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REPORT ON THE REHABILITATION OF THE MALUKU STEEL MILL (SOSIDER), ZAIRE AND RECOMMENDATIONS FOR FURTHER DEVELOPMENT OF THE IRON AND STEEL INDUSTRY AS CATALYST FOR THE INDUSTRIALIZATION OF ZAIRE*

Sectoral working paper

Prepared by

Industrial Statistics and Sectoral Surveys Branch
Policy and Perspectives Division

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* This document has not been edited.

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ZAIRE

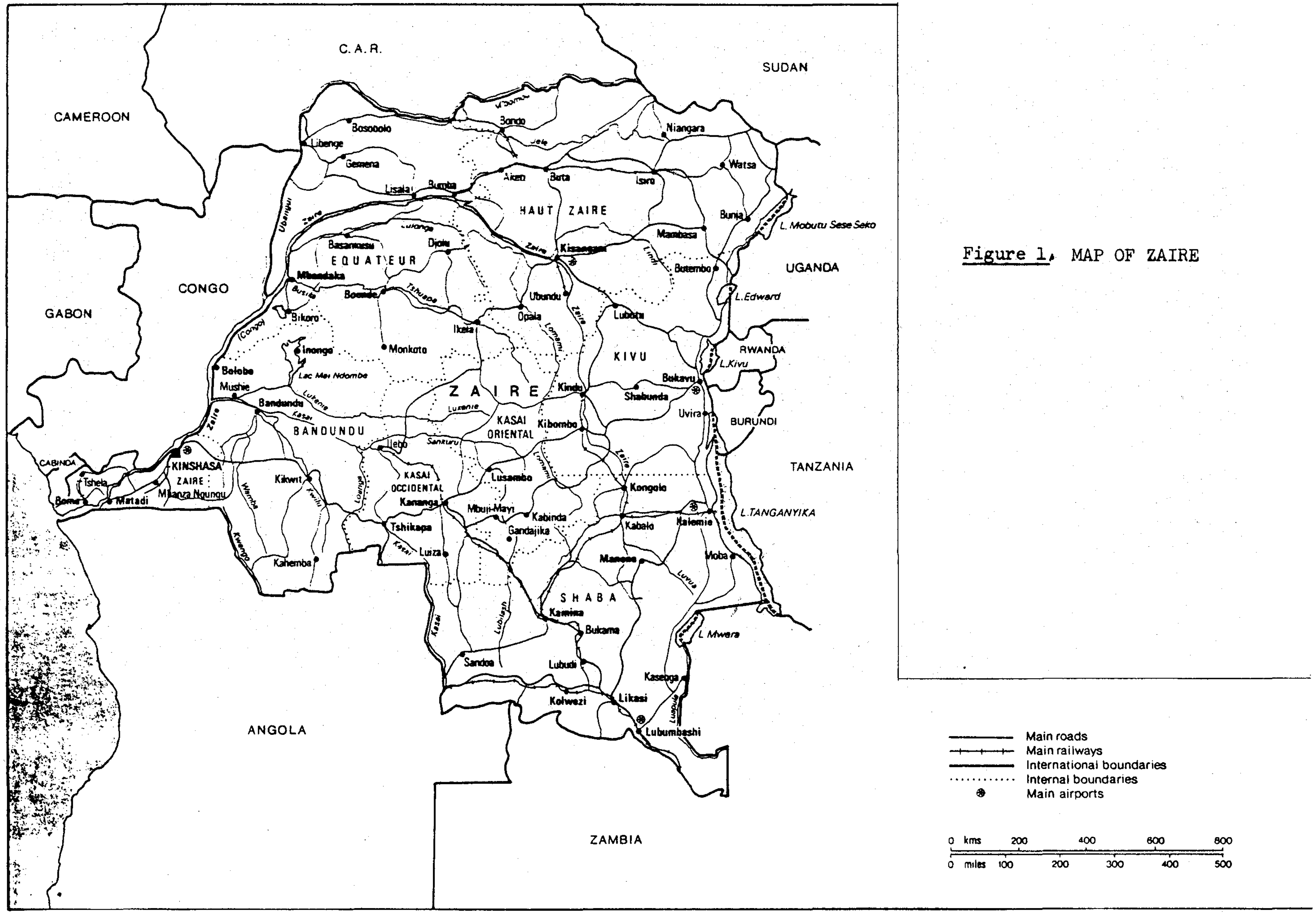
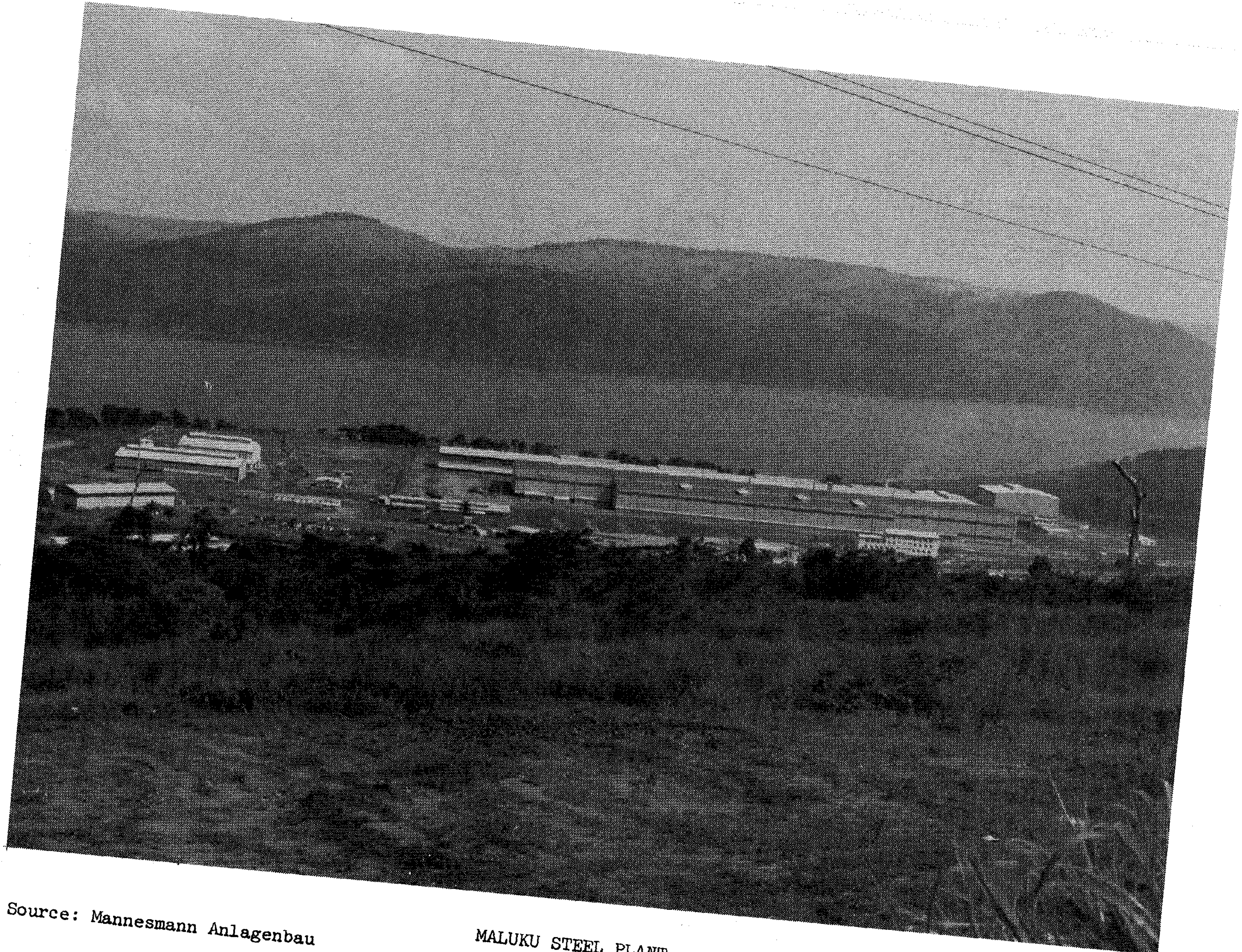


Figure 1. MAP OF ZAIRE



Source: Mannesmann Anlagenbau

MALUKU STEEL PLANT

PREFACE

1. This report presents a broad range of economic and technical analyses of the Maluku steel mill in Zaire and its economic background. It concerns the analysis of steel-making operations and its rehabilitation, taking into consideration a further expansion of metallurgical industries at national level as well as the integrated development of the iron and steel industry in Zaire and possibly in the Central African region in the future.

Recommendations for immediate and future joint action by the Zaire government and SOSIDER (Société d'explotation sidérurgique)1/ as well as economic and technical proposals for the rehabilitation of the Maluku steel mill are ennumerated in detail after a thorough assessment of (a) the operating practices and state of equipment for electric arc steel making, continuous casting and rolling operation at the Maluku steel mill, (b) the managerial operation of SOSIDER, and (c) the business and economic situation in Zaire.

The object of the technical assistance undertaken for the rehabilitation of the plant is to analyse its specific problems both at plant and at national level and to carefully elaborate and implement a solution for the equipment utilization in the interest of both the country's economy and the enterprise SOSIDER. The three experts of UNIDO mentioned below have made a detailed technical and economic assessment of the operation of the Maluku steel plant in the framework of the assistance requested by the Zaire government for the rehabilitation of the Maluku steel mill in the context of national economy.

The mission found that the steel plant at Maluku can be viable and productive despite the fact that it is regarded by many, within and outside the country, as a costly investment which brings little or no benefit to the country. The present report shows that rentability can be reached on both short- and medium term. The mission also found that the overall problems to be solved for the rehabilitation of the Maluku steel mill originate principally in management-related matters, and secondly in financial, marketing, and technical operations.

UNIDO specialists involved in this mission:

Mr. Barry Crowston - metallurgist/engineer
Mr. Fidelino Figueiredo - Africa area specialist
Mr. Fujio J. Tanaka - metallurgist/industrial economist (author of this report)

While Mr. Tanaka writes this report Mr. Crowston will prepare specific projects on technical assistance required for the immediate and medium term after separate consultations with Mr. Figuereido and Mr. Tanaka.

2. According to the rehabilitation proposal made by the above experts, the reactivation of the plant can be made in three phases of which the first two are combined.

Phase I (1989-1991) Re-starting the operation at a 7,500-ton level in the present condition of the economy, utilizing the local scrap or other raw materials needed and achieve a production target of 25,000 tons/year.

1/ SOSIDER is Maluku Steel's operator.

Prepare a study for a rational system for the collection, processing and utilization of steel scrap in Zaire.

Phase II (1992-1993) Keep production level at a 30,000-ton level in 1992 and in 1993. In the meantime solve all operational, financial and marketing problems.

Prepare a study for the adaptation of the cold rolling facilities at the Maluku steel mill to a steel service center to provide the local manufacturing industries with sheets and strip.

Undertake a feasibility study for the installation of a direct reduced sponge iron having a capacity of 100,000 to 150,000 tons/year using local raw materials such as iron ore, coal, charcoal, etc.

Elaborate a programme for the phased assessment of the possibilities for the production of directly reduced sponge (DRI) iron in the country based on the above feasibility study.

Phase III (1994-1995) Elaborate a programme for the phase assessment of the possibilities to produce DRI in the country for the integrated linkage with the existing melting and rolling mills of the Maluku plant.

After careful market research on cold rolled products, the re-start of cold rolled mill should be considered using imported cold rolled products.

Phase IV (1996-2000) Actual implementation and commissioning of direct reduction plant which can afford to implement the additional module (100,000 tons).

A concrete plan based on the production of the Maluku steel mill should be prepared for the integrated development of the iron and steel industry in the Economic Community of Central African States for the immediate start of regional co-operation.

There are many more activities required for the achievement of the above programmes which are not spelled out but implied in the four phases of programme action activities.

In order to make this programme successful the following main points should be carried out:

(a) High level mission of expatriates must be sent

(b) $100/ton of consumable materials, refractories, electrodes, finishings as well as certain spare parts must be provided from either the government or a private investor.

The high level expatriates to run the plant for two to three years must be composed of:

- One plant management officer working independently from a government body.

- One financial and marketing officer in charge of day-to-day accounting transactions and sales promotion of the steel products produced by the Maluku steel plant.

- One mechanical engineer specialized in the selection of input material and other inputs required for steel melting.

The foreign currency component for imported raw materials and spare parts can be self-financed from the operating surpluses so that SOSIDER can provide for its own operating cost whether it is run by the public corporation or whether it is privatized. It should be emphasized, however, that the shortage of foreign exchange is the main reason why the plant is not working at more than 2 per cent of rated capacity at the present time.

This report was written at the request of the Government of Zaire after a short mission in September 1988 to study the possibilities for the rehabilitation of the Maluku steel plant in Zaire. The author takes upon himself the responsibility for any errors made.

INTRODUCTION

This report is divided into four parts.

In the first part it starts with the overview of the economy of Zaire with the aim of assessing the present situation of the iron and steel industry and of presenting some issues and constraints crucial to tackling the rehabilitation programme of the Maluku steel complex and for the further development of the iron and steel industry in Zaire and eventual integration of the Maluku steel mill into the integrated develoment of the iron and steel industry in the sub-region. This integrated development is still a long way away since there is an agreement, in principle, with respect to the iron and steel industry, at political level, but no mutual agreement has been made at business level.

Consequently first rehabilitation and expansion of the Maluku steel mill should be considered at national level. The regional co-operation programme for the iron and steel industry among the economic community of Central African countries[1/] can be carried out only when firm commitments are made by all these countries for the integrated development of the iron and steel industry at industrial level in the region.

In sector background and recent performance, an overview is made of the performance and activities of the industrial sector in Zaire with an emphasis on the metallurgical industries sector and metal-related industries such as fabricators, foundries and forges.

In the iron and steel industry of Zaire, the role of the Maluku steel mill in Zaire is described and its future contribution to the industrialization of the country, when the economy is to become more independent from both copper exports and import goods, and agricultural production needs to expand in a balanced, integrated way so as to meet a large share of demand through efficient use of domestic resources and to generate new export revenues. Regarding the management of the Maluku steel mill, a brief discussion on management problems is touched upon to prepare the re-start of steel production in 1989. The analysis of steel production, and the data from the Maluku steel mill and SOSIDER are sometimes not consistent, so there are some discrepancies in data figures in the sales and pricing of national products. Sales amounts of steel products and total taxes paid for the steel products sold since 1974 and tax rates on steel products are explained.

The mission did not agree with the negative report prepared by Coopers and the Lybrandt for the World Bank. We compared our production programme with this report and elaborated on the findings in a new production programme of the Maluku steel mill from 1989 to 1995. Later, an analysis is made on the demand for steel products and imports of iron and steel products.

1/ The community of Central African States is comprised of Burundi, Cameroon, Central African Republic, Chad, Congo, Equatorial Guinea, Gabon, Rwanda, Sao Tome and Principe, and Zaire.

The second part of the present report indicates the resources needed for iron and steel making plants through direct reduced iron (DRI)-Electric Arc Furnace (EAF) steel making rolling mills. Zaire will face shortages of steel scrap in the foreseeable future and will require an import of semis or an own production of sponge iron or pig iron to make steel. Study was made on availability of mineral, fuel minerals and energy and their production/consumption balances on steel-making in electric arc furnaces with ferrous scrap, availability of scrap, prices of scrap in Zaire and in the world as a whole as well as capital cost of DRI production. Emphasis is made on the plan for a DRI plant in Zaire using coal as the reducing agent for two reasons:
1. Oil and gas are still under exploration and Zaire production of oil and gas is not large enough but the country has considerably large coal deposits, and
2. There is a lot of information on gas-based DRI plants.

Emphasis is made on analysis and data on coal-based and charcoal-based DRI plants in developing countries such as Brazil and India which have charcoal-based DR (and charcoal pig iron) plants; coal-based DR plants exist as a main iron producing plant. A study was made comparing the data[1/] on the Brazil and India DRI plants with the possibilities in Zaire.

Part three describes and details operational problems in the Maluku steel mill; considers the modernization of the plant without major modifictions and replacement of existing facilities. The equipment at the Maluku steel was examined: it consists of an electric arc furnace, continuous casting, hot- and cold-rolling mills. Since electrodes and electricity are major factors in conversion costs of electric arc furnaces aside from ferrous scrap, requirements of raw materials, electricity and energy used for the production of one ton of liquid steel are illustrated for scrap-EAF process and DRI-EAF process. Here an explanation is given on how the cost-saving strategy for the major factor cost items is made.

In continuous casting, the characteristics of continuous casting along the close examination of the machine itself are spelled out. How water-cooled panels and computer control of electric steel-making have saved cost of production because they save energy, time, and consumption of raw materials. It is felt that the services of the cold-rolling mill should be put aside for the time being. The plant for the cold-rolling mill can be converted into a steel service center to make more value-added products.

Lastly, suggestions are made for the modernization of the Maluku steel mill with minimum investment. For example, scrap pre-heating, water-cooled roof and walls. Fuel burners, ladle furnace and direct charging. These are some things the Maluku steel mill would have to install in order to improve production and cost competitiveness of existing products in a foreseeable future, perhaps around 1995.

The report provides conclusions and recommendations for both short and long term for the rehabilitation of the Maluku steel mill considering its overall performance and the environment in which it operates.

1/ Bureau de Recherches Géologiques et Minièrs, Orléans, France, Minerais de fer du haut-Zaire, Interet de leur Erude, RDM/DPM No. 84/104/350

I. ZAIRE AND THE MALUKU STEEL MILL

1. Zaire's economy - yesterday

Zaire, the third largest country in Africa with an area of 2.3 million km^2 has a population of about 33 million, of which approximately one third live in urban centers. The principal and central feature of the country is the Zaire river, which provides the main transport network, irrigation and drainage of the national economy. In terms of economic potential Zaire is one of Africa's richest nations, with generous reserves of land, water and mineral wealth.

With Sudan and Angola, Zaire is one of the three largest countries in Africa. Zaire's frontiers are with the Central Republic to the north; Sudan to the northeast; Uganda, Rwanda, Burundi and Tanzania to the east; Zambia to the south; Angola to the south-west, and Congo to the north-west. There is a 25-mile coastline with the Atlantic (Figure 1).

The sectoral composition of GDP has changed substantially over the past two decades, due to both the drop in the real value of mineral production and to the collapse of other sectors, including transport and manufacturing. Agriculture accounted for 21 per cent of GDP in 1965; industry, including mining) 26 per cent, of which manufacturing was 16 percent, and services 53 per cent. By contrast with the trend in the rest of sub-Saharan Africa, where agriculture has tended to lose ground to other sectors, in Zaire agriculture's share of GDP has climbed to 31.4 per cent, partially because of relative decreases in other sectors, with industry still at 30.6 per cent (of which manufacturing was only 2.5 per cent) and services falling to 32.5 per cent as table 2 indicates on the next page.

Agriculture is the most important sector contributing 31.4 per cent of GDP and employing more than 75 per cent of active population. Mineral processing represents 33 per cent of GDP, is the largest source of public revenues, and accounts for more than two-thirds of the country's export earnings. Three commodities each accounted for more than 10 per cent of total earnings in 1986 on the basis of the figures from the Ministry of Economy and Industry. The breakdown of exports in main commodities is shown in table 1.

Table 1. Breakdown of major exports
(millions of dollars)

	1981	1984	1985	1986
Cobalt	173	232	225	148
Coffee	115	153	97	238
Copper	739	609	637	636
Crude oil	239	370	310	84
Diamonds	53	213	202	228
Zinc	54	47	48	49

Source: Conjoncture Economique 1987

Table 2. Distribution of GDP at constant 1980 prices by sector of origin

Year	Agriculture	Total Industrial Activity	Manufacturing	Construction	Wholesale and retail trade, hotels etc.	Transport, storage and communication	Other services	Statistical discrepancy	GDP
	(p e r c e n t a g e)								(million $)
	at constant 1980 prices								
1970	26.8	24.0	3.4	5.1	13.4	2.3	21.8	6.6	5422.4
1971	25.7	23.4	3.5	5.4	13.6	2.3	22.0	7.5	5846.7
1972	25.8	23.9	3.5	4.8	14.3	2.0	22.5	6.7	5879.7
1973	24.3	23.8	3.5	5.0	14.0	2.2	23.7	6.8	6353.0
1974	23.7	23.2	3.6	5.3	14.4	2.2	25.6	5.5	6738.6
1975	26.0	24.8	3.6	5.9	14.7	2.2	21.4	5.0	6068.2
1976	29.5	23.6	3.6	5.3	15.9	2.1	21.9	1.7	5662.7
1977	28.8	25.0	3.5	4.4	16.1	1.9	22.6	1.1	5621.7
1978	30.7	28.1	3.4	5.1	14.6	2.2	23.6	-4.3	5321.0
1979	31.3	26.1	3.1	4.4	14.4	2.0	22.6	-0.8	5335.3
1980	31.4	27.4	3.0	4.4	15.0	2.1	20.1	-0.5	5461.7
1981	31.5	28.5	3.0	4.3	15.3	2.2	18.2	-0.0	5596.2
1982	31.3	27.8	2.7	4.5	15.0	1.9	18.5	1.1	5501.3
1983	31.4	28.1	2.6	5.0	15.5	2.0	17.8	0.1	5584.1
1984	31.0	28.9	2.4	4.7	13.7	2.0	17.3	2.4	5902.0
1985	31.4	30.6	2.5	4.5	14.4	2.1	17.1	-0.0	5901.0

Source: Industrial Statistics and Sectoral Surveys Branch 1988

The percentage of agricultural exports has fallen since independence on account of a growing population and the exceedingly low level of investments in the sector. Coffee is now the only agricultural export of importance. Previously, palm oil and rubber were significant export earners. In 1986, a year of sharply lower crude oil receipts, the mineral sector accounted for about 79 per cent of exports and GECAMINES (La Générale des Carrières et des Mines) which is now under the rehabilitation programme. This project is an important element of government's objective to improve Zaire's balance of payments through continuing export and foreign exchange earnings. GECAMINES' continued ability to generate foreign exchange is essential to support the government's strategy of diversification of its economic structure, attract foreign capital, and permit economic growth[1/].

From 1967 to 1974, GDP grew at a rate of 7 per cent/year in real terms, spurred by high copper and coffee prices. This prosperity encouraged the government to embark on an ambitious programme of investment, mainly in large scale capital projects for energy and power, manufacturing industry. The Maluku steel plant was one of the large investment projects undertaken, but GDP decreased thereafter. By 1979, GDP at constant prices was about 10 per cent below its 1972-74 level. Table 3. shows comparative average annual rates of growth by economic sector. Over 1970-80 GDP in real terms contracted by 3.7 per cent at the same time as population expanded at an annual average rate of around 3 per cent. The evident decline in real per capita incomes ($248 in 1970 to $197 in 1985 at 1980 constant prices) implied a severe and steady fall in living standards. The World Bank projects an annual population growth of 3 per cent, from 1985 until the end of the century which would make a population of 47 million by the year 2000. This requires Zaire to make more than 5 per cent of economic growth attainable. Over 1983-1985 economic growth is estimated at an average 2 per cent per annum, still some way below the population increase.

A slight economic recovery was registered in 1980 and in 1981 when, aided by a recovery in copper production, there was a real GDP growth of 2.3 and 2.8 per cent in earh year. These two years of moderate recovery, however, were followed by a further contraction (about 2.3 per cent) of real GDP in 1982 and an increased shortage of foreign exchange due mainly to a fall in copper prices. The economic sitation improved in 1984 aided by some favourable external developments. In 1985, the performance was less favourable. Exports grew slower than anticipated because of weaker copper prices and lower oil production. The resulting shortage of foreign exchange was compounded by inadequate disbursements of external capital and contributed to a slow-down in the GDP growth to about 2 per cent. Zaire currency depreciated faster than expected. Between the end of 1983 and the end of 1985, it depreciated by 46 per cent against the US dollar.

1/ GECAMINES' rehabilitation programme which has been extended to 1990 because of the low level of execution in the 1984-85 period. The main objectives of the project are to improve GECAMINES' efficiency throughout the whole chain of production and commercialization of its metals products, to raise the company's productivity at the mines and in the surface plants and hence, while maintaining production capacity at its present level of about 470,000 tons/year during 1986-87, assure the continues flow of the principal source of foreign exchange earning to Zaire.

Table 3. Comparative average annual rates of growth, at constant 1980 prices by economic sector

Sectors	Period	Country	Africa	Developing countries Total	Developed Market Economies
Agriculture	1970-1980	1.5	0.1	2.4	1.0
	1981-1985	1.6	1.7	2.5	2.0
	1970-1985	1.5	0.5	2.4	1.4
Total Industrial Activity(incl. MVA)	1970-1980	0.6	2.8	4.6	2.9
	1981-1985	3.6	2.3	0.8	3.5
	1970-1985	1.4	1.3	2.2	2.5
Manufacturing	1970-1980	-2.0	5.0	6.5	3.0
	1981-1985	-2.6	2.6	3.1	3.8
	1970-1985	-2.9	4.8	5.1	2.6
Construction	1970-1980	-2.4	8.0	8.7	0.7
	1981-1985	3.2	-3.4	-2.8	-0.2
	1970-1985	-1.5	4.7	5.4	0.0
Wholesale & retail trade, hotels e.t.c	1970-1980	0.2	3.7	5.4	3.5
	1981-1985	-0.5	-0.8	1.6	3.3
	1970-1985	0.0	2.8	4.4	3.0
Transport, storage and communication	1970-1980	-2.0	6.8	8.4	3.8
	1981-1985	1.3	0.1	3.0	2.7
	1970-1985	-1.2	5.3	6.7	3.2
Other services	1970-1980	-1.3	6.5	7.1	3.7
	1981-1985	-0.1	3.0	2.7	3.0
	1970-1985	-2.4	5.9	5.7	3.4
GDP per capita	1970-1980	-3.7	1.5	3.1	2.2
	1981-1985	-1.2	-1.7	-0.5	2.1
	1970-1985	-3.2	0.3	1.8	1.9
MVA per capita	1970-1980	-4.7	2.0	3.9	2.1
	1981-1985	-5.4	-0.3	0.7	3.2
	1970-1985	-5.7	1.8	2.6	1.8

Source: Industrial Statistics and Sectoral Surveys Branch, 1988

The history of the currency since independence has been one of steadily decreasing value. The link with the SDR was scrapped after repeated devaluations, leaving the Zaire floating and the commercial bank free to set their own rates. By September 1988, the rate had slipped to Z.202 = $1; in the black market $1 = Z.270.

Since independence, the major policy of government was the establishment of a prominent planning role for the State, with the aim of converting Zaire into a regional industrial power. "La politique de grands travaux" involved a number of prestigious projects on an enormous scale, the largest being the Inga hydroelectric complex, the Sozir oil refinery; the Maluku steel mill was built under these circumstances.

It was hoped that Zaire would become an important exporter of energy, a steel producer and a regional influence in the oil industry. The government expected to transform a primarily agricultural economy into a modern industrial economy on a Western scale through centralized control and selective public investment.

Where the government policy for nationalization of economy (with very few exceptions, foreign businesses were nationalized or passed to private Zairean control) had aimed to produce a stable economic environment with the guiding hand of the State, in practice the reverse happened as conditions became disordered and government intervention hindered rather than helped modernization. The private sector suffered from non-replacement of stocks and machinery and the withdrawal of working capital. This forced the government to reverse the policies above in order to liberalize Zaïre's economy for more growth-oriented economy in the late 1970s. Real GNP declined in the 1970s and far from becoming a major industrial power house, Zaire has remained an exporter of raw materials and an importer of machinery.

The economy of Zaire, like many other African countries, is undergoing great difficulties due, in particular, to the fall in the prices of raw materials. (Zaire is a great exporter of cobalt and copper and saw its export receipts fall dramatically in 1986.)

2. Zaire's economy - today

Despite its vast natural resources, Zaire was classified by the World Bank as the world's ninth poorest country in 1985, with GNP per capita of just $170[1/]. International comparisons of economic performance in Zaire is shown in table 4. GDP per capita at 1980 constant is one third of African averages, manufactured value-added per capita is less than one tenth of African average in 1985. The ratio of gross fixed capital formation to GDP is 15 per cent in 1985 against 22 per cent in average African countries; only seven other countries rank lower. The reversal of economic nationalistic policies started tentatively in the late 1970s.

The underlying principles of the liberalization programme are restated in the 1987-90 priority investment plan which emphasizes the role of private sector and industry as one of the liberalization policies. Thus the privatization of the Maluku steel mill was brought to the fore. Since 1983 the Zairean government has been engaged in a liberalization and stabilization programme with the support of the International Monerary Fund (IMF) in order

1/ World Development Report, 1987, The World Bank.

Table 4. International comparisons of economic performance at constant 1980 prices

Indicator	Year or period	Country	Africa	Developing countries Total	Developed Market Economies
GDP per capita (US $)	1970	278	634	732	8074
	1975	271	694	868	8907
	1981	210	709	973	10225
	1984	203	667	954	10743
	1985	197	669	948	11012
MVA per capita (US $)	1970	9	46	113	2015
	1975	10	52	140	2158
	1981	6	60	164	2518
	1984	5	59	167	2707
	1985	5	60	168	2803
Total exports/capita (US $)	1970	47	276	249	1226
	1975	54	208	265	1566
	1981	80	197	264	2103
	1984	88	184	251	2296
	1985	91	191	247	2390
Total imports/capita (US $)	1970	32	160	132	1412
	1975	37	205	188	1677
	1981	61	235	262	2095
	1984	54	186	235	2338
	1985	55	195	224	2430
Total exports/GDP (percent)	1970	16.8	43.6	34.0	15.2
	1975	20.0	30.0	30.6	17.6
	1981	37.8	27.8	27.1	20.6
	1984	43.4	27.7	26.3	21.4
	1985	45.9	28.6	26.0	21.7
Total imports/GDP (percent)	1970	11.5	25.2	18.0	17.5
	1975	13.5	29.6	21.6	18.8
	1981	29.0	33.2	26.9	20.5
	1984	26.5	27.9	24.6	21.8
	1985	27.7	29.2	23.6	22.1
Gross fixed capital formation per capita (US $)	1970	20	95	127	1936
	1975	27	146	183	1992
	1981	30	179	228	2220
	1984	26	144	204	2292
	1985	30	147	198	2394
GFCF/GDP (percent)	1970	7.1	15.0	17.3	24.0
	1975	10.1	21.0	21.1	22.4
	1981	14.3	25.2	23.4	21.7
	1984	12.7	21.7	21.4	21.3
	1985	15.3	22.0	20.9	21.7

Source: Industrial Statistics and Sectoral Surveys Branch 1988 to achieve a balance in state finances and in the economy. Zaire suffered from external public debt which is estimated to be 18.2 per cent of debt service ratio which indicates debt service as percentage of exports of goods and services in 1986.[1/]

After long discussions with the World Bank and the IMF in December 1986 and January 1987, the government reaffirmed its commitment to the structural adjustment programme and reforms set up since 1983. It decided to reform its economy which was based on achieving maximum profits rather than on developing productive activities, since the development problems of Zaire were structural and not just circumstantial.[2/] Consequently, rehabilitation projects have come up for the revitalization of existing industries in Zaire. Under these circumstances steps for the rehabilitation of the Maluku steel mill were initiated. The adjustment rests on the fundamental role that the private sector must play in the Zairean economy in order to increase the country's production. However, needless to say, the government must create a favourable climate for investments by the foreign private and also national private sector.

UNIDO's GDP and MVA growth projections for 1988 and 1989 for Zaire[3/] as well as the economic community of Central African states shows:

Table 5. GDP and MVA growth projections

Country	GDP growth (percent)			MVA growth (percent)			GDP growth rates (optimistic scenario)			
	1987	1988	1989	1987	1988	1989	1989	1990	1991	1992
Burundi	.8	2.8	5.1	4.0	4.2	4.0	5.1	5.5	6.5	5.3
Cameroon	9.5	10.1	9.4	18.5	19.9	18.0	9.4	8.3	7.8	7.9
Central African Rep.	2.8	3.1	3.3	-0.7	-0.6	-0.6	2.3	2.6	2.7	2.7
Chad	2.3	-4.4	-3.6	-0.3	-5.1	-4.6	-3.6	-3.8	-6.6	-5.5
Congo	-4.0	0.5	-	-1.9	1.6	-	-	-	-	-
Equat. Guinea	2.0	6.5	6.6	11.3	12.2	11.8	6.6	8.1	10.0	11.2
Gabon	1.6	4.0	3.0	-	-	-	3.0	4.5	4.0	3.3
Rwanda	7.5	4.8	6.4	-	-	-	6.4	5.5	5.7	5.1
Sao Tomé and Principe	-0.7	0.3	-1.2	0.5	1.3	0.1	-1.2	-1.9	-2.0	-1.6
Zaire	1.4	-2.8	1.5	-0.4	-3.6	-3.5	-1.5	2.5	0.5	2.9
Tropical Africa	2.1	2.4	3.5	4.6	5.7	6.8	3.5	4.0	4.5	4.6

Source: Industry and Development, Global Report 1988/89, UNIDO.

1/ The World Bank projected public debt service due at $819 million and $897 million in 1989, falling to just over $600 million in 1984. Such sums are well beyond Zaire's capacity to pay, barring a dramatic rise in mineral export prices. The government will therefore have to enter into regular negotiations with its creditors for several years to come.

2/ African Research Bulletin, August 1987

3/ Industry and Development, Global Report 1988/89, UNIDO.

Zaire's GDP growth rate in 1987 was lower than the average figures of total tropical African countries whose tendency will continue for 1988 and 1989. An especially negative growth rate is forecasted for most countries except Cameroon, Rwanda and Burundi. Their GDP growth rates are forecast to be slower than their population growth. Negative growth rates are estimated for manufactured value added in 1988 and 1989; even optimistic GDP growth rates are not higher than the population growth of 3 per cent.

The underlying principles of the liberalization programme as mentioned before, are restated in the 1987-90 priority investment plan. This sets out the government's commitment to further economic liberalization, the encouragement of private enterprise and decentralization of economic activity. The plan established a target of real GDP growth rising from the official estimate of 2.6 per cent in 1986 to 4.0 per cent by 1990. It projects a fall in the inflation rate (annual average rate of inflation in 1975-83 at 48.2 per cent) to less than 15 per cent in 1990, and an increase in fixed investment from the current level of 12 per cent of GDP to 18 per cent in 1990.

However, in order to achieve this growth rate target for the years to come, Zaire requires substantial changes in investment and consumption/saving behaviour of both the public and the private sector. Production needs to be restructured towards diversification, there should be more exports of non-mineral goods, a genuinely foreign exchange saving import substitution and greater use of domestic raw materials.

3. Industrial sector and recent performance

Zaire's industrial sector (including maufacturing and agro-industries but excluding mineral processing and construction) contributed about $200 million to GDP in 1984 and employed an estimated 150,000 workers or ten per cent of total employment in the modern sector. However, the share of industry in Zaire's GDP is five per cent, now among the lowest in sub-Saharan Africa.

Since the beginning of the economic crisis of 1975, industrial output decreased without interruption until 1983 to 31 per cent below its 1975 level, a decline three times greater than that registered by GDP. The decline in industrial output started with the collapse of copper prices in the aftermath of the first round of oil price increases. The resulting shortage of foreign exchange, together with the unfavourable investment climate due to domestic policy measures, caused a sharp decrease in industrial capacity utilization and a deterioration of equipment. For example, the Maluku steel plant's capacity utilization in 1984 and 1985 was so low that it produced only 2,457 tons of hot rolled products and 489.5 tons of cold-rolled products. Meferco-Zaire manufactures car parts and busses after it buys parts of buses and cars from General Motors, IVECO and Renault-Zaire, but only produced 1,052 tons of parts of bus bodies against its 12,850 tons of capacity. In 1986 G.C.M. Rolling Cables (2,000 tons capacity) only produced 550 tons, Cement Industry Company (881,000 tons capacity) produced 439,733 tons. The utilization rate of the bicycle industry was 33 per cent and almost all industries are overstaffed. At the same time, the worsening situation in agriculture and transport led to shortages of local inputs such as spare parts, capital goods and agricultural irrigation machinery and equipment.

Following the adoption of stabilization policies (a broad and comprehensive programme of policy reforms in collaboration with the IMF), there was a relatively modest recovery in industrial output in 1984 when it grew by nearly 2 per cent, compared to a GDP growth of 2.8 per cent[1/]. Preliminary estimations for 1985, however, indicate that while GDP grew by about 2 per cent, industrial output actually declined by just under 1 per cent, mainly as a result of foreign exchange shortages for the importation of raw materials and spare parts. Because of foreign exchange shortages, it is not unusual to find a car manufacturer which undertakes little more than basic assembly and has substantial import requirements, trading in zinc, coffee or diamonds so as to secure regular foreign currency allocations.

Over the last ten years, there has been no significant change in the structure of the sector or the location of enterprises. Zaire's manufacturing industry is still closely linked to commerce, with many enterprises having substatial commercial operations. Kinshasa, the capital city, remains the main center of industrial activity, with Lubumbashi, a major mining city and Kisangani, located near areas of significant agricultural production, important secondary centers.

There has been a marked change in government policy towards manufacturing since the 1983 devaluation, removing restrictions on profit remission and simplifying import procedures. The 1987-90 priority investment plan makes no allocations for industrial development which it considers the responsibility of the private sector. These measures and aim of the austerity programme to create a stable economic and financial climate have improved investor's confidence in Zaire. Figures from Conjocture Economique for 1986 suggest an improved performance from the consumer goods industries.

Table 6 indicates the production of principal manufacturing goods from 1983 to 1986. The metal industries sector remains largely an importer of finished and semi-finished products and an agent of basic assembly and processing. This is partially due to low rates of utilization of iron and steel mill and foundry operations (it is believed that few factories in manufacturing sector have been able to operate at more than 30 per cent of capacity)[2/]. In transport equipment, the production of bicycles and lorries tends to increase. Bicycles, autocycles and motorcycles are manufactured and assembled by Cyclor Corporation which has capacity for 32,000 bicycles, 8,000 autocycles and 5,000 motorcycles.

The manufacturing industries continue to be highly import-oriented for machinery, equipment, and raw material inputs. The imports of basic metal products, machinery and electric equipment, and transport equipment in 1985 were respectively 67,850 tons (3,172 million Zaires), 24,306 tons (9,994 million Zaires), and 53,682 tons (8,549 million Zaires) in 1986. These imports decreased to 44,201 tons (3,944 million Zaires), 28,700 tons (8,398 million Zaires), and 1,064 tons (997.7 million Zaires) respectively, but they are still substantial amounts in the total imports. For example, in 1985, 32 per cent of imports were for these products although they decreased to 15 per cent. Metal fabrication and construction in 1986 was 7,442 tons, down 735 tons from the 1985 level. The breakdown of metal fabrication and construction is shown in table 7.

1/ The World Bank, 1987.

2/ Country Profile, Zaire, Rwanda, Burundi, Economic Intelligence Unit 1988-1989.

The marked sensitivity of domestic manufacturing production to fluctuations in the availability of foreign exchange reflects the unbalanced industrial pattern which exists in the Zairian economy. Very few manufacturing enterprises are designated to utilize domestic material and to develop linkages with other sectors of the economy, such as agriculture and capital goods. Table 6 shows why the basic metal industries have a relative poor performance in comparison with other manufacturing industries, especially the consumer goods industries, for example, increases in the output of beer to 4.28 million hl, cigarettes to 4.6 million, soft drinks to 997,000 hl and sugar to 63,928 tons.

3.1 The metallurgical sector in Zaire

There are dozens of metal-working factories and mills but only eight - except SOSIDER, are visible as an industry. They are TREFILKIN, F.N.M.A., TUBETRA, UMAZ, COBEGA, CHANIMETAL, MECELZA and L.C. All companies are being operated at 40 per cent capacity, or more, except for SOSIDER AND UMAZ whose capacity utilization is below ten percent[1/]. They are engaged in the transformation of imported metal products. The reason why the capacity utilization in these companies was so low is partially the extremely low production activities at the Maluku steel mill which provides major steel products to them for their making of final products. Table 8 shows the main fabricators or producers of metal products in Zaire.

1/ Actes de la premiere table ronde nationale sur l'integration et la rehabilitation de l'industrie Zairoise, 1986.

Table 6. Production of principal manufactures
(tons unless otherwise stated)

	1983	1984	1985	1986
1. <u>Food, drink & tobacco</u>				
Coffee	-	77,157	65,938	132,402
Maize flour	120,860	111,501	118,823	123,472
Palm oil	-	83,952	84,3055	76.346
Sugar	50,978	60,914	62,732	63,928
Sugar cane	8,932	12,628	17,582	18,419
Animal feedstuffs	26,459	18,653	19,199	16,139
Cotton	26,786	20,552	22,327	19,102
Beer ('000 hl)	3,699	4,222	4,284	4,284
Cigarettes (mn)	3,472	3,300	4,181	4,595
Soft drinks ('000 hl)	838	826	880	997
2. <u>Textile industries & shoes</u>				
Cotton fabrics ('000 m^2)	61,012	61,255	58,160	61,263
Printed fabrics ('000 m^2)	44,235	48,836	49,428	63,920
Shoes ('000 pairs)	10,730	13,106	12,724	8,696
3. <u>Timber industries</u>				
Logs (m^3)	391.000	388,000	390,000	380,000
Sawn wood (m^3)	114,000	120,500	101,000	86,000
Plywood (m^3)	14,407	19,207	12,586	8,715
Veneers (m^2)	6,686	10,912	10,831	12,223
Matches ('000 boxes)	115,529	190,799	198,010	214,000
4. <u>Metal industries</u>				
Iron & steel foundry goods	4,467	8,534	6,693	3,560
Metal fabrication and construction	3,637	4,892	8,178	7,442
5. <u>Transport equipment</u>				
Barges, pushers and boats (units)	23	17	23	21
Bicycles (units)	14,260	15,220	14,826	13,500
Auto-and motorcycles(un.)	944	1,200	858	800
Lorries of 6-8 t (units)	76	180	245	222
Automobiles assemblied (units)	1,484	1,857	2,041	2,084
6. <u>Industrial chemicals</u>				
Plastics	8,445	9,758	9,861	9,597
Sulphuric acid	159,864	152,735	169,022	146,374
Tires (pieces)	-	122,799	132,509	133,361
Explosives	8,850	8,168	3,030	7,689
Alcohol (hl)	8,954	7,063	7,220	7,972
Soap	47,133	43,444	54,013	65,358
Paints	3,489	3,414	3,104	2,906
7. <u>Non-metallic minerals</u>				
Lime	106,993	109,856	115,365	144,177
Cement	513,232	533,992	443,773	439,733
Bottles (thousands)	25,621	19,184	22,600	27,697

Note: - = figures not available
<u>Source</u>: Conjoncture Economique, 1986 and 1987.

Table 7. Production of metal fabrication and construction
(metric tons)

Product	1986	1985	1984	1983	1980
Copper wares	415	449	346	387	302
Metal frame works	2,706	3,154	2,059	1,878	1,257
Sheet metals	1,948	657	595	517	611
Shipbuilding	3,273	3,918	1,892	855	1,358
Total	7,442	8,178	4,892	3,637	3,528

Source: Conjoncture Economique, 1987.

Table 8. Main fabricators of metal products

Metal products	Companies
Steel, casting	SOSIDER, CHANIMETAL
Wire rods and steel rounds	TREFILKIN, COBEGA, CHANIMETAL, TUBETRA, MECELZA
Hot- and cold-rolled sheets	CHANIMETAL' COBEGA, TUBETRA, FINMA, UMAZ, MECELZA
Sections and shapes	CHANIMETAL, TUBETRA, FINMA, MECELZA

Source: Industrial Statistics and Sectoral Surveys Branch, 1988

SOSIDER is the centre of these companies. Under normal circumstances it is supposed to provide metal products to these companies for further fabrication but in 1984 it produced only 10 per cent of the hot-rolled products and only 0.004 per cent of the cold-rolled products which these companies required. This means that almost 10,000 tons of hot-rolled products and 3,000 tons of cold-rolled products were on demand from these companies in 1984 as illustrated in the following diagram:

	Raw materials		Steel making		Semi-products (local market)
Local	Scrap from various suppliers Lime (limestone) from CIZA Ferro-manganese from CIMSHABA	→	SOSIDER iron and steel casting hot-rolled products cold-rolled products	→	TREFILKIN: rounds and wire rods GECAMINES construction: angles FINMA: T-shaped sections COBEGA: flat bars RVM: hot-rolled sheets TUBETRA Zaire: cold-rolled sheets
Import	Refractory materials Other materials				

SOSIDER's role in the metal industries: SOSIDER bought ferrous scrap from many agents and lime from CIZA and sold steel products to its customers for the production of final steel products for their customers who make consumer and capital goods. These companies who buy steel products from the MALUKU steel mill are mainly located in Kinshasa, Lubumbashi and Shaba.

TREFILKIN (capital: 32.7 million Z., 179 workers) specializes in wire works manufactures such as nails, spikes, barbed wire, wire netting, and re-inforced bars. It imported 100 per cent of all the steel products it needed: 1,435.42 tons of wire rods (24,918,891 Z.) although SOSIDER could have produced them, 30 tons of small rounds (1,263,340 Z.) and 292.24 tons of galvanized wires which could be produced locally, and other metal products.

Using imported materials, TREFILKIN made 1,042 tons of nails, 108 tons of wire netting, 58 tons of lattice-work, 70 tons of barbed wire, 1,380 tons of wire-drawing, 336 tons of re-inforced concrete bars and 6 tons of other miscallaneous items. The following table 9. indicates the breakdown of production from 1983 to 1986. (Source: Conjuncture Economique, 1987).

Table 9. Production of TREFILKIN
(metric tons)

Product	Capacity	1986	1985	1984	1983
Nails, spikes	3,000	1,326	1,306	1,042	845
Barbed wire	300	55	93	70	75
Wire netting	300	95	66	108	87
Wire drawing	2,500	2,716	2,203	1,380	131
Lattice work	300	89	80	58	53
Wire mesh	1,200	-	-	-	29
Re-inforcing bars	-	1,306	726	336	-
Others	300	86	24	6	29
Total	7,900	5,668	4,498	3,000	1,249

Table 10. Production of TUBTRA-Zaire
(metric tons)

Product	1986	1985	1984	1983	1980
Metal manufactures	777	725	517	528	368
Steel tubes (13-63 mm diameter)	341	711	525	249	327
PVC tubes (5/8 to 225 mm diam.)	482	653	481	420	259

Table 11. Production of UMAZ
(pieces)

Product	1986	1985	1984	1983
Spades	-	252	13,046	9,485
Large hoes	302	275	-	1,775
Weed cutters	20,155	6,108	55,646	36,489
Large hatchets	-	-	18,361	1,194
Small hoes	56,547	15,115	37,602	8,470
Small hatchets	81,791	114,263	133,501	94,000
Shovels	-	21,365	13,810	5,473
Rakes	150	647	115,807	1,155
Leaf collectors	98	4	252	-

Table 12. Production of FNMA
(pieces)

Product	1986	1985	1984	1983
Metal boxes	32,643	28,115	33,675	39,543
Metal furniture	17,660	17,489	36,119	27,836
Residential furniture	6,113	1,365	1,196	1,334
Medical furniture	25,266	1,204	1,066	1,136
Aluminium frames (tons)	15	38	30	35
Refrigerators				
Electric	962	1,126	825	
Gasoline (gas)	347	286	210	
Solar	386	71	35	
Freezers	2,824	560	213	0

Table 13. Production of COBEGA

Product	Capacity	1986	1985	1984	1983	1980
Packing cases	3,000,000 (20-lt.)	1,317,040	914,072	602,736	204,087	854,512
Galvanized	500,000 (pieces)	318,050	239,037	-	-	-
Jerry cans	75,000 (pieces)	78,615	62,833	25,055	66,218	3,655
Crown plugs	400,000,000	597,109	535,939	364,295	108,733	143,091

TUBETRA Company (capital: 7 million Z.) is a subsidiary of the Meuse Iron and Steel plant in Belgium and employs 362 workers. It imported 263 tons of steel products (5,935,121 Z.), 543.5 tons of hoop iron (12,542,406 Z.) which SOSIDER could have provided, 42 tons of adjuvants, 52.5 tons of PVC powder. Had SOSIDER operated normally in 1984, it could also have provided steel products and hoop iron. TUBETRA made 51.7 tons of metal manufactures, 481 tons of plastic tubes and 525 tons of steel tubes which were bought by FNMA and CHANIMETAL. Table 10 shows the details of production in 1986 when it provided 1,600 tons of metal products.

UMAZ (capital: 12.1 million Z.), which at present employs 138 workers, in 1984 bought 330,840 pieces of rivets and small rounds (418,834 Z.), oil hydran and oil soluble and imported 35,714 tons of steel plates and 199.2 tons of steel sheets (which SOSIDER could make) and other metal products. It made 49,145 pieces of hatchets for the agricultural industry and 12,924 pieces of hatchets for public works, 49,065 shovels for PME, 12,869 hatchets, 5,410 covers and other metal products. For its customers, the total production in 1984 was 388,025 pieces which were 228,982 more than in 1986. Table 11. shows the breakdown of products produced.

FNMA, (capital: 10 million Z.), which employed 798 workers in 1987, produced 1,429 metal desks, 81 metal tables, 22,480 boxes, 1,335 metal cabinets, 1,143 filing drawers, 6,346 metal shelves and 962 refrigerators out of 73,339 metal products. It also produced 30 tons of aluminium frames in 1984. The only products which were produced more than in 1984 were furniture, refrigerators and freezers (see table 12.).

COBEGA (capital: 4.1 million Z.), which employs 305 workers, is owned by three parties: African Holding Co. (60%), SOFIDE (25%) and private investors in Zaire (15%). In 1984 COBEGA bought zinc and wire prawings locally and sold products to GECAMINES. It imported hot-rolled and cold-rolled products (more than 1,000 tons) which SOSIDER could have provided, 12 tons of PVC (9,720,000 Z.), 800 tons of tin plates (24 million Z.) were also imported to make 850 million cromed plugs, 218 million tin cans, 600,000 buckets, 160,000 drums and other metal products (see table 13).

As some cases illustrated above, there have been substantial industrial linkages with the Maluku steel mill which can act as a promoter of downstream industries in Zaire.

3.2. Foundries in Zaire

For an industrial concern to function effectively, it is imperative that the various resources invested and utilized in the production activity be optimized. For achieving this, the existence and development of ancillary industries and back-up support facilities required for the development of machine tools, agricultural machinery, tractors, commercial vehicles, etc., are foundries, forges and tool rooms along with metal treatment, metal forming and fabrication and metal coating. However, these are not well developed in Zaire. A few good foundries and forges are engaged only for GECAMINES. The capability of spare parts making for the metal producing works is at most 20 per cent in the entire country.

The manufactures of original equipment and spare parts by these facilities can play a vital role in promoting the accelarated, rational and integrated development of the industrial sector as a whole in Zaire since the existence and development of sound ancillary industries and backup support facilities leads to greater horizontal integration at the country level (of course, this can be extended even to the regional level in cases like the Community of Central African States).

There are six major foundries, forming shops and mechanical workshops, in the areas of Kinshasa and Shaba, which can play central roles in the integration of metal-working industries.

However, existing foundries, forges, mechanical workshops in Zaire require upgrading in order to support the integrated development of the industrial sector as a whole. Since capacity utilization is so low and at present they are operated at 36.4 per cent of capacity, and inefficient operations are prevailing across the country (in 1986, 3,803 tons of foundry products were produced but it was almost 50 per cent down from the 1984 level and close to the production of 1983. This was caused partially by the inability of Maluku Steel Mill to provide raw materials.

Table 14. Installed capacity of major foundries, forges and mechanical workshops

Company	Workers	Cast iron	Steel (incl.cast)	Non-ferrous	
SHABA, general workshop of SNCZ		Forges, maintenance and repair for railways; boiler workshop; machine			Mainly forging shops and the capacity for handling 200 wagons a year.
Central workshop of PANDA (GECAMINES) with foundry		Forging shop, spare parts marking mainly for GECAMINES. 600/month	10	Some	Three divisions of metallurgical, mechanical, no electric. 7-ton casting machine.
FONDAF, foundry in Lubumbashi	271	19,200	720	1,650	1 coke furnace (9.6 tons) 1 cupola furnace (9.6 tons) 1 elec. furnace (1,200 t)
TEXAL, foundry in Lubumbashi	51	4 tons/hr 6 tons/day	 - approx.	2,150 150	2 coke cupola 2 oil-fired furn.
METALEC in Lubumbashi	12	1 tons/hour 820	- -	Lead: 100 k/h 180	1 electric furnace 1 arc furnace 1 coke furnace Forging facilities
CHANIMETAL, with foundry and forging shop	2,360	1,200	300	180	Multi-business machine tools, agric. machinery, ship repair and forging, 1 electric furnace (12,000 t) 1 oil-fuelled furnace (180 t)
ONATRA with foundry whop	22,177	Some	Some	Some	Multi-business, forging & machine tool shops for railways and Air Zaire; spare parts, alloy products and transport equipment.
AIR Zaire with foundry	2,549	Some	Some	Some	Forging shop, machine tools, spare parts, assembling shops, mainly for Air Zaire

Source: Industrial Statistics and Sectoral Surveys Branch, UNIDO, 1988.

In the mining and non-ferrous metals industries which are not relevant to the present study, there is an on-going rehabilitation programme for GECAMINES. In order to rationalize its operations, maintain its competitiveness on the world market and to ensure its future financial viability, Zaire needs a programme for metal working industries such as iron and steel mills, foundries, forges and mechanical workshops as a whole. It is necessary to promote the integrated development of metal-working industries for further development of down-stream industries. Table 15 shows the production of foundry products in 1984. The breakdown of foundry production is given in table 16. As can be seen, steel cast and cast iron are the main products in the foundry shops.

Table 15. Foundry production of main producers, 1984
(metric tons)

Company	Steel	Iron casting	Non-ferrous metals
CHANIMETAL	150	250	60
FONDAF	-	3,000	30
TEXAL	-	250	27.5
METALEC	-	2.7	2.6

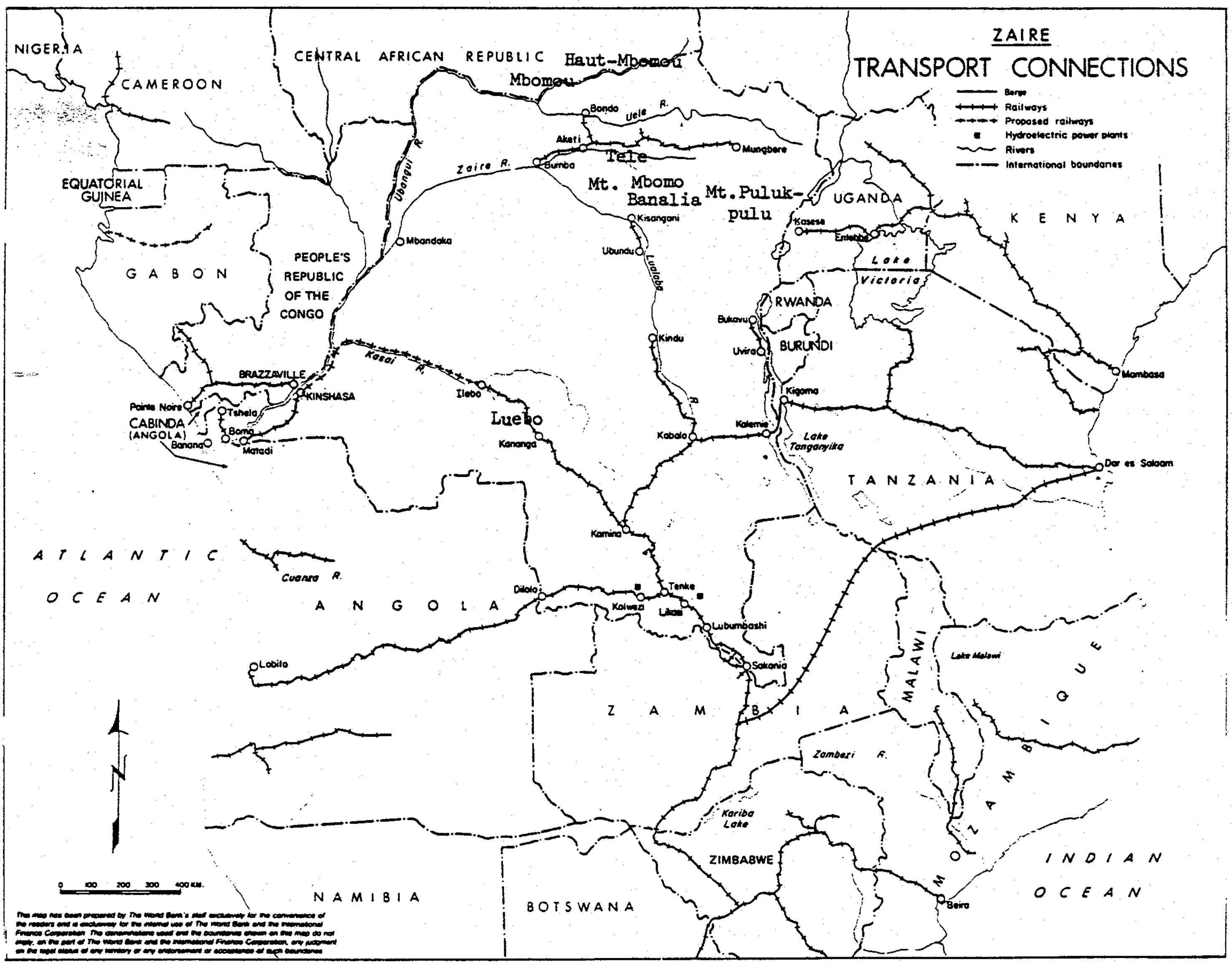
Source: Integration and Rehabilitation of Industriès of Zaire, Office of President, 1986.

Table 16. Foundry production of metal products
(metric tons)

Product	1986	1985	1984	1983
Steel	166	135	129	142
Bronze	173	70	77	61
Cast iron	3,394	5,611	5,759	3,307
Non-ferrous products	24	33	29	55
Lead-related products	46	126	208	79
	3,803	5,975	6,200	3,644

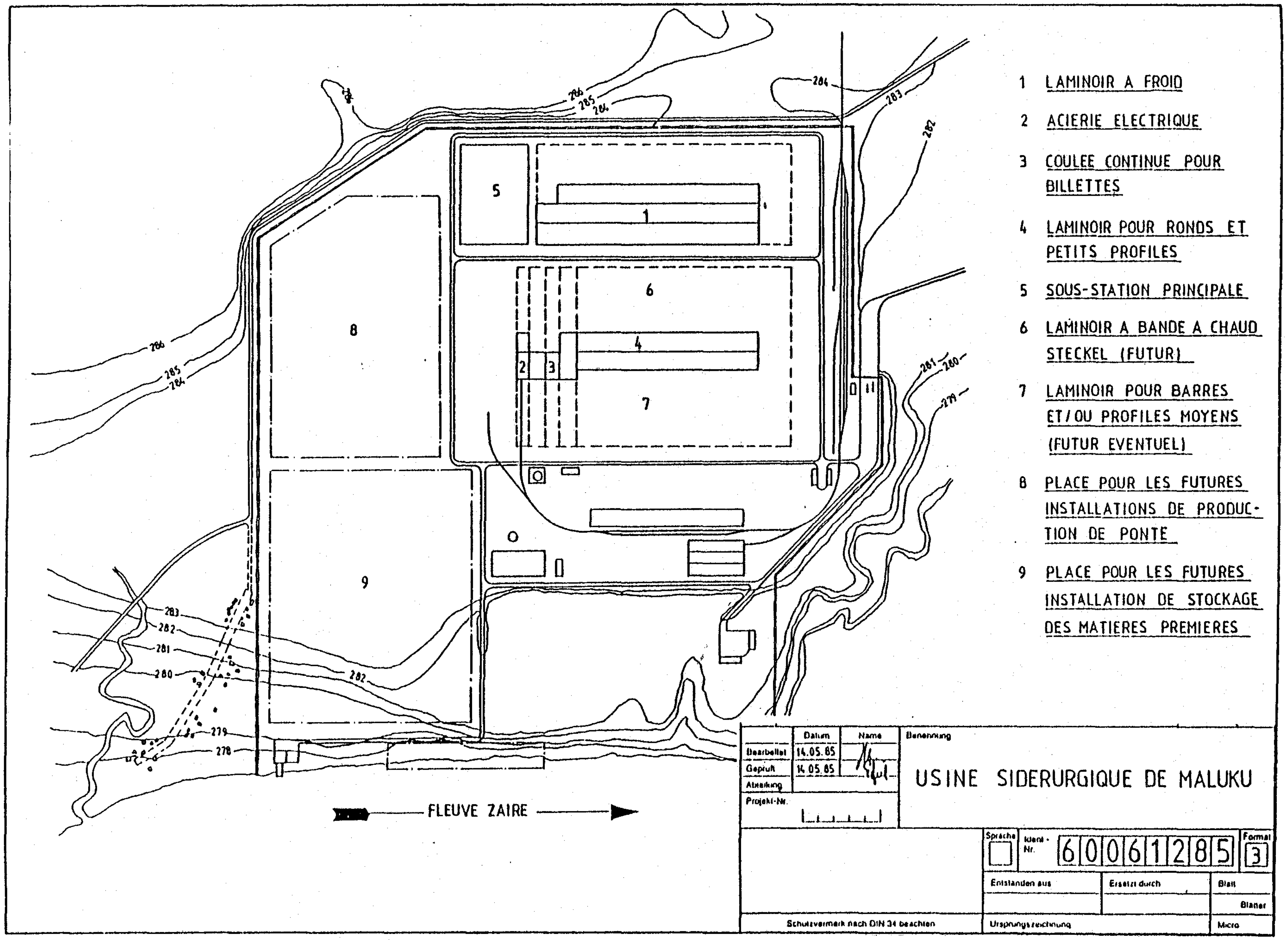
Source: Conjoncture Economique, 1987

Figure 3. Transport Connections in Zaire



Source: The World Bank 1986

Figure 4. Maluku Steel Plant (technical drawing of site)



Source: Mannesmann Anlagebau 1985

4. The iron and steel sector in Zaire

4.1 The role of the Maluku steel mill

The government tried to establish a presence in the manufacturing sector as part of the programme of the Manifeste de la Nsele. It hoped to alter Zairean trading patterns and encourage the manufacture of finished goods in Zaire. It founded SOSIDER in 1972 as the first stage towards an iron and steel industry.

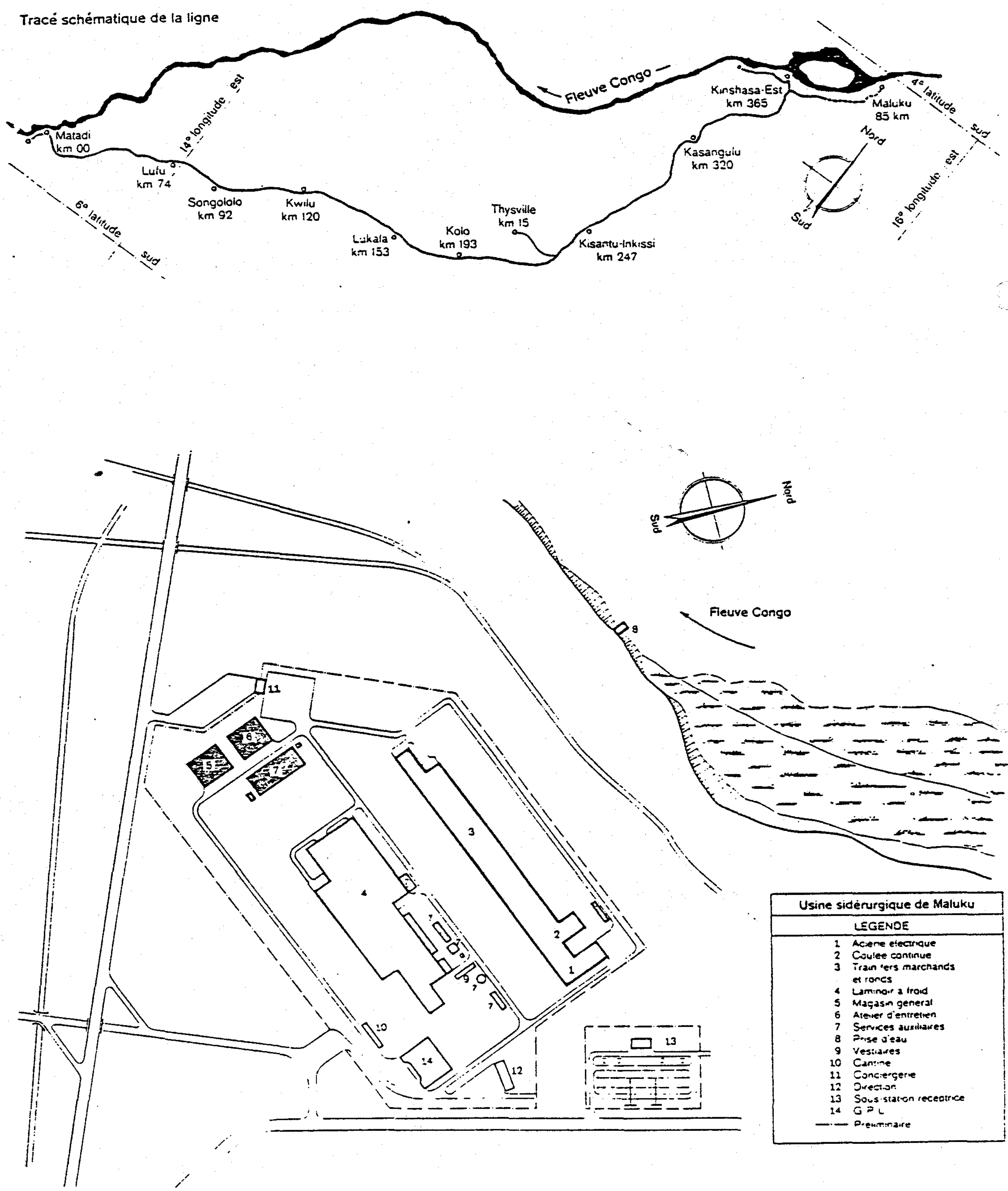
The present site was chosen for various reasons such as plenty of electric energy supply from INGA (which at present does not provide enough), abundant fresh water supply from the Zaire river, adequate road and river transport facilities and proximity to the major market. The Maluku steel plant is located at Maluku, 85 km north-west of Kinshasa (see figure 2.). This plant has good housing facilites for employees. The location of the plant is along the Zaire river which provides plenty of fresh water. There is a small harbour but it is not equipped for product shipments and scrap collections. Transportation of imported raw materials and product shipments to the Atlantic Ocean by ship is not possible because there is a natural fall in the way to the Atlantic Ocean. There is a beautiful highway between Kinshasa and Maluku which can be used to collect scrap and sell steel products. Between Kinshasa and Kisangani, a distance of about 1,600 km there is a regular passenger and freight service by river. Barges could be used for transport, however, beyond Kisangani and on many tributaries the waterways are in urgent need of dredging. Transport interruptions exist due to the low level of the river between Ilebo and Kinshasa. The infrastructure in transport as a whole has steadily deteriorated since independence due to lack of investment by government as well as external problems such as the closure of the Benguela railway to Lobito because of the Angolan civil war. The result has been that transport had become the most quoted difficulty of industry and commerce. Figure 3 shows transport connections[1/].

The Maluku steel plant, with an investment of $120 million, was designed to produce 250,000 tons of liquid steel annually and started operation in 1974. The plant consists of a 50-ton electric-arc furnace (considering three shift operations) for scrap melting producing carbon steel, a continuous billets strand casting (the output billet 100 x 100 m), and there is the output billet 140 x 140 m but never in use. A hot-rolling mill to produce bars, sections and wire rods with a capacity of 100,000 tons per year, a cold-rolling mill including a galvanized line (which was never in operation), and facilities for the production of corrugated sheets with capacity of 150,000 tons per year and other facilities such as maintenance workshop, energy supply facilities and township (figure 5).

The capacity utilization of the Maluku iron and steel plant of SOSIDER during 1974-1984 was as low as 2.5 per cent because the plant was working intermittantly. In 1986 it was completely shut down due to insufficient power supply and shortage of inputs of raw materials and refractories.

1/ Donors pledged $220 million in March 1988 for the rehabilitation of transport which will be carried out jointly by SNCZ and the Office National des Transports du Zaire (ONATRA). The programme starts in early 1989 for completion in five years to overhaul the aging "Voie Nationale", the rail and river route along which copper and other mineral exports are transported from Lubumbashi to Matadi port (AED, April 1988)

Figure 5. Maluku steel plant (technical drawing of site)



Source: Mannesmann Anlagenbau

In reality, the Maluku steel mill has only operated sporadically and it is put into operation periodically only in order to be sure that it is in working condition. This was true for the cold-rolling mill for some time. The plant appears to be in a good condition with almost all the equipment except for cold-rolled facilities. The Maluku steel mill is equipped with relatively up-to-date technology and good quality control unit and the mechanical workshop which has the capacity to produce some spare parts necessary for the steady operation of the plant. The plant maintenance is satisfactory and the plant can easily be put into operation with minor repairs and spare parts. Technical and operational staff have been trained and they are adequate to produce standard steel products, also at a profit. At present there are 515 staff members, almost 200 down since the end of 1982.

The economy of Zaire must become independent of both copper exports and import goods, and industrial and agricultural production must expand in a balanced, integrated way. In order to meet a large share of demand through efficient use of domestic resources and to generate new export revenues the development of the iron and steel industry, such as the existing Maluku steel mill, has an important role to play in Zaire's future economic development.

Many countries believe that steel is the symbol of national strength and of a self-supporting economy. The iron and steel industry is the backbone of the heavy chemical industry. Because it supplies the basic materials to all major industrial fields such as the machinery, automobile, construction, electrical and electronic industries, it is one of the key industries in the economy because it has important backward and forward linkages to other industries. In addition, it is of great importance in that it is the basis for the industrialization of developing countries such as Zaire and other regions of the Central African countries[1/].

Manufacturing is the engine of growth and industrialization. It is the key to the economic development of Zaire as well as of other neighbouring regions. For a successful development of a manufacturing and agro-based industry, the iron and steel industry such as the Maluku steel plant as well as foundry and forge facilities such as CHANIMETAL, FONDAF, TEXAL and METALEC are important. The iron and steel industry can produce intermediate goods as well as raw materials for the manufacturing and agro-based industries which are badly needed in Zaire. Foundries and forges provide these industries with spare parts, metal coating and metal fabricating to maintain their continuous operation. Right now, the manufacturing and agro-based industries in Zaire are facing an acute shortage of essential raw materials such as iron and steel of specific grades, particularly in the metal-working industries sector whose main requirement is steel-related products[2/].

Zaire is at present dependant on metal revenues from non-ferrous metals such as copper, cobalt, and zinc to finance its investment programmes, to develop other sectors of the economy and to diversify the country's economic base. Thus the rehabilitation of the Maluku steel plant is important for the diversification and lessening of the country's dependence on the copper mining industry to which other minerals such as cobalt and coal are closely associated for the production and refining of copper.

1/ SEAISI Quarterly, July 1987, Vol. 16-3, pp. 13-15.
2/ TEKKOKAI, Japan Iron and Steel Federation, March 1987, pp. 2-11.

4.2 Organization and management of the Maluku steel mill

The Maluku steel complex was built between 1971 and 1974 by the consortium of Italian and German companies: Societá Italiana Impianti S.p.A., Genoa, Italy and Mannesmann Demag AG., Duisburg, Federal Republic of Germany. The total amount of investment was $120 million, excluding $80 million for housing, social amenities, etc. The complex is owned by SIDERNA (Société national de sidérurgie), a State holding company. The Maluku steel plant is operated by SOSIDER Iron and Steel and Mining Company, whose capital is $6 million Zaires. Capital investment in SOSIDER was made by the following joint groups and the initial share of capital investment was as follows:

Zaire government		50%
FINSIDER	5.91%	
FINSIDER International S.A.	19.09%	25%
Societá Italiana Impianti S.p.A.	19.15%	
Demag AG.	5.85%	25%

FINSIDER was the main management participator when the Maluku steel plant started operating. It is a holding company in Italy which was established in 1939 and has dozens of State iron and steel corporations and related enterprises under control 1/. According to a contract with the Zairean government, FINSIDER's obligations were the following:

1. To make a corporate organization chart;
2. To make the installations in the plant;
3. To help technical operations;
4. To administer management and commerce;
5. To supply scrap to its electric arc furnace and steel coils to its cold rolling mill.

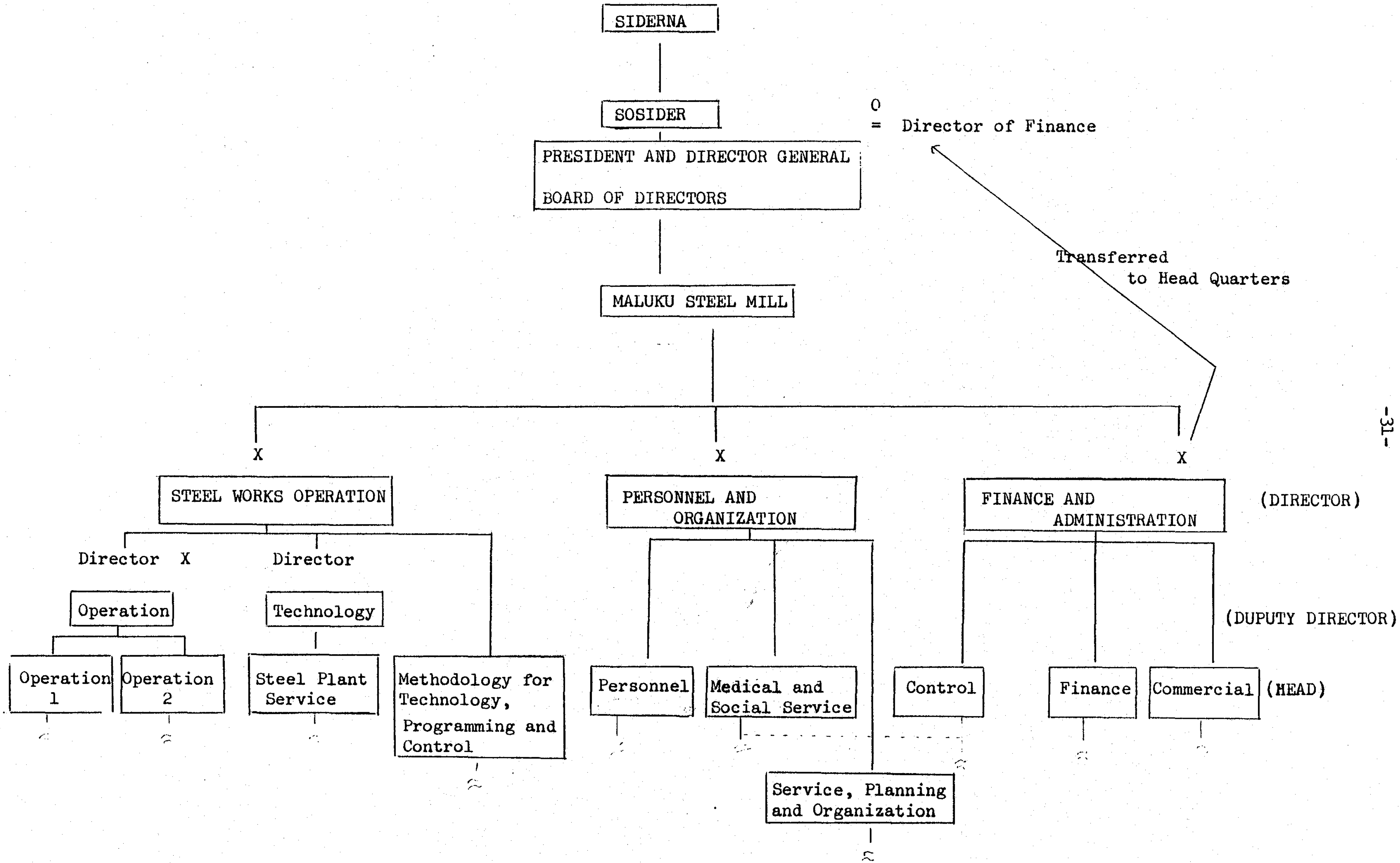
These obligations were carried out with minor success: five years after operations commenced production level was only at 15,663 tons. At the end of the contract in 1979 FINSIDER withdrew because of foreign currency problems for importing the required inputs and due to other local and outside reasons. Its withdrawal created more bottlenecks in management, finance, production and operation. The organization chart in November 1974 was as follows:

DIRECTOR GENERAL →	DIRECTORS →	DEPUTY DIRECTORS →	DIVISION HEADS →	BRANCH HEADS →	SECTION HEADS →	UNITS + WORK UNITS
1	3	2	9	23	24	99

In this corporate organization, SOSIDER is supposed to report to the State holding corporation SIDERNA all business and management as well as daily production operations. Since the start of operations in 1974 there were changes in corporate structure. After FINSIDER left, the existing structure is the one described in figure 5. indicating the abolished posts and the new ones. Some posts were abolished and others transferred to the headquarters of SOSIDER in Kinshasa.

1/ Metal Bulletin, 1988.

Figure 6. Organization Chart



Note X = Abolished Posts
o = New Posts

There were management problems from the very beginning. The Italian firm FINSIDER submitted the corporate organization in accordance with contracts with SIDERNA. Figure 5 shows that there were too many directors, section heads, and units which made co-ordination among and between units difficult. Consequently, production of the first year was 3,731 tons of hot-rolled products and plant utilization was 3.7 per cent. Cold-rolled products made with imported coils were 1,603 tons. The maximum production of the Maluku steel plant was only 12,663 tons, only 12.7 per cent of a total capacity of 250,000 tons in 1979. However, right now all posts of directors are abolished except for the Financial Director who was transferred to SOSIDER headquarters to supervise the entire financial flow. There is a need for a thorough reorganization although after a cut of 200 employees no further cut seems to be necessary, at least at production level.

Human resources is one of the key issues in planning the rehabilitation of the Maluku steel mill. A labour agreement with the Union which would assure lower production costs is needed. The number of working staff is still too high for the size of the plant and the size of production at present. Even if all staff, especially production workers and engineers, are be kept for the scheduled production programme to be seen later in this report, the cost of labour must be kept at a minimum. With three years at least it might be possible to see if a further expansion programme is feasible; only 33 per cent of the staff was reduced since 1982 but the average salaries increased almost 325 per cent to keep up with the rate of inflation between 1982 and 1985. The wage per worker increased from 20,000 Z/year in 1983 to 65,000 Z/year in 1986[1/].

. While new technology is critically important for rehabilitation of the Maluku steel mill, the Maluku steel mill must implement a human resources activity programme planned for a high degree of staff participation on a regular basis. The problem affecting the plant is not technology but human resources, and good management. In the past this plant did not run properly even though all refractory materials were available.

A labour agreement will affect the way work is organized and performed in the new Maluku steel mill regardless of whether it is operated by government or private corporation. Staff would be paid for the quality of their work and so result in a highly trained, flexible, motivated work force. Further production staff would share in some of the responsibility for maintenance of their equipment. They would be organized into work teams empowered to resolve problems relating to quality, production, and safety. A joint labour/management committee should be operative, with the assistance of outside management expertise, until steel-making operations become profitable.

4.3 Steel production

Since the Maluku steel plant started operating in 1974 SOSIDER has produced only a total of 81,551 tons of steel products (67,927 tons of hot-rolled products, 13,624 tons of cold-rolled products). Table 17. shows the production of steel products from 1974 to September 1988. The capacity of Maluku steel plant is a nominal 250,000 tpy of long products. The plants have 16,512 tons in 1975 which was the highest production volume in its history.

1/ Republique du Zaire, Etudes sur la reforme des entreprises publiques, Composante B., February 1988.

The cold-rolled products were produced for the first three years (1,603 tons in 1974, 8,164 in 1975 and 2,249 in 1976). Then they were not produced for five years (1977 to 1981). Since 1982 this cold-rolled mill was activated not because of producing cold-rolled products but because of adjusting and maintaining for future operation. For this purpose 2,000 tons of hot-coils were imported in 1981.

Table 17. Production of steel products in Maluku from 1974 to 1988. (metric tons in terms of products)

Year	Hot-rolled products	Cold-rolled products	TOTAL
1974	3,731	1,603	5,334
1975	8,348	8,164	16,512
1976	9,100	2,249	11,349
1977	7,993	-	7,993
1978	8,053	-	8,053
1979	12,663	-	12,663
1980	1,130	-	1,130
1981	7,482	-	7,482
1982	4,086	304	4,390
1983	259	760	1,019
1984	2,070	533	2,603
1985	936	11	947
1986	-	-	-
1987	89	-	89
1988	1,987	-	1,987
TOTAL	67,927	13,624	81,551

Source: SOSIDER, September 1988.

Hot-rolled products have a better record of production at least until 1979: average production was 9,231 tons per year from 1975 to 1979 for five years which was likely to make profits. Since then, production has a decreasing tendency except in 1981 which recorded a production of 7,482 tons. In 1986 there was no production due to technical and economic problems in addition to management inability for handling these problems in a forward manner and making a quick decision.

The main hot-rolled products are: wire rods, smooth round rods and notched round rods. The principal production of smooth round rods (12-16 mm, 18-22 mm) were produced only in 1973, 1976, 1977 and 1981; 24 mm and 32 mm were produced only once during this period. Size 26 mm was never produced. The principal production of notched round rods were also sizes 12-16 mm. Size 20 mm was produced in 1975, 1976, 1978 and 1979. Other sizes (18, 11, 13 and 32 mm) were produced only once. Size 26 and 27 mm were never produced.

Cold-rolled steel products produced in the past were cold-rolled sheet, cold-rolled strip and hot sheets: 1,603 tons in 1975, 8,164 tons in 1975 and 2,249 tons in 1976. Production then stopped until Maluku steel mill started producing its cold-rolled products after importing 2,000 tons of hot coils. At present there is no production but maintenance work is always being done.

Table 18. Production of hot-rolled products, 1974-1988
(per cent)

	Wire rods (6-19 mm)	Smooth round rods (12-21 mm)	Notched round rods (12-13 mm)	Profiles	Total
1974	0	100	0	0	100
1975	52	21	27	0	100
1976	53	29	18	0	100
1977	48	52	0	0	100
1978	62	7	31	0	100
1979	63	21	16	0	100
1980	0	100	0	0	100
1981	75	18	7	0	100
1982	54	21	0	25	100
1983	16	5	79	0	100
1984	63	21	16	0	100
1985	34	26	40	0	100
1986	0	0	0	0	100
1987	43	22	35	0	100
1988	51	10	29	0	100

4.4 Sales and pricing of national steel products

Table 19. Total sales of steel production and taxes paid

Year	Total sales (Zaires)	Total sales (Tons)	Price/t (Zaires)	Taxes (Zaires)
1974	329,056	904	364	8,507
1975	5,119,730	16,786	305	91,506
1976	6,064,874	11,273	538	209,265
1977	6,762,700	9,661	700	513,237
1978	6,433,700	9,191	700	492,438
1979	19,182,464	8,672	2,212	1,429,399
1980	21,551,004	4,878	4,418	1,093,949
1981	71,190,028	7,196	9,893	6,490,400
1982	36,653,565	3,705	9,893	3,405,097
1983	33,618,000	1,724	19,500	1,974,997
1984	29,399,650	1,330	22,105	2,602,210
1985	31,128,640	1,424	21,860	3,867,194
1986	17,150,985	681	25,185	2,080,434
1987	16,248,625	215	75,575	2,552,564
1988		1,987		

Table 19 shows value of total sales, tons sold, prices per ton and taxes paid from 1974 to 1987. The production of 1,987 tons in 1988 is only up to September as mentioned before. Figures were calculated based on data received from SOSIDER who adds 20 per cent margin to its products when sold to a third party. Tax on the product sold to retailers is charged 12 per cent in 1988 (20 per cent until 1982 and 18 per cent until 1986). Tax on the product sold to fabricators or processors is at present 3 per cent[1/].

1/ There is a discrepancy in taxes paid on the total steel tons sold.

Management expressed the fact that it faced various marketing problems since 1982. They and the factory people were asked the following questions: How do you sell your products? Do you have a marketing strategy? Their answer was that whatever they produced was sold and whoever needed their products fetched it from the plant using their own transport. When SOSIDER starts producing according to the production schedule we made up for them, they need a good marketing strategy.

The Maluku steel mill must rely on its home market for all its turnover for some years to come but many companies at present depend on imports of steel products. First of all the Maluku steel mill faces difficulties in finding the customers again, since they have no idea if they were reasonably satisfied with the products and service that had been provided. However, it was noted that some customers considered that the product range, product quality and delivery could and should be improved.

The Maluku steel mill should prevent the user from importing material that they themselves can produce without relying on an import licensing system which SOSIDER users have done until recently[1/]. SOSIDER faces competition with imported steel products on which many former Maluku steel customers depend because of Maluku steel mill's inability of steady supply. Many companies can now import steel products relatively free if they have foreign currency reserves.

SOSIDER and its steel mill Maluku need to make a full effort of marketing strategies for its steel products. It must also encourage users to adapt designs or dimensions to accommodate Maluku steel products. This is something that has never been tried in the past. If Maluku steel mill continues to produce steel at the projected level, there will be an excess of some products available for export, therefore expansion of the product range, improvements in product quality and delivery will assist in enlarging the home market. Especially in view of the limited product range an active selling policy must be followed with careful selection of the most remunerative markets.

5. What the World Bank sees with respect to the rehabilitation of the Maluku steel mill

In 1983 production of the Maluku steel mill went down to 1,019 tons from 4,390 tons in 1982. In 1986 the plant did not produce at all although it sold 681 tons of long products left over from 1985. Consequently the World Bank, by making an analysis of rentability of the Maluku steel mill covering the years 1983 to 1986 picked the worst years. It also analyzed the breakdown of material components in cost of production in 1986, despite the fact that the mill was paralized. It concluded that the cost for running the plant is too high; the oil used was too much; there were too many workers and the level of utilization capacity was almost always far from the one needed for a financial viability. Finaly it said that SOSIDER could not manage the plant profitably even with the government subsidy which should have spent it in a more productive way.

1/ This import licensing system has in part discouraged the Maluku steel mill from improving efficiency, quality of products and sales efforts.

What the World Bank sees is correct. Failures in management as well as financial, technical and marketing are the causes for the present critical situation as can be seen in table 20. The World Bank also foresees demand restrictions in the domestic and export markets and comes to the conclusion that the only rational option is to liquidate the enterprise as soon as possible[1/].

Table 20. SOSIDER - income statements

		1983	1984	1985
Sales (million Zaires)		28	34	51
Sales (tons)		1,724	1,330	1,424
Production (tons)		1,019	1,603	947
Production (Zaires/ton)		3,925	425	1,605
Labour cost (Zaires/t)		1,200	233	591
Costs (per cent):	materials	16 (36%)	3 (10%)	31 (47%)
	labour	16 (36%)	22 (73%)	28 (42%)
	miscellaneous	12 (28%)	5 (17%)	7 (11%)
		44 (100%)	30 (100%)	66 (100)
Profit or loss		-16	4	-15
Other charges		5	6	6
Interest		2	3	4
Amortization		1	1	1
Net loss		24	6	25
Subsidy		26	42	36

Note: ( ) are added by the author
Source: Republique du Zaire. Etudes sur la reforme des entreprise publiques. Composante B., vol IV, Etudes individuelles des entreprises non-commerciales, February 1988.

A comparison was made in 1987 between SOSIDER's financial statement with that of other four companies. "A" company has an integrated mini-steel mill (DR--EAF - rolling mill) which produced more than three million tons. The share of labour in the cost of production is 21 per cent and the labour cost per ton is $59.1. "B" company has an OHF and produces 70,000 tons. The share of labour in the cost of production is 5 per cent and the labour cost per ton is $27.6. "C" company, on the other hand, receives billets from its parent company and makes reinforcing bars using its own bar mill whose production capacity is 90,000 tons. The share of labour to the total production cost is 7 per cent and the labour cost per ton is $15. "D" corporation has an integrated steel works (BOF-BF-rolling mill) and produces long and flat products. The labour cost per ton is $62 and the labour cost per hour is $3 which is less than that in Venezuela ($3.5).

1/ Republique du Zaire - Etudes sur la reforme des entreprises publiques, Composante B, volume IV, Etudes individuelles des entreprises non-commerciales, February 1988.

The labour cost in Maluku is obviously abnormally high but the material costs are not as high as the World Bank claimed. Of course they are high if only the income statement of 1986 are seen since that was the year with worst management problems, even though the plant received 47 million Z of subsidy from the government.

	Materials	Labour	Financial taxes + depreciation	Interests + financial costs	
			(percentage)		
Maluku	33	46	2	19	100
"A": Venezuela	24	21	28	27	100
"B": Bangladesh	80	5	9	6	100
"C": Trinidad and Tobago	71	7	12	10	100
"D": Brazil	69	16	5	10	100

In the overall analysis made by the World Bank on the rentability of the Maluku steel mill, we feel that it is not quite fair to SOSIDER since the average production from 1975 to 1981 was 9,665 tons per year from which can be seen that the plant was operating at a profit, even if other costs for interest and amortization were added. This refers to the hot-rolled steel production because we do not consider at this point the cold-rolling mill which has never been viable due to the lack of demand and of technical capability; in this we fully agree with the World Bank.

The UNIDO team which carried out this study believes that the Maluku steel plant could be run profitably. If the World Bank had really wanted to revitalize the plant, it should have analyzed the record of 1981 when the plant produced 7,482 tons of hot-rolled products. In 1983 and 1985 the production costs per ton were too high because of the small quantity of production but in 1984 the plant produced 2,603 tons. The production cost per ton ($425) is far lower than the price of imported steel products. Past devaluation of Zairian currency against the US dollar could also help the plant run at a profit. Zairean currency was overvalued for a long time which was in part the reason for difficulties in obtaining hard currency apart from the governments's macro-economic currency policy.

6. Demand for steel products in Zaire and neighbouring countries

The demand for steel products in Zaire at present amounts to 30,000 tons and it is assumed that the quantity produced is completely absorbed by the internal market. Export would have to be considered only for a marginal surplus of products for at least another five years, even the Maluku steel mill produces 16,000 metric tons of steel products which would be the largest volume of production in its history. The demand in 1991 and 1992 is estimated for 40,000 and 42,000 tons respectively and estimates for 1993 and 1994 are between 42,000 and 47,000 tons. If the Zairian economy picks up, it is expected that demand would be for 55,000 tons.

The demand for flat products is about 35 per cent of total steel demand in Zaire and 25 per cent in the region of the Central African countries. However, flat products should be imported into Zaire until enough demand returns. Furthermore, regional competition among Central African countries is required to re-run this cold-rolling mill of Maluku whose capacity is 150,000 tons/year, since Zaire will never have 25,000 tons of demand for flat products before 1995.

Table 21 shows apparent steel consumption in terms of crude steel equivalent in Zaire and other countries from 1965 to 1990. When the Maluku steel plans started operating in 1974 there was a demand in Zaire for 198,000 tons of steel. Between 1969 and 1974 the average steel demand was for 153,000 tons, but after 1975 it showed a decreasing tendency except in 1984. Particularly during 1986, 1987 and 1988 the demand for steel was less than 50,000 metric tons. Steel consumption per capita has never been more than 9 kg in the past. For 1988 the estimate is unusually low at 0.9 kg per capita.

The Central African region as a whole, except for countries which are not listed in table 21., had a total steel demand for 364,000 tons which increased to 540,000 by 1974 but then decreased until 1981. Since then, demand has again increased although not as high as before and in 1990 it is estimated to be 360,000 tons. If the steel demand of Zambia and Angola is added, the total in 1991 would be 454,000 tons. If the demand ratio of long flat products is considered the result is 75 to 25, then 340,000 tons of long products and 113,000 tons of flat products will be required to satisfy the demand for steel in the region. The demand for flat products is still expected to be lower than the flat product capacity of the Maluku steel mill.

The Economic Commission for Africa (ECA) estimated[1/] the crude steel demand in ten Central African countries as 1,452 million tons in 1990 and 3,734,000 tons in the year 2000. These countries are Burundi (44,000 tons), Cameroon (220,000 tons), Central African Republic (33,000 tons), Congo (154,000 tons), Gabon (264,000 tons), Rwanda (44,000 tons), and Zaire (660,000 tons). However, judging from the steel import statistics of the Economic Commission for Europe (ECE), the demand figures in 1990 are too optimistic since steel imports of these countries are around 15-18 per cent of the total steel imports. Steel production in these countries in the past and in the present is very small. In 1981 the total of African countries imported six million tons of steel products, the largest quantity ever. If apparent steel consumption is calculated for the Central African countries based on this figure, the steel demand is at best 900,000 tons, but steel imports in 1986 were 2.3 million metric tons. Steel demand in 1990 was calculated based on this import figure. Apparent steel consumption is around 400,000 tons, far from the 1.4 million tons estimated by the ECA.

Discussions and meetings among Central African subregional countries have been going on for five years regarding regional co-operation for the subregional integrated iron and steel plant for production of steel products using local resources to meet a subregional demand. Almost all participants from each government agree on the proposal in principle and at a political level, but not at economic and business levels. They all talk about co-operation among themselves but they have never carried out joint research on demand for steel products, i.e. flat as well as long products. Each wants to benefit at the expense of the other. Zaire wants its Maluku steel plant to be rehabilitated through the regional co-operation, while other countries have their own steel plant projects which have been shelved.

1/ The technological options for small integrated iron and steel plants based on direct reduction in ECA member countries, ECA/IND/MET/008/87, 1988.

Table 21. Apparent steel consumption in crude steel equivalents
(thousands of metric tons)

Country	65	66	67	68	69	70	71	71	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90E
Cameroon	–	–	–	–	–	100	–	–	–	150	–	–	–	–	–	–	60	–	–	–	80*	–	–	–	–	120
Congo	–	–	–	–	–	27	50	38	44	59	32	41	41	17	32	84	27	70	62	62	60	55	32	–	–	70
Gabon	–	–	–	–	–	33	37	27	81	88	110	112	129	40	35	72	74	71	53	64	70*	–	–	–	–	80
Centr.Afric. Republic	–	–	–	–	–	30	–	–	–	30	–	–	–	–	–	–	15	–	–	–	10*	–	–	–	–	13
Zaire	55	83	67	87	120	161	163	142	138	198	97	54	81	53	63	81	62	61	42	99	66	46	40	30E	30E	40
Burundi, Ruanda	4	–	–	–	–	13	–	–	–	15	5	–	–	18	–	24	26	35	37	38	36	30	30	30E	34E	37
Total						364				540							264				322					360
Angola	61	93	133	168	122	109	130	95	123	172	52	50	59	39	52	81	77	53	15	72	57	50	50	49E	52E	59
Zambia	12	17	26	42	42	59	171	107	126	230	68	40	52	30	47	28	15	11	9	13	27	28	29	29E	31E	35
Total						532				942							356				406					454

Note: * = ECA estimates
– = figures not available
E = estimated

Source: International Iron and Steel Institute and Japan Iron and Steel Federation and the Industrial Statistics and Sectoral Surveys Branch of UNIDO.

There have been no concrete plans of action. For example, there is no economic agreement even between Zaire and Congo which are neighbours. Transport systems, and taxes on import-export are one of the many points still to be solved such as what kind of product exchange should take place between Zaire and Congo in return for Zaire's export of steel. Political science should get down to business if co-operation is really wished for the establishment of the integrated development of the iron and steel industry for the whole region. Some economists propose that Zaire and the Central African countries should obtain steel products from Zimbabwe which has a substantial production capacity; however this is not a wise proposal since the plant in Zimbabwe is not working well and will not work well for some time because it needs its own rehabilitation programme. Moreover, there is no concrete co-operation even among PTA countries.

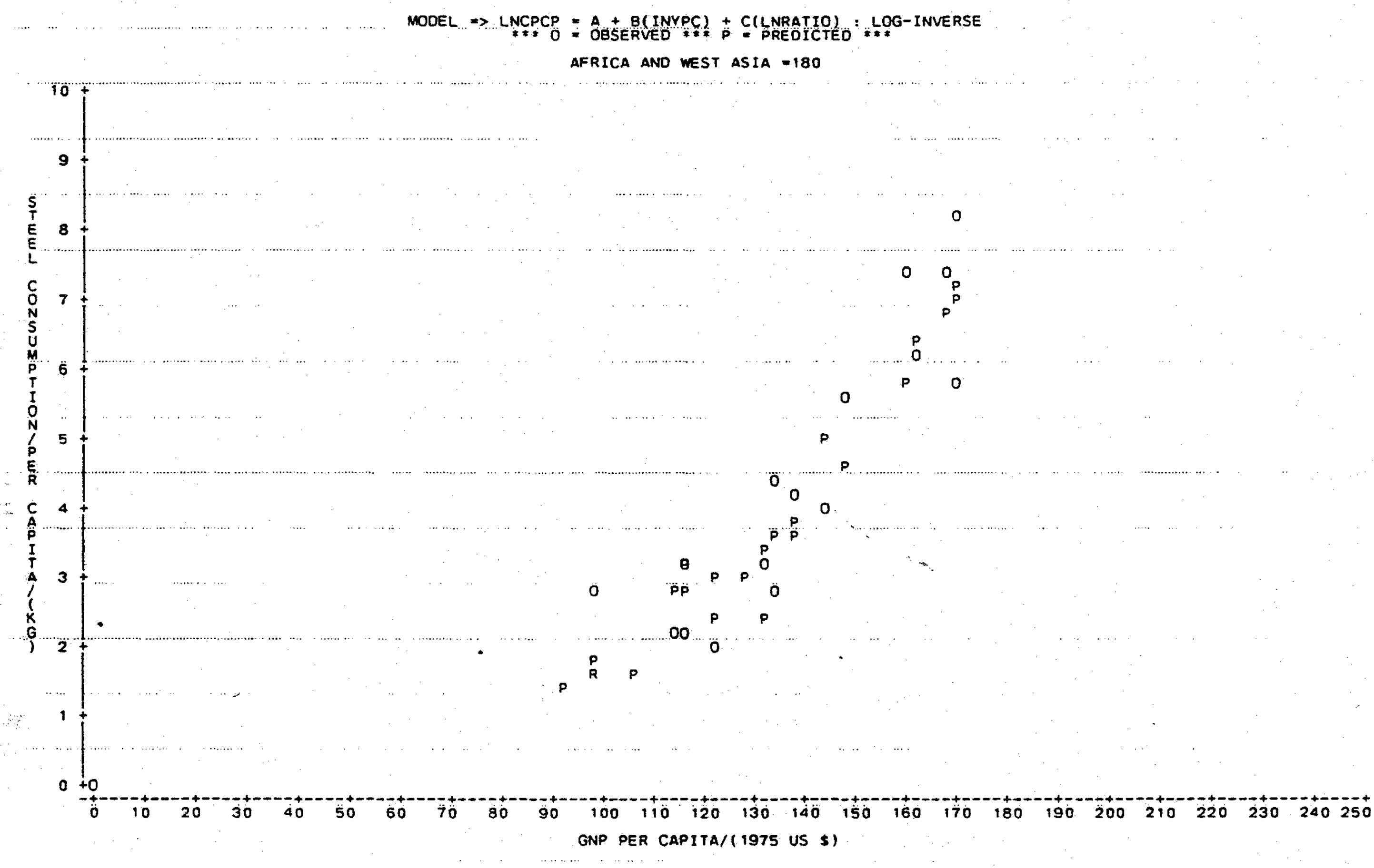
It is true that there is a substantial demand for steel products but in the Central African region there are only two existing steel mills. For long products Cameroon has one rolling mill (40,000 tons of hot-rolled capacity) and Zaire has 250,000 tons of liquid steel capacity; 250,000 tons of rolling mill capacity, that is, hot-rolling mill of 100,000 capacity; whereas for cold-rolled products there is one cold-rolling mill of 150,000 capacity.

Even if Angola has 35,000 tons of liquid steel capacity and 50,000 tons of rolling mill capacity for long products, the demand for steel products in the region cannot be satisfied. However, existing iron and steel plants in these countries have recorded a very low utilization rate due to, among others, lack of raw materials, and foreign exchange.

The countries which have steel making facilities and rolling mill capability must revitalize their plants at least up to a break-even point before co-operation actually starts, otherwise their plants would not be viable without exports, counting on export only which means no development of downstream industries for the integrated development of the iron and steel industry in the country. Eventually it will taper off its own economy and industries. A recent rapid rise in the capital formation share of GDP in Zaire has not yet produced a full scale development of manufacturing. This is because the industrial linkages in society, among other things, have not been formed correctly. The rehabilitation of the Maluku steel plant as a promoter to form a connecting link between capital goods and consumer goods industries is urgently needed.

The demand for steel products in Zaire can be facilitated if Zairean economy goes back to normal as figure 1 indicates where a positive gradient over the period is sustained. This possible relationship between steel consumption and GDP means that resources are increasingly moving into more steel-intensive sectors, such as more advanced forms of agriculture, mining, transport, other infrastructure development and industry itself as GDP per capita rises. Zaire has a potential for the development of its economy because of increasing share of gross capital formation. However, to take off from the stage of under-development, an economy such as Zaire's needs capital formation for industrialization which needs to be developed smoothly within the overall framework of the economy. Fortunately, it seems that at present capital formation is on the rise and thus it is expected that steel consumption will grow together with a steady progress in its industrialization and in the development of its infrastructure.

Figure 7. Variation of steel consumption in Zaire, per capita with GNP per capita



Source: The Iron and Steel Industry of West, North and Central Africa, Sectoral Studies Series No. 41 UNIDO 1988

7. Imports of iron and steel products by Zaire and its neighbouring countries.

Table 22 indicates total imports of semi-finished and finished steel products from 1965 to 1986 in Zaire and in the entire African developing countries except Egypt which imported 976,000 metric tons in 1986. Egypt imported 1,949,000 metric tons in 1985 which amounted to 37 per cent of the total of the African developing countries. Egypt is one of the largest importers of steel products in the African developing countries along with Algeria. A total of seven countries imported 253.8 thousand tons in 1975, 294,3 thousand tons in 1980. The average volume of imports from 1970 to 1986 is 265 thousand tons. This volume may continue for another ten years.

Table 22. Total imports of semi-finished and finished steel products in African developing countries
(thousands of metric tons)

Country	1965	1970	1975	1978	1979	1980	1981	1982	1983	1984	1985	1986
Angola	45.6	85.0	37.4	28.2	39.1	58.6	64.9	38.0	18.9	51.1	40.0	35.7
Burundi, Rwanda	3.4	10.1	3.2	15.0	15.9	18.1	21.9	23.7	27.1	28.4	26.7	22.3
Congo	34.1	19.9	23.6	12.6	23.0	66.6	63.4	47.1	44.7	45.2	42.1	23.3
Gabon	-	23.9	29.8	28.7	24.7	59.8	57.0	49.4	37.4	46.8	47.7	15.3
Tanzania	-	62.5	55.2	99.8	74.1	67.8	31.9	65.2	68.6	58.3	56.1	42.4
Uganda	-	22.3	4.2	2.8	2.2	9.4	76.0	43.4	3.9	7.1	130.7	23.5
Zambia	8.9	44.7	50.4	24.0	24.9	23.0	11.6	8.8	7.0	11.3	6.5	23.6
Total	83.1	268.4	253.8	211.1	203.9	294.3	326.7	275.6	207.6	248.3	349.8	186.1
Zaire	38.1	130.9	73.9	45.5	50.2	60.0	50.7	43.0	31.2	71.5	48.1	19.0
Total Africa	2,734.1	3,174.7	4,885.1	4,884.5	4,651.0	6,071.8	5,864.8	3,626.7	4,177.2	4,247.2	4,031.0	2,362.8

Note: Data in 1965 for Congo includes Gabon;
- = data not available
Source: ECE 1988.

Steel imports by Zaire recorded 130,000 tons in 1970 but they decreased to 73,000 in 1975. By 1984 they decreased again to 72,000 tons and in 1986 Zaire imported 48,000 and 19,000 tons respectively. The volume of imports in 1986 was less than half of that in 1985, which shows that the economic activities in Zaire are slowing down.

Table 23. Structural changes of imports of steel products in Africa (percentage)

Products	1970	1974	1978	1980	1981	1982	1983	1984	1985	1986
Ingots & semis	5.9	10.0	11.4	11.5	11.7	13.3	10.9	13.9	19.3	18.2
Long products	36.6	40.4	40.3	40.9	41.6	42.7	37.0	45.0	30.4	27.4
Flat products	31.5	31.7	25.9	25.6	25.4	25.2	32.9	25.0	27.7	34.0
Wire	3.8	3.2	3.3	3.0	2.2	2.7	3.2	2.9	2.8	6.0
Tubes and fittings	22.2	14.7	19.1	19.0	19.1	16.1	16.0	13.2	19.8	14.4
Total	100	100	100	100	100	100	100	100	100	100

Source: ECE 1988

African imports, excluding South Africa, grew from 2.734 million tons in 1965 to 4.885 million tons in 1970. Following a decrease in 1978 and 1979, they grew again up to 1980 when they reached their peak and declined to 4.177 million tons in 1983. In 1986 African countries imported 2.362 million tons. The share of African total world steel imports has fluctuated around 5.5 per cent for the past 17 years. In 1982 the share of importing steel products from EEC and other European market economy countries was over 30 per cent, Latin America and Asia export about 5 per cent each of total imports of African countries. The major share of total steel imports of Africa, accounting for 36.6 per cent in 1970, was made up of the group of long products. After 1970 there was an upward trend and by 1984 the share of these products had increased to 45 per cent.

Another important group of products in the region's steel imports was flat products. However, during the period under review, the share of these products declined from 31.5 per cent in 1970 to 25 per cent in 1984 at which time they began to increase. The share of the group of ingots and semis grew from 5.9 per cent in 1970 to 18.2 per cent in 1986, while the group of tubes and fittings declined from 22.2 per cent to 14.4 per cent in 1986 (see table 23).

Zaire mainly imported long, flat products, and tubes and fittings as indicated in table 24. The share of imported flat products is very high in comparison with other neighbouring regions, but this does not mean that Zaire needs more flat products than long products. Long products have been the main demand in the country for the past twenty three years. If apparent steel consumption of steel products is considered, this is obvious through the production of long products by the Maluku steel mill and foundries. In the past Zaire had to import more flat products because of Malaku steel's inability to produce cold-rolled products. Zaire will have to import more flat products for five more years until the Maluku steel mill goes back into operation of cold-rolled mill. Flat sheets are in great demand in Zaire, which imported an average of 9.6 thousand tons between 1981 and 1986.

Table 24. Structural changes of imports of steel products in Zaire (percentage)

Product	1981	1982	1983	1984	1985	1986
Ingots and semis	14.2	4.0	0	0	0	
Long products	24.8	23.4	54.8	38.8	23.0	17.9
Flat products	45.7	55.2	32.0	38.8	35.5	62.5
Wire	1.6	2.8	1.7	1.0	1.5	0.4
Tubes and fittings	13.7	14.9	11.5	21.4	40.0	19.2
Total	100	100	100	100	100	100
Flat production in Maluku (metric tons)	0	396	760	533	11	0
Non-flat production in Maluku (metric tons)	7,482	4,086	259	2,070	936	0
Foundry production of iron and steel products (metric tons)	-	2,425	3,446	5,886	5,746	3,559

Note: - = not available
<u>Source</u>: ECE 1988.

Table 25. Total imports of semi-finished and finished steel products, by Zaire and developing African countries (thousands of tons)

Product	Ingots and semis	Heavy sections	Light sections	Plates	Sheets less than 3 mm	Hoop and strip	Tinplate	Railway track material	Wire rods	Wire	Tubes and fittings	Wheels tyres & axles	Total
Destination	1	2	3	4	5	6	7	8	9	10	11	12	13
Africa 1986	431.07	122.82	359.69	109.34	521.01	57.35	117.67	69.97	88.69	142.89	340.19	2.20	2,362.89
Zaire 1986	-	0.39	2.25	1.24	8.92	0.62	1.14	0.16	0.58	0.08	3.67	0.00	19.05
Africa 1985	627.76	222.89	546.47	123.68	577.05	52.67	147.12	105.97	102.91	95.40	643.91	1.36	3,247.19
Zaire 1985	-	0.29	3.64	1.31	6.08	0.71	0.49	1.03	0.36	0.38	9.89	0.01	24.19
Africa 1984	584.67	382.35	1209.35	187.45	652.39	50.77	162.81	133.80	150.30	124.73	554.43	3.42	4,196.94
Zaire 1984	0.01	4.64	12.80	11.38	13.61	1.63	1.53	9.69	0.59	0.76	15.58	0.31	72.53
Africa 1983	328.24	260.36	566.93	187.00	605.56	51.88	141.79	134.49	134.04	97.30	480.35	20.19	2,990.13
Zaire 1983	0.00	1.30	3.32	3.84	4.64	0.93	0.88	12.03	0.11	0.54	3.60	0.00	31.19
Africa 1982	501.80	217.87	651.09	144.11	810.96	57.48	180.70	74.37	164.60	92.05	723.62	8.12	3,362.77
Zaire 1982	1.74	2.77	7.44	4.96	9.24	0.35	0.99	7.40	0.38	1.22	6.44	0.13	43.06
Africa 1981	688.59	264.67	1868.54	256.43	1048.10	76.39	165.61	70.38	167.21	130.04	1125.93	2.96	5,864.85
Zaire 1981	7.25	2.51	9.08	5.89	14.94	0.74	1.66	0.02	0.32	0.82	6.99	0.52	50.74

Note: Egypt is excluded

Source: ECE 1988

8. <u>New production programme of the Maluku steel mill from 1989 to 1995</u>.

Table 26. Production schedule for the Maluku steel mill
(metric tons in terms of products)

	1989	1990	1991	1992	1993	1994	1995
Hot-rolled production	7,500	15,000	25,000	30,000	30,000	40,000	50,000
Steel-making capacity utilization rate (250,000 tons)	3%	6%	10%	12%	12%	16%	20%
Hot-rolling mill utilization rate (100,000 tons)	7.5%	15%	25%	30%	30%	40%	50%

Table 26 shows the production schedule recommended by our mission group until 1995. In 1975 and 1979 Maluku steel recorded 16,512 and 12,603 metric tons of steel production respectively as shown in table 17, but the expert team set Maluku's production target for 7,500 tons in the first year. One reason for this figure was that the maximum production of this plant after the Italian experts left was 7,482 tons and it was assumed that the plant could produce 7,500 tons if it can receive enough materials necessary to start it up again. The production for the second year is set at 15,000 metric tons which is twice as much, and the reasoning behind this is the same: if enough materials are received, all the production can be sold; there are enough capable engineers and production workers to make this work, but an engineering manager should be hired to supervise the whole operation under a management contract.

In order to continue this production of 7,500 tons in 1989, 534 million Zaires are required: 168 million for fixed costs and 366 million for variable costs. If the Maluku steel mill can product 15,000 tons in 1989, it needs 900 million Zaires. If 20,000 tons are reached, then 985 million Zaires are necessary. Thus if inflation is considered in the next few years and if the plant wants to produce over the production schedule, then the money required can be estimated.

The last import to be made for adequate operation is for the renovation of a transfer car which costs 52.5 million Zaires. However, this is not so urgently needed so that it can be made after the 1989 production. Thus the actual cost of production is shown below.

The raw materials which SOSIDER can obtain locally (208.5 million Z) are ferro-scrap, fuels, combustives (gas company), energy, limestone, etc.

The total capital required for the production of steel products is as follows:

	15,000 metric tons	7,500 metric tons
	(in millions of Zaires)	
Variable cost	315	157.5
	105	52.5
	417	208.5
Fixed cost	168	168.0
	1,005	586.5
Cost per ton	67,000 Z	78,200.0 Z
US$ = 205 Z	($326.8)	($381.4)

The fixed cost is the same but the variable cost is very different if the cost of renovation of the transfer car is excluded from the total. Maluku has to spend 374 million Zaires and imports for raw materials mentioned above which cost 160 million Zaires equivalent to $780,487.8. The cost of production is 534 million Zaires and the cost per ton is 71,200 Zaires or $347.3 at a dollar rate of $1 to 205 Z. (see table 27).

If a strong marketing campaign is launched and SOSIDER can sell all its production, it can make 3.5 million dollars profit. Since the selling price of reinforcing bars per ton is $814 (166,870Z) and the cost per ton is $347.3 (71,196 Z), the difference is the margin but actually it becomes less because the fixed costs (168 million Zaires) are made up from labour costs, financial charges, insurance, etc. The variable costs are divided into two parts: (a) the materials SOSIDER can buy in the country with local currency, and (b) the materials which must be imported with hard currency. For this purpose SOSIDER should try to find a corporation which provides some raw materials in exchange for steel products from the Maluku steel mill. This would save foreign currency and marketing costs for overseas sales. There are many developed countries which are doing this in other regions of Africa and Asia. If Maluku steel could produce 25,000 tons of steel products, the cost of production would be $240 per ton which is competitive in the international market. For example, an EAF steel producer in Perú produced one ton of rebars at $648 (plus financial cost) in 1987[1]. Employment cost was $95 and raw materials $553.

The breakdown of variable costs submitted by SOSIDER for the rehabilitation of the Maluku mill is as follows:

Imports: 160 million Zaires:
- raw materials +
- refractory raw materials — $768,292 = 160 million Z
- materials for renovation of transfer car — $256,097 = 52.5 million Z.

Locally available: 206 million Zaires ($1,004,878)

What SOSIDER must import are operating raw materials: replacements and refractory materials for a value of 160 million Ziares ($780,487.8) based on c.i.f Matadi port in Zaire. The Maluku steel mill needs foreign currency at a rate of $100 per ton which the Zairian government could provide. SOSIDER could follow the production schedule provided that three experts be hired for supervising management, finance and marketing, and engineering groups because at the present time this expertise is lacking.

1/ Sectoral Studies database, UNIDO 1988.

The raw materials necessary for operating the plant are mainly the following:

1. Argon
2. Cork (bouchon) for ladle
3. Nozzles (busette) for ladle
4. Nozzles for turndish
5. Electrodes 507 x 1800 mm with nipples
6. Ferro-manganese
7. Ferro-silicon-manganese
8. Ferro-silicon
9. Ferrous 400 - n/type accuthermt
10. Fluorite, type VA CAF 2 75/85% - GR: 3-30 mm
11. Asbestos plates
12. Gate nozzles for ladle
13. Calcium silicide
14. Thermo couple - n/type ptpt rh 10%, 1200 mm
15. Protean 192 - n/type isotherm gr
16. Normal joints (ferole)
17. Ferro-alloy

The reflectory materials consist mainly of the following:

18. BG 40 - n/type spray mix
19. Normal heat, n/type gt - universal
20. F.40C
21. HL-7-n/type Sinter magnesite 005
22. Permasit A - n/type go- universal
23. RBM 97
24. Scaligum 3 - n/type gum 80
25. Fire clay - n/type, aerstop - B
26. Supersinter - 75
27. Purotab - n/type 95 tab
28. Other refractory materials for arc furnace
29. Electrodes and graphite

Table 27. Cost breakdown in the production of rebars
(millions of Zaires)

	7,500 tons	15,000 tons	20,000 tons
Fixed cost	168	168	168
Variable cost	366 (160 for imports)	732 (315 for imports)	817 (400 for imports)
Total cost (excl.interests and amortization)	534 (71,200 Z/ton)	900 (60,000 Z/ton)	985 (49,250 Z/ton)
Cost/ton at $1 = 205Z	$347.3	$292.6	$240.2
Sales price, 20% mark-up	$416.7	$351.1	$288.2
International price f.o.b. Brussels	$300	$300	$300
Import price	$814	$814	$814

In this production programme, it is assumed that the government will provide about $100 per ton produced in foreign currency for four years until all replacements of spare parts and minor repairs are completed. SOSIDER would repay it in Zaires, so no problems can arise for emergency imports for refractories, other raw materials, and spare parts.

Table 28. Transaction between government and SOSIDER (at 1988 prices)

		GOVERNM.	Additions considered	SOSIDER	Revenues	Profit accumulation
1989	Jan.	$781,000				
	Dec.		Inflation, low interest	160,105,000Z	1,251.5 mill.Z.	717,551,250 Z
1990	Jan.	$781,000				Remaining profits in 1989:
	Dec.		Inflation, low interest	160,105,000 Z	2,503.05 mill.Z.	1,435,102,500 Z
1991	Jan.	$781,000				Remaining profits in 1990:
	Dec.	$781,000	Inflation, low interest	160,105,000 Z	4,171.75 mill.Z.	2,391,837.500 Z.
1992	Jan.	$781,000				Remaining profits in 1991:
	Dec.		Inflation, low interest	160,105,000 Z	5,006.1 mill. Z.	2,870,205,000 Z.

The US dollar figures shown are at the 1988 level so if inflation is considered they will increase. However, this is no problem because this increase can be absorbed by an increase in local sales prices. SOSIDER has no trouble in buying raw materials and spare parts necessary to run the Maluku steel mill and it would be advantageous if no interests are imposed on loans from the government.

Since the rate of profit is over 57 per cent (95,673.5/166,870), the profit accumulation for four years would enable SOSIDER to make its own projects and promote regional co-operation among the Central African countries. Even if the sales price is cut to $100 per ton, the rate of profit remains at 51 per cent, as indicated in table 28.

The three experts on management, finance and marketing, and engineering should strive to bring to a minimim the probable additonal costs such as marketing, workers' training, transport, scrap collection for the following years, and repayment of debts (if any) on working capital.

For this production programme to be effective, it is recommended that the government impose no tax on imports of raw materials and spare parts during four years (at present 3 per cent) and advise steel consuming industries to buy steel products from SOSIDER by raising taxes on finished product imports which are available locally.

9. Prices and pricing mechanism of imported steel products

Present general export prices f.o.b. Antwerp are given below. Through these prices the sales prices of hot-rolled (in this case rebars) and cold-rolled (cr coil) are calculated using the exchange rate of one dollar to 233.34 Zaires (September average 1988)[1/].

Table 29. Pricing of imported steel products

	Rebars		CR Coils	
	US$	Zaires	US$	Zaires
Basic price	300	70,000	475	110,830
Transportation	43	10,000	43	10,000
Import tax	21	5,000	21	5,000
Import price (Kinshasa)	364	85,000	539	125,800
Mark-up by importer	514	120,000	761	177,600
Wholesale price	685	160,000	1,014	236,800
Retail price	814	190,000	1,200	281,200

1/ Billet prices in Brazil in October 1988 are some $245-250 per ton f.o.b. Brazil and Brazil f.o.b. rebar prices range from $261 to $281/ton. Wire rod export prices are at around $285/ton f.o.b.

Table 29 was made after conversations with managers at the Maluku plant and a financial manager of SOSIDER at Kinshasa headquarters. Consequently the figures given for import tax on cold-rolled coils are not accurate. Thus, the price of rebars and cold-rolled coil goes from $300 to $814 and from $475 to $1,200 respectively. One of the financial officers informed that in the economic recession the price of rebars went down to 140,000 Zaires ($682.9). Until 1982 importers of steel products needed permission from SOSIDER but this kind of protection is not given now. Any amount can be imported as long as they have foreign exchange and pay import taxes.

The break-even point for hot-rolled products is calculated using the table which shows how much money is needed to run the Maluku plant in 1989. It can run at a profit even if it produces 5,000 tons because, according to the company president, the government had written off its accumulated debt. Rebars can be produced at a price range between $350 and $400. If the plant produces 7,500 tons per year it could take care of its accumulated debt on working capital in 1988 (if any).

II. PLANNING FOR DIRECT REDUCED IRON (DRI)-BASED INTEGRATED MINI-STEEL PLANTS IN ZAIRE

1. Resources needed for iron- and steel-making plants

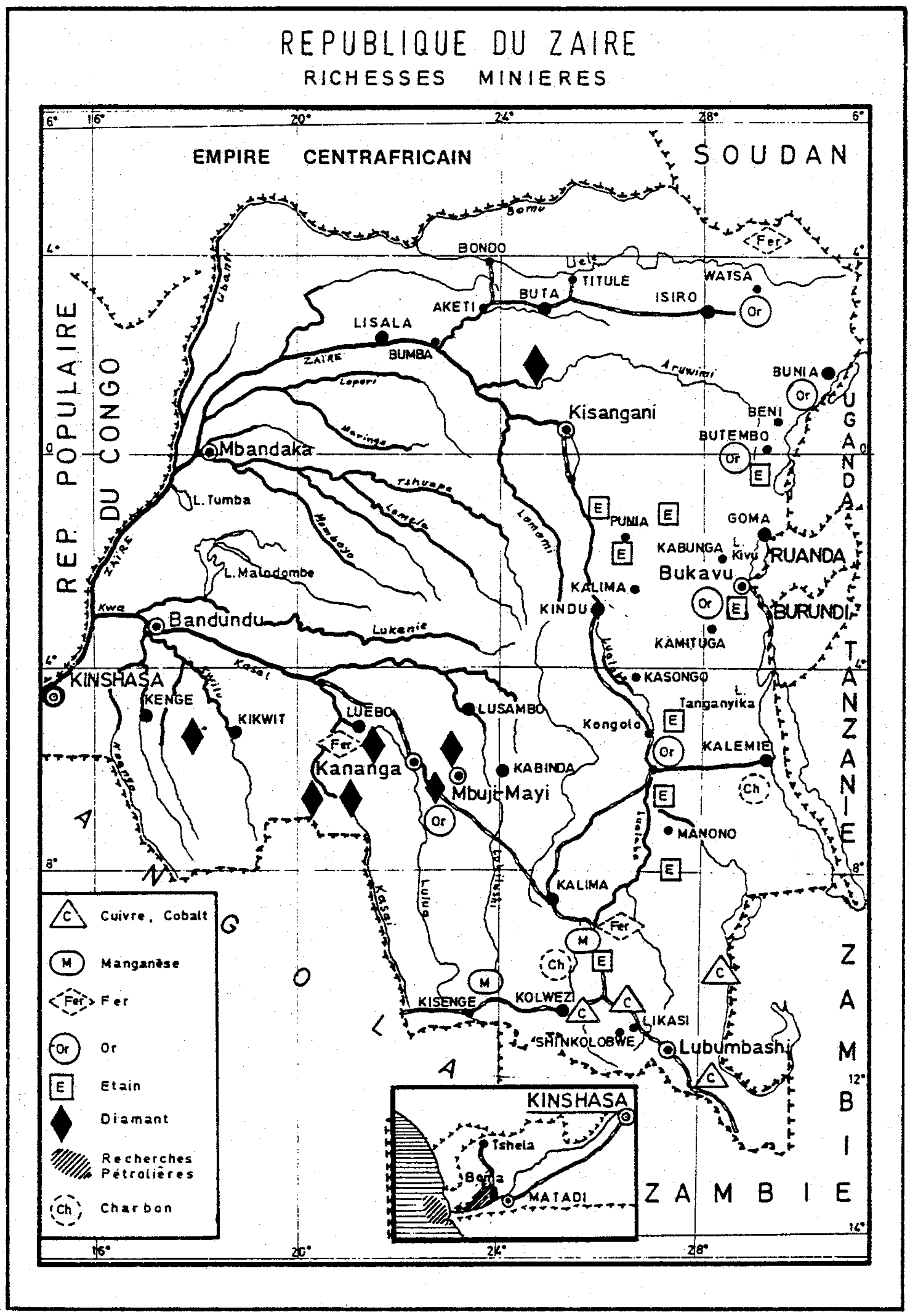
The direct-reduced/electric furnace (DR/EF) route can be operated effectively on a small scale. This can decidedly be an advantage where steel markets are small, where the supplies of raw material are insufficient for large operations, and where investment funding is difficult. With the construction of new DR plants and the increased use of DRI in the steel industry in developing countries, the electric arc furnace (EAF) has resumed increasing importance as a steel-producing process.

The ability of the mini-steel mills (EAF - rolling mills) or integrated mini-steel mills (DR - EAF - rolling mills) to operate at a relatively small-scale, made it attractive to developing countries like Zaire seeking to establish iron and steel industry to satisfy local demand for re-inforcing bars, structural steels and similar products essential to developing industrial sectors such as agro-based and construction industries. At present in the developing African countries, a number of nations are committed to the establishment of an indigenous industrial base of which iron and steel-making forms a key part. Zaire built the Maluku steel plant, a mini-mill, in 1974. The main available raw material for the plant is ferro-scrap which is used to produce steel according to the planned programme would last for six or seven years, provided that good networks of collection (three collection places in Zaire exist so far), and processing plants be established; if arising scrap is considered, then nine to ten years. The plant can make steel using internally generated scrap as well as existing capital stocks of scrap. However, it depends upon the amount of steel produced each year: the more steel produced, the sooner will scrap be exhausted. Then Zaire will have to import scrap which is now around $140/ton, or build its own DR-plant which reduces iron ore in the solid state to metallic iron whose product is known as direct reduced iron (DRI) or commonly refered to as sponge iron.

What Zaire needs as raw material inputs in order to produce iron and steel products using the process DR - EAF - rolling mills, are iron ore, oil (or natural gas), coal (or charcoal) and electricity for the integrated mini-mills. Other minor raw materials are not considered here, not because they are unimportant but because their share in raw materials is small.

In order to more fully explore the potentials and limitations for the development of an integrated iron and steel mini-mill in Zaire, as well as the potentials of combining steel with other metals and non-metallic minerals, the availability of mineral and energy resources must be considered. For example, Venezuela is rich in natural resources. It has the fifth largest iron ore reserves in the world, mostly high grade ore. It has the thirteenth largest natural gas reserves in the world and has one of the largest hydro-electric dams in the world. All these resources are close to each other, and together they give Venezuela an economic advantage for production of DRI which is difficult or impossible to beat. Zaire has oil, natural gas, is rich in natural resources; it has, among other things, iron ore, coal and electricity, making Zaire's hydroelectric potential the largest in Africa. The river Zaire runs north through Shaba to Kisangani before turning in a wide arc to the Atlantic coast beyond Matadi and with its tributaries brings water, transport and potential power to all regions (Figure 8).

Figure 8. Mineral resources of Zaire



Source: Conjoncture Economique 1987

1.1 Iron ore

Common impurities found in iron are carbon, silicon, phosphorous and sulfur. Iron and carbon form an important series of alloys known as steel. Some impurities such as titanium and tungsten in iron ore make oxidizing extremely difficult which is the case in Africa. The presence of these impurities lowers the melting point of the usual commercial forms markedly. According to ECA's report1/ Zaire has substantial iron ore suitable for a DR plant which should be studied in detail. Since there appears to have been no substantive field work carried out in the past nor have there been any metallurgical tests, it is necessary to plan a number of appropriate laboratory trials.

Iron ore resources are widely distributed in Zaire. Iron ore is hematite with 45-65 per cent iron content, as well as magnetite. The estimated size of the deposit is over 5,150 million metric tons. It is believed that it could provide the raw material base for the DR plant. However, any decision as to exploitation of iron ore for the purpose of iron and steel production would be predicated on such considerations as: (a) economically extractable, (b) content of Fe ore, and (c) commercial scale of operation.

For the viability of the Maluku steel plant, it is important that careful consideration be given to the identification of more conveniently located deposits in order to reduce transport distance and costs. It must always be borne in mind that water transport is cheaper and particularly suitable for bulk goods and each and every shipment of bulk goods such as iron ore, involves not only handling costs but a loss of content too. Furthermore, the transport cost of iron ore from any mine site in Zaire to the Maluku steel plant, as well as the transport of pellets produced at the mine site, is likely to constitute a heavy burden for the project. Also, supply routes and transport system could prove inadequate or become increasingly unreliable when distances are considerable.

If iron ore at Luebo in the Kananga region has a good Fe content its utilization is advisable, to make pellets. Iron ore in the Kisangani region is rich in Fe and estimates of potential resources are put at 5,000 million metric tons with 45 to 65% Fe but there is no transport route between the mine and Kisangani although there is water transportation between Kinshasa and Kisangani. For example, Mount Mbomo iron ore reserves (hematite, Fe 61.5%, SIO_2 6.6%) and Mount Polukpulu (hematite, Fe 65.5%, SIO_2 2.7%) are located 250 km away from Kigangani and the distance from Kisangani to Kinshasa (via Zaire river) is 1,560 km. Table 29 indicates the regions of iron deposits, types of ore, Fe content and estimated reserves to date.

A major group of iron ore consists of primary or not-enriched and un-altered Lake Superior-type bedded formation. The iron content is usually about 30 per cent. The principal economic iron mineral is magnetite. The gangue minerals are mainly silica and silicates, including iron silicates. Another important group of Lake Superior type ores includes the highly metamorphosed ores. The principal iron mineral is specular haematite with minor magnetites.

1/ Iron ore reserves and production in Africa, ECA, 1980.

Table 30. Iron ore resources in Zaire
(millions of metric tons)

Region/district deposit	Nearest significant location	Type of ore	Principal mineral	Fe	Total resources
Kisanga, Kambove		Bilbao	Haematite	56	50
and Kanunka	Likasi (Ka-		Magnetite	-	-
	tanga region)	Lake Superior	Haematite	54	-
Kilomoto area	Kisangani	Lake Superior	Haematite	45-65	5,000
Luebo	Kananga	Lake Superior	Haematite	35	100

Note: - = not available
Source: ECA 1980 and UNIDO 1988.

Iron reserves which are located at Kisange-Kambove and Kanunka are estimated at 50 million metric tons with 56 per cent Fe but have the disadvantage of poor transport facilities because of poor maintenance and trafic congestion of freight from the industries around the copper belts (figure 9)

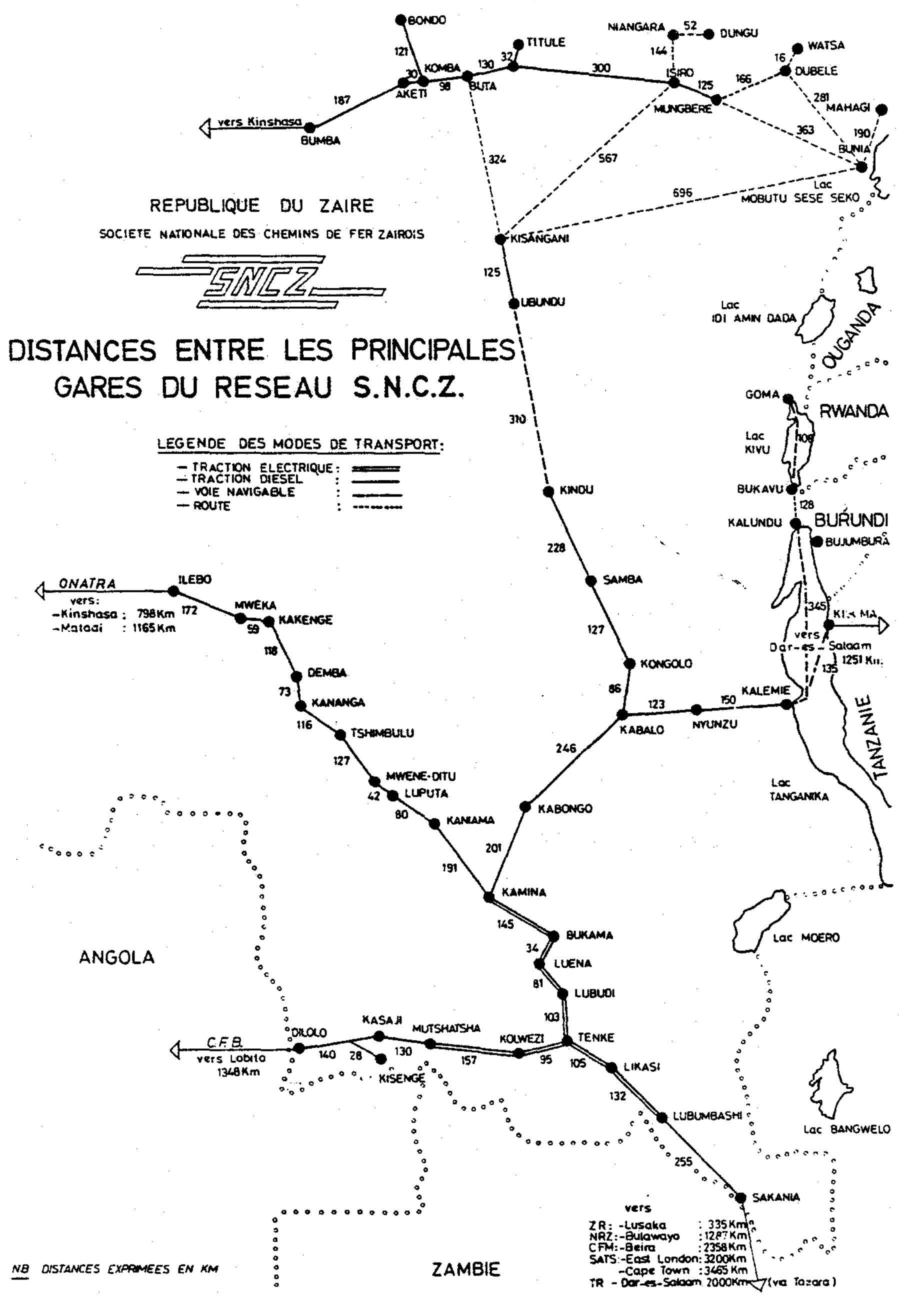
In the case of iron ore in the Katanga region, there are two kinds of iron ores, oxides, magnetite and haematite. The iron ore deposits of haematite and magnetite require different ore benefication/concentration technology and flow sheets. Magnetite iron ore is rarely found with any high degree of purity in nature, is strongly magnetic and contains 72.4 per cent iron and 27.6 per cent oxygen when pure, and will basically need wet magnetic separation treatment to reduce its silica content. Haematite iron ore is the most important of iron minerals and contains approximtely 70 per cent iron and 30 per cent oxygen when pure. However, it may need washing and gravity separation, and possibly heavy media separation to produce high grade concentrate. Therefore ore benefication/concentration of the iron ores in this region would require more money.

All these benefication/concentration/pelletization treatment of iron ore deposits in Zaire need to be fully investigated on the laboratory bench and pilot plant scale for suitability for directly reducing the materials to produce sponge iron. In India, a 3 million TPY pelletizing plant at Mangalore cost 1,030 million RS ($83.3 million) in 1986.

Table 31 shows the typical composition of some of the DR-grade oxide feed used in a DR plant[1/]. Higher iron contents are better for the production of sponge iron but it is to be noted that not all high grade ores are suitable for direct reduction. Many of the ores tend to decrepitate. Moreover, other considerations such as reducibility, and phosphorus content, are of significant importance in selecting the oxide feed for the DR processes mentioned above.

1/ Direct reduction of iron ores - The example of India, IO/18 (SPEC), UNIDO, August 1988.

Figure 9. Distances between the principal stations



Source: Conjoncture Economique 1987

Table 31. Composition of raw materials for DR processes
(percentage)

Source		Country	Fe	SIO_2	Al_2O_3	caO	MgO	D	p
Gas-based DR units									
FERTECO	Lump	Brazil	68.0	1.20	0.90	0.08	0.02	0.007	0.04
CVRD MED MgO	Pellets	Brazil	67.7	1.06	0.51	0.77	0.73	0.003	0.02
SIDOR	Pellets	Venezuela	66.7	1.30	0.80	1.60	0.60	0.011	0.05
Coal-based rotary kiln units									
POSTMASBURG	Lump	S.Africa	65.4	3.62	1.45	0.20	0.10	0.012	0.03
URUCUM	Lump	Brazil	69.4	0.58	-	0.03	-	-	-
BAYARAM	Lump	India	63.0	4.50	-	0.01	-	-	-
BANSPANI	Lump	India	67.2	1.78	0.93	Trace	Trace	0.005	0.027
ITABIRA	Pellets	Brazil	67.0	2.40	-	1.6	-	-	-

For use in electric furnace steel making, DRI should have a high degree of metallization. It should be dense and resist degradation. Furthermore, it should have a minimum amount of minus 3 mm (1/8 in.) fines and should contain a minimum of undesirable chemical elements. The steps for DR processes generally consist of drying, pre-heating, reduction, and cooling. The chemical and physical behaviour of the feed material affects the efficiency of the process.

1.2 Manganese, lime, tungsten, and tin

Zaire produces manganese, tin, lime, tungsten and other mineral and non-mineral products as shown in table 32. Reserves of manganese are placed at about 5 million tons but production has declined in the last decade to less than 50,000 tons of ore per year. The mine works are located near Kisenga and are operated by Société Minière de Kisenge, a wholly-owned government company. In 1984, 37,240 tons of manganese were produced but it decreased to 913 tons. In 1984 Gabon had a production capacity of 1,3 million tons and a reserve of 110 million short tons[1/]. In 1986 Gabon produced about 2.5 metric million tons and the present production capacity is estimated at somewhat more. Manganese is essential for the production of virtually all steels and is important for the production of cast iron. This is due to the functions it performs as a desulfurizing, deoxidizing, and/or alloying element, and from its chemical properties.

1/ Mineral Facts and Problems, 1985 edition. Bureau of Mines, U.S.A., 1986.

Table 32. Production of mineral commodities in Zaire
(metric tons unless otherwise specified)

Commodity	1980	1981	1982	1983	1984	1985	1986	1987	
Manganese ore and concentrate	6,321	18,214	16,319	1,803	30,776	37,240	913	-	
Tin: mine output, metal content	3,159	3,321	3,144	2,930	4,120	3,000	2,600	1,900	Reserve (1987): 20,000 t Capacity: 5,000 t
Smelter, primary	216	450	353	181	98	85	45	55	Capacity: 5,000 t
Lime	113,600	123,500	103,800	106,993	109,856	115,365	144,177	-	Capacity: 200,000 t
Tungsten	69	46	38	44	31	-	-	-	Capacity: 80 t

Note: - = not available
Source: Mineral Yearbook 1984, Tin Statistics 1976-1986, and Mining 1988.

Manganese deposits in Zaire are known to occur at Kasekelesa, Kisenga, Kiale, Kipupa and Buyofwe. Of these, only those at Kasekelesa and Kisenga have been exploited. EMKMN (Entreprise Minière de Kisenge Manganèse, Société d'etat), which hires 588 employees is the sole agent to produce manganese.

Lime is a manufactured product made by calcinating limestone or other high calcium materials at 2000°F. It is never found in a natural state. Lime is one of the raw materials for EAF steel making at Maluku. Zaire produces an average of 100,000 tons every year but some lime is imported. Lime is produced by CALCAIRE-CHAUX-CIMENT (CCC) of Likasi, Division of GECAMINES, in the Shaba region. During the first six months in 1987 it produced 65,500 tons. Its capacity utilization has been 50 per cent on average against its installed capacity (60,000 tons and 2 x 70,000 tons).

Tungsten materials can be divided into major classes depending on use: (a) a carbide in cutting and wear-resistant materials, and welding and hard-facing rods - accounting for an average of 65 per cent; (b) mill products made from essentially pure metal - 25 per cent; (c) an alloy constituent in high-speed tool and dye steels, super alloys, and non-ferrous metal alloys - 9 per cent; (d) other than metal product - one per cent. Tungsten mining is located in the Kivi region. Phosphate is located near Lukula.

Most tin is used as a protective coating or as an alloy with other metals. Tin is used in coatings for steel containers, in solders for joining pipes or electrical conductors, and in bearings and other alloys for widely diversified applications.

There were five producers for tin concentrate in 1984: Société Minière de Kivu (SOMINIKI), Société Zairetain (ZAIRETAIN), Société Minière de Goma (SMDG), Entreprise Minière du Zaire (EMZ), and Société Miniére de Kanis (SOMIKA). SOMINKI was the largest producer and increased its output by nearly 760 tons over that of 1983 owing to updating of one of its main open pit concentrators. Due to lack of financing for necessary plant and equipment, Zairetain, the only tin metal producer in Zaire, had a decline in output to less than 240 tons of cassiterite and 100 tons of metal. It has a capacity of 700,000 tons/year. Zaire exported tin and primary tin (3,300 tons/year on average)from 1976 to 1986.

1.3 Fuel minerals

The choice of fuels for the production of gaseous reductants for DR processes is comparatively broad. Natural gas is currently the most widely used for this purpose. It has the advantage of a low sulfur content and good transportability and can be converted relatively easily into hydrogen and carbon monoxide by catalytic reforming with steam. The composition of the gas upon extraction, which contains methane (25%), carbon dioxide (73.5%) and inert gases (1.5%), is enriched by washing with surface water to 72% methane, with a net calorific value of 4,500 kcal/m^3. In addition to natural gas, light hydrocarbons, such as butane or naphtha, can be catalytically reformed with steam to produce hydrogen and carbon monoxide. Reducing gas for direct reduction or for fuel can be generated by gasifying coal with oxygen in a separate gasifier, or by adding the coal to the iron oxide and feeding it to the reduction system. When coal is gasified externally, the carbon and hydrogen in the coal are the source of both the fuel and the reductant. Typical H/C atomic ratios for natural gas, butane, naphtha and fuel oil are 4.0, 2.4, 1.1 and 0.8 (partial oxidation of heavy hydrocarbons such as fuel oil to produce a synthesis gas is popular because oil is more available than either natural gas or naphtha).

The following four fuels can be used as a reducing agent in Zaire:

(a) Coal from the Luena or Lukuga coal fields in North ad South Shaba province;
(b) Bituminous shale reported upstream from Kisangani along the Zaire River;
(c) LpG from Zaire's Muanda oil refinery on the Atlantic coast;
(d) Methane gas from the Kivi Lake where an estimated 50 billion m^3 of methane gas is dissolved into its deep waters mainly at depths below 300 m.

However, gas reserve is small and the conditions for the development of a coal-based DR plant seem to be favourable although this should be preceded by detailed exploration and testing.

1.3.1 Coal

Coal is found in two major deposits in Eastern Zaire: Luena near Bukama (Shaba), and Lukuga, north-west of Kalemie (North Shaba). Total proven reserves have been estimated at 20 million tons for Luena and 700 million tons for Lukuga, but only a small fraction is commercially exploited at each site. Commercial reserves at Luena are found in three major mines: Kisulu, exploited from 1950 to 1962 for a total production of 1.2 million tons; Luena-Sud, producing 3.7 million tons between 1922 and 1961; and Kuluku, in production since 1962. Reserves at Lukuga are concentrated in three deep seams of the Makala mine yielding approximately 50 million tons of commercial coal. All deposits of Zairian coal are of average to low quality, with a high ash content and relatively low average calorific value. Production and consumption of coal from the Luena and Lukaga reserves is summarized in table 33. There are two corporations which produce coals. They are Charbonnage de Luena and Charbonnage du Tanganyika (capital 5 million Z) which employ 148 workers.

Table 33. Coal production and consumption
(thousands of metric tons)

		1973	1977	1980	1981	1982	1983	1984	1985	1986
Total production		112.3	128.0	137.3	129.4	123.7	110.4	121.2	104.3	119.2
Lukuga		14.7	14.7	12.9	12.4	11.0	11.0	16.8	16.3	23.1
Luena		97.6	80.8	124.4	117.0	112.7	99.4	104.3	104.2	96.1
Imports:	Coke	-	-	-	-	-	-	94.4	57.3	12.8
	Coal	-	-	-	115.0	138.0	130.0	62.3	50.9	61.8
Consumed by:										
GECAMINES		53.4	82.8	89.2	86.9	79.2	71.5	75.5		
KIMSHABA and SNCZ		40.2	27.2	30.2	22.6	22.0	22.5	25.3	228.9	254.0
Other		2.9	4.1	2.7	6.1	8.5	5.1	3.5		

Source: GECAMINES and Conjonture Economique, 1987.

GECAMINES consumes two-thirds of production and CIMSHABA and SNCZ consume almost one third. The Kaluku mine of Luena is mined by GECAMINES for its own energy needs and for those of SNCZ in Haut Shaba and the CIMSHABA cement plants at Lubudi and Kakontwe. The coal from the Luena deposit is not suitable for coking and many metallurgical operations. GECAMINES also imports approximately 55,000 tons of coal and 80,000 of coke each year mainly from Zimbabwe[1/].

1/ Conjoncture Economique, 1987.

Table 34 shows the typical characteristics of coals used in rotary kiln plants[1].

Table 34. Characteristics of coals used in rotary kiln plants

Plant	Sponge Iron India (India)	Orissa Sponge Iron (India)	ISCOR (South Africa)	Acos Finos Piratini SA Brazil
Coal source	Singareni	Gidi	Wit Bank	Charqueadas
PR process	SL/RN	Accar	SL/RN	SL/RN
A. Chemical analysis				
Fixed carbon, (%)	44	45-49	59	36
Volatile matter, (%)	22	28-30	26	23
Ash, (%)	24	20-27	14	32
Moisture (%)	10	8	8	9
Sulphur (%)	0.4	upto 1.06	0.6	0.4
B. Net heating value				
Calorific value, Kcal/kg	6,000	5,100	6,450	4.600
C. Other properties				
Ash softening point, c°	1,160	above 1,200	N.A.	above 1,250
Reactivity	Moderate	N.A.	N.A.	High

Coal as a reducing agent should have a high ash-fusion temperature and contain no more than about one per cent sulfur. According to studies conducted in various pilot plants, the coals which meet solid reductant requirements for operating rotary kilns are either sub-bituminous or low-volatile bituminous. Bituminous coals are not satisfactory for direct reduction kiln. Coals have to have ash-softening temperatures greater than 1150°C (2100°F) and should contain no more than about one per cent sulfur.

Principal burden materials for the SL/RN process are indurated iron oxide pellets. However, lump ores can also be used. Iron sands are used commercially in the plant in New Zealand, but this required special design modifictions to the equipment to provide efficient operation. It is important for the coal to have a high reactivity, a low free-swelling index, a high ash-fusion temperature, and to be non-coking. A low ash-fusion temperature is undesirable because it promotes the formation of accretions. The composition of the ash is also important because if it is too siliceous, it might react with ferrous oxide to form the low-melting compound, ferrous silicate, and this would interfere with the reduction to metallic iron[2].

1.3.2 Charcoal and operating cost of charcoal-based DRI plant

The use of wood charcoal as a reducing agent is considered. At present 25 per cent of fuel wood is consumed in Zaire in the form of charcoal. Both charcoal and firewood are consumed in urban areas but rural areas consumption is limited to firewood. Zaire is the most heavily forested country in Africa. Its forest cover extends over 122 million hectares, with a theoretical energy potential of 8.7 billion t.o.e. The actual energy yield of the forests is not known, but it should be 2 to 3 per cent of this figure as

1/ Direct reduction of iron ores - The example of India, UNIDO, IO.18 (SPEC.) august 1988.

2/ SEAISI Quarterly, July 1987, vol. 16-3, pp. 13-40.

much of the forest cover is not physically accessible or economically exploitable. However, the use of charcoal as a reducing agent requires a detailed reforestation programme and a continued control to avoid environmental damage. According to an ECA estimate, charcoal consumption would be of the order of 1/3 iron ore, (500,000 tons/year for 250,000 to 300,000 tons of liquid steel/year), i.e. some 168,000 tons of charcoal/year[1/].

The production cost of charcoal at the Bateke Plateau which is located 150 km from Kinshasa, was estimated in May 1984. Total investment costs for the Bateke plantation project was estimated at 1.4 billion Z ($35 million) in constant 1984 value. The average cost of reforestation is about 10,000 ($250) per hectare. Taking into account these figures, it was estimated that the cost of charcoal delivered to Kinshasa is 8,981 Z ($224.56).

	Cost/ton (Z)	
Cost of dry wood prepared for carbonization	689	
Ex-kiln cost of charcoal (48,000 tons/year)	2,621	(90 workers)
Transportation costs	1,550	
Total cost delivered in bulk to Kinshasa	4,120	
	8,981	

The transportation costs make up more than half the total cost. However, these estimates will need to be updated subsequent to review of project components and design.

Brazil is the country which produces pig iron using charcoal blast furnace. In 1985 charcoal blast furnaces contributed to 35 per cent of the country's total pig iron tonnage (6.8 million metric tons per year). It is worth mentioning for future reference that iron produced from a charcoal blast furnace is known to be of higher grade than that of coke blast furnace because of its lower sulfur content. This is particularly true in Brazil, where low phosphorous iron ore produces an iron which is low in both sulfur and phosphorous. The charcoal blast furnace has some basic differences compared to the coke blast furnace, due to the character of charcoal when compared to normal coke[2/].

1/ Analysis of the previous studies and proposals opn the iron and related ores and energy required for developing the iron and steel industry in Zaire, Addis Ababa, ECA, 1984.

2/ KTS Korf Technologica Siderurgica Ltda, 1985/1986.

Typical parameters for two furnaces of different sizes[1]:

	Furnace 1	Furnace 2
Nominal capacity	180	a/ 400
Yearly production (liquid)	63,000	140,000
Operating days per year	350	350
Length of campaign	3 to 4	4 to 5
Re-lining time (tap to tap)	20	20

a/ Real production is as high as 460 tons/day with a 515 tons/day record.

The cost of reforestation is presented in table 35, being mainly a function of the quality of soil and of the interest rate, apart from the planting techniques, fertilizers, etc. $2/st may be taken as an average price for standing wood. Since specific consumption of eucalyptus wood is 2 st/m^3 of charcoal, the resulting cost of wood is $4/$m^3$ of charcoal.

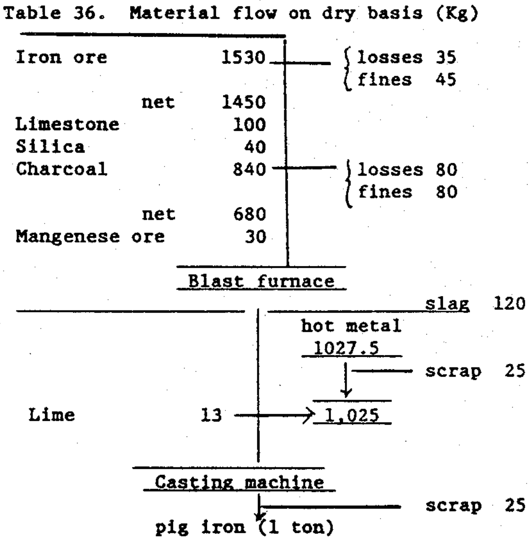
Table 35. Cost of reforestation of standing wood ($/st)[2]

		Three-cut cycle (22 years)		One-cut cycle (8 years)	
		Weak soil	Ave. soil	Weak soil	Ave. soil
Total production	st/ha	260	520	100	200
Increment	st/ha y	11.8	23.6	12.5	25.0
Interest	0	1.92	0.96	4.00	2.00
Rate	6	3.66	1.83	5.92	2.96
Pct/year	10	6.06	3.03	7.60	3.80

Charcoal is a meterogenous material for which there are no standard specifications. Its quality and characteristics depends on the kind of wood employed and on the carbonization process parameters, specially with regard to temperature and time. Since charcoal is much more reactive than coke, the reaction $C + CO_2$ -- 2CO begins around 750-800°C in the charcoal blast furnace, as against 900-950°C in the case of coke.

The material flow chart shows a representative example of material balance for a charcoal blast furnace. The balance is based on Brazilian raw materials of the usual characteristics, specially the iron ore with about 65 per cent FE, of 1/4 to 3/4 inches diameter.

Table 36. Material flow on dry basis (Kg)



1/ Metalurgia International, Vol. 1, October 1987.
2/ Metallurgia International, Vol. 2, No. 1, October 1987.

Under usual Brazilian conditions, the production cost of basic charcoal pig iron may be illustrated as shown on table 36. If depreciation is added at a rate of 10 per cent on fixed investment, total cost comes to about $90/ton of pig iron.

Table 37. Production cost for basic hot metal
(dollars per ton)

Raw materials			
Charcoal		56.00	
Iron ore		15.32	
Lime dolmite		0.80	
Silica		0.24	
Manganese ore		0.45	
	Total		72.81
Labour			5.00
Miscellaneous			
Electric energy		2.50	
Others (water)		1.10	
	Total		3.60
Services under contract and or materials for maintenance, internal transport, etc.			4.00
Provision for new lining			0.50
	TOTAL		85.91

In the case of a plant producing 63,000 tons/year given as an example, the following labour would be required for continuous four-shift operation:

Charcoal unloading	14
Raw materials handling and charging	16
Tapping and casting	22
Maintenance and utilities, lab.	15
Miscellaneous	8
Administration and supervision	10
Total staff	85

With the above crew, total labour amounts to about 3.3 working hours per ton of pig iron, at a cost of about $5.00 per ton under Brazilian conditions. Productivity is in the range of 730 tons per working year. At present the f.o.b. price for basic pig iron is about $105 tons, whereas foundry pig iron costs $6 to $10 more. Domestic price corresponds to the f.o.b. price plus taxes1/.

1/ Metallurgia International, Vol.1, No.1, October 1987.

1.3.3 Petroleum oil and gas

Zaire has useful deposits of crude oil with production at 318,000 barrels/day in 1987, although it is unlikely to become a major oil producer like neighbouring Angola and Congo. Zaire has three sedimentary areas of very different size and potential, separated by basement uplifts. From east to west, they are the coastal basin, where all of Zaire's production originates, the central basin (cuvette centrale), which has been barely explored, and the Taganyika Graben, which has shown some hydrocarbon. Estimated proved oil reserves are 112 million barrels (gas: 30,000 million cu ft). There are 104 wells producing 31,800 barrels/day; refining capacity 17,000 barrels per day[1/].

Table 38. Crude oil production and capacity
(millions of tons)

	1979	1980	1981	1982	1983	1984	1985	1986	1987
Production	1.0	1.0	1.0	1.1	1.3	1.3	1.5	1.6	1.6
Refining capacity	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Source: International Petroleum Encyclopedia, 1988.

Zaire first began offshore oil production in the coastal basin in 1975 and in other areas in 1979. Production in all fields involves injection of associated and non-associated gas. The bulk of gas production consists of associated gas. At present, most of the associated and non-associated gas is injected into the oil fields to sustain oil production, and the rest is flared. The average gas/oil ratio is 200-300 cu ft/barrel on offshore fields, and a much more variable 125-45,000 cu ft/barrel on offshore fields.

The only gas field was discovered in Motoba in the offshore concession but its extension and reserves are not well known yet. Eight gas wells were drilled, but only one was successful. However, the high costs and the great difficulties involved in developing them are well known. It thus seems prudent to discount their significance until it can be shown that the technological and environmental problems associated with their exploitation on a large scale are capable of being solved. Refining capacity is small, so that most domestic petroleum needs are at present being met by imports. Oil refining is done by The Société Zaire-Italienne de Raffinage (SOZIR) which employs 657 workers and has a capacity of 750,000 tons per year.

The share of oil in energy consumption in 1986 was 60 per cent. This shows and increasing tendency from 1985 with 59 per cent and 1984 with 54 per cent. Table 39 shows the breakdown of energy consumption in 1986 and 1985.

1/ International Petroleum Encyclopedia, 1988.

Table 39. Energy consumption
(tons of oil equivalent)

Products	1986	%	1985	%
Petrol	115,069	13.9	101,323	13.9
Crude oil	47,052	5.7	44,328	6.1
Fuel oil	54,374	6.6	54,989	7.5
Gas oil	414,813	50.3	399,608	54.7
Jet fuel	183,944	22.3	121,199	16.6
Aviation gas	4,392	0.5	6,142	0.8
Cleaning oil	5,196	0.7	2,704	0.4
Total	824,840	60	730,393	59
Coal	89,666	7	72,196	6
Electricity	457,573	33	436,799	35
Total	1,372,079	13.4	1,289,388	13.0
Wood	8,838,000	86.6	8,581,000	87.0
TOTAL	10,210,079		9,870,388	

Source: Conjoncture Economique, 1987.

Imports of crude oil and refinery products are given in Table 39 which shows that while imports of crude oil for refinery have been decreasing, those of refinery products have been increasing. More development of downstream industries is encouraged.

Table 40. Imports of crude oil and refinery products
(tons)

	Import	Local	Total	Refinery products
1979	383,450	75,557	459,007	400,549
1980	366,055	62,149	428,204	444,913
1981	285,348	20,058	305,406	493,722
1982	89,686	-	89,686	596,232
1983	43,518	-	43,518	693,068
1984	182,636	-	182,636	483,983
1985	324	-	324	702,361
1986	90,279	-	90,279	641,533

Source: Conjoncture Economique 1987.

The prices of imported petroleum products range from 20 Z to 30 Z/litre in March 1987. The following prices are given below:

	West way	East way	South way
Crude oil (litres)	33.5	45	
Gas oil (litres)	38.5	45	45
Fuel oil (litres)	20	-	
Gas (tons)	123,950		

Note: West way = Kinshasa
East way = Ango Ango
South way = Lubumbashi-Likasi

The gasoline price per litre in Kinshasa on 22 September 1988 was 57 Z. Transportation cost ranged from 0 in Kinshasa to 16.07 Z/litre in Kalundu. Transport differentials (Z) are given below as taken from Conjuncture Economique, 1987.

	Crude oil	Petrol	Gas oil
Ilebo	4.14	4.43	3.62
Kisangani	5.16	5.51	4.51
Lubumbashi	12.99	13.64	12.39
Kalundu	15.66	16.07	15.42

1.4 Energy sector

1.4.1 Electricity

Zaire has an abundance of ingeneous energy resources, mostly in the form of hydraulic (installed capacity 2,497.4 MW) and woody biomass potential (8,346.6 million t.o.e.) with moderate petroleum reserves (recoverable proven reserves, 101 million barrels); exploitation of some marginal resources such as coal (proven reserves 720 million tons), methane gas (estimated 50 billion m^3) and solar and geothermal energy (estimated at 4.7 $kWh/m^2/day$)1/.

However, Zaire's major energy resources are hydropower and forest. Hydropower is the source of 98 per cent of its electricity. The total hydro potential of Zaire is estimated at 740,000 GWh, roughly half of Africa's hydro potential. Although 1.5 per cent of the potential is developed (11,000 GWh), Zaire is faced with a large surplus of installed capacity (total generation was only 5,160 GWh in 1986) and underutilization of the facility, a significant part of which is located near Inga on the lower Zaire River. About 95 per cent of it is operated by the Société Nationale d'electricité (SNEL) and the rest by auto producers. About 96 per cent of installed capacity is hydroelectric; the rest is higher cost thermal power, found mainly in isolated areas so far by-passed by the development of hydroelectric resources. SNEL is now reviewing and updating studies of small rivers and this is expected to lead to the identification of suitable sites for constructing mini- and micro-hydroelectric plants.

Table 41. Installed capacity by ownership and technology in 1987.

Production technology	SNEL	Auto producers	Installed capacity
Hydro	2,402 MW (93%)	80 MW (3%)	2,482 MW (96%)
Thermal	60 MW (2%)	55 MW (2%)	115 MW (4%)
Total	2,462 MW (95%)	135 MW (5%)	2,597 MW (100%)

Source: The World Bank, 1987.

1/ Mineral Resources in Africa, 1986.

The distribution of installed capacity shows its concentration in the Bas Zaire and Kinshasa area (72 per cent) where the Inga I and Inga II power plants are located and from where the Maluku steel plant receives its electric power. Twenty one per cent of installed capacity is distributed in the Shaba Province.

At present, installed capacity in the power subsector is significantly underutilized. Annual consumption of electricity in Zaire stands at about 5,000 GWh which is less than half the productive potential of the country's installed capacity. Some 70 per cent of power is sold to high-voltage consumers, particularly GECAMINES, and the rest is more or less equally divided between medium- and low-voltage consumers. Access to electricity is limited to 3.5 per cent of the population. About 75 per cent of electricity is consumed in the Shaba Province where GECAMINES is located, and another 22 per cent in Bas Zaire and Kinshasa where most industries and residential connections are located. Power consumption in Zaire has grown only 1.8 per cent per year since 1974, but is growing faster since 1983 at 4.8 per cent.

Mineral and metal industries consumed 2,816 mkWh in 1986 which amounts to 54 per cent of the total electric supply. Maluku steel consumed 25 GWh in 1978, 8 GWh in 1983, 12 GWh in 1984, 8 GWh in 1985 and 7 GWh in 1986.

The Inga II hydroelectric plant is currently utilized at only about 30 per cent of capacity (1,424 MW); its operation is hampered by design characteristics, poor technical support and lack of funds for maintenance. As a result, it was not possible to synchronize the Inga I, Inga II and Inga-Shaba line. Thus Kinshasa is fed only by Inga I while Inga II feeds the Shaba Province via the Inga-Shaba line. Because of this pattern of load distribution between Inga I and II, and the design characteristics, the turbines at Inga II are running under conditions of severe cavitation and accelerated deterioration. However, the Inga II hydroelectric plant is the most important facility of its kind in Zaire and one of the largest in Africa, with eight generating sets of 278 MW each.

Zaire exports its electricity to Congo from Inga II and to Zimbabwe from the Inga-Shaba line. However, power loss is greater than the export amount although the situation is slowly improving. Table 41 shows the electricity supply and demand balance from 1982 to 1986.

Table 42. Electricity supply balance
(millions of kWh)

	1982	1983	1984	1985	1986
Supply					
1. Shaba stations	2,761	2,765	2,121	1,913	1,668
Mwa Dingusha	-	405	310	268	192
N'Seke	1,567	1,564	1,209	1,093	977
Koni	-	194	150	131	136
2. Kilubi (Kamina)	7	11	11	11	9
3. Eastern stations (Kaléme, Bukavu and Kisangani)	189	183	197	229	233
4. Bas Zaire stations	1,455	1,514	2,259	2,747	3,250
Sanga	2	2	2	2	2
Inga I	578	386	409	387	641
Inga II	777	1,063	1,888	2,307	2,488
Zongo	-	63	60	51	119
Imports	11	6	7	7	3
Total	4,423	4,479	4,695	4,907	5,163
Consumption					
Mineral & metal industries	2,619	2,656	2,690	2,767	2,816
Town of Kinshasa	676	702	976	1,201	1,236
Non-industrial south Shaba	205	212	231	257	259
Eastern towns (Kisangani Bukavu, Malemie)	166	150	187	196	204
Western towns & commercial consumers(CINAT, CIZA, Rail Kin-Matabi, Boma, Matabi, Maluku)	151	187	160	165	170
Losses & other	498	531	316	167	291
Exports	108	91	135	154	187
Total	4,423	4,479	4,695	4,907	5,163

Note: - = not available
Source: Conjoncture Economique, 1987.

1.4.2 Electricity consumption in a mini-steel mill

This section reviews the energy requirements in the mini-steel plant on specification. Maluku steel requires 649.83 kWh/ton; actually, it consumes a little more, around 693.64 kWh/ton, higher than the standard rate. In the Federal Republic of Germany the rate of electric (65 tons) energy consumption is 600 kWh, and at Metas in Turkey (2 x 45 tons) it was 774 kWh before new technologies were introduced, such as water cooling panels, jet burner system, ladle furnace, etc.[1/]. After various technological measures, electricity consumption became 470 kWh at a plant in the Fed. Rep. of Germany and 510 kWh at Metas.

1/ Seminar on the requirements of steel industries in ECE countries developing from the economic point of view, ECE, May 1986.

Usually EAF consumes 65 per cent of electricity; reheating 18 per cent equivalent to 1,544 GJ.ton; rolling 12.5 per cent. Table 43 shows electricity consumption within 100,000 tons/year mini-mill and fuel consumption and their standard ranges. In this case, EAF consumes 78 per cent, rolling mill 15 per cent, reheating furnace 2 per cent equivalent to 1.5 GJ/ton, continuous casting 1 per cent, and scrap 1 per cent.

Table 43. Energy consumption within a hypothetical 100,000 ton/year mini-mill

Operation	Electricity kWh/ton[a/]	Range	Fuel GJ/t	Range	Total equivalent primary energy GJ/ton	%
Scrap preparation	7	3-10			0.072	1
EAF steel-making	540	330-700			5.6	65
Liquid metal crane	4	2-6			0.041	0.5
Continuous casting	8	4-9			0.082	1
Reheating furnace	14	10-20	1.4	1.2-2.5	1.544	18
Rolling mill	105	80-120			1.080	12.5
Other	15	8-30			0.154	2
Total	693	437-895	1.4	1.2-2.5	8.573	100

a/ For conversion to equivalent primary energy (GJ/ton) it is based on the generating efficiency of 35 per cent.

Source: Steel Times International March 1987.

In general, four main energy-consuming units in this model mini-steel mill can be identified:

(a) preparation and melting raw materials;
(b) casting, 120 x 120 m billets;
(c) reheating and rolling;
(d) ancillary service

Raw material preparation of a charge for EAF may include any, or all of the following operations:

(a) scrap bundling or shredding;
(b) scrap preheating;
(c) scrap handling.

Energy is consumed in all these operations and typical figures based on a 100,000 tons/year mini-steels, may be listed as follows:

30-35 tons/h bundling press	approx. 6 kWh/ton
16 tons/h scrap shredding	approx. 12 kWh/ton
Scrap preheating plant (to 400°C)	approx. 84 kWh/ton
Typical scrap handling (cranes,etc) at 85 per cent utilization	approx. 7 kWh/ton

Melting and refining of raw materials in EAF is the most energy-intensive operation and consumes about 3/4 of all electric energy required for a mini-steel mill. The power consumed in scrap melting in EAF is known to vary widely depending upon a number of factors which are not detailed here.

Consequently, the electric power consumption to melt 100 per cent scrap can vary between 450 and 600 kWh/ton of steel tapped. With modern practices described later, it is possible to achieve electric consumption levels at 330 kWh/ton, with oxygen usage at 51 Mm^3/ton, and kerosene usage at 8.5 l/ton. For ultra high powered (UHP) operation at 800-1000 kVA/ton level, the steel-making time (tap-to-tap) is only 55 minutes[1/], which shows the productivity of steel production.

The extent of energy requirement for continuous casting is much less, as the whole operation of casting is to remove quickly sensible heat and latent heat of socidification by intensive water cooling through both mould and spray systems. This consumes relatively small additional energy for metal handling, billet costing and for cooling table. A typical 100,000 tons/year caster will consume just 8 kWh/ton for producing 120 x 120 mm billets[2/].

Reheating and rolling of billets are the second major usage of energy, accounting for about 30 per cent of total energy consumed in a mini-mill. Reheating furnace has normally an output of 30-100 tons/h which requires fuel (gas or oil) varying between 1.2 to 2.5 GJ/ton, depending on the type of reheating furnace. Maluku steel plant has a pusher-type reheating furnace (35 tons/h). Electrical energy required for furnace operation is small, around 10-20 kWh/ton.

With regard to the rolling, the mill motors represent a major utilization of electrical energy. The power requirement of these motors are related to the mill layout, output and the size of feedstock to the mill. In addition to the mill proper, energy will also be consumed by other machineries, e.g. cranes, shears, roller tables, coiler, etc.. An approximate requirement for the whole mill for an output of about 120,000 tons/year would be around 100-110 kWh/ton[3/].

Although the average requirement for a ton of steel is about 8.6 GJ, individual mini-steel mills vary from as low as 5.7 to as high as 11.2 GJ/ton, indicating that some steel mills should be able to move towards a higher energy efficiency. Also, it must be remembered that saving of energy in the form of electricity will result in the saving of over three times as much energy in the form of primary fuel burnt at the power station. This refers to the conventional power stations for which 35 per cent is a typical thermal efficiency after allowing for both generator and transmission losses.

1/ SEAISI, Vol. 12-1, Jan. 1983.

2/ Iron and Steel Making, No. 4, 1975.

3/ Seminar on the requirements of steel industries in ECE countries developing from the economic point of view, ECE, May 1986.

2. Steel-making in electric arc furnaces (EAF) using ferrous scrap

2.1 Raw materials

The quality of feedstock for the EAF has a significant effect on the energy requirement, therefore the expenditures for the purchase and preparation of raw materials and for the energy to process them should be closely monitored and analysed. Of prime importance to this steel-making process is, of course, the intrinsic value of scrap as an energy source since it effectively contains at least 12,000 MJ/ton (3,333 kWh/ton): that is the difference between the amount of primary energy required to produce crude steel from raw ore and from scrap.

The price of scrap varies widely according to local and international conditions and quality. Consequently, there can never be a unique relationship between expenditure for the purchase and preparation of scrap, and process energy. It is a fundamental fact that better quality scrap will give improved yield and consequently reduce specific energy consumption. To give some indication of the potential improvement by this means, the yield from unprocessed light scrap can be as low as 80 per cent compared with yields of 92 per cent from heavy structural or fragmented scrap. This not only represents a direct saving of about 15 per cent on the specific cost of energy, but the potential revenue from increase production is also improved.

Upgrading of purchased scrap is widely practiced and usually involves improving the cleanliness and increasing the density of the material to be charged. Unfortunately, information on this upgrading of purchased scrap was not given to the expert team on mission in Zaire. Cleanliness is significant because the direct effect of, say, a percentage point rise in the amount of non-metallic material, moisture, or iron oxide present in the charge, can increase energy consumption by as much as 15 kWh/ton. Similarly, low scrap density increases the number of baskets to be charged, thereby extending the tap-to-tap time, which increases the standing energy losses and also the losses incurred when the furnace roof is removed for charging. Typically, each additional basket increases the power consumption by 5-10 kWh/ton[1/].

Table 44 indicates the breakdown of EAF steel-making costs. In production costs, scrap and electricity are the largest costs. This is the same for the melting operating costs. This table shows the typical influence that raw material characteristics can have on energy consumption. Scrap represents half of the raw material.

Table 44. Cost breakdown for EAF steel-making[2/]
(percentage)

Production costs		Melting operating costs	
Scrap	45.8	Scrap	53
Electricity	15.8	Energy incl. electrodes	20
Electrodes	6.5	Refractories	5
Refractories	5.3	Labour	10
Labour	9.9	Other	12
Other energy	2.9		
Other materials	10.0		
Other costs	3.9		

1/ The Electric Arc Furnace, IISI, 1983.

2/ Iron and Steel Engineer, January 1986, and ILAFA Energy Congress, Brazil 1981.

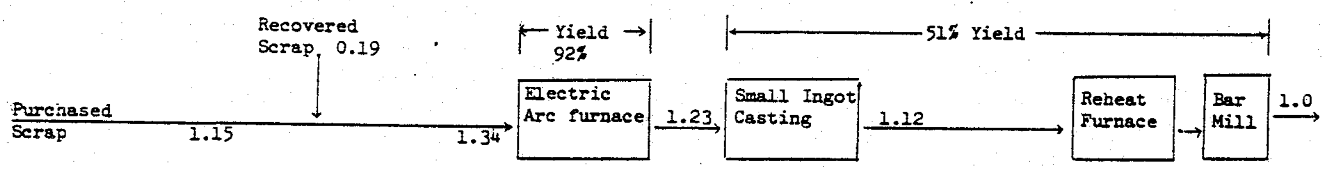
While scrap preparation undoubtedly maximizes the availability of high quality scrap, the amount of low quality, high regional scrap that can be used remains limited for many grades of steel. Poor scrap can be frequently utilized by diluting the residuals by adding virgin iron units to the charge. The addition of granulated iron and direct reduced iron is common and in many situations these materials are continuously fed, with consequent energy benefits due to savings in melting time and losses associated with removal of the roof. In addition, reduction is refining time is achieved.

Perhaps at this point it is interesting to note the theoretical energy efficiency of shipbreaking as a source of material. It was learned at Maluku that there are some shipbuilding yards along the Zaire River which are ready to provide scrap to the Maluku steel mills (one shipbuilding yard was seen at Kinshasa). In shipbreaking operations, some plate can be sold as finished/semi-finished products, thus minimizing the input of energy; furthermore the scrap generated from such sources is usually of good quality which results in less energy consumption at the EAF stage of reprocessing. Lastly, the ship carrying the imported scrap (vessel and cargo) only consumes fuel for a one way trip.

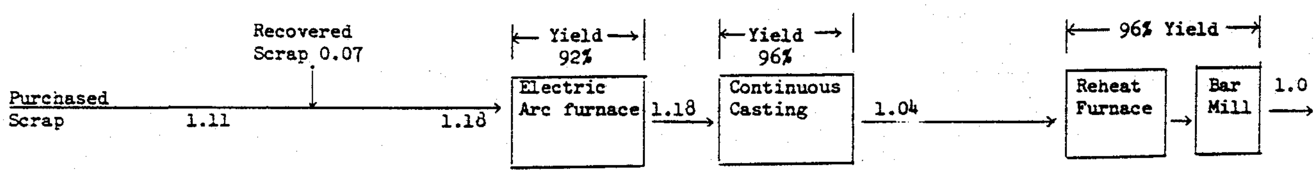
Figure 10 shows typical configurations for production of bar from scrap and indicates how much scrap is needed to produce one ton of bar products[1/].

Figure 10. Typical configurations: production of bar from scrap

1. Small ingot route



2. Continuous casting route



1/ SEAISI, 1985.

The first is an ingot route with ingot casting, reheating furnace and bar mill, the small ingots being charged directly to the reheating furnace. The second has the continuous casting machine followed by the reheating furnace and the bar mill (like in the Maluku steel mill). The continuous casting route consumes less scrap - but generates less crap internally - and produces more steel products. There is the essential difference in energy consumption which different rates of yields indicate.

These simple comparisons illustrate two important points concerning energy saving utilizing continuous casting. First, the savings extend beyond the immediate casting area and second, the savings which can be achieved by converting from small ingot casting may be significantly less than often assumed. This latter method is a practice widely used in developing countries, especially in the South East Asian region. The Maluku steel mill should make good use of its continuous casting by improving scrap handling which seemed to be badly managed during the visit of the team.

2.2 Availability of ferrous scrap in Zaire for iron and steel making

One of the biggest problems facing the existing and future small-scale iron and steel industries such as mini-steel mills (EAF - rolling mills) and foundries in the steel production process, is the scrap problem: its availability, generation, collection and preparation. This is not only in Zaire. Some studies show that if not in the near future, then within the next 6 to 11 years a considerable shortage of steel scrap will arise in Zaire. At this moment, the Maluku steel mill has 20,000 tons of scrap in its yard. There were 10,000 tons of ferrous scrap along the highway to Maluku. It was learned that there were three main scrap collection places in Zaire but they are not systematically operated. According to the study conducted in 1986, about 308,000 tons of ferrous scrap is available in all Zaire. 208,000 tons out of 308,000 are located in Kinshasa, Bas Zaire, Bandundu, Shaba and Equateur. Scrap generation from metal-working industries and other scrapped metals is estimated as 100,000 tons between 1988 and 1994 (10,000 tons in 1988, 10,000 in 1989, 15,000 in 1990, 15,000 in 1991, 15,000 in 1992, 15,000 in 1993 and 20,000 tons in 1994). Reprocessing scrap also makes an important contribution to a country's steel requirements, since scraps are inputs for the metal industry to produce agricultural machinery, capital goods and spare parts for all other metal-working industries.

According to the study conducted in 1986[2/] the total availability of usable metal scrap was as follows:

Kinshasa	61,000 tons
Bas Zaire	75,000
Bandundu	21,000
Equateur	16,000
Shaba	35,000
	298,000 tons

1/ SOSIDER, Rapport Technique, Installation d'un systeme de ramassage et conditionnement de ferraille, UNIDO 1986.
2/ ibid.

There is no indication if these figures show actual collectable quantity or effective scrap availability based on scrap collection efficiency factor. Substantial capital scrap has been accumulated. This means that five regions of the country possess considerable reserves of metal scrap. Accumulated scrap in Zaire is larger than that of Angola (206,793 tons) and of Zambia (79,000 tons)3/. However, since there is no suitable national structure in Zaire for the collection, processing and supply of material/metal scrap, the Maluku steel mill will face a scrap shortage in a few years, not because scrap does not exist, but because of the inability to collect it.

After a techno-economic feasibility study the Angolan government decided to establish a pilot plant scrap enterprise, the SUCANORE center in Luanda, which includes the establishment of two basic regional enterprises for scrap collection and processing, SUCANOR (Luanda) and SUCASUL (Lobito), as well as a detailed programme for the establishment of a national network of small enterprises (scrap centers) throughout the country. These centres are of three basic types of magnitude and account for geographical and infrastructural factors of allocation, generation, and consumption requirements of metal scrap1/.

The government of Zaire is urged to consider the scrap situation as soon as possible and prepare a bankable study for a rational system for collection, processing and utilization of steel scrap in the country. Such studies have been made by individual experts in the past but these are out of date and insufficient in coverage and detail.

2.2.1 Situation and prices of world ferrous scrap

The strongest demand for scrap still comes from iron and steel works, although demand by steel foundries and iron foundries constitutes an appreciable proportion of total demand in certain countries, and may reach 25 per cent of the demand in some countries (Fed. Rep. of Germany, Japan, and USA). Zaire has considerable foundry facilities which require semi-iron and steel products and scrap. Purchase requirements are dependent upon the production level and on the type of process, because specific consumption differs greatly from process to process:

	kg/ton
Oxygen	180-280
Integrated open hearth	400-600
Electric and isolated open hearth	1,000-1,100

Electric arc furnace and open hearth furnace consume far more than BOF steel shops. EAF consumes almost twice as much scrap as open hearth furnace. In Europe and in the USA as well as in Japan, there is more than enough ferrous scrap for the next ten years. However, the possibility of scrap supplies becoming tight within the next ten years exists, chiefly due to steel makers' increased demands for high quality scrap 2/. The situation in developing countries is completely different because their small industrial base generates little ferrous scrap and thus they soon run out of the little capital scrap available.

1/ Fujio J. Tanaka, UNIDO, Metallurgical Industries in Angola, August 1988.

2/ BIR Congress, Amsterdam, 1988.

3/ Fujio J. Tanaka, Metallurgical Industries in Zambia, UNIDO, May 1988.

According to IISI statistics, there was a decreasing tendency in scrap consumption between 1977 and 1986 in the industrialized world as a whole. Except for the planned economy countries, developing countries have been importing at an increasing rate since 1977[1/], (and have been exporting scrap at a rate of one tenth of total import). The following table illustrates scrap available in thousands of tons:

	1977	1980	1983	1984	1985	1986
EEC total	73,459	73,012	65,060	68,282	66,450	62,298
USA	62,869	60,380	44,449	46,980	48,264	44,846
Japan	34,606	43,809	40,160	43,485	44,166	40,260
Total world	264,950	276,758	246,524	258,005	255,721	248,043

While the scrap market drifted up and down a generally flat line since 1977, because of economic downturns which tend to reflect on the quality of scrap available, the market was bad till the middle of 1987 when demand for ferrous scrap began to increase. Dollar scrap prices rose by over 30 per cent between July 1987 and July 1988, making imported scrap a more costly alternative for import-prone countries such as India. During 1981-1982 a total of almost 600,000 tons of scrap was imported by India. By 1986-1987 the quantity had risen sharply to almost two million tons. In the current year imports are expected to be between 2.5 to 3 million tons. This trend is expected to continue in the immediate future. Zaire will be faced with this situation soon unless it establishes scrap collection facilities all over the country.

There are, however, opposing factors that could affect scrap requirements in the next decade, such as technological developments in steel-making by the increase of continuous casting which generates less works' arisings; also pre-treatment of molten iron raises the quality of iron and requires less scrap as a cooling agent. Recent developments in ladle metallurgy combined with the growth in the ratio of continuous cast steel means that the consumption of scrap in BOF steel shops has fallen sharply.

However, these opposing factors may be cancelled out. For example, integrated iron and steel works have been attempting to find a way to fill the head space in a converter with scrap and use the converter as a melting furnace for scrap. If such a method is satisfactorily developed then integrated iron and steel works will be able to compete better with mini-mills on long products. If such a process were to be used on a large scale then the demand for scrap for integrated works using the process could rise substantially.

Scrap requirements will increase wherever the number of mini-mills grows. Mini-mills have an advantage over large integrated iron and steel works because investment costs required are relatively small and overheads low; for this reason the contribution of mini-mills to steel output is rising sharply. If demand for scrap starts picking up because of increased annual production, Zaire will experience scrap shortage.

The present world scrap supply situation in 1988 shows a steadily declining surplus of scrap in the USA and in Europe; in the Third World and in the Far East in particular there is a shortage. There is the imbalance in supply between the UK, Federal Republic of Germany, France and the Benelux countries where supply outstrips demand, and Italy and Spain where the reverse applies[2/].

1/ IISI, 1987.
2/ Metal Bulletin, June 1988.

Finally, there is a widely held perception in the steel industry that the overall quality of purchased scrap, in terms of its residual levels, is declining, and this is giving cause for some concern. The major reasons given for this decline include the increased mechanization of scrap yards and a greater proportion of alloy steels in the product mix. The steel consumer is also demanding more rigorous product specifications and steel makers are thus feeling the pressure from both sides, i.e., poorer quality inputs and a demand for higher quality products.

2.2.2 Ferrous scrap in Zaire

In mini-steel mills, foundries, and even integrated iron and steel works, scrap is one of the principal ferrous materials which can be remelted for making steel and, in some cases, even directly fabricated or rolled if suitable. It thus helps to conserve the large inputs of iron ore, coal and fluxes that go into making iron and steel, and therefore is considered a national asset (capital scrap) instead of being an industrial waste. Scrap arises at three different stages of the steel cycle: making, processing and use[2/].

In the process of making and shaping steel, scrap arises in such forms as pit scrap, ingot butts, rejected ingots, crop ends, shear cuttings from flat-rolled products, cut ends from bars, etc. This is known as circulating scrap, as it arises in the steel plant and is generally consumed within the plant itself for conversion into steel[3/]. Circulating scrap is a high value material of known chemical composition and physical characteristics. The quantity of scrap generated depends upon the level of steel production and the yield of finished steel from crude steel. The Maluku steel mill has never in its corporate history produced more than 20,000 tons of steel products.

Processing is the next stage of the steel cycle in the engineering industries where a certain amount of scrap is generated in the form of plate or sheet cuttings, trimmings, forging flash, turnings, borings and off-cuts. This is termed process scrap. The specific generation of this scrap is declining as steel consumers increase their yields and the process industries order made-to-measure rather than standard products. In this latter case, more scrap would be generated upstream. Since process scrap depends upon steel consumption, it swells with steel imports. Zaire imports a lot of steel products.

When a steel product has become obsolete, corroded, worn out, or broken and discarded, it forms capital scrap as stock. Such scrap comes from demolished structures and discarded machinery, rolling stock, ships and consumer durables. In Zaire scrap is used for melting in the Maluku steel mill and in foundries such as Chanimetal and Fondaf. The potential supply of capital scrap is related to the amount of steel products used during previous years. The wastage of process scrap depends on various factors. In comparison with highly industrialized countries, Zaire has lower manpower skills, less automation and a lower level of standardization, all of which would tend to increase the proportion of process scrap to steel consumption.

2/ Metallurgical industries in Zambia, UNIDO, May 1988.
3/ ibid.

The following table shows two kinds of purchased scrap available in the different regions of Zaire. Purchased scrap is, by definition, that scrap which is bought by the steel industry or other scrap consumers. The supply of purchased (merchant) scrap is a function of present and historical steel consumption, and it is often divided into process (prompt industrial) scrap and obsolete (old, capital) scrap.

Province	Cut scrap	Crushed scrap	Total
Kinshasa Bas Zaire Bandundu L'equateur Shaba	173,000 tons	35,000 tons	208,000 tons

While in industrialized countries the potential supply of capital scrap is linked with that of process scrap availability in terms of a pre-determined ratio, in developing countries like Zaire this is not appropriate. Instead, a rational method is to make an assessment in terms of past steel consumption. With this method, the quantity of capital scrap recoverable each year is calculated and related to steel consumption (product consumption multiplied by steel content) over preceding years with certain assumptions regarding such products. However, even this has a limited validity in the case of Zaire in estimating availability of capital scrap, since in the extremely low capacity utilization (2-3 per cent) of steel-producing facilities, circulating scrap is not generated any more, the steel-based engineering industries are very limited in number and small in size[1/] as a result of which the process scrap generation is small.

All capital equipment is imported. Data pertaining to steel consumption norms and life of equipment have not been developed. One more important thing is that, as mentioned before, there is no systematic way of collecting capital scrap in Zaire; this would require the formation of regional scrap collection/processing centres to cater to local small metal-working factories such as foundries and forges. Only GECAMINES Copper Corporation has its own scrap collection center although it is small.

It should also be considered that almost all capital scrap collected in the region of Shaba where the copper mine industry is located, is consumed in the region so that capital scrap expected from the Shaba region is not optimistic. For example, in Zambia almost all capital scrap collected in the copper belt goes to the copper mine industry to make borings[2/]. According to SOSIDER[3/] it is estimated that capital scrap would be generated as follows (in tons/per year):

1987	5,000
1988	10,000
1989	10,000
1990	15,000
1991	15,000
1992	15,000
1993	15,000
1994	20,000
Total	105,000, Average: 13,125 tons/year.

1/ Conjoncture Economique, 1987.

2/ Metallurgical industries in Zambia, Unido, May 1988.

3/ SOSIDER, Rapport technique, installation d'un systems de ramassage et conditionnement de ferraile, UNIDO, 1986.

However, for the Maluku steel mill, the major problems are the non-standard nature of scrap, varying in value and use from lot to lot, and the difficulties to accurately predict shortages or surpluses of home scrap since scrap contracts are usually concluded on a month-to-month basis while other steel-making raw materials are subject to long-term supply agreements. It is necessary to purchase the mill's usage and it is necessary to maintain a comfortable but practical inventory that can be used when needed and not just stored as it is now in the scrap yard at Maluku.

Once the scrap has been collected, the Maluku steel mill will either pay for it in cash as with the itinerant collector. The range of scrap material is vast from old cans to obsolete cruise ships. With such a varied range of products to be handled, a wide range of processes are needed, including shearing, pressing, crusing, cropping, fragmentising, segreggation and analysis. Obviously these processes require specialized equipment which can be expensive without outside help. Unless specialized analytical equipment is available the scrap will be down-graded and hence lose a lot of its inherent value.

In industrialized countries, on the other hand, the scrap produced by major consumers of iron and steel, such as process scrap in steel-making, off-cuts from fabrication and capital scrap from demolition and ingot moulds, are often processed by the consumers. Scrap from these sources are separate from the scrap produced by the rest of the economy, which is sorted and processed by specialist merchants. However, this is not the case in Zaire yet and it will take a long time to come.

During the conference on mini-mills held in Dallas, Texas, in early 1988, it was said that "scrap availability will not limit the growth of US mini-mills for the foreseeable future". However, now the issue is not just tons but quality and price as well. Either of these factors could threaten future mini-mill growth, especially since the high value markets which mini-mills are trying to penetrate require tighter quality controls[3/]. However, in Zaire the issue is tons, and hence availability of scrap, because of the demand especially for long products which can be made using ferrous scrap.

2.2.3 Scrap prices

Table 44 shows how nominal prices for these various materials have developed since 1973. Price movements for most material inputs are correlated in varying degrees, with movements in the price of petroleum. It is notable, however, that the price of coke has not risen in real terms and has increased much less, and been more stable than the prices of natural gas and electricity. It is also notable that the prices of iron ore and agglomerates have not risen in real terms in spite of the fact that their production can be relatively intensive.

3/ Metal Bulletin, 28 March 1988.

Table 45. Price developments since 1973 for the main ferrous and energy inputs to ironmaking
(US dollar price index, 1973 = 100)

	1976	1980	1985	1986
Ferrous materials [a]				
Fines (55% Fe)	133	183	163	148
Pellets (65% Fe)	158	190	140	136
Energy [b]				
Coke	200	212	212	210
Natural gas	224	648	767	603
Electricity	167	267	375	392
Memo items				
Ferrous scrap [c]	134	168	132	129
Petroleum [d]	436	1086	1009	570
United Nations export price index of manufactured goods	137	217	187	226

a/ C.i.f. Rotterdam
b/ F.o.b. or delivered, United States.
c/ United States No. 1 heavy melting.
d/ Spot, Arabian light crude.

Source: UNCTAD Secretariat, based on World Steel Dynamics, November 1987

As for scrap, the prices of scrap on the international market have not only increased less than other ferrous material prices, but have tended to stay below level. In 1987 it was $100/ton and in September 1988 the scrap price for number one heavy melting in USA is $111.50. In Brussels, the merchant selling price for electric furnace was BFr 4,400 ($111.2). US scrap export prices tend to set international standard and these rose to highs of $112-114/ton for number one heavy melting in November 1987 from $80 to $83 a year earlier. Prices have eased somewhat since then but remain high.

In Zambia, total scrap collection cost (operating plus capital) per ton would be estimated at about $72, if Zambia sets up successfully and operates scrap collection and processing centres[1].

With regard to zaire, table 46 shows cost of scrap and its transport. The scrap price in the Kinshasa area has no transportation cost, it is probably marginal in other areas. Thus it can be assumed that the scrap cost includes transport. The price of scrap in 1986 ranged from 900Z (approx. $12.50) to

1/ Report on availability of ferrous scrap in Zambia, Tata Export, India, 1986.

8,290 Z (approx. $ 148), on ferraille cisaillé (cut scrap). As for crushed scrap, it ranges from 500 Z ($8.9) to 1,730 Z (approx. $30.9). The cost of scrap itself is very low but the cost of transportation is very high, which is very different in Zambia and Angola.

High scrap prices have buoyed up pig iron prices in 1988 but traders report that this is tailing off now as scrap prices are no longer climbing. For example, an average f.o.b. scrap price in 1987 was $104.8/ton and but it went up to $122-$123. China is now exporting pig iron at a competitive $120/ton f.o.b., which would be equivalent to $130 c.i.f. in Japan. Brazil is reportedly offering pig iron at $157/ton c.i.f. to Japan[1/].

All mini-mills in the world depend on ferrous scrap of suitable quality and at prices that will keep them competitive. But in the case of Zaire, although scrap is availale at competitive prices, in some cases internal freight and unreliable railways make the scrap price (scrap collection and delivery) more expensive and unattainable.

2.3 Capital costs of direct reduced iron production

2.3.1 Prices of directly reduced iron (DRI)

The Maluklu steel plant will face shortages of ferrous scrap within ten years if the present production schedule is established. It would then need imported scrap or DRI produced domestically since the import of DRI is too expensive. In developing countries where there is little domestic scrap, DRI can more easily compete with imported scrap which often has to travel great distances. Zaire has a future to build its own DRI plant because of its natural resources and abundant electricity, in addition to the big steel market in the economic community of the Central African countries, which the Maluku steel mill can play as catalyst for the integrated development of the iron and steel industry in the Central African sub-region[2/].

DRI has the advantage of high purity so that good quality of long and flat products can be made but its use can quickly become uneconomical if energy costs increase rapidly, or if scrap prices drop. Consequently the growth in DRI is destined to be strongest in countries with low energy costs and where scrap supplies are limited and costly to import (if the country has hard currency). For example, Venezuela, with its plentiful ore supply, cheap energy, skilled work force, and easy access to the market, is ideal territory for DRI production. If scrap prices rise too sharply in response to increased demand, there is always an alternative for steel mills to buy DRI if the price is more favourable than scrap which, however, is unlikely in industrialized countries now and in the near future. So the availability of DRI as an alternative furnace feed will limit the extent to which scrap prices will rise; it seems that in the present ecomnomic situation this limit is around $130/ton.

1/ Metal Bulletin Monthly, 1988.

2/ Review of present status/trends and supply/demand market study on the iron and steel products in the Central African sub-region, ECA/IND/MET/001/87.

Table 46. Cost per ton of scrap collection (in Zaires when US$ = 50 Z)

Site	Purchase price	Transport cost	Total cost
Cut scrap			
Kinshasa	900	-	900
Boma, Tshela Lemba	500	2.165	2.665
Matadi, Inga	500	1.430	1.930
Lufu-Toto Kwilu-Ngongo Kimpese, Lukala	500	946	1.446
Lusanga-PLZ Dima, Kimbili Dondo, Kikwit	500	1.070	1.570
Mbandaka	500	2.595	3.095
Lubumbashi	500	7.790	8.290
Likasi/Kolwezi	500	7.510	8.010
Crushed scrap			
Kinshasa	500	-	500
Matadi	300	1.430	1.730
Mbandaka	300	950	1.250

Looking at the present scrap supply situation across the world, its attraction is on its purity. Since there is plenty of scrap around but not enough without metallic contamination in terms of iron units, DRI will probably always be more expensive than scrap. People making the cheapest products, like REBAR, will most likely be unable to justify high DRI prices[1/]. It finds a ready market only when the prices of DRI and high grade scrap are comparable. This is when scrap quality deteriorates, leaving a shortage of high quality scrap for electric arc furnaces. Consequently prices will rise as the market for prime scrap tightens.

Thus the future of DRI seems to depend upon three cost factors: iron ore, natural gas or coal, and facilities. The cost and supply of iron ore and natural gas or coal should present no hinderance to DRI especially in countries where supplies are abundant and where governments may be willing to see that costs for DRI producers are kept low. Capital costs are the major problem in a country like Zaire unless there are fundamental changes or simplifications in technology that is not likely to change in a few years.

Foundries such as CHANIMETAL can use DRI for their iron and steel casting production. The melting processes generally used in foundries include EAF cupola furnaces and reverberatory furnaces. A cupola is a vertical shaft furnace in which the major fuel is metallurgical foundry coke. As far as DRI is used for iron melting in foundry cupola, several tests2/ showed up to 15 to 20 per cent of the scrap portion of the charge could be replaced by DRI pellets without creating excessive wind box pressures. With DRI pellets in the charge, additional silicon and manganese are generally required. Although using DRI pellets in place of scrap has the advantage of lowering the tramp element content of the product, the cupola furnace is limited to the cast iron grades because it is operated with a bed of incandescent coke in the hearth. Under this condition, it is impossible to prevent a high content of carbon from dissolving in the metal. The electric arc and the electric induction furnaces, however, can be used for all the different grades of iron and steel. Low-sulphur DRI is particularly advantageous in electric furnace melting where considerable time can be saved by not having to remove sulphur in the melting furnace. The major difference between DRI and the conventional foundry charge materials, such as pig iron and clean scrap, is the relatively high gangue content, about 3 to 6 per cent, and the unreduced iron oxide content, about 4 to 12 per cent of the DRI. The amount of gangue depends almost entirely on the gangue content of the raw material from which the DRI was made.

2.3.2 DRI vs. scrap

In the early 1980s it was difficult to pick up an article on direct reduction without seeing a list of 15 or more processes that were classified as commercially available. There has been a significant shake up of direct reduction technology since that time and now only a handful of DR processes continue to be actively promoted. Table 16. shows DRI capacity by country from 1980 to 1987. World-wide capacity of DRI has increased from 14.73 million metric tons in 1980 to 22.39 million metric tons in 1987. The production of DRI in 1980 was 7.36 million metric tons and 13.66 million metric tons was recorded in 1987, giving an average rate of utilization of 50 per cent, production remained well below full capacity. Gas-based DR plants made 92 per cent of total output, with coal-based plants production only 1.16 million metric tons in 1987. Total installed capacity of DRI rose 9 per cent in 1988 to 24.39 million metric tons, though at 14.24 million tons production accounted for only 58 per cent of capacity. Venezuela was the leading producer with 2.93 million tons out of 4.5 million tons capacity, followed by the USSR, Mexico, Argentina and Saudi Arabia, all with more than one million tons of production.

1/ Metal Bulletin, November 1988.

2/ Direct reduced iron, technology and eocnomics of production and use, Iron and Steel Society of AIME, 1980.

Table 47. Steelmaking grade DRI capacity by country (metric tons/year)

	1980	1981	1982	1983	1984	1985	1986	1987
Argentina	0.75	0.75	9.75	0.93	0.93	0.93	0.93	0.93
Brazil	0.67	0.32	0.32	0.32	0.32	0.32	0.32	0.32
Burma		0.02	0.02	0.02	0.04	0.04	0.04	0.04
Canada	1.63	1.63	1.63	1.35	1.00	1.00	1.00	1.00
Egypt							0.72	0.72
India	0.03	0.03	0.03	0.18	0.21	0.21	0.30	0.30
Indonesia	1.15	1.15	2.30	2.30	2.30	2.30	2.30	2.30
Iran	0.33	0.33	0.33	0.33	0.33	0.73	0.73	0.73
Iraq	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
Italy	0.05	0.05	0.01	0.00	0.00	0.00	0.00	0.00
Japan	0.15	0.15	0.15	0.00	0.00	0.00	0.00	0.00
Libya								
Malaysia					0.72	1.32	1.32	1.32
Mexico	2.00	2.00	2.00	2.03	2.03	2.03	2.03	2.03
New Zealand	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Nigeria			1.02	1.02	1.02	1.02	1.02	1.02
Peru	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Qaatar	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Saudi Arabia			0.40	0.80	0.80	0.80	0.80	0.80
South Africa	0.15	0.15	0.15	0.23	0.83	1.11	1.11	1.11
Sweden		0.07	0.07	0.07	0.07	0.00	0.00	0.00
Trinidad	0.42	0.42	0.84	0.84	0.84	0.84	0.84	0.84
UK	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
USA	1.09	1.09	1.09	1.03	0.70	0.40	0.40	0.40
USSR				0.42	0.42	0.83	1.25	1.67
Venezuela	3.80	4.50	4.50	4.50	4.50	4.50	4.50	4.50
West Germany	0.55	1.43	1.28	1.28	1.28	1.28	1.28	0.40
Total	14.73	16.05	18.85	19.61	20.30	21.62	22.85	22.39

Source: Steel Times, June 1988.

However, the direct reduction of iron has had a bumpy history. Developed in the late 1960s the original oil/gas-based processes were just beginning to take off when oil prices surged, making any plant not based on its own gas or oil resources uneconomic. The recession which the oil crisis provoked meant that steel demand in the developed world began to decline rather than expand vigorously as had been expected, and many of the DR plants which had been planned were no longer justified. With the surge of oil prices attention turned to coal-based processes, a prime attractions of which was the fact that they did not require the high quality coking coal demanded by the blast furnace route to iron. The development of viable coal-based processes proved rather more difficult than had been anticipated and coal-based plants remain seldom, except in countries like India and South Africa where poor quality coal is plentiful.

While the other materials used by the DR process might not need to be of the highest quality, direct reduction does require good quality iron ore. The ore must have high Fe content, be relatively free of impurities and be in the form of high integrity lump or pellet. One of the few countries in the developing world where the two are associated is Venezuela, and it is there that most of the current development is taking place.

At present commercial scale direct reduction processes are basically classified into four categories: shaft furnace process, static bed process, fluidized bed process, and rotary kiln process. For the first three processes, gas reducing reagents are used as fuel, whereas for the rotary kiln process, solid fuel is used. With regard to the feedstock used, the fluidized bet process employs relatively fine ores, while the shaft furnace process and the static bed process employ lump ore or pellets. In the case of the rotary kiln process, an extensive size range of feedstock from coarser fine to lump ores can be used and this process is suitable for small scale iron and steel making based on coal as fuel.

With reference to the costs of iron making, the gas-based DR-EAF route is cheaper ($140.8/ton) than the coal-based DR-EAF route ($148.6/ton)[1/]. EAF steel making in both cases is based on the compound meeting of DRI (77 %) and scrap (23 %). Construction cost per ton of crude steel capacity for gas-based DR plants in developing countries ranges from $700 of Qatar Steel Co. (450,000 tons) in 1983, $952 of El Pixheila, Egypt (840,000 tons) in 1987, to $1,080 of Samoi Iron and Steel Plant (800,000 tons) in 1983.

2.3.3 Plan for a DRI plant in Zaire

In the Minerais de fer du Haut Zaire Interet de leur etude[2/] there is a proposal for the establishment of a DR plant using pellet out of the combination of iron ore in Haut Zaire and fuels (methane from Lake Kivu, oil or charcoal from wood) at Maluku or at Kisangani. In this case, Hyl and Midrex processes at 200,000/400,000 capacity are refered. This plan is as follows: iron ore concentrates are transported to Kisangani for shipment by barge to Maluku where pellets (284,000 tons/year) are made for the direct reduction plant (200,000 tons/year).

The cost breakdown includes amortization and a financial charge of 4 per cent. Using 200,000 tons/year in the DR plant, the cost per ton is $150($130 for 400,000 tons/year DR plant). In 1984 the price of scrap (no. 1 heavy melting) was $90 f.o.b. ($110 in 1988). If imported scrap is delivered, it costs about $140. Thus this report concludes that building a DR plant instead of importing scrap is better because it pays off.

Table 48. Cost of sponge iron in Zaire

Price of concentrates shipped to Maluku steel plant	Quarry + treatment	111 F ($13.88)
	Road transport (250 km)	219 F ($27.38)
	Transport by barge	222 F ($27.75)
	Pelletization and direct reduction	461 F ($57.63)
	General services and administration expenses	170 F ($21.25)
	Cost of DR iron	1,183 F ($147.89)
		approx. 1,200 F ($150)

1/ Steel Times International, 1987.

2/ Mineraise de fer du Haut Zaire interet de leug etude, proposition de programme, Direction des Projects Minières, March 1984.

A relative new form of DRI of interest to operators of electric arc furnaces and foundries is hot briquetted iron (HBI). It is designed for easy, safe transportation and handling when used as supplement or subtitute for low-residual, high-quality scrap or pig iron in EAF or foundry operations. The briquettes are sized for handling with the same equipment used for handling scrap, so HBI is a good product if Zaire has to export it in the region.

2.3.4 DRI plants using coal as a reducing agent

The newest DR plant in India, Bihar Sponge Iron Ltd (BSIL) is a coal-based rotary kiln DR plant which was to be commissioned in December 1988. There are three different coal-based rotary kiln DR processes in operation. Another unit based on a fourth process is in an advanced stage of construction. The first gas-based sponge iron plant is under implementation. The existing, or under construction DR plants are as follows:

Table 49. Coal-based DR plants in India

Plant	Location	Start-up year	No.of units	Annual capacity (tons/year)
Sponge Iron India Ltd., (SIIL)	Paloncha, Andhra, Pradesh	1980/85	2	60,000 (30,000 + 30,000)
Orissa Sponge Iron Ltd. (OSIL)	Parasponge, Orissa	1983	1	150,000 a/
Ipitata	Joda, Orissa	1986	1	90,000
Bihar Sponge Iron Ltd. (BSIL)	Chandil, Bihar	1988	1	150,000 b/

a/ The plant capacity is reported to have been derated.
b/ Includes 25 per cent additional capacity.

Source: Direct Reduction of Iron Ores - The Example of India, UNIDO 1988.

The SIIL plant was set up by the Government of India with the assistance of UNDP/UNIDO. The first unit with a capacity of 30,000 tons/year became operational in 1980. The prime objective was to test raw materials available in the country at a semi-commercial level of operation and establish techno-economic feasibility for producing sponge iron using 100 per cent coal as reductant.

The plant is based on the SL/RN rotary kiln technology and was designed and engineered by DASTUR & Co. SIIL has been carrying out studies on the effect of using coal of varying ash contents on production and productivity. SIIL has been contracted by UNIDO for bulk scale testing of raw materials from Vietnam and for laboratory testing of raw materials from Nepal and Niger. These tests are in progress.

The OSIL plant adopted the Allis Chalmers (ACCAR) process. This unit is reported to be the first and only ACCAR plant based on duel fuel, i.e. 80 per cent coal and 20 per cent fuel oil, with maximum 20 per cent ash content. The use of oil under Indian conditions has not been beneficial. However, due to problems arising out of changes in raw materials characteristics and some design constraints, the plant is forced to operate with coal ash of 35 per cent and above. It has been reported that the plant capacity has been derated, depending on the raw materials: it may perhaps be between 120,000 and 135,000 tons/year.

Ipitata (India) is the first commercial sponge iron plant using indigenous technology known as TISCO direct reduction (TDR) process. The Ipitata plant promoted by Ipicol and Tata Steel, is located at Silaipada near Joda in Orissa; commercial production started in April 1986. BSIL is another coal-based rotary kiln direct reduction plant which is an advanced stage of construction at Chandil, Bihar, and will cost $61.7 million. It is reported to be commissioned in December 1988. The size of the rotary kiln is 4.8 m diameter x 80 m long.

Lurgi sees India as the most promising country for the first commercial application of its combismelt steel making developed jointly with Mannesman Demag. The Indian experience indicates that coal-based direct reduction processes are highly sensitive to the characteristics of raw materials. The iron ores and coals available in different countries and even different plants in the same country vary widely in their characteristics. It is therefore necessary for each plant to suitably master the technology and adjust the operating parameters accordingly. Under prevailing conditions in India, it is observed that the coal-based DR plants are facing problems in obtaining a regular supply of consistent quality coal[1/].

Economics of DRI in India

Recent estimates indicate that the plant capital costs for the production of DRI in India is about RS 5,000/ton (equivalent to about $385) for a coal based DR unit of 150,000 tons/year capacity. Compared to this, a gas-based plant of 400,000 tons/year capacity would require approximately RS 400 (about $346) per ton. These costs could be somewhat lower if second hand units were installed. The 200,000 tons/year DR-based mini-mill at Bhandara, built in 1987 by India's Sun Flag Group, cost RS 2,030 million ($15,661,163) or some RS 10,00 ($771) per ton of installed capacity. Steel making facilities consist of a 50-ton-excentric bottom tapped ladle furnace, and a three strand continuous billet coaster feeding a 200,000 tons/year light section mill. Birla Jute and Industries has a plan for a 150,000 tons/year DRI plant in Madhya Pradesh. The project will cost some RS 850 million ($65,576,300). The construction cost per ton is RS 5,666.67 ($437). India's Kudrumukn Iron Ore Co. has put forward plans for a 500,000 tons/year DR iron plant costing RS1,000 million ($79.3 million). The construction cost per ton is $258.6 at 1986 constant.

1/ Direct Reduction of Iron Ores - The Example of India, UNIDO 1988.

The typical works cost of production of DRI in India is estimated at about $1,100 ($85) per ton for coal-based units, and RS 1,550 ($119) per ton for a gas-based unit. The higher works cost of gas-based units is due to the use of more expensive oxide feedstock (pellets) and also because of the higher natural gas price: about RS200 ($15.5) per Gcal compared to RS 70 ($5.4) per Gcal for coal. This means that coal-based processes are advantageous in India. The DRI is sold in India at about RS 2,450 ($188.5) per ton ex works, while the prevailing price of heavy melting scrap is RS 3,800 ($292) per ton. Import scrap at Bombay as of March 1988 cost RS 2,600 ($184.2) per ton, while imported DRI costs RS 2,350 ($166) per ton c.i.f. Bombay. Home-produced DRI costs some RS 2,050 ($145) per ton[1/]. At present India imposes 20 per cent import duty on ferrous crap, which makes raw material costs uncompetitive.

1/ Metal Bulletin, March 1988.

III. OPERATIONAL PROBLEMS IN THE MALUKU STEEL MILL

1. Description of existing facilities

1.1 Electric arc furnace (EAF)

Electric arc furnaces are slightly faster than OH but much slower than BOF in producing raw steel. A major advantage of the EAF is its flexibility. It can make ranges of steel, use a variety of raw materials and so adapt to market conditions and its output is readily regulated to suit demand. However, EAFs are mainly used in the manufacture of long products, for special forgings and for all types of stainless steel products. The Maluku steel plant produces long products like other EAF steel making in developing countries.

Flat product specifications usually entail low residual levels which can only be satisfied economically by the electric arc furnace if suitable low residual raw materials are available. Usually, electric arc furnaces which produce carbon steel using scraps do not have such a capacity. The size of an electric arc furnace is defined in terms of its shell diameter and transformer rating. Although the shell diamter for a given furnace is largely chosen as a function of the tap weight required and the steelmaking practice to be adopted, the current trend is to larger shell diamters for a given tap weight. The choice of tap weight is influenced by such factors as dedication to a continuous casting machine, productivity requirements and capital cost. When the furnace electrical specifications, including transformer size, is established, the rate at which the furnace can melt ferrous raw materials is also determined.

The Maluku steel plant has a maximum loading capacity of 50 tons EAF (surface 5,900 m^2) with transformer rating 30 kVA; the melting cycle (melting capacity) with a furnace charge is converted to molten metal, is 36 kV, and it is characterized by an overloading of 20 per cent which produces about 400 tons of liquid steel per day. A bridge of casting of 85/25 tons transports the liquid steel in a ladle up to the continuous casting machine. There is a small control laboratory for steel testing.

When we see the cost components of steel making, the typical production cost breakdown for EAF on average is as follows[1/]:

Raw materials:	77%
Electrodes:	8%
Energy:	10%
Refractories:	2%
Labour:	3%

While the breakdown of production costs varies from furnace to furnace and from plant to plant as well as from country to country, energy and electrode costs are always major items as the above figures show. In other words, electrode costs, together with the cost of electricity, are a major factor in conversion cost of the electric arc furnace process.

1/ The Electric Arc Furnace, IISI, 1983.

The scrap melting electric arc furnace represents an extremely energy-efficient means to bring a low cost metallic iron unit to a molten state and thus, improvements are difficult to achieve. Energy conservation and minimum electrode consumption are now major factors in the renovation and modification of electric arc furnaces for the modernization of a mill. This is true for the Maluku steel mill. For example, electrode consumption costs are currently between 10 and 15 per cent of the conversion cost of steel in an electric arc furnace. Electrode-specific consumption at Maluku is higher than 5 kg. More efficient use of electrodes plays an important part in reducing the cost of EAF steel production. Of course, electrode quality is largely determined by the raw materials used and by the method of manufacture. Thus, how to choose good electrodes with low electrical resistance and high mechanical strength is also an important factor.

The most common raw material is petroleum coke to which pitch is added. Electrode performance substantially affects the operation costs of a furnace since it influences directly or indirectly the duration of the melting and refining stages. Higher productivity depends on better refractory quality which greatly reduces the limitations imposed by refractory wear on the increase of electical power input.

At the Maluku steel mill, the slag in the arc furnace is basic, so is the range of basic refractories such as magnesite. More general use of magnesite bricks for the working hearth is becoming common although the standard of bricklaying must be high. Consumption of bricks for lining is 26,529 kg/ton of liquid steel; the electrode specific consumption of liquid steel is 6.4 kg/ton. The refractories' life is limited to 102 melts. Lime is locally supplied: the consumption of limestone and lime is respectively 79.5 kg and 5.1 kg per ton of liquid steel. The tapping temperature of steel 1,650°C. The insulate ladles and the turndishes are used for feeding the metal to the mould[1/]. Table 50 indicates the specifications of raw material consumption per ton at the Maluku steel mill.

Before the immediate improvement and repairs required for the Maluku steel mill are shown, the amount of energy and raw materials required are indicated, by using direct reduction plant to produce one ton of steel. The following diagram shows the importance of turning the existing steel mill into an efficient and energy-saving plant for the development of the Maluku steel mill. The following data is shown as reference:

Materials and energy for the production of steel per ton: (a) electric arc steel making process designed for melting scrap; (b) combination of gas-based direct reduction process (MIDREX) or coal-based DR process (SL/RN) with EAF steel making process[2/].

1/ Report on a mission to Zaire related to the Maluku steel mill (7-14 January 1984), ECA, 1984.

2/ Iron and Steel International, 1987.

Table 50. Specifications of selected raw material consumption per ton in the Maluku steel mill

Raw material	Consumption standard	Unit
Scrap	1,060	kg
Lime	79.7	kg
Limestone	5.1	kg
Flux	2.3	kg
Graphite	9.1	kg
Anthracite	4.5	kg
Ferro Manganese	5.2	kg
FeSiMn	5.2	kg
FeSi	3.3	kg
Aluminium	0.12	kg
Coke	–	
Electrodes	6.4	kg
Thermocouples	(9)	Nb/c
Zone Cove	102	c/C
Zone Scorie	102	c/C
Zone Sous Scorie	102	c/C
Sole complete	800	c/C
Voute complete	110	c/C
HL 7	4.8	kg/t
Scaligon 3	3.42	kg/t
RBM 97	1.02	kg/t
Permasita	9	t/ref
Purotab (four voussont)	3	t/ref

(a) Scrap – EAF

Scrap + Fe alloy
1,063 tons
↓

Arc furnace

Carbon additive 8 kg
Electrodes 4 kg
Electricity:
melting 500 kWh
AUX 25 kWh
Oxygen 25 Nm^3

↓
one ton of liquid steel

(b) Direct reduction (shaft furnace or rotary kiln) – EAF

Oxide pellets
1,266 tons
↓

Direct reduction

Shaft furnace: Natural gas: 264 m^3; Electricity: 110 kWh
Rotary kiln: Coal: 527 kg; 66 kwH

↓
DRI
0.879 t
0.806 t Fe (91.7% Fe)
↓

(arc furnace)

Scrap, Fe allow 0.269 t
Carbon additive 1 kg
Electrodes 4 kg
Electricity:
shaft furnace 550 kWh
rotary kiln 550 kWh
25 kWh
Oxygen 25 Nm^3

↓
One ton of liquid steel

These figures, composed of 95 per cent factor costs, show requirements of raw materials, energy and electricity for the production of one ton of liquid steel. This means that the prices of raw materials such as scrap and electricity electrodes for the EAF steel making processs have a great influence on the cost, cost saving strategy for these cost components is crucial.

Electrode production is mainly in the hands of a small number of large multinational companies which operate within the industrialized countries. A country like Zaire must import with hard currency. Although many electrodes are produced within the planned economy countries, these countries also rely heavily on imported electrodes. This means that Zaire needs help from a country which has hard currency. The Maluku steel mill needs raw materials and it can import them, with some luck, from countries that buy the products produced by the mill. However, technical assistance and transfer of technology can only be obtained utilizing hard currency.

The immediate improvements and repairs required by the Maluku steel plant are as follows:

1. Improvements in the control of the electrodes movements, and repair of some analytical equipment in the adjacent control (stage) laboratory.

2. The refractories, magnesite for the basic and walls, and high quality alumina for the roof must be imported. The reason is because performance of high alumina roofs correlates with the stress/strain properties of the material used to a remarkable degree.

3. Tap to tap time, which indicates productivity of liquid steel production, is excessive, up to 5 hours, which results in high refractories and electricity; perhaps the introduction of oxygen should be allowed.

4. There are other refractory materials which should be considered to be replaced little by little, but only after the mill starts producing again, for example, refactories which stand 2,000 to 3,000 casting operations, and placement of furnace roof with water cooled roof. This is not essential for the EAF at Malaku although it is essential for UHP furnaces where the roof ring is water cooled and the nose of the ring which is most vulnerable to thermal failure is preferably cooled. The benefits of replacing a refractory roof with a water cooled roof have proved to be better than expected from early trials. Reductions in refractory cost of the order of $1.5/ton and a reduction in electrode consumption of between 0.1 and 0.4 kg/ton has been noticed on most applications. The life of the water cooled area generally exceeds 2,500 heats.1/

All these suggestions require outside technical assistance. The Maluku steel mill needs one or two electric furnace experts, as well as maintenance experts on mechanics and electricity.

In conclusion and for future reference, in order to improve the operation of the Maluku steel mill, some new, but already popular technology to modernize the arc furnace is suggested, among which are two recent developments in electric steel making which continue to have a major influence on plant design and operation: (a) replacement of a large proportion of the refractory lining of the furnace with water cooled elements allows the

1/ Electric Arc Furnace, 1983, IISI.

electrical design of the furnace to be based on parameters which improve melting and electrode consumption. To gain full benefit from a modern furnace designed in this way, as many of the metallurgical operations as possible should be carried out outside the furnace. (b) Impact of secondary making techniques, simple or sophisticated, which give rise to after-furnace steel making practice.

The Maluku steel mill should consider adopting in the near future the water-cooled lining of side walls and of the roof. This requires a supply of good quality water; secondary steel making is a plus which allows final steel making operations to be completed outside the furnace, for better steel quality and shortening tap-to-tap times in the arc furnace as a melting unit only. This means the separation of the traditional production process or carbon steel in an electric arc furnace into two units, melting and refining, the latter including an oxidizing phase and sometimes a reducing phase.

The introduction of water cooled elements into the critical areas of the furnace wall and the use of water-cooled roofs have removed the limitations formerly imposed on the arc characteristics regarding the need to have a satisfactory life from the furnace refractories.[1/] It has permitted a better utlization of the available furnace power during melting, leading to increased productivity, and it has permitted redesign of the furnace electrical characteristic to achieve the low current operation designed for minimizing electric consumption.

1.1.2 <u>Continuous casting billet</u>

In continuous casting, liquid steel is directly cast into semis like billets and continuous casting has many advantages such as yield derived from sequential casting, energy saving and consistent quality. It obviates the need for a breakdown mill for rolling the ingot to billets. It is possible to produce steel in billet size, which is more cost efficient.

It is considered that the introduction of the continuous casting method and the improvement of its operational technology has contributed a great deal to the improvement in quality of the products of minimills since raw materals for melting in the minimills naturally contain a high degree of impurities because of their dependence upon scraps which tends to place a certain limit on their quality.

In the days of conventional casting teeming steel into small ingot cases, the productivity of EAF could not rapidly increase because of the bottleneck of casting work. However, the introduction of the continuous casting method has solved this problem. Table 51 shows the ratio of productivity at a minimill between the conventional casting and the continuous casting methods with one 70-ton EAF. In the case of conventional casting the maximum efficiency of teeming and tapping was 3 hours/heat.

1/ Iron and Steel Maker, January 1982.

Table 51. Comparison of conventional and continuous casting processes on productivity

Facilities	Conventional casting	Continuous casting
EAF	1 x 70 tons	1 x 70 tons
Casting facilities	Twin ingot mould:	Billet caster
	140 mm^2	140 mm^2
	4 stool x 48 mould	4 strand
	2 units	2 unit
Heat cycle	180 minutes	70 minutes
Productivity	23 tons/hour	60 tons/hour

Source: SEAISI, April 1988.

By the introduction of the continuous casting method, casting hours of ingot cases has been cut down, now attaining the productivity of 60 tons per hour; 70 minutes/heat. Recently, the EAF was repidly spreading owing to the introduction of oxy-fuel burners as additional heating equipment and the effective use of oxygen.

Table 52. Ratio of installed billet caster by design

Design	Percentage
Vertical machine	3
Vertical with single point bending and straightening	4
Vertical with progressive bending and straightening curved machine	3
Curved machine	79
Curved with progressive straightening	9
Other	2
Total	100

Source: SEAISI, April 1988.

The ratio according to types of installing the billet caster throughout the world is shown in table 52 above.

The four line continuous casting unit at Maluku, the output billet 100 x 100 mm, is quite reliable but needs minor repairs for full operation. This continuous casting is DEMAG. A straight mould, S-curved machine, billets are cut to lengths of 2.60 and 6 m and are stored in a shop supplied by a travelling crane of 10 tons; it is essential to improve cooling of the billets immediately below the mould, and to reduce breakouts, since the refractories can stand only 17 casting operations. In addition, the current yield of 93 per cent is not acceptable therefore improved turndish design and operation will be needed to improve yields to 97-98 per cent. According to Maluku's engineer the turndish especially needs to be repaired after each casting. For this purpose, a continuous casting expert from outside should be hired.

The efficiency of the electric steel making process can be improved by computer control of such tasks as power input programmes which are based on the weight and composition of the materials charged, the type of steel to be produced and the resources available for melting.

1/ Steel Times International, June 1983.

Table 53 shows that while energy consumption increases by some 9 kW/t of liquid steel when water-cooled panels are used, the indirect energy savings associated with reduced refractory consumption are high and hence a net gain of 12.4 kW/t is obtained[1]. At present, most of the cooling systems are designed for only moderate rise in temperature of colling water. The heat loss in cooling water is low grade and uneconomical to be recovered.

Table 53. Energy balance of water-cooled panels

	One year prior to use of panels	One year using panels
Refractory consumption kg/ton of liquid steel	7.02	1.95
Reduction in refractory consumption, kg/t of liquid steel	-	5.07
Increase in furnace energy, kWh/ton of liquid steel	-	9.0
Energy to produce refractories, kwh/ton of liquid steel	31.83	10.41
Energy balance, kWh/ton of liquid steel	-	-12.4

Source: Metal Society, April 1980.

1.1.3 Hot-rolling mills

The equipment for hot rolling at Maluku is found in two shops measuring 320 x 28 m, corresponding to a covered area of 18,000 m^2. There is a reheating pusher type furnace (35 tons/hour) for a loading in one or two lines.

Hot-rolling mills are composed of roughing mill, merchant bar, intermediate and finishing mill as well as wire rod and wire finishing mill with different ancillary facilities. The following products can be made in hot-rolling mills of 100,000 tons/year capacity:

	Size
30,000 tons/year of wire	6-12 mm
20,000 tons/year of rounds	12-20 mm
12,000 tons/year of rounds	20-32 mm
12,000 tons/year of flat bars	20 x 70 x 5 - 20 mm
8,000 tons/year of angles	20-40 mm
5,000 tons/year of sections and T sections	20-35 mm

Regarding the section rod and bar mills, three high roughing mills and subsequent stands for rolling small sections and loop rolling of rods and bars are in good order. There are adequate rolls and guides for the 65-32 mm diameter bars and rods. The rolls and guides for small sections are limited as these products have rarely been rolled. These rolling mills and other equiment are well maintained and ready to roll steel products. Good maintenance work is needed on other parts of the equipment which should be cleaned from rust and lubricated. There are some products listed above which have never been made in the company history.

1.1.4 Cold-rolling mill

The cold-rolling mill at Maluku has a capacity of 150,000 tons per year. It has a cut-to-length line, pickling facilities, cold-rolling mill, annealing furnace, galvanizing line, and profiling facility for corrugated sheets. The cold rolling mill is installed in three shops of about 330 m long and 30 m wide each corresponding to a covered area of 30,000 m^2.

The first shop, which is supplied by two moving cranes of 20 tons, has:

- line for cutting cold-rolled strip
- continuous pickling
- electric sub-station with distribution and command equipment of the cold-rolling.

The second shop, which is supplied by two moving cranes of 60/25 and 20 tons, has:

- Four-fold reversible cold-rolling mill with two working rollers of 405 mm diameter for the reduction phase and 510 mm diameter for the skin pass phase, as well as supporting rollers of 1,350 mm diameter. The rolling mill is driven by two twin motor of 2000 HP each;
- Cutting line for cold rolled bands or strips (15 ton/hour) conceived for cuts of 15 tons maximum weight, between 1,250 and 600 mm wide and 2.5 to 9. mm thick;
- Repair shop for rollers.

In the third shop supplied by two moving cranes of 20 tons, there are:

- Furnace line for annealing, using oil heating (leading of 40 tons each, duration of annealing 56 hours;
- Galvanizing line (7 tons/hour, 76 m/minute speed, 380 g/m^2 average thickness of zinc coating on both sides);

The line for corrugated sheets.

The capacity of the cold rolling equipment is calculated as an aggregate volume of 150,000 tons of finished products:

48,000 tons/year of	hot-rolled sheets.	Size: 1,250x2.5x4,000 mm
25,000 tons/year of	cold-rolled sheets	Size: 1,250x0.6x4,000 mm
	galvanized sheets (33%)	Size: 1,250x1.0x4,000 mm
67,000 tons/year of	corrugated sheets (67%)	Size: 1,000x1.0x4,000 mm

The state of the equipment and the original concept and design of the cold-rolling mill is a matter of concern. The equipment has not been in operation for over twelve months. Provided the roof is kept water-tight and bearings and drive shafts are periodically overhauled, the plant can be kept "moth-balled". A proposal has been included in the programme for the development of the iron and steel sector to convert these facilities into a steel service center to make more value-added products. In the next few years it should be maintained at minimum cost and emphasis should be placed on the rehabilitation of the hot rolling mill. However, the cold-rolling plant will have a role in the long run because of the demand for cold-rolled products in the country and in the region as a whole. When steel demand starts picking up the plant can be adapted into a steel service centre to provide cut and shaped hot and cold rolled sheets and strip, as well as other finished steel products for the local manufacturing industries.

2.1 Some considerations for modernizing the existing mill for further development.

Furnace productivity is determined by tap-to-tap time or melting capacity in tons per hour. Increasing the energy input is one of the first measures to improve the melting capacity of a furnace. While in 1970 a furnace with a power rating of 35 kVa per ton was already classified as an ultra high power (UHP) furnace, modern UHP furnaces operate over 700 kVa per ton.

The melting time, which can be reduced by higher energy input, is only part of the total furnace operation. Additional time is consumed for refining, superheating, adjusting of analysis and molding times. However, a series of new developments has permitted a considerable increase in productivity, for example scrap pre-heating, computer control, jet burner, ladle furnace, water-cooled wall and roof, and secondary metallurgy. Considering new techniques as such, the design of a modern minimill would differ very much from those built in the 1970s. The integration of continuous casting in a minimill with direct charging to the rolling mill comes very close to continuous steel making. The practice of charging hot billets directly from a continuous caster into a reheat furnace is aimed primarily at conserving the heat contained in the cast billet (approximately 500,000 Btu per ton at caster runout). With energy costs comprising almost a quarter of the mill conversion costs (energy 24%), potential saving is considerable. Further benefits stem from increased reheat furnace throughput and improved yield.

Perhaps less obvious are some of the layout and operational problems that must be overcome: close co-ordination of melt shop and mill operating schedules; hot inspection, or alternatively defect-free casting, and reheating of hot and cold billets in a single furnace (or preheating of cold billets). Direct rolling, an extension of the philosophy of not charging, involves the direct feeding of hot billets from the continuous caster to the mill. The most successful practioner of this concept is perhaps Nucor Corp. in the USA.

In order to improve cost competitiveness of existing products of the Maluku steel plant, certain technological tasks must be undertaken in the future, such as the hot charging or direct charging, in which hot billets are sent straight to the rolling mill reheating furnace, or directly to the first mill stand in order to reduce energy costs. Furthermore, in order for minimills to move into new product areas and to improve cost competitiveness, some new continuous casting processes have to be developed. These include:

(a) Billet continuous casting technology for high grade steel;
(b) Horizontal continuous casting to reduce investment costs and to improve casting workability;
(c) Thin slab casting technology for flat products.

Schematically the following two designs are considered:

1. Conventional design:

EAF ⟶ CC ⟶ BILLET STORAGE ⟶ REHEATING FURNACE ⟶ ROLLING MILLS

2. New designs:

(a) EAF ⟶ LADLE FURNACE ⟶ CC ⟶ HOT CHARGING ⟶ ROLLING MILLS

(b) SCRAP PRE-HEATER FURNACE ⟶ EAF ⟶ LADLE FURNACE ⟶ CC ⟶ DIRECT CHARGING ⟶ ROLLING MILLS

According to the case study which compared the EAF furnace of conventional design with that of new design, the energy consumption will be cut by 35 per cent[1/]. In this case, using 50 tons EAF, this mill could produce the same amount of steel products against 65 tons EAF in the conventional design.

2.1.1 Scrap preheating

Almost 70 per cent of the total conversion costs in the melt shop are direct and indirect energy costs. It is therefore worth looking at the possibilities of recovering waste energy. The energy balance of the EAF operation shows that exhaust gases from the furnace will yield 130-150 kWh of electric energy[2/] per ton of molten steel. Part of this energy can be used for scrap pre-heating (filter -- preheater). The waste gas normally contains about 19 per cent of total energy input to EAF steel making. It can recover about 6 per cent of the heat loss from the exhaust gas and reduce energy requirements for EAF by 55-60 kWh/ton of steel[3/].

2.1.2 Water-cooled walls and roof

Operating with high power input, increases the radiation from the arcs to the walls and roof of the furnace and causes a shorter refractory life. The installation of water-cooled panels in the furnace reduces refractory cost drastically and makes the furnace more available as a result of shorter repair periods. Because practices previously employed to protect refractory are no longer required, tap-to-tap times can be reduced by 5 to 10 minutes. Using this equipment the Maluku steel mill could increase productivity and cut energy and raw material costs. Furthermore, the application of externally placed cooling boxes offers the advantages of a 30 per cent enlarged furnace volume, thus allowing the charging of bigger scrap quantitites and reducing the number of baskets to be charged.

Water-cooled panels have also proved successful in the furnace roof. Owing to the risk of arching between electrode and colling panels, the centre of the roof is still lined with refractory. These parts can be exchanged within a relatively short period. The lifetime is more than 1000 heats. The installation of water-cooled panels saves substantial amount of refractory consumption.

1/, 2/ A New Minimill Design saves Cost and energy, ECE Steel Committee, 1986.

3/ Electric Furnace Proceeding, Vol. 42, 1984.

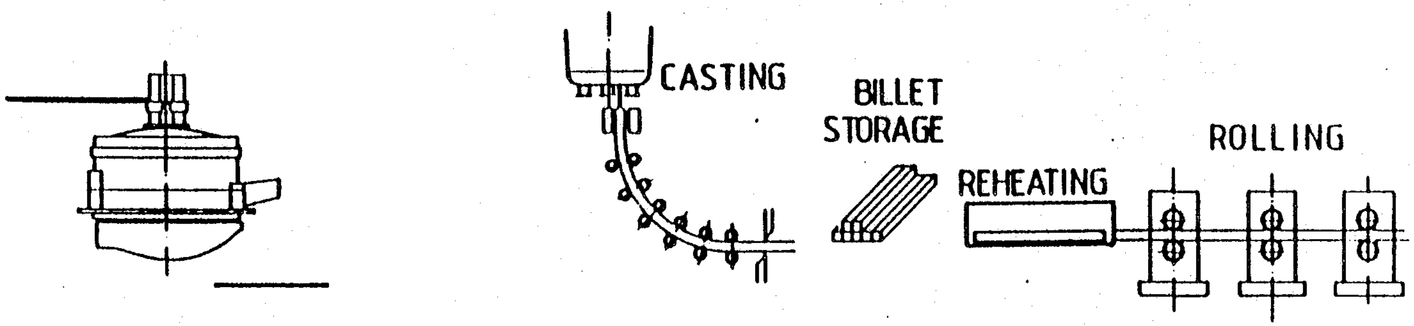
As shown in table 54 the energy consumption in a modern steel plant will be cut by approximately 35 per cent compared with a conventional minimill. Precisely for this reason future developments should be observed.

Table 54. Summary of energy-saving measures for an EAF meltshop

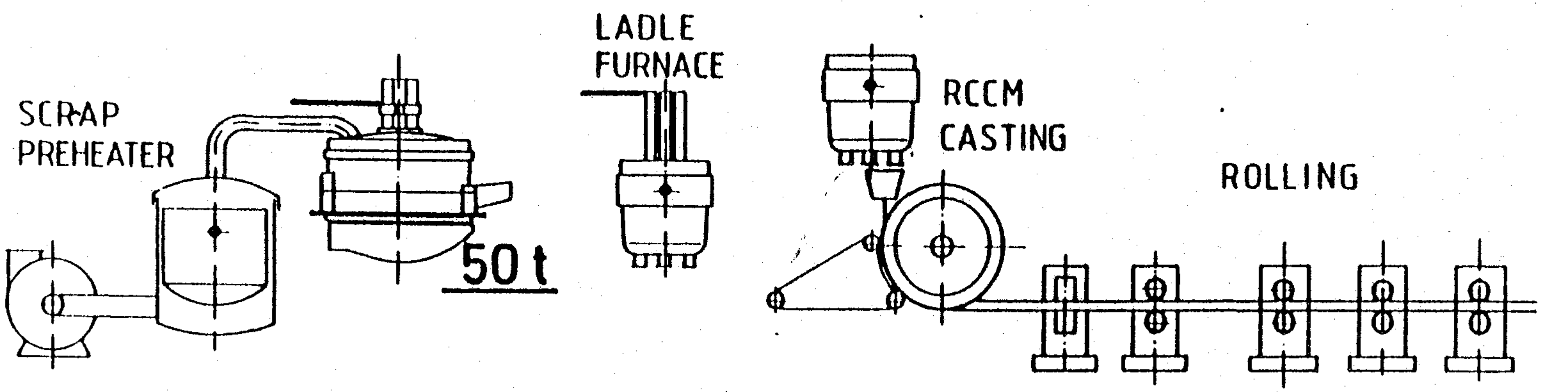
Classification	Method	Energy reduction	Remarks
Raw materials	Material flow optimisation	3-5%	Improved scrap handling logistics
	DRI continuous hot charging	3-10%	DRI 10-30% of total charge
Effective use of waste-gas	Scrap preheater	5-10%	Scrap preheat temp. of approx. 350°C
Operation	Oxy-fuel burners	10-20%	With 200-300MJ/t of oxy-fuel energy
	UHP operation and foamy slag practice	5-10%	Installed power of 750 KVA/t
	Process automation	approx. 5%	Computer control and automatic alloying
	Bottom tapping system	2%	Reduction in tapping temperature
	Ladle furnace	5%	Lower tapping temperature and shorter melting time
Facilities	Water-cooled panels and roofs	5-10%	Reduction in tap-to-tap time
	Variable volume furance	1%	About 5kWh/t energy saved
	Clean-house enclosure	3%	Equivalent to 15-20kWh/t energy reduction

Source: International Steel Times, 1987.

Figure 11. Maluku Type of Steel Plant



A: Maluku Type Steel Plant



B: A New Mini-mill Design at Korf Engineering GmbH
The Integration of a Continuous casting in a mini mill with direct charging to the rolling mill.

Source: Steel Committee, ECE 1986

2.1.3 Fuel burners

Oxy fuel burners are used and directed towards the cold spots between the electrodes to provide a uniform and accelerated scrap melting. Results claimed that by supplying 1 m^3 of natural gas and oxigen per ton of steel via oxy fuel burners, specific electrical energy consumption may be reduced by 7.8 kWh/ton and 4.4 kWh/ton respectively[1/].

2.1.4 Ladle furnace

The EAF operation includes several different steps, which previously were normally performed successively in the furnace. However, in order to increase the availability of the furnace as a melter, it has proved advantageous to separate superheating, deoxidation, refining and alloying from the melting. In this case, the EAF is used only as a melting unit, i.e., in this procedure scrap is rapidly melted at the maximum input of power without superheating, the tapping temperature being about 60°C lower than in the former case. Consequently the energy consumption in the furnace is reduced.

After tapping the molten steel, the ladle is transferred to the ladle furnace in which the steel undergoes further treatment. Any temperature loss caused by refining and alloying is compensated by a two-phase or three-phase arc heater. To homogenize temperature and composition, the molten steel is purged by argon or nitrogen through a porous plug in the bottom of the ladle. A feeding and lancing system provides for all metallurgical operations necessary. Absorption of oxygen, nitrogen or hydrogen during heating is prevented by an intert-gas atmosphere.

Another advantage of the ladle furnace is the possibility of molding the temperature over extended periods in case of down times in the continous caster. This compensates for irregularities of the operations.

2.1.5 Direct charging

The well-established link between melt shop and rolling mill is the continuous caster. While between melting and casting a semi-continuous flow of the steel has already been achieved, there is still a gap between casting and rolling. For several years attempts have been made in the direct charging of billet strands to rolling mills to avoid reheating. One of the main difficulties has been the adaption of the rather low casting speed of conventional casters to rolling mill speed. This gap makes possible direct charging to rolling using various new continuous castings invented.

1/ Iron and Steel Maker, November 1986.

IV. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. In terms of economic potential Zaire is one of Africa's richest nations, with generous reserves of land, water and mineral wealth. In order to make full use of this potential, Zaire is expected to transform a primary mineral and agricultural economy into a modern industrial economy and to diversify primary commodity export-oriented industries into a more self-reliant industrial base for value added.

2. If the economy is to become more independent of both copper exports and import goods, industrial and agricultural production must expand in a balanced, integrated way so as to meet a large share of demand through efficient use of domestic resources and to generate new export revenues. For this to be materialized, the development of the iron and steel industry such as the existing Maluku steel mill and auxiliary foundries and forges has an important role to play in Zaire's future economic development. The iron and steel industry is one of the key industries in the economy because it has important backward and forward linkages to other industries. It supplies the basic materials to all major industrial fields. A maximum effect on the economy is possible if the steel industry is based on indigenous resources.

3. At present Zaire depends on revenues from non-ferrous metals exports to finance its investment programmes, to develop other sectors of the economy and to diversify the country's economic base. Therefore the rehabilitation of the Maluku steel mill is important for the diversification of industries which are dependent upon exports of primary commodities such as agricultural and mineral goods.

4. However, for an industrial concern to function effectively , it is imperative that the various resources invested and utilized in the production activity be optimized. For achieving this, it is necessary to have and develop ancillary industries and back-up facilities required for the development of machine tools, agricultural machinery, tractors, commercial vehicles, etc.. These ancillary and support facilities are foundries, forging shops, tool rooms along with heat treatment, metal forming and fabrication and metal coating, which have not developed well in Zaire although there are eight such ancillary facilities visible which now need substantial upgrading. The manufactures of original equipment and spare parts by these facilities can play a vital role in promoting the accelerated, rational and integrated development of the industrial sector as a whole in Zaire. These ancillary and support facilities together with the Maluku steel mill will lead to greater horizontal integration at the country level and is a pre-requisite for the industrialization of Zaire.

5. The rehabilitation of the Maluku steel mill will not be meaningful unless a comprehensive programme is carried out for the integrated development of industrial sectors as a whole as well as the diversification of industrial bases. Rehabilitating the steel plant for one year is easy but the important thing to be considered are the backward linkages to other related industries which would make the plant economically viable on a permanent basis.

6. According to the assessment of the UNIDO team regarding the Maluku steel mill, the following three main problems should be solved in order to rehabilitate the plant in the short run:

(a) Management;
(b) Financial/Marketing;
(c) Technical/Engineering

7. Shortage of essential inputs of refractories and certain spare parts, and not technology, is mostly responsible for the plant not operating productively, as stated before. The plant appeared to be in a good condition with almost all equipment generally satisfactory and could easily be made operational. It was built in 1974. In spite of obtaining financial aid such as working capital, the plant has not worked very long. Management is responsible for the comprehensive programmes for the operation of the steel plant. This includes finance, marketing, as well as technical operation. Since management can be defined as the ability to obtain desired results through effective utilization of the resources availalbe, it is management's responsibility to bring into balance the various aspects of the work and to co-ordinate the efforts of all persons to meet the goals set. And this co-ordination is missing in the operation of SOSIDER (also SIDERNA, the holding company).

8. The Maluku steel mill has been facing marketing problems especially since 1982, even though the production volume is so small. SOSIDER will need a good marketing strategy when it starts producing according to the new schedule. The Maluku steel mill must rely on its home market for all its turnover for some years to come. Many companies at present depend on imports of steel products due to Maluku steel mill's inability to offer a steady supply. Thus SOSIDER will face competition with imported steel products and needs to make a strong effort in its marketing strategies for its steel products and in the expansion of improvements in product quality and delivery.

9. There is enough demand for steel products in Zaire. The present demand is around 30,000 tons per year and it will go up to 40,000 tons in a few years. Zaire used to have 198,000 ton steel demand many years ago. For this amount the capacity of the Maluku steel mill is sufficient, but since 1975 the demand for steel products has been declining, and this necessitates regional co-operation to revitalize the plant. If Zaire tries to achieve the integrated development of the iron and steel industry with other existing industries, the demand for steel products will easily go up to 50,000 tons within a two-year period.

10. Steel imports by Zaire recorded 130,000 tons in 1970 and since then they have decreased. In 1983 Zaire imported only 31.200 tons, but in 1984 they increased to 72,500 tons, in part due to the inability of Maluku steel operations. Zaire mainly imported long, flat products, tubes and fittings. The Maluku steel mill and existing foundries can provide most of the products required in the industrial sectors.

11. In order for the Maluku steel mill to produce steel products on the new production programme, each ton of production requires an import of approximately $100 per ton of consumable materials, refractories, electrodes, finishings as well as certain spare parts. The $750,000 required for the 1989 production of 7,500 tons will need to be forthcoming from either the government or a private investor. An assessment of the production costs of the hot rolling mill shows that an output of 7,500 tons in 1989 would provide an operating surplus which is calculated based on actual fixed and viable costs at Maluku and current selling prices in Zaire.

12. Careful planning for DRI-based integrated mini-steel mills based on local raw materials must be made due to limited availability of ferrous scrap which will be exhausted in 5 to 7 years. The DRI/EF route can be operated effectively on a small scale, and size capacity can be matched with the exact market requirements and, when necessary, modular expansion can be resorted to for meeting the increase in demand1/. The raw materials which DRI plants require are iron ore, coal (or charcoal) or natural gas (or oil) in addition to electricity which is plentiful in Zaire. In order to more fully explore the potentials and limitations of the development of an integrated iron and steel mini-steel mill, there is a need to examine the availability of mineral and energy resources.

13. Some detailed studies of iron ore, the typical composition of some of the DR-grade oxide feed used in DR plants, raw materials such as manganese, lime and tin, as well as fuel minerals were made in this paper (see pp. 52-59). Therefore only concrete project programmes are needed for the development of integrated mini-steel mills and other related industries.

14. Detailed analysis of DRI plants and cost components have been made in this paper (see pp. 61-65 and 81-88). Some case studies are explored such as charcoal (and coal), and operating cost of charcoal-based DRI plants and electricity consumption in the mini-steel mill for the rehabilitation of the Maluku steel mill.

15. Case studies on steel making in EAF using ferrous scrap and analysis of availability of ferrous scrap as well as scrap prices in Zaire have been presented (see pp. 73-83). In Zaire, about 208,000 tons of ferrous scrap are available/collected. However, there is a need for preparation of a bankable study for a rational system for the collection, processing and utiliztion of ferrous scrap in the country. Detailed studies of DRI plants using coal as a reducing agent are investigated for possible adoption of the system in Zaire (see page 85). Some case studies in India are also analyzed (see page 87).

16. As far as operational problems are concerned, description of existing facilities are suggestions of immediate imrovements and repairs required for the Maluku steel mill are spelled out (see page 92).

1/ SEAISI (South East Asia Iron and Steel Institute) Quarterly, April 1986, Vol.15-2, pp 14-26.

Recommendations

1. Considering the rehabilitation of the Maluku steel plant, special attention should be paid to the multiplying effects of the development of the steel industry on the development of other sectors of the economy and on wider opportunities for employment.

Consultations with the government of Zaire and with other countries that form distinct regional groups such as the Community of Central African States, should co-ordinate their research and development plans for the iron and steel industry of the region. Where geographically feasible, consideration should be given to the establishment of regional iron and steel research and development institutes with adequate pilot plant facilities for investigating iron and steel technology.

2. The steel industry provides various indirect socio-economic benefits. These should be considered when dealing with the overall steel policy of Zaire. A social evaluation as a consequence of the rehabilitation of the Maluku steel should be undertaken by the government itself on the basis of techno-economic feasibility studies carried out by the UNIDO technical mission.

3. It is of great importance that the policy-makers stick to the three phases of the rehabilitation proposed (set out in detail in the Preface of this report) so as to achieve the integrated development of the iron and steel industry in Zaire as well as the integrated development programme in co-operation with the Central African States at a later stage.

4. In order to make the rehabilitation programme based on the mission's proposals successful, the policy-maker should bear in mind that the main points raised for the revitalization of the Maluku steel mill should be carried out on a continuous basis.

5. Human resources is one of the key issues in planning the rehabilitation of the Maluku steel mill. The mill and its owner SOSIDER must establish a human resources activity programme planned for a high degree of staff participation on a regular basis. A joint labour/management committee should be operative, with the assistance of UNIDO's training programme.

6. The Government of Zaire, in close co-operation with UNIDO and its technical advisers, should arrange to carry out further action for the rehabilitation of the Maluku steel mill and its operator, SOSIDER itself. This includes production, operation of the plant, marketing and financing, as well as careful systematic studies of the iron ore, coal and sponge iron plants. Especially, UNIDO experts should help develop a programme on inventory management and production planning and control which interface with financing and marketing. For this purpose, an introduction of systems for quantitative analysis techniques such as operation research and management information systems is recommended.

7. Full account should be taken of current developments in direct reduction processes and their potential applications in Zaire possessing different resources of iron ores and fuels.

8. Detailed studies on the suitable transportation of Maluku steel mill inputs (ferrous scrap, iron ores, sponge iron) and output (steel products) will be required.

9. Before major ventures are undertaken, pre-investment and feasiblity studies should be prepared. Also to be studied is what kind of technology can best be applied to fit local conditions.

10. Availability of ferrous scrap in the ECCAS (Economic Community of Central African States) and payment mechanism have to be investigated.

11. Study of steel demand for iron and steel products in each country of ECCAS has to be made in order to draw a clear picture of overall steel demand in the region for the integrated development of the iron and steel industry as a whole.