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04883

United Nations Industrial Development Organization

Distr.
LIMITED

ID/WG.146/99
18 July 1973

ORIGINAL: ENGLISH

Third Interregional Symposium
on the Iron and Steel Industry
Brasilia, Brazil, 14 - 21 October 1973

Agenda item 3

EXPANSION OF THE NON-FLAT ROLLED PRODUCTS SECTOR IN BRAZIL : ASPECTS RELATING TO ECONOMIES OF SCALE[1/]

by

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1/ The views and opinions expressed in this paper are those of the authors and do not necessarily reflect the views of the secretariat of UNIDO.

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04883

ID

Distr. LIMITEE

ID/WG.[illegible]/RESUME
10 juillet 1973

FRANCAIS
Original : ANGLAIS

Organisation des Nations Unies pour le développement industriel

Troisième Colloque interrégional
sur la sidérurgie

Brasilia (Brésil), 14-21 octobre 1973

Point 3 de l'ordre du jour

RESUME

LE DEVELOPPEMENT DE LA PRODUCTION DE LAMINES AUTRES QUE LES TOLES AU BRESIL : PROBLEMES RELATIFS AUX ECONOMIES D'ECHELLE

par
Carlos Heitor Miranda de Faria et Olinto Alvarez Villas Bôas
(Conselho Nacional de Industria Siderurgica - CONSIDER)
(Brésil)

Cette communication comprend une série d'études préparées par les experts de CONSIDER sur la planification et l'expansion de la production des laminés en acier courant, autres que les tôles.

Dans la deuxième partie, les auteurs décrivent les débouchés dont disposent ces produits et les mesures envisagées pour augmenter la capacité installée des laminoirs.

Les diverses solutions possibles pour accroître leur capacité de production sont analysées dans la troisième partie où les auteurs indiquent les charges de capital, les coûts détaillés d'exploitation et la rentabilité des installations ayant une capacité de production de 900 000 et de 1,8 million de tonnes de produits laminés par a

Dans la quatrième partie, les solutions examinées dans les sections précédentes sont comparées aux conditions d'implantation et d'exploitation d'usines ayant une capacité de production inférieure et utilisant le charbon de bois et la ferraille. Le concept de coût total unitaire a été utilisé pour cette analyse.

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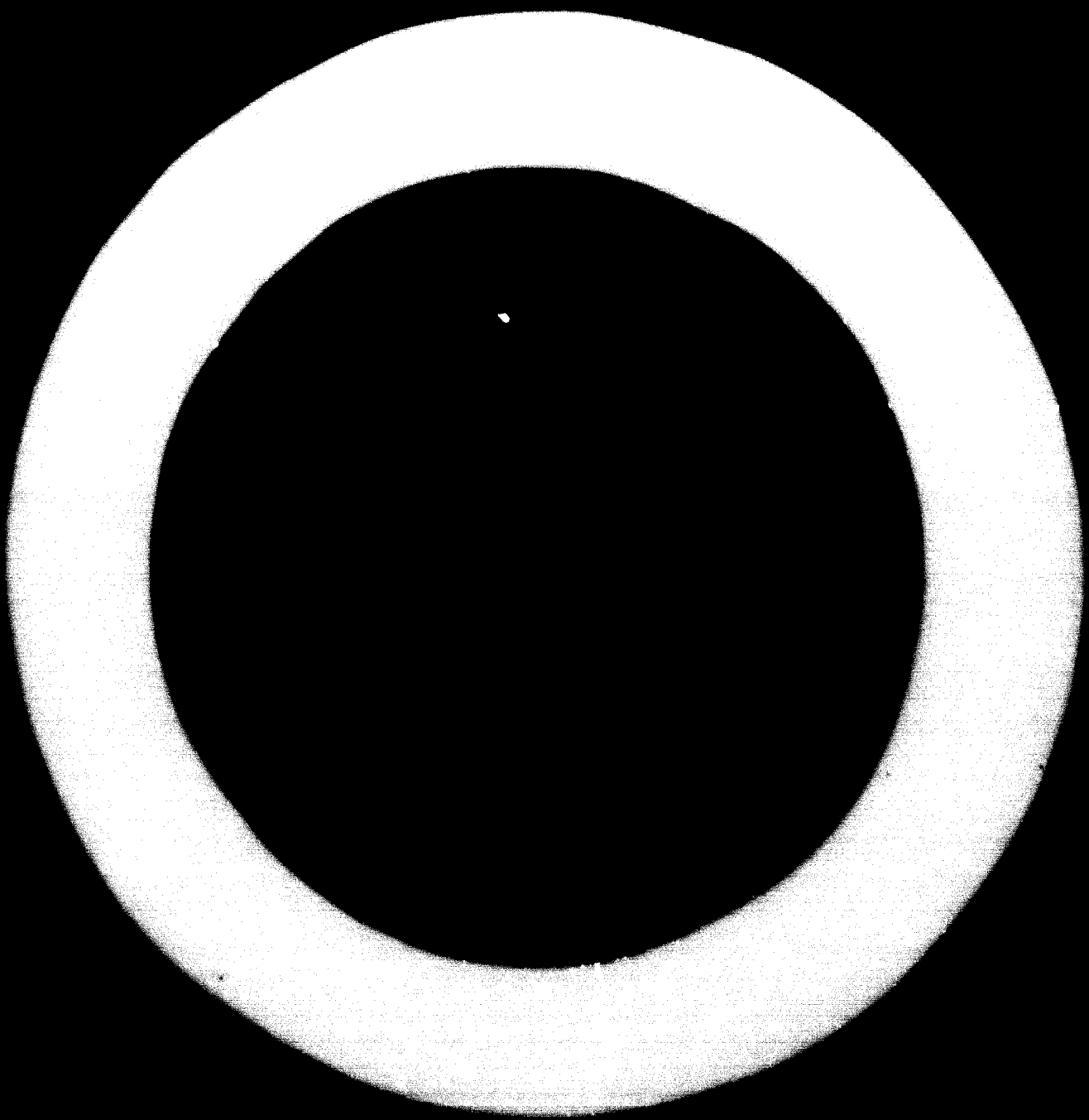

Le coût du charbon de bois et les perspectives d'avenir de ce produit sont ensuite examinés. Le marché de la ferraille (conditions d'approvisionnement et prix) est étudié [illegible].

Enfin, la compétitivité des usines utilisant le charbon de bois et la ferraille est comparée avec celle des usines ayant une capacité de production supérieure pour, d'une part, différents volumes d'investissements et, d'autre part, divers prix du charbon de bois et de la ferraille.

La capacité des usines utilisant le charbon de bois est indiquée pour différents volumes d'investissement et compte tenu de l'accroissement possible de la main-d'oeuvre pour assurer la production du charbon de bois.

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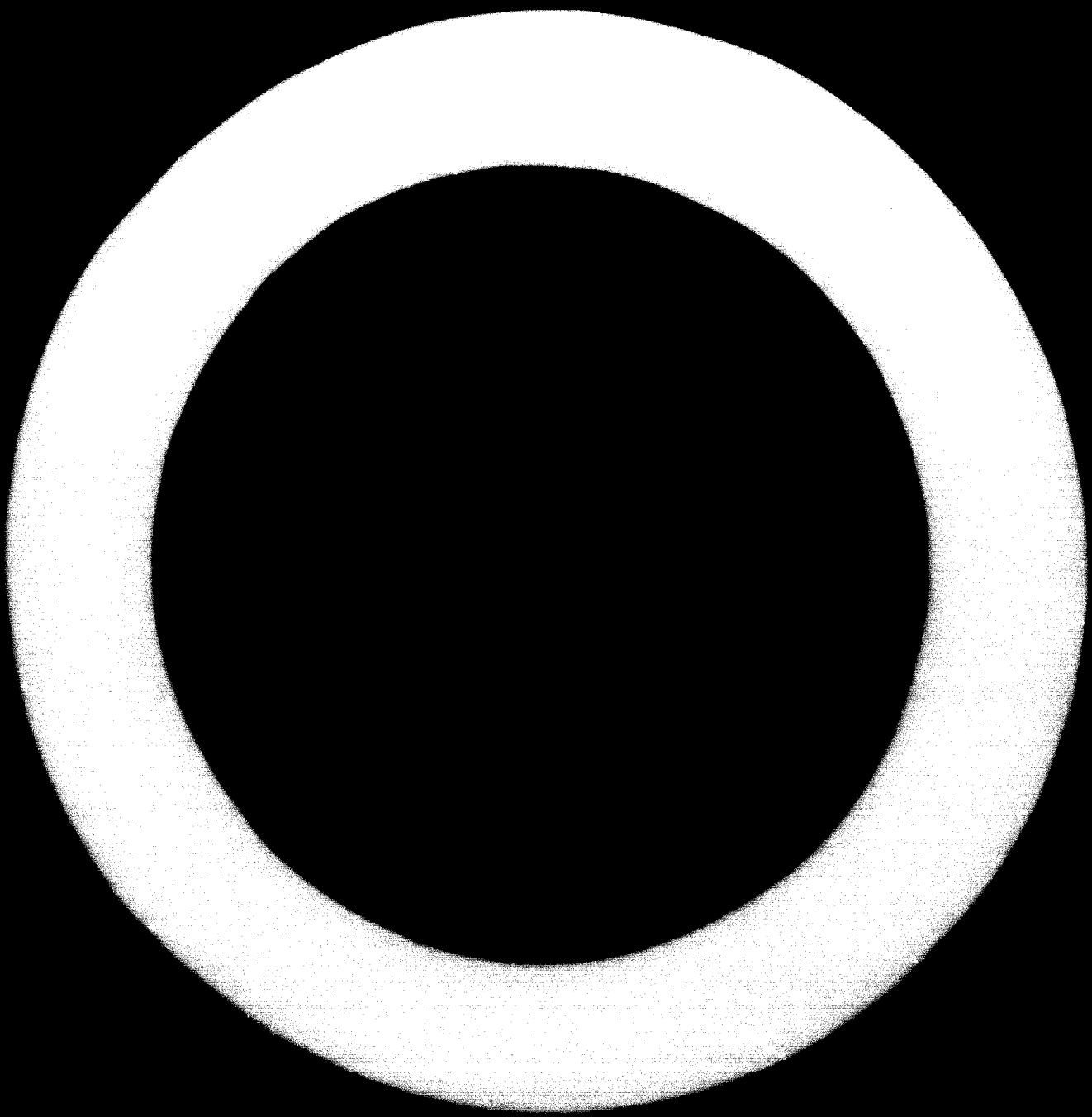

SUMMARY

The paper presents studies prepared by CONSIDER experts on the planning of the expansion of the non-flat ordinary-grade steel rolling sector.

Section 2 outlines the market and the programme for expanding the installed capacity.

The alternatives for increasing the capacity are analysed in section 3, which gives the investments and the details of operational costs of plants with capacities of 900,000 and 1,300,000 tons per year of rolled products, together with their profitability.

In section 4, the solutions studied in the preceding section are compared with lower-capacity plants based on charcoal and scrap. The concept of total unitary cost was used.

Considerations on the cost of charcoal and its prospects for development are discussed. The scrap supply and price situation is summarized.

Finally, the competitiveness of plants utilizing charcoal and scrap is compared with that of plants of higher capacity at different levels of investment for expansion and different charcoal and scrap prices respectively.

The capacity of the plants using charcoal for various amounts of investment is demonstrated, taking into account a possible increase of manpower for the production of charcoal.

1. General Aspects of the Sector

The production of [illegible] steel in Brazil was [illegible] by CONSIDER. [illegible] of the Brazilian [illegible] industry [illegible], controlled by private capital; the Government's intention [illegible] as far as possible without affecting the objectives and guidelines of the national iron and steel industry.

The study of the Brazilian steel market completed in 1972 indicated an increase of internal demand for these products from 3,032,000 ingot tons in 1973 to 3,759,000 tons in 1975, reaching 6,765,100 tons in 1980. On the other hand, the capacity in 1973 was 3,130,000 ingot tons and this should, according to the programme of expansion and installation of new plants being implemented, reach 4,030,000 tons in 1975.

In accordance with the Government directives, installation of a production capacity corresponding to 1.25 of the internal demand was planned in order to take account of the external market and to set aside a part of the capacity to meet peak demands. The position is as follows (in 1000 ingot tons):

Years	Planned capacity	Existing capacity*	Capacity to be installed
1975	4,700	4,030	670
1980	8,450	4,330	4,120

* Including programmes under implementation

The present production comes from 30 plants with installed capacities varying from 4,000 to 650,000 tons/year, including semi-integrated plants based on electric melting shops using scrap and integrated plants with charcoal blast furnaces and rolling mills. Only the Companhia Siderúrgica Nacional, manufacturer of rails and sections, produces steel from iron ore and coke.

2. Alternatives for expansion

In order to cover part of the planned increase in production capacity, a study was initially made of the possibility of installing a plant consisting of coke-oven plant, blast furnace, LD melting shop, and continuous-casting machines with a production capacity of 2,000,000 tons of billets which would be processed at independent rolling-mill plants, with capacities of 300,000 to 600,000 tons/year of rolled products. This plant, known as "Central de Aço" (Steel Centre), would have as shareholders the owners of the rolling-mill plants; the production of billets would be divided among them in accordance with their requirements. The fundamental concept is based in the economies of scale that would result from producing steel in a large plant rather than dispersing the resources available in the installation of several sources of steel. This project, however, did not attract the support of the enterprises and so CONSIDER was obliged to submit other solutions for the expansion of the sector.

A study was therefore made of integrated plants based on coke with production capacities of 900,000 and 1,800,000 tons/year of rolled products (1,000,000 and 2,000,000 tons of billets respectively), comprising coke-oven plant, a blast-furnace, continuous-casting machines, and continuous rolling mills.

The capital and operational costs for each of these plants would be:

	Plant of 900,000 tons	Plant of ,800,000 tons
Capital costs (US$ 1,000)		
Equipment, transportation, planning, insurance, and contingencies	135,400	237,700
Construction	47,600	70,300
Total	183,000	308,000
Operational costs (1) (rolled product US$/t)	71,41	67,95

(1) including depreciation

Detailed operational [illegible] Part [illegible] II.

These investments have the following [illegible]:

Plant of 900,000 t.p.a. - 1.5%

Plant of 1,800,000 t.p.a. - 1.8%

These values have been calculated taking into account the following factors:

- Location - State of Minas Gerais (1)
- Giro capital requirements
  - Plant of 900,000 tons - US$ 26,000,000
  - Plant of 1,800,000 tons - US$ 52,100,000
- Sale price f.o.b. works, excluding taxes:
  - Rolled products - US$ 134,000/t
- Depreciation - linear, in 15 years
  - Price of ore - from US$ 3,22 to US$ 5,03/t
  - Coal price - from US$ 30,01 to US$ 34,00/t
  - Coke rate - 500 kg/t pig iron; oil consumption on the blast furnace - 50 kg/t of pig iron

---

(1) The location of these plants in the State of Minas Gerais, and more specifically at Ipatinga, is due exclusively to the existence of the various raw materials in this region, for which reason the USIMINAS plant, manufacturing flat steel products and at present undergoing an expansion programme to reach 2,400,000 tons/year, is located here. The study for the siting of a new integrated plant is not covered by this paper.

Table I - A - Plant of 900,000 t capacity: Operational billet cost

	SINTER 1,678 x 10^6 t			TOTAL COKE 0,64 x 10^6 t			PIG IRON -,044 x 10^6 t			LIQUID STEEL 1,04[illegible] x 10^6 t			BILLETS 1 x 10^6 t			TOTAL BILLET[illegible] x 10^6 t		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
	t/t	US$/t	US$/t	t/t	US$/t	US$/t	t/t	US$/t	US$/t	t/t	US$/t	US$/t	t/t	US$/t	US$/t	t/t	US$/t	[illegible]
DIRECT MANPOWER [A] (no. of persons)	123		0,21	137		0,09	175		0,46	3[illegible]5		0,35	69		0,[illegible]			
DIRECT RAW MATERIALS [B]			6,36			41,84			35,29			44,5[illegible]			[illegible],[illegible]			[illegible]
Coal blends	-	-	-	[illegible],333	31,39	41,84	-	-	-	-	-	-	-	-	-	-	-	[illegible]
Iron ore (fines)	0,995	3,22	3,21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[illegible]
Iron ore (lump)	-	-	-	-	-	-	-	-	-	0,[illegible]30	5,05	0,40	-	-	-	-	-	[illegible]
Manganese ore	-	-	-	-	-	-	0,028	15,12	0,42	0,005	15,12	0,0[illegible]	-	-	-	-	-	[illegible]
Limestone	-	-	-	-	-	-	0,030	5,70	0,17	-	-	-	-	-	-	-	-	[illegible]
Crushed limestone	0,087	8,78	0,76	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[illegible]
Lime	0,011	26,06	0,29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	[illegible]
Dolomite	0,042	5,87	0,25	-	-	-	0,057	5,87	0,33	-	-	-	-	-	-	-	-	[illegible]
Scrap	-	-	-	-	-	-	-	-	-	0,040	-	-	-	-	-	-	-	[illegible]
Sinter	-	-	-	-	-	-	1,600	7,68	12,29	-	-	-	-	-	-	-	-	[illegible]
Coke and coke breeze	0,054	43,60	2,35	-	-	-	0,500	44,15	22,08	-	-	-	-	-	-	-	-	[illegible]
Pig iron	-	-	-	-	-	-	-	-	-	[illegible],006	40,08	42,48	-	-	-	-	-	[illegible]
Liquid steel	-	-	-	-	-	-	-	-	-	-	-	-	1,048	50,77	52,90	-	-	[illegible]
DIRECT MANUFACTURING COSTS [C]	-	-	0,24	-	-	0,16	-	-	2,31	-	-	3,22	-	-	0,[illegible]	-	-	[illegible]
Elect. energy (kWh/t)	27	0,009	0,24	18	0,009	0,16	60	0,009	0,54	9	0,009	0,08	24	0,009	0,[illegible]	-	-	[illegible]
Heavy oil	-	-	-	-	-	-	0,050	25,35	1,27	-	-	-	-	-	-	-	-	[illegible]
Oxygen (m^3/t)	-	-	-	-	-	-	25	0,02	0,50	56	0,02	1,12	-	-	-	-	-	[illegible]
Ferro-alloys	-	-	-	-	-	-	-	-	-	0,007	296,50	2,08	-	-	-	-	-	[illegible]
TOTAL DIRECT COSTS (A + B + C)																		[illegible]
INDIRECT MANUFACTURING COSTS [D]	-	-	0,37	-	-	1,51	-	-	2,00	-	-	2,97	-	-	2,24	-	-	[illegible]
OPERATIONAL COSTS	-	-	7,68	-	-	44,15	-	-	40,08	-	-	50,77	-	-	55,56	-	-	57,[illegible]

A = Consumption per unit
B = Price

Table I - B - Plant of 900,000 t capacity: Operational cost of rolled products

	Unit	Consumption per unit	Price (US$/unit)	Unit Cost (US$/t)
A) DIRECT MANPOWER	H_h	0,60	0,30	0,18
B) DIRECT RAW MATERIALS				
- Time	t	1,11	57,26	63,56
C) DIRECT MANUFACTURING COSTS				2,02
- Rolls	kg	0,60	1,04	0,62
- Oil	t	0,055	22,40	1,23
- Electrical energy	kwh	130	0,009	1,17
D) INDIRECT MANUFACTURING COSTS	-	-	-	2,58
E) CREDITS				(3,23)
- Scrap	kg	90	-	-
- Substitution of fuel oil by coke-oven gas	-	-	-	(3,23)
F) OPERATIONAL COSTS				72,33

Table II - A - Plant of 1,800,000 t capacity: Operational billet cost

	SINTER 3,354,000 t			TOTAL COKE 1,229,000 t			PIG IRON 2,097,000 t			LIQUID STEEL 2,084,000 t			BILLETS 2,000,000 t			TOTAL BILLETS 2,000,000 t		
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
	t/t	US$/t	US$/t	t/t	US$/t	US$/t	t/t	US$/t	US$/t	t/t	US$/t	US$/t	t/t	US$/t	US$/t	t/t	US$/t	US$/
DIRECT MANPOWER [A] (no. of persons)	134		0,11	143		0,30	340		0,43	310		0,41	453		0,62			
DIRECT RAW MATERIALS [B]			6,86			41,84			34,70			41,63			49,83			
Coal blends	-	-	-	1,333	31,39	41,84	-	-	-	-	-	-	-	-	-			
Iron ore (fines)	0,995	3,22	3,21	-	-	-	-	-	-	-	-	-	-	-	-			
Iron ore (lump)	-	-	-	-	-	-	-	-	-	0,080	5,05	0,40	-	-	-			
Manganese ore	-	-	-	-	-	-	0,028	15,12	0,42	0,005	15,12	0,08	-	-	-			
Limestone	-	-	-	-	-	-	0,030	5,70	0,17	-	-	-	-	-	-			
Crushed limestone	0,087	8,78	0,76	-	-	-	-	-	-	-	-	-	-	-	-			
Lime	0,011	26,06	0,29	-	-	-	-	-	-	0,062	26,06	1,62	-	-	-			
Dolomite	0,042	5,87	0,25	-	-	-	0,057	5,87	0,33	-	-	-	-	-	-			
Scrap	-	-	-	-	-	-	-	-	-	0,040	-	-	-	-	-			
Sinter	-	-	-	-	-	-	1,600	7,49	11,98	-	-	-	-	-	-			
Coke and coke breeze	0,054	43,60	2,35	-	-	-	0,500	43,60	21,80	-	-	-	-	-	-			
Pig iron	-	-	-	-	-	-	-	-	-	1,000	39,30	39,52	-	-	-			
Liquid steel	-	-	-	-	-	-	-	-	-	-	-	-	1,042	47,82	49,83			
DIRECT MANUFACTURING COSTS [C]			0,24			0,16			2,36			3,28			0,22			
Elect. energy (kWh/t)	27	0,09	0,24	18	0,00	0,16	60	0,09	0,5	9	0,08	0,08	24	0,08	0,08			
Heavy oil	-	-	-	-	-	-	0,050	25,35	1,27	-	-	-	-	-	-			
Oxygen (m^3/t)	-	-	-	-	-	-	25	0,02	0,50	56	0,02	1,12	-	-	-			
Ferro-alloys	-	-	-	-	-	-	-	-	-	0,007	296,50	2,08	-	-	-			
INDIRECT MANUFACTURING COSTS [D]			0,28			1,30			1,86			2,50			2,02			9,6
OPERATIONAL COSTS (A + B + C + D)			7,49			43,60			39,30			47,82			52,69			54,3

A - Consumption per unit
B - Price

B = Price
C = Unit cost

Table II - 3 - Plant of 1,800,000 t capacity: Operational cost of rolled products

	Unit	Consumption per unit	Price (US$/unit)	Unit Cost (US$/t)
A) DIRECT LABOUR	H_h	0,50	0,80	0,40
B) DIRECT RAW MATERIALS				
- Billet	t	1,11	54,37	60,35
C) DIRECT MANUFACTURING COSTS				3,02
- Rolls	kg	0,60	1,04	0,62
- Oil	t	0,055	22,40	1,23
- Electrical energy	kwh	130	0,009	1,17
D) INDIRECT MANUFACTURING COSTS	-	-	-	5,44
E) CREDITS				(3,11)
- Scrap	kg	90	-	-
- Substitution of fuel oil by coke-oven gas	-	-	-	(3,11)
F) OPERATIONAL COSTS				67,25

3. Market demand and comparison with plants based on charcoal and scrap - economies of scale

Other alternatives for increasing the installed capacity would be the construction (or expansion) of integrated plants based on charcoal and of semi-integrated plants based on scrap, which would in effect mean preserving the present technological structure of the sector.

Let us compare the total costs of billets from new or expanded plants based on charcoal and scrap and from coke-based plants of 1,000,000 to 2,000,000 tons as indicated in the last item.

The concept of total unitary cost was utilized as developed by MILLS and SOAN (2). This consists of considering the operational cost and the capital cost (which is represented by a part only) as a function of the planned investments, which includes:

- depreciation
- a satisfactory profit margin (except during the period of construction)
- risk of the undertaking

It is intended to analyse points on the curves which show the total costs as a function of different levels of production, employing several technological solutions (classic curves of economy of scale). The studies by Atkins Planning for UNIDO on the Brazilian iron and steel industry produced the economy curves shown in Fig. I, for the different methods of producing steel (3).

In the case of the units based on coke and with capacities of 1,000,000 and 2,000,000 tons, the following are the total costs for produced billets (see details of operational costs in Tables I and II):

---

(2) Mills, H.R. and Soan, B.S. Determination of the optimum capacity of the fully integrated iron and steel plants and its parts. Paper submitted to the Second Inter-regional Iron and Steel Symposium, Moscow 1968.

(3) Atkins Planning - Technological innovation and its implication for long-range planning of the iron and steel industry in Brazil. A report for UNIDO - November 1972; the total costs of Table I, which refer to the production of liquid steel, can only be related to those indicated in other parts of the present paper if a proportion relating to the transformation of the liquid steel into billets is added.

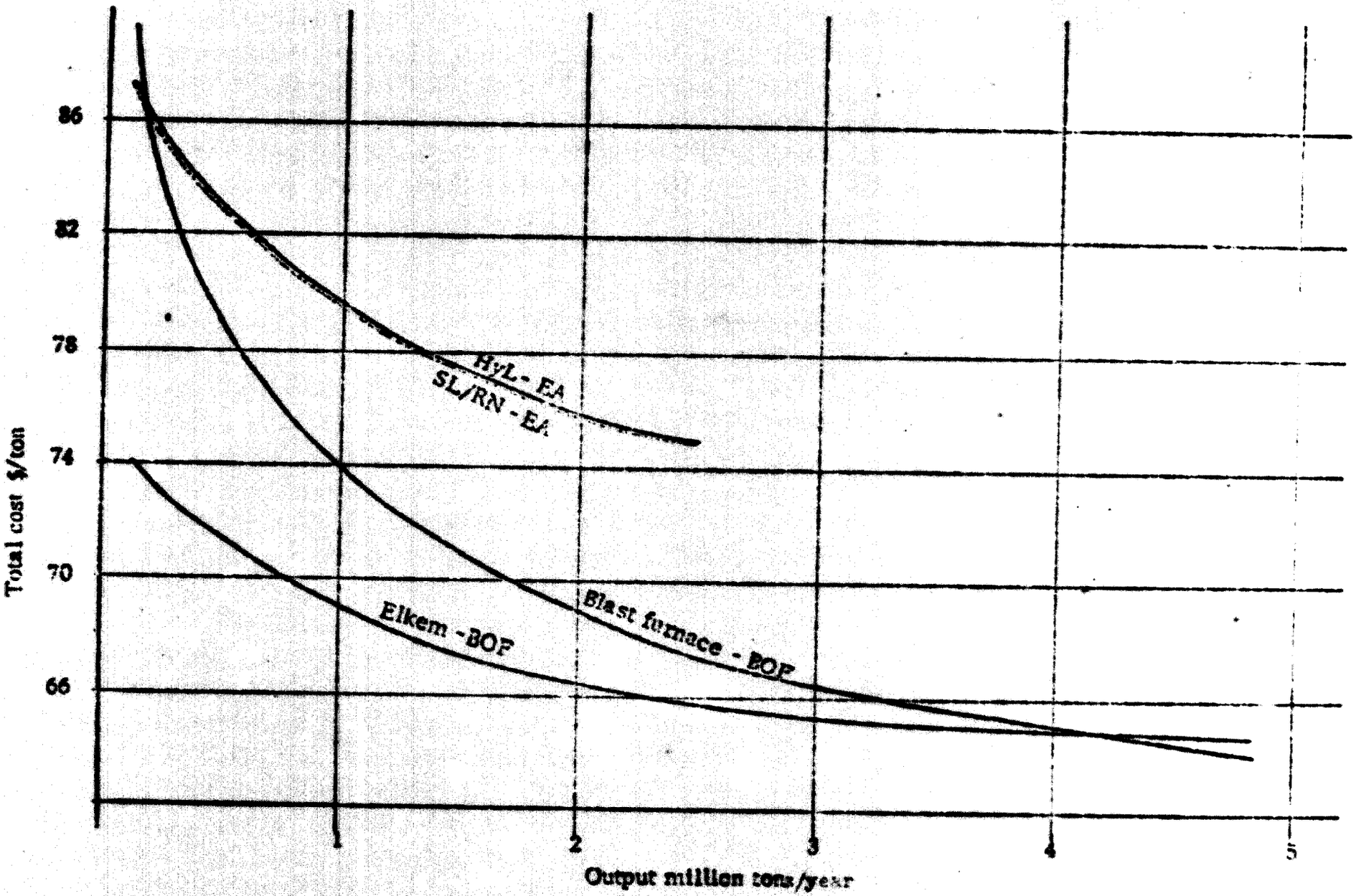

FIGURE 1 - ECONOMIES OF SCALE OF VARIOUS PROCESS ROUTES TO LIQUID STEEL.

	Unit 1 : 1 mill.t/y	Unit 2 : 2 mill.t/y
- Operational costs	61,26	54,37
- Depreciation and amortization of pre-operational expenses	9,14	7,80
- Capital remuneration	17,70	15,00
- Total cost	83,60	77,17

For plants based on charcoal, a production considered to be representative was taken (250,000 t/year of billets) for which it is possible to have a blast furnace operating economically with charcoal. In accordance with the projects submitted in CONSIDER for new plants of this size, the melting shop consists of LD converters of small capacity.

For plants using scrap (U.H.P. electric furnaces and continuous-casting machines), a capacity of 250,000 t/year of billets was also considered, also in accordance with the trend in Brazilian iron and steel enterprises.

In each of the above-mentioned cases, the main problem in determining the billet cost lies in deciding the charcoal and scrap prices.

The Brazilian iron and steel plants are supplied with charcoal produced from wood from the "cerrado" (savannah) region, and from natural forests and plantations of eucalyptus. The study undertaken by a working group co-ordinated by the Brazilian Institute for Forest Development (IBDF), with the participation of the Ministry for Industry and Commerce through CONSIDER, showed that in 1971 the charcoal consumed by the iron and steel industry had the following origins: (4)

- Cerrado - 60%
- Natural forests - 30%
- Plantations - 10%

(4) Instituto Brasileiro of Forest Development. Final report of the Working Group on Charcoal in the iron and steel industry. February 1973.

The costs of the charcoal vary according to its origin as well as with the transport distance from the production site to the steel plant. Again, according to the IBDF study in 1972, the costs of production and transport were as follows:

	US$/m³		
	Cerrado	Natural Forests	Plantations
- Costs of production	4,58	4,91	6,19
- Transport (distance average)	2,60	2,60	0,87
- Cost at the plant	7,18	7,57	7,06

However, a significant increase in the costs can be expected. With the upgrading of rural manpower and, in the specific case of the "cerradon", with the establishment of new national methods of exploitation to replace the present uncontrolled deforestation system, and also with a probable increase in transport distances, the costs tend to increase (5). On the other hand, there should be added to the cost an additional element which remunerates the enterprises involved in the production of this raw material.

With regard to scrap, the studies undertaken indicate that in the present decade the existing gap between consumption and production will worsen. Estimates for these two items indicate the following evolution (6):

	1,000 tons	
	1973	1980
- Production of scrap	3,059	6,730
- Consumption of scrap	3,904	10,088
- Deficit	845	3,358

(5) In the case of the cerrados, the sale of wood for charcoal is made mostly with the object of clearing the ground in order to use it in other activities, as, for instance, cattle. The IBDF intend to exploit the cerrados in order to make the sale of wood for charcoal a permanent profitable activity for the farmer. Therefore, measures for the working of the cerrados should be taken in order to allow for regeneration (over a period of 10 to 15 years) and consequently further felling of the trees. Of course, in these circumstances the price of wood for charcoal will reflect a cost structure that is higher than at present, which is a marginal rent for the owners of the grounds.

(6) Poubel, Ethienne V. - The Brazilian scrap market: Paper submitted to the ILAFA Seminar "Scrap in the Latin American iron and steel industry", Buenos Aires, 10/13 July 1973.

For this reason it was considered that the internal price would tend to equal the price of imported scrap. It was estimated that these prices will be over US$ 50/t (7).

Based on these premises, the total billet cost for plants utilizing charcoal and scrap are estimated as follows (details of the operational costs are given in Tables III and IV):

	Total costs (US$/t)			
	Plant utilizing charcoal		Plant utilizing scrap	
	Charcoal at US$ 7,5/m³	Charcoal at US$ 3/m³	Scrap at US$ 40/t	Scrap at US$ 50/t
- Operational costs	62,08	64,32	73,99	84,79
- Depreciation and amortization of pre-operational expenses	7,50	7,50	3,10	3,10
- Capital remuneration	14,20	14,20	6,50	6,50
- Total cost	83,78	86,02	83,59	94,39

(7) Owing to the increase in scrap prices in 1973, this imported raw material was offered at US$ 39,00/t at the Brazilian plants.

Table III - Plant operating on charcoal - 250,000 t capacity

Operational Cost of the Billet

	SINTER			PIG IRON			LIQUID STEEL			BILLET		
	A	B	C	A	B	C	A	B	C	A	B	C
	t/t	US$/t	US$/t	t/t	US$/t	US$/t	t/t	US$/t	US$/t	t/t	US$/t	US$/t
DIRECT MANPOWER [A]			0,30			1,81			0,33			[illegible]
DIRECT RAW MATERIALS [B]			1,05			35,47			47,70			[illegible]
Iron ore	0,900	3,00	2,70	0,490	3,00	[illegible]	0,046	3,00	0,14	-	-	-
Limestone	0,012	5,70	0,07	-	-	-	0,052	20,00	[illegible]	-	-	-
Dolomite	0,197	5,87	1,16	-	-	-	-	-	-	-	-	-
Charcoal - m^3	0,300	9,00	3,12	3,00	8,00	24,00	-	-	-	-	-	-
Manganese ore				0,01	15,12	0,47	-	-	-	-	-	-
Sinter				1,160	8,22	9,53	-	-	-	-	-	-
Pig iron							1,074	40,03	[illegible]	-	-	-
Liquid steel										[illegible]	[illegible]	[illegible]
DIRECT MANUFACTURING COSTS [C]			0,27			2,36			[illegible]			[illegible]
Electr. energy (kWh)	30	0,009	0,27	150	0,009	1,35	12	0,009	0,11	[illegible]	[illegible]	[illegible]
Oil	-	-	-	0,040	25,35	1,01	-	-	-	-	-	-
Oxygen (m^3)	-	-	-	-	-	-	52	0,02	1,01	[illegible]	[illegible]	[illegible]
Ferro-alloys	-	-	-	-	-	-	0,007	296,50	2,07	-	-	-
INDIRECT MANUFACTURING COSTS [D]			0,60			3,33			[illegible]			[illegible]
OPERATIONAL COSTS [E]			3,22			43,03			50,29			[illegible]

A = Consumption per unit
B = Price
C = Unit cost

Table IV - Plant operating on scrap - 250,000 t capacity

Operational Cost of the Billet

	Consumption t/t	Price US$/t	Unit Cost US$/t
A) DIRECT MANPOWER	-	-	2,10
B) DIRECT RAW MATERIALS			54,00
- scrap	1,08	50	54,00
C) DIRECT MANUFACTURING COSTS	-	-	17,37
- Electr. energy (kWh)	560	0,009	5,04
- Oxygen (m^3)	16	0,16	2,56
- Electrodes	0,006	855,00	5,13
- Ferro-alloys	0,016	290,00	4,64
D) INDIRECT MANUFACTURING COSTS	-	-	11,32
E) OPERATIONAL COSTS	-	-	84,79

The competitiveness of [illegible] operating on [illegible] compared with 1,000,000 and [illegible],000,000 tons/year plants operating on coke [illegible] as the prices of charcoal [illegible] the [illegible] increase. With a charcoal price of US$ [illegible]/m^3, [illegible] operating on charcoal would have practically the same total cost as a [illegible],000,000 ton plant (US$ [illegible],60/t), although this cost is US$ [illegible]/t higher than that of the [illegible],000,000 tons/year plant. However, if the price increases to US$ [illegible],00/m^3 (a more realistic value), the final cost would be US$ [illegible],4[illegible]/t and US$ [illegible],[illegible]/t above the costs of the plants of [illegible],000,000 and 2,000,000 tons/year, respectively (8).

With regard to the scrap-based plant, when this raw material is at US$ 40/t, its costs will be the same as those of an iron and steel plant of 1,000,000 t/year, but US$ 6,42/t above the cost of the 2,000,000 t/year plant. Its competitiveness decreases significantly when the price of scrap reaches US$ 50/t; the costs by comparison with the plants of 1,000,000 to 2,000,000 tons/year would be, respectively higher by US$ 10,79/t and US$ 17,22/t. It should be noted the location of a plant based on scrap in these circumstances would not be unfavourable, since one unit of this type would be located in a large consumer market (in the Brazilian case in São Paulo or in Rio de Janeiro), thus partially compensating for the costs of products distribution which a plant of larger size would incur (9).

Turning to the possibility of expanding the existing plants based on charcoal or scrap, Table V and VI show the total costs for several levels of investment (US$ per ton of additional capacity) and for various charcoal or scrap prices. The competitiveness between those plants and the coke-based plants of the sizes discussed in this paper is clearly shown. An expansion of the charcoal-based works with investment of the order of US$ 90/t, for instance, would only be competitive with a coke-based plant of 2,000,000 t/year if the charcoal price were under US$ 7/m^3. On the other hand (Table V) the expansion of a scrap-based plant, with investments of US$ 60/t, will only result in a lower billet price if scrap is bought at between US$ 30 and 35 per ton.

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(8) In the first quarter of 1973, the charcoal price at the plants reached US$ 8,50/m^3.

(9) An iron and steel plant of 1,000,000 or 2,000,000 t/year of capacity incurs costs for the distribution of its products in the markets (transport expenses) higher than those of a smaller plant located in the market area. In the case studied in the present paper, the calculation of the operational costs of the scrap-based plant assumed it to be located in Rio de Janeiro.

Finally, Tables VII and VIII demonstrate the effect of an increase in charcoal prices, in the likely event of an increase in rural manpower costs (annual increase of 5% was assumed), on the total plant costs, on the basis of 10% charcoal prices and at different levels of expansion.

4. Conclusions

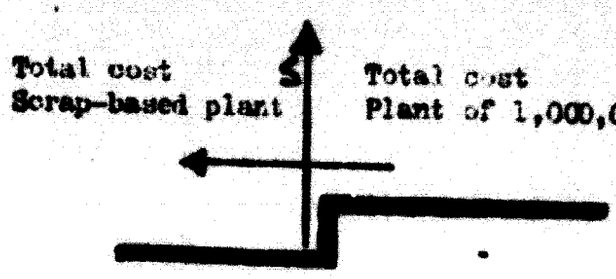
In the cases analysed, a plant operating on coke, with a capacity of 2,000,000 tons/year of billets, appears to have lower total costs than plants operating on charcoal and on scrap, on the operating scales considered and within the anticipated scrap prices.

Semi-integrated plants using scrap at US$ 40 and 50/t will be able to compete with coke-based integrated plants with capacities of 1,000,000 tons.

A new plant operating on charcoal will not be competitive with coke-based plants of 1,000,000 or 2,000,000 tons. The expansions of existing plants permit competition for varying periods and in relation to the level of expansion.

Table V - Levels of expansion and price of scrap (US$/t)

Scrap Cost US$/t \ Fixed Investment US$/t	30	40	50	60	70	80
30	71,00	72,60	74,10	75,70	77,20	78,80
35	76,40	78,00	79,50	81,10	82,60	84,20
40	81,80	83,40	84,90	86,50	88,00	89,60
45	87,20	88,80	90,30	91,90	93,40	95,00
50	92,60	94,20	95,70	97,30	98,80	100,40



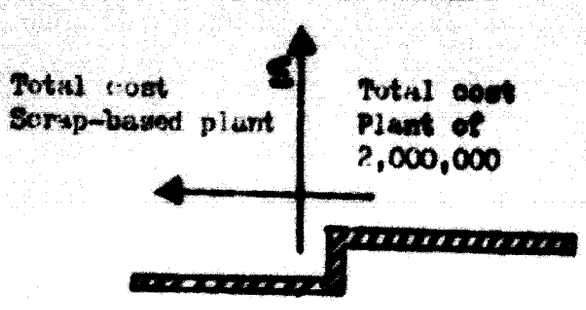


Table VI - Plant on charcoal - Cost of billet according to level of expansion and prices of charcoal (US$/t)

Charcoal Cost US$/m³ \ Fixed Investment US$/t	60	70	80	90	100	110	120	130
5	65,60	67,20	68,70	70,30	71,80	73,40	74,90	76,50
6	69,50	71,10	72,60	74,20	75,70	77,30	78,80	
7	73,40	75,00	76,50	78,10	79,60	81,20	82,70	
8	77,30	78,80	80,40	81,90	83,50	85,00	86,60	
9	81,20	82,70	84,30	85,80	87,40	88,90	90,50	
10	85,00	86,60	88,10	89,70	91,20	92,90	94,30	

Table VII - Pixed production charcoal

Cost of pellet according to level of operation

and increase of cost of increase for

charcoal (% per year)

Case of "Cerrado" charcoal

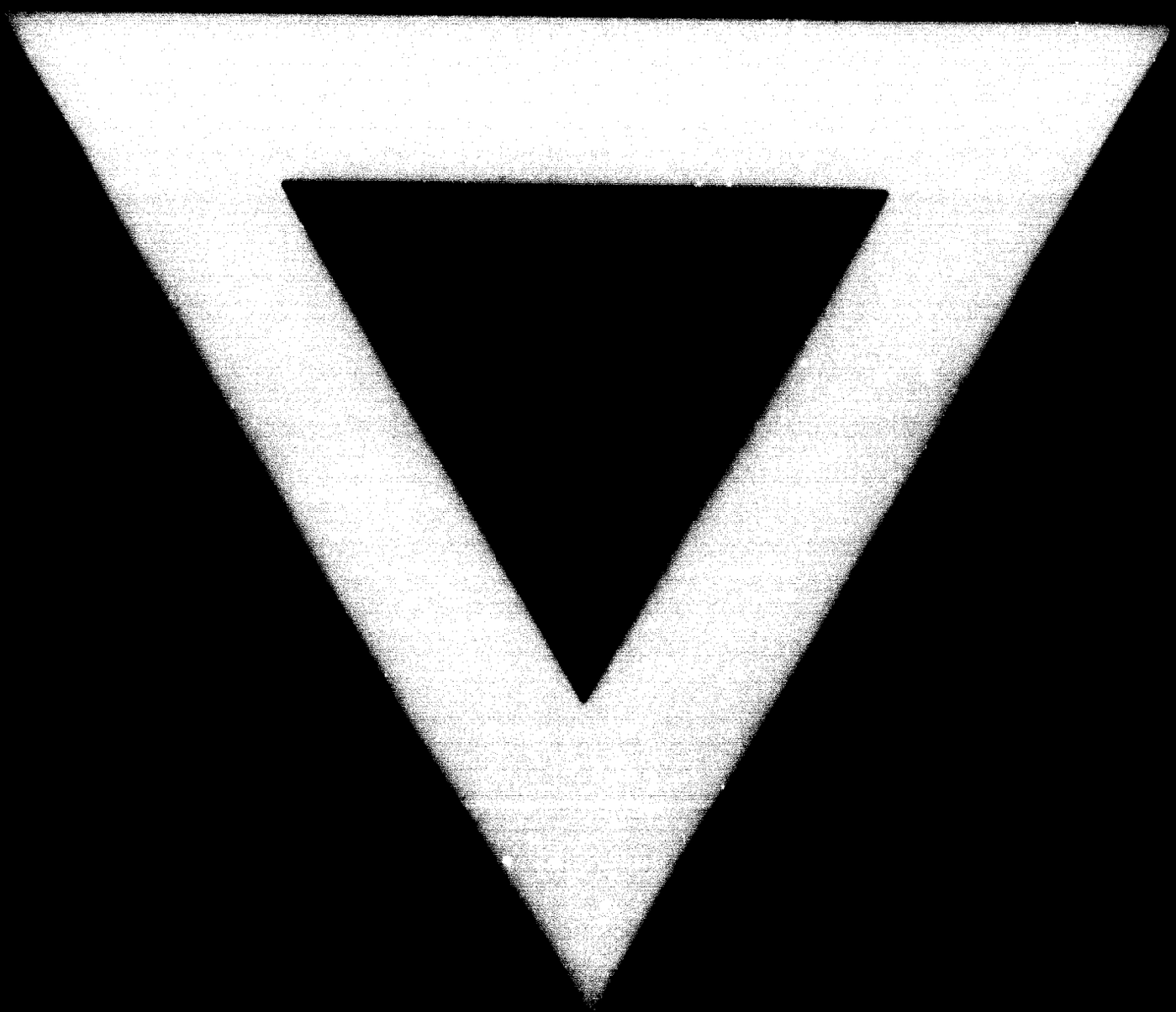
US$/t

Year \ Fixed investment	60	70	80	90	100	110	120
1971	74,40	75,90	77,50	79,00	80,60	82,10	83,70
1972	74,80	76,30	77,90	79,40	81,00	82,50	84,10
1973	75,20	76,70	78,20	79,80	81,30	82,90	84,40
1974	75,60	77,10	78,70	80,20	81,80	83,30	84,90
1975	76,00	77,50	79,10	80,60	82,20	83,70	85,30
1976	76,40	78,00	79,50	81,10	82,60	84,20	85,70
1977	76,90	78,40	80,00	81,50	83,10	84,60	86,20
1978	77,40	78,90	80,50	82,00	83,60	85,1[illegible]	86,70
1979	77,80	79,40	80,90	82,50	84,00	85,60	87,10
1980	78,30	79,90	81,40	83,00	84,50	86,10	87,60
1981	78,90	80,40	82,00	83,50	85,10	86,70	
1982	79,40	80,90	82,50	84,00	85,60	87,20	
1983	79,90	81,50	83,10	84,60	86,20	87,80	
1984	80,50	82,10	83,70	85,20	86,80	88,40	
1985	81,10	82,70	84,30	85,80	87,40		
1986	81,70	83,30	84,90	86,40	88,00		
1987	82,30	83,90	85,50	87,00			
1988	82,90	84,50	86,10	87,60			
1989	83,50	85,10	86,70	88,20			
1990	84,30	85,70	87,30				

Table VIII – Plant operating on charcoal – Cost of billet according to level of expansion and increase of the part of manpower for charcoal (3% per year)

Case of Coal from forest plantations (US$/t)

Year \ Fixed investment US$/t	60	70	80	90	100	110	120
1971	75,30	77,40	78,90	80,50	82,00	83,60	85,10
1972	76,50	78,00	79,60	81,10	82,70	84,20	85,80
1973	77,10	78,70	80,20	81,80	83,30	84,90	86,40
1974	77,80	79,30	80,90	82,40	84,00	85,50	87,10
1975	78,50	80,00	81,60	83,10	84,70	86,20	87,80
1976	79,20	80,70	82,30	83,80	85,40	86,90	88,40
1977	79,90	81,40	83,00	84,50	86,10	87,60	89,20
1978	80,70	82,20	83,80	85,30	86,90	88,40	90,00
1979	81,50	83,00	84,60	86,10	87,70	89,20	90,80
1980	82,30	83,80	85,40	86,90	88,50	90,00	91,60
1981	83,20	84,70	86,30	87,80	89,40	90,90	92,50
1982	84,00	85,60	87,10	88,70	90,20	91,80	93,30
1983	84,90	86,50	88,00	89,60	91,10	92,70	94,20
1984	85,80	87,40	88,90	90,50	92,00	93,60	95,10
1985	86,80	88,30	89,90	91,40	93,00	94,50	96,10



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