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MINI-STEEL PLANTS: AN ANALYSIS OF THEIR MAIN CHARACTERISTICS AND LEVEL OF INTEGRATION AND THE POSSIBILITIES FOR CO-OPERATION*

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The objectives of this study are: first, to analyze mini-steel plants as a technological alternative for developing countries that can permit a more integrated development of the iron and steel industry with other economic sectors, thus promoting a more self-reliant industrialization in accordance with the goals of the Lima Declaration and Plan of Action; and second, to analyze the main characteristics, problems and achievements of mini-steel plants in developing and developed countries. The study includes an analysis of data collected in a survey of 74 mini-steel plants in developing and developed countries.

Mini-steel plants are defined as small-scale steel plants that usually include an electric arc furnace for producing steel from scrap and/or directly reduced iron (DRI) and a casting operation. These operations may be integrated downstream with a rolling mill and/or upstream with a plant for the direct reduction of iron. Some mini plants do not include a rolling mill, while others consist only of a rolling mill or other operation for processing semi-finished products (semis) produced elsewhere.

While in developed countries the capacity of mini-steel plants is now usually between 100,000 and 500,000 tons per year (t/a) and may be as high as 1,000,000 t/a, in developing countries their capacity may be only 5,000 t/a or less and is often between 10,000 and 40,000 t/a.

The advantages of mini-steel plants are their relatively low investment cost per ton, their relatively short construction time, and the fact that they can be economically built and operated with a much smaller capacity than is possible with conventional technologies. These advantages have made them a useful alternative to traditional large-scale technologies in the developed countries that are major steel producers and make them an interesting possibility in many cases for developing countries, both for newcomers to the iron and steel sector and for those that already have well-established steel industries. Much of recent investment in steel capacity in both developed and developing countries has been in mini plants.

The 74 plants covered in the survey include a wide range of sizes and a variety of types of plants located in 23 developing and 13 developed countries. They are classified in four main categories: integrated plants that include all operations from the reduction of iron-ore to rolling finished products, semi-integrated plants that start with steel scrap or DRI and produce finished products, plants that produce crude steel from scrap and/or DRI, and plants that process semis into finished products.

A relatively high degree of integration could be observed in both developing and developed countries between mini-steel plants and the construction, capital goods and petroleum industries. More than 70 per cent of the output of all plants studied and 80 per cent of that of those in developing countries is consumed domestically. About three quarters of the output is long products (rod and bar, wire rod, sections); the rest consists of pipes and tubes, crude steel and small percentages of castings and forgings and special steel. The output of about one third of the plants is used entirely by the construction sector, that of another third by both the capital goods and construction industries and that of **about 20 per cent** entirely by the capital goods sector. The output of a further 10 per cent of plants is pipes and tubes used mainly for oil, gas or water, but also for equipment and construction, and that of the remaining plants is used for wire for electrification and construction.

An analysis of the motivating factors that determined the establishment and location of the mini plants studied showed that the most important factor was local demand, the second was availability of raw materials, and others included the availability of skilled labour, of capital, of infrastructure or of energy.

The problems encountered by the plants studied included difficulties with supplies of raw materials and energy, financial difficulties and problems with technology. The areas in which plants were particularly successful included the adaptation of production processes and equipment to local conditions and needs, the production of high-quality products that met national and international standards, and management.

Most of the plants studied had conducted or planned training programmes, including technical training for engineers, skilled and unskilled workers, management training etc.

More than 90 per cent of the plants studied in developing countries, as well as 60 per cent of those in developed countries, are interested in participating in technical co-operation activities. This is significantly more than the proportion of plants that have already participated in such activities in developing countries, approximately 45 per cent, and also more than in developed countries, approximately 50 per cent.

It can be concluded that mini-steel plants represent an important technological alternative for developing countries for establishing a more integrated development of the iron and steel industry with the capital goods industries and other economic sectors in developing countries.

It is essential to make available to developing countries the necessary technological, economic and other information about the mini-steel route that will facilitate planning the development of the iron and steel industry integrated with other sectors of the economy and the selection of suitable technological options that will permit this type of development.

Introduction

In the Lima Declaration and Plan of Action on Industrial Development and Co-operation, in which countries declared their firm intention of promoting the industrial development of developing countries, the importance for developing countries of the full utilization of their natural resources, of self-reliance and of an integrated and multisectoral approach to development is emphasized.1/ In their efforts to attain these objectives, it is stressed, developing countries should devote particular attention to the development of basic industries such as steel, thereby consolidating their economic independence and establishing the indispensable basis for industrialization.2/

In the New Delhi Declaration and Plan of Action, in which countries strongly reaffirmed the Lima Declaration and Plan of Action and their firm determination to strengthen national industries as a fundamental means to self-sustained and comprehensive economic and social development, the importance is stressed, *inter alia*, of measures to assist developing countries in acquiring technology and technical knowledge as part of a strategy for their further industrialization.3/

At the First and Second Consultation on the Iron and Steel Industry, in discussions and recommendations directed towards expanding the steel production capabilities of developing countries, the possibilities of small-scale production of steel were already mentioned.4/ At the Third Consultation, the necessity was stressed of reducing the costs of steel projects by better relating the size of projects both to local capabilities and to markets.5/

1/ *Lima Declaration and Plan of Action on Industrial Development and Co-operation* (PI/38), paras. 24, 29, 49, 50.

2/ *Ibid.*, paras. 52, 58.

3/ *New Delhi Declaration and Plan of Action on Industrialization of Developing Countries and International Co-operation for their Industrial Development* (PI/72), paras. 3, 48, 95-98.

4/ First Consultation on the Iron and Steel Industry, Report (ID/WG.243/6/Rev.1), para.9; Second Consultation on the Iron and Steel Industry, Report (ID/224), para.53.

5/ Third Consultation on the Iron and Steel Industry, Report (ID/291), para.11; "Water use and treatment practices and other environmental considerations in the iron and steel industry" (UNIDO/IS.263), p.37.

The recommendations of the Third Consultation on the Iron and Steel Industry relating to the entry of newcomers into the steel sector emphasized the importance of making the most appropriate experience available to newcomer countries, of promoting South-South as well as North-South co-operation and of assisting these countries in establishing mini-steel plants.6/ During the discussions at the Third Consultation it was stressed that the lack of experience on the part of newcomers was a major handicap and that it was therefore essential to provide better guidance and technical assistance to newcomer countries.7/

At the International Iron and Steel Seminar, organized by UNIDO in co-operation with Pakistan Steel Plant and held in Karachi, Pakistan, from 19 to 27 May 1984, UNIDO was requested to consider the preparation of guidelines relating to the establishment of small steel plants based on the mini-steel route, utilizing the knowledge and experience of experts from developed and developing countries in the preparation of these guidelines.8/ It was also agreed that there should be a greater exchange of information amongst developing countries and between developed and developing countries with regard to experience in the construction and operation of steel plants.9/

As part of UNIDO's programme to implement the various recommendations aimed at assisting newcomers to the steel industry, in particular in connection with the examination of mini-steel plants as a technological alternative well suited to developing countries, a survey was conducted of 74 small-scale steel plants - 50 plants in 23 developing countries and 24 plants in 13 developed countries. The information collected can serve as a basis for further study of mini-steel plants and provide background material for the preparation of guidelines on the establishment and operation of mini-steel plants.

6/ Ibid., para.16.

7/ Ibid., para.94.

8/ International Iron and Steel Seminar, Karachi, Pakistan, 19-27 May 1984, conclusions and recommendations, recommendation no.I-1.

9/ Ibid., recommendation no.IV.-3.

1. Objectives of the study

The recession in which the steel industry has been caught since 1975 has affected the developed market economy countries especially severely; they have suffered sharp reductions in steel production, cuts in earnings and even losses, leading to large-scale capacity closures and widespread unemployment in the industry. In contrast to the trends in the developed countries, many developing countries embarked upon a programme of expansion in the late 1970s and early 1980s. However, with the exception of one or two countries, most notably the Republic of Korea, they have not been able to carry out these plans on schedule. Faced with economic and financial problems, many countries have had to delay or suspend planned projects.[10/]

In this context, the possibility of constructing small-scale facilities with a relatively low investment cost and short construction time gains particular importance for developing countries. It is with this in mind that the present study has been undertaken. The objectives of this study are: first, to analyze mini-steel plants as a technological alternative that can permit a more integrated development of the steel industry in developing countries with other economic sectors such as construction, capital goods, agricultural machinery etc., and make better use of the available natural resources in developing countries; and second, to analyze the main characteristics, problems and achievements of mini-steel plants that have been established in both developing and developed countries.

2. Definition of mini-steel plants

The question of scale has long been considered a serious obstacle to the industrialization of developing countries. Technologies available for transfer from developed countries are adapted to the conditions prevailing in large industrialized countries, where there is a well-developed infrastructure, a large market, and where the cost of labour is high. They

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10/ W.T. Hogan, World Steel in the 1980s: a Case of Survival (Lexington, Mass., D.C. Heath and Company, 1983), p.XV.

are often based on economies of scale and therefore make domestic production using these technologies in developing countries with smaller markets uneconomic or unfeasible in many sectors. In the past this has also been the case with traditional technologies for steel production based on the blast furnace/open hearth or basic oxygen furnace route. However, in the last three decades or so, the small-scale production of steel has played an increasingly important role in developed countries.11/ This technology also represents a particularly promising area for developing countries.

The increasing importance of small-scale steel production has been brought about by a number of technological and economic developments. The production of steel on a small scale in "mini-steel plants" or "mini mills" is based on an alternative route to the conventional blast furnace/basic oxygen furnace route of iron-ore smelting and steelmaking. This alternative route uses electric arc furnaces to melt scrap and/or sponge iron (directly reduced iron - DRI) and convert it into steel.12/

As is pointed out in the literature, it is difficult to agree on a single definition of a mini-steel plant. A widely accepted definition of a mini plant is a small-scale steel plant that melts and refines cold metal (either scrap or directly reduced iron (DRI) or both) in an electric arc furnace and casts it into billet or slab in a continuous casting machine. It may or may not carry out rolling operations on the same site.13/ In many cases a mini-steel plant also includes a direct reduction plant at the same site for the production of the DRI used in the steelmaking process. On the other hand, a mini plant may be a non-integrated facility, such as a re-rolling mill, that uses semi-finished products as inputs which it further processes into finished products. While in developed countries the usual

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11/ See, for example, D.F. Barnett and L. Schorsch, Steel: Upheaval in a Basic Industry (Cambridge, Mass., Ballinger, 1983), pp.83-103.

12/ See: W.K.V. Gale, "Origins and development of small-scale steelmaking", in: R.D. Walker (ed.) Small-scale Steelmaking (London and New York, Applied Science Publishers, 1983), pp.1-20.

13/ Ibid., p.2.

capacity of mini-steel plants was between 50,000 and 500,000 tons per year (t/a) and is now between 100,000 and 500,000 t/a and may be as high as 1 million t/a,[14/] in developing countries mini-steel plants may have a capacity as small as 5,000 t/a or less and are often between 10,000 and 40,000 t/a.[15/]

The types of plants included in the definition of mini-steel plants given here can be classified in four categories:

(a) Integrated plants that include all operations, beginning from the reduction or smelting of iron-ore to iron, through conversion into steel, casting operations and rolling into finished products (rods, bars, sections, flat products, tubes and pipes etc.);

(b) Semi-integrated plants that start with steel scrap and/or directly reduced iron (DRI) as a raw material to produce steel in an electric arc furnace and include casting and rolling into finished products;

(c) Plants that melt scrap and DRI in an electric arc furnace, but only produce crude steel cast into ingots or billets which is then sold to other facilities for rolling into finished products;

(d) Non-integrated plants, such as re-rolling mills, that use semi-finished products ("semis"), such as billets or strips, as inputs and produce finished products by rolling and other operations.

The digram in Figure 1 illustrates the operations that can be included in a mini plant.

14/ Ibid., p.2.

15/ See, for example, S.S. Sidhu, The Steel Industry in India: Problems and Perspective (New Delhi, Vikas Publishing House Pvt. Ltd., 1983), chapter 7, "Mini-steel Industry", pp.81-100.

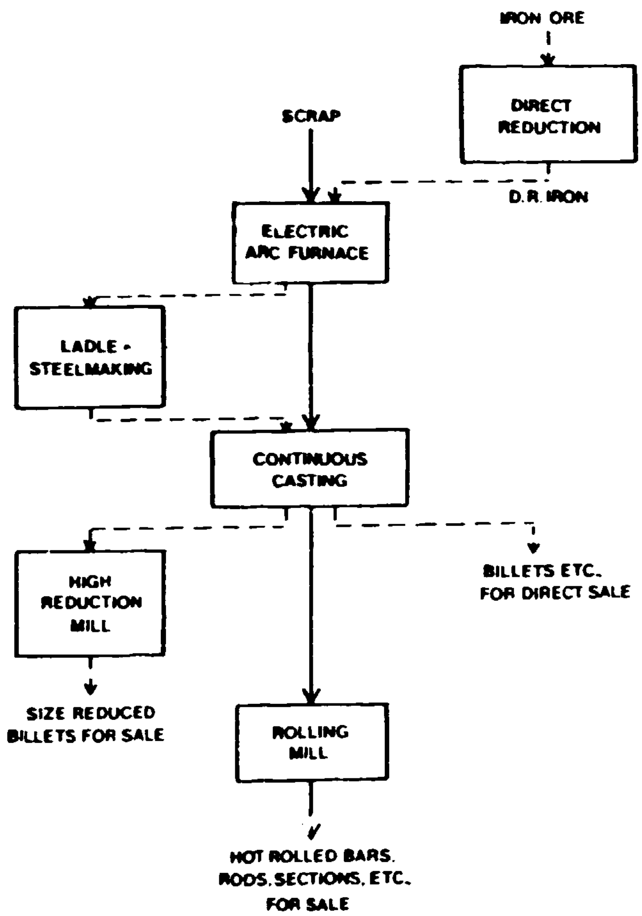

FIG. 1. Schematic diagram showing the features of a typical mini-steelworks. Optional routes are indicated by dashed lines.

Source: W.K.V. Gale, op.cit., p.3.

3. Advantages of mini-steel plants

Mini plants present an attractive option for many developing countries where circumstances are appropriate. Some of the advantages of mini plants are the following: 16/

(a) The total capital investment required for a mini-steel plant is much lower per ton of installed capacity than it is for a conventional route plant. 17/

(b) The construction time can be much shorter, as little as 2 years, in comparison with 4 to 12 years for a conventional plant.

(c) Capacity can be determined by the appropriate size for the country or area and there is greater flexibility of operation to cope with demand fluctuations. This facilitates integration with other sectors at the national and regional level.

(d) Modular construction means that the size of an installation and the range of products can be expanded to meet increased demand; the range of different operations performed at one location, rolling, casting, melting, direct reduction of iron etc., can also be expanded as desired.

(e) Many of the operations and much of the expensive infrastructure needed by a conventional integrated plant, such as a sintering facility or coal coking plant and extensive transport equipment, are not required for a mini plant, which makes this a less complex technological route.

(f) In general, mini plants have lower requirements in terms of highly skilled manpower and management expertise, which has been found to be advantageous in countries where there is a shortage of trained personnel.

16/ See: S.N. Acharya, Mini-steel Industry (ID/WG.363/1), UNIDO, 1982, pp.5-6.

17/ It was estimated in 1981 that the investment cost per ton of installed capacity of a mini-steel plant consisting of an electric are furnace using scrap or a combination of scrap and sponge iron, a continuous casting unit, and a bar mill could be as low as $350 to $450, or in specific cases even lower. This would mean that the investment cost per ton of installing a semi-integrated mini-steel plant is only 40 per cent of the cost of installing an integrated steel plant based on the traditional blast furnace/basic oxygen furnace route. If a direct reduction unit that produces sponge iron is added, thus making a fully integrated mini-steel plant, the investment cost per ton is still only 60 per cent of that of an integrated steel plant based on traditional BF/BOF technology. Ibid., p.19.

(q) The generally less complex processing route in the case of scrap-based plants can mean lower specific labour costs.

In general, many of the disadvantages of large-scale production facilities, which often serve to counteract the possible economy-of-scale advantages, particularly in developing countries, can be, at least to some extent, avoided by the more economical functioning of mini-steel plants.

In the light of these advantages, for a developing country that is considering the various possibilities for installing a steel production facility, whether the country is a relative newcomer to the steel industry, is expanding a small existing industry, or is even a well-established steel producer, a small-scale steel plant may in many cases represent the most favourable choice.

4. Production of mini-steel plants

World crude steel production was 663.4 million tons (Mt) in 1983. Of this total, developing countries accounted for 109.4 Mt or 16.5 per cent. This represents a 100 per cent increase for developing countries since 1974, when their production was only 54.9 Mt or 7.8 per cent of that year's total of 704.5 Mt.18/

Just as it is difficult to provide a single, generally agreed definition of mini-steel plants, so it is difficult to provide a figure for the proportion of world crude steel production that is accounted for by mini plants in developing and developed countries. One problem is to ascertain the number of mini plants world-wide. A 1983 figure put the number of mini-steel works in the world at 260.19/ This includes plants in more than 50 countries that range in capacity from 30,000 to 1 Mt/a. While this figure includes integrated and semi-integrated small-scale steel plants that produce reinforcing bars or other rolled products as well as those that only produce

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18/ Steel Statistical Yearbook 1984 (Brussels, International Iron and Steel Institute, 1984), Tables 1 and 2.

19/ W.K.V. Gale, op.cit., p.8

billets, it excludes re-rolling mills and other facilities that only process semi-finished products into finished products.

There is a clear trend towards an increasing proportion of world steel production by mini plants. For example, while the growth rate of world crude steel production between 1969 and 1979 was approximately 1.8 per cent, the corresponding rate for production by the mini-steel route was 5.3 per cent.[20/] Much of the recent investment in new steel plants in large steel-producing countries has been in mini plants. In the United States, practicaly all new crude steel capacities are based in mini-steel plants. In 1980, approximately 27 per cent of the production of crude steel in the United States was in mini plants, in Italy 55 per cent, in Japan 23 per cent, and in the EEC countries 26 per cent.[21/]

The growth rate in developing countries is equally impressive. India already has approximately 2.5 Mt of installed capacity in mini-steel plants. Other countries which are installing or have installed mini-steel plants, including facilities for the direct reduction of iron, include Argentina, Brazil, Mexico, Nigeria, Qatar, Trinidad and Tobago, and Venezuela. The projected figures for 1990 are that Mexico may add another 10 Mt/a capacity Venezuela 6 Mt/a and Brazil 4 Mt/a.[22/]

5. Characteristics of mini plants

(a) Types of plants

As has already been pointed out, there is a diversity of definitions of mini plants, both in terms of size, and with reference to other characteristics. Therefore the 74 plants included in the present study

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20/ ID/WG.363/1, op.cit., p.7.

21/ W. Korf, "The significance of scrap and DR iron for steel production in the 1980s", The British Steel Maker.

22/ ID/WG.363/1, op.cit., p.7.

cover a wide spectrum of types and sizes and are located in all regions of the world (see Table 1, p.34).

Two thirds of the plants in the sample are located in developing countries and one third in developed countries. Of those in developing countries 60 per cent are in Asia, 25 per cent in Latin America, 10 per cent in Africa, and the others in the Middle East and Europe.[23/] Of those in developed countries 80 per cent are in Europe and 20 per cent in the United States, Australia and New Zealand. Classified by type, there are 4 integrated plants, 43 semi-integrated plants that produce finished products, 9 plants that produce only crude steel (ingots and semi-finished products, "semis"), and 18 plants that process semis into finished products.

The 50 plants studied in developing countries cover the four main categories of mini plants: 50 per cent are semi-integrated plants that produce finished products, 30 per cent process semi-finished products into finished products, 12 per cent produce crude steel that is further processed elsewhere , and 8 per cent are integrated plants. The regional distribution is as follows: Africa, 3 semi-integrated plants and 2 plants that process semis; Asia, 15 semi-integrated plants, 6 that produce crude steel and 9 that process semis; Latin America, 4 integrated plants, 7 semi-integrated plants and 1 plant that processes semis; Middle East, 2 plants that process semis; and Europe, 1 plant that processes semis.

Seventy-five per cent of the 24 plants studied in developed countries are semi-integrated and the rest is equally divided between producers of crude steel and processors of semis. The breakdown is as follows: 18 semi-integrated plants, 14 in Europe, 2 in Oceania, and 2 in the United States; 3 producers of crude steel, all in Europe and 3 processors of semis, 2 in Europe and one in the United States.

23/ In this study Yugoslavia, which is a member of the Group of 77, is included in the developing countries and Turkey, which is a member of Group B, is included in the developed countries of Europe.

(b) Size of plants

A disaggregation of the plants in the study in terms of size reveals a significant difference between developing and developed countries (see Table 2, p.35 and Tables 3-6, pp.36-54). Nearly half (48 per cent) of those in developing countries have an annual capacity between 5,000 and 40,000 tons, another 16 per cent are between 41,000 and 100,000 t/a, 26 per cent are between 101,000 and 200,000 t/a, and 10 per cent have a capacity greater than 200,000 t/a.

This contrasts with the pattern in the developed countries, where only 12 per cent of plants in the study have an annual capacity of 40,000 tons or less, 21 per cent between 41,000 and 100,000 tons, 42 per cent between 101,000 and 200,000 tons, and 25 per cent can produce more than 200,000 t/a.

The average sizes of the plants studied vary widely between the groups of developing countries. The average annual capacity of the 12 Latin American plants, 230,000 t/a, is the largest, and next is the plant in a European developing country, with 170,000 t/a. The average sizes on the other continents are much smaller: in Africa it is 60,000 t/a, Asia, 50,000 t/a, and the Middle East, 40,000 t/a.

Plant size was seen to be closely related to the type of plant. The largest studied were the integrated plants, all located in Latin America, which range in size from 150,000 t/a to 650,000 t/a. The semi-integrated plants studied were of all sizes: 25 per cent are between 2,500 and 40,000 t/a, 19 per cent between 41,000 and 100,000 t/a, 37 per cent between 101,000 and 200,000 t/a, and 19 per cent larger than 200,000 t/a. The processors of semi-finished products tended to be small, 55 per cent between 5,000 and 40,000 t/a, 22 per cent between 41,000 and 100,000 t/a, 17 per cent between 101,000 and 200,000 t/a, and only 6 per cent over 200,000 t/a. The smallest on average were the producers of crude steel. All of the ones in India and one in Europe were between 18,000 and 50,000 t/a, and only two located in Europe produced more than 100,000 t/a.

Most of the plants studied in developing countries (approximately 85 per cent) had plans to expand capacity or modernize or both, or had just finished expanding capacity. In developed countries, more than 60 per cent of the plants studied had plans for modernization or expansion, although most of these were for modernization rather than expansion, apparently a reflection of the current situation of excess capacity in developed countries.

(c) Age of plants

More than half (54 per cent) of the mini plants in the survey have begun production since 1970. Forty-four per cent began production between 1970 and 1979 and 10 per cent have begun since 1980. (The survey included one project that will start up in 1988.) Twenty-one per cent started up between 1960 and 1969, 14 per cent between 1945 and 1959, and 11 per cent before 1945 (the oldest began production in 1906) (see Tables 3-6, pp.36-54).

Significant differences can be seen in the age of plants between the developed and developing countries. For example, while 43 per cent of the mini plants in developed countries were built before 1960, in developing countries it was only 17 per cent.

In developed countries 30 per cent of the mini plants began production between 1970 and 1979 and 13 per cent between 1980 and 1985. Thirteen per cent started up between 1960 and 1969, 17 per cent between 1945 and 1959, and 26 per cent before 1945.

In developing countries 50 per cent of the plants studied began production between 1970 and 1979, and 25 per cent between 1960 and 1969. Only 8 per cent of the plants have been built since 1980, a reflection of the difficult financial situation of most developing countries. There are many fewer older plants than in developed countries: 13 per cent started up between 1945 and 1959 and 4 per cent before 1945. Specifically: in Asia, 21 per cent of the plants were built between 1960 and 1969, 69 per cent between 1970 and 1979, but only one plant (3 per cent) since 1980. In Latin America, the average age of the plants is greater, 36 per cent were built before 1960, 36 per cent between 1960 and 1969, and 27 per cent since 1970. The five African plants in the study were all built in different decades between 1947 and 1983.

(d) Technologies used and their source

(i) Semi-integrated plants

Fifty per cent of the plants in developing countries included in this study are semi-integrated installations, consisting of electric arc furnaces, casting operations (in most cases continuous casting), rolling mills, in some cases forging operations, and various finishing processes (see Table 3, pp.36-46). There is a great diversity in the sources of technology used in these plants, including Federal Republic of Germany, France, Italy, Japan, Sweden, Switzerland and the United States.

In developed countries, 75 per cent of the plants studied are semi-integrated plants, also consisting of electric arc furnaces, casting (mostly continuous casting), rolling mills and in some cases forging operations.

(ii) Integrated plants

Two of the four fully integrated plants included in this study, the one in Brazil and the one in Mexico, which have annual capacities of 240,000 t/a and 650,000 t/a respectively, use the Mexican Hyl process for the direct reduction of iron (see Table 4, p.47).[24/] The HyL process uses natural gas as the reducing agent and thus its feasibility depends on the availability and price of natural gas supplies. The sponge iron which is produced by this process is then used as the input, together with scrap, for steelmaking in electric arc furnaces. The other technologies used in the Brazilian plant are Stein Surface, France, for the electric furnace, and Schloemann and Villares from the Federal Republic of Germany and Brazil, respectively, for the rolling mill.

24/ The other two small-scale integrated plants which were studied do not fit the standard category of mini plants as they smelt iron-ore by the blast furnace route, both using domestic charcoal as a reducing agent. The one in Argentina, which started production in 1945, has a capacity of 170,000 t/a and the one in Paraguay, which will begin production in 1985, has a capacity of 150,000 t/a.

(iii) Plants that produce crude steel

One variant of the mini-steel plant concept is a plant that produces crude steel in the form of ingots or billets. The installation thus consists primarily of an electric arc furnace and either a continuous casting unit or other casting operation; there is no rolling mill in the facility. The crude steel plants studied in developing countries are all in India and use domestic technology (see Table 5, pp.48-50).

The crude steel plants studied in developed countries were located in Italy and Sweden. They used either continuous casting technology and produced billets which were sold to rolling mills or cast ingots destined to be used to produce forged products (see Table 5, p.50).

(iv) Plants that process semi-finished products

This study of mini-steel plants also included non-integrated small-scale plants that use semi-finished products (crude steel) produced elsewhere as inputs and produce final products (see Table 6, p.51-54). The plants of this type included in this study in developing countries fall into two categories. One type are the re-rolling mills that produce long products for construction, mainly bars. Sources of technology for this group are India, Italy and Japan. The other type of plant are those that produce pipes and tubes. The operations in these plants include welding steel strips or coil into pipes, threading the pipes, galvanizing them etc. While most of the plants processing semis that were studied were located in developing countries, a few were located in developed countries as well, both re-rolling mills and a producer of welded tubing.

(e) Raw materials and energy used by mini plants

(i) Semi-integrated plants

All of the semi-integrated plants in developing countries in this study use scrap as their basic raw material; of these, more than half (60 per cent) also add alloys and 3 (2 in India, one in Colombia) also use directly reduced iron (see Table 3, pp.36-46). While half of the plants are able to meet their demand for scrap exclusively from domestic supplies (Egypt, Kenya, Philippines, Sri Lanka, Thailand, most Brazilian plants and a few Indian plants), the other half must supplement domestic scrap with imports (most Indian plants, Republic of Korea, Colombia, Venezuela) and the Indonesian plant uses 100 per cent imported scrap. While India, the Philippines, the Republic of Korea, Brazil and Venezuela use domestic as well as imported alloys, the plants in Egypt, Sri Lanka, Thailand and Colombia import 100 per cent of supplies of alloys. In a number of the plants in developing countries other essential inputs must be imported. Bottlenecks in importing these supplies can create severe problems.

The energy sources used by these plants, besides electricity, are fuel oil (Egypt, India, Indonesia, Republic of Korea, Philippines, Sri Lanka, Thailand, Brazil), propane gas (Republic of Korea), liquefied petroleum gas (Philippines and Sri Lanka) and coke (Egypt).

All of the semi-integrated plants in developed countries in this study use scrap and 40 per cent also add alloys as raw materials. None of them uses directly reduced iron (see Table 3, pp.36-46). While more than half the plants are able to supply their scrap requirements from domestic sources (France, Switzerland, United Kingdom, Australia, New Zealand, United States), the other plants use both domestic and imported scrap (Finland, Greece, Italy, Netherlands, Spain, Sweden, Turkey). Two thirds of the plants that add alloys to the scrap obtain these from domestic suppliers, while one third uses imports. Two plants use also crude steel billets, one domestic and one imported.

The energy sources that are used by these plants, in addition to electricity, are natural gas (Finland, United Kingdom, Australia, New Zealand, United States) and fuel oil (France, Greece, Spain, Turkey).

(ii) Integrated plants

As was pointed out, the integrated plants in the study are all in Latin America (see Table, 4, p.47).[25/] The plants in Brazil and Mexico use domestic iron-ore and domestic scrap as raw materials. They both use natural gas for direct reduction by the HyL process. The energy sources used are electric, natural gas, and fuel oil (Brazil).

(iii) Plants that produce crude steel

All of the plants producing crude steel in developing countries that were included in this study are located in India (see Table 5, pp.48-50). Half of them use only domestic scrap while the other half uses both domestic and imported supplies; one also uses domestically produced DRI and one adds alloys from domestic sources. In addition to the electric power used by all plants, one plant uses oil as well.

The plants producing crude steel in developed countries in the study, located in Italy and Sweden, use both domestic and imported supplies of scrap as inputs (see Table 5, p.50). Besides electricity, one Italian plant uses liquefied petroleum gas and one Swedish plant uses fuel oil as energy sources.

(iv) Plants that process semi-finished products

The plants that process semi-finished products located in developing countries that are included in this study are either rolling mills that produce long products from cast billets or tube mills that produce pipes and tubes from steel strip or coil that was rolled elsewhere (see Table 6, pp.51-54). Most of the plants depend on imports for all or some of their raw materials (Mauritius, Nigeria, Bangladesh, Malaysia, Yugoslavia, Ecuador, Jordan, Kuwait). Only the plants located in Pakistan and one in Bangladesh use domestically supplied inputs exclusively.

25/ As already pointed out, the two small-scale integrated plants in Argentina and Paraguay smelt iron-ore in blast furnaces. Both rely on imported iron-ore and also add imported alloys; the plant in Argentina also adds domestic scrap. The charcoal used as a reducing agent by both plants is domestic. The energy sources are electric and furnace gas.

The energy sources used (some use more than one type of energy) and their distribution are: electricity 75 per cent, oil 50 per cent, natural gas 25 per cent, and one plant uses only furnace gas.

The plants studied in developed countries that process semi-finished products include re-rollers that produce bars and sections from billets and a tube mill that produces welded tubing. While the American plant uses only domestic billets, the plant in Turkey uses both domestic and imported inputs and the one in France only imports. All plants studied use electricity, one also uses oil and one also uses gas (see Table 6, p.54).

6. Integration of mini-steel plants with other industrial sectors

An integrated approach to the development of the iron and steel industry with other economic sectors, especially the capital goods sector, in developing countries is important in order to ensure an integrated and interlinked industrial sector, to promote further processing of semi-processed and processed raw materials, thus increasing national value added, to permit better utilization of investment and resources, and to promote a more self-reliant industrialization process. Particularly, but not exclusively, for smaller-sized countries, small-scale production of steel in mini plants can provide an alternative route that permits a more self-reliant development of the iron and steel industry as well as a more integrated development with the capital goods and other sectors.[26/]

The examination of the production structure, destination and final uses of the products produced in the mini plants studied in both developed and developing countries undertaken in the following section reveals a significant degree of integration of mini-steel plants with the construction, capital goods and petroleum industries. More than 70 per cent of the output of the

26/ For a detailed analysis of the integration of the iron and steel industry with the capital goods industries and with the agricultural and agro-industries sectors, see: S. Samarapungavan, Integrated Development of Steel Industry, Particularly Mini-steel Linked to Capital Goods and Agricultural Machinery, April 1984 (paper prepared by a UNIDO consultant).

plants studied overall and 80 per cent of that of those in developing countries is destined for domestic consumption. Approximately three quarters of the output consists of long products (rod and bar, wire rod, sections); most of the rest is pipes and tubes or crude steel, with small percentages of castings and forgings and special steel. Thirty-six per cent of all the plants in the study produce steel entirely for the construction sector, another 30 per cent of the plants produce for both the construction and capital goods sectors, and another 22 per cent of the plants produce entirely for the capital goods sector. About 10 per cent of the plants produce pipes and tubes, mainly for the petroleum industry, gas or water, but also for factory equipment parts and construction, and the remaining plants produce wire used for electrification and construction.

(a) Production structure of mini plants

Tables 7 and 7a (pp.77-78) give an overview of the types of products produced by mini-steel plants and the proportions of these products produced by the plants in the study. One of the distinguishing characteristics of mini-steel plants in developed countries is that they are usually designed to produce a limited range of products.[27/] This is, however, more true of the plants in developed countries, where the output of a mini plant is aimed at a clearly defined section of the market, than in developing countries, where mini-steel plants have to be more flexible and produce a wider range of types of products for a variety of end uses.[28/]

A large proportion of the output of mini-steel plants in both developed and developing countries comprises rod and bar products and wire rod and wire products. For the plants covered in this study the figures (calculated on the basis of percentages of tons produced, as shown in Tables 7 and 7a) are: 41 per cent rod and bar products and 22 per cent wire rod and wire products. The percentage of other products are: pipes and tubes, 11 per cent; ingots and semis, 10 per cent; section products, 10 per cent; castings and forgings, 3 per cent; and special steel, 3 per cent.

27/ See W.K.V. Gale, op.cit., and J.D. Snarp, Rolling Mills for Mini-steel Plants, in: R.D. Walker (ed.), op.cit., pp.115-148.

28/ Ibid., p.116.

In the plants studied in developing countries, while rods and bars and wire rod and wire products dominate overall, pipes and tubes form a significant proportion of the output of those plants that process semis (58 per cent) and integrated plants (37 per cent). A similar pattern holds true in the plants studied in developed countries: rod and bar products and wire rod and wire products account for 70 per cent of total output (78 per cent in semi-integrated plants), while pipes and tubes account for 48 per cent of the output of the plants that process semi-finished products.

The regional patterns of production of the plants studied in developing countries are quite diverse (see Tables 3-7). In the African plants most of the output is rod and bar products, with a small percentage of castings and wire. In the Middle East plants (Kuwait and Jordan) and the plant in Yugoslavia 100 per cent of production is pipes and tubes. In the Latin American plants, approximately 70 per cent of output is rod and bar products and wire rod and wire, 20 per cent tubes and pipes (Mexico), 5 per cent crude steel, and the remainder distributed among various products. In the Asian plants, approximately 45 per cent of output is rod and bar products and wire rod and wire products, 20 per cent crude steel, 20 per cent special steel, 10 per cent sections and the rest various.

(b) Destination of the output of mini plants

Approximately 72 per cent of the output of the mini plants in this study is for domestic consumption and 28 per cent is exported[29/] (see Tables 3-7). The plants studied in developing countries tended to concentrate more on production for the domestic market than those of developed countries; approximately 80 per cent of their output is for domestic use. For the plants studied in developed countries about 64 per cent is destined for domestic consumption and 36 per cent is exported. There are wide regional variations within the country groupings. Among the developed countries, the share of exports in total production is highest for the European plants studied and

29/ The countries of destination of the exports of the plants studied were not reported.

lowest for the US plants. The figures are: 40 per cent for the European plants, 20 per cent for the plants in Oceania, and only a small percentage for the US plants. Of the developing countries, the largest percentage is exported by the plant in Yugoslavia, which exports 50 per cent of its products. In Asia only the Korean plants export 40 per cent of their production; the plants in other Asian countries export between zero and 5 per cent of their output. Twenty-six per cent of the production of the Latin American plants is exported, some of the production of the Middle East plants (the percentage was not given), and less than 1 per cent of the total output of the African plants.

(c) Main uses of products of mini plants

The analysis of the main uses of the output of mini plants can be best undertaken by examining the individual categories of products.30/ The crude steel (ingots and semis) produced is mainly destined for the construction and capital goods sectors. Part of it is further processed in rolling mills, where it is rolled into bars and sections, which are mainly used in construction, and part of it is forged into parts for machinery and equipment. Wire rod is used for drawing into wire and other products such as nails; the uses include construction, electric wires, barbed wire used in agriculture, spokes for wheels of bicycles and motor vehicles, machinery etc. The rod and bar products are primarily used in construction, as concrete reinforcing bars etc., but are also used for forging, for motor vehicle parts and machinery. Section products are mainly used for construction but also in manufacturing tools and motor vehicle parts. Steel castings are used as parts in motor vehicles, machinery, equipment etc. Pipes and tubes are used for water, oil, gas etc., for equipment in processing industries, in construction, as poles and in metal furniture. Special steel is used in the manufacture of motor vehicle parts, machinery, chemical tanks and piping, armour plate, gun barrels etc.

30/ For a breakdown of the uses of individual iron and steel products in the capital goods and agro-based industries see: S. Samarapungavan, op.cit., Annexures 9 and 10.

The final uses of the products of the mini plants studied that were described above can be grouped into the following four main categories: construction; manufacture of equipment, machinery, motor vehicle parts, tools, and other industrial products (generally capital goods); pipes for the petroleum industry, for gas and water; and wire used for electric wire.

Some differences could be observed in the patterns of use of the output of plants studied between those in developing countries and those in developed countries, as well as in the patterns of use of output of different types of plants (see Tables 8 and 8a, pp.79-81). In developing countries, the output of one third of the plants (34 per cent) was used entirely for construction; the output of 28 per cent of plants for both construction and the manufacture of capital goods; that of 20 per cent entirely for manufacturing capital goods; that of 10 per cent for pipes for oil, water and gas; and the output of the remaining 8 per cent for wire and pipes for other uses. In the developed countries, the output of 42 per cent of the plants studied was used entirely for construction, that of 33 per cent for both construction and the manufacture of capital goods; and that of 25 per cent of the plants entirely for the manufacture of capital goods.

Regional differences can be observed in the main uses of the output of the mini plants studied in developing countries. In Africa the output of 80 per cent of the plants studied was used for construction and that of 20 per cent for both construction and capital goods. In Asia the output of 37 per cent of the plants was used for construction only, that of 30 per cent for construction and capital goods, that of 23 per cent for capital goods only, and that of 10 per cent for pipes used for water, gas and construction. In Latin America the output of 17 per cent of the plants was used entirely for construction; that of 33 per cent for both construction and capital goods; that of 25 per cent only for capital goods; that of 17 per cent for both electric wire and construction, and that of 8 per cent for both oil pipes and machinery parts. The output of the plants studied in the Middle East (Kuwait and Jordan) and in Yugoslavia consists 100 per cent of pipes for water, oil and gas.

An examination of the main uses of the output of the various types of plants studied in developing and developed countries (see Table 8a, p.81) shows that for the semi-integrated plants, the output of 30 per cent of the plants was used entirely for construction, that of 35 per cent for both construction and capital goods, that of 30 per cent only for capital goods, and that of 5 per cent for electric wire and for construction. The pattern for crude steel producers is that the output of 33 per cent of the plants was used for construction, that of 56 per cent for both construction and capital goc s, and that of 11 per cent for capital goods only. The plants that process semi-finished products into finished products exhibit a somewhat different pattern. More than half of them (56 per cent) produce entirely for construction uses, 11 per cent of them for capital goods, and 33 per cent produce pipes for oil, water and gas and for construction.

7. Motivating factors for the establishment and location of plants and choice of technology

An analysis of the motivating factors that determined the establishment and location of the mini-steel plants in both developed and developing countries covered in this study reveals that the most important factor by far was the local demand, which was mentioned for 82 per cent of all plants and for 93 per cent of plants in developing countries (see Tables 3a-6a, pp.55-76). The second most important factor is the availability of raw materials, which was mentioned by 45 per cent of plants in both developing and developed countries. Some of the other factors that were mentioned were the availability of skilled labour, of capital, of infrastructure and of energy. For one plant in India, the motivating factor was government incentives.

Looking at the factors that determined the choice of technology, no single factor was most important. Some mentioned that the ty [illegible] product to be produced determined the required technology; others sta [illegible] at the technology was the most cost-efficient, produced the necessary quality, had the highest productivity, was the best, most reliable, most modern or appropriate. Individual plants also mentioned that a technology was chosen because it had the shortest gestation period, or because it was provided with the best aid terms.

8. Problems encountered

(a) Developing countries

The problems encountered by the plants in developing countries that were studied can be classified in five main groups: raw materials, energy, technology, financial and others (see Tables 3a-6a, pp.55-76). Certain patterns could be observed according to geographical areas.

(i) Africa

The plants in Africa encountered problems with shortages of raw materials, specifically shortages of local scrap, as well as shortages and high prices of electric power. There are problems with outmoded technology, a lack of training facilities and consequent shortage of trained manpower. Financial difficulties include hard currency shortages, interest and repayments on foreign debt, and lack of available financing. Other problems encountered include an inadequate infrastructure, and lack of testing facilities for quality control.

(ii) Asia

The Asian plants in this study face problems with raw materials, both in terms of availability and quality, specifically the irregularity of supply and the high prices and lack of foreign exchange to buy imported raw materials. India presented an exception to this pattern; the plants there generally had no major problems with raw materials. Energy was the area in which particularly the Indian plants faced problems of shortages and irregularity of the electric power supply; this was seen by many as their main problem. In connection with technology, there are problems with imported spare parts, a shortage of foreign experts and the cost of modern technology. Others complained of obsolete technology, a too small furnace, low yields and frequent breakdowns. Only a few plants in Asia mentioned financial constraints. Other problems faced by some plants included inadequate infrastructure and difficulty recruiting trained personnel.

(iii) Latin America

With reference to raw materials, the plants in Colombia and Venezuela reported problems with importing scrap, while only one plant in Brazil reported problems in obtaining raw materials. The Latin

American plants did not report any problems with energy. Problems related to technology included a shortage of spares (due to lack of foreign currency) and manufacturing specific products. Some financial problems were reported, including high interest rates. Other problems encountered were market fluctuations and language difficulties.

(iv) Europe and the Middle East

The plant studied in a developing country in Europe (Yugoslavia) reported that, while not faced with any insurmountable problems, it had experienced difficulties in obtaining supplies of raw materials as well as specific technical difficulties in the plant production line. The plants studied in the Middle East reported no significant problems in any area.

(b) Developed countries

It is instructive to compare the problems encountered by developing countries with those of developed countries. The plants studied in developed countries also encountered most of their difficulties in relation to raw materials. Here the major problem was the cost of raw materials, both the high and fluctuating price of scrap being mentioned. The poor quality of scrap (Finland), the necessity of importing it (France, Italy), and scrap shortages (New Zealand) also gave rise to complaints. The high price of energy (United Kingdom) was mentioned.

In connection with technology, both high cost (Italy) and the need to import it (France) were seen as problems. Financial problems included the lack of capital and high cost of capital, insufficient past investment, and high working capital requirements. Other problems faced by these plants were market fluctuations (France), fluctuating prices (Italy), and having to compete with government-subsidized European producers (United Kingdom).

9. Areas of success

Some of the areas in which the plants studied achieved successes were in adapting processes and equipment to local conditions and needs and in the quality of product they produce (see Tables 3a-6a, pp.55-76).

The African plants studied all reported success in adapting processes and equipment to local conditions and needs; for example, one mentioned maximizing EAF production. Most also mentioned quality of product, meeting international standards.

Approximately 75 per cent of the plants studied in Asia were successful in the adaptation of processes and equipment to local conditions and needs; specific areas mentioned were the volume of production achieved, developing sophisticated grades of steel and continuing to work successfully under adverse conditions such as energy shortages, inadequate infrastructure etc. About two thirds of the plants also reported success in the quality of products, which met or surpassed national and international standards. Other areas of success were good management, good labour relations, good service to clients.

The area in which almost all Latin American plants studied achieved success was in the quality of product produced, succeeding in meeting standards for all different product qualities, including highest grades of steel. Fifty per cent of the plants also reported success in adapting processes and equipment, specifically in the volume of steel produced and in developing new products. Another area in which success was achieved was in the development of human resources.

The plants studied in both Europe and the Middle East were successful in the area of quality, meeting international standards of quality for the products produced.

10. Training programmes

Most of the plants studied in both developing and developed countries (more than 85 per cent) had carried out or planned training programmes in some or all of the following areas: technical training for engineers, for skilled workers, for ordinary workers, management training, and training in other areas such as language, safety etc.

Ninety-five per cent of the semi-integrated plants in developing countries provided or planned training as did 80 per cent of the plants that process semi-finished products, 75 per cent of integrated plants and

50 per cent of those that produce crude steel. In the case of some of the plants that process semis, the view was expressed that training was not necessary, apparently a reflection of the static nature of the technology and the work force in those plants and not representative of the general pattern.

11. Technical co-operation activities in mini-steel plants

More than 90 per cent of the plants studied in developing countries, as well as over 60 per cent of those in developed countries, expressed interest in participation in technical co-operation or technical assistance activities (see Tables 3a-6a, pp.55-76). This is significantly more for developing countries and also more for developed countries than the proportions of plants that have already participated in technical co-operation activities, which are approximately 50 per cent for developed and only 45 per cent for developing countries. (A difference in the general pattern was observed for semi-integrated plants, where two thirds of those in developing countries and over 60 per cent of those in developed countries have participated.)

The areas in which plants in developing countries expressed interest in receiving technical assistance include technological advances (electric arc furnace technology, ladle metallurgy, continuous casting, rolling); training in various areas, for example to achieve improvements in operation and maintenance procedures; improving quality and quality control; increasing productivity; saving energy; reducing costs; as well as training in administration, management, accounting, financial procedures etc.

Several of the plants in developing countries also demonstrated capabilities for providing technical assistance. Particularly in countries that have a great deal of experience in mini-steel production, such as India, there has also been a considerable amount of domestic technical co-operation, i.e. co-operation with other plants, within the same country. Domestic technical co-operation was also reported in Brazil, Egypt and Pakistan. Some developing countries in which plants expressed willingness to provide technical assistance included Brazil, India, Mexico and Yugoslavia.

KEY TO TABLES

General abbreviations

n.a. = not available

– = answer "no" for a particular subheading

Tables 3-7

Raw materials and source (5):

DRI = directly reduced iron
D = domestic
I = imported

Energy source (6):

LGP = liquefied petroleum gas

Plant operations, technology and source (7) and (8):

EAF = electric arc furnace
UHP = ultra high power
cont. cast. = continuous casting
The name of a country or a firm in parentheses, e.g. (Italy), refers to the source of the technology.

Plans for modernization or expansion (4):

mod. = modernization
exp. = expansion

Tables 3a-7a

Motivating factors for establishing plant, choice of technology and location (14):

a = local demand (existence of/size of)
b = availability of raw materials
c = other
technology = factor(s) determining choice of technology
max. prod. = maximum productivity

Problems (15):

a = raw materials and/or energy
b = technology
c = financing of: plant, training, infrastructure
d = other

Successes (16):

a = technological innovations, adapting process and equipment to local conditions and needs
b = quality of product
c = other

Training (17):

a = technical training for workers
b = technical training for skilled workers
c = technical training for engineers
d = managerial training
other = (language, safety etc.)

Participation in technical co-operation or technical assistance (17) and Interest in technical co-operation or technical assistance (18):

Unless otherwise indicated it is assumed that the replies from developing countries refer to receiving technical assistance and those from developed countries to providing technical assistance.

domestic = technical co-operation with partners from the same country
TA = technical assistance

Note: The numbers in parentheses in the column headings refer to the question numbers in the original questionnaire.

Table 1: Countries represented in the survey

Region/countries	Number of plants included in survey: Total	Integrated	Semi-integrated	Raw steel producers	Processors of semis	Capacity (000 tons)	Output 1983 (000 tons)
Developing countries							
Africa							
Egypt	2		2			215	190
Kenya	1		1			25	11
Mauritius	1				1	10	n.a.[a/]
Nigeria	1				1	60	5
Total Africa	5		3		2	310	216
Asia							
Bangladesh	4				4	84	30
India	15		9	6		671	432
Indonesia	2		1		1	37	28
Malaysia	1				1	14	n.a.[a/]
Pakistan	3				3	152	97
Philippines	1		1			60	50
Republic of Korea	2		2			325	200
Sri Lanka	1		1			60	12
Thailand	1		1			190	149
Total Asia	30		15	6	9	1,593	1,012
Europe							
Yugoslavia	1				1	170	n.a.[a/]
Latin America							
Argentina	1	1				170	135
Brazil	6	1	5			1,077	823
Colombia	1		1			105	70
Ecuador	1				1	450	87
Mexico	1	1				650	370
Paraguay	1	1				150	-
Venezuela	1		1			160	100
Total Latin America	12	4	7		1	2,762	1,585
Middle East							
Jordan	1				1	12	13
Kuwait	1				1	65	70
Total Middle East	2	–	–	–	2	77	83
Total developing countries	50	4	25	6	15	4,912	3,066
Developed countries							
Europe							
Finland	2		2			450	338
France	3		2		1	453	402
Greece	1		1			400	115
Italy	4		2	2		390	352
Netherlands	1		1			200	200
Spain	1		1			400	285
Sweden	2		1	1		200	166
Switzerland	1		1			250	200
Turkey	2		1		1	475	305
United Kingdom	2		2			290	260
Total Europe	19		14	3	2	3,508	2,623
USA	3		2		1	220	64
Oceania							
Australia	1		1			200	70
New Zealand	1		1			160	250
Total Oceania	2	–	2	–	–	360	320
Total developed countries	24	–	18	3	3	4,088	3,007
Total of sample	74	4	43	9	18	9,000	6,073

a/ 1983 output not available. Arbitrarily assumed to equal capacity for calculation of totals.

Table 2: Plants represented in the survey by type and size

Region	Total number	Number of integrated plants	Number of semi-integrated plants (Annual capacity in 000 tons)				Number of producers of crude steel (Annual capacity in 000 tons)				Number of processors of semi-finished products (Annual capacity in 000 tons)			
			1-40	41-100	101-200	>200	1-40	41-100	101-200	>200	1-40	41-100	101-200	>200
Developing countries														
Africa (4 countries)	5		1	1	1						1	1		
Asia (9 countries)	30		8	3	4		5	1			7	1	1	
Europe (1 country)	1												1	
Latin America (7 countries)	12	4	1		4	2								1
Middle East (2 countries)	2										1	1		
Total developing countries (23 countries)	50	4	10	4	9	2	5	1			9	3	2	1
Developed countries														
Europe (10 countries)	19		1	2	5	6	1		2			1	1	
Oceania (2 countries)	2				2									
USA	3			2							1			
Total developed countries (13 countries)	24		1	4	7	6	1		2		1	1	1	
Total world	74	4	11	8	16	8	6	1	2		10	4	3	1

Table 3: Semi-integrated plants surveyed

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernization or expansion (4)
Developing countries										
AFRICA										
Egypt A	1952	90	90	bars, rolls, castings, wire ropes wire netting	construction	0	scrap - D pig iron - D coal - D alloys - I refractories -I electrodes - I	electr., fuel oil	EAP OHF	Yes
B	1947	125	99.7	rebar 75% wire 15% cast steel 4% cast iron 6%	construction, castings for machinery, vehicles etc.	0	scrap - D alloys - I refractories -I	electric, some coke	EAF - Italy hot rolling, cold drawing, foundry	Yes
Kenya	1974 (1949, 1968)	25	10.6	reinforcing bars	construction	10-15% (neighbour countries)	scrap - D	electr.	EAF casting	Yes continuous casting

Table 3: Semi-integrated plants surveyed (continued)

Country/plant	Year pro-duction started (1)	Capa-city (000 tons) (2)	Out-put 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for moderni-zation or expansion (4)
ASIA										
India A	1974	20.5	18.2	tor steels and rounds } 90% castings 10%	construction castings for machinery and equipment	0	scrap - D 40% I 60%	electr., fuel oil	EAF casting	Yes exp.
" B	1972	20	15	CTD bars pencil ingots rounds castings	construction castings for machinery, automobiles	0	scrap - D + I electrodes - D+I alloys D coal D oil D	electr. fuel oil	melting refining casting re-rolling foundry	Yes
" C	1975	36	34	billets bars (forging quality)	motor vehicle parts	0	scrap - D 60% I 40%	electr.	melting double slag refining cogging rolling conditioning acid pickling heat treatm.	Yes, mod. under way plan VD/VOD with MAN-GHH technology (F.R.Germany)
" D	1978	36	32	ingots channels angles rounds	construction	0	scrap - D	electr.	EAF rolling	Yes

Table 3: Semi-integrated plants surveyed (continued)

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernization or expansion (4)
India (contd)										
" E	1972	36	25	round bars	construction motor vehicle parts	0	scrap – D + I	electr., furnace oil	EAF cont.cast rolling	Yes
" F	1965	38	19	flat sections 69% rounds 19% triangulars 12%	motor vehicle parts railway	0	scrap – D + I DRI	electr.	EAF, double slagging	Yes exp. by [illegible] mod.
" G	1975	40	41.5	billets + bars 75% flats 25%	motor vehicle parts machinery agric.implements	0	ferro-alloys D + I	electr., fuel oil	EAF, double slagging (France-CLE) casting rolling	Yes
" H	1972	100	50	wire rods 96% bright bar 4%	wire for bicycle and automobile wheels, barbed wire etc.	0	scrap – I 50% DRI D + I others D	electr.	EAF, vacuum tech.(ASEA/SKF) ladle injection (scandinavian lancers) captive refractory, oxygen and lime plants	Yes mod. (techn.) under way

Table 3: Semi-integrated plants surveyed (continued)

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernization or expansion (4)
India (contd) " I	1935	165	60	flats 20% rounds 15% sections 5% profiles 20% wire rods 40%	hand tools, wire drawing, motor vehicle parts defence industry	0	scrap - D alloys - D	electr., fuel oil	EAF cont.cast hot rolling foundry	Yes mod. soon
Indonesia	1976	13	12.2	round bars 85% other bars 15%	construction	0	scrap - I	electr., fuel oil	shearing reheating re-rolling	No
Korea (Republic of) A* B*	1971 1976	325	200	spec.steel long prod. 48% stainless sheets, strips 48% seamless tubes, pipes 4%	motor vehicle parts machinery chem.equipment gun barrels armour plate	40	scrap D + I alloys D + I coils J	electr. light oil propane gas	Vacuum degassing(FRG) Electroslag remelt (FRG) Stainless cold rolling (Jap) Vacuum induction melt (USA)	Yes mod. exp.
Philippines	1977	60	50	billets 50% grinding rods and balls 50%	re-rolling (construction + manufacturing) mining industry	5	scrap D alloys D 80% electrodes I charcoal D limestone D	electr., fuel oil LPG	EAF cont.cast rolling forging (USA,Japan)	Yes

* Figures given represent combined output of both plants; separate figures not available.

Table 3: Semi-integrated plants surveyed (continued)

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernization or expansion (4)
Sri Lanka	1981	60	12	Rolled products	construction	0	scrap D alloys I limestone D iron ore D	electr., furnance oil, LPG	EAF cont.cast. rolling mill	Yes
Thailand	1970	190	149	bars 55% wire rod 35% wire 10%	construction nails, wire mesh	0	scrap D alloys I	electr., medium oil	EAF cont.cast. rolling	Yes
LATIN AMERICA										
Brazil A	1988	7	0	bars tool steel	motor vehicle parts, forging cutting tools machinery, equipment	0	scrap D lime D alloys D+I	electr.,	EAF, teemings forgings rolling (USA)	Yes
" B	1948	120	23	castings 60% ingots 40%	motor vehicle parts railway cars shipbuilding machinery, equipment	15	scrap D pig iron D alloys D+I	electr., fuel oil	EAF foundry (domestic)	Yes exp. foundry capac.

Table 3: Semi-integrated plants surveyed (continued)

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernization or expansion (4)
LATIN AMERICA										
Brazil C	1963	120	105	round rolled bars 100%	construct. 80% machinery 20%	70	scrap D	hydro-elec. 70% oil 30%	EAF (Brazil) cont.cast. (Switzerland) rolling mill (Japan/Italy)	Yes
" D	1962	240	183	wire rods, wire drawn artifacts 63% Concrete reinforcing bars 37%	construction agriculture electrification	40% of reinforcing bars	scrap D pig iron D	electr.	EAF - UHP rolling drawing	Yes mod. of mill
" E	1966	350	265	bars 60% billets 30% heated and finished bars 10%	motor vehicle parts machinery	30 billets and bars	scrap D + I pig iron D alloys	electr. heavy oil	EAF vacuum degas. ladle treatment (SKF-Sweden)	Yes exp. melting shop
Colombia	1938	105	70	bars 80% wire 18% flats 2%	construction hydroelectric	0	scrap D + I DRI I alloys I billets I	hydro-electr.	cont.cast. rolling mill	Yes
Venezuela	n.a.	160	100	bars 10% rods 85% flats 5%	constr. 85% industr.iron 15%	32	scrap D + I coke D alloys D + I	electric D	EAF rolling ("conventional technology")	-

Table 3: Semi-integrated plants surveyed (continued)

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernization or expansion (4)
Developed Countries										
EUROPE										
Finland A	1976	200	122	flats	process industry construction kitchen ware	>80	scrap D alloy D nickel D + I	electr.	EAF AOD convertor cont. cast., rolling (Sendzimir mill)	no
Finland B	1937	250	216	long products	automobile industry 30% machinery 25% construction 20% fasteners 15% petrochem. industry 10%	55	scrap D + I	electr. nat. gas	EAF ladle injection cont.cast. and ingot cast billet conditioning rolling finishing	yes mod.
France A	1916	2,5	2,3	drawn products 30% round bars 25% flat + square bars 40% rings and tool bib 5%	cutting tools	60	scrap D billets I alloys D	electr. oil	EAF hydraulic press hammers three-high rolling mill	yes

Table 3: Semi-integrated plants surveyed (continued)

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernisation or expansion (4)
Developed Countries										
EUROPE (cont.)										
France B	1975	400	360	wire rod	construction	30	scrap D lime D alloys D refractories	electr.	EAF cont. cast rolling mill	yes
Greece	1952	400	115	bars rods	construction	15 - 20	scrap D+I	electr. fuel oil	EAF cont. cast hot rolling	yes
Italy A	1962	80	72	wire rod	wire drawing	5	scrap 80% D 20% I	electr.	EAF casting rolling	no
Italy B	1920	120	120	bars rods	construction	15	scrap D+I	electr.	EAF casting rolling	no
Netherlands	1938	200	200	wire rod wire	construction	85	scrap D+I	electr.	EAF casting rolling wire drawing	yes mod.
Spain	1965	400	285	bars rods	construction	65	scrap 30% D 70% I	electr. fuel oil	EAF casting rolling	no

Table 3: Semi-integrated plants surveyed (continued)

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernization or expansion (4)
Developed Countries										
EUROPE (cont.)										
Switzerland	1918	250-300	200	flats angles reinforcing bars wire rod wire mesh forgings	construction metal industry mechanical engineering	40	scrap D	electr.	EAF cont. cast rolling mill forging	no
Sweden	1950	75	52	closed die forgings	motor vehicle parts	30	scrap 50% D 50% I	electr.	EAF ASEA/SKF degassing unit induction furnaces	no
Turkey	1956	325	275	rods bars spring steels wire-rope steels electrode steels carbon steels low alloy steels	construction (mainly) some wire-ropes and springs	35	scrap D+I FeSi D SiMn D	electr. fuel oil oxygen	EAF (DEMAG) with oxy. fuel burners and water cooled panels (NIKKO, Japan) concast (DEMAG) rolling	yes mod.

Table 3: Semi-integrated plants surveyed (continued)

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernization or expansion (4)
Developed Countries										
EUROPE (cont.)										
UK A	1975	130	120	bars 85% billets 15%	construction	10	scrap D alloys D	electr. nat. gas	EAF rolling	yes mod. -
UK B	1975	160	140	wire rod 85% billets 15%	construction wire drawing	10	scrap D alloys I	electr. nat. gas	EAF rolling	yes mod. -
OCEANIA										
Australia	1984	200	70	rounds bars flats angles channels billets	construction machinery	0	scrap D	electr. nat. gas	EAF continuous casting rolling	n.a.
New Zealand	1962	160 (250)?	250	merchant bar 55% wire rod 45%	construction manufacturing agriculture	25	scrap D billets D	electr. nat.gas	EAF continuous casting rolling	yes mod. -

Table 3: Semi-integrated plants surveyed (continued)

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernization or expansion (4)
Developed Countries										
USA A	1952	100	50	large heavy forgings	closed die forging industry automobile industry mining industry	5	scrap D alloys D 50% I 50%	electr.	EAF with vacuum arc degassing	no
USA B	1984	50	-	reb´ :	construction	0	scrap D	electr. nat.gas	EAF continuous casting rolling finishing	yes

TABLE 4: INTEGRATED PLANTS SURVEYED

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernization or expansion (4)
Developing Countries										
LATIN AMERICA										
Argentina	1945	170	135	bars rounds sections wire	construction motor vehicle parts railway cars agric. machinery weapons	0	scrap D iron ore I alloys I	electr. nat. gas furnace gas, charcoal coke	blast furnace EAF OBM	No
Brazil	1973	240	247	rods 96% wire rod 4%	construction	70% of rod	scrap D DRI D nat.gas D	hydro-electr. fuel oil	DRI-HyL (Mexico) EAF-Stein Surf (F) rolling-Schloeman/Villares (FRG/Brazil)	Yes Exp. 400%
Mexico	1954	650	370	seamless pipes 90% bars 10%	oil industry motor vehicle parts forgings	30%	scrap D iron ore D round bars I	electr. D nat. gas D	DRI-HyL EAF cont.cast. rolling seamless pipe production	n.a.
Paraguay	1985	150	-	rods wires light sections	construction wire drawing machinery	0	iron ore I alloys I charcoal D lime D	electr. furnace gas D charcoal D	n.a.	No

TABLE 5: PLANTS SURVEYED THAT PRODUCE CRUDE STEEL

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernization or expansion (4)
Developing Countries										
ASIA										
India J	1977	18	15.8	pencil ingots	re-rolling for construction and motor vehicle parts	0	scrap D DRI D	electr. furnace oil	EAF	yes
India K	1975	18	11.7	ingots	construction, free cutting steel, spring steel for motor vehicles	0	scrap D + I	electr.	EAF-double slag and single slag process	yes
India L	1977	22	19.5	billets	re-rolling: rounds flats angles wire rods	0	scrap D	electr.	EAF	yes
India M	1979	36	29.5	ingots billets	construction motor vehicle parts machinery	0	scrap D60%, I40% alloys D electrodes D	electr.	EAF - single slag process	just expanded 100%

TABLE 5 : PLANTS SURVEYED THAT PRODUCE CRUDE STEEL (continued)

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernization or expansion (4)
Developing Countries										
ASIA (cont.)										
India N	1972	36	18	ingots	construction	0	scrap D + I	electr.	EAF	yes
India O	1974	50	42	billets	construction, wire drawing, motor vehicle parts, machinery	0	scrap D + I	electr.	EAF ladle injection continuous casting	yes

Table 5: Plants surveyed that produce crude steel (continued)

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernization or expansion (4)
DEVELOPED COUNTRIES										
Europe										
Italy C	1972	30	30	ingots	forged products	40	scrap D and I	electricity	EAF, ladle treatment with argon (Mannesmann)	yes
D	1978	160	130	billets (square)	re-rolling mills for construction	50	scrap D 50% I 50%	electricity, L.P.G.	EAF (Tagliaferri) concast, 4-strand (Danieli)	yes - exp.
Sweden	1966	125	114	square castings (semi-finished)	hot and cold rolling for construction	none directly, but customer exports	scrap D and I	electricity, fuel oil	EAF (ASEA) continuous casting (concast) injection (Scandinavian Lancers)	no

TABLE 6: PLANTS SURVEYED THAT PROCESS SEMI-FINISHED PRODUCTS

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernization or expansion (4)
Developing Countries										
AFRICA										
Mauritius	1968	9-10	n.a.	bars	construction	0	billets I (from R.S.A)	fuel oil	rolling (India)	no
Nigeria	1983	60	5	rounds 80% wire mesh 10% bars and angles 10%	construction	0	billets D + I	fuel oil	rolling (Italy)	no
ASIA										
Bangladesh A	1968	6	4.5	round bars 50% flat bars 20% bars 15% angles 15%	construction	0	billets D	furnace gas	rolling	yes mod.
Bangladesh B	1968	12	5	rods 100%	construction	0	billets D + I	furnace oil	re-rolling (Kobe - Japan)	yes coop. with Japan
Bangladesh C	1963	21	4.5	rods bars angles channels	construction	0	billets D + I	electr.	re-rolling	yes

TABLE 6: PLANTS SURVEYED THAT PROCESS SEMI-FINISHED PRODUCTS (continued)

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernization or expansion (4)
ASIA (contd)										
Bangladesh D	1964	45	16	pipes tubes	water, gas pipes	0	steels strip I zinc and aluminium ingots I	electr. gas	welding threading	yes mod. exp.
Indonesia	1973	16	16	pipes	construction projects, steel poles	0	steel coil zinc ingots	electr.	tube mills slitting galvanizing hot dip	yes - diversification
Malaysia	1969	14.4	n.a.	pipes	water, general uses	0	steel coil I(fr. Japan and Taiwan province)	electr.	welding galvanizing	n.a.
Pakistan A	1974	12	8	bars	construction	small percentage	billets D	electr. nat. gas	re-rolling	yes - -
Pakistan B	1971	15	12	bars	construction	small percentage	billets D	electr. nat. gas	re-rolling	yes - -
Pakistan C	1954	125	77	bars angles wire rods wire products	construction	yes	billest D	electr. nat. gas	rolling wire-drawing wire rope galvanizing	- exp. (new rolling mill)

TABLE 6: PLANTS SURVEYED THAT PROCESS SEMI-FINISHED PRODUCTS (continued)

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernization or expansion (4)
LATIN AMERICA										
Ecuador	1966	450	87	bars wires	construction	0	billets I	electr. oil	re-rolling	yes mod.
MIDDLE EAST										
Jordan	1978	12	13	pipes	water pipes	20-30%	hot rolled strips I	electr. oil	welding	yes later
Kuwait	1967	65	70	pipes rolled products	petroleum, water pipes	yes	I	electr. oil	rolling welding	n.a.
EUROPE										
Yugoslavia	1972	170	n.a.	pipes (spiral welded and longitudinal welded)	plumbing gas, oil, pipelines	50%	alloys D + I	electr. oil	welding	yes

Table 6 Plants surveyed that process semi-finished products (continued)

Country/plant	Year production started (1)	Capacity (000 tons) (2)	Output 1983 (000 tons) (3)	Major products (9)	Final uses (10)	Amount exported (in %) (11)	Raw materials and source (5)	Energy source (6)	Plant operations, technology and source (7) and (8)	Plans for modernization or expansion (4)
DEVELOPED COUNTRIES										
Europe										
France	1906	50	40	welded tubing	food industry automotive industry architecture (buildings and furniture)	38	mild steel, stainless steel alloys I	electr.	3 welding processes	Yes
Turkey	1983	150	30	bars sections	construction	50	scrap I billets D + I	electr. fuel oil	re-rolling	Yes - exp.
USA	1976	20	14	rebar	closed die forging industry automotive industry mining industry	5	billets D	electr. gas	re-rolling	Yes

Table 3a: Semi-integrated plants surveyed

Country/plant	Capacity (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Participated in technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
DEVELOPING COUNTRIES								
Africa								
Egypt A	90	a b	a b - sometimes c	a b	technical with UNIDO and others	scholarship; project contract	no	no
B	125	a b	a - temporary shortages b - outmoded c - cyclical hard currency shortages	a	a b c d	own funds	technical co-operation with other domestic institutes, training with UNIDO, technical assistance from Yugoslavia	yes
Kenya	25	a	a - local scrap scarce; electricity expensive - c d - lack national institution and testing facilities	a b c - maximized EAF production	in-plant; at local polytechnic; foreign technicians (India)	own funds	no	yes technology for concast billets

Table 3a: Semi-integrated plants surveyed (continued)

Country/plant	Capacity (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Participated in technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
Asia								
India A	20	a b c – government incentives	a – power cuts; scrap shortage – –	a b c – training local workers	a) b) in-plant c) d) external, domestic	own funds	yes domestic, with entrepreneurs to set up linked operations; with other mini-plants to increase efficiency	yes with developed countries in establishing and improving plants
B	20	n.a.	a – energy supply main problem b – obsolete technology plant size (furnace too small) –	– b	– – c) d) seminars and conferences	own funds	no	yes new technology to save energy, reduce costs, automate
C	36	technology choice based on end-product and efficient capital investment	a – energy fluctuating voltage, raw material poor quality and shortage – – d – demand recession 1982-83	a – "company's principal strength" b c – good management	a) b) c) in-house d – external, domestic	own funds	no	yes will accept foreign in-plant trainees or send trainers in management, technical and financial areas

Table 3a: Semi-integrated plants surveyed (continued)

Country/plant	Capacity (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Participated in technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
Asia (continued)								
India D	36	b	a - energy: irregular supply - -	a b -	no	-	no	yes in steel melting and modernizing rolling mill
E	36	a b	a - shortage of energy and raw material b - obsolete technology, low power furnaces c - shortage of finance d - shortage of qualified personnel	a b -	- b c d	own funds	yes USSR aid setting up plant	yes in EAF, continuous casting, rolling
F	38	a b c - energy available	none	a - designing rolling mills and rolling schedules - -	- - c - brief visits abroad	own funds	no	yes in ladle metallurgy and continuous casting

Table 3a: Semi-integrated plants surveyed (continued)

Country/plant		Capa-city (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Participated in technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
Asia (continued)									
India	G	40	a b c - available skills	none	a b -	a) b) in-plant c	-	yes provided training for Nigerian personnel	yes provide TA in erecting and commissioning plants and training in steelmaking, casting, processing, maintenance etc.
	H	100	a b c - technology: short gestation period	a - energy and raw material (import restrictions) b c - training	a - volume b c - management	- - - d - in-plant	own funds	yes in India	yes to provide TA to new and existing EAF plants
	I	165	a - c - skilled labour available	a - energy shortage -	a b c - import substitution	- - c d - in-plant	own funds	yes - had Japanese consultant for two years - also machinery and know-how from GDR	yes to provide TA (have 50 years of experience in setting up plants)

Table 3a: Semi-integrated plants surveyed (continued)

Country/plant	Capacity (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Participated in technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
Asia (continued)								
Indonesia	13	a	a - raw material: government regulation of imports - c	a b	a b c - in-plant	own funds	yes with Japan and the Republic of Korea	n.a.
Korea (Republic of) A* B*	325	a - c - technology: material required quality standards d - language availability	a - raw material b - difficulty assessing advanced technology c - limited capital availability	a b c - process control, data processing	a b c d - on-the-job and independent training centre	mainly own funds	yes feasibility studies on stainless mill project	yes in management training, transfer of know-how
Philippines	60	- - c - technology: appropriate	a - energy prices and raw material import prices b - cost and capital intensity c - long-term capital	a b c - management	a b c d	own funds and USAID, Colombo Plan, Government etc.	yes with parent company	yes in DRI use, energy conservation, steelmaking technology

* Information applies to both plants.

Table 3a: Semi-integrated plants surveyed (continued)

Country/plant	Capacity (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Participated in technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
Asia (continued)								
Sri Lanka	60	a - c - best aid terms	- b - low yields high reject rate - d - lack of infrastructure and trained personnel	-	in-plant, under Soviet specialist	Government and USSR	yes	yes
Thailand	190	a	a - raw material imports b - lack of modern technology	a b	- - c - teachers from Japan d - university courses and scholarship	own funds	yes technical assistance from TOSHIN and SHINKO (Japan)	yes

Table 3a: Semi-integrated plants surveyed (continued)

Country/plant	Capacity (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Participated in technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
Latin America								
Brazil A	7	a b	none	-	- b c - at Latrobe Steel, USA, and in-plant	own funds and Government	yes, with Latrobe Steel, United States	yes
B	120	n.a.	none	a b	a b c d	own funds	no	yes
C	120	a b c - infrastructure, low cost labour	a - raw material - c - some d - market fluctuation government price control	a b c - low cost	a b c d	own funds (tax deduction)	yes domestic	yes
D	240	a - plant grew slowly, in response to demand	- - c - some	- b c - human resources and training	a b c d	own funds	yes (Nippon Steel)	no
E	350	a b	none	a b	a b c d	own funds	yes, with SKF Sweden	yes

Table 3a: Semi-integrated plants surveyed (continued)

Country/plant	Capacity (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Participated in technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
Latin America (continued)								
Colombia	105	a - c - expertise and reliability of providers of technology	a - raw material b - certain types of wire rod c - high interest rates d - language	a b c - product development	- - c - continuous casting	own funds	yes with ABEX, USA, and with Spain	yes
Venezuela	160	n.a.	a - raw material b - spares (due to lack of foreign currency) -	a b	a b c d	own funds	n.a.	yes

Table 3a Semi - integrated plants surveyed (continued)

Country/plant	Capa-city (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
Developed Countries Europe F land A	200	- b c - technology: most modern	none	a b	a b c d in-plant training and training of customers: India, Greece Philippines	customer paid	yes > 100 projects whole world	yes producing ferro alloys and stainless steel
" B	250	a b c - technology: production and in-vestment costs	a - raw material quality of scrap b - low tempera-ture	a b	a b c d in-plant	own funds	yes project by OVAKO in steel prod. + rolling	yes (many possi-bilities)
France A	2.5	- - c - availability of skilled labour	a - raw material - c -lack of invest-ment in the past d - market fluct-ations	- b c - staff selection	a b c d +English cour-ses	special tax: 1% of gross company sala-ries for ind-ustrial train-ing + grants from Chamber of Commerce	no	no

Table 3a Semi - integrated plants surveyed (continued)

Country/plant	Capa-city (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
Europe (cont'd)								
France B	400	a b c - infrastructure available	none	a b	- b } in-plant c } -	own funds	yes, provided training in Spain, Portugal Malaysia, Greece	yes, world-wide
Greece	400	"local conditions in general"	a -increased costs - -	-	- b c in Italy (tech. suppliers)	own funds	no	no
Italy A	80	"by tradition"	a-high cost - -	- b c - flexibility of production and delivery	no	-	no	no
" B	120	a -	none	a -	- b c in plant	own funds	no	yes

Table 3a Semi - integrated plants surveyed (continued)

Country/plant	Capa-city (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
Europe (cont'd)								
Netherlands	200	- b c - demand of parent company	none	- b	- b c -	own funds	no	no
Spain	400	- - c - technology: determined by type of final product	a - increased costs	a b	no	-	no	no
Switzerland	250	a b	none	a b	a b c d - permanently int.+ external	own funds	yes exchange of know-how	no
Sweden	75	n.a	a - raw material high cost	- b	no	-	yes, TA in integ. plants Brazil, Algeria; forge in Albania	no, no longer have capac. to sell know-how

Table 3a Semi - integrated plants surveyed (continued)

Country/plant	Capacity (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
Europe (cont'd)								
Turkey	150	a b c - capital availablity	- - c - imported raw material necessiates high working capital, due to constant devaluation this causes difficulties.	a b	- - c d D I (Austria, Japan,Germany)	own funds	yes, Nikko, Japan Rokop Devy, UK; AEG, FRG	yes, to receive TA in high efficiency ste.l production
United Kingdom A	130	a b	a - expensive energy and fluctuating raw material prices b - due to lack of capital c d - competition with subsidized European producers	a - energy targetting and monitoring b c - cost effective operation	a b c d	own funds	yes trained personnel from New Zealand	yes
" B	160	a b	a - expensive energy and fluctuating raw material prices	a b	a b c d	own funds	yes domestic co-operation in training	yes

Table 3a Semi - integrated plants surveyed (continued)

Country/plant	Capacity (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
OCEANIA Australia	200	a - c - technology: best available on world market to meet market needs	none	a b	a b in-plant	own funds	no	yes visitors
New Zealand	160	n.a.	a - raw material: shortage of scrap - -	a	a b c - in-plant and foreign	own funds	yes in some geog. regions i.e. South Pacific	yes
USA A	100	a	none	a b	technical training planned	own funds	yes, provide operational and metallurgical assistance to plants that buy the firms's patented vacuum and degassing equipment	yes, will provide training in conjunction with sale of equipment
USA B	100	- - c - technology: high tech, low-cost investment	- - c - initial financing problems	a b	a b c d } future	own funds + state matching funds	yes, in training	yes, to provide training

TABLE 4a: INTEGRATED PLANTS SURVEYED

Country/plant	Capacity (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Participated in technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
Developing Countries								
LATIN AMERICA								
Argentina	170	a b	a - normal problems importing ferro-alloys	- b	by suppliers of technology and in-plant; study abroad	own funds; government and other scholarships	no	yes
Brazil	240	a b	none	- b	-	-	yes with SIDOR, Venezuela	yes
Mexico	650	a b c-technology: productivity	none	a-cont.cast. b - -	a b c -	own funds	at time of start-up (new technologies)	yes
Paraguay	150	a b	n.a.	-	planned with Brazil	various	-	not at present

TABLE 5a: PLANTS SURVEYED THAT PRODUCE CRUDE STEEL

Country/plant	Capa-city (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
Developing Countries								
ASIA								
India J	18	a - c - technology: superior	a - energy: shut down 1974-1977 due to lack elec. now only 25% power supply - -	- - c-continue work despite highly adverse conditions	none	-	no	yes, to receive technology, latest information
India K	18	a - c - technology: max. prod. and quality	a - energy - c	- b c-labour relations	planned	-	no	yes, with Japan
India L	36	a	a - energy - -	a b	none	-	no	yes
India M	36	a b	a - energy and raw materials (necessary to import raw mat.) - -	a-product. 160% of nameplate capacity - c-maximize automati-zation	- - - d - foreign	own funds	no	yes, to provide TA setting-up plants, improving productivity etc.

TABLE 5a: PLANTS SURVEYED THAT PRODUCE CRUDE STEEL (continued)

Country/plant	Capacity (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
Developing Countries								
ASIA (cont.)								
India N	36	a	a - energy - -	a b	none	-	no	yes
India O	50	a b c - technology: quality requirements	a - energy, raw materials: quality and price - -	a b c - labour relations	- b c d	own funds	yes with Finland	yes, to receive TA to increase productivity and to provide TA in setting up plants

Table 5a: Plants surveyed that produce crude steel (continued)

Country/plant	Capacity (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Participated in technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
DEVELOPED COUNTRIES								
Europe								
Italy C	30	a	a - cost b - cost of new equipment for vacuum de-gassing c - high cost of capital	a b c - timely deliveries	weekly technical meetings	-	no	yes
D	160	a	a- raw material 50% imported international price fluctuations - - d - semis market always pressed by fluctuating prices	a b -	- b c d - computers	own funds	no	no
Sweden	125	a b c - skilled labour d - own water power installation	none	- b	a) b) in-plant as c) necessary d)	own funds	yes domestic	would be difficult to participate

Table 6a - Plants surveyed that process semi-finished products

Country/plant	Capa-city (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
Developing countries AFRICA								
Mauritius	9-10	a - c - availability of funds	- - c - lack of funds for training d - lack of training opportunities and materials (books)	a b c - sole producer of TOR steel	past training at Univ. of Mauritius and by Indian engineers	own funds and local banks	Course in USSR (pd.by UNIDO)	Yes
Nigeria	60	a b - oil	a - raw mat. <10% available 1984 b - not enough foreign technicians c d - inadequate infrastructure	a b	- - c - in Italy d - in-plant and external	own funds	with Italy (teaching personnel)	Yes
ASIA								
Bangladesh A	6	a b	a - raw mat. - c - inadeq.finance for plant	- b	- - - d - external (domestic)	own funds	No	Yes

Table 6a – Plants surveyed that process semi-finished products (continued)

Country/plant	Capacity (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
ASIA								
Bangladesh B	12	a –	a – raw mat. and energy expensive b – technology expensive spares inadequate – d – shortage of experts; transport	– b	– b } Kobe, c } Japan –	Kobe, Japan	with Kobe, Japan	Yes from Japan or Korea
" C	21	a	a	a	on the job	own funds	No	Yes
" D	45	a	a b	a b	a b c d ext. (dom.)	own funds	No	Yes personnel exchange
Indonesia	24	a	a – raw material delivery time and payment – – d – lack of know-how, lack of motivation for training	a	little, in-plant	none	No	Yes, in training to improve work efficiency

Table 6a - Plants surveyed that process semi-finished products (continued)

Country/plant	Capacity (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
ASIA								
Malaysia	14.4	a	- - - d - marketing	-	on the job	-	No	Yes
Pakistan A	12	n.a.	a - raw mat. and energy expensive in some areas of country - c - financing infrastructure	a b c - service	"training not needed"	-	Yes (domestic)	Yes technology to improve quality
" B	15	n.a.	a - c - financing infrastructure	a b	"not necessary"	-	Yes (domestic)	Yes
" C	125	a	a - raw material b - obsolete technology frequent break downs	a	a, b, c, d } internal and external	own funds	No	Yes, in rolling technology
EUROPE								
Yugoslavia	170	a b c - personnel available; export market	a - raw material b	- b	a b c further technical and language training planned	own funds	provided TA in welding, etc. to buyers of firm's products	Yes, in pipe production, installation and corrosion control

Table 6a - Plants surveyed that process semi-finished products (continued)

Country/plant	Capacity (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
LATIN AMERICA								
Ecuador	450	n.a.	-	-	None	-	No	Yes, to receive TA in rolling, administration and accounting
Middle East Jordan	12	a - c - export market	none	- b	a - local - c - at company that supplied machines	company	Yes from France: Vallourec and D.M.S.	n.a.
Kuwait	65	a - c - export market	-	- b	a b c d	own funds	n.a.	n.a.

Table 6a - Plants surveyed that process semi-finished products (continued)

Country/plant	Capacity (000 tons) (2)	Motivative factors for establishing plant, choice of technology and location (14)	Problems (15)	Successes (16)	Training programme (12)	Source of finance for training (13)	Technical co-operation or technical assistance (17)	Interest in technical co-operation or technical assistance (18)
DEVELOPED COUNTRIES Europe France	50	- b	a - raw mat. 50% must be imported b - technology 40% must be imported c	a b	- b c - in plant	own funds	yes established subsidiary plant in Ireland	yes in developed countries
Turkey	150	a - c - export market	- - c	a b	a - in plant b } in plant + c } abroad	own funds	no	yes, in EAF, cont.casting, secondary metallurgy and rolling
USA	20	- - c - commercial viability	none	- - c - quality of service and safety record	a b c - e - safety training	own funds	no	yes

TABLE 7: PRODUCTION STRUCTURE BY TYPE OF PRODUCT: DEVELOPED COUNTRIES

(Percentage)

Type and Size of Plant	No. of Plants in Sample	Output 1983 (000 tons)	TYPE OF PRODUCT						
			Ingots and Semis	Wire Rod and Wire Products	Rod and Bar Products	Sections, Flats, Angles, etc.	Forgings	Pipes and Tubes	Total
Semi-integrated Plants									
1-40,000 t/a	1	2	-	-	100	-	-	-	100
41-100,000 t/a	4	174	-	32	22	-	46	-	100
101-200,000 t/a	7	1,022	5	40	40	15	-	-	100
> 200,000 t/a	6	1,451	-	34	46	17	3	-	100
Total Semi-integrated Plants	18	2,649	2	36	42	15	5	-	100
Crude Steel Producers	3	274	100	-	-	-	-	-	100
Processors of Semi-finished Products	3	84	-	-	52	-	-	48	100
Total Developed Countries in Sample	24	3,007	12	32	38	13	4	1	100

TABLE 7a: PRODUCTION STRUCTURE BY TYPE OF PRODUCT: DEVELOPING COUNTRIES

(Percentage)

Type and Size of Plant	No. of Plants in Sample	Output 1983 (000 tons)	TYPE OF PRODUCT							
			Ingots and Semis	Wire Rod and Wire Products	Rod and Bar Products	Sections, Flats, Angles, etc.	Steel Castings	Pipes and Tubes	Spec. Steel Products	Total
Semi-integrated Plants										
1-40,000 t/a	10	208	21	-	54	23	2	-	-	100
41-100,000 t/a	4	202	12	39	39	-	10	-	-	100
101-200,000 t/a	9	807	3	13	51	5	3	-	25	100
> 200,000 t/a	2	448	18	26	56	-	-	-	-	100
Total semi-integrated plants	25	1,585	10	18	52	5	3	-	12	100
Integrated Plants	4	752	-	11	42	10	-	37	-	100
Crude Steel Producers	6	138	100	-	-	-	-	-	-	100
Processors of semi-finished products										
1-40,000 t/a	9	87	-	-	46	4	-	50	-	100
41-100,000 t/a	3	91	-	-	5	-	-	95	-	100
101-200.000 t/a	2	247	-	11	10	10	-	69	-	100
> 200,000 t/a	1	87	-	31	69	-	-	-	-	100
Total Processors	15	512	-	11	25	6	-	58	-	100
Total Developing Countries in Sample	50	3,066	10	14	43	6	2	19	6	100
Total of sample, developed and developing countries	74	6,073	10	22	41	10	3	11	3	100

Table 8: Main uses of the output of mini-steel plants surveyed - by region and type of plant

Region/countries and type of plants	Output 1983 (000 tons)	Number of plants	Main uses of output: Construction only	Construction and manufacturing equipment etc.	Manufacturing equipment, machinery, tools, motor vehicle parts etc.	Wire for electrification and construction	Pipes for oil, water, gas	Pipes for oil and parts for machinery	Pipes for construction
Developing countries									
Africa									
Semi-integrated plants	201	3	2	1					
Processors of semis	15	2	2						
Total Africa	216	5	4	1					
Asia									
India									
Semi-integrated plants	295	9	1	3	5				
Crude steel producers	137	6	1	5					
Republic of Korea									
Semi-integrated plants	200	2			2				
Thailand									
Semi-integrated plants	149	1	1						
Other Asian countries									
Semi-integrated plants	74	3	2	1					
Processors of semis	157	9	6				2		1
Total Asia	1,012	30	11	9	7		2		1
Europe									
Yugoslavia									
Processors of semis (*assumed equal to capacity 170,000 tons)	n.a.*	1					1		
Latin America									
Integrated plants	752	4	1	2				1	
Semi-integrated plants	746	7		2	3	2			
Processors of semis	87	1	1						
Total Latin America	1,585	12	2	4	3	2		1	

Table 8: Main uses of the output of mini-steel plants surveyed - by region and type of plant (continued)

Region/countries and type of plants	Output 1983 (000 tons)	Number of plants	Main uses of output: Construction only	Construction and manufacturing equipment etc.	Manufacturing equipment, machinery, tools, motor vehicle parts etc.	Wire for electrification and construction	Pipes for oil, water, gas	Pipes for oil and parts for machinery	Pipes for construction
Developing countries (continued)									
Middle East									
Processors of semis	83	2					2		
Total developing countries	3,066	50	17	14	10	2	5	1	1
Developed countries									
Europe									
Semi-integrated plants	2,279	14	6	6	2				
Crude steel producers	274	3	2		1				
Processors of semis	70	2	1		1				
Total Europe	2,623	19	9	6	4				
Oceania									
Semi-integrated plants	320	2		2					
USA									
Semi-integrated plants	50	2	1		1				
Processors of semis	14	1			1				
Total USA	64	3	1		2				
Total developed countries	3,007	24	10	8	6				
Total in sample, developed and developing countries	6,073	74	27	22	16	2	5	1	1

Table 8a: Main uses of the output of mini-steel plants surveyed - by type of plant

Type of plants	Output 1983 (000 tons)	Number of plants	Main uses of output: Construction only	Construction and manufacturing equipment etc.	Manufacturing equipment, machinery, tools, motor vehicle parts etc.	Wire for electrification and construction	Pipes for oil, water, gas	Pipes for oil and parts for machinery	Pipes for construction
Semi-integrated plants									
Developing countries	1,664	25	6	7	10	2			
Developed countries	2,649	18	7	8	3	—			
Total semi-integrated plants	4,313	43	13	15	13	2			
Integrated plants									
Developing countries	752	4	1	2				1	
Crude steel producers									
Developing countries	137	6	1	5					
Developed countries	274	3	2	—	1				
Total crude steel producers	411	9	3	5	1				
Processors of semis									
Developing countries	512	15	9				5		1
Developed countries	84	3	1		2				
Total processors of semis	596	18	10		2		5		1
Total all plants in sample	6,073	74	27	22	16	2	5	1	1