNIDO study.

The IISI method consists of constructing a "steel intensity curve", that is to say to relate the rise in the consumption of steel to the growth of the per capita gross national product.

This is a function which can be written, in a simplified way, as follows:

$$C_j = F(y) + A_j$$

where F(y) is an empirical function constructed on the basis of a graph prepared by the members of the working group and using the information collected from twenty countries. The same basic curve is used for each country, variations in the constant A_j taking into account the differences in the structure of each national economy. The IISI working group put forward the hypothesis that the values of A_j remained relatively constant.

31. The steel intensity curve obtained by this method indicated that the consumption of steel initially increases much more than proportionately to the increase in the gross national product; that it then reaches a summit, after which it tends to become stabilised. The IISI drew the following conclusions:

a) No significant increase in the steel intensity appears until the per capita income reaches $300 (at 1963 prices), this being the minimum level required for "economic take-off".

(41) IISI Committee on Economic Studies "Projection 85", Brussels, March 1972.

(42) EEC/Steel "Long-term prospects for the consumption of steel up to 1985 and estimates for 1990; past trends in production and trading" - October 1976.

b) Once this level is reached then, normally, a process of rapid industrialisation develops, calling for an increase in the level of investment in productive installations and infrastructures and causing an increase in the consumption of steel which is more rapid than the increase in the gross national product. This is shown by a rapid rise in the steel intensity.

c) During the following phase the industrialisation movement becomes more balanced and the change in the steel intensity tends to become stabilised.

d) Industry becomes more sophisticated and the services sector increases its relative part. When the per capita revenue (1963 prices) is in the region of $2,500, the steel intensity begins to decline.

32. Operation of the IISI method - and related methods - depends on a number of hypotheses:

- a hypothesis of long and regular growth;
- a hypothesis of growth taking place according to a number of stages from before industrial take-off and up to post-industrial growth;
- a hypothesis of the privileged relationship between the rise in the consumption of steel and the rise in national revenue, etc.

33. It seems, in the present situation, that this type of method does not operate any longer. In this new context it seems therefore to be of value to proceed to its critical analysis so as to identify and define the new paths to be explored.

<u>The failings of the method based on the steel intensity curve</u>

34. The Committee for Economic Studies of the IISI admitted that the method used for the 1985 projections presented a number of problems(43), in particular problems relating to the efficiency of the method when it involved not developed countries but developing countries. These may be limited to the following:

(43) "Steel intensity and GNP structure". IISI Committee on Economic Studies, Brussels 1974.

35. The developing countries form only a small part of the sample used as the base for producing the steel intensity curve. The result is that "no indication can be supplied as to the measurement of steel intensity for per capita revenues below $400 at 1963 prices". However the developing countries concerned have a total population of about 2,000 million.

For the same reason one must not expect the steel intensity curve to provide any precise information on indicators relating to take-off or the phenomena which then arise, nor their incidence on steel consumption.

36. The critical analysis by the IISI pointed out that it was probably necessary to take into account, in the case of the developing countries, not only the apparent direct consumption of steel but also the indirect consumptions.

The summary analysis of concrete cases chosen from amongst the developing countries, such as the Republic of Korea, Brazil, Indonesia and Mexico, shows that the rise in the consumption of steel depended much less on changes in the gross national product and per capita revenue than on other variables.

The Republic of Korea, for example, had the highest steel intensity whereas it had (at 1963 prices) a very low level of per capita national product. By contrast the opposite applied in Mexico where a relatively low steel intensity coexisted with the highest per capita national product in the developing countries being considered.

37. It was therefore a simplifying hypothesis to consider that A_j[44], a residual factor, remained constant with time; this was equivalent to assuming that the whole of the system changes in a homogeneous manner, that is to say that there is no structural change and that the least favoured developing countries would not develop.

(44) Referring to the equation: $C_j = F(y) + A_j$

38. The crisis showed that the method was no longer valid but, before the crisis, the validity of the method had already been contested for use in the evaluation of the demand for steel in the developing countries, insofar as these countries were proposing to transform profoundly the structures of their economy by creating and then by developing new iron and steel capacities.

Some considerations on the elaboration of new forecasting methods

39. The production of new bases and new forecasting methods is now one of the priority subjects in the programmes of the major organisations interested in the development of the world iron and steel industry.

The IISI has started its projection activities from the ground by analysing all the available data on developments over the last four years so as to be able to identify, by successive tests, those correlations (and, as a consequence, the methodological approach routes) which are significant. No date is forecast for the completion of this work, which is still in its initial stages.

On its part, the Steel Committee of the ECE has decided that when it will deal again with the long-term projection problems, an experts meeting will be called beforehand to examine the possibility of conceiving a method for iron and steel industry projections.

This indicates that we are now in a period of active research on new forecasting methods; research work of which some of the lines of approach can already be seen.

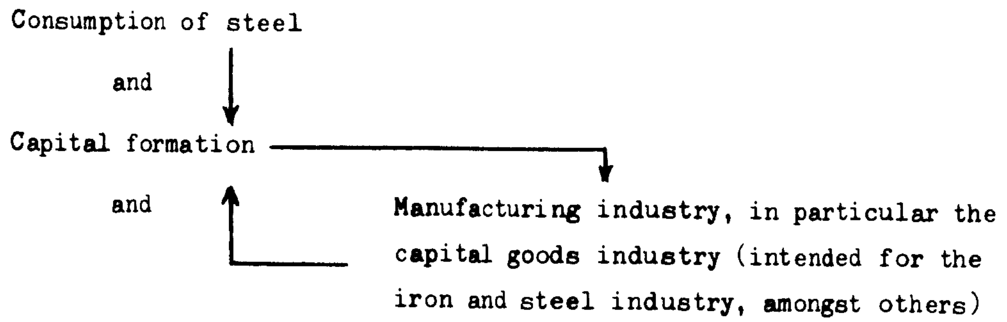
40. The critical analysis carried out by the IISI(45) on its own research method has drawn attention to the low degree of correlation which exists between the per capita national product and the level of steel consumption (steel intensity factor) in the developing countries. The countries studied were the Republic of Korea, Mexico, Brazil, Iran and the Philippines. The weakness of this correlation had also been noted in Colombia between 1925 and 1958 and in Tunisia between 1950 and 1964(46).

(45) Steel intensity and GNP structure: op. cit.

(46) The iron and steel industry at Menzel Bourguiba (Tunisia) - P. Judet 1967

The study of these various examples suggests, by contrast, the importance of that part of the national product which is allocated to the formation of fixed capital as compared with the development of the consumption of steel. This high degree of correlation was equally confirmed in the case of Colombia and the case of Tunisia.

41. By advancing this direction of research one is led to make a link between that part of the national product allocated to the formation of fixed capital and the importance of the manufacturing industry; but also between the part of the national product allocated to the formation of capital and the existence and the importance of the production of equipment goods. The first analysis sketched out in this way by IISI shows clearly the dynamic relationship which tends to become established between:



This seems to be a promising route, and it is important to continue exploring it.

42. The production of a method tends normally towards the development of a formula of general application(47). Before arriving at this degree of elaboration it is necessary to follow a more analytical approach making it possible to survey the land, that is to say to integrate the totality and diversity of reality. From this point of view IISI decided to become more particularly interested in several sectors chosen as a function of their importance in the development of the consumption of steel:

- The building sector;
- the machinery and equipment sector;
- the private vehicles sector;
- the commercial vehicles sector;
- the shipbuilding sector;
- other sectors.

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(47) Of the type of the equation $C_j = F(y) + A_j$, as described above.

43. A knowledge of the development of each of these sectors should make possible a better approach to the development of steel consumption. However this is on the condition that satisfactory replies can be given to some very important questions:

a) First question: How, for each of these sectors, is one to produce correct medium and long-term projections ?
The reply to this is not easy, since it assumes that numerous problems are solved, for example:

- The problem of substitution of materials: Is it safe, on the subject of substitutions between steel on the one hand and aluminium and plastics materials on the other, to assume that "the easiest and most logical substitutions may have already taken place, and they are fully reflected in the data for past periods on which future projections are based. The rate of substitution is likely to be lower in the future ..... The plastics and aluminium industries may have reached maturity and their rate of technological advance is slowing down and becoming more comparable to that of the steel industry ....."(48) ? The subject of substitutions between materials is a very difficult subject; the availability of good projections in respect of long-term developments in technologies would surely allow a better evaluation of probable trends.

- The problem of the life cycle of the so-called durable consumer goods: (automobiles, domestic electric appliances, etc.). The increase in the price of energy is likely to have important consequences in this field. New energy policies will result in the modification of models and a reduction in the weight of steel used in them(49). The fact that in the future an automobile will last on average 10 years instead of 5 will not be without effect either on the consumption of steel or on the availability of scrap iron, etc. It would be desirable, on this subject, to be able to evaluate the effect of the energy policies which will

(48) UNIDO/ICIS Report, December 1976, op. cit., pages 31 and 32.

(49) For example General Motors in the USA appear to consider as inevitable, because of the new energy policy, the modification of models and the reduction of weight of metal used in them. (See interview with Mr. T.A. Murphy -President of the General Motors Corporation, Times, 27 March 1978.)

be implemented throughout the world, particularly in the major consumer countries. To carry out a study by sectors does not therefore only imply the collection and integration of all the basic elements but also the establishment of an analytical inventory of the different variables and the combinations of variables which condition the development of each of these sectors.

b) A second question is posed in relation to the actual choice of the sectors to be studied as priorities. The sectors retained by the IISI, private and commercial vehicles, machinery and equipment, shipbuilding, etc. correspond to the preoccupations and priorities of the developed countries, whilst being at the same time the sectors which are most sensitive in respect of their consumption of steel.

It is not certain that a large number of the developing countries, desirous of listing the most decisive factors for the development of their consumption of steel, will be led to choose the same sectors. What sectors will they retain ? Certain developing countries have already posed the question from the point of view of the creation and development of a national iron and steel industry. Certain of them have estimated, for example[50] that the agricultural sector and that of building, consisting of dwellings, industrial buildings and infrastructure, and the mechanical engineering sector constitute, at least initially, the priority sectors to be analysed.

44. Discussion is largely open on a field of research work where taking into account the points of view of the developing countries conditions the validity of the methods which will progressively be developed. From this aspect the satisfaction of the basic needs of the population is certainly one of the factors which conditions the development of the consumption (and production) of steel in many countries. In fact whilst the private vehicles sector is only of small interest at the present time to Upper Volta, Laos or the Republic of Yemen the agricultural sector, with tools, machinery, equipment and the infrastructures involved in its modernisation, form a sector of high priority for these countries, very closely linked with the development of the iron and steel industry. It is therefore necessary to utilise methods which are capable of correctly appreciating this development.

(50) For example the National Iron and Steel Company in Algeria, whose departments are exploring various forecasting methods.

45. Another method is used by several developing countries to project the development of the demand for steel in the medium and long term. This is also a highly global method, involving assuming that the national consumption of steel at this or that date can be approximately evaluated from the effective consumption of steel in one or other country, chosen as a reference, 10, or 15 or 20 years previously[51]. The value and efficiency of such a method of temporal relationships depends upon the more or less well-based character of the analogies which exist between economies situated at more or less advanced stages of development. The method has something of a mobilising character (to achieve a per capita consumption already exceeded by others) but one finds, starting from a new point of departure, those problems which are linked to the steel intensity curve, that is to say the hypothesis that a group movement continues and passes through a certain number of stages and thresholds before reaching a culminating point, approximately defined in the work of the IISI by the steel consumption of the United States.

46. The determination and development of the culminating point poses several questions:

a) If per capita steel consumption has already (or nearly) arrived at its maximum level is no significant increase probable up to the year 2000 ? Under such conditions is it probable that the consumption of steel in Europe and Japan will not exceed (if they attain) the American consumption both quantitatively and qualitatively (breakdown between flat and long products, between ordinary steels and special steels) ? What will be the consumption of the developing countries: will it pass through the various stages of a curve of the same rate, with a time delay, or will it, as a function of original priorities, involve a different rate and structure ?

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(51) For example: the planner in the developing countries. He estimates that the per capita steel consumption in his country will reach 250 kg, as in Spain in the year 19.., or again the planner of the developing country that the per capita consumption of his country will reach 150 kg, like Bulgaria, in the year 19..

b) Will the curve showing the growth in the per capita steel consumption in the USSR flatten out, or will it continue to rise up to the year 2000, well beyond 600 kg per capita and per year[52], under the influence of the high priority given to industry and to infrastructures ? In this case how can this development serve as a long-term reference for certain developing countries ?

c) What is the real significance of the summit of the steel intensity curve, reached today for example in the United States ? Does a descending phase automatically follow this culminating point ? It has justly been pointed out on this subject that no country yet has experience of an economy which has arrived at this stage. Inasfar as the American economy is the only industrialised economy in the world whose infrastructures were not destroyed by the war it did not have to reconstruct them. Will not the time arrive when such reconstructions have to be undertaken in the transport sector, in the energy sector, in the whole of the industrial base ....? This question has been posed by an American economist[53]. This significantly enlarges the field of investigation for the development of methods suitable for grasping the development of the demand for steel and of the world iron and steel industry.

Towards new forecasting methods: the priority tasks

47. In 1978 the development of the crisis profoundly altered the situation; it showed that the customary forecasting methods were no longer usable, and that new methods had to be developed. From this standpoint new priorities must be defined, both for the medium term and for the long term.

(52) Robert U. Ayres, within the framework of Model II of his projections of steel demand for 1985 and the year 2000 gives, for the USSR in 1985, 705 to 790 kg per capita and in the year 2000 835 to 1050 kg per capita - doc. cit.

(53) Article by Donald B. Thomson in Industry Week, quoted in the Bulletin of the Arbed Company, 13 and 14 July 1978 - Nos. 132 and 133.

Forecasting the demand and evaluating the supply position in the medium term

48. The development of new forecasting methods and general formulae requires time. The development of the world iron and steel industry, of the demand and the production, of investments and projects, will not stop for this. It is a development which it is necessary to try to understand and, if possible, to anticipate.

49. A certain **convergence of opinion can be seen on the 1985 prospects:**

- The world demand for steel in 1985 will probably be less than 1,000 million tonnes; the forecasts - to be followed up and updated - oscillate between 960 million and 1,000 million tonnes.
- Steel production in the developing countries in 1985 is likely to be less than 150 million tonnes, inasfar as the projects which are capable of entering into production by that date represent a new capacity of less than 55 million tonnes[(54)] (excluding China).

50. In the present context where developments are rapid, where projects are appearing, disappearing or are modified on several occasions, the collection and processing of information on projects and on trends constitutes a priority task.

The new President of the American Iron and Steel Industry has stated in this respect that "the world steel industry will function more efficiently if information and data on steel capacity, production and trade are promptly made available to all concerned parties .... the whole global steel industry is in pretty much the same leaky boat ...."[(55)]

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(54) See the article by W.T. Hogan "Future plans in the Third World" Iron and Steel Engineer - November 1977, page 26.

(55) American Iron and Steel Institute - Press Release, 20 June 1978

51. When forecasting of the demand in the short and medium term comes up against apparently unsurmountable obstacles it is very useful to know that evaluation of the supply position remains possible, full knowledge of existing projects and their developments making it possible to locate the 1985 supply position with reasonable approximation. By using methods which make it possible to follow up effectively the development of projects the International Centre for Industrial Studies, in conjunction with the other departments of UNIDO concerned with the iron and steel industry, has made a contribution which can be directly used by the developing countries and also by partners in future bilateral or multilateral negotiations.

The development of new forecasting methods

52. Several specialised international organisations are undertaking this work, which will be difficult and long: the International Iron and Steel Institute in Brussels (IISI) and the CMEA. The steel Committee of the ECE in Geneva projects to realize a study in this field.

These specialised organisations are particularly well informed on the problems which are presented in the most advanced countries in controlling the iron and steel industry.

53. Now it is very important that the specific problems of the developing countries, which only have an embryonic iron and steel industry or still do not have one at all, should be stated and integrated into the research on defining new methods for forecasting the demand. It is not without value to recall, in this connection, that the population of the countries where the per capita revenue was less than $400 (in 1963 dollars), and in respect of which one does not have any indication on the coefficients of elasticity of the consumption of steel, represent about half the population of the globe. All countries are concerned in the development of general formulae, but the developing countries are particularly interested in opening up concrete approach routes and identifying the most sensitive sectors in relation, for example, with the satisfaction of requirements which are felt to be basic.

From this point of view it is desirable that UNIDO, in conjunction with specialised organisations, should be in a position to contribute to the consideration and integration of this type of preoccupation in the work which is being undertaken at the present time.

54. In this period, where research into new instruments implies a considerable confrontation of experience, it is of interest to know and to use the forecasting experience of the **centrally planned economy countries where the** iron and steel industry has shown the highest rates of growth over the last thirty years. Soviet experience has, in practice, developed in the following directions:

- In the USSR and other socialist countries forecasting is regarded as an integral part of socialist planning, contributing towards reinforcing the scientific character of long term plans.
- Forecasting of iron and steel demand is based on meeting the requirements of basic metal consuming industries in the national economy, such as metalworking, capital construction, railways, exports, etc.
- In this connection the total demand for steel is determined by adding together the requirements for metal in all the branches of the national economy. The general forecasting scheme can be formalised as follows:

$$(Z \vee G \vee F) \longrightarrow P \,*$$

Two groups of factors have a fundamental influence on forecasting the demand for iron and steel products(56):

1. Factors which are constantly at work, and which cause an increase or a decrease in the demand as a function of the development of the mechanical engineering industries, the building industries, technical progress, etc.;

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* Z = set of concepts relating to development trends in the sector concerned,

G = set of scientific hypotheses and ideas concerning future possible lines of development of demand and its various links.

F = set of concepts relating to determinant factors and the conditions favouring the acceleration or slowing down of growth.

P = forecasts: conclusions and recommendations.

(56) R.G. Kamalov, A.A. Schitikova "Forecasting of Steel demand" CCRIITES of State Committee of the Council of Ministries of the USSR on material supplies - 1975. See also German D. Surguchov "Problem-Oriented Modeling in Industrial Technology: The Steel Industry" Technological Forecasting Social,Change Volume 12, Numbers 2/3 August 1978

2. Random factors acting from time to time, such as: the international situation, changes in external economic relations, the emergence of new economic and social objectives, etc. These factors affect the rate of growth of all branches of the economy, together with the volume of consumption of iron and steel products.

The laws and tendencies governing the development of steel consumption can be established with the aid of detailed studies of existing consumption of these products in the national economy.

Numerous reports have recently been published in the USSR dealing with various aspects of the projection of the demand for steel, and particularly the long term demand.

Projection of the demand(57) is based on their method by extrapolation, the results of which are then monitored by a group of experts. The model assumes that the national revenue (based on 1965 prices) is an independent variable. The hypotheses on which the principal conclusions and calculations are based are as follows:

- With an average per capita steel production of 500 kg the Soviet economy will be affected by what might be termed "steel saturation", leading to a reduction in the specific steel consumption per unit of product (in terms of net national product). This will be shown, during the coming years, by a slowing down in the rate of increase of the production.

- Furthermore it will be necessary to compare with this process not only the per capita average production (or consumption) but also changes in the per capita steel stock-pile(58), inasfar as in the future the nature of the long term needs of the national economy for steel will be highly conditioned by the degree of saturation in iron and steel products which has been reached by the national economy, that is to say by the size of the steel stocks held in the country. The best index which makes it possible to measure the degree of saturation reached in a given country is probably the <u>per capita steel stock</u>(58).

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(57) B.N. Michalevsky, Y.P. Solovjev "Economy and Mathematic Methods", 1968 IV issue 3.

(58) P.A. Shirgaev, A.M. Poljak "Steel consumption in the USSR" - <u>Metallurgia</u> 1970.

When it is a question of long term projections (over more than 10 years) the value of production (and consumption) must be taken into account, together with the development of technical progress and structural changes affecting the overall economy and the iron and steel industry in particular.

55. It can be seen that the Soviet economists introduced into their forecasts two original elements:

- Taking into account not only the per capita consumption (and production), but also the concept of per capita national steel stock and national stock.

- The inter-reactions between the demand for steel and the supply.

However the Soviet economists seem to come up against the considerable problems posed today by very long term forecasts; in this respect they are confronted with the same difficulties as face all forecasters throughout the world at the present time.

4. A PROSPECTIVE STUDY OF THE SECTOR

56. It is agreed today that the method of forecasting the demand for steel which was used up to the crisis was based on a very small number of variables around a central variable, the per capita national product. The relative poverty of this model was not a problem as long as it was masked by a long and regular movement of growth. The present questioning of the validity of the method leads to questions on the relationship of the iron and steel industry to its environment, and also to an appreciation of the iron and steel industry itself as a complex reality.

57. The crisis showed up the close relationship existing between the iron and steel industry and the environment[(59)]. The latter comprises various components of the national economies but also those of an economy which is becoming international and where the national, global or per capita product is not the only magnitude of interest but where it is also necessary to consider gross fixed capital formation; the distribution of the national product between the major activity sectors, the structure of the manufacturing industry, the place occupied by the production of equipment goods or by certain services such as engineering.

(59) See on this subject "World Economic Survey 1977" United National Economic and Social Council - E/1978/70 - 26 May 1978. "For most countries, developing as well as developed, prospects are seen to depend quite heavily on events external to the domestic economy." page 1.

It is necessary to draw all the conclusions from the finding which has been made that the iron and steel industry is not an isolated oasis nor even a quasi-autonomous reality linked by a single link with the movement of the global economy.

58. The iron and steel industry does, in fact, form a complex system where the various grades of steel are interlinked with the range of products and the very wide variety of uses made of them by the clients.

Diagram 4 on the following page[60] gives some idea of these interrelations. However this only imperfectly shows the structure of this industry, and it is also necessary to show the resources and the technical routes, the sizes and the financing problems, the factors linked to the organisation, to the external market, etc. Similar interrelations of iron and steel industry were given by the USSR, Hungary, Poland and Czechoslovakia in the ECE study.

59. The multiplicity of the factors makes a large number of alternative combinations possible: this indicates the richness of the material for the writing of scenarios[61] integrating, according to various dynamics, the structured linkages between factors.

60. Polarisation in respect of the demand and its forecasting runs the risk of damaging the complex reality of this industry. There is certainly a constraint on demand, that is to say a market constraint; one cannot however neglect, as is proved by the example of the iron and steel industries of the USSR and the Eastern European socialist countries, what has been termed "the activism of the supply"[62]. This proceeds simply from the finding that the movements which affect the economy do not arise exclusively from the trend as an expression as some kind of fatality which submerges the economic agents in an inevitable manner: companies, national economies or world economies.

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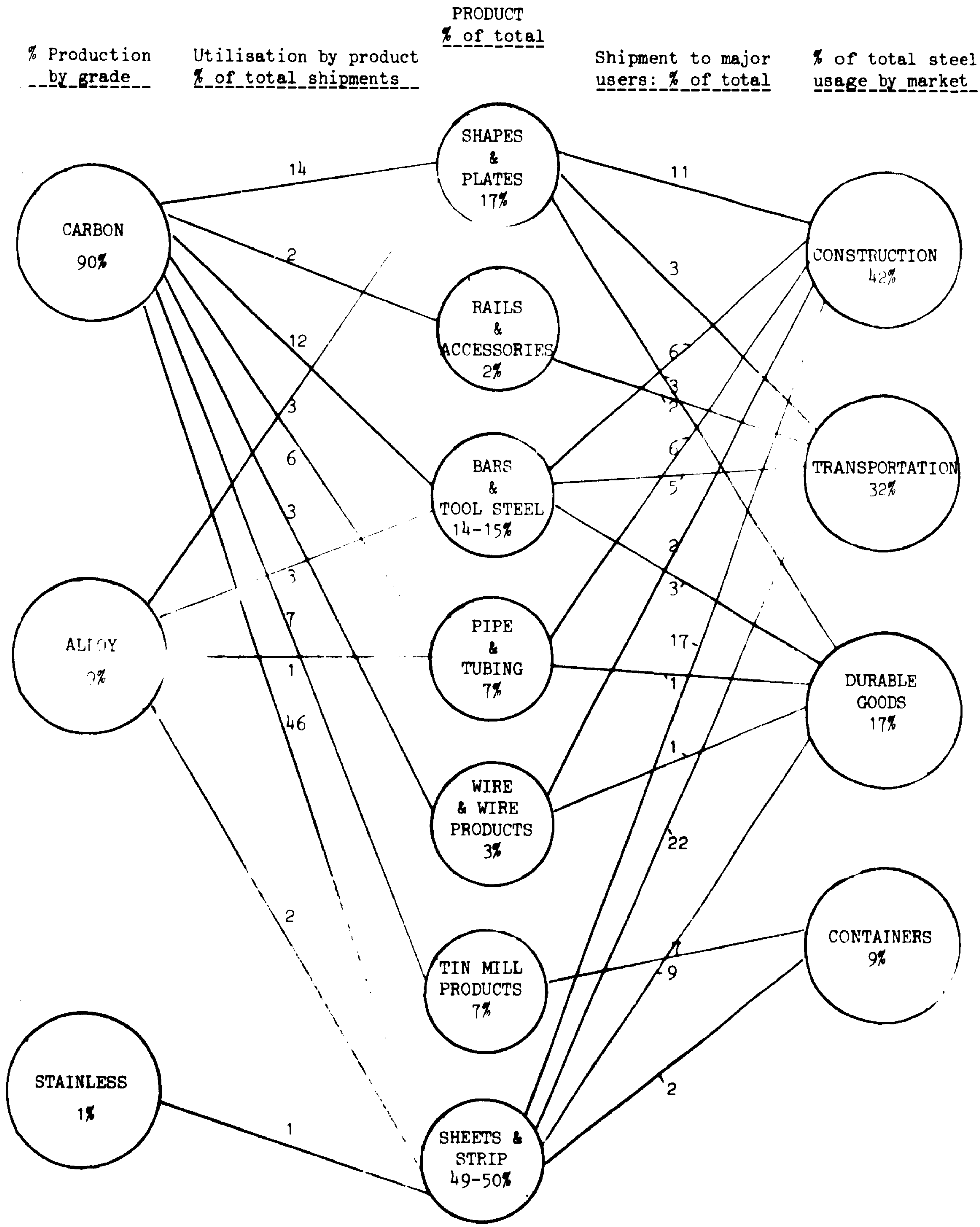
(60) Taken from Robert U. Ayres, doc. cit.

(61) In order to avoid any equivocation in the acceptance of the term "scenario", which is often used in different senses, the following definition will be retained for this study: "a unity formed by the description of a future situation and the events which make it possible to pass from the original situation to the future situation". Jean-Claude Bluet and Josée Zemos: Geographical prospective, research methods and directions - METRA, Vol. IX, No. 1 - 1970

(62) Expression used by Fr. Perroux in "The economy of the twentieth century", PUF, Paris, 1969.

Diagram 4 : STEEL PRODUCT DIFFERENTIATION AND DEMAND IN THE U.S.
(Derived from 1976 shipments, net tonnes)



The various economic agents are also actors capable of forming projects, of taking decisions, of initiating actions which contribute to modelling the future. Neither the Soviet iron and steel industry, nor those in Korea or Brazil, are the fruits of the "trend", even if they have had to establish themselves within a system of constraints and sometimes to come to terms with them.

61. There is not one future, but several futures. It is possible to distinguish the "dominant future" from the "dominated future"[(63)]. One understands by this the tendency of the past to dominate the future and the possibilities of dominating the future. It is in this way that one is able to define:

a) The "trend future", where the future is deduced from the trends of the past - all other things being equal. The implicit postulate is that the future will be determined by the same variables, in the same proportions, of the same intensity and at the same rate as in the past. This is the field of projections.

b) The "possible futures", where the futures are deduced from past and present futures and from those which may manifest themselves during the period being considered. The possible futures diverge from the trend future. The future will be a mixture of changes in the composition and actions of the variables and of inflexions capable of being caused by the actors (or agents).

c) The "normative future or futures". The image of the future corresponds to the situation where one or more objectives are assumed to be realised in accordance with the will, interests, wishes or needs of one or more actors. The future is teleogical. In this sense the Lima objectives are a normative future.

d) The "probable future". The realisable futures are delimited in relation to the possible futures by taking into account existing constraints. The probable future is selected as a function of the probabilities of events, of interactions of variables and of the actions of agents. The probable future is not an inert and fatalistic future. It results from a mixture of possible futures and normative interventions.

These concepts of the future are of considerable significance.

(63) Bertrand de Jouvenel - The art of conjecture - Editions du Rocher - Monaco 1964.

The "trend future" leads to the identification of a single future, presenting the appearance of certainty. Although the trend image of the past is valuable this method has nothing to do with the prospective approach. The "possible", "normative" and "probable" futures, by contrast, result from a concept according to which the forecastable future is multiple and indeterminate. "It is as a result of the confrontation of the various actors involved and their projects that one or other future will be born"(64).

62. It follows that the medium term future reality is, to a certain extent, knowable and anticipatable (probable future) and that there is, on this basis, a field open to the negotiation of bilateral or multilateral cooperation between the "probable" and "normative" futures.

63. Without questioning the value of forecasts of the demand it is, under such conditions, necessary to "locate" it by pointing out that to make a forecast and to construct new forecasting methods does not dispense with a more prospective approach. If it has become impossible to make forecasts of the demand in the long term (2000 or 1990) it is still possible to develop long and very long term prospective objectives to horizons of 1985, 1990 or 2000. It is from this viewpoint that the objectives defined at Lima continue to be located. Their realisation assumes in effect that it is not a convergence of trends but a transformation of the permanent structures which today characterises the world iron and steel industry.

64. This implies, amongst other things, an organisation of information orientated in a priority manner towards the acquisition of all the data capable of illuminating not only the improvement of the traditional routes of the iron and steel industry but, in particular, of anticipating all those possibilities which are clearly acquired or which are only sketched out, along new routes, in particular around those points which are most sensitive from the point of view of size, the quality of the product, of cost, of novelty of impact, etc. The scheme put forward in Annex 1(65) makes it possible to locate these sensitive points, and in this way to provide assistance in the restructuring of information located within a prospective approach for promotion of the world iron and steel industry.

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(64) Michel Godet - The forecasting crisis and the growth of prospective studies, examples and methods. PUF - L'économiste - 1977.

(65) Robert U. Ayres, op. cit. "Materials - process Flows in the Iron and Steel Industries".

65. Summarising, therefore, long term forecasting of the development of the iron and steel industry is a real question. But is it the real problem ? The true problem, in order to emerge from the impasse of forecasts, appears rather to be directed towards the prospective approach, that is to say a methodology starting from an analysis of the structures of the sector and its environment and the dynamics of the strategies of the actors.

C. THE ACTORS AND THE STRATEGIES

66. The iron and steel industry is an old one; it has had a long history since the invention of the coke blast furnace in Great Britain in the second half of the XVIIIth century. During the following two centuries the centre of gravity of the world industry has shifted on several occasions, as is shown in table 5 on the following page.

67. For a century Great Britain was the leading world centre for iron and steel production and exports. The United States then took over; up to the end of the Second World War they had an absolute superiority. Within a few years the production of the USSR exceeded American production; between 1960 and 1975 the Japanese iron and steel industry became the most dynamic and was tending to catch up with America.

The appearance and development of the iron and steel industry in the developing countries constituted, in the seventies, a new factor which is far from having exhausted its potentialities.

68. It is important therefore to take an interest in the various actors in the world iron and steel industry, to identify their positions and to analyse their strategies so as to clarify, as far as possible, the terms for negotiation and the elements of cooperation.

The actors can be divided initially between those in the developed countries and those in the developing countries.

1. THE DEVELOPED COUNTRIES

a) THE GROUP OF CENTRALLY PLANNED ECONOMY COUNTRIES

i) THE USSR AND THE EASTERN EUROPEAN SOCIALIST COUNTRIES

69. Unlike the developed countries with a market economy iron and steel production in the USSR and in Eastern European socialist countries has not ceased to increase during the period 1974-1977. Its rate of increase has now slowed down slightly: 3% per year on average, with a slowing-down which was more marked in the USSR (1.5% between 1976 and 1977), but it is generally agreed that this situation will be corrected in the coming years(66).

(66) It does not appear that any long term predictions are officially published by the CMEA, but several countries (Czechoslovakia, Hungary, Poland and USSR) have transmitted to the ECE national forecast for 1981-85 and 1986-90.

Table 5

Historical development of iron and steel production

	Production as % of total				
	EEC[1]	UK	USA	Japan	USSR
1870	30.6	37.4	16.2		2.7
1880	31.0	26.8	27.5		4.0
1890	25.9	26.0	32.4		3.4
1900	26.3	17.5	35.4		6.2
1910	27.0	12.0	43.6		4.7
1920	20.3	13.4	59.8	1.1	5.1
1930	31.9	7.8	43.5	2.4	8.3
1940	20.5	9.3	42.9	4.8	12.9
1945	4.2	10.5	63.4	1.7	10.7
1950	16.5	8.6	47.1	2.5	14.2
1955	19.2	7.4	39.3	3.5	16.7
1960	21.0	7.1	26.4	6.4	18.8
1965	18.7	6.0	26.7	9.0	19.8
1966	17.9	5.2	26.3	10.1	20.4
1967	18.0	4.9	23.7	12.5	20.5
1968	18.6	5.0	23.0	12.6	20.1
1969	18.6	4.7	22.8	14.3	19.2
1970	18.9	4.9	21.1	16.1	20.0
1971	18.4	4.3	19.9	15.7	21.4
1972	18.6	4.2	20.3	15.9	20.6
1973	18.3	4.0	20.8	17.8	19.6
1974	19.4	3.3	19.8	17.1	19.9
1975	16.9	3.2	17.6	16.5	22.8

Sources: Statistical office of the European Communities
Statistical Yearbook of the Iron and Steel Industry Association

(1) **The EEC of the 6 countries.**

A major American company, for example, estimates that production will develop in the following manner:

	Millions of tonnes		
	1975	1985	2000
USSR	141.3	188.0	250.0
Eastern European socialist countries	54.3	87.0	134.8

Other observers, basing their views on the slowing-down of production: 6.6% growth between 1972 and 1973, 3.2% between 1973 and 1974, 3.0% between 1974 and 1975 and 2.6% between 1975 and 1976, judge that future increases will be much more modest than up to now.

At all events the USSR has become the leading iron and steel power in the world. The USSR has all the factors necessary for rapid expansion. It has enormous reserves of high purity iron ore, coking coal, low grade coal, natural gas and also major timber and hydroelectric resources. Furthermore it has the means for applying nuclear energy to iron and steel production.

Expansion of the Soviet iron and steel industry forms the basis of the industrialisation and integration of its economy. The production of the Soviet iron and steel industry is intended, as a priority, to meet the domestic demand. The USSR imports iron and steel products: tubes, piping and other products, whereas it is also developing exports (towards Europe) which are tending to balance these imports. The USSR is able to offer a wide range of engineering services and iron and steel plant which makes it an important partner for the developing countries in the construction of their own iron and steel industries.

70. **The socialist countries of Eastern Europe, the German Democratic Republic, Poland, Czechoslovakia, Hungary, Roumania and Bulgaria have started** their iron and steel industry from scratch (Bulgaria) or developed it at a very fast rate (the other countries) since the end of the forties. Poland, Czechoslovakia and Roumania are today amongst the fifteen leading iron and steel powers in the world. Only Poland has major reserves of coking coal whilst Roumania is well provided with natural gas and oil; the

other countries have to rely largely on the USSR or on other sources of supply to meet their requirements of iron ore or coking coal. However there are major resources of low grade coal in the German Democratic Republic and in the Balkan countries for using non-coaking coals.

Poland, Czechoslovakia, Hungary and Roumania have become exporters of iron and steel products, whereas in Bulgaria the development of the iron and steel industry had a tendency to follow rather than precede the general movement for development of the economy and, in particular, that of the mechanical engineering industry.

Up to the present time it does not seem that these countries are able to offer complete supplies of equipment for the iron and steel industry, nor engineering services corresponding to contracts of the turnkey type. Their capacities for the construction of heavy equipment, sometimes highly developed (Czechoslovakia and Poland) are generally involved within the framework of sub-contracting operations in conjunction with the USSR, or even sometimes with Western suppliers. By contrast several socialist countries in Eastern Europe, including Poland and Roumania, are particularly active in the field of projects and mining management.

ii) THE ROLE OF THE CENTRALLY PLANNED ECONOMY COUNTRIES IN THE DEVELOPMENT OF THE IRON AND STEEL INDUSTRIES OF THE DEVELOPING COUNTRIES

71. The centrally planned countries have already played an active role in the development of the iron and steel industries of several developing countries, and have contributed towards the creation of numerous production units.

There are in general iron and steel units of medium or large size, producing long products as well as flat products and conceived on the basis of the modern layout of the classical production route of blast furnace, LD converter and often with continuous casting, etc.

72. The centrally planned economy countries are, in general, prepared to envisage and negotiate the absorption of temporary surpluses produced by the new units to which they have contributed, inasfar as such surpluses remain marginal as compared with the increasing size of their markets.

73. The rapid development of the iron and steel industries in the Eastern European socialist countries has led these countries to become interested in possible supplies. This applies to supplies of coking coal, but in this field the developing countries have nothing to offer(67). As far as supplies of iron ore are concerned trading has existed for a long while from certain African and Latin American countries to Roumania, Bulgaria, Yugoslavia and Poland. The agreement which has been concluded between Poland and Brazil(68), which over a period of more than ten years will exchange Polish coking coal against high grade iron ore from Brazil, is significant as a type of agreement which will probably have a tendency to become more widespread during the coming years.

74. Finally we should emphasise the experience which has been accumulated over the last thirty years in the Eastern European socialist countries in the field of construction and management of iron and steel units. This experience is based on the creation of more than 40 million tonnes of annual capacity: coastal units of large size of the Galatzi (Roumania) type, units of small size, several times remodelled, of the Pernik (Bulgarian) type, together with medium-sized units; very specialised units or of a very wide range of products, etc. Such an experience, in its variety, is capable of supplying information and valuable indications to the developing countries on the possible routes and entries to follow, starting from an extremely wide range of conditions, particularly in the case of medium-sized economies.

(67) Except for one very rare exception: Roumania has recently acquired a coking coal mine in the United States.

(68) Financial Times of 17 July 1978

b) THE GROUP OF MARKET ECONOMY COUNTRIES

i) THE MEMBERS OF THE GROUP

75. **Industrialization and the history of steel making are narrowly linked in the market economy industrialized countries. These have been therefore at the origin of the major technological innovations. Very evidently they have played and play an essential role in the transfer of industries and technologies to the developing countries to which they could supply all the range of technical assistance. The developed countries with a market economy, which belong to OECD, are dominated by three poles: the United States, the European Economic Community and Japan; the production capacity of each unit represents 150 to 200 million tonnes of steel.**

The iron and steel industries of these three groups invested more or less similar sums of money between 1957 and 1976 for the renewal, modernisation and extension of their capacities:

In billions US dollars

34.8 in the United States(69)

29.7 in the EEC

26.9 in Japan

But although this has resulted in an increase in the iron and steel production capacity of 34% in the United States (from 119 to 156 million tonnes) the increase was 979% in Japan (from 14 millions in 1956 to 151 million tonnes in 1976). Although more than 100 million tonnes of additional capacity arose, in the case of Japan, from entirely new installations, this type of installation only contributed 11 million tonnes of increased capacity in the American iron and steel industry(70).

This explains why, although the share of the developed countries with a market economy in world iron and steel production is steadily falling, the Japanese iron and steel industry has never ceased to confirm its dynamism within this group.

Table 6

Respective shares in world iron and steel production

	1965	1976	1977
USA	26.1	17.0	16.8
EEC	24.9	19.7	19.7
Japan	9.0	15.7	15.2
Remainder of the world	40.0	47.6	48.3
Total	100	100	100

(69) "Steel Industry Economics" by Hans Mueller and Kiyoshi Kawahito, Japan Steel Information Centre - April 1978, page 5. It would appear that the American figure also includes investments made in mines or other activities by iron and steel companies, and this probably makes the figures even more comparable.

(70) H. Mueller and K. Kawahito, op. cit.

76. In addition to these three poles the group also includes other European countries with an old iron and steel tradition such as Sweden and Austria or countries where the iron and steel industry is of more recent growth such as Spain, Finland, Turkey, etc.

77. Finally the group also includes other non-European countries such as Canada, Australia and South Africa where the future of the iron and steel industry depends on very abundant resources of iron ore and coking coal.

ii) THE JAPANESE MODEL AND THE NON-INTEGRATED PRODUCERS

78. The Japanese iron and steel industry, although largely unprovided with raw materials, has reached such a level of efficiency and competitiveness in twenty years that certain commentators have been able to express the view that it now effectively occupies the position of "arbitrator" in the world debate.

It is not surprising, under these conditions, that the Japanese iron and steel industry has served for the last fifteen years as the model and reference point for most of the large world iron and steel industries. Japan has had to organise the import of the iron ore and coking coal which is necessary for operating its plants. In order to do this the Japanese companies have built on the coasts, often on land gained from the sea, installations of a very large size. These units, the capacity of which now reaches 15 million tonnes per year, are organised around giant blast furnaces(71) adjusted to the capacity of the steelworks, continuous casting machines and rolling mills. These installations are the result of systematisation on a large scale of schemes borrowed from the American industry(72); they are orientated as a priority towards the production of flat products, using processes which tend to become continuous and progressively automated(73).

79. It is in this direction that the principal world iron and steel industries evolved during the sixties and the first years of the seventies. They have had a tendency to abandon proximity to former deposits of iron ore and coal and to establish themselves "on the water" in the shape of large

(71) From 10,000 to 14,000 tonnes of cast iron per day.

(72) The first lines for hot continuous rolling of wide sheet made their appearance in the United States in the twenties.

(73) In 1975 the Japanese iron and steel industry used 381 process computers, including 53 for the production of blast furnace iron and 186 for rolling (see Japan's Iron and Steel Industry - 1976).

capacity units of 3 to 10 million tonnes at Ghent, Dunkirk, Fos, Sagunto, Taranto, Galatzi, Annaba, Iskenderun, etc., so as to be well placed to import raw materials and to export the sheet which they produce.

80. Nevertheless the priority given by the major iron and steel plants of the West to the installation of units of very large size directed towards the production of bulk flat products has left an unoccupied sector; a sector which is now being occupied by an increasing number of non-integrated or semi-integrated producers. These producers, which in general limit their production to concrete reinforcing rod and merchant goods of small size, but which are now beginning to take control of certain flat products, have multiplied not only in Italy in the Brescia region (leading to the term which is often applied to them of "Bresciani") but also in the United States, Spain, Denmark, Greece, Japan and in Great Britain. These producers operate on a small scale, in general from 50,000 to 200,000 tonnes, and have profited from the improved performance of high-power electric furnaces. They have also profited from the advantage resulting from the very low price of scrap iron to establish themselves to the detriment of the larger companies in those sectors where they have established themselves. In Italy the major iron and steel groups have already practically abandoned the production of concrete reinforcing rod to the "Bresciani"; in Great Britain the outlets of the B.S.C. are threatened in this field. More generally these mini-steelworks are strongly attacking the European market for long products, whilst in the United States the non-integrated producers have become "one of the market components", the more so as the price of scrap iron falls.

iii) THE CRISIS AND COMPETITION

81. The crisis in the iron and steel industry has resulted, particularly in the last two years, in controversies between the three major iron and steel industries in the developed countries with a market economy: between the American industry and the European and Japanese on the one hand[(74)] and between the European (EEC) industry and the Japanese and other European industries on the other.

82. The iron and steel industries in the market economy developed countries are, in fact, the industries which are most involved in international trading in iron and steel products.

(74) The polemic is sometimes very sharp. Mr Lewis Foy, the President of the American Institute of Iron and Steel, accuses the producers of steel in the EEC which export to the USA of dumping, and has asked for an enquiry from the American Treasury. Le Monde, 3-4 September 1978.

Table 7

Contributions to world exports

excluding intra-block trading (intra-EEC or intra-CMEA)

	1970	1973	1976
	%	%	%
USA	11.1	5.1	2.9
Japan	30.4	34.3	42.4
EEC	32.6	37.1	27.8
CMEA	9.6	8.1	8.2
Remainder of the world	16.3	15.4	18.7
TOTAL	100.0	100.0	100.0

Source: **Statistics of world steel trade UN/ECE**

This is shown at the present time by very keen competition in which Japan is playing a determinant role.

83. But it is also necessary to take into account new realities:

- The arrival on the market of new exporters, such as the Republic of Korea, Spain, Finland, Australia and some others, the dynamism of which permits a direct attack on the European and American iron and steel markets, at the same time as eating away the traditional external outlets for the European iron and steel industry.

- The pressure exercised by the non-integrated or semi-integrated producers which are tending to dispossess the major European iron and steel groups of the relatively rigid control which they exercise on their national markets in terms of prices and supplies(75); so much so that at the time when the excess production capacities were rising a foreign iron and steel company built a production unit for 1 million tonnes in Great Britain and a private British rolling mill obtained supplies of billets from Canada(76).

- The increasing role of iron merchants (traders in iron and steel products), who are tending to become technical advisers to their clients, and who are also tending to operate increasingly frequently on the price possibilities opened up by importing(77).

(75) Numerous comments on this subject in the Financial Times, the Nouveau Journal, Business Week, etc.

(76) Financial Times of 6 June 1978.

(77) Nearly 15% of the "iron merchants" are controlled in the United States by foreign iron and steel companies, in particular by the Japanese.

It is in this context of keen competition that it is necessary to locate the development of those strategies which are involved in a process of "redeployment" of the iron and steel productive apparatus.

iv) REDEPLOYMENT

84. The market economy countries have played a major role in the past in the development of the iron and steel industries in the developing countries. But with this "redeployment" it now appears to involve an operation of a totally different magnitude. In fact during recent years the directions which have been successively taken by this process can be seen to be contradictory. This leads to the value of carrying out a detailed analysis so as to identify, if possible, the significance of this.

First intimations of a vast redeployment movement

85. During the period of sustained growth of iron and steel production, up to 1973-1974, the Japanese iron and steel industry was seen to be much more active than their European and American competitors in participating, in the form of direct investment, technical assistance or the supply of semi-products, in the establishment of a network of production units related directly to iron and steel production or the first converting of metals in South East Asia[78] and also in a number of African countries[79].

86. It seems, by contrast, at the time of the rapid expansion of production in 1973-1974, that a major opening-up movement was taking place. Japan and the Federal Republic of Germany's iron and steel technologists declared that it would be difficult to envisage the construction of new iron and steel installations on national spaces which were becoming saturated without running the risk of exceeding acceptable pollution thresholds.

These statements, together with the numerous projects which were announced, gave the impression of a systematic delocalisation which would be undertaken in the direction of countries having rich supplies of ores, abundant energy resources at a cheap price or, quite simply, more space.

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(78) In Thailand, the Philippines, Malaysia, Indonesia, etc.

(79) East and West Africa: galvanising of sheets, production of tubes, etc.

87. The zones which were envisaged were, amongst others:

- Brazil - a major producer of iron ore where several projects were envisaged between Brazilian producers of ore (CVRD[80]) and Japanese, Federal Republic of Germany's and Italian iron and steel companies
- The Antilles, where the Trinidad project was launched with Japanese and the Federal Republic of Germany's participation
- Australia, with USA, Japanese and the Federal Rep.of Germany's iron and steel companies
- Canada with Japanese participation
- The Mediterranean and the Middle East with major projects in Iran, Turkey and Spain together with projects based on the direct reduction of iron ore with natural gas and located at Qatar, Saudi Arabia, Abu Dhabi, Kuwait, Egypt, Libya, Tunisia, etc. The Tunisian project was representative of this type of project: Brazilian iron ore supplied by CVRD would be reduced in the South of Tunisia using natural Tunisian gas; the sponge iron obtained would then be converted into steel in a country in Northern Europe. The project was supported by the original companies in Japan, the Federal Republic of Germany and Brazil.

<u>The sudden halt and the "back-flow"</u>

88. The profound recession of 1975 rapidly modified these prospects. The question of redeployment no longer figured - except in the form of allusions - in the agenda of the annual I.I.S.I. Conference in October 1975.

89. By contrast one could at that time make the following statements:

- in the Mediterranean and Middle Eastern zone several projects were either purely and simply abandoned, such as projects supported by the Itoh company in Tunisia and Egypt, or were temporarily laid aside as in the case of the Abu Dhabi project and the major Saudi Arabian project.

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(80) "Compañia Vale de Rio Doce", State Company for the working of iron ores.

- in Brazil the Japanese companies withdrew from the Itaqui project (Kawasaki Steel), from one of the Tubarão projects (Kobe Steel) and also from a second Itaqui project (Nippon Steel).
- the Japanese companies also withdrew from the Trinidad iron and steel project.
- in Australia the Dutch-German Estel group withdrew from a project for building a giant plant.

90. By contrast the iron and steel companies in the developed countries seemed to be sketching out a movement of a "return to the North" which the obstacles presented by pollution and the shortage of space had appeared to make impossible a few months previously.

91. The following interesting projects could in fact be listed:

- The extension of the Estel installations at Ijmuiden in Holland[81]
- The extension of the Roechling group installations in the Saar[82]
- The acceleration of the rate of investments in the Japanese iron and steel industry[83]
- The increase in the production capacities in the United States so as to increase them from 157 million tonnes in 1975 to 180-185 million tonnes in 1980[84]. These projects included, amongst others, an entirely new installation[85].
- The acceleration in the building of units using the direct reduction process in Spain[86], in the Federal Republic of Germany[85] and in Great Britain.

This shows, at least in the medium-term, a movement of the iron and steel industries of the "North" to regroup, extend and modernise their production capacities on their own soil.

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(81) Usine Nouvelle of 18 March 1976

(82) Financial Times of 6 April 1976

(83) Nippon Steel News No. 68 of December 1975

(84) "Steel's not so solid expansion plans" in Fortune, January 1976

(85) Metal Bulletin of 2 April 1976

(86) Metal Bulletin of 6 April 1976

92. Such a strategy was apparently justified both:

- By a search for security, as a result of reduced dependence on third countries;
- By a desire for a reduction of costs and to improve competitiveness: the existence of already considerable production capacities making it possible to undertake operations of modernisation and extension which were less expensive than new creations on new sites(87). It was therefore understandable that Japanese, American and European iron and steel companies exploited the basic advantage which they temporarily held (up to the beginning of the eighties) as compared with the Third World countries, which were obliged to construct production units at a cost two or three times greater. This position was perfectly compatible with the consolidation of technological advance and the control of the wider diffusion of techniques.

The back-flow is confirmed in 1977

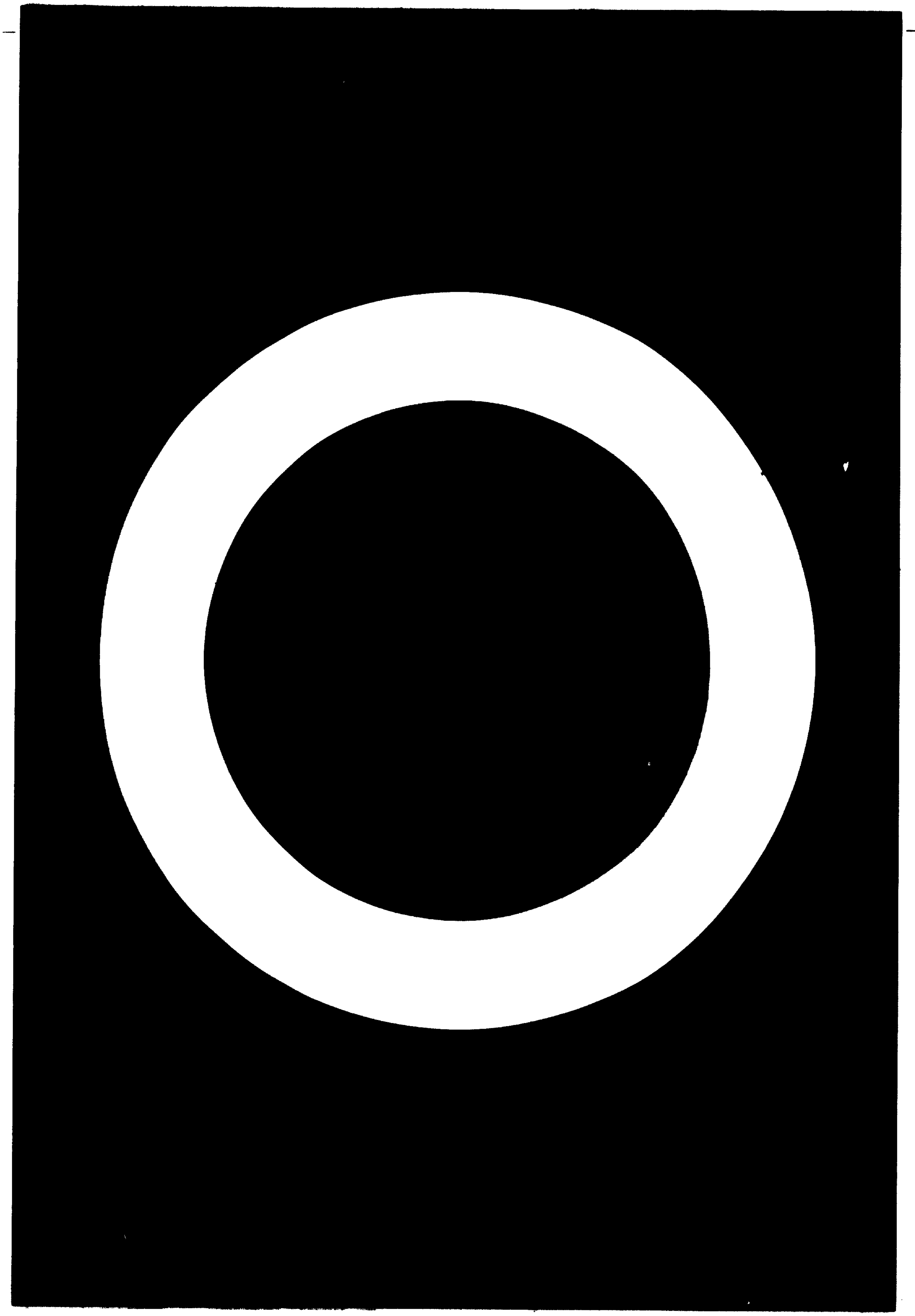
93. The year 1977 brought not only the confirmation of the halt in the redeployment movement but also showed that, in many cases, the extension of production capacities in the larger iron and steel producing countries was cancelled or deferred(87).

94. The following decisions were successively announced:

- The abandonment by the Australian BHP company of its participation in a project for constructing an iron and steel installation in Saudi Arabia
- Abandonment of the LD steelmaking project at Roechling Burback in the Saar
- Abandonment of the extension project of the Estel group at Ijmuiden (Holland)
- The postponement, to an indefinite date, of the construction of the second phase of the Solmer unit at Fos sur Mer (France)
- Abandonment of the Italian Gioia Tauro project in Calabria (Italy)
- A questioning of the continued construction of the Sagunto unit in Spain and rumours on the withdrawal of US Steel from the capital of the AHM company(88).

(87) See Metal Bulletin, 2 and 20 September 1977, 7 October 1977, etc.

(88) Altos Hornos del Mediterraneo: the company to which the Sagunto unit belongs.



Since when a developing country is involved it is necessary to increase this cost by a factor of 1.3, 1.5 or even 2 one can understand the reversal of the situation; the more so since these reasons of costs were combined with the

98. Reasons concerning the market. The 1975 recession continued and was transformed into a crisis without anyone knowing when or how it would end. Since markets were shrinking and competition was becoming keener investments tended to stagnate and diminish.

Most of the projects launched in 1974 in the Middle East and in Brazil were based on the purchase of part or all of the new production by the participating iron and steel companies, whether Japanese or American. It is interesting, in this respect, to follow the progress of the long negotiations between the national Brazilian iron and steel company and the Japanese Kawasaki steel company on the subject of Tubarão, the only mixed project which continued in Brazil after the reversal of the flow. According to the available information the Japanese company was ready to consider the Brazilian request for financial credit "on condition of being relieved of its obligation to purchase a million tonnes per year of semi-finished flat products ...."[93], given the state of saturation of the world market. When market levels for the iron and steel industry do not exceed 70% and sometimes even 60% in Europe and in Japan, it can be understood why the industries in the market economy developed countries were deferring projects for the construction of new capacity and, with even more reason, the massive investments in the developing countries.

v) TOWARDS NEW STRATEGIES ?

99. For 20 years each of the iron and steel industries in the developed countries developed, with its own characteristics, in an extended pattern of growth so that time is now necessary for adjusting their outlooks and strategies. In this context the year 1977 was a turning point, after which the strategies in course of evaluation and definition began to be drawn up.

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(93) Financial Times of 24 October 1977. The agreement was finally signed in July 1978. See below, chapter III, 5) : An example of a negotiation in the new context.

100. Up to the end of 1976, in effect, and on the basis of past developments, priority was still given to increasing the productive apparatus; optimism prevailed both in Japan, where investments reached a record level(94), in the United States and even in Europe. In this way growth objectives were defined which were largely based on the movement of relocation in the direction of certain exterior spaces. The new relocated installations tended to constitute take-over points for the major iron and steel groups.

Within this perspective it became important for the developed countries with a market economy to control the process as tightly as possible so that it did not extend outside the intended framework. It was estimated that steel production in the developing countries was not large enough to have a serious impact on the world markets, but that it was nevertheless sufficient to "throw a lengthening shadow over the future"(95). This is why the idea appeared to develop amongst those directing the iron and steel industry that the objectives and the limits of assistance (in the construction of new iron and steel industries in the developing countries) should be the subject of careful examination, and that in particular if such assistance were to give rise to a flow of products imperiling the world iron and steel markets such developments would become unreasonable; it was also difficult to expect the industrialised countries to accept the cost of such a construction programme(96). One finds, in the many opinions and declarations of this period, reference to practices described as "reasonable"(97). It was along this line of policy that emphasis was placed on the need to operate a progressive displacement of the centres of the world iron and steel industry, but one which did not question the balance of the major iron and steel industries, depending on their technical advance and also on their close links with the steel converting industries (mechanical engineering industries)(98).

(94) See Far Eastern Economic Review of 24 October 1976, Fortune of January 1976, etc.

(95) According to the phrase used in Business Week of 19 September 1977, page 84.

(96) Annual IISI conference at Osaka - October 1976 cited by Metal Bulletin 22 October 1976

(97) See for example the interview with Mr. Köhler reported in Metal Bulletin of 1 April 1977 and the statement by Mr. Agnelli at the IISI Conference in Rome - Metal Bulletin of 14 October 1977

101. From 1977 onward it seems that the positions of the iron and steel industries in the developed countries with a market economy were being modified. This still did not result in clearly defined strategies but only the first orientations of these. The subjects considered, and the policies which arose, can be summarised as follows:

102. a) The recession which affected the iron and steel industry does not apply only to a group of random elements but to structural factors. This introduced into the present period a prolonged element of uncertainty. The Chairman of the Japanese Nippon Steel company spoke, in this regard, of "a discontinuity manifested in the relationship between the economy and steel demand"(99). The contribution of the unknown to the new situation was such that it was difficult to make a pronouncement on the time that the period of readjustment would last. Under these conditions "crisis management"(100) constitutes a priority task which sometimes tends to submerge longer term preoccupations.

103. b) The future being uncertain, not only in the long and very long term but also in the medium term, it was necessary to try to effect a permanent adjustment of investments to the growth of demand and the development of the market. This resulted in a withdrawal movement by the American iron and steel industries, but more particularly by the Japanese and European industries.

This withdrawal implied the generalised abandonment of external projects; it also implied a noticeable fall in investments together with stagnation or even a reduction in the production capacities in the medium and long term.

104. The American iron and steel industries are probably still the only ones to discuss the opportuneness of undertaking the construction of entirely new units on greenfield sites(101). They have, in practice, the advantage of a vast market (perhaps promising), together with abundant reserves of minerals and energy. It is however significant that a recent exhibition of equipment for the iron and steel industry placed the accent mainly on two categories of equipment, that intended for the fight against pollution and that making it possible to economise on the various resources.

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(98) See article by J. Ferry in Le Monde diplomatique, April 1975.

(99) Interview with M. Inayama in Metal Bulletin, 2 August 1977.

(100) According to the expression used by M. Köhler, one of the directors of the German iron and steel industry, Metal Bulletin, 1 April 1977.

(101) See Edgar Speer, President of US Steel. Metal Bulletin, 2 June 1978.

105. The Japanese iron and steel industry is now in a position described as "precarious"[102]. Investments have been reduced by 35% as compared with forecasts. They will be reduced even more between now and 1980, since it is no longer a question of developing new capacity but simply of improving what now exists and of increasing control over pollution[103]. At all events the expected production for 1978 is not likely to exceed the production actually recorded in 1973 and 1974.

106. The prospects for the iron and steel industry in Europe are even darker. The difficult phase through which the EEC iron and steel industry is going is well known: no national industry has escaped from this, from Belgium to France where the construction of a steelworks which was already 90% erected has now been stopped[104], to Italy and **United Kingdom,** where the £5,000m investments over 5 years as described in May 1977 have been reduced to £600m a year later in 1978 and to some £200m in the following months[105]. Those responsible for **Federal Rep. of Germany's iron and steel industry themselves estimate** "that no new installation on a greenfield site will be constructed"[106]. The proposals of the EEC Commission show the gravity of the situation by recommending measures which are very radical, namely the closing as rapidly as possible of 13 to 16% of the installed capacity, since the production possibilities necessary for the year 1990, at least as far as quantities is concerned, will not exceed the existing capacity at the present time[107].

107. A similar movement is affecting other European countries such as Sweden, Austria and Spain, where numerous projects have been successively cancelled and "where scepticism reigns over the possibility of making serious forecasts"[108].

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(102) Inayama - Metal Bulletin of 2 August 1977.

(103) "Japan; the steel boom is over". Far Eastern Economic Review, 26 August 1977. Between now and 1980 investments will be reduced by 50%.

(104) Aciérie de Neuves Maisons, Le Monde, of 29 July 1978.

(105) Financial Times of 26 May 1977 and 15 March 1978.

(106) Metal Bulletin of 1 April 1977

(107) According to the Metal Bulletin of 21 July 1978

(108) Metal Bulletin of 1 April 1977

108. c) Whatever dramatic character this brutal withdrawal movement takes here and there the crisis should not lead to the dislocation of the iron and steel industry, including those countries most affected by it in the European Economic Community. On the contrary the clearly shown objective of all measures taken, even including those which cut into the flesh, is to restructure the iron and steel industry and to make it a coherent and competitive modern unit. The Japanese iron and steel industry is attempting to maintain and, if possible, to improve its advance against the competition. The object of the modernisation of the American iron and steel industry is to overcome the gap which now separates it from the Japanese. In the EEC it is considered that severe cuts in the excess capacities will be an essential preliminary to re-establishing its competitiveness on the world market.

A directing line of this restructuring is to effect a more advantageous distribution of the added value by the iron and steel industry by improving its share in the products at the upper end of the range (alloy and special steels).

109. This is obviously a readjustment to a ew situation, which has been shown up by the crisis, where not everything is clear but where the general lines of orientation seem to be located within the following perspectives(109):

- To re-establish the bases of the iron and steel industries, the dynamism of which will be measured by its degree of competitiveness;
- Whilst envisaging certain specialisations at a world scale and certain types of a new international division of labour the dynamic base of the iron and steel industry in the developed countries with a market economy must remain a largely national base;
- To accept inevitable reverses on the export market, whilst considering that this situation is not entirely irreversible; the essential point being that the balance of trading in iron and steel should remain positive; this is the condition of independence which the major iron and steel industries in this group of countries hope to confirm and maintain(110).

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(109) As can be seen from the statements, articles and interviews with numerous directors of the iron and steel industries in the market economy developed countries: US Steel and Messrs. Speer, Köhler, Inayama, Villiers, Ferry, Agnelli, etc.

(110) M.J. Ferry has emphasised these points.

It is a question therefore of maintaining the "market shares", whilst at the same time being increasingly conscious of production costs and profit rather than simply the tonnage produced(111).

110. The required adjustment takes the form of the closing of plants and mergers of companies, accompanied by the development of practices of the protectionist type in response to a very aggressive competition: measures taken by the United States (trigger prices), bilateral agreements negotiated by the European Economic Community and measures of voluntary restriction taken by Japan. Each of the major partners in the group of market economy industrial countries continues however to refer to the GATT rules and tries not to damage irreparably the edifice of international industrial and commercial relations. The partners are beginning, in practice, to locate themselves within a perspective of major negotiation.

It is within this perspective of discussion on a new structuring of the iron and steel industry that each is attempting to reconstitute a dynamic base to ensure its industry a place in the new equilibrium.

111. At the present time one fact is obvious, irrespective of the magnitude of this negotiation, and this is that the technical capacity of the iron and steel industries in the industrialised countries with a market economy represents their trump card, whether it is a question of mastery of processes and know-how, of mastery of equipment and engineering, or mastery of management capacity. It is this card that the American, European and particularly the Japanese companies must play to their best by offering package deals which include feasibility studies, licensing agreements, technical supervision, technical assistance, etc., for the construction and commissioning of new iron and steel units(112).

2. THE DEVELOPING COUNTRIES

112. Even if iron and steel production in the developing countries is increasing at a more sustained rate than in the market economy developed countries this production is still at an extremely low level:

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(111) The examples of the Austrian and Swedish iron and steel industries are very significant in this respect: the investments programmed over the coming five years are in fact entirely devoted to the accelerated development of productivity. See Les Echos of 10 November 1977 and Metal Bulletin of 5 May 1978.

(112) See on this subject the Far Eastern Economic Review "Japan: The boom is over", 26 August 1978, p. 51. The article concludes with the following sally: "look at the 20-storey Nippon Steel building. The top three floors are full of directors, and the next ten are devoted to engineering".

55 million tonnes in 1973, and undoubtedly 76 million tonnes in 1977 (about 11% of the world production). This reminder is not without value since it has become customary to evoke the danger which the new iron and steel production of the developing countries represents for the market equilibrium. It is true, in fact, that certain iron and steel industries in the developing countries have recently made an entry into Western markets. It must be emphasised that these are the exceptions which confirm the rule, namely that the developing countries are far from meeting their own requirements from their own production.

i) SUCCESSIVE ENTRIES INTO THE IRON AND STEEL INDUSTRY

113. One can distinguish various categories of countries according to the period in which they developed their first iron and steel units.

114. The first group consists of those countries which installed their first iron and steel base before 1950: Argentina, China, Brazil, Egypt, Yugoslavia, India, Mexico and Turkey.

These countries, except China, have about 800 million inhabitants and their iron and steel production is about 30 million tonnes or 40 kg of steel per capita. People's Republic of China, where the first iron and steel installations date from the beginning of the century, occupy however a special place within this group: by the volume of its production, 30 million tonnes in 1977, which is greater than the total production in France, Italy and Great Britain, and by the size of its iron ore and coking coal resources, together with the size of the capacities for constructing equipment goods intended for the iron and steel industry(113). The People's Republic of China now envisages building 10 new units of 6 million tonnes each, so bringing its production up to 60 million tonnes between now and 1985(114).

(113) This has allowed People's Rep. of China to give assistance in the construction of iron and steel units abroad, for example for the construction of the El Basan complex with a capacity of 700,000 tonnes per year.

(114) Metal Bulletin of 3 February 1978 and a series of analyses on the Chinese iron and steel industry which appeared in Business China from 18 January 1978 (bulletin published by Business International).

115. Group 2 consists of those countries where the first iron and steel installations date from the 1950s. These are the following countries:

- Chile, Colombia, Israel, Peru, the Philippines, the Republic of Korea, Tunisia, Venezuela, Yugoslavia and Turkey.

These countries total about 180 million inhabitants and their iron and steel production is now about 15 million tonnes, or 80 kg per capita.

116. Group 3 consists of those countries where the first iron and steel installations date from the end of the sixties and the beginning of the seventies. These are the following countries:

- Albania, Algeria, Cuba, Hong Kong, Indonesia, Iran, Iraq, Lebanon, Malaysia, Pakistan, Qatar, Sri Lanka, Syria, Thailand and Zaire.

These countries have about 350 million inhabitants, and their iron and steel production is now about 10 million tonnes or 30 kg per capita.

116a. Group 4 consists of those countries where the first iron and steel installation is still under construction or in the project stage, or where the already existing iron and steel unit, of small dimensions, often consists of a simple rolling mill for concrete reinforcing rod. These are the following countries(115):

- Abu Dhabi, Bolivia, Dominican Republic, Dubai, Ecuador, Ghana, Guatemala, Honduras, Ivory Coast, Jordan, Kenya, Kuwait, Lebanon, Libya, Mauritania, Morocco, Nigeria, Paraguay, Qatar, Salvador, Saudi Arabia, Senegal, Singapore, Tanzania, Togo, Trinidad, Uganda, Uruguay and Zambia.

These countries total about 200 million inhabitants and their production of iron and steel is very low, almost certainly being less than 2 million tonnes per year.

Those "excluded" from iron and steel production

117. It can be seen from this rapid survey that more than 40 independent countries either do not have any existing iron and steel installation nor, it

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(115) This provisional list is now being verified by the I.C.I.S. of UNIDO on the basis of the collection of more precise information on the real state of advancement of a certain number of projects.

would appear, any concrete project. These are in general countries with a small population; certain in this group however have 5, 10 or even more than 20 million inhabitants, and their total population is more than 140 million.

It can be seen, on the basis of the available information:

a) That Latin America is relatively well provided with iron and steel bases, but that there are some gaps in this region:

- In Central America where the existing units are of very small capacity;
- In the islands: one unit in Cuba, a project in Trinidad (the size of which has been reduced) and a small unit in the Dominican Republic;
- On the north-eastern and southern fringes: Guyana, Paraguay, Surinam and Uruguay where there is no integrated unit;

b) That Asia is already well supplied except for a certain number of countries: Afghanistan, Bahrein, Burma, **Kampuchea**, Laos, Nepal, New Guinea, Oman, UEA, **Democratic Yemen and Yemen.**

c) That Africa, by contrast, is the most deprived zone, where only the northern region is involved in a continuous way from Egypt to Mauritania with some randomly distributed points in the other regions: ~~South Africa,~~ Ivory Coast, Ghana, Nigeria, ~~Rhodesia,~~ Togo, Zaire, Zambia, etc. Africa is a continent where most of the countries have neither an iron and steel installation nor a project for an iron and steel unit.

A realistic analysis of the iron and steel industry in the developing countries

118. This initial approach makes it possible to draw up a more realistic table of the iron and steel industries in the developing countries and to relativise the fears frequently expressed on the subject of the arrival of the production of these new industries on the world market. The situation must be evaluated in its true size by stating that, at the present time, the iron and steel industries in the developing countries which have the necessary bases to launch themselves into massive exporting policies are very rare.

119. Exceptions do however exist, in particular the Republic of Korea where the growth of the iron and steel industry is taking place at a very rapid rate. Republic of Korea and some other countries are becoming serious competitors, and extension of capacity is in rapid course of realisation:

- from 3.0 to 8.5 million tonnes capacity in the Republic of Korea between now and 1981-1982[116].

120. Import by the developing countries as a whole has rather increased in the recent years, 18 mt in 1967, 26 mt in 1972 and 39 mt in 1977 (it was 49 mt in 1974). Because of growing neet for steel in the developing countries, the growth rate in consumption has been slightly higher than that of production. This might continue for the immidiate medium term future, increasing further import of steel by the developing countries.

The recent 18th Congress said that the Latin American iron and steel industries would arrive at a state of self-sufficiency by about the year 2000; the Mexican iron and steel industry for its part forecasts a major deficit up to 1985 (after having previously envisaged for this date a considerable surplus available for export)[117].

(116) Metal Bulletin of 4 November 1977.

(117) The "remodelling" of the plans of the Brazilian iron and steel industry is also very revealing in this respect (in millions of tonnes)

	1978	1980	1983	1986	
1971 National Steel Plan		20			(In brackets: production capacities)
1973 Revision	20	20-27 (32)		40	
1977 Steel Master Plan 1977/86		18	(28)	(37)	
1976 UNIDO consultation			18.5	33.5	

Source: Bank of London of South America. "Brazil - The iron and steel industry", Vol. II, July 1977, and UNIDO consultation 1978.

121. The reality seems to be much less threatening for the developed countries; it is on the other hand much more preoccupying for a large number of the developing countries who aspire to mastery of the iron and steel industry.

ii) A DIFFERENTIATED INDUSTRY

Iron and steel and first converting: flat products and long products

122. This finding of "exclusion", as described above, can probably be modified by taking into account the existence, in many countries without an iron and steel production basis, of units carrying out the first conversion of steel, producing wire and wire products, small tubes, galvanised sheet, enamelled sheet objects, etc. It is, in practice, difficult to mark out a clear frontier between stages situated well downstream from the iron and steel industry and operations of the first conversion of steel.

One passes therefore more or less imperceptively from one to another since a large number of the iron and steel plants installed in the developing countries are limited to a production of long products and, in particular, to the production of concrete reinforcing rod. The multi-product installations which produce long products (concrete reinforcing rod, merchant goods up to large beams and rails) and flat products (hot and cold-rolled sheets, subsequently tinned or galvanised) only exist in a limited number of developing countries:

- in Africa : in Algeria (under construction) and in Egypt
- in Latin America : Argentine, Brazil, Chile, Colombia, Mexico, Peru and Venezuela
- in Asia : India, Iran (under construction), Republic of Korea

123. Most of the countries are still only in a limited field of iron and steel production, namely the production of long products; this is furthermore often limited to the production of concrete reinforcing rod, machine wire and small merchant goods produced in non-integrated or semi-integrated units; large integrated still remain very much the exception.

Ordinary steels and high tensile steels

124. The number of producers of alloy steels amongst the developing countries is even smaller:

- in Africa : **Egypt and Algeria** (in the project stage)
- in Latin America : Argentine, Brazil, Chile and Mexico
- in Asia : India, Iran (under construction), Republic of Korea.

This results in a deformed and **incomplete** development of the iron and steel industry.

125. The weakness in the production of flat products and also of **high tension** steels is significant of an iron and steel production (and hence an iron and steel industry) forced into paths which must be described as "secondary", inasfar as the production of equipment goods and durable consumer goods necessitates both:

- flat products : thick plate for heavy equipment goods, thin sheet for durable consumer goods (automobiles, domestic electrical appliances)
- alloy steels, whether for grinder sheets, "boilerware" for the chemical industry or various parts for the manufacture of motors, turbines, alternators, etc.

126. The developing countries at the present time remain largely outside these circuits; they are still restricted to the production of long products used by the building and public works industry (buildings and infrastructures) or the production of semi-products intended for export.

127. Limitation of iron and steel production to certain types of products, whether long products or merchant steel, is one of the problems which must be at the centre of any discussion on the future redistribution of the activities of the world iron and steel industries. This will raise the question of the criteria for redistribution, together with that of the evaluation of the constraints which influence the creation and development of a new iron and steel industry. Undoubtedly it has sometimes been stated, a little too readily, that certain of these are insurmountable or immutable, such as criteria relating to resources. The principal ones which are generally accepted should be subjected to close scrutiny so as to re-evaluate, under the conditions obtaining at the end of the century, the access routes to the iron and steel industry, particularly when these routes are new ones and are not yet clearly marked out with adequate certainty.

iii) CRITERIA OF ACCESS TO THE IRON AND STEEL INDUSTRY

128. The discussion on favourable conditions and criteria conditions the definition of autonomous strategies. The first report of the International Centre for Industrial Studies has marked out the route to be followed(118):

a) By identifying the conditions which are favourable to the creation and expansion of the iron and steel industry.

   The availability or absence of eight kinds of sources have been taken into consideration: iron ore, manganese ore, coking coal, natural gas, natural gas flared off, timber resources, petroleum and hydroelectric power.

(118) ONUDI/ICIS.25 op. cit. pp 194 et seq.

b) By carrying out an initial classification of the developing countries into three categories:

<u>Category 1</u> - countries having favourable conditions (natural resources) for the development of an iron and steel industry:
29 countries, including 10 in Africa
10 in Asia
9 in Latin America

<u>Category 2</u> - countries having less favourable conditions:
46 countries, including 22 in Africa
18 in Asia
6 in Latin America

<u>Category 3</u> - countries not having favourable conditions:
51 countries, including 16 in Africa
11 in Asia
14 in Latin America
10 in Oceania

The availability or non-availability of certain natural resources are valuable indications. This is, however, not a decisive constraint since recent developments show that certain iron and steel industries, which do not possess such resources, can be counted amongst those which have experienced the most rapid rates of expansion: the iron and steel industries in Japan and the Republic of Korea, and the non-integrated or semi-integrated iron and steel industry in the Brescia region, etc.

Criteria of dimensions

129. This criteria is a simple and usable one, since it concerns the size of the population and that of the market. In practice there is normally a close relationship between:

- The size of a developing country and the existence or not of an iron and steel industry;
- The size of a developing country and the structure of its iron and steel production.

The existence of such a relationship is shown by the following facts:

- With the exception of Qatar and Abu Dhabi, which are in an exceptional situation as oil producers, no country with less than a million inhabitants has examined an iron and steel project;
- No developing country with less than 10 million inhabitants (with one exception)[119] possesses or has constructed a capacity for the production of flat products;
- No developing country with less than 30-40 million inhabitants (except Algeria, Argentine and Chile) possesses or has constructed a capacity for the production of fine and alloy steels.

130. This finding provides indications which it is necessary to take into account. However it is undoubtedly less certain that a finding of the situation which results at any given moment from the state of techniques and markets can be erected into a rigid principle. Does, for example, a capacity of 1 million tonnes constitute a minimum threshold for constructing a production unit for long products in a country of 8 million inhabitants with a per capita consumption of 130 kg[120]? This is not so certain inasfar as techniques are developing and where factors are capable of combining differently in the future.

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(119) The exception being Chile which is now however approaching 10 million inhabitants.

(120) These are the standards set out during the annual Conference of the IISI held in Rome in October 1977.

131. Rather than place the primary accent on one type of constraint, or giving priority, by isolating it, to one criterion - even if an essential one - amongst others, it is preferable to enlarge the field of analysis by demonstrating the complexity and diversity of the criteria relative to the creation and development of new iron and steel units. A recent American study[121] has drawn up an initial list of these criteria:

The stature of the steel industry

Profit motive

Government/steel relationship

The degree of Government involvement in steelmaking decisions

Government protection of domestic steel markets

Expansion plans

Availability of emergency funds

Existing large steel market

Availability of skilled workers

Ability to lay-off workers

Energy availability and cost

Indigenous raw materials:
- Iron ore
- Coal

Producers' pricing freedom

Extent of supportive infrastructure

Steel plant sites on deep-water ports

Pollution abatement requirements

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(121) Mitchell, Hutchins, op. cit. Exhibit 39

This list is not an exhaustive one; it would gain from being supplemented and modified so as to take into account more precisely the problems which are specific to various developing countries, in particular problems relating to employment and the individual and collective training of workers. However this formulation has the advantage of not limiting the problems of the development of the iron and steel industry to the classical constraints linked solely to natural resources nor to theoretical criteria of size. It therefore constitutes a real opening and marks progress in the analysis.

iv) TOWARDS MORE AUTONOMOUS STRATEGIES ?

132. The development of the iron and steel industry in the developing countries is a recent phenomenon. It is not so long ago when, with rare **exceptions, experts estimate that iron and steel** industries could not develop except in economies already endowed with a strong industrial tradition. The 9 to **11%** of the world iron and steel production which comes from the developing countries in 1977 may perhaps be considered in two ways: it represents, on the one hand, very little as compared with the 90% supplied by the developed countries; it can, however, be considered that it demonstrates an extremely rapid development of the process of industrialisation during the last 20 years, and in particular the last 10 years, since about 60 developing countries are producing, or are preparing to produce, steel.

133. The recent development of this phenomenon is accompanied by differentiations in industrial attitudes and strategies.

134. The development of iron and steel industries in the developing countries has often been presented as being linked directly to exporting on the world markets. It can be seen, in fact, that the reality is very different. It is true that the iron and steel **industry in the Republic of Korea has systematically and efficiently launched itself into major** exporting activities; the same is not true, as we have seen, for the other and most advanced iron and steel industries in the developing countries.

India, Brazil, Venezuela, Mexico and Argentine have, it is true, announced that their iron and steel industries would become exporters, and sometimes major exporters, in the long, medium or even short term. In fact India and Brazil have begun to export from 500,000 to 1 million tonnes per year, but the quantities exported are not likely to increase rapidly in the coming years; the development prospects of the iron and steel industries have been revised, or are being revised. It seems that everywhere, even if more moderate exporting objectives remain, priority will always be given to satisfying the rapidly increasing domestic consumption.

135. It is also of interest to note that the development of the iron and steel industry tends to depend, in some developing countries, on a national capacity for establishing the iron and steel industry itself: Brazilian industry is capable of supplying 70 to 80% of the equipment necessary for building a large integrated iron and steel unit; **People's Rep. of China has already supplied** the equipment necessary for building an iron and steel unit in Albania, and India is also very advanced in this field; Mexico and Argentine are capable of integrating many parts of the iron and steel equipment. Countries which are newly arrived in this branch, such as Iran and Algeria, are also beginning to integrate national equipment(122) in the iron and steel units which they are building.

Furthermore People's Rep. of China and INdia (with the MECON and DASUR companies), but also Brazil, Mexico and Algeria, have complete engineering organisations or at least the initial study and works units, specialising in the construction of installations for iron and steel production or the first converting of steel.

136. A process of integration of the iron and steel industry in the constructing of national industrial systems has therefore appeared, not only through the product of this industry but also through its downstream implementation. Such a process tends to build the bases on which the capacities for national initiative and more autonomous strategies can develop.

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(122) Metal constructions, but also travelling cranes, speed reducers, etc.

The recent abandonment of a very large number of export oriented iron and steel projects linked to the process of relocation, directly inspired by the major Japanese and European iron and steel companies, is the result of a crisis the cost of which is high for the world industry. However this abandonment may not only have negative aspects. It also provides an opportunity to accentuate the priority given to strategies which present a much more marked character of national (or regional) integration. The revision of strategies which are operating at the present time in many developing countries seems to be moving in this direction where the construction of more autonomous prospects becomes of priority importance, without active participation in world trading being entirely excluded.

II. KEY PROBLEMS FOR THE DEVELOPING COUNTRIES

137. A large number of questions affect in a direct manner the creation and development of the iron and steel industry in the developing countries. Rather than draw up a catalogue of these a selection has been made, and the analysis has been concentrated on those which are of the most importance when defining and implementing long-term strategies.

This chapter is therefore devoted:

- To the new possibilities and routes in the field of processes and also in the field of size;
- To obstacles to entry into the branch, or at least those which hold it back, in particular the problem of cost and financing.

A. THE INPUTS AND PROCESSES

138. In what follows we will deal concisely with the problems of supplies of iron ore and reducing agents in order to arrive at the essential point: the development of direct reduction processes.

1. IRON ORE AND THE IRON AND STEEL INDUSTRY IN THE DEVELOPING COUNTRIES

139. The first UNIDO report[(123)], together with several recent reports[(124)], have led to a series of conclusions to which it is not necessary to refer. We will limit ourselves to the following comments:

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(123) op. cit. UNIDO/ICIS - 25 November 1976.

(124) Coking coal

a) Appraisal of future (1985-2000) world demand for coking coal, trend in production, global export availability and environmental impacts; b) Working paper for the Working group meeting on coking coal, Vienna, 6-8 April 1978, UNIDO/EX.36, 24.2.78; c) Report of the Working group meeting on coking coal, Vienna, 6-8 April 1978, UNIDO/EX.39, 20.4.78.

Iron ore

a) Report of the Working group meeting on iron ore, Vienna, 3-5 April 1978, UNIDO/EX.38, 20.4.78; b) Working paper for the Working group meeting on iron ore, Vienna, 3-5 April 1978, UNIDO/EX.35, 21.2.78; c) Consideration of international measures on iron ore (Report by the UNCTAD secretariat), TD/B/IPC/IRON ORE/3, 9.8.78.

140. The developing countries (including China) own 30.4% of the world reserves of iron ore. However these reserves are divided up in a very unequal manner between the continents. Latin America is the richest region (Bolivia and Brazil), followed by East Asia (People's Rep.of China) and South Asia (India). The resources are better distributed in Africa, except in the southern region of the continent. By contrast South-west Asia (Middle and Near East) and South-east Asia (Indochina and Burma) are very poorly supplied.

141. It is of value to compare this distribution of resources with the present and forecast rate of working of the resources for export. A recent study dealing with the balance between the supply and demand for iron ore over the period 1980-1990(125) makes it possible to carry out a first comparison between the forecasts of world availabilities of iron ore for export and the contribution of the developing countries towards these total availabilities:

TABLE 8

Contribution of the developing countries to the exports and world resources of iron ore
(thousands metric tonnes)

		1980	1985	1990
Total availabilities				
(I) for iron ore exports		497,000	595,000	656,000
Including: (II)	contribution by developing countries	241,000	301,000	344,000
II/I	%	48.4	50.6	52.4
Share of the developing countries in world resources			about 30%	

It can be seen that the level of contribution of the developing countries to world exports of iron ore is considerably greater than their relative availability where total reserves of iron ore are concerned. This distortion

(125) Iron Ore Supply/Demand 1980-1990 CAEMI-International BV The Hague - December 1976.

is particularly noticeable in Africa where the lag in the iron and steel industry is most marked. The recent development of the world iron and steel industry to the profit of the so-called "waterside" units of very large size has, in fact, accentuated the pressure on exports of high quality African, Latin American and Asiatic ore (but also Australian and Canadian ores). In general the most interesting deposits, because of their content, purity, size or closeness to the coast, have been worked as priorities. During the coming years it will be necessary to satisfy both the demand for exports together with the new national requirements; this runs the risk of leading, in certain cases, to a negative effect on operating costs and, as a consequence, on the price of ores supplying the new national iron and steel industries. This is the case in Tunisia where the iron ore which is most easily accessible has been exhausted after about eighty years of working, and where it is now necessary to undertake costly investments to utilise those minerals which are still available. This is also the case in Algeria where the industry must bring its ore in from more than 1,500 km away since the reserves of those mines which are nearest to the coast are largely exhausted.

142. World reserves of iron ore are abundant, so that theoretically no long-term supply problems are presented to the iron and steel industry throughout the world. Practically, however, matters are not so simple, inasfar as the opening of new mines has become an expensive operation, requiring the mobilisation of very considerable amounts of capital. The operation becomes even more expensive when the opening of the mine is linked with a railway for carrying the ore to the coasts: more than 500 km in Gabon, 700 km in Mauritania, 1,500 km in Algeria, etc. The amount of capital needed is not usually available in the country concerned; it is therefore necessary to go outside, to the possible buyers of the ore, to the banks or to other funding authorities. At the present time it seems that many important mining projects, recognised as being economically valid, are being held up for lack of external financing. The withdrawal of US STEEL from the large Brazilian project of Carajas, whatever may have been the real reasons for this, indicates objectively a change in policy which is probably based not only on the state of the world iron and steel industry and the rapid increase in investment costs but also

on policies of diversification of risks and supplies[126]. Whatever the position this constitutes a problem, the data on which must be closely analysed, integrating the developments introduced by the new type of agreements concluded between developing countries: for example that between Iran and India[127].

143. The recent development of the iron and steel industry has operated in favour of the production of high quality ores to be used in large blast furnaces; the development of direct reduction will also operate in favour of very pure and high quality ores. Such developments tend to make ores of lower quality and lower purity of less value. The risk is therefore that the creation and development of national iron and steel industries will be biased by these trends. Several experiments in the construction of iron and steel **industries - particularly in People's Rep.of China - demonstrate the possibility of using in an economic manner ores which are neither of high quality nor very pure[128]. It is therefore important that the "economic" character of the use of these** ores should not be evaluated according to the standards which are used in the major centres of the international iron and steel industry, but rather on the basis of criteria corresponding to national or regional data directly involved in the construction of a national iron and steel industry and its production.

2. REDUCING AGENTS

144. Coke is the traditional reducing agent used in the iron and steel industry. This is obtained from coking coal, the deposits of which are particularly unequally distributed throughout the world:

94.8% in the developed countries[129]

5.2% in the developing countries

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(126) The policy regarding supplies of iron ore to US STEEL has been directed in the following ways:

- to develop mines and pelleting installations in the United States;
- to limit sources of supply abroad to a maximum of 5 million tonnes per year and country of origin;

according to the Annales de Mines - page 64 E - April 1976

(127) Agreement signed on the creation and working of the Kudremukh mine in India. Iran will finance the operation, being reimbursed with iron ore.

(128) The experience of New Zealand, for example, which after several years of tests can now use the iron ores which are available in that country.

(129) UNIDO document, op. cit., pages 193 et seq.

Finally it should be pointed out that three developing countries share practically all these resources: **People's Republic of China, India and Colombia (plus Mexico, Brazil and Chile).**

Under these conditions it is entirely logical that the industrialised countries have developed a predominant production route starting from coke and coking coal. One can also understand the difficulty which most of the developing countries have in relation to a route which is adapted to a radically different environment.

145. The situation in the developing countries is scarcely more favourable in the field of non-coking or low-grade coals. It is true that in overall figures the developing zone has 14.6% of the world reserves of coal (as against 84.5% for the developed countries).

Once again People's Rep. of China and India have practically all these reserves (13.5% out of 14.6%). Current research work, the considerable interest of which must be emphasized, on the use of non-coaking coals either as a reducing agent in the blast furnace or as a reducing agent in the direct reduction processes, will be mainly to the advantage of certain developed countries (Balkan and Mediterranean Europe, but more particularly the USA, the USSR, etc.) rather than the group of developing countries.

146. Wood charcoal was for several centuries the only reducing agent used in the production of cast iron and iron; its use is now exceptional, Brazil being one of the rare countries to operate blast furnaces on charcoal[(130)]. It is true that Brazil itself has 20% of the world forest resources, whereas the resources of Africa are much more modest in this field. At all events the use of charcoal cannot be increased in any appreciable manner, since about 30,000 hectares of forest are necessary to supply a very small blast furnace (of 300 tonnes/day or 100,000 tonnes/year). Only Brazil, **Malaysia, Thailand and to some extend India, could find** it of interest to study "internal" iron and steel installations of small size (from 100,000 to 150,000 t) based on the simultaneous existence of

(130) with **Malaysia**

iron ore and timber resources (131).

147. The developing countries are, on the other hand, much better provided with:

- natural gas : 45.8% of the world resources
- petroleum : 79.0% of the world resources
- hydroelectric potential : 62.7% of the world resources.

The distribution of these resources is to the advantage of Asia (Middle East) and Africa (North Africa in the case of gas and petroleum, Central, East and West Africa in the case of hydroelectric power), so that this distribution contributes towards a certain balance in favour of regions which are more or less totally deprived of coal (coking or otherwise) and forests.

148. These realities demonstrate the interest, for many regions of the world which do not have coal resources and up to the present time have therefore remained on the margin of the iron and steel industry, of the development of viable alternatives to the classical route based on coke. It is from this point of view that it is necessary to describe the present state of development of the direct reduction processes.

3. THE DIRECT REDUCTION PROCESSES: PROBLEMS AND PROSPECTS FOR THEIR USE IN THE DEVELOPING COUNTRIES

149. The direct reduction or prereduction processes are so named since they make it possible to achieve economies in heavy and therefore costly installations and to pass directly from iron ore to a product called sponge iron which is capable of being charged into an electric furnace to be converted into steel.

These processes operate, as is known, either with a solid reducing agent (low grade coal) or a reducer in gas form which then uses a stack furnace, a fixed bed, a fluidised bed, etc.

(131) Tests are at the present time being carried out in the Philippines involving growing a plant called the Ipil-Ipil which is characterised by its very rapid growth (6-7 metres in four years) and which can be converted into charcoal: a Japanese company hopes to be able to use this in its sinter production plant and also in its blast furnaces. Certain developments may therefore be expected on this side - cf. Technocrat Vol. 2, February 1978.

150. The principal direct reduction processes are the following[132]:

Solid reducing agent	External heating		ECHEVERRIA
			KINGLOR-METOR (DANIELI-MONTEFORNO)
	Internal heating (rotating furnaces)		KRUPP SL/RN
Gaseous reducing agent	Stack furnace	with gas recycling	MIDREX
			PUROFER
		without gas recycling	ARMCO
	fixed bed		HYL
	fluidised bed	under pressure	HIB
			FIOR
		at normal pressure	NOVALFER (pure H_2)

a) <u>THE DIFFICULT MARKET PENETRATION OF THE DIRECT REDUCTION PROCESSES</u>

151. For a long time now tests have been undertaken by the major iron and steel companies to develop processes for the direct reduction of iron ore. This research work resulted in the construction in Mexico in 1957 of the first direct reduction unit of 200 tonnes/day[133]. The process, to which the company gave its name HYL[134], is a direct reduction process using natural gas and producing, from a high grade ore, iron pellets[135] which are then converted into steel in an electric furnace. The HYL process was developed by the Mexican company in collaboration with the American KELLOG company. The Mexicans had been encouraged in their research and development of this new process by their desire to use their national resources of natural gas so as to be free from imports of scrap iron and coking coal.

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(132) According to <u>SEASI Quarterly</u>, January 1977 "Direct Reduction: a promising or auxiliary process".

(133) A pilot unit of 30 tonnes/day has been operating in Mexico since 1955.

(134) Hojalata y Lamina

(135) "Sponge iron".

152. This was a major innovation, making it possible to open up, at the side of the classical blast furnace route, a new iron and steel route, the more so since direct reduction could be coupled with the electric steelworks, and since the availability of natural gas provided both the reducing agent and a cheap source of electrical energy. In practice this innovation has for a long while remained a strictly Mexican affair, and it was the object of very considerable caution in world iron and steel circles. According to the statements of experts in the first half of the sixties the direct reduction process was still a text book example and the Mexican Monterrey factory was in fact a laboratory or, at the limit, just an "industrial pilot-scale unit". It was possible to hear statements in official circles that it was not realistic to base an iron and steel industry on a direct reduction process. Several years had to pass[136] before all the iron and steel experts acknowledged that the direct reduction process had ceased to be a text book example and had become an effective industrial alternative.

This reminder of the facts should not suggest the conclusion that there has been a kind of conspiracy against the direct reduction processes. In fact, these phenomenons can be explained, on the one hand, by the natural cautiousness of experts, and on the other hand, by the dynamics followed by the iron and steel industry deeply involved in developing other technical production routes.

As from the end of the sixties several iron and steel units based on direct reduction processes were already operating, were being built or being projected not only in Mexico but also in Venezuela, Brazil, the United States, New Zealand, Republic of Korea, etc.

b) WHAT IS THE PRESENT STATE OF DEVELOPMENT OF DIRECT REDUCTION IRON AND STEEL PRODUCTION ?

153. Since the end of the sixties direct reduction has proved itself, but its progress is still only modest. At the present time realisations are falling behind forecasts.

A specialist in direct reduction has stated, for example, that in 1977 there were 39 plants using the direct reduction process in twelve countries; 25 units were under construction, twelve of which would be completed by 1977. The production capacities were as follows:

15 million tonnes in 1977,
31 million tonnes in 1981,
51 million tonnes in 1985[137].

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(136) Up to the Evian Conference in 1967.

(137) Forecast by M. MILLER in Metal Bulletin of 29.4.1977.

The data **presented at the Second ECE Seminar in Bucharest were more optimistic:**

13 million tonnes capacity in 1976, and
34.8 million tonnes capacity in 1980(138).

154. It seems, in fact, that by 1 January 1977 total capacities of 8.8 million tonnes were in production and that, on the same date(139), capacities of 22.2 million tonnes "were the object of a contract with prospects of completion before the end of 1980" (including 12 in 1977, 7 in 1978, 4 in 1979 and 4 in 1980).

It can be seen from this information that the expansion of the direct reduction process is likely to be less rapid than was forecast, but that it is possible that on the basis of its advantages this process has high priority in certain countries and that the rate of effective realisation is speeding up.

155. At the present time the geographical distribution of plants already built and projects is as follows(140):

Up to 1 January 1977 the industrialised countries owned about 75% of the direct reduction installations. However 60% of the installations which were to enter into service from 1977 up to 1980 are located in the developing countries. This proportion will be maintained for projects retained or studied up to 1985 and beyond. Mexico, Venezuela and Brazil in Latin America, Iran, Iraq and Indonesia in the Middle East and Asia are the countries which have made a deliberate (though not exclusive) choice in favour of direct reduction. By contrast, and except in Iraq and Qatar, the direct reduction projects are scarcely progressing in the Arab countries(141), these countries not having iron ores available which are of high enough purity and quality(142a).

(138) **Mr. J. Astier's paper presented at the Second ECE Seminar in Bucharest, 1973.**

(139) Metal Bulletin Monthly, June 1977. Furthermore 41 projects retained for the period 1981-1985 represent a capacity of 24.2 million tonnes, whilst 41 other projects are being studied, representing a capacity of 26.4 million tonnes.

(140) **"A few aspects of the progress recently realized in the production of sponge iron". UNIDO Memo submitted at the Seminar on the utilization of pre-reduced materials in steelmaking. Bucharest, May 1976.**

(141) A contract has, however, been signed in Algeria for the Jijel project.

(142a) Cf. "Arabs' disenchantment". Metal Bulletin of 27 September 1977. Nevertheless the theoretical potential for direct reduction by natural gas in the Middle East countries is enormous. It is estimated in fact that using the gas which at the present time is flared off one could produce 240 million tonnes of sponge iron per year (Iron and Steel International, October 1977 "Direct reduction; progress and plans").

156. In the industrialised countries units have been closed, the construction of new units has been held up, and various projects have been frozen since the price of scrap iron, the substitute for sponge iron, is still falling because of the prolonged crisis(142b). "As long as the crisis lasts the chances of a real increase in direct reduction capacities appear to be very small. With prices of scrap iron so low iron and steel technicians have no encouragement to invest even the most modest sums in the production of sponge iron, even if it can be clearly seen that when the steel market improves the supply of scrap iron could shrink very rapidly". "It seems, when all is said and done, that it would be a hard winter for direct reduction(143)". In this context the Spanish, who were actively pressing forward their projects for direct reduction at Gibraltar and Bilbao, have frozen them. They remain however very conscious of the future of the process, given the probability of shortages of scrap iron in the more or less near future(144).

A Spanish iron and steel technician has stated quite clearly: "it is clear that there will be a shortage of scrap iron. It is clear that direct reduction is the solution ...... it is clear therefore that we must start on this(145a)". **These statements concerning the role and supply prospects of scrap are doubtlessly somehow strong, but the fact remains that scrap is becoming a balance giving raw material the role of which is premordial. The subjection of the iron and steel industry to the scrap supply tends to increase becawse of transformation and mutations in the manufacturing apparatus(145b).**

c) WHICH REDUCING AGENT: GAS OR SOLID REDUCER ?

157. The "breakthrough" at the end of the sixties and the beginning of the seventies gave priority to direct reduction processes based on gas, either natural gas or reforming gas. Most of the units constructed, under construction or in the project stage, use the two principal processes using gas, MIDREX and HYL. The existence of immense reserves of natural gas in the OPEC countries has opened up very large prospects to these processes. However attention has been drawn to the advanced tests carried out in the United States on the direct reduction of iron ore using low grade (lignite) coal.

(142b) On changes in the price of scrap iron see the study of the European Economic Commission, Iron and Steel SCRAP - its significance and influence on further developments in the iron and steel industries - Steel/AC.3/R.4/Add. 4. 21 March 1978 and Steel/AC.3/R.3/Add. 3 - 9 May 1977.

(143) Taking stock of DR, Metal Bulletin of 27 September 1977.

(144) Cf. Metal Bulletin of 20 January 1978. Salis confident on D.R.

(145a) UNESID May 1978, page 20. Considerations concerning the use of pre-reduction processes - by Henrique Abad, Technical Director of Fundaciones Echevarria S.A.

(145b) Economic Commission for Europe - Committee on Steel: Scrap, its importance and influences on the evolution of iron and steel industry - ECE/STEEL/24, 17 August 1978, French version.

"Tests on direct reduction based on low grade coal are being carried out in many advanced countries, and certain of these efforts are beginning to bear fruit. A process using low grade coal of the lignite type is approaching final development on the American continent[146]". This is a LURGI process, converted by the Canadian STELCO company: the unit is operating at an industrial stage[147], but it has still to prove itself technically and financially over several years.

It would appear that much research work is at the present time being carried out to promote processes with a solid reducing agent or to make possible the use of several types of solid or gaseous reducing agents[148].

This opens up a possibility for regions which have high resources of low grade (lignite) coal, that is to say the **USA, USSR, and Federal Rep.of Germany but also** BRAZIL, the BALKANS (Bulgaria, Yugoslavia, Greece), INDIA, AUSTRALIA and **probably People's Rep.of CHINA.** Apart from Brazil and India these countries are industrialised. With natural gas an alternative is opened up for numerous developing countries; reduction with low grade coal gives new advantages to the industrialised countries, except apparently Japan.

d) IS DIRECT REDUCTION ONLY A MARGINAL INNOVATION ?

158. This is a question which is being asked at the present time in many publications[149] **and the common opinion in Western Europe is that the pre-reduced ore might mainly serve to regulate the price of scrap.**

A certain number of developments which affect the direct reduction process in **Western Europe tend to make it a partial substitution solution. Pre-reduced ore,** or sponge iron, is a product which can **serve as a regulator of the scrap prices**

It is as a substitution product that the direct reduction process is being integrated into the iron and steel production routes.

(146) Fortune "The sponge iron" - January 1976

(147) According to Fortune this produced 85,000 tonnes in 7 months (400,000 t/year), but it was shut down because of the fall in the price of scrap iron.

(148) For example the Kinglor Metor process, according to the director of the Kinglor Metor SpA; s' on this subject Iron Age Metalworking International "The worldwide explosion of direct reduction" 10/1977.

(149) Cf titles of recent articles "Direct reduction: a promising or auxiliary process" SEAISI Quarterly - January 1977 - "Direct reduction iron as a substitute for scrap in electric furnace steel making". Paper presented to the Kaohsiung symposium - SEAISI 1976.

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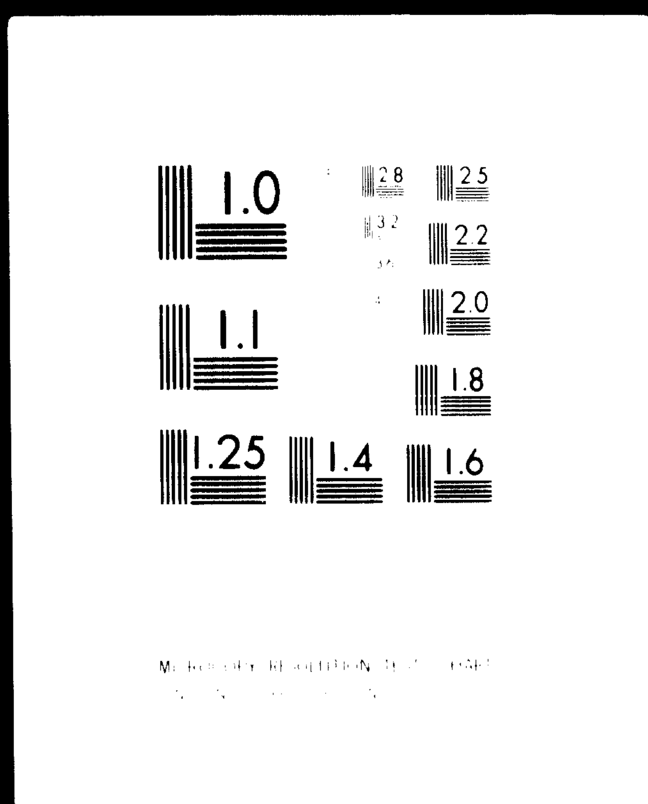

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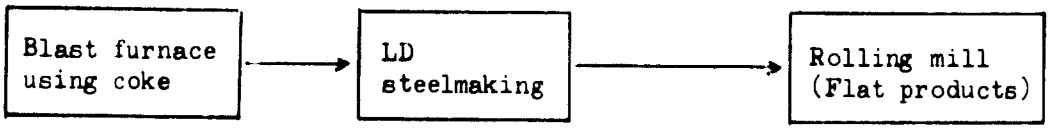
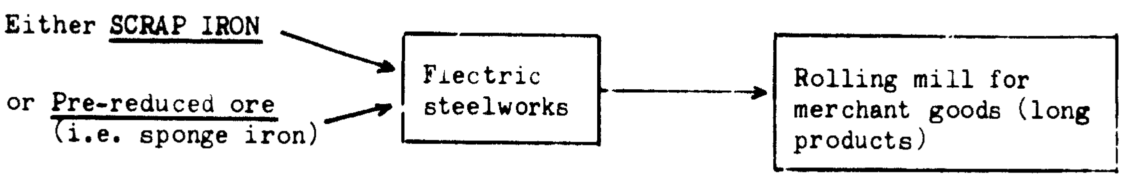
But this is still only a marginal integration, since the process simply enriches a variant or secondary route as compared with the one which remains the major classical route.

<u>Maxi-plant</u> (classical route)



<u>Mini-plant</u> (ancillary route)



This explains the variations in the opinions expressed in Europe on the interest of the process: when scrap iron is expensive it is the process of the future, but when prices of scrap iron collapse, the process is almost at the limit of "science fiction"[150].

159. This limited and somewhat simplified vision of the direct reduction process is beginning to change as the major potentialities which it opens up begins to be appreciated:

a - Sponge iron is a <u>high-quality product</u> which can be used not only for the production of ordinary steels but also for fine and alloy steels. "It has been proved in Mexico, as in the Argentine, that sponge iron is an excellent material for the production of special steels[151]". This may be

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(150) Cf. <u>Metal Bulletin</u>

(151) <u>Siderurgia latino-Americana</u> No. 207, July 1977. "In 1980 Latin America will maintain its leadership in direct reduction". J.R. Miller.

compared with the information given at the Bucharest symposium according to which "sponge iron is particularly suitable for producing carbon steels and spring steels, together with high-strength steels for welding[152]".

b - Very optimistic evaluations were also made concerning the cost advantages presented by direct reduction processes as compared with the classical processes. In the case of the Venezuelan SIDOR installations the investment, including continuous casting but excluding the rolling mills, was 40% lower than the investment which the classical route would have necessitated. This is shown at operating level by a 20% advantage on the cost of slabs[153]. These evaluations always call for a certain amount of reserve whilst awaiting their verification in an experimental manner when the installations are completed, put into service and run in.

c - By contrast it would seem that the direct reduction processes are characterised by their flexibility:

- From the point of view of the <u>ores which can be used</u>: up to now there has been an insistence on the high iron content required of the ores treated by this process, but it appears that recent developments are tending to enlarge the range of ores which can be used in the direction, for example, of sulphur-containing ores[154]. This aspect is the subject of active experimental work;

- From the point of view of the <u>reducing agents</u>, certain of the processes previously developed for the use of low grade coals are able to accommodate themselves to the use of fuel oil, natural gas or coking gas[154].

- From the point of view of <u>size</u>. The normal size of direct reduction installations is in the region of:

  300,000 t/year for installations with rotary furnaces,

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(152) **Bucharest: Second International Symposium on the utilization of pre-reduced materials in steelmaking, May, 1976; also "Considerations regarding the use of pre-reduced materials", article cited above - UNESID, May 1978.**

(153) <u>Siderurgia Latino-Americana</u> - "In 1980 Latin America .....", article cited above, pp. 31 and 32.

(154) IAMI "The worldwide explosion of direct reduction" October 1977. It should also be noted that the direct reduction process seems to be particularly suitable for the treatment of complex minerals such as the titanium-bearing sands of New Zealand (8% TiO2), treated in a rotating furnace with a solid reducing agent, "Direct Reduction: Progress and Plans". U. Kalla and R. Steffen, <u>Iron and Steel International</u>, October 1977. A.314.

600,000 t/year for fixed bed and stack furnace installations
300,000 t/year for fluidised bed installations[155].

In reality the variety of the processes makes it possible to envisage not only much smaller sizes, down to 20,000 t/year in the case of the Italo-Swiss Kinglor-Metor process, but also much larger sizes, since at the present time the possibility is being studied of producing units of 1,000,000 t/year[156].

At all events, and since the HYL, MIDREX and PUROFER direct reduction units are perfectly juxtaposable, there is nothing to date to prevent the construction of integrated iron and steel units of large size, up to several millions of tonnes annual capacity, using the direct reduction process. It is this which is now being done in Venezuela with the extension of the SIDOR unit at Matanzas. "The view of the industry in 1972 that direct reduction iron is useful mainly for electric furnace steelmaking in relatively small plants has been expanded to include very large operations with annual capacities of several million tonnes of pre-reduced iron[157]".

At the same time the complementarity of direct reduction units with large classical steelmaking units has been shown to be extremely profitable, since small direct reduction units are able to use and valorise steelmaking dust in the production of sponge iron[158]. From the very smallest size to the largest size the direct reduction processes in this way enlarge the range of possibilities of access to the iron and steel industry. This is of great interest for all concerned, in particular in the developing countries[159].

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(155) SEAISI - Quarterly, January 1977 "Direct Reduction: a promising or auxiliary process" P. Dhelft - page 43.

(156) Korf MIDREX process.

(157) Ironmaking and Steelmaking No. 5, 1977 "use of direct reduced iron ore and balanced integrated iron and steel operations" J.R. Miller, page 259.

(158) It is only recently that the direct reduction process has become of importance in the field of steelmaking residues and dusts and blast furnace gas. Cf. "Direct Reduction: progress and plans" U. Kalla and R. Steffen, Iron and Steel International, October 1977, pages 307-319.

(159) On this point see the developments below on scale economies.

e) DIRECT REDUCTION AND THE POSSIBILITY OF ACCELERATING THE DEVELOPMENT OF THE IRON AND STEEL INDUSTRY IN MANY DEVELOPING COUNTRIES

160. Irrespective of the problems encountered by the expansion of direct reduction the various processes which are available are arousing increasing interest not only in the developed countries but also in the developing countries:

- In Africa: Mauritius, Nigeria and Zambia;
- In Latin America: Chile, Colombia, Ecuador, Peru, Salvador and Trinidad;
- In Asia: Bangladesh, Malaysia, Singapore and Thailand;
- In the Middle East and the Mediterranean: Abu Dhabi, Algeria, Egypt, Libya, Morocco, Saudi Arabia and Tunisia.

161. If direct reduction is to become effectively and universally accessible it is necessary that the various direct reduction processes can operate within a wide variety of contexts.

162. This assumes that the following problems are solved:

- The transport of sponge iron (oxidation)
  This problem seems to be on the way to being solved. Its importance is less when the sponge iron is directly loaded into the electric furnace. This would be the case in most of the units installed in the developing countries, where satisfying the domestic consumption is more important than export prospects.

- Size and modules
  The advance of solutions is rapid both in respect of installations of very small size (20,000 t/year) and those of very large size with unit modules of 1,000,000 t/year.

- The ores which can be used
  It is necessary that local ores and not only high purity ores with a high iron content can be utilised. This constitutes one of the limitations to the more rapid utilisations of direct reduction processes. This problem is not given the highest priority amongst

those who at the present time have the research capacities. It will be recalled in this context that, in the last century, at a time when research capacities were much smaller than today, only just over twenty years (1855-60 to 1879) were necessary to use phosphorus-containing cast irons in a converter of the Bessemer type, as a result of the discovery of the Thomas process. Twenty years have now already passed since the entry into service of the first industrial HYL installation in Mexico, and the range of ores which can be used in direct reduction installations is still relatively small.

163. The direct reduction processes are controlled by major iron and steel groups belonging to the market economy developed countries.

- MIDREX process: the Midrex Corporation (owned by the German KORF company) has granted a licence to LURGI for Eastern Europe (excluding the USSR), Tunisia, Egypt, Nigeria and Spain.

  A licence has also been granted to MITSUI (with KOBE STEEL) for the Far East and Australia, KORF reserving for itself Western Europe, the USSR, Africa (except Nigeria) and the Middle East countries.

  However 49% of the capital of KORF has recently been acquired by the Austrian VOEST-ALPINE Company.

- HYL process: this was the first process to be made operational by the Mexican HOJALATA y LAMINA company. This company has made the American PULLMAN SWINDELL company its exclusive licencee(160). PULLMAN SWINDELL has, in its turn, signed an agreement with the Japanese Kawasaki Heavy Industry Company to commercialise the HYL process on the international market.

- PUROFER process: it may be operated by oil and hot discharge is possible and by using lump ores instead of pellets and coke oven gas instead of natural gas.

- ARMCO process: Armco-Foster Wheeler withdrew from the field of direct reduction, but after new positive tests is again offering its process on the market. The German Krupp company holds the licence for the Armco company (gas reducing agent), whilst at the same time developing and offering its own process using a solid reducing agent.

(160) Division of PULLMAN Inc.: within this framework PULLMAN SWINDELL has the responsibility for the engineering and construction of the Matanzas unit in Venezuela (SIDOR), whilst the Venezuelan personnel will go to the Monterrey plant in Mexico for training - IASI - February 1976.

All the processes are therefore controlled and offered by iron and steel companies belonging to the market economy developed countries.

164. It follows that any serious discussion on co-operation in the iron and steel sector should consider the routes and resources capable of favouring the introduction and progress of direct reduction processes in the developing countries.

165. It would seem to be particularly important to favour, in these countries, the implementation of research and development capacities making it possible to speed up the adaptation of the processes to a variety of contexts.

166. Inter-regional "triangular" collaboration could be studied in this respect. The Indian iron and steel industry has undertaken initial research in this direction[161]. The experience of Latin America in respect of direct reduction is already not unimportant; the interest of the petroleum and gas producing countries in this route is very considerable. Is it not possible to consider bringing together these various interests and capacities (technical and financial) for the creation of joint venture operations with the major European, Japanese or American iron and steel companies, or by other ways to create active instruments for the accelerated promotion of direct reduction ? This new route could then experience a very rapid growth.

f) THE USE OF ATOMIC ENERGY

167. The use of atomic energy in the production of steel is at the present time the subject of experiments in several countries: the United States, Japan and the Federal Republic of Germany.

Atomic energy makes it possible to obtain hydrogen from gaseous hydrocarbons treated at a very high temperature, or even from water.

This hydrogen is then used in a process for the direct reduction of iron ore so as to obtain sponge iron, etc.

The possible use of this process calls for two comments:

i) Its use depends on the cost at which the hydrogen necessary for reduction can be supplied. Because of the development of atomic energy costs it would seem to be difficult to forecast any rapid spread of the process;

(161) "The Tisco Study - direct reduction in India", Iron and Steel International, June 1976.

ii) Only the most advanced economies have the scientific and financial resources to master this process in the coming years. This process does not therefore seem to be of interest to the very large majority of the developing countries, either in the short or in the medium term.

B. PROBLEMS OF SIZE AND SCALE ECONOMIES

168. Many of the developing countries are of small size: more than 50 of them have less than 1 million inhabitants. Industrialisation of these countries comes up against the general trend towards scale economies.

1. A WORLD STANDARD: SCALE ECONOMIES

169. It is accepted that the use of units of increasing size results in substantial economies, termed scale economies. Scale economies today affect most of the sectors of the economy: - large freight aircraft and bulk ore carriers, and supermarkets; but scale economies are mainly developed in industry where all branches have been successively involved.

170. The general concept of scale economies proceeds from simple statements: the area of land used, the quantity of equipment employed, the number of personnel and in particular of skilled personnel required, do not vary in proportion to the increase in the productive capacity. Physical phenomena linked to increases in the size of equipment and instruments improve performance.

Under such conditions an industrial unit of very large size costs less per tonne installed than a much smaller installation.

During recent decades systematic research into scale economies has been accelerated and has become accepted as a world standard: the standard of "scaling-up".

A considerable part of process innovations consist in scaling-up innovations. This method has been very considerably used in JAPAN and in the USSR[162].

2. SCALE ECONOMIES AND THE IRON AND STEEL INDUSTRY

171. Up to the beginning of the second half of the nineteenth century the iron and steel industry was characterised by units of small size which used local resources of iron ore, and wood charcoal and which supplied local markets.

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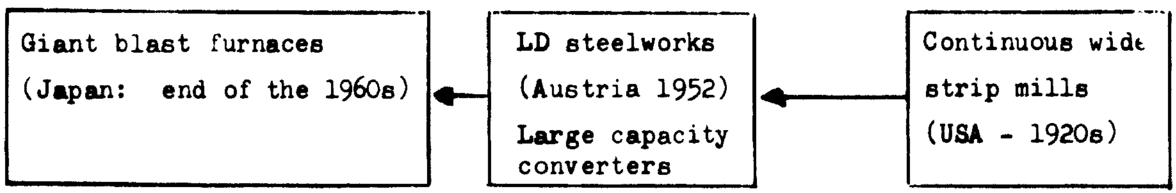
(162) Joseph Berliner - The Innovation Decision in Soviet Industry. M.I.T. Press Cambridge - 1976.

The replacement of charcoal by coking coal was not initially shown by any considerable increase in the size of blast furnaces.

172. The first moves towards larger dimensions took place from 1860 onwards when the increasing requirements for rails for railway construction in Europe encouraged the development of a new product, steel produced in large quantities by the Bessemer process, rapidly followed by the Siemens-Martin process and by the Thomas process. Up to the beginning of the twentieth century 100,000 to 200,000 tonnes of annual capacity was a fair average size for integrated iron and steel units.

173. The second move forward was started in the United States under the pressure of the necessity for a massive consumption of sheet intended both for the automobile industry, for domestic electrical appliances, for packagings and also for transport and oil refining. The first hot rolling mill for wide strips dates from 1926; its capacity was 600,000 tonnes; fifty years later integrated units for the production of flat units have capacities ranging from 3 million to 10 million tonnes; the size of steelworks and blast furnaces has shifted upwards until the time when the Japanese built giant blast furnaces with a capacity of 14,000 tonnes of **pig iron** per day.

The process moved from downstream to upstream:



174. This scaling-up movement has become essential and has successively affected those routes which seemed, initially, to depend on the advantages of small scale, such as the electric furnace. The development of high power

furnaces (UHP) triggered off the move to large sizes: 50, 100 and then 200 tonnes, with even larger units being expected(163). The installations for direct reduction also constitute units with an average capacity of 200,000 tonnes/year; here again it is proposed to move rapidly to 400,000 tonnes/year, whilst units of 600,000 tonnes/year are being studied and there are proposals for units of 1,000,000 tonnes/year (KORF, MIDREX).

175. Table 9 provides factors for comparison between the Japanese iron and steel industry and some of the large industries in the world, and shows the gains obtained by the systematic use of very large units(164).

TABLE 9

Productivity ratios

	Japan	USA	F.R.G.	France
Investment to produce 1 tonne of crude steel (US$ 1965/1973)	173	912	312	664
Crude steel per worker (tonnes/man)	325	178	-	171

However scale economies are not the only advantages which Japanese industry has, compared with its competitors.

The study of world iron and steel industry produced by UNIDO in November 1976 reflected this world standard by indicating, in Tables 10, 11 and 12 which are reproduced below, the capital gains obtained by scale economies:

(163) Prototypes of 400 and 600 tonnes are in existence at the present time in the United States and possibilities are now open to go up to 800 tonnes. Cf. UNESID - May 1978 "Considerations on the use of pre-reduced materials".

(164) Japan's Iron and Steel Industry - 1976 - page 77.

TABLE 10

Capital cost of a unit based on the "blast furnace/ oxygen steelmaking" route(165)

Unit capacities (in tonnes)	Capital costs: 100 = cost for a capacity of 5,000,000 t
200,000	213
300,000	180
400,000	164
500,000	155
600,000	146
700,000	140
1,000,000	129
2,000,000	115
3,000,000	110
5,000,000	100

TABLE 11

Capital cost of a unit based on direct reduction and the electric furnace(165)

Unit capacities (in tonnes)	Costs (US $/t)	
	Direct reduction, including site costs	Electric furnace
200,000	130	79
300,000	111	67
400,000	100	61
500,000	93	56
600,000	88	52
700,000	85	51
1,000,000	84	50
2,000,000	84	49
3,000,000	83	49

(165) UNIDO/ICIS - *op. cit.* page 200

TABLE 12

Capital cost of the construction of a blast furnace[165]

Unit capacity of the blast furnace (tonnes)	Capital cost (US $/t)
300,000	160
500,000	123
750,000	102
1,250,000	95

It can be seen from these tables that the scale economies obtained in respect of the blast furnace and the classical route (blast furnace + oxygen steelmaking) are very considerable. By contrast the scale economies are considerably less substantial in the direct reduction/electric furnace route inasfar as, to obtain capacities of more than 400,000 tonnes/year, it has until recently been necessary to juxtapose at least several direct reduction modules and several electric furnaces.

176. The **concept of scale economies also tends to be imposed in all the routes** of iron and steel production so as to obtain systematic gains in respect of capital and, as a consequence, gains in operating costs. But it should be emphasised here that, at the same time, the operation of this law exercises a negative influence by making it more difficult to obtain access to the iron and steel industry for developing countries of small or medium size.

Such a negative influence is clearly shown in the field of flat products where rolling mills with continuous lines and large slabbing units disqualify small size and even medium size installations. The same negative incidence may also operate one day on the direct reduction/electric furnace route where the same process of development of medium and then of large capacity is being followed.

177. **In this sense the scale economies constitute sometimes serious obstacles to entry for the developing countries within activities where the market is not large enough (for instance - flat products).**

3. REALITY AND THE LIMITS OF SCALE ECONOMIES

178. The universal value of the concept of scale economies seems to be very solidly based. But now it is beginning to be questioned. On the one hand the experience which is accumulating in the developing countries indicates that this law operates less uniformly than had been assumed. Furthermore the continuing crisis which in the industrialised market economy countries shows failings in what had been believed to have been very solidly based.

a) IN THE MARKET ECONOMY DEVELOPED COUNTRIES

179. Scale economies bore all their fruit during the period of long growth, from the time when industrial installations operated at very high utilisation levels of their capacity of more than 90% and up to 100%.

180. The crisis made these levels fall in a lasting manner to below 80% and sometimes to below 60% in certain European iron and steel industries. The damage caused by operating under capacity is the more noticeable when very large units are involved and where the very high fixed costs are not compensated for by a high level of production.

"The crisis has shown, amongst other matters, ... the vulnerability of the large works because of their high investments and ..... the greater adaptability of the so-called mini-mills ....."(166)

181. Other disadvantages linked to large size did not need the crisis to show them up, in particular the longer period necessary before entering into operation, together with the time for raising production up to the normal running rate in very large iron and steel units. This extension of the time necessary arises from the difficulty of mastering a complex assembly of very large size, where the continuity of the process implies precise articulation between the various sections, together with efficient adjustment to the environment. As the scale of sizes rises so the "teething problems"

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(166) "The shape of things to come" Editorial, Metal Bulletin of 9 May 1978, p. 19.

are extended which over two, three or even four years have questioned the advantages to be drawn from scale economies.

b) IN THE DEVELOPING COUNTRIES

182. The previous phenomena are amplified.

183. The time required for construction: The position has now been reached when the time necessary for building an iron and steel unit in a developing country is much longer than the normally accepted standard in the developed countries.

Weaknesses in constructional capacities, shortages of cement, concrete reinforcing rods and skilled labour, bureaucratic slowness of customs and financial administrations, failings in transport and infrastructures, all combine together to multiply these delays.

Recent examples indicate that an integrated iron and steel unit of 2.5 million tonnes was constructed in 36 months in an EEC country and an iron and steel unit of 1.0 million tonnes was built in the same time in Eastern Asia, whereas it took 80 months to build a unit for 0.5 million tonnes in Africa and the Middle East.

Such delays are very expensive: it can in fact be calculated that each month of delay increases the initially forecast investment by 1.2 to 1.4%[(167)].

184. Entry into production also takes much longer in the developing countries than in the developed countries. In the iron and steel industry, where it is a continuous process, this entry into production depends amongst other factors on efficient adjustment between the various units. Time is necessary to reach an operating level of 20-30%. More time is then needed to move beyond 60-70% once this threshold has been reached. This assumes that not only are a certain number of technical problems solved but also the difficult problems of management.

185. The environment: It is difficult - even more difficult in a short period - to adjust the physical, economic and human components of a new iron and steel unit to an environment which is totally or still very largely foreign to

(167) Report of the group of industrial experts delivered on the initiative of the Minister for Industry and Energy of the Democratic and Popular Algerian Republic - in February 1971.

industry. Bottlenecks inevitably appear: irregular supplies, limited storage areas and inadequate worker accommodation all introduce hazards which are prejudicial to the entry into production and which exercise a negative impact on costs, productivity, etc.

186. Labour: even if long and detailed training is carried out abroad and is carefully organised it is essential that the labour force of foremen, technicians, workers and other employees, are given specific apprenticeship in the commissioning and operation of the new iron and steel unit. This means that hundreds and sometimes thousands of workers of all skills and all categories are integrated into a collective working organisation. Even if each of the workers is trained and competent this is not sufficient if the collective operation of each of the component parts and of the unit itself is to be carried out in an effective manner(168).

Under these conditions it does not seem that the argument which is sometimes advanced, and according to which it is more effective, and economic, to use a small available number of qualified or highly-qualified workers by allocating them to highly automated and large-size units, is a very satisfactory one. It must on the contrary be asked if a few highly-qualified workers are capable of compensating for a low level not only of knowledge but of accumulated technical experience. It may also be asked whether there is not an inverse relationship between the size of iron and steel units and the possibility of bringing an inexperienced working group up to its maximum efficiency.

187. The developing countries have experienced so many checks in the training of personnel - irrespective of the place where the training took place - that it has encouraged them to rethink the problem of training as a function of the size of the production unit and also of parameters which are not taken sufficiently into consideration, in particular the links between the technological processes and the form of individual and team work(169).

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(168) Cf. on this subject it is interesting to emphasise the observation of M. Liassine, then Director General of the Societé Nationale de Sidérurgie in Algeria, to the Symposium organised at Dijon on 29 and 30 September and 1 October 1976 on the "Transfer of technology and development". M. Liassine remarked that "taken individually the workers of the new El Hadjar iron and steel unit can stand comparison with the workers in other countries, but the problem which it presented was the problem of collective operation". "Transfer of Technology and Development", Les Editions Techniques - 1977 Paris.

(169) See Jean Perrin - Social repercussions of the transfer of technology - working conditions and the transfer of technologies - Document drawn up for the B.I.T., July 1977.

4. NEW PROSPECTS

New analyses on the basis of new bases

188. The available information on the developments which are taking place both in the developing countries and also in the developed countries tend to question the universality of the operation of the law of scale economies[170]. On the occasion of recent events it has been noted that an iron and steel production unit does not only consist of surface areas and volumes but also of a group of workers required to master technical processes which are increasingly continuous and on the basis of complex machine systems. Such a mastery can only be progressive; it implies stages, it implements social laws and not simply physical constants. This context requires to be better perceived, better evaluated and analysed so as to arrive at the definition of thresholds from which scale economies can effectively operate.

"Scaling-up" and "scaling-down"

189. The move towards scale economies and the movement of "scaling-up", considered for a long while as irreversible, developed in the most advanced industrialised economies, USA, USSR, JAPAN, Federal Rep.of GERMANY, UNITED KINGDOM, etc. which are or have been economies of world scale. Today the phenomenon of the crisis, together with the desire for industrialization of numerous developing countries of small or medium size, presents the problem in new terms: not only of scaling-up but also of scaling-down, and new approaches to what is not entirely fair to term "miniaturisation"[171].

Taking account of experience

190. In order to advance along this route consideration must be taken of numerous concrete experiences which fall outside the normal.

The "mini-mills", or small size iron and steel units, have multiplied over the last fifteen years in Italy, where the companies in the Brescia region have acquired a considerable notoriety, but also in the United States, in Spain, in Great Britain and in Japan. These are iron and steel units with unit capacities of 50,000 to 150,000 tonnes per year: non-integrated simple rolling units, semi-integrated units using UHP electric furnaces, and operating from scrap iron, and integrated units using the direct reduction/electric furnace route.

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(170) Obviously one must not deny the existence of this. On this subject it is necessary to emphasise strongly the fact that several developing countries are effectively mastering very large integrated units in Asia, in Latin America and, recently, in the Middle East and in Africa.

(171) Inasfar as this term has pejorative overtones.

These units specialise in the production of concrete reinforcing rod and also merchant goods.

There are also small integrated iron and steel units (100,000 to 200,000 t/year) following the classical routes:

Blast furnace ⟶ Oxygen steelmaking ⟶ Continuous casting ⟶ Rolling mills for concrete reinforcing rod and small merchant goods.

Such units are operating in a satisfactory manner (for example at Menzel Bourgaiba, in Tunisia), contradicting certain recommendations which advised not going below a threshold of 1 million tonnes per year for integrated units producing long products.

191. The problem of size, which seems to be solved in the case of concrete reinforcing rod and small merchant goods, continues to be posed in the field of heavy sections and rails, but particularly in the field of flat products, in the production of slabs, hot-rolled sheet and heavy plates. The size of the mini-mills would therefore be inadequate to integrate modern rolling mills producing flat products[172].

However it is important not to ignore the possibilities which do exist, including the manufacture of certain products in this category. Certain authorities feel that "by accepting a product of slightly lower quality, it is possible to produce flat products in small size units using mills of the Steckel or Sendzimir type. At the present time this is exceptional, but technical developments are possible in this field"[172]. In any event it is significant that a new unit recently installed in Great Britain with a capacity of 250,000 tonnes (which may be increased to 800,000 - 1,000,000 tonnes/year) is competitive, because of its hot rolling mill which produces flat products, with the production of a major integrated iron and steel unit which is nearby[173]. Competition will become even keener when a cold rolling mill makes it possible to pass from hot-rolled coils to cold-rolled flat products for the automobile industry. These new possibilities could have important consequences.

192. Initially the quality of these products may not be as good, but the highest quality is not required for all uses of flat products. It would therefore be advantageous to identify, in the developing countries interested, what proportion of the possible uses are covered by the quality obtained from medium-sized flat product rolling mills. It is highly probable that this proportion would not be negligible.

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(172) Iron and Steel International - April 1978 "The changing face of steel: analysis of world-wide trends". A. Van der Rijst and H.H.J.M. Derkx, page 110.

(173) In the case of the iron and steel unit cited only 1,000 employees are necessary for producing 800,000 tonnes. cf. on this subject the Financial Times of 19 June 1978 "Mini-mills challenge to the steel giants".

Finally, and if what is termed "the bottom of the range"(174) will also escape from the larger installations to the profit of the smaller and medium and hence less expensive installations, this runs the risk of depriving the larger installations of the mass production, the income from which is essential for their profitability, that is to say for the operation of scale economies. The stakes are therefore high.

In the same way the opinion of one of the directors of the European Iron and Steel industry according to whom "the era of scale economies is past", could be not just a passing comment but could indicate, amongst other things, that "mini-mills" or "medi-mills" are not just marginal phenomena but important events in the development of the iron and steel industry;

These "portents of the future" are particularly important for developing countries which wish to master the various ranges of iron and steel production. This is why the analysis of concrete experiences in respect of medium-sized iron and steel units should be carefully undertaken: in Yugoslavia, Bulgaria, Egypt, Chile, Algeria and New Zealand (project), and anywhere where medium-sized units integrate the production of flat products or medium and heavy sections. This is because it is of value to compare these realities, diverse as possible, with what has been put forward as the definitive imperative of scale economies.

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(174) This comment does not mean that it is proposed in the document to confine the iron and steel production of many developing countries to the lower end of the scale, but on the contrary to identify those routes which make it possible to obtain progressive access to the highest parts of the range. It is also necessary to point out the value of limiting the number of grades of steel used: the French standards committee has shown, for example, that about fifty grades of steel out of the 400 or 500 used at the present time are sufficient to cover some 80% of all uses. See "Les industries mécaniques", June 1974. See also on this subject the work of the Economic Commission for Europe: "Symposium on the relations between the iron and steel industry and the steel consuming industries, 12 - 16 December 1972 - Steel/SEM/3-2, 24 May 1978.

SCALE ECONOMIES, EQUIPMENT GOODS AND ENGINEERING

103. One must not pass over in silence the relationship which exists between the size of an industrial unit (iron and steel) with the origin of equipment goods on the one hand and the origin of the studies which enter into its design and its construction on the other.

As the size of the unit becomes greater so there are fewer engineering companies and suppliers of equipment goods capable of submitting tenders. In the limit several engineering companies in the world have the resources to construct to time, almost to the day, a giant unit of 7 to 10 million tonnes. By contrast, and based on the multiplication of the small iron and steel units around Brescia, a small supplier of equipment and studies has started up and is now of international repute.

The calculation of the real gains obtained from scale economies cannot therefore ignore the possibility or otherwise of calling on, creating or promoting the production of equipment goods and national design and construction capabilities.

We see here again the link, which it is not possible to evade in a country which is launching its iron and steel industry, between the iron and steel activity itself and the upstream and downstream industrial activities.

C. FINANCING

194. It is clear that development of the iron and steel industry in the developing countries poses numerous problems in all fields: technical, management, pollution, social problems, but also financial problems. In the present situation it seems that the problems of cost and financing constitute one of the sensitive points, in respect of which the terms of the discussion must be re-stated.

1. THE HYPOTHESES RETAINED IN 1976

195. The first UNIDO study on the world iron and steel industry devoted its closing chapter to the "Capital requirements" corresponding to the 1985 and 2000 projections for the consumption and production of steel. The capital necessary to build, up to the year 2000, 446 million tonnes of new capacity in the developing countries was estimated at a total of US $231,500 million(175), divided up between 62,000 million over the period 1975-1985 and 169,500 million over the period 1986-2000.

196. These estimates were based on the following hypotheses:

a) Two reference figures were retained for the cost per annual tonne installed: the highest cost, US $690 per tonne, corresponding to a 3,000,000 t/year integrated unit built using the classical blast furnace and converter route and the lowest cost, of US $312 per tonne, corresponding to a unit constructed using the direct reduction/electric furnace route.

These figures were obtained from published information or information obtained from private sources; they were felt to represent averages for the 1970's(176).

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(175) UNIDO/ICIS. 25. 15 December 1976, pages 198 to 214. These were all gross investments; the net investments amounted to US $215,600 million.

(176) cf. report cited, pages 202 and 203.

b) These capital costs did not include:

- Either the investments required by the opening of mines, by the possible construction of an electric power station directly linked with the iron and steel plant, or the construction of dwellings;
- Or any unforeseen events(177);
- Or additional interest charges.

c) Scale economies were assumed to operate "normally", both in respect of the classical route and also for the direct reduction/electric furnace route.

197. These hypotheses were relatively optimistic. They under-estimated the obstacles to the normal operation of scale economies in developing countries, a context characterised by the magnitude of hazards, unforeseen events and additional interest which was increased by delays, together with a series of other costs which were difficult to dissociate from the iron and steel investment itself.

198. From the beginning of 1976 the evaluations of other specialists in respect of capital costs were very much less optimistic, since the cost per annual tonne of capacity installed rose to(178):

US $350 - 500 in the case of modernisation and expansion operations
US $800 - 1,000 in the case of entirely new units.

It is true that these estimates relate to the United States of America and not to the whole of the world. It was therefore difficult to define an average capital cost precisely. It was necessary to make a choice, and this was what was done in the UNIDO study.

2. AN ESSAY IN THE RE-EVALUATION AND UPDATING OF CAPITAL COSTS

199. Such an operation comes up against the same difficulties as those encountered by the 1976 study: the multitude and dispersion of the information, and the absence of any solid criteria for choice.

(177) In respect of which a figure of 10% is normally accepted.
(178) Fortune - January 1976 "Steel's not so solid expansion plans".

200. As a consequence there is no other way but to identify the changes by means of the estimates of specialists.

a) The Mitchell report(179), published in May 1977 indicated, for example, that according to estimates made at the end of 1976 the capital cost per tonne installed was US $500 in the case of expansion and modernisation operations but US $1,200 in the case of entirely new constructions using the classical route (blast furnace/LD). This was an increase of more than 70% on the US $690 figure retained by the UNIDO report in 1976.

b) The new estimates by W.T. Hogan published at the end of 1977(180) showed that the capital costs varied according to the different types of installations envisaged:

from US $1,000/tonne in the case of large integrated installations (a cost which was likely to rise rapidly with time to reach at least US $1,300 in 1980),

to US $700 to 800/tonne on average for extension and modernisation operations;

and to approximately US $490/tonne for installations of the direct reduction/electric furnace type (US $140/tonne for the direct reduction installation and US $350/tonne for the electric furnace, continuous casting and a small standard rolling mill).

These estimates are likely to vary according to the countries and as a function of local conditions. It is very improbable that they would be lower than those indicated here, but on the contrary it is very possible that they will be higher in many cases(181).

c) Estimates are also contained in a recent report entitled "Steel industry economics"(182).

The following figures are put forward on the basis of capital costs per installed tonne in the United States and in Japan.

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(179) Mitchell Hutchins op. cit. May 1977

(180) Iron and Steel Engineer November 1977 "Future steel plans in the Third World".

(181) Article cited, page 30.

(182) "A comparative analysis of structure, conduct and performance" by Hans Mueller and Kiyoshi Kawahito - Japan Steel Information Centre, New York, April 1978.

The costs, expressed in 1965 United States dollars, have increased steadily and rapidly since 1970 and particularly since 1973.

Table 13

Cost per tonne installed

(in 1976 United States dollars)

	Extension/modernisation	Entirely new installation(183)
USA	520 - 560	1,050
Japan	470	700

201. These various estimates converged towards capital costs which are very much higher than the costs retained in the first UNIDO report, the more so since it is necessary to take account of the generally higher cost of building in the developing countries.

202. The real or forecast costs of iron and steel installations in different parts of the world show a wide dispersion and various trends:

- In the case of semi-integrated units:

  US $200/tonne for a unit of 250,000 tonnes built in the United States(184);

  US $270/tonne for a 300,000 tonne unit recently built in Sweden at Bofors(185);

  About US $2,000 per tonne in Algeria for a unit comprising an electric steelworks and an installation for the production of non-welded tubes(186).

(183) These costs have been calculated in the following manner:

- in the USA on the basis of the estimates of US Steel for its project for a steelworks at Connecticut and on the hypothesis that the tonnage of finished products represented 77% of the crude steel products

- in Japan by applying a factor of 85%.

(184) Haron Steel Co., according to IASI of August 1977.

(185) Industries et Techniques - No. 370 of 10 May 1978; US $135/tonne for the steel and US $135/tonne for the rolling mills.

(186) This unit is in fact located on the same site as the integrated unit of El Hadjar.

US $800/tonne for a project for a 100,000 tonne unit in Paraguay, financed by a Brazilian loan(187).

- <u>In the case of integrated units</u>:

About US $700/tonne for an integrated unit at Fos-sur-Mer in France (estimate in 1972-1973 costs),

US $700/tonne for the third phase (completion end 1978) of the Pohang Steel unit in the Republic of Korea(188);

US $700/tonne for the construction of the 1,300,000 tonne unit of the China Steel Corporation at Taiwan, completed at the end of 1977.

Approximately US $2,000/tonne according to estimates made for the Venezuelan Zulia project (5,000,000 tonnes)(189);

Approximately US $2,000/tonne for the first phase of the Algerian Annaba iron and steel plant (500,000 tonnes)(190).

This information indicates a very wide dispersion in the costs; it does, however, make it possible to see the following trends:

- Certain developing countries (Far East Asia) show capital costs which are lower than the average costs in the United States and Western Europe; their costs have a tendency to be aligned on those of Japanese costs.
- In other developing countries the costs are much higher than in the developed countries; in several cases it is probably necessary to use a factor of 1.8 or 2 rather than a factor of 1.3 or 1.4, at least in the first phases of creation of an iron and steel industry.

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(187) <u>Metal Bulletin</u> of 21 July 1978

(188) This is therefore an extension (from 2,600,000 to 5,500,000 tonnes capacity) according to the <u>SEAISI Newsletter</u> of 18 May 1978 (US $1 = 500 won)

(189) According to the <u>Financial Times</u> of 5 December 1977 and <u>Business Latin America</u> of 22 March 1978

(190) It is true that it is difficult to make an estimate as far as certain installations are already dimensioned as a function of the second phase, and where the Algerian national companies integrate numerous infrastructure investments in their costs.

203. The increase in capital costs has therefore been rapid, and all the available information indicates that the process is continuing. The example of the Moroccan project for the installation of an iron and steel unit of 1,000,000 t/year is significant. By 1978 the estimated cost of the project had increased by 60% as compared with the estimate made in 1975[191].

The various indices which are available show the acceleration in the costs of equipment for the iron and steel industry which constitutes the principal part of the capital costs[192]. The index for equipment costs for the iron and steel industry has increased as follows in the USA[193]:

1967 : 100.0
1970 : 116.3
1976 : 202.0

According to the European Economic Community the cost of equipment for the iron and steel industry increased by 35% between 1960 and 1970 but by more than 50% between 1970 and 1975[194]. However as a result of the slowing down in investments and the shortage of projects competition between equipment manufacturers - very frequently the iron and steel producers themselves - have the effect of reducing certain prices, whereas the costs still increased. This impression unfortunately cannot be supported by the statistics.

According to another estimate the increase in costs was 67% between 1970 and 1975[195].

204. It is difficult to forecast how capital costs will change in the medium and long term. Will the rate of increase be as rapid, or will it tend to slow down ? Available information does not make it possible to formulate any clear prognosis, the more so since two contradictory trends are operating, the respective weight of which is difficult to estimate.

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(191) cf. "La Vie Economique" of 12 May 1978. The estimated cost of the unit which was still in the course of study had already reached US $1,300/tonne (for the production of long products).

(192) Again one must not under-estimate, particularly in the developing countries, the magnitude of the civil engineering, building and various infrastructure costs, etc.

(193) Mitchell, Hutchins op. cit. Exhibit 44

(194) ECSC "Investments in the community coal and steel industries".

(195) Peter F. Marcus "World Steel Supply Dynamics", New York, March 1976.

a) Engineering companies specialising in the iron and steel industry, and the producers of equipment for this industry, in particular key equipment such as blast furnaces, LD converters, continuous casting, rolling mills, etc., are concentrated in the market economy developed countries and the USSR. The greater part of the iron and steel units which they have built over the last twenty years are situated in North America and Oceania and particularly in Europe and Japan. The prospects for the construction of new iron and steel installations or even of extensions in these regions for the next ten years are very pessimistic. These engineering companies and constructors of equipment goods find, under such conditions, an interest in increasing their sales in the developing countries and hence to make proposals which are acceptable to economies where available capital is generally in short supply.

b) However the engineering companies and manufacturers of equipment goods for the iron and steel industry are also motivated by another preoccupation, namely that of maintaining the profitability of their industry by compensating for a relative reduction in their activities by increasingly high prices, when these can be obtained, in particular in those operations where it is possible to link government or bank credit given to the client country with the engineering and equipment services. This is very frequently the case when the construction of iron and steel units in the developing countries is involved.

The development of a compromise resulting from the interaction of these contradictory trends cannot be prejudged. This compromise is both the object and the result of negotiations.

3. THE CONSEQUENCES OF RISING CAPITAL COSTS IN THE IRON AND STEEL INDUSTRY

205. These consequences are developing in two directions: both by way of their impact on production costs, and also on financing problems.

206. The impact on production costs. Production costs in the iron and steel industry are particularly sensitive to the cost of labour per tonne of steel produced and to the level of utilisation of capacity and, in particular, to the capital costs per annual tonne installed[(196)].

(196) Iron and Steel International - April 1978 "The changing face of steel: analysis of worldwide trends" A. van der Rijst and H.H.J.M. Derkx.

Up to the present time, because of the relatively low level of capital costs in the installed iron and steel works - it is calculated for example that 100 million tonnes of capacity were installed in Japan for an average cost of US $200 per tonne - the contribution of amortisation costs and financial costs in production costs remained at a relatively low level.

They accounted for US $33.11 per tonne of steel in Japan (average) and US $80.78 per tonne of steel in the United States (average)(197), or US $22.50 per tonne of steel in the United States (average)(198).

The rise in capital costs during recent years is necessarily shown by a rise in amortisation and financial costs. A capital cost of US $1,200 per tonne installed is shown by investment and financial costs of US $103(199). Amortisation and financial costs in the case of new installations accounted for US $177 in the United States for an average capital cost of US $1,050 per tonne and US $199 in Japan for an average capital cost of US $700 per tonne(200).

In the case of extension and modernisation operations the amortisation and financial costs amounted to US $88 to 110 in the United States and US $80 in Japan(200).

207. These various facts call for the following comments:

a) The present increase in capital costs is shown by a change in the order of magnitude of amortisation of financial costs in production costs. This change becomes even greater as the operating level in the iron and steel industry tends to fall to a low or very low level, and when prices on the world market are subject to very keen competition.

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(197) Japan Steel Information Centre - Mueller and Kawahito, op. cit. page 22

(198) Mitchell, Hutchins, op. cit. Exhibit No. 15 - in these two cases integrated iron and steel units were involved.

(199) Mitchell Exhibit 15

(200) Mueller and Kawahito page 47 - Capital costs for extension and modernisation operations being estimated as:

US $520 to 650 per tonne in the USA and US $470/tonne in Japan.

It is only necessary to point out on this subject that steel prices for export frequently dropped below US $250 per tonne, the price of certain grades of Japanese sheet, for example, having fallen from US $270/tonne FOB in September 1973 to US $240 in January 1978[201].

b) These costs are estimated on the basis of data relating to the American or Japanese iron and steel industries. The capital costs involved today in many developing countries are, as has been seen, generally much higher, often by 50% or even 100%, as compared with estimated costs in the United States. This means that, under these conditions, amortisation and financial costs could rise to US $206 per tonne on the basis of the first estimate (US $103 x 2) or US $354 per tonne if one retains the second estimate (US $177 x 2).

Finally account must be taken of the fact that these calculations are made on the basis of an operating level regarded as normal and that, also, the financial costs may be relatively higher in countries where new iron and steel installations may have to depend largely on loans and also on foreign financing, the cost of which is generally high.

208. The impact on financing. Financing is one of the major problems for the development of the iron and steel industry in the developing countries.

The iron and steel industry is becoming an increasingly heavy industry. For example the estimated cost of the Moroccan Nador project represented more than a quarter of the gross domestic product in Morocco in 1975, about 150% of the added value of industry in 1975 and about 150% of the gross fixed capital formation in 1974[202].

(201) **SEAISI Newsletter** 16 March 1975

(202) Cost estimated at 7,000m Dirhams, cf. "**La Vie Economique**" of 12 May 1978.

209. The petroleum producing countries, with abundant currency surpluses, together with some developing countries where high productivity has already reduced capital costs, were able to cover the financing of the capital costs required for building large integrated units. The same does not apply in a large number of cases. W.T. Hogan observes that "the problem of financing is a most formidable one .... with funds from the sale of oil a number of Middle East countries can finance their own expansions: however other countries which are not producers of oil, will have to depend on outside financing ....."(203). This prognosis seems, at the present time, to correspond to reality.

210. **Some projects launched in the developing countries cannot in effect enter the realization stage because of the shortage of financing.**

This appears to be the case with the Moroccan Nador project(204) and also the Venezuelan project for the second iron and steel complex at Zulia(205,206).

The fact that Brazil, in the process of re-evaluating its expansion plans for the iron and steel industry, seems to be adopting the principal that no new project will be launched before its financing is certain(207), is significant of the situation which exists in most of the developing countries.

211. The need which developing countries find of applying to sources of outside financing raises numerous problems for these countries.

(203) Iron and Steel Engineer - November 1977. W.T. Hogan "Future Steel plans in the Third World" op. cit. page 31.

(204) Metal Bulletin of 28 March 1978

(205) Financial Times of 5 December 1977.

(206) Metal Bulletin of 6 June 1978.

(207) Metal Bulletin - 27 June 1978 "Brazil rethinks steel plan".

a) The oil producing countries, Saudi Arabia and the Persian Gulf countries, are interested in financing iron and steel industries in the developing countries. For example Kuwaiti funds have been granted to Mauritania, but such interventions are limited.

The USSR and the Eastern European socialist countries have, from their side, partially financed several iron and steel installations in the developing countries.

It is therefore reasonable to assume that the greater part of all external financing woul' be negotiated by the developing countries with international organisations such as the IBRD or the IDB, with banks or with various financing organisations established by the governments of the market economy developed countries.

b) These organisations, in which the parties concerned are private companies, state companies or the states themselves, therefore exercise, through the financing capacity which they offer, not necessarily a power of decision but at least of holding back, accelerating or orientating the projects proposed by the developing countries[208].

c) The supply of engineering services, equipment goods and know-how is, in practice, often linked with financing. Japanese financing was finally granted to the Tubarão project on the basis of the acceptance of a greater proportion of Japanese equipment than that which Brazil desired initially[209]. This shows one of the major constraints resulting from the need to call on external financing. This constraint is in practice often in contradiction with the promotion of national industries for the production of equipment goods for the iron and steel industry, together with national capacities for engineering in the developing countries which constitutes one of the major components of a process for inserting the iron and steel industry into an integrated national industrial system.

(208) The example of Tubarão in Brazil clearly shows this situation.

(209) And that which the Brazilian industry was in fact capable of supplying.

It is this which was expressed in one of the replies to the questionnaire sent by UNIDO dealing with the iron and steel industry: "an increasing supply of equipment produced by the national industry depends on an increased effort of national financing or foreign shareholding in the capital, since it is improbable that this type of support will be received by the iron and steel industry in the developed countries because of the excess capacity which is at present obtaining in the world industry"(210).

d) The weakness in their own capacities for financing is already a characteristic of numerous iron and steel industries in the market economy developed countries in Japan and in Europe where, progressively, indigenous capital tends to represent only a minority part of the outgoings: less than 20% and sometimes less than 12% in certain European iron and steel industries. One already knows the impact of such a structure of capital on costs, by way of the financial costs linked with long, medium and short-term loans. Most of the iron and steel companies in the developing countries are constrained, in the absence of their own resources, to accept a capital structure of this type, and they must then pay the price in interest and in financial costs.

212. Analysis of financial constraints shows the interests of the new technical routes which make it possible to obtain an increasingly wide range of products from installations of reduced size.

It has been seen that the costs of an iron and steel installation based on direct reduction and the electric furnace are less than US $500/tonne for capacities of 300,000 to 400,000 t/year.

(210) UNIDO. Questionnaire on the iron and steel industry,

It has also been seen that such installations produce, at the present time, a limited range of products, based on iron ore of a certain quality, etc. This shows the major interest of research work intended to promote the possible extension of inputs and also to enlarge the possible range of productions (towards flat products).

213. The financial restrictions do not therefore appear so ineluctable. Other chains of causality are possible: lower capital costs ⟶ relaxation of the constraints from external financing ⟶ enlargement of possibilities of integration of the iron and steel industry into a national system, etc.

This analysis finally suggests that there is not a problem of financing in itself, but that the latter occupies a central position in the elements which interact and which constitute the data of the complex negotiations involved in the creation and promotion of the iron and steel industry in the developing countries.

III. INTERNATIONAL COOPERATION

214. The iron and steel industry is sensitive to developments in the world economy which, at the present time, are directed towards a slowing-down of the rate of growth. The realistic taking into account of these negative trends is not however contradictory to the elaboration of a long term prospective approach, inspired by the desire to promote dynamic development and a better distribution of world industry to the profit of the developing countries. It has in fact made it more necessary.

215. The existing strategies and actors constitute the starting point of a process which will be increasingly developed along the line of complex negotiations between the partners, relying on the advantages which they have and discovering the potential dynamism of new complementarities.

216. This third part, which is also the conclusion of this study, attempts to elucidate the "system" which the world iron and steel industry forms, with its characteristic structures and motor variables, so as to be able to identify more efficiently within this field the context and the contours of the process of negotiation.

A. FROM THE OPTIMISTIC CONSENSUS OF LIMA TO THE START OF A PROCESS OF NEGOTIATION

217. The development which took place, and which is analysed in Chapter I, can be summarised in this way: the Lima Conference was held in March 1975, whereas the recession had for several months already affected the activity of the iron and steel industry. Everyone thought that this was a simple cyclic movement, forming part of the long trend towards sustained growth which had lasted for more than twenty years. This climate was maintained up to the first part of 1977. The optimistic outlook of growth and the distribution of the world iron and steel industries presented by the first UNIDO report for 1985 and the year 2000 were well received by the developing countries and also by the developed countries. From the point of view of the market economy developed countries this prospective view corresponded to the major relocation projects of the industry, which were announced at that time, in the direction of the developing countries. So much so that 150 million tonnes of production capacity forecast for 1985 and 400 - 500 million tonnes forecast for the year 2000 in the developing countries seemed to be not unreasonable objectives.

More pessimistic trends developed during 1977 in market economy developed countries. An event which was originally regarded as temporary was progressively characterized as a major structural transformation. Optimism and euphoria gave place to pessimism. Forecasts were revised downwards, including those for a large number of developed countries. The forecasts for 1985, and even more so those for the year 2000, became uncertain, the more so since the forecasting method used no longer functioned, and it was necessary to develop new ones.

Most of the recent analyses and comments give the impression that the very pessimistic short term trend constitutes a major handicap for the future.

Recovering the significance and dynamism of the objectives defined at Lima

218. The first part of the study insisted on the distinction to be made between "projections", the production of which depended directly on trends noted in the past, and which finally postulated a certain permanent arrangement of factors (structural arrangement), and the "prospective approach". The originality of the prospective approach is simply that it takes as its point of departure the break with trends, so as to project into the future new and lasting combinations of factors, whilst marking out the process of articulation of these new combinations and their conditions of association and realisation.

219. In the pessimistic climate of the second part of 1978(211), when the projected trend developed its negative consequences, it was a question of relocating the objectives accepted at the conclusion of the Lima Conference, and which were then translated into the proposed objectives for the development of the iron and steel industry up to the year 2000.

It is true that despite the crisis in the market economy industrialized countries, the progress in steel making has gone on, although inequally, in the developing countries. The question is if, in the long term, because of the generalized interdependencies, this progress could be maintained with persisting recession, stagnation or even a slight growth, in the market economy developed countries.

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(211) This report was completed in September 1978.

Such a distribution implies a modification of the structure of the world iron and steel industry. In practice this distribution depends on the development of new processes, new routes, a new orientation of research work and greater autonomy in choices, a certain displacement of the centres of decision, etc. Far from putting the Lima objectives into abeyance the present crisis is an invitation to emphasise the prospective significance, capable of supplying the bases for a new arrangement of factors and of stimulating the long process of negotiations which is necessary.

The beginning of a process of negotiation

220. The crisis situation in the world iron and steel industry initially aroused a series of defence movements: on the part of the United States the implementation of a system of "trigger prices" to limit European imports, but more particularly Japanese imports; on the part of the European Economic Community, protecting its market on the basis of agreements for the limitation of sales negotiated with the principal importers, together with a system of floor prices. These protectionist measures seriously threaten the structure built on the principles of free trading. The various actors are conscious of this, and are very desirous of showing that the measures taken, temporarily, are not incompatible with their adhesion to GATT. They are, in effect, emergency and short-term measures which are not adequate for defining long term or even medium term policies.

221. This is why there has appeared, and is being affirmed in an increasingly explicit manner, a call in favour of the organisation of a major negotiation on the future of the world iron and steel industry. The formulations are diverse, whether it is a question of a discussion or of a world forum, or more explicitly of negotiation.

222. Very extensive discussion on the future of the world iron and steel industry is recommended and it is desirable, for example, that there should be a move towards an agreement of the "multifibre" agreement (AMF)[(212)]; other Europeans are more reserved as to the implementation of such a process[(213)].

(212) Metal Bulletin; 11 July 1977 (interview with M. Ferry)

(213) Metal Bulletin; 1 April 1977 (interview with M. Köhler, one of the Directors of Dénélux).

Certain executives in the Japanese iron and steel industry are, on their side, partisan towards a very extensive international consultation[214], whereas the United States are actively promoting the organisation of negotiation at a world scale. For the last two years several executives in the iron and steel industry and the American administration have insistently developed this subject. In September 1977 a special representative of President Carter declared before a Congress Committee in the United States: "We feel that the complexity of the questions in the iron and steel industry, together with the changes which are taking place, make it essential to create a permanent international group to oversee the development of the branch and to facilitate international cooperation whenever problems arise ...."[215]. This approach was reconsidered at the time of establishing the system of "trigger prices"[216]. They began to be applied by way of the creation of a new committee within OECD[217][218], marking a stage towards the opening up of a discussion on the world iron and steel industry. The new President of the American Iron and Steel Institute emphasised, in this respect, that "the aim is not to form a

(214) Metal Bulletin; 2 August 1977 (Interview with Mr. Inayama, President of the Japan Iron and Steel Federation).

(215) Statement, on 20 September 1977, by Mr. Robert Strauss.

(216) Cf. Solomon report of 7 December 1977.

(217) An ad hoc working group was established by the Secretary General of OECD in the middle of 1977. This established an information system to follow up the situation closely.

(218) The creation of a steel committee was under discussion during the summer of 1978. It was to establish "a continuous forum" to facilitate consultation between parties interested.

The working group considered that priority attention should be given to the long term necessity for restructuring and modernisation. It recognised that rationalisation of the national iron and steel industries would be a difficult and sometimes painful process ..... This rationalisation should be carried out under conditions of the free and honest flow of international trading. No solution regarding the fundamental problems of the steel industries could be found with quantitative restrictions. In addition the group hopes that a warning system to identify problems would facilitate rational investment decisions in the future by way of increasing the transparency of the world industry (OECD Press release of 30 November 1977 and Steel Committee of the Economic Commission for Europe - Steel R/31/Add.2, 14 August 1978).

global steel cartel as some people fear, ... the time is ripe for steel sectorial talks, since all other major steel-producing and steel-consuming nations are at least as concerned about the steel situation as we are .... the long term solution to global steel industry problems lies in multilateral negotiation, leading to an international steel agreement amongst the governments of the steel-producing nations"[219].

223. A more or less extended process of moving towards world negotiation in the iron and steel industry is therefore taking place. It is important that this negotiation, born of the crisis, should achieve full significance by integrating the objectives defined at Lima. It is important that, in the new definition and readjustment of the world iron and steel industry, the interests of the developing countries should be put forward.

B. TOWARDS A MAJOR NEGOTIATION ?

224. If we retain this perspective it is not without interest to collect together the materials which are capable of forming a preparatory dossier for possible world iron and steel negotiation. The expression "world" and not "international" is deliberately being used. Economic imperatives are today on a world and not only on an international basis[220]. The debate is no longer limited to the market economy industrial countries. Two realities must be faced up to:

- The Soviet Union has now a strong position as iron and steel producer; the Soviet Union and the socialist countries of Europe today constitute a major component of the world iron and steel industry, both as producers and also as actual and potential suppliers of techniques and equipment;
- the developing countries are today participating up to a level of about 10% of the world production of steel; a movement has begun, and everybody now agrees that it will not be possible to reverse this.

The dimension of the regulation of the iron and steel market can only be, at this end of the century, on a world basis.

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(219) Statement by Mr. Lewis W. Foy, American Iron and Steel Institute, Press release 20 June 1978.

(220) See analysis by Prof. A. Cotta. France and world imperatives, 1978.

225. Other realities must also be considered: the role of the State in national iron and steel industries, the development of contractual forms of industrial arrangements, the indissociability of the components for negotiations. These are matters of underlying trends which any prospective essay must consider. They are the first elements which the International Centre for Industrial Studies hopes to provide for the negotiation dossier.

1. The role of the State

226. The actors and their respective strategies have been briefly described in Chapter I. This analysis would not be complete if it did not regard the State as being the essential agent in regulating the national iron and steel industries.

- The State has always played an exclusive role in the iron and steel industries of the centrally planned economy countries;
- The State plays, either directly by nationalisation or indirectly by the supply of credits and guarantees, an increasing role in the market economy developed countries, particularly in Europe;
- finally the State is the major initiator and promotor of the iron and steel industry in all the developing countries.

The table on the following page shows the increasing role of the State in those countries where private companies are tending to become minority shareholders, involved only in the form of a joint venture with a State company or organisation.

It is clear, under these conditions, that any discussion, or even more so, any negotiation on the iron and steel industry, involves the responsibility of States.

Table 14

Percentage of the production capacity of the iron and steel industry controlled by the State or by the public sector in various countries

Developing countries	1975 capacity	Forecast capacity for 1985-1988
Latin America		
- Argentine	70	80
- Brazil	60	80
- Chile	100	100
- Mexico	50	65
- Peru	100	100
- Venezuela	86	90
Asia		
- India	65	75
- Iran	100	100
- Republic of Korea	100	100
- Saudi Arabia	-	100
Africa		
- Libya	-	100
- Tunisia	100	100
- Algeria	100	100
- Morocco	-	100
Europe		
- Spain	51	65
- Turkey	90	90

Sources: Various issues of Metal Bulletin; Iron and Steel International, Stahl and Eisen, Siderurgia Latino-Americana.

2. DEVELOPMENTS IN THE CONTRACTUAL FORMS FOR INDUSTRIAL ARRANGEMENTS

227. A general trend can be seen in all industrial sectors, not only in the iron and steel sector, involving the adaptation of contractual forms towards a "packet" of services, and the appearance of new forms of equilibrium in these services and counterparts in industrial negotiations.

228. Sales of complex assemblies of machinery and equipment (industrial assemblies) are tending to develop much more rapidly than unit sales of these same types of goods. It is rare for the supply of industrial equipment not to be organised around the sale of a licence, the implementation of which calls for the supply of documentation, know-how, if necessary extended by a technical assistance service. It has also become normal for the training of the client's personnel to be provided for contractually. In this way one enters into a field of organisation and management, of circuits from supplies to the marketing of the product. From a simple sales contract one has arrived, in a few years, at formulae for turnkey contracts(221) and then "product available"(222) or "market available" contracts, and passing through a series of intermediate formulae. This development in agreements indicates that the strictly technical aspect, linked with the machinery, equipment and processes, forms only part of the package. The increasing complexity of contractual forms corresponds to the successive taking into account of numerous components of the industry including training, organisation and management, financing, trading, etc.

(221) This involves the supply of an industrial assembly, comprising design, study, construction and delivery in operating order, of all the works and equipment for a contractual total price and under fixed production conditions.

(222) Unlike what is involved in the turnkey contract the contracting company assumes technical responsibility, in the "product available" contract, up to the time when local technicians, trained by him, are able to take over all the production operations.

229. The development of compensation agreements introduced into contractual relationships a new and important element where the sale of industrial units does not simply give rise to a financial flow but to a flow of goods, directly or indirectly linked with the new unit. These new methods, involving "buy-back" or "self-supporting" agreements, mark the passage from the sale of industrial units to more complex relationships involving the establishment of trading, capable of resulting in new distributions of activities and cooperative actions.

230. The organisations involved in the development and realisation of these new contractual relationships have had to adapt their structures to this development. Purely technical engineering companies, or purely trading companies, have tended to acquire, at an international level, the capacity for mobilisation and organisation of these factors.

231. This general development illuminates the context within which is located discussion and negotiation on the world iron and steel industry: it is a globalising context, the components of which cannot be dissociated.

3. INDISSOCIABILITY OF THE COMPONENTS OF NEGOTIATION

232. Until now the field of trading has been the exclusive object of negotiations. The first measures taken throughout the world as a result of the crisis in the world iron and steel industry were in this field, where at the beginning only the more acute aspect was perceived, giving rise to agreements on limitations of exports, systems for protecting national markets, either American or European, and the American "trigger prices" system or the European "floor price" system.

233. This view, and this practice, do not today meet the need for regulating the world iron and steel industry. This is undoubtedly why, in the market economy developed countries, there has been a tendency to disengage the discussion on the future of the industry from the exclusive framework of tarrifs and negotiations within a framework which is no longer limited solely to trading.

234. One cannot discuss trading in iron and steel products without also becoming interested in a series of other aspects of this industry, since trading precedes the installation of production, whether old, new or projected; actors have different means and resources, and States have different strategies.

Natural resources and those of financing and of science and technology are variously distributed, and give rise to multiple combinations. International trading is basically only an effect or a reflection of the force relationships which are changing. The link between these factors is so direct that it is no longer possible to treat them separately. Negotiation necessarily has a global and more complex character.

4. AVAILABILITIES OF FACTORS AND PARTNERS

235. The partners have different, and unequal, trump cards. These factors, although changing, are relatively stable. Their analysis forms an integral part of the factors of a negotiation.

The UNIDO report on the world iron and steel industry placed the emphasis on the geographical distribution of the main resources as being essential factors in the production of steel and for the future development of the industry[(223)].

This involved firstly iron and manganese ores and secondly coking coal, natural gas, oil and potential hydroelectric and timber esources.

236. These factors are not the only ones to be considered. Other factors emerge in the modern iron and steel industry, for example:

Factors relative to the construction and operation of the iron and steel industry.

- Capacity for the production of equipment goods for the iron and steel industry;
- Capacity for iron and steel engineering;
- Capacity in respect of technical know-how;
- Research and development capacity;
- Innovatory capacity in respect of scaling-up, scaling-down and direct reduction.

Factors relative to organisation and management: (management, training)

Factors relative to financial aspects

Factors relative to the market:

- Dynamic domestic market;
- Export market.

(223) UNIDO/ICIS, op. cit. p. 176, pages 176 to 197.

237. The selection of factors is not as neutral an exercise as it may appear a priori.

The use which one makes of these factors is sometimes directed by hypotheses which are not in general formulated:

If we consider, for example, that resources (ores and reducing agents) are the determinant factors of the future development of the iron and steel industries; that a minimum size of market is the first condition for envisaging the creation of an iron and steel unit, then these are a representation of a predetermined development of the iron and steel industry. Reciprocally the exclusion of other factors is therefore an implicit rejection of other possible developments.

238. As a function of the preceding analyses it has been necessary to revise a summary list of the factors listed above; from this point of view the situation of some representative countries belonging to various groups has been examined. Table 15 summarises the results.

239. A rapid glance at Table 15 shows that the availability of iron ore and sources of energy are certainly an important factor, but this does not constitute the determinant factor for the development of the iron and steel industry. Neither Japan, the Republic of Korea nor Taiwan have major resources of iron ore, coking coal or hydrocarbons. These countries have however built, or are in the process of building, iron and steel industries which are amongst the most dynamic.

240. Financing also seems to be a factor which seriously holds back the growth of the iron and steel industry in India, in Brazil and in all the developing countries which are not oil producers; questions must however be asked in regard to its determinant character, since the absence of easy domestic financing does not seem to have held back the growth of the Korean and Taiwan iron and steel industries whereas, on the other hand, the abundance of financial resources in the oil producing countries does not seem to have been automatically translated into a rapid development of the iron and steel industry.

Table 15

Availabilities of factors in iron and steel partners

	Iron ore	Coking coal	Natural gas (or low grade coal)	Engineering, Equipment goods	R and D in general	R and D in Direct Reduction	Innovatory capacity Scaling -up	Innovatory capacity Scaling -down	Manage-ment	Financing	Domestic market	Export capability
USSR	XX	XX	XX	XX	XX	0	XX	0	x	x	XX	x
EEC	(x)	x	(x)	XX	XX	XX	XX	XX	XX	XX	XX	x
USA	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
Canada	XX	XX	XX	(x)	(x)	0	0	0	x	(x)	(x)	x
Australia	XX	XX	XX	x	x	0	0	0	x	(x)	(x)	x
Japan	0	0	0	XX	XX	XX	XX	XX	XX	XX	XX	x
China, People's Rep.	XX	XX	XX	x	x	0	0	x	(x)	(x)	XX	(x)
India	XX	XX	x	x	(x)	(x)	0	0	(x)	0	x	(x)
Korea, Rep. of	0	0	0	x	(x)	0	0	0	XX	0	XX	x
Brazil	XX	(x)	(x)	x	(x)	0	0	0	(x)	0	x	x
Oil producing countries	0	0	XX	0	0	0	0	0	0	XX	x	x
Non oil producing developed countries	(x)	0	0	0	0	0	0	0	0	0	0	0

XX = well supplied, or very considerable impact
x = well supplied, or strong impact
(x) = small supply, or weak impact
0 = major constraint

241. One sees, on the other hand, that the availability of technico-economic factors (or their rapid potential growth) is very strongly linked to all developments of the iron and steel industry. Whilst the oil producing countries have natural gas, it is the United States, Europe and Japan which control the direct reduction processes which use natural gas; this power is based on their capacity for innovation, which itself cannot be separated from the group consisting of R and D, equipment goods, engineering capabilities, etc.

242. The table also indicates that the domestic market or, more precisely, the dynamic link between the domestic market and the iron and steel industry, is probably a more promising factor than export capability which often seems to be rather hazardous.

One can also see how certain factors combine according to the links which structure the iron and steel industry. These links become modified with time; during a large part of the nineteenth century it was true that the "resources" factors were determinant; the iron and steel industries therefore developed in the immediate proximity of iron ore mines and sources of energy (forests and charcoal, then coking coal). At this time resources formed a decisive factor of prime importance: those countries which lacked them were practically excluded from the iron and steel industry. Then there was the development of transport, railways, bulk ore carriers, which relativised the importance of this resource factor: this allowed Italy, Japan and then Korea and Taiwan to build powerful iron and steel industries.

243. It would be interesting to interpret, within this historical perspective, the development noted between the announcement of the major movement of relocation in 1974 and the return movement of 1977.

The redeployment movement favoured, in fact, the classical factors which explained the localization of the iron and steel industry (the "resources", the increase in price of raw materials and energy, the market, the financing). The surging back movement which was started places emphasis,on the contrary, on the other factors which characterise modern steel making: research and development and innovation capacity.

244. The changes are rapid; they delineate the lines of force which are constantly being modified, and it is important to evaluate these permanently, inasfar as they constitute the framework of any negotiation.

C. THE NEW TASKS FOR UNIDO

245. To define the objectives. Global **consultation** on the world iron and steel industry implies clear definition of the objectives which are being pursued. The development of the sector during recent years has resulted - and this is the interpretation of this document - in a re-evaluation of the whole which, in its turn, cannot fail to influence the reformulation of the objectives.

246. Within this new context organisation of the iron and steel sector on a world scale could constitute the first objective, the term "organisation" being interpreted in the sense of systems analysis, that is to say as a combination of information and as regulation. Regulation does not, however, mean having recourse to a "steel cartel", since it will be designed to be implemented under conditions of market competition.

247. To achieve or exceed the target of 25% of the world production of the iron and steel industry in the year 2000 in the developing countries could constitute the second objective, within the framework of an organisation of the sector on a world scale.

248. The re-evaluation of perspectives, which requires considerable methodological work, will therefore be carried out by envisaging a normative scenario derived from the Lima declaration.

To elaborate the routes and resources. The routes and resources of a global negotiation are very complex: they assume both reflection and precise elaboration. No procedure is imposed on this, since there are probably numerous alternative routes: one of these could be explored in the following direction:
1) Within the framework of an analysis of the iron and steel industry as a system: the list of variables (see Table 16 which gives a preliminary list of the essential variables) will be revised and corrected by the experts, then the analysis of the linkages between these variables will be carried out in depth. 2) Systematic information on the projects and the strategies of the actors will be organised, and information collected corresponding to the

TABLE 16

ESSENTIAL VARIABLES OF THE IRON AND STEEL "SYSTEM"

W	Rate of growth of the demand in the future
P_n	Projects for iron and steel investments throughout the world
F	Financing the investments
	f : financing costs
	v : minority shareholdings in the capital
	v' : majority shareholdings in the capital
T	Technology
	O : ownership of processes
	L : licencing
	E : engineering
	I : technico-economico-commercial information
	M : management
	N : know-how
Q	Equipment goods
R	Research and development
S	Production scales
	S^u : scaling-up innovation
	S^d : scaling-down innovation
D	New technological routes
H	Differentiation of iron and steel production
	H_l : long products
	H_f : flat products
	H_s : special steels
X_o	Price of iron and steel outputs
	X_{otr} : transport costs
X_i	Price of iron and steel inputs
	X_{iq} : price of equipment
	X_{is} : price of scrap iron
	$X_{i\beta}$: price of energy
Y	Sensitivity to imports of iron and steel products
	Y_f : substitution of foreign imports for domestic production
	Y_n : substitution of national products for imports
Z	Exports of iron and steel products
	Z_a : exports "in all directions"
	Z_t : exports to third party space
	Z_c : compensatory exports
K	Supplies to the domestic iron and steel market
	K_n : potentiality of the national market
J	Royalties
α	Iron ore working
	α_m : manganese ore working
β	Exploitation of energy
	β_G : exploitation of natural gas
γ	Coking coal working
	γ_o : exploitation of other reducing agents
ϕ	Preservation of the environment

principal variables which were selected. 3) The long term prospective, in the form not of a single future but of possible futures, would then be described, taking into account:

a) a methodological revision of forecasting the demand, in particular in the least developed countries,
b) the technological trends,
c) the projects of the actors.

4 - The configuration of possible cooperations and conflicts would then be derived from this prospective view, the space for cooperation being limited by the space of conflicts.

Analysis of the linkages and interdependences of the sub-assemblies would then make it possible to delimit the zones of conflicts, to examine possible methods, and to reduce them.

Analysis of the combinations of the practicable industrial arrangements would then make it possible to identify, with greater realism, the components of possible cooperations.

The establishment of an operational method would undoubtedly necessitate successive tests and constant iteration between the analysis of concrete cases and their interpretation.

If it is found to be possible to develop this instrument for action effectively it could be used at two levels : within a world analysis by groups of countries having structures and/or iron and steel strategies which were similar or compatible, and also in bilateral relationships between companies and countries.

5 - The explicit acknowledgement of conflicts and cooperations, and the various futures which can be envisaged within a long term prospective view, would make it possible to establish alternative scenarios which would be put forward for selection by the international community. The chosen scenario could be, for example, a scenario intermediate between the most probable scenario and a normative scenario inspired by the Lima Declaration.

The conditions for realisation of this reference scenario would then be analysed and submitted for discussion by the international community. They would include the whole of the Plan of action concerning the regulation of production and trading, of transfers of various natures and the financing of operations, together with a programme for progressive development of the iron and steel industry in the developing countries.

Even if it is unlikely that such a plan could have any imperative value one may nevertheless feel that it would play an indicative and orientating rôle in bilateral negotiations.

249. Obviously other routes may be envisaged, but irrespective of the modes of the mechanism certain tasks remain necessary. One cannot in practice advance concretely towards forms of regulation of the iron and steel industry unless, firstly, the systematic understanding of the sector progresses and, secondly, unless information on the projects of the partners is organised. Cooperation implies, in effect, informed partners; it must be pointed out that, despite the power and quality of national and international iron and steel institutes, the information gaps remain very large.

The absence of centralised information on investment projects has also been pointed out, but these gaps involve also the understanding of the structures whilst, surprising as it may appear, there do not seem to exist any available studies on a particularly important subject, since it is one which touches on central aspect of the structure of the iron and steel industry - namely the problems of links and integrations between the capital goods industry supplying the iron and steel industry and the iron and steel industry itself.

250. An initial identification of the variables in the sector leads, therefore, to a first inventory of the information to be assembled and the studies to be carried out in order to improve long term forecasting, and also to prepare for a global negotiation on the structures of the industry. This inventory is set out below.

251. UNIDO cannot claim to be able to carry out these tasks by itself, but certainly it has a role to play: in the field of information and studies, in the field of consultations and of exchange of opinions, and without forgetting the role which it plays as an international forum, revealing the strategies and scenarios which arise.

The re-evaluation of the situation and of the problems of the iron and steel industry which is set out in this document therefore leads to putting forward, in a new light, the tasks of UNIDO in respect of information and studies.

252. In the field of information, and in accordance with its mandates, UNIDO will establish a technological information bank in which information for the iron and steel industry is one of the components [224]. The first realisations of this have already appeared [225]; others will follow.

The utility of the "Questions and answers" services is ongoing. Re-evaluation of the problems posed by the creation (strategies of entry) and progress of the iron and steel industry in the developing countries leads to envisaging other "styles" of information within the framework of the activities of this technological information bank.

Those developing countries which already have an iron and steel industry need information which is capable of increasing their productivity and improving their performance. This is "tactical" information. Those developing countries which propose to enter the iron and steel field need another type of information. They must select the technological route and opt for a development and financing strategy: this therefore necessitates "strategic" information, the collection and dissemination of which necessitates the implementation of a specific structure organised around the technological routes and processes. Within this framework information on the direct reduction routes should include all the technical, economic and commercial elements, making it possible to facilitate the choices made by the national decision-makers. The information should therefore be structured as a function of the process of policy making [226]. The appended diagram summarises the principal technological routes which are used at the present time, those which offer potentialities of development, and those in which development is envisaged in the future [227].

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(224) See "Establishment of an industrial and technological information Bank", report by the Executive Director of UNIDO ID/B/183, 12 April 1977.

(225) Technological profiles on the Iron and Steel Industry by G.P. Mathur, UNIDO/IOD.191 - 14 June 1978

(226) The Iron and Steel Industry in Developing Countries, an overview for the decision-maker with emphasis on technological choices and facility planning - a report to the International Centre for Industrial Studies, Industrial Information Bank Project (INTIB), March 1978, by Michel R. Mounier, consultant.

(227) R.W. Ayres, op. cit.

Technological route by technological route, stage by stage, and within each of these, it would be of value to organise information on the technological alternatives, specifying the economico-commercial characteristics of each of these alternative routes. The "style" of the information required is no longer therefore the "passive" style of the "Questions and answers" services, which waits for the questions before providing the answer, but an "active" style, going forward to meet the needs of the decision-makers in the developing countries.

253. In the field of integrating studies and information

The constitution of information and studies forms a couple. The conclusions of the studies orientate the search for information, whilst at the same time the information feeds the studies. It is therefore necessary to advance this double process along an integrated line.

Selection of the essential variables in the iron and steel "system" makes it possible to draw up an initial inventory of the information and studies required (see Annex II).

254. Carrying out a programme of study and research centred on the analysis of structures and agents in the iron and steel industry requires extensive international collaboration.

Whilst the understanding of trading flows is generally good the same does not apply to the structures, the actors and their strategies. In the field of understanding the technico-economic realities of the iron and steel industry the ECE has made considerable work over more than 20 years, and the study of structural changes is one of its tasks(228). It is the same for the establishment of long-term prospects for the industry(229).

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(228) See the work "Structural changes in the iron and steel industry".

(229) Work Programme for 1979-1983, ECE/STEEL/R.33, 26 July 1978.

The programme proposed above is supplementary, and envisages other aspects relative to the understanding of the structures and projects on a world basis. These programmes could therefore be easily coordinated.

Other specific liaisons will need to be organised with other organs of the United Nations, UNCTAD, the ITO and the United Nations Programme for the Environment and also, in addition to these, with the new specialised committee of OECD, the departments of the European Economic Community and other regional and national organisations.

Within the framework of a working programme, if not integrated at least coordinated, the community of international institutions could operate a division of labour and usefully contribute towards preparing for the regulation of the world iron and steel industry, for negotiation and for cooperation in the future.

ANNEX I

AN EXAMPLE OF NEGOTIATION IN THE NEW CONTEXT

1. Interdependence of the factors is detectable through the analysis of agreements which have effectively been concluded, and this makes it possible to clarify, on the concrete bases provided by the stages of the negotiations and also through the final compromise, the scope and limits of the activities which every negotiation implies.

2. The example examined here comes from Brazil where SIDERBRAS has signed with the Japanese KAWASAKI STEEL company and the Italian FINSIDER company an agreement for the construction of an integrated iron and steel unit with a capacity of three million tonnes per year at Tubarão[1].

3. The Tubarão project was launched in the euphoria of 1974, on the joint initiative of Siderbras, Kawasaki Steel and Finsider. The two latter companies were very interested in the supply of semi-products, which they undertook to buy back at a proportion equivalent to their shareholding, that is to say up to 49% (24.5% each). The crisis made this project, like many others, lose much of the value which it represented for the two foreign companies. Siderbras, which counted on this new production capacity, was however forced to keep the project alive and to continue negotiations until the agreement was signed in July 1978.

4. The agreement which was signed is a compromise. Kawasaki Steel and Finsider were no longer interested in buying back semi-products; each of them finally agreed to buy back 10% of the production. As a counterpart Siderbras asked its partners (in fact Kawasaki) to finance the project beyond the total of their shareholding in the capital: 700 million dollars were advanced by Kawasaki. This loan was only agreed finally on the basis of a compromise: the equipment provided by the foreign partners would represent not 49% but 66% of the total equipment, although the Brazilian industry was able to supply 51% or even more.

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(1) _Financial Times_ of 18 July 1978

It may be assumed that the continued interest of Kawasaki and Finsider in this project could not be dissociated from the importance of Brazil as a source of supply for iron ore, and as a major market with a considerable future. Finally it will be noted that Siderbras and Finsider are companies in which the State holds a majority shareholding, and that the undertaking of Kawasaki, a private company, could not be achieved without locating itself firmly in the official line of Japanese iron and steel policy. In this way the role of the state partner in the centre of such a complex negotiation is clearly confirmed.

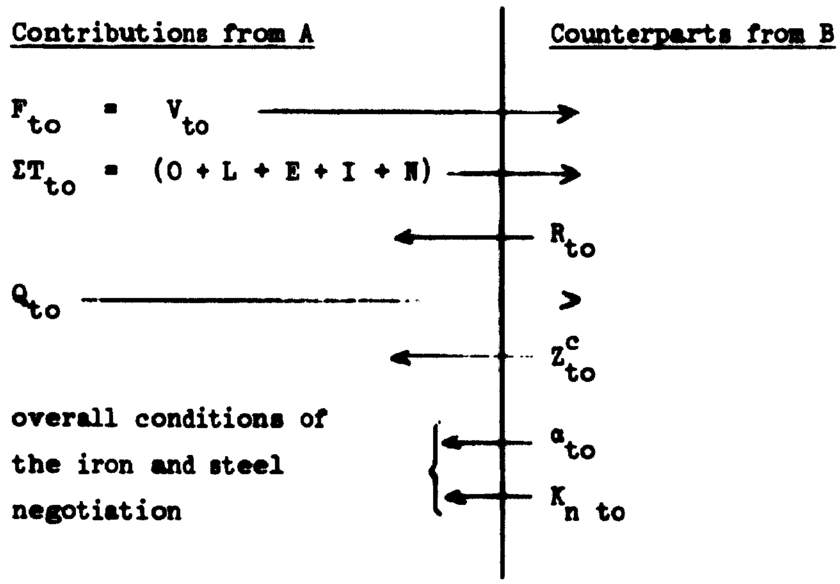
5. Provided that the published information faithfully reflects the strategies of the actors concerned one may attempt to formalise the sequence of the negotiations and the final agreement in the way shown on the following pages :

Annex I

<u>INITIAL PROJECT</u> (P_{to}) : balancing of contributions and counterparts -

partners A : Kawasaki (Japan), Finsider (Italy)

partner B : Siderbras (Brazil)



where :

- F_{to} = financing of the initial project P_{to}
- V = minority shareholding in the capital
- ΣT = technological contribution (total)
- O = ownership of the technological processes[2]
- L = licensing
- E = engineering
- I = technological and economic information
- N = know-how
- R = royalties
- Q = equipment goods
- Z^c = compensatory exports of iron and steel semi-products
- α = supplies of iron ore
- K_n = potential of the Brazilian market

6. The balancing equation for the initial project (P_{to}), showing the contributions and counterparts, may therefore be written as follows :

$$V_{to} + \Sigma T_{to} + Q_{to} = Z^c_{to} + R_{to} + \alpha_{to} + K_{n\ to}$$

(2) Insofar as these processes are patented.

Annex I

<u>FINAL PROJECT</u> (P_{t1}) : re-balancing of contributions and counterparts -

Contributions from A		Counterparts from B
- reduced interest in the importing of semi-products Z^c_{to}	------→	Z^c_{t1} where $Z^c_{t1} < Z^c_{to}$
- confirmation of V ($V_{t1} = V_{to}$)	←------	request for compensatory financing F_{t1} where $F_{t1} > F_{to}$
additional financing costs f_{t1} $V_{t1} + f_{t1} = F_{t1} > F_{to}$ ↓ requirement of increased supply of equipment goods :		
$Q_{t1} > Q_{to}$	------→	acceptance of Q_{t1}
$R_{t1} = R_{to}$ (1)	←------	royalties (3)
$\alpha_{t1} = \alpha_{to}$ (1)	←------	supplies of ore (3)
$K_{nt1} = K_{nto}$ (1)	←------	potential of deomestic market

7. The balancing equation for the final project (P_{t1}) may therefore be written as follows :

$$f_{t1} + V_{t1} + T_{t1} + Q_{t1} = Z^c_{t1} + R_{t1} + \alpha_{t1} + K_{nt1}$$

8. This formalisation is undoubtedly a simplification of a more complex reality. It would be possible to produce a model of the structure of the iron and steel industries and the interrelations of the actors, provided that sufficient information was available. It does however suggest a way of identifying the main lines of an overall negotiation in the iron and steel industry (4).

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(3) Situation unchanged, on the basis of the available information.

(4) Other formalisations are possible, particularly by the applications of games theory. Interested readers may refer to recent work on the application of games theory to international negotiations: J.V. Gillespie, D.A. Zinnes and G.S. Tahim "Embedded Game Analysis of a Problem in international relations" in Transactions on systems, man and cybernetics. Institute of Electrical and Electronics Engineers, August 1978, and P. Terrence Hopmann "Asymmetrical bargaining in the Conference on security and cooperation in Europe" in the special issue of "International Organization" on "Dependence and dependency in the global system", Winter 1978.

ANNEX II

AN INITIAL INVENTORY OF THE INFORMATION AND STUDIES NEEDED

- Variable W : Rate of growth of the demand in the future.

  a) List of variables in the iron and steel system;

  b) Cross matrix analysis of the essential variables;

  c) Identification of the motor and passive variables;

  d) Hypotheses on the devslopment of the essential variables;

  e) Analysis of the coefficients of elasticity of demand in the least developed countries;

  f) Prospsctive study of the development of the coefficients of elasticity of demand in countries having reached an apparent saturation of demand;

  g) New methodology of projections incorporating other variables and coefficients of elasticity by development thresholds.

- Variable P_n : Projects for iron and steel investments throughout the world.

  a) Centralisation of available information at UNIDO

  b) Organisation of periodical "surveys" based on the essential variables of the system;

  c) Analysis of the information : detection of the strategies of the actors and compatibilities and incompatibilities of the projects between themselves.

- Variable F : Financing the investments

    a) Constitution of basic information on methods of financing the iron and steel industry : relative importance of local, bilateral and multilateral financing;

    b) Analysis of the links or independence between new financing and shareholdings;

    c) Possible links between financing and compensation agreements.

- Variable T : Technology

    - O : Ownership of the processes

        a) Listing of processes by technological routes;

        b) Identification of the owners of the processes.

    - L : Licencing :

        a) Identification of licences granted by processes;

        b) Information on the commercial conditions for granting licences.

    - E : Engineering

        a) Identification of the principal engineering companies offering services to the iron and steel industry;

        b) Identification of agreements or links between the owners of technological processes and engineering companies;

        c) Ditto, with manufacturers of equipment for the iron and steel industry;

        d) Basic curriculum for training in engineering;

        e) Identification of existing opportunities in the industrialised countries for training engineering technicians from the developing countries;

        f) Analysis of a strategy of progressive development of iron and steel engineering on the basis of experience in countries such as India, Brazil, Argentine and South Korea.

    - I : Technico-economico-commercial Information : see paragraph 252

    - M : Management :

        a) Summarising work, in the iron and steel industry, on the correspondence relationships which are necessary between production and management systems.

b) analysis of the repercussions on management of the "scaling-down innovation" trend and of "mini-mills";

c) identification of the possibilities of training in management in existing small installations.

- N : Know-how :

a) analysis of the results of training action, explanation of the difficulties observed in practice;

b) analysis of the self-regulating margins of production tasks by workers in the iron and steel industry;

c) inventory of companies specialising in training, and the methods used;

d) study of the repercussions on the orientation of training of the new technological routes.

- Variable Q : Equipment goods

a) analysis of the structures of the industry offering equipment goods for the iron and steel industry, location and integration of production and trading[(1)],

b) analysis of sub-groups by technological routes and levels of complexity[(1)],

c) analysis of goods capable of being manufactured in certain developing countries[(1)],

- Variable R : Research and development

a) inventory of research work being carried out in the world;

b) analysis of innovations external to the iron and steel industry but capable of being transferred to it;

c) establishment of a programme of specific research work on the requirements of the developing countries.

- Variable S : Production scales

- S^u: Scaling-up innovation :

a) study of cost and social benefits in economies and scale economies.

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(1) The study of capital goods for the iron and steel industry comes within the terms of reference of the study on the capital goods sector which at the present time is being produced by the International Centre for Industrial Studies.

b) prospects for the trend

- S^d: Scaling-down innovation

  a) study of present potentialities, monographs on realisations;

  b) prospects.

- Variable D : New technological routes

  a) listing of research and development problems in the developing countries linked to the application of direct reduction processes;

  b) prospects for other routes.

- Variable H : Differentiation of iron and steel production : H_l = long products, H_f = flat products, H_s = special and alloy steels.

  a) study of the technological levels and complexity and difficulty of production within the groups of products;

  b) table of the technical and management conditions making it possible for developing countries to enter into these activities;

  c) analysis of the possibilities of reducing the number of grades and the quality of the products as a function of the real needs of the industry in the developing countries, according to the stages of growth of their economy.

- Variable X_o : price of iron and steel outputs

  a) establishment of a long chronological series of prices in order to evaluate the development of profitability in the iron and steel industry;

  b) analysis of the repercussion of transport prices on the relocation and redeployment of the iron and steel industry.

- Variable X_i : price of iron and steel inputs

- X_{iq} : price of equipment :

  a) constitution of basic information on the price of iron and steel equipment;

  b) constitution of a specific price index.

- X_{is} : price of scrap iron

  a) analysis of the repercussions of the price of scrap iron on new technological routes, and in particular on direct reduction;

  b) development prospects.

- X_{ib} : price of energy

  a) hypotheses on changes in the price of energy;

  b) repercussions on the cost structure of the iron and steel industry.

- Variable Y : sensitivity to imports of iron and steel products

  - Y_f : substitution of foreign imports for domestic production

    a) classification of countries according to the sensitivities observed;

    b) development prospects.

  - Y_n : substitution of national products for imports

    a) analysis of the substitutions observed;

    b) prospects.

- Variable Z : exports of iron and steel products

  - Z_a : exports "in all directions"

    a) identification of countries practising this strategy;

    b) examination of investment projects (see variable P_n);

    c) identification of intersections in export spaces.

  - Z_t : export to third party space

    a) examination of agreements for industrial arrangements;

    b) identification of the countries and/or companies practising this strategy.

  - Z_c : compensatory export

    a) examination of industrial arrangements;

    b) analysis of compensation in iron and steel products.

- Variable K : supplies to the domestic iron and steel market

  a) examination of investment projects (see P_n);

  b) identification of "self-sufficiency" projects;

  c) consequences of the latter on international trading.

- Variable J : Royalties

    information on royalty payments

- Variable α : Iron ore working

    a) information on long term agreements for iron ore supplies
    b) analysis of the "free" market;
    c) information on the development of costs of working new mines

    α_m : Manganese ore working

    a) information on projects for exploiting sea-floor nodules;
    b) study of the long term repercussions on international trading in manganese and the function of certain developing countries.

- Variable β : Exploitation of energy

    a) balance sheet of energy consumption by the iron and steel industry
    b) sources of energy economies
    c) repercussions of new energy policies on the consumption of iron and steel products;
    d) analysis of the consumption of energy by technological routes;
    e) establishment of prospective balance sheets for the consumption of energy in the sector (related to W and P_n)

- Variable γ : Coking coal working

    a) listing of long term supply agreements
    b) analysis of the "free" market
    c) study of the repercussions of the development of the use of direct reduction processes on coking coal requirements

    γ_o : Exploitation of other reducing agents

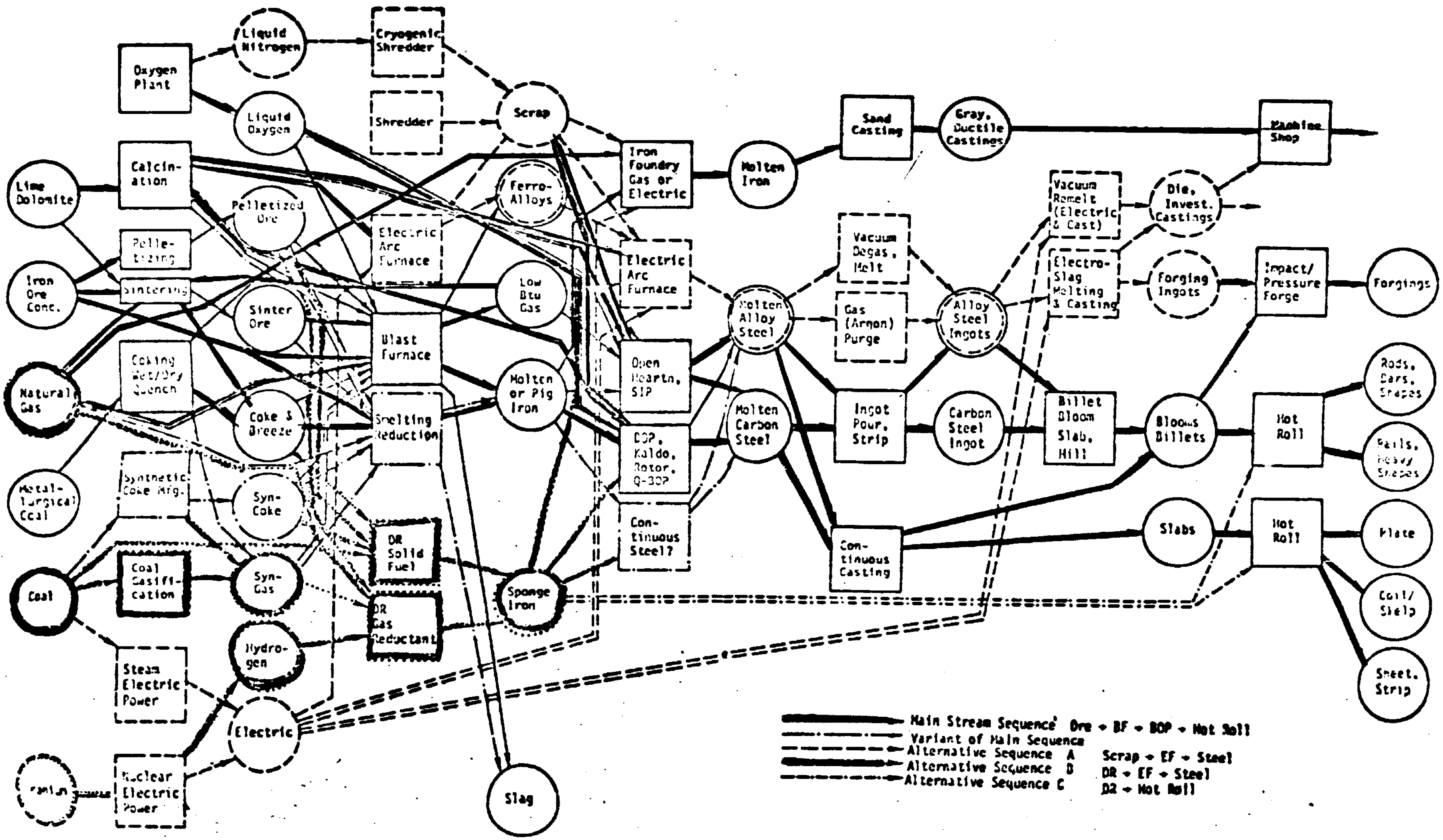
    a) analysis of the state of the question;
    b) prospects.

- Variable ϕ : Preservation of the environment

    a) ranking of technological routes from the point of view of their effects on the environment
    b) taking this variable into account in the alternative scenarios for the development of the world iron and steel industry

ANNEX III

MATERIALS-PROCESS FLOWS IN IRON & STEEL INDUSTRIES



ANNEX IV

ELEMENTS FOR THE FORECAST OF ENERGY REQUIREMENTS AND ENERGY POLICY IN THE IRON AND STEEL INDUSTRY

SUMMARY AND CONCLUSIONS

1. The iron and steel industry is the largest industrial user of energy (545 million tons of coal-equivalent or about 7 per cent of total world energy consumption in 1973). In some developed countries this industry is the largest energy consumer in the economy. For example, in Japan the iron and steel industry accounts for about 20 per cent of total energy consumption.

2. Developing countries* in 1973 consumed 35 million tce or 4.9% of total energy consumption.

3. The requirements for coking coal have reached large volumes (470 million tons in 1973). This is creating certain problem for developing countries which consumed about 30 million tons in 1973. It should be noted that developing countries account for about 5% of the total world coking coal reserves.

4. The cost of coking coal consumed in the world's iron and steel industry is estimated at about 19 billion dollars or about 38 per cent of the total worth of raw materials used in metallurgical plants in the world.

5. The main consumers of primary energy are the blast furnaces or iron-making (about 50-65 per cent), steel-making (about 10 per cent), rolling mills and other operations (30-40%).

6. The total energy consumption for production of one ton of steel in the world in the period 1960-1973 has been diminishing gradually from more than 1,200 kgce to 840 kgce. For example, in the U.S.A. the specific energy consumption descreased in this period from 1,018 kgce to 866 kgce, in Belgium from 995 kgce to 758 kgce, in Japan from 700 kgce to 597 kgce and in the United Kingdom from 1,120 kgce to 867 kgce.

7. There is a steady trend of reduction in the use of coke in iron-making. The coke consumption diminished in 1960-1973 in the U.S.A. from 770 kg to

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*Excluding China

502 kg, in The Federal Republic of Germany from 834 kg to 495 kg, in the U.K. from 825 kg to 575 kg, in Japan from 619 kg to 435 kg, in France from 972 kg to 560 kg, etc.

8. Contrary to the reduction of the coke rate, no appreciable decrease could be observed in overall energy consumption in iron-making in most developed countries. The reason for this phenomenon is the diminishing of volume of blast furnace gas produced in modern blast furnaces in comparison with old furnaces which consumed more coke but produced more gas. In energy cost, however, the saving is considerable for modern blast furnaces which consume much less coke than old furnaces under the economic conditions prevailing in most countries.

9. Parallel with the development of the metallurgical processes, there were substantial changes in the fuel-sheet of energy consumption. in the iron and steel industry. During 1960-1973, the share of solid fuel (coal, coke) sharply decreased in all steel-producing countries and the share of hydrocarbons (oil, natural gas) and electricity rapidly increased.

10. The modern electric arc furnaces using 100% steel scrap gives the lowest energy consumption figure (458 kgce per one ton of liquid steel) followed by the BF-BOF route (594-749 kgce), while the electric arc furnaces using direct reduced material show one of the highest energy-consumption figures, as was expected (724 kgce). The highest energy consumption (834 kgce) and the lowest efficiency (30.8 per cent) is in the case when oil and reformed natural gas are injected. However, if secondary energy sources are taken into account, the figures show that energy is used most efficiently in the conventional steel-making method (blast furnace process-oxygen convertors: 50.4-55.8 per cent). Open hearth furnaces consume more energy for the production of one ton of

steel than BOF and BF. However, the BOF requires substantially more hot metal (less scrap) than the open hearth. When the energy of the hot metal is considered, it is found that in total the BOF takes about 14.4 kgce more per ton of steel than does the open hearth.

11. Three major trends are expected to be followed in blast furnace operations in the next three decades. In areas where coke is expensive (the majority of developing countries, especially in Africa) the trend will be to reduce the coke rate as far as possible by the application of injection of fuels in the tuyeres and hot gas in the stack or to introduce direct reduction processes (HYL, MIDREX, etc.).

12. The second pattern of use of coke would be followed in regions where there are adequate supplies of coals not suitable for coking, but which can be converted to form coke by various processes such as coal drying, "formed" coke, etc.

13. The third pattern would be followed where supplies of reasonably good coking coals will be available to the end of the present century (India, Columbia).

14. Reduction processes are mainly developed in developing countries where cheap quantities of natural gas are available. Two trends can now be foreseen: on the one hand, the construction of integrated direct reduction plants where the iron sponges are transformed into steel. On the other hand, the development of very large direct reduction facilities exporting their production toward countries which either have a large potential of cheap electricity (hydroelectric as in Zaire or Brazil, or nuclear), or are big consumers (industrialized countries).

15. According to the highly tentative and provisional data of IISI, the total energy requirements of the world iron and steel industry could increase by about 235 million TCE -- i.e., 40 per cent by 1985, from

about 545 million TCE in 1973 to about 780 million TCE in 1985.

16. These forecasts of total future energy requirements imply an improvement of about 12 per cent in the efficiency with which energy is used. Total energy usage per metric ton of crude steel produced is expected to fall from 840 kgce in 1973 to just under 740 kgce in 1985.

17. The total energy requirements of the iron and steel industry in the developing countries could increase by about 45 million TCE, i.e., about 2.3 times by the year 1985, from about 35 million TCE in 1973 to about 80 million TCE by 1985.

18. A working group in IISI developed a model plant, a hypothetical steel mill equipped with the most advanced equipment and up-to-date operational technology for making steel. One can assume that such plants will be in operation in the next two decades. Specific energy consumption in the first model plant with a basic oxygen furnace is equal to 524 kgce, in the second model plant with direct reduction in the process it is equal to 680 kgce, and in the third model plant using 100 per cent scrap it is equal to 196 kgce. Energy requirements of these model plants should be compared with the actual energy consumption figures of a country, in order to see what the difference is between these two figures, and which measures should be taken to approach the figures of a model plant.

19. The iron and steel industry has a big potential for energy conservation, especially in developing countries, although long before the energy crisis of this industry had achieved considerable energy savings.

20. The process of reducing unit energy consumption in the iron and steel industry will continue. First of all, due to development of various technologies for:

1) improving raw materials to be fed to blast furnaces;
2) sending hot blasts into the furnace to promote combustion in it; and

3) maintaining adequate gas and temperature distribution in the furnace.

21. According to the Battelle report, the total amount for energy savings due to various innovations in the U.S.A.'s iron and steel industry could be 95 kgce per ton of steel product or about 11-16 per cent of specific energy consumption for various developed countries.

22. The measures for energy savings should be considered for each country in accordance with the structure of its iron and steel industry.

23. A new possibility of energy saving for industrially developed market economy countries is the implementation of existing plants to construct limited-cycle plants in developing countries offering favourable conditions as to raw materials, manpower, energy, etc. Such plants then should deliver semi-finished steel products to the countries that have supplied the capital and technology for their construction and required semi-finished materials for its rolling mills located in the traditional centres of steel consumption. The fact that this form of co-operation is also possible among socialist countries with centrally planned economies is confirmed by the current implementation of a project for the construction of a jointly-owned plant in the Soviet Union for the mass production of pellets, semi-finished products and certain kinds of finished products for the CMEA member countries, which have invested in the joint project.

24. It should be stressed that the availability and conditions of supply of various kinds of energy to the world's iron and steel industry over the last few years have shown that difficulties of supply have less effect on the iron and steel industry than on other industries, especially with respect to the availability of the required volume of energy, although the effect of increased energy prices is significant.

25. Nevertheless, the scale of the problem passed by the far-reaching jump in energy price levels ought not to be understated. In the case of the integrated hot metal plant in particular, the increased weight of the energy cost element is very noticeable. Energy is now constituting a heavier cost burden at a modern plant than either ferrous raw materials or labour and almost three times as heavy as that imposed by fixed capital costs (i.e., depreciation and interest charges). In an integrated model plant, the cost of energy is estimated at about 25 per cent of total cost in 1975; at the same time in a scrap-based model plant the energy cost accounts for 11 per cent.

26. The coking coal/oil price relationship is of particular importance to the steel industry's long-term energy policy.

27. It may be noted that electricity and natural gas prices, while also following coking coal prices in the wake of oil prices, were normally advanced by appreciably less, possibly because of the existence of supply contracts with public utility undertakings.

28. The energy crisis has confirmed the view that in the iron and steel industry it is a mistake to economise on research even when a general economic recession has led to a fall in profits.

29. The problem of steel production can be aggravated in the future and appropriate measures should be taken to solve this problem. For example, intensive efforts have to be made towards:

a) the fuller use of non-coking coals as a reductant for iron ore reduction in direct reduction processes;

b) the use of "formed coke" in blast furnace iron-making;

c) the development of coal washing and blending of semi- and non-coking and coking coals for iron smelting (such as India, Brasil, etc.)

The potential of charcoal as a reductant is also the object of attention in developing countries, since this renewable resource can be the basis of sizeable iron and steel production, as is the case of Brazil.

30. Due to scarcity of reserves of coking coal, the coking coal requirements are likely to create special problems to meet the general world expansion of the steel industry, although intense and concrete efforts should be taken to cut down coke consumption for iron production during the last decade through various technological innovations.

31. Co-operation is needed to develop the production of coking coal in developed and developing countries and arrive at warning agreements to ensure that developing countries will have their demand for coking coal satisfied.

I. DIFFICULTIES OF FORECASTING ENERGY REQUIREMENTS.

A. Importance of the use of energy in the iron and steel industry.

1. The steel industry is the largest industrial user of energy. The magnitude of its energy requirements is truly enormous. Of total world energy consumption in 1973 which was at 7.8 billion tons of coal equivalent (TCE), the consumption of energy (coal, coke, oil, natural gas, etc.) by the world iron and steel industry is estimated to have used about 7 per cent or 545 million TCE (of which about 470 million tons is coking coal). Furthermore, if account is taken of the energy required to mine and beneficiate coal and ore, to collect and prepare scrap, and to transport all of it over often long distances, the volume of energy used for producing finished steel products would be even higher by perhaps another 10 per cent, bringing it to an estimated 640 million TCD or more than 8 per cent of total world energy used in industry. In some developed countries this industry is the greatest consumer in economy. For example, in Japan the iron and steel industry amounts to about 20 per cent of the total energy consumption in the country.

2. On the estimation of the IISI, known reserves of fossil fuels would appear to be enough to keep steel production at an average annual growth rate of 4.5 per cent by 2000 at least. This assumes, of course, that the industry's energy requirements will be available in usable form and at costs which are reasonable in view of the overall economic situation including realistic price levels for steel products. Less certain, however, than hypothetical availability of needed energy, is the geographical pattern and form of the energy units, on the one hand, and the location of the steel-producing units on the other. For example, at present there is a discrepancy between the two factors: in 1970 over

50 per cent of crude steel output was produced in countries having a deficit in energy supply; 45 per cent of their total energy consumption was imported, representing a total of 1.2 billion TCE. The requirements for good coking coal have reached volumes (470 million tons in 1973) which create special problems for the developing countries. For example, the cost of coking coal was estimated in 1973 as about 19 billion dollars or about 38 per cent of the total worth of raw materials used in metallurgical plants in the world. If we take into consideration the consumption of natural gas and oil in this indutry and the sharp rise in prices for fuels in the last years, it can be seen that energy requirements are a very heavy burden for the economy of the steel-producing countries, especially for developing countries.

3. The importance of energy consumption in the iron and steel industry necessitates outling the prospects of its possible evolution in the future.

4. The question is not only to describe possible magnitude figures but to propose alternatives according to hypotheses in the production choices and to evolutions in the technologies. In turn the prospects of energy consumption are likely to have a retroactive effect on the choices of the national decision-makers: energy consumption varies according to the technological process; the minimizing of the energy consumption per ton of steel produced might be one of the decision-making criteria.

5. The same applies, incidentally, to the consequences on the environment. Minimizing pollution is also a decision-making criterion. The question arises if the minimizing of energy consumption and pollution would lead to the same technological options.

6. The establishment of evolution alternatives based on the consumption of

energy encounters serious difficulties. An inventory of present consumption must first be established. The past tendencies must be understood and various evolutions -- either of the steel-production structure or of the technological innovations and their diffusion -- must be envisaged.

7. As surprising as it might appear at first sight, the present steel-making energy consumption is known with a very rough approximation.

8. The repartition of steel-making by sub-branches such as iron-making, steel-making, rolling mills and others is known on a worldwide basis with sufficient accuracy, as is the breakdown of steel-making by technological processes. But the missing information is a country-by-country "pyramid" of the various technological generations incorporated within the existing production apparatus.

9. The productivity of the energy-consuming installations varies with the time. The national production capacities, and sometimes those of the same enterprise, juxtapose technologically heterogeneous production units. The existing capacities are the legacy of various technological questions, particularly in the industrialized countries where the iron and steel industry has been established for a long time. The productivity of energy consumption in the various processes is known for various time periods. The missing information at the world-wide level is the age structure of production installations.

10. This information is available in numerous countries and could be completed elsewhere; the obstacle is not insurmountable. However, lacking this information at present, the only possible inventory of energy consumption is a standard count, hypothetically assuming that the steel-making industry uses modern technological processes wherever the energy consumption by product unit is less than in the past. This

calculation lessens, therefore, the real energy consumption.

11. The estimation of future energy consumption raises other problems; in the first place, naturally, is that of forecasting steel production itself. The present crisis situation of the forecasting methods has been seen in the report (see Chapter I, paragraph B: medium- and long-term projections). As long as this is not overcome, it will be impossible to forecast seriously the energy needs. It should be possible to establish likely orders of magnitude. This is even further grounds for the breakdown of production to be even more hasardous.

12. As has been demonstrated in the study, the diversification of the iron and steel industry, particularly in the developing countries, is a question depending on the policies followed. In the industrialized market economies, the crisis in the steel-making industry gives rise to the restructuring of the production apparatus. There are, therefore, various possible alternatives, and more than one projection.

13. The options among various technological processes are equally possible. The present study has stressed particularly the utilisation potentialities of the direct reduction processes. These options constitute another set of/ hypotheses.

14. Finally the present technological processes are bound to evolve from now to the turn of the century. New breakthroughs comparable to the oxygen steel process cannot be dismissed a priori. Three categories of technological progress ought to be therefore distinguished:

    a. The diffusion of present technologies, which implies the progressive replacement of technologically obsolete production installations.

    b. The improvement of existing technologies permitting an improvement in productivity.

c. The appearance of better performing technologies.

The bulk of these hypotheses constitutes the technological forecasting of the sector.

15. This analysis must also take into account the perspectives of price evolution among the various sources of energy because the technological choices are not made on an abstract basis, but also take into account the relative costs of the various inputs. The diffusion of technological innovations is a function of the price system. This leads to an elaboration of a wealth of interrelated hypotheses. The difficulties are considerable and the alternatives can differ, but here, also, nothing is insurmountable.

16. In the end, the prospects of the steel industry energy require:

a. Information on the structures by age and by process of the present capacities installed.

b. The formulation of the following hypotheses:

H1 - hypothesis concerning the evolution in the volume of steel production

H2 - hypothesis concerning the evolution in the sub-branches of production

H3 - hypothesis concerning the evolution in the repartition of technological processes

H4 - hypothesis concerning the diffusion of present technologies in the period of time considered

H5 - hypothesis concerning the improvement of present technologies and their diffusion

H6 - hypothesis concerning the research and development of new technologies

17. The information on the age "pyramid" of the technological processes should be collected by country[1] for hypotheses H1, H2, H3 and H4. Hypotheses H5 and H6 are more connected to the international plan, i.e., to technological progress in general. Hypotheses H3 and H4 and also H5 and H6 imply an estimate of inertia factors at the national scale which are likely to slow down the diffusion of technical progress, and, conversely, moving forces for saving energy.

18. This enumeration shows the importance of the work and the information which should take place in order to achieve real prospects for the energy consumption in the sector. As has been said, however, the main difficulty resides in emitting a solidly established prognosis for the long-term steel production. The other tasks to be performed are difficult but not unsurmountable.

B. <u>Elements collected in this study for the use of national policy-makers:</u>

19. Information exists for the U.S.A., Japan, The Federal Republic of Germany, U.K., France and Belgium concerning an initial series of data and hypotheses:

a. The evaluation of total energy consumption in this industry in the past period (since 1950-1960);

b. Breakdown of steel production of a country by various furnaces in this period;

c. Energy consumption in different branches of steel-making (iron-making, steel-making, rolling mills and others) in this period;

d. Energy consumption by various furnaces (BOF, EF, OH, etc.) in the same period;

e. Total energy consumption per one ton of steel product or specific energy consumption in this period;

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[1] UNIDO has started gathering data for most of the developing countries.

f. Specific energy consumption in various branches of steel-making at the same period;

g. Specific energy consumption by various furnaces in this period;

h. Estimation of potential for energy savings;

20. Information exists also in the U.S.A., Japan and The Federal Republic of Germany concerning a second series of data and hypotheses:

a. The total amount of steel production in forecasting years (for example, in 1985 and 2000);

b. Future technological development in this industry;

c. The future breakdown of steel production by furnaces;

d. Future total specific energy requirements;

e. Future specific energy requirements in different branches of steel-making.

f. Future specific energy consumption by various furnaces;

g. Changes in the total energy balance of a country by energy sources in the future;

h. Use of non-conventional energy sources in a forecasting period;

i. Future relative energy prices of different types of energy sources;

j. Future situation in the national coal-mining industry.

21. On developed countries data, an hypothesis exists in the first series. As regards the second series, it is not the same and it cannot be the same. Information depends on projects — certain of which are not yet formulated — and technological progress which depend essentially on the industrial centres in the industrialised countries.

22. Lacking a prospective inventory, now out of reach, partial information was gathered in Chapter II likely nonetheless to be useful to the

national policy-makers, enabling, among other things, the comparison of the energetic incidence in the technological choices. These have been classified to refer to the present situation, past tendencies or future energy needs.

23. In Chapter III information was gathered on envisageable means through which economy in energy could be made in the steel-making sector. It is not the purpose of this work to be exhaustive, but it aims to suggest a direction for thoughts and research so that the variable "energy" could progressively be incorporated in the decisions of policy-makers in the developing countries as an explicit criterion. The same intellectual exercise is suggested as regards the environmental problem (see Annex V.)

II. INFORMATION FOR ENERGY PROSPECTS IN THE IRON AND STEEL INDUSTRY

A. Present situation

24. In order to estimate energy consumption in the iron and steel industry and to take appropriate measures for energy conservation, it is necessary to show major consumers in this industry's steadily diminishing specific energy consumption and changes in energy fuel-sheet.

1. Breakdown by major consumers in the iron and steel industry

25. The main consumers of primary energy are the blast furnace, or iron-making, steel-making, rolling-mill and by-product coke sectors, which account for more than 75 per cent of the total fuel input. From Table 1 it can be seen that for six major steel producers of the world, iron-making accounts for 50-65 per cent, steel-making for 10 per cent and rolling and other operations 30-40 per cent of total energy consumption (see Table 1).

Table 1.

Breakdown of total energy consumption in different branches of steelmaking in 1973.
(per ton of crude steel)
(in per cent)

	Total, TCE	Ironmaking	Steelmaking	Rolling and others
Belgium	0.758	62	5	33
France	0.791	64	10	36
Germany	0.744	54	10	36
Japan	0.597	68	9	23
United Kingdom	0.867	44	17	39
United States	0.866	47	10	43

Source: IISI/E/1008/0 Panel discussion: Energy and Steel. Study of the Technological Aspects, p.7.

2. Breakdown by processes

26. As shown earlier, the total energy consumption per one ton of steel in various countries is steadily diminishing. These data which depend on the structure of steel production by different methods, on the equipment, on operating conditions, etc., and on many other factors oan give us the approximate boundaries of energy requirements in an industry for rough calculations. But is is very important for more preoise calculations of energy requirements in this industry to give some examples of specific energy consumption by various furnaces.

27. Although it is impossible to give unified average specific energy consumptian by different furnaces, which depend on many parameters such as ratio coke, fuel, pig iron, scrap, etc., it is necessary, nevertheless, to show some comparatice data on the energy balance for the production of one ton of liquid steel by different processes. Table 2 and Figure 1 show these data submitted by P.S. Barnes to the International Iron and Steel Congress (1974). The smelting of 100 per cent scrap in an electric furnace has been included in the table for comparative purposes and also in order to show that with this steel-making prooess energy is the most fully utilized even if, on the oon-sumption side, losses or the generation of eleotrioity are taken into account. The electrio arc furnaoe using 100 per cent steel scrap gives the lowest energy consumption figure, followed by the BF-BOF route, while the eleotrio arc furnace using direot reduoed material shows one of the highest energy oonsumption, as was expected. The highest energy oonsumption and the lowest efficiency (30.8 per cent) is in the oase when oil and reformed natural gas are injected. However, if secondary energy souroes are taken into account, the figures show that energy is used the most efficiently in the conventional steel-making

method (blast furnace process-oxygen converter: 50.4-55.3 per cent). As shown in Table 2, open hearth furnaces consume much more energy for production of one ton of steel than (except in the case of fuel oil and reformed gas injection) basic oxygen furnaces and electric furnaces.

B. Past trends

1. Breakdown by major consumers

Iron-making

28. The most conspicuous thing which has occurred in iron-making is the reduction in the use of coke in various countries from 1950 to 1973. Coke consumption in the iron and steel industry is determined by economic and technical factors. Of the many factors, it is worth mentioning the fundamental dependance of coke consumption on pig-iron production, and of pig-iron production itself on the production of steel and steel products. Steel output and pig-iron requirements depend to a certain extent on the quantity of scrap used in the steel-making process. Improvements in steel-making technology have also changed the quantity of pig iron needed to produce one ton of crude steel. For example, the pig iron input per ton of steel was 525 kg in 1950, and had reached 550-600 kg by 1970. Trends in coke consumption per ton of pig iron smelted in some countries are shown in Table 3. Coke consumption per ton of pig iron fell sharply in the mid-1960's and continued to fall thereafter, but less rapidly. The drop in the coke rate was due to better preparation of the charge and improved blast furnace design and technology.

29. At the time of the coke shortage and the consequent sharp rise in coke prices (1970-1971), there was an increase in the use of liquid fuels and natural gas, accompanied by a fall in coke consumption.

Table 2.

Energy requirements [illegible] the production of 1 ton of liquid steel [illegible] following processes

	(1) 100% scrap EAF	(2) Coke-oven gas injection Blast furnace converter	([illegible]) [illegible] oil [illegible]ection Blast furnace converter	(4) [illegible]rect reduction EAF	(5) 100% coke Blast furnace converter	(6) Fuel oil and reformed gas injection Blast furnace converter	(7) open hearth furnace
Energy input							
Million J/t							
Coal/coke	520	14,480	13,830	----	19,200	9,840	....
Fuel oil	----	----	3,430	----	----	2,720	....
Natural gas	----	----	----	12,940	----	8,840	....
Scrap	7,470	2,200	2,200	1,730	2,200	2,200	....
Carbon electrode	160	----	----	160	----	----	....
Oxygen	----	230	230	----	230	230	....
Limestone	100	200	200	110	200	200	....
Electricity a/	4,960	----	----	5,940	----	----	....
Total	13,210	17,130	19,880	20,880	21,850	24,050	21,935
Kgce.	(458)b	(594)b	(672)b	(724)b	(749)b	(834)b	(761)b

Source: ECE/Steel/12; The potential for energy conservation in nine selected industries, 2 June 1974, page 73; 112.

Note: a/ For electricity generation, a coefficient of 30 per cent is assumed; b/ Kg. of coal equivalent. (1 Kgce = 28 824.10[3] jouls), (1).... Scrap/coke, electric are furnace (EAF - 100 per cent scrap); (2) Blast furnace with coke oven gas injection and remelting in oxygen converter (with the addition of 27 per cent scrap); (3) Blast furnace with the fuel oil injection (97 kg) with remelting in oxygen converter; (4) Direct reduction, electric are furnace (20 per cent scrap); (5) Blast furnace with remelting in oxygen converter (27 per cent scrap); (6) Blast furnace with fuel oil and reformed natural gas injection and with remelting in oxygen converter (27 per cent scrap); (7) Open hearth furnace with mix of pig iron (41 per cent scrap), in the USA 1970.

Table 3.

Trends in coke consumption per ton of pig iron smelted in various countries

Country	1950 kg/t		1955 kg/t		1960 kg/t		1965 kg/t		1970 kg/t		1973 kg/t
Austria	803	100	750	93.4	730	90.9	617	76.8	510	63.5	...
Belgium	798	100	876	109.8	844	105.8	646	81.0	584	73.2	555
France	994	100	1022	102.8	972	97.8	784	78.9	626	63.0	560
Germany Fed. Rep.	947	100	946	99.9	834	88.1	672	71.0	559	59.0	495
Italy	980	100	893	91.1	777	79.3	663	67.7	540	55.1	...
Luxembourg	1041	100	1006	96.6	1092	104.9	860	82.6	730	70.1	595
Netherlands	1156	100	991	85.7	790	68.3	559	48.4	483	41.8	...
United Kingdom	1027	100	982	95.6	825	80.3	680	66.2	625	60.9	575
Yugoslavia	1330	100	1123	84.5	1127	84.7	961	72.3	763	57.4	...
Western Europe 1/	972	100	962	99.0	860	88.5	700	72.0	600	61.7	...
USA	933	100	851	91.2	770	82.5	650	69.7	658	70.5	602
Japan	910	100	723	79.5	619	68.0	507	55.7	473	52.5	435
Czechoslovakia	1089	100	1202	110.4	988	90.7	768	70.5	...	....	...
Poland	1100	100	1174	106.7	1041	94.6	900	81.8	704	64.0	...
USSR	944	100	880	93.2	724	76.7	586	62.1	575	60.9	...

Source: Quarterly Bulletin of fuel statistics for Europe, United Nations, Various bulletins.
1/..... Weighted average for western European countries.

At the same time there is a very important trend of total energy consumption in iron-making. Contrary to the reduction of the coke rate, no appreciable decrease could be observed in overall energy consumption in most developed countries. Table 4 shows the change of the net energy consumption in blast furnaces for iron-making in different countries from 1960-1973.

30. What is the reason behind this phenomenon? The fact is that the blast furnace is thermally a very efficient process as the reaction in the furnace takes place in the counter-current flow of the descending raw materials and the ascending reducing gas. Old blast furnaces with unprepared burden and low temperature blast consumed a large amount of coke but at the same time generated a large quantity of blast furnace gas in excess of requirements even in the plant after it was used for heating stoves. Modern blast furnaces, on the other hand, use well-prepared burden materials, high temperature blast, injected auxiliary fuel such as heavy oil, and consume 500 kg of coke or less. A much smaller volume of blast furnace gas is produced. Energy is required for sintering iron ores and for heating the blast to high temperatures.

Table 4.

Net Energy Consumption in Ironmaking
(per ton of hot metal)
(in TCE)

	1960	1973
Belgium	0.573	0.578
France	0.699	0.686
Germany	0.638	0.576
Japan	0.552	0.548
Luxemburg	0.774	0.715
United Kingdom	0.657	0.639
United States	0.740	0.622

Net energy consumption, therefore, will be of the same order for both cases, provided that there is not appreciable change in Fe content in the burden. In energy cost, however, the saving is considerable for modern blast furnaces which consume much less coke than old furnaces under the economic conditions prevailing in most countries.

Steel-making

31. Energy required by the basic oxygen steel-making process (top and bottom blowing) is very low, about one-third to one-tenth of what is needed by the open hearth furnace depending upon the operating conditions. As a result, in those countries where open hearth furnaces have been replaced by basic oxygen convertors, a significant decrease of energy consumption has been observed. While in some countries in Western Europe where high-phosphorous hot metal is being produced, the change is from the basic Bessemer process to the basic oxygen converter - top or bottom blowing - and it does not bring about any significant change in energy consumption. This is exactly what has happened in Belgium and Luxemburg in the past. A wide selection of raw materials to be melted including steel scrap is the advantage of the open hearth furnace. When open hearth furnaces are replaced by basic oxygen converters which have limitations in the use of steel scrap due to the thermal balance, UHP type electric arc furnaces have been widely adopted as a process to absorb steel scrap and to make plain carbon steel.

2. Trends in total specific energy consumption.

32. The total energy consumption for production of one ton of steel in the period 1960-1973 has been diminishing gradually by reducing energy consumption in blast furnaces, by modifying production structures

(for example, open hearth consumes much more energy than the convertor), and operating conditions, by introducing continuous casting processes, by recovery of waste energy, by changing the form in which energy is supplied, by increasing the efficiency of furnaces, etc. Figure 2 shows that the trends of energy consumption per ton of crude steel including the energy required to manufacture the final product in 12 different countries. In most countries, a definite trend of energy saving can be seen between 1960 and 1973. The next three countries, namely Belgium, The Federal Republic of Germany and the United States are shown in Figures 3, 4, and 5, so that the trend of energy use in each of these countries can be studied in detail.

3. Changing in energy fuel-sheet of energy consumption in the iron and steel industry.

33. Parallel with the development of the metallurgical processes, there were substantial changes in the energy market. From 1950 a cheaper fuel with a higher caloric value began to appear on the market. Changes in the consumption of the various types of energy per ton of steel over a period of ten years are shown in Table 5.

Coke

34. Trends in coke consumption in production of one ton of pig iron are shown in Table 3.

Fuel oil

35. Fuel oil began to be used in open hearth furnaces at first because of a shortage of the traditional fuel, and then to increase productivity. It later found an application in blast furnaces, especially after the substantial rise in the coke price in 1970. This injection of fuel oil in the blast furnace led to the decline of the specific consumption of coke per ton of iron. Specific oil consumption for 1 ton of steel production is increasing with each year in many countries of the world.

Table 5

Consumption of various forms of energy in selected countries

(Kgcc per ton of steel)

	Western Europe		Japan		France		Spain		United Kingdom		United States		Poland	
	1960	1970	1960	1970	1960	1970	1960	1970	1960	1970	1960	1970	1960	1970
Total kgcc	973	932	777	704	934	904	1367	826	998	1000	1010	892	1529	1211
coal in %	6,4	2,7	5,5	0,6	3,5	0,8	10,5	9,4	14,5	2,5	7,3	4,4	26,1	14,3
coke in %	71,0	51,4	42,1	51,4	70,3	60,5	72,5	57,3	54,8	45,4	48,7	46,5	51,4	44,5
pitch tar %	—	—	—	—	0,4	0,4	—	—	4,9	1,4	2,1	1,5	—	—
oil in %	5,9	11,6	20,0	21,5	6,2	12,4	4,0	7,3	14,9	24,5	1,5	6,3	0,6	5,7
natural gas	—	9,2	—	—	0,9	2,0	—	—	—	1,4	14,6	21,0	1,4	14,3
coke gas	11,3	8,5	22,7	1,0	4,4	4,0	9,0	15,0	6,7	6,8	13,0	14,8	9,9	7,5
electric power	5,4	16,6	10,0	25,6	5,3	19,9	3,5	17,0	4,2	18,0	4,1	5,5	10,6	13,7

Source: ECE/Steel/12, 16 Sept. 1975 page 25.

In the period 1960-1970 it grew in The Federal Republic of Germany from 38 kg/ to 72 kg; in France 39 kg and 75 kg; in the U.K. 99 and 163 kg; in Poland 6 and 46 kg respectively. At the same time, in the U.S.A. oil consumption decreased from 69 kg to 37 kg because of the drop in the production of steel made by the open hearth process. In Japan and Spain this amount of oil injected remained at the same level: 100 kg and 40 kg respectively.

36. The future of this technique will depend mainly on the evolution of the relative price of coke, oil and gas. In countries where there exists a ratio between oil or gas price and coke price, injection rates of more than 100 kg of oil and 10^6 K cal. of natural gas can be envisaged for new plants[1/]. (Oil price of 1.5 times the coke price.) But it should be stressed that it is impossible to substitute total coke in a blast furnace used for oil or natural gas. Coke will continue to play/a very important part in the traditional blast furnace process.

Natural gas.

37. Natural gas is mainly used for steel production in direct reduction processes which are particularly developed in those developing countries where cheap quantities of natural gas are available. The using of natural gas in developed countries mainly depends on the fact of how large the reserves of natural gas they possess/are and what share of fuel balance of a country is covered by it. For example, in 1969 over 18 per cent of the energy needs of the U.S. steel industry were supplied by natural gas, in the U.S.S.R. in 1972 the share of natural gas was equal to 23 per cent. In Europe, steel-worked natural gas has been used since 1960, although the proportion has been small, fluctuating around 5-6 per cent. In steel works it is mainly used for rolling-mill reheat furnaces, blast

1/ B. Lapillonne, "Technological Developments and Their Impact on Energy Requirements in the Iron and Steel Industry," July 1976.

furnaces (in recent years) and boilers for heat treatment and other purposes. Japan did not use natural gas in iron and steel industry at all[2/].

Electricity

38. It should be stressed that the trend in the world iron and steel industry is now the continual growing of the share of electric steel production. If in 1950 it was equal to 7.2 per cent of total world steel production (187.9 million tons), in 1974 the share increased to 17.4 per cent. In the period 1965-1973 this share increased in the U.S.A. from 10.5 per cent to 18.2 per cent; in The Federal Republic of Germany from 8.5 to 19.9 per cent in France from 9.0 to 10.6 per cent; in Italy from 37.4 to 39.9 per cent[3/]. Also the share of electric energy consumption for production of one ton of steel is increasing constantly, though the total specific energy consumption per ton of steel is gradually declining.

4. Trends in energy prices and energy policy: cost of energy for the iron and steel industry

39. Energy problems have a direct effect on every country's economic structure. They have also begun to make themselves felt at the world level and both they and efforts to solve them are assuming a long-term character and are influencing the structure of the iron and steel industry.

40. The energy crisis which came to a head in 1973, but which had, in latent form, existed for more than a quarter of a century, may lead to great changes in the world economy and substantially disturb its balance. The availability of energy resources and their geographical distribution, as well as the future conditions of energy supply to industry, will in many countries have a still greater influence on the movement of prices

2/ ECE/Steel/12, 16 September 1975, "Changing Pattern of Energy Use in the Iron and Steel Industry," pp. 9-30.

3/ ibid. p. 42

of different forms of energy, investment in the development of energy production, the availability or shortage of capital and the balance of payments; these factors will affect not only the geographical distribution of energy production and consumption, but also structural changes in the iron and steel industry and its location. In certain countries, this is already happening.

The structural changes in the iron and steel industry represent only a part of the problem of energy availability and conditions of energy supply faced by industry in general.

41. The iron and steel industry is one of the largest consumers of energy in a country (for example, at the present time Japan's iron and steel industry accounts for about 20 per cent of total energy consumption). But it should be stressed that the availability and conditions of supply of various kinds of energy to the world's iron and steel industry over the increase in oil prices on the international market has led to a considerable rise in the prices of other kinds of energy. This has had an adverse effect on the competitiveness of the iron and steel industry of many countries. Countries with better conditions of raw materials supply and cheaper energy (those with coal, oil and gas

resources of their own), including developing countries, are unquestionably more competitive than those handicapped in this respect. The situation is forcing many industrially-developed countries to intensify their efforts to increase labour productivity and to assimilate new technological processes. While success in this area makes them more competitive, it also necessitates new investment in the iron and steel industry. All this is causing changes in the structure of production and the location of the world iron and steel industry, although this inescapable process is, for the time being, developing only slowly. Changes in the conditions of energy and in energy prices do not as yet directly threaten the level of steel production. Increases in production costs may initially be covered by increases in steel prices. The volume of production can be influenced only by a change in demand and not by inflation. The energy crisis may, however, indirectly affect the demand for steel and, consequently, steel production, forcing many steel producers to revise their development plans.

42. The scale of the problem posed by the far-reaching jump in energy price levels ought not to be understated. Though there is as yet no way of measuring the change in the absolute level of energy costs in the steel industry, Table 6 provides some indication of how the new energy situation has increased the importance of the energy cost element in steel-making costs. The data, drawn from work done by the Technology Committee of IISI, relates to costs at two hypothetical "model plants," the one designed to produce flat products in bulk by the blast furnace (oxygen converter) continuous casting route and the other designed to produce a mix of carbon and special steel products from scrap through the electric arc furnace/continuous casting route.

Table 6.

Cost pattern at model plants, 1972 and 1975.
(in percentage)

	Integrated Works 1972	Integrated Works 1975	Scrap Based Works 1972	Scrap Based Works 1975
Ore, scrap and other materials	22	20	24	28
Energy	18	25	10	11
Employment costs	20	22	28	27
Repairs, stores, etc.	13	12	16	15
Other items (sales, transport, etc.)	15	12	12	10
Depreciation and interest	12	9	10	9
TOTAL	100	100	100	100

Source: IISI/E/F/G/J/1006/AnnexI.

43. In the case of the integrated hot metal plant in particular, the increased weight of the energy cost element is very noticeable. Energy is shown as now constituting a heavier cost burden at a modern plant than either ferrous raw materials or labour, and almost three times as heavy a burden as that imposed by fixed capital costs (i.e., depreciation and interest charges). This has implications for the priorities in the search for cost savings. For example, it means that it has become rather more attractive to pursue energy savings of the type which are obtainable only at the expense of a heavier use of other inputs, such as more scrap, richer and more expensive iron ore, or more investment of capital in energy-saving plants. For example, in the U.S.A. the cost of energy used to produce raw steel amounts to $9.36 per ton which amounts to 10.8 per cent of the value of the product ($87/ton in 1970). Only in production of one ton of cement and one ton of resin and rubber the share of energy cost is higher than in raw steel. Even in aluminum industry the cost of energy is less (9.8 per cent) than in the iron and steel industry.

44. The new energy situation has also had an important effect on the pattern of relative energy prices. Throughout the 1950's and 1960's, oil was so plentifully available and so relatively cheap that it effectively determined the general energy price level, since all other energy supply industries knew that any substantial price increases on their part would exacerbate their already considerable loss of market share to the oil suppliers. Since 1973-1974 the subsequent energy price adjustments varied appreciably from product to product, however. Thus, steel companies were left facing a noticeably different pattern of relative energy prices than they had in the late 1960's and early 1970's, and so a new set of factors influencing policy on plant development. The most striking adjustment of this sort affected the price relationship between coking coal and oil. Throughout nearly all of the period covered by the 14-country survey of energy data, i.e., from 1960 to 1974, fuel oil was very cheap relative to coking coal in nearly all of the countries. The only exceptions were countries with large coal outputs where the local cost of coal was low (Table 7). In 1973-1974, however, this relationship was sharply reversed as shown in Table 8. This coking coal/oil price relationship is of particular importance for the steel industry's long-term energy policy.

45. Since more than half of the industry's total energy usage occurs in the blast furnaces and their supporting facilities, it is in this area that any really significant changes in the energy pattern must be sought. And the main technological possibility now open to the industry if it were to wish to change the pattern of energy usage in this key sector would be to shift over to a much more substantial extent than has yet been done from reliance on the use of coke to reliance on the use of

injected hydrocarbons (especially fuel oil), as a way of fuelling the blast furnaces. Though oil injection has more or less maintained its present relatively limited role in the blast furnace energy pattern, the abrupt shift in the coking coal/oil price relationship in 1973/74 appears to have put an end to the radical plans which some companies were reputed to be considering in the early 1970's for bringing about major increases in tuyere injection of oil and possibly later in both injections, so enabling them to cut back correspondingly on investment in coke oven facilities.

Table 7.

OIL PRICE AS PERCENTAGE OF COKING COAL PRICE

	1960	1965	1970	1973
Germany Fed. Rep.	94	80	72	70
France	112	104	72	75
United Kingdom	na	na	94	91
USA	169	164	118	122
Japan (low sulphur oil)	108	90	61	100

Source: see table 6.

Table 8.

CHANGES IN COKING COAL AND OIL PRICES, 1973-1974

	% increase in each Price 1974 on 1973		Oil Price as % of Coking Coal Price	
	coal	oil	1973	1974
Germany Fed. Rep.	33	107	70	108
France	54	148	75	120
United Kingdom	41	173	91	178
USA	96	175	122	170
Japan	78	197	100	166

Source: see table 6.

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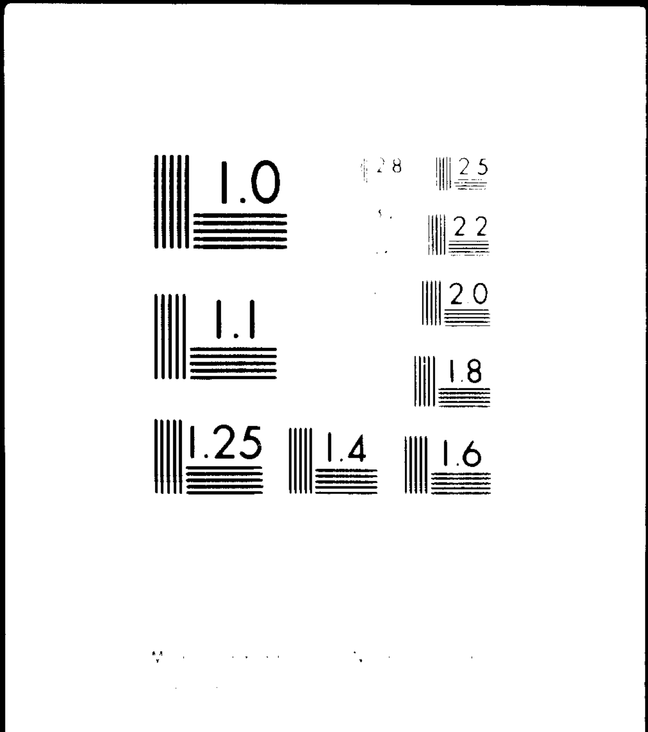

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46. Reverting to price movements, the change in the coking coal/oil price relationship ought not to be interpreted as implying that coking coal prices remained relatively stable in 1973-1974. Far from it. The coal suppliers as a whole had long been under a profit squeeze, because competition from oil had restricted their ability to raise prices, while union pressure on wages - a major factor in this labour-intensive industry in most countries - had appreciably forced up their costs. They therefore took vigorous advantage of the room for maneuver vis-à-vis coking coal prices created by the steep rise in oil prices - perhaps more vigorous advantage than may prove altogether helpful to their interests in the long-term (Table 9).

47. To conclude, it may be noted that electricity and natural gas prices, while also following coking coal prices up in the wake of oil prices, were normally advanced by appreciably less, possibly because of the existence of supply contracts with public utility undertakings in the former case. There was, however, an exceptionally large adjustment in electricity prices in 1974 in Japan (Table 10).

Table 9.

ANNUAL RATES OF INCREASE IN COKING COAL PRICES

(percentage)

	1965 - 1973	1974 on 1973
Germany Fed. Rep.	4.1	33.3
Japan	3.5	78.0
United Kingdom	8.0	40.5

Source: see table 6.

Table 10.

ELECTRICITY AND NATURAL GAS PRICES

	Increase, 1974 over 1973	
	Electricity	Natural Gas
Germany Fed. Rep.	9%	8%
France	6%	50%
United Kingdom	9%	7%
USA	33%	17%
Japan	105%	na

Source: see table 6.

c. Future specific energy requirements for steel production.

48. Three major trends are expected to be following in blast furnace operations in the next three decades.

49. In areas where coke is expensive, the trend will be to reduce the coke rate as far as possible by the application of injection of fuels in the tuyeres and hot gases in the stack.

50. The second pattern of use of coke would be followed in regions where there are adequate supplies of coals not suitable for coking, but which can be converted to form coke by various processes such as coal drying, "formed" coke, etc. It is possible that this fuel would be used as the principal fuel in the blast furnace and the use of injected fuels would be limited. At least an additional five years is probably needed for form-coke to become available on a large scale.

51. The third pattern would be followed where supplies of reasonably good coking coals will be available to the end of the present century.

52. Beyond 1985 the injection of gases in the stack will also be used. The share of injection will depend on comparative prices for coke, oil and gas. For the simplicity of calculations of energy requirements in the iron and steel industry in the year 2000 one can consider that this amount of energy will be only coke.

53. Compared to the traditional process which has been developed and improved for many years, the new processes of direct reduction have a very short period of industrial experiment; this means that a lot of technical improvement must be expected, especially with respect to their energy requirements.

Two processes are now really developed on a large scale. The HYL process has been the first one to be utilized at the industrial level, mainly in Mexico (world capacity in 1974 about 1 million tons). Since 1970, the MIDREX process is strongly competing with it and seems now to prevail as most of the industrial projects currently announced are based upon MIDREX (world capacity in 1974 about 3 million tons), planned capacity for 1976: 5.8 million tons).

Besides these two main processes, four others can be considered as potential technology for direct reduction:

Fior, based upon hydrogen

Purofer, the principle of which is very similar to MIDREX

SL/RN which is very attractive because of its possibility to be based upon low content coal or lignites

Krupp, similar to SL/Rn

Reduction processes are mainly developed in developing countries where cheap quantities of natural gas are available. Two trends can now be foreseen; on the one hand the construction of integrated direct reduction plant where the iron sponges are transformed into steel. On the other hand, the development of very large direct reduction facilities exporting their production towards countries which either have a large potential of cheap electricity (hydroelectric as in Zaire or Brazil, or nuclear) or are big steel consumers (industrialized countries). One can consider that in 1985 MIDREX and HYL will be used for the iron and steel production; but because it is impossible to estimate the share of steel produced by these methods it was assumed for calculations of energy requirements that it will be only MIDREX. One can suppose that in 1985 developing countries will not have enough own scrap and the production of steel by this method will be neglible. But it could be assumed that in the year 2000, 50 per cent of the total steel produced by electrical furnace will use this method. The rest, 50 per cent, will be MIDREX or HYL. The increasing consumption of electricity, especially by the last method, will call for establishment of many power plants which have to produce cheap electricity. In a number of countries, electricity can be generated at very low cost, particularly where hydroelectric schemes can be installed.

54. In order to forecast energy requirements in the iron and steel industry, the working group of IISI developed a model plant, which is a hypothetical steel mill equipped with the most advanced equipment and the most up-to-date operational technology for making steel. By computing energy consumption in the model plant, which would certainly be the lowest minimum figure one could think of now, it was thought that something like a guidepost or a target for energy consumption in the steel industry in the foreseeable future could be set up (for example, in 1985 and 2000).

Three different cases were chosen for the model plant study, one of the BF-BOF (case A) and the other two electric arc furnace rolling mill combinations using different materials for melting: 100 per cent scrap (case B_1) and direct reduction process (case B_2). For the computation of energy consumption in these three cases, various assumptions had to be made. Only the conclusion of the study will be presented here as energy consumption per ton of crude steel up to the melting stage, as shown in Table 11.

The electric arc furnace using 100 per cent steel scrap gives the lowest energy consumption figure, followed by the BF-BOF route, while the electric arc furnace using direct reduced material shows the highest energy consumption, as was expected

In this connection, it must be noted that the energy consumption figures used in the model plant study are more than two years old, and that it is possible that some technological improvements to further save energy might have been made since then.

Table 11.

Energy consumption in model plant (up to crude steel stage)

	Gcal/t	TCE/t
Model Plant A	3.67	0.524
Model Plant B_1	1.37	0.196
Model Plant B_2	4.80	0.686

Source: IISI/E/1008/4.

55. If one compares the actual energy consumption figures of a country with that of the model plant modified taking into account the production structure and operating conditions of this country one can see that the actual energy consumption value for Japan is very close to the model plant level which indicates the fact that in Japan the energy consumed to produce crude steel is already very low (see Table 12).

The fact that three other countries have much higher actual values does not necessarily mean that in these countries energy to produce steel is not efficiently utilized or steel-making operations are not efficient.

Table 12.

Comparison of Actual Energy Consumption Value with Model Plant Level (up to crude steel stage)

	Model Plant Level (A) (in TCE)	Actual Value (B) (in TCE)	B/A x 100 per cent
West Germany	0.387	0.478	123.5
Japan	0.414	0.460	111.1
United Kingdom	0.357	0.527	147.6
United States	0.364	0.493	135.4

Source: IISI/E/1008/5.

It should be pointed out that in this connection the steel-making operation should not be judged only from the energy consumption point of view. It is a more complicated and complex operation and the overall judgment whether or not the steel-making operation is efficiently done should be based not only on its energy consumption but also on the relative cost and other cost-involving factors. For these rea ons one can easily see why there exist such differences in energy consumption among the four countries.

III. POTENTIAL FOR ENERGY SAVINGS IN THE IRON AND STEEL INDUSTRY.

56. Long before the energy crisis, the iron and steel industry of the industrially developed countries had achieved considerable energy savings. Technological advances, particularly in the 1950's and 1960's, made it possible in some cases to reduce energy consumption by as much as 30 per cent as a result of lower coke consumption, improvements in the blast furnace process, the replacement of open hearth furnaces by oxygen converters and the introduction of continuous casting.

57. The process of reducing unit energy consumption in the iron and steel industry will continue, but the more noticeable results will have been achieved in the early stages, and certain new processes, although economical as a whole, may even entail increased energy consumption (for example, direct reduction of iron).

At present, steel makers are developing various technologies for (1) improving raw materials to be fed to blast furnaces, (2) sending hot blast into the furnace to promote combustion in it, and (3) maintaining adequate gas and temperature distribution in the furnace.

58. The potential for energy conservation in the iron and steel industry in the future includes most present innovations as technologically feasible. But it should be stressed that some of the items which were considered technologically feasible are not considered to be economically practicable. For instance, increased injection of coal to blast furnaces for the near future is not considered economically practicable because most of the present furnaces are fitted for injection of hydrocarbon liquids. However, after 1980, new blast furnaces will be built and it is likely that these will incorporate coal-injection

facilities. It would be necessary to describe some possible energy conservation measures which could give the level of possible energy savings per one ton of steel. These data are based on the Battelle Report for FFA (1978):

1. Increased pellet usage in blast furnaces (5.58 kgce per ton of steel product).

   The usage of pellets in the blast furnace has been responsible for an increase in productivity and a decrease in coke rate. It saves 5.58 kgce/ton of steel product.

2. Increase in coke ash (2.52 kgce/ton of steel product).

   Energy penalties occur in steel-making because the quality of coking coal with regard to ash and sulfur content has been deteriorating and this trend is expected to continue.

3. Increase in coke sulfur (0.2 kgce/ton of steel product).

   The coke rate increases about 2.5 kg per net ton of hot metal for each one per cent increase in sulfur coke. This is a technological factor of such a nature that its effect on energy consumption is the same on an economic basis as on a technological basis.

4. Increase recovery of blast furnace gas (14.04 kgce per net of steel product).

   All blast furnace gas is not presently being recovered.

5. New and modernized blast furnaces (4.68 kgce per net ton of steel product).

   The introduction of new blast furnaces, ranging in capacity from 5000 to 8000 tons per day gives lower coke rates and higher productivity.

6. Dry quenching of coke (5.04 kgce per ton of steel product).

   Dry quenching of coke involves the use of an inert gas as the coke-cooling agent and as a heat-transfer medium. The gas is continuously recirculated in a closed system, removing and transferring a major portion of the sensible heat in the coke to a waste heat boiler or other type of heat exchanger. Most of the existing dry-quenching systems are used to generate high pressure steam.

7. Blast furnace coal injection (3.24 kgce per ton of steel product).

This technology was proven several years ago and showed good results. At present this is considered to be technologically feasible but not economically practicable.

8. External desulfurization of hot metal (5.76 kgce per ton of steel product).

External desulfurization refers to those processes which are used to lower the sulfur content of hot metal external to the blast furnace, i.e., after tapping the hot metal from the blast furnace.

9. Substitution of basic-oxygen furnaces for open-hearth furnaces (0.36 kgce per ton of steel product).

The historical and continued replacement of open hearth furnaces with new BOF facilities increases by 14.4 kgce per one ton of steel (if the energy in hot metal is included).

10. Recovery of BOF offgas (1.44 kgce per ton of steel product).

During the oxygen-blowing period of a BOF, a large volume gas is generated. This gas contains up to 90 per cent carbon monoxide and can be used as a fuel if collected. In several countries, such as West Germany and Japan, the gas is collected by means of a closed hood over the furnace and a suitable gas-handling system. The energy savings by this component is technically feasible by collecting and recovering 10 per cent of the BOF offgas.

11. Preheating scrap for basic oxygen furnace with oxygen-fuel burners (4.32 kgce per ton of steel product).

This process has been shown to be technologically feasible. The energy saving derives mainly from decreased amount of hot metal (which has a high energy content per ton of steel produced).

12. Increased electric-furnace capacity (8.01 kgce per ton of steel product).

Steel scrap is the major metallic component in the charge to the electric furnace.

13. Increased continuous casting capacity (2.92 kgce per ton of steel).

Continuously cast steel can be produced with less energy consumption than ingot cast steel because of the higher yield of semi-finished steel such as slabs, blooms or billets.

14. Increased use of induction heating of steel slabs (2.[illegible]2 kgce per ton of steel).

The usual practice of using fuel-fired reheat furnaces are in many cases thermally less efficient than using electric induction heating of steel slabs.

15. Improvements in soaking pits, reheat, annealing and heat-treating facilities (16.2 kgce per ton of steel product).

Steel ingots are reheated in soaking pits and after being formed into slabs, blooms or billets are again heated in reheat furnaces for hot rolling. These improvements have potential for energy savings, such as:

a) Improved skid insulation in reheat furnaces to lower energy losses in cooling water;

b) Improved reheat-furnace control as related to rolling-mill schedules;

c) Installation of recuperators on those reheat and annealing furnaces not presently fitted with such heat-recovery devices;

d) Conversion of batch-type annealing furnaces from radiant tubes to direct firing;

e) Increased use of fibrous refractory insulation in annealing and heat-treating furnaces;

f) Lower leakage from furnaces;

g) Improved burner design and maintenance.

16. 16. Housekeeping (23.4 kgce per ton of steel).

All housekeeping items are considered technologically and economically practicable. The total amount for energy savings due to innovations in all these items could be 95.19 kgce per ton of steel product, or about 11-16 per cent for various developed countries. Developing countries which possess not so advanced technology of steel-making and consume more energy per one ton of steel have much more potential possibilities for energy conservation than developed countries. Other possible energy-conserving technological process changes on the horizon include: recovery of top gases in the basic oxygen process, introduction of the dry quenching process in coke production, more rapid displacement of energy intensive steel processing steps by technologies tied to the use of continuous casting and greater reliance on oxygen injection into the blast furnace. These measures could reduce energy consumption per ton of shipments by at least 36-44 kgce, equivalent to a roughly 4 per cent further decline in energy consumption for new installations. Although there are still some unresolved technical problems associated with these technologies, the major obstacle to adoption is economics.

Figure 1.

Gross Energy Consumption per Ton of Liquid Steel.

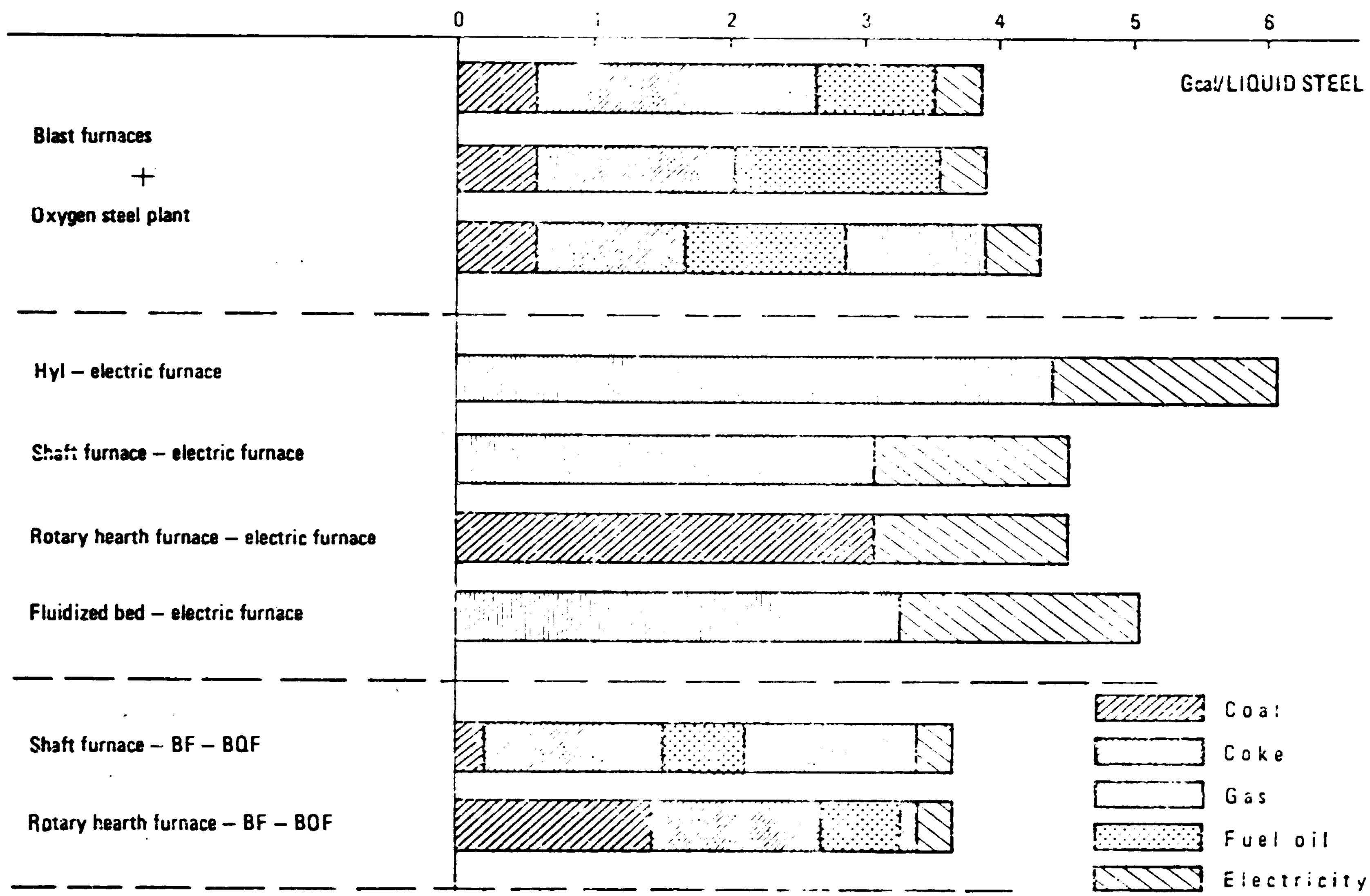
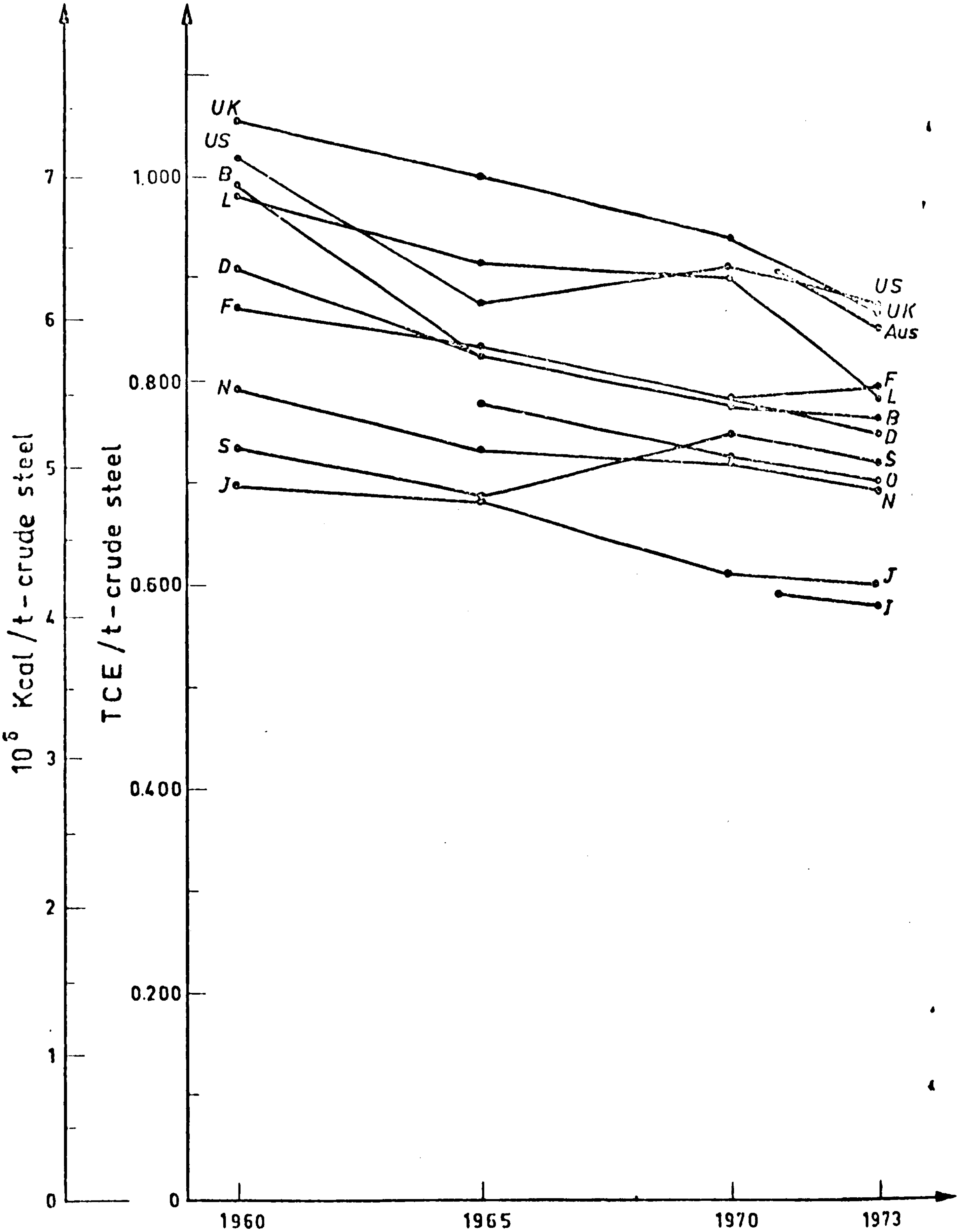


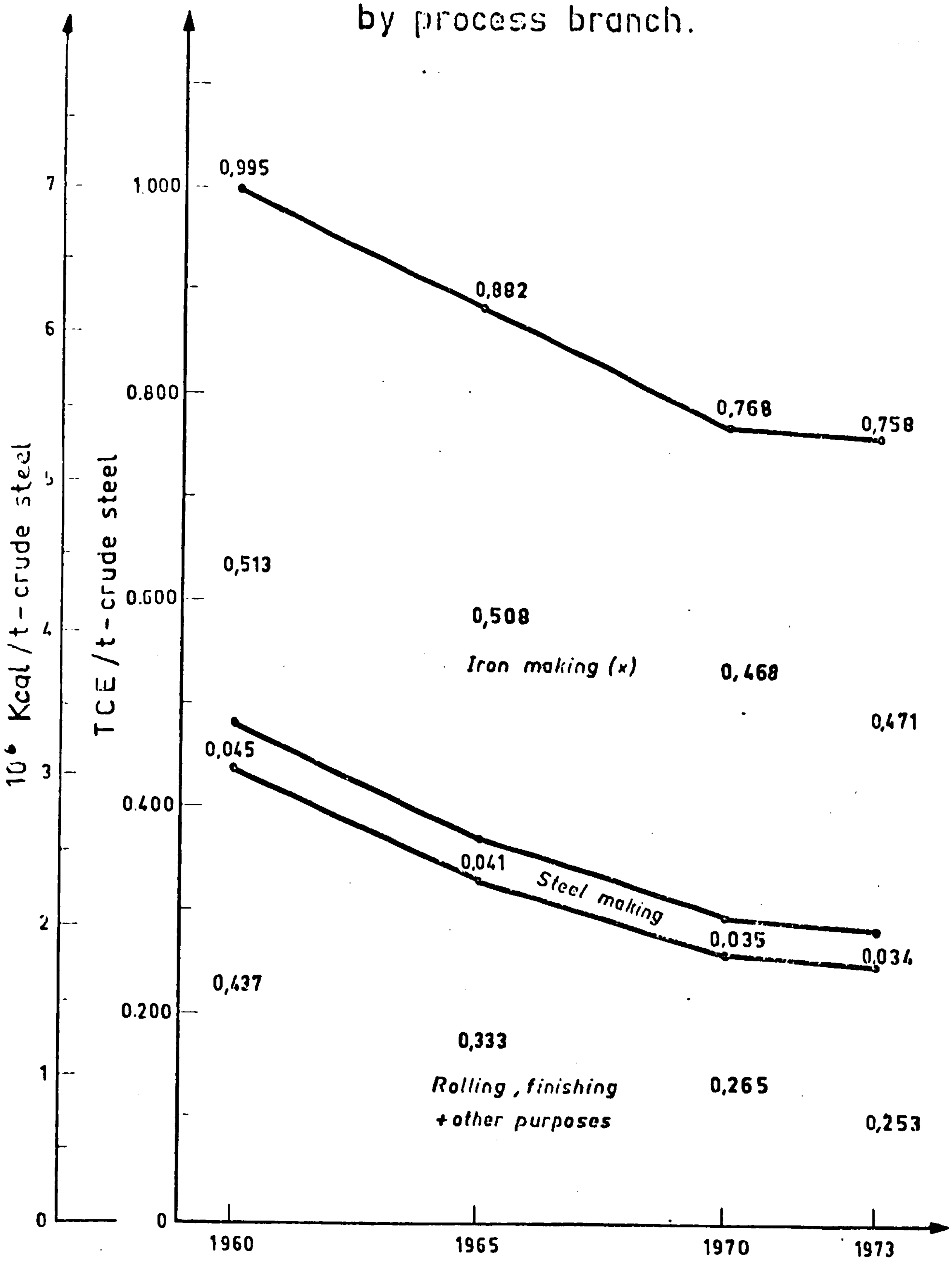
Figure 2.

Overall consumption of energy by country.



Source: IISI/E/F/G/1008/Annex 4.

Fig_3 Overall energy consumption by process branch.



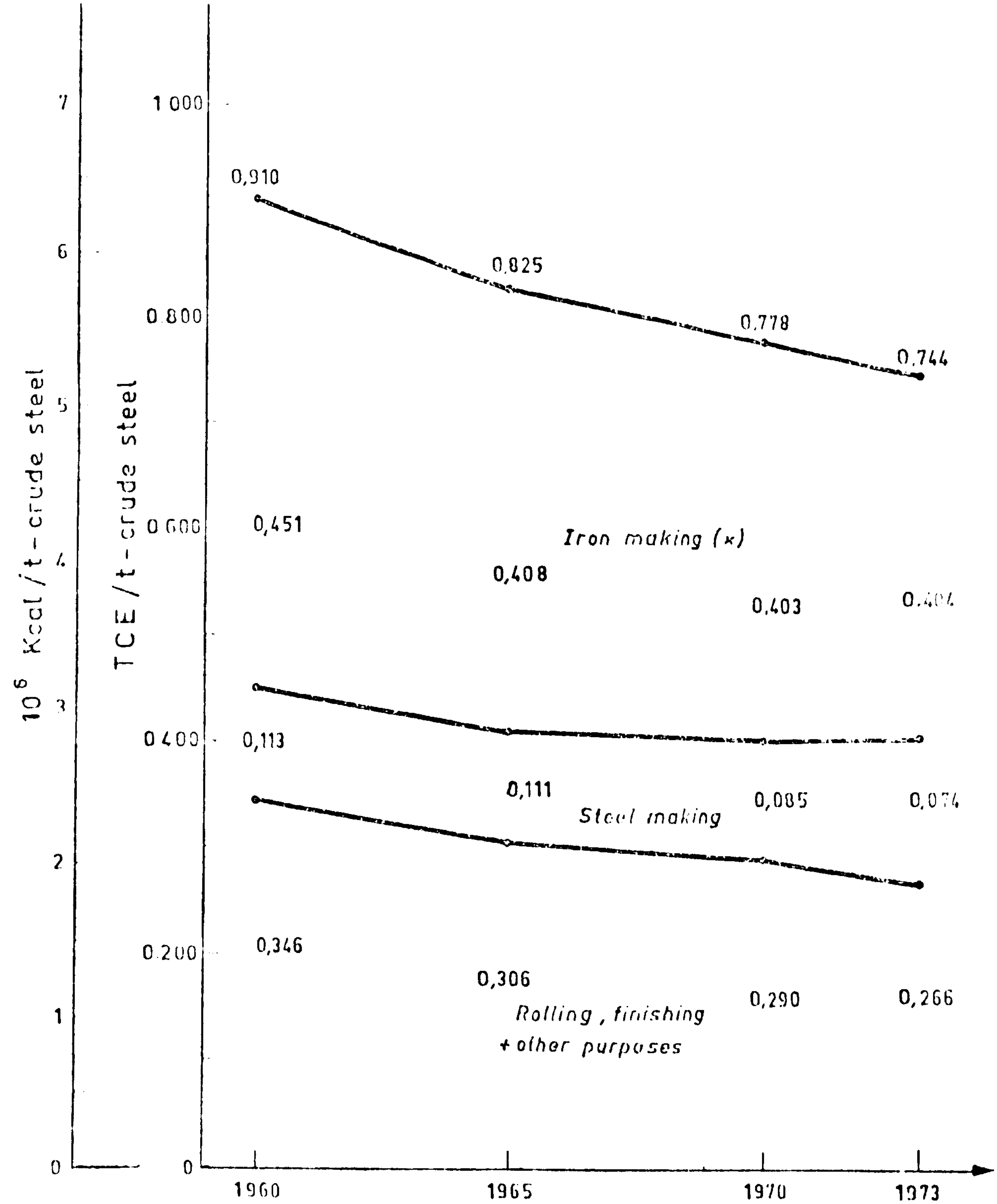
(x) Excluding energy for foundry iron and other use iron

BELGIUM

Source: IISI/E/F/G/1008/Annex 5.

Figure 4.

Overall energy consumption by process branch.



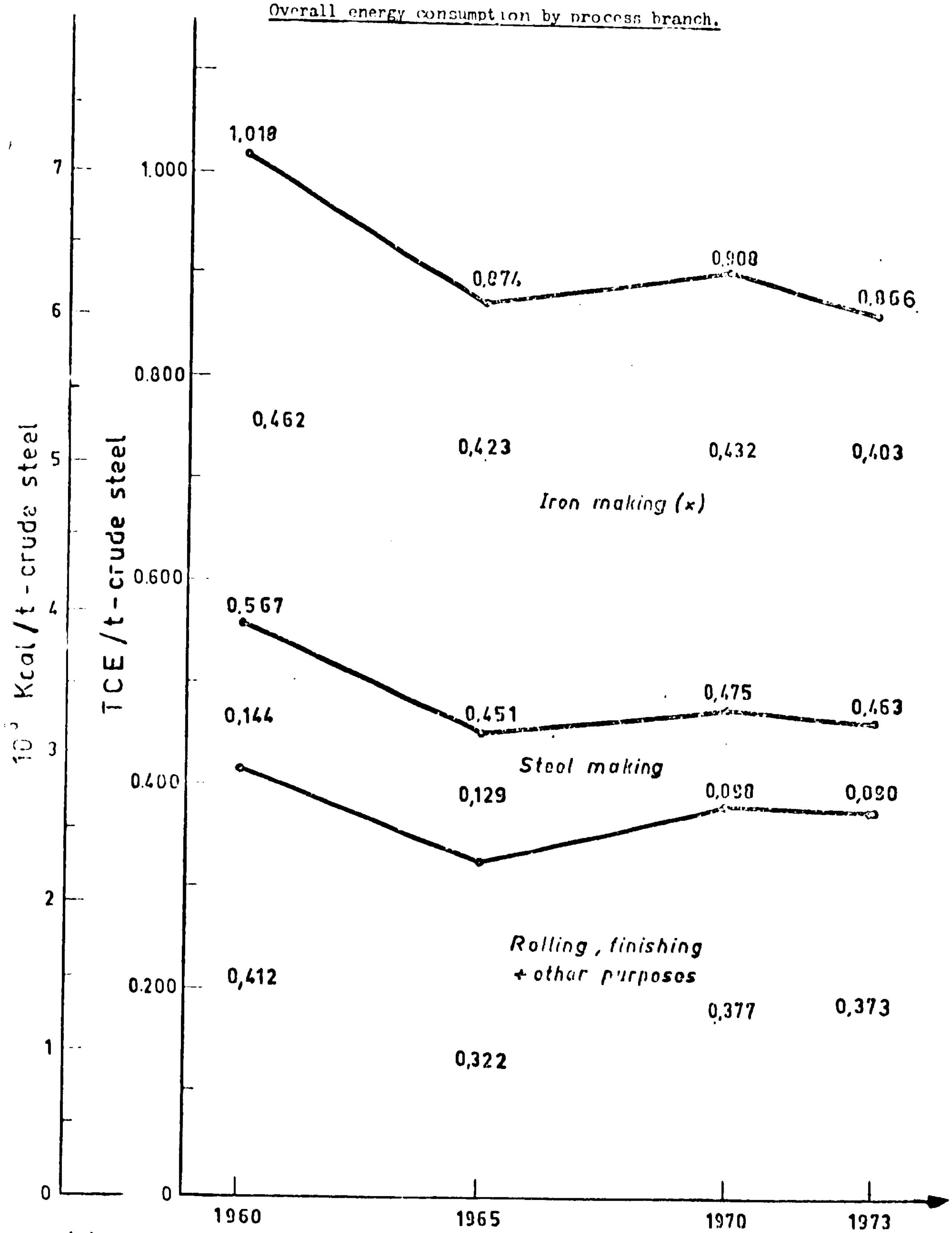
(x) Excluding energy for foundry iron and other use iron

GERMANY

Source: IISI/E/F/G/1008/Annex 6.

Figure 5.

Overall energy consumption by process branch.



(x) Excluding energy for foundry iron and other use iron

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