COMMISSION OF THE EUROPEAN COMMUNITIES

DIRECTORATE-GENERAL FOR DEVELOPMENT AND COOPERATION

DIRECTORATE FOR TRADE AND DEVELOPMENT

POSSIBILITIES OF ESTABLISHING EXPORT INDUSTRIES IN THE ASSOCIATED AFRICAN AND MALAGASY STATES

IRON AND STEEL PRODUCTION

- *Pelletization of iron and electro-metallurgy*
- *Ferro-alloys (ferro-silicon, ferro-manganese and ferro-nickel)*

SUMMARY REPORT

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FOREWORD

Considering the priority given by the second Association Convention (Yaoundé II) to the aim of industrialising the Associated African States and Malagasy, and considering the prospects which the manufacture of certain goods for export could offer some of these States, the Commission of the European Communities has carried out, with the consent of the Associated States, the Commission of the European Communities has carried out, with the consent of the Associated States, a study programme on the possibilities of setting up various export industries in these countries.

This programme of studies, industry by industry, deals with the production or processing of the following products :

- livestock produce
  - meat
  - leather and hides
  - shoes
  - leather goods
- electrical and electronic products
  - electro-mechanical products
  - electronic products
- processing of wood and manufacture of wooden articles
  - first processing stage (sawing, veneer, peeling, cutting)
  - second processing stage (shapes, mouldings, plywood, panels)
  - finished goods (for construction and furnishing)
- iron and steel production
  - pelletization of iron ore and electro-metallurgy
  - ferro-alloys (ferro-silicon, manganese and nickel)
- preserved foods and tropical fruits
  (dates, bananas, citrus fruits and essential oils, pineapples and tinned fruits in syrup, cashew nuts and almond nuts, edible groundnuts, various tropical fruits)
- manufacture of cigars and cigarillos.

All these studies were conducted along the same lines. Each includes, first of all, an analysis of the openings which would occur in the markets of industrialized countries (especially those within the Community) for goods manufactured in the AASM and then the analysis of specific production conditions for these goods in the AASM countries best equipped to produce and export them.

Each study was entrusted to independent experts. The competent sections within the Commission set down the aims of this research and followed the work from beginning to end. The experts nevertheless worked completely independently, especially as regards methodology, and their reports express nothing more, therefore, than the result of their research and the conclusions they draw from it.

The study of production in the iron and steel sector (pelletization of iron ore and electro-metallurgy, iron alloys) was carried out by the Italian Research Bureau SICAI (Società d'Ingegneria e Conzulenza Attività Industriale). The experts responsible for this research were :

Messrs Luciano MORI-UBALDINI, geological engineer
Piero SCHEDA, industrial economist
Enrico BREGONZIO, mechanical engineer.

The study for the iron and steel sector was drawn up in 3 volumes. The first is an investigation of resources in the AASM countries of iron ore, silicon, manganese and nickel, based on library research and, for some of these countries, following a field mission.

The 2nd and 3rd volumes deal with demand, production processes, the choice of sites and the economic evaluation of the two lines of production, that is of iron and steel and ferro-alloys respectively.

Examining the AASM's chances of developing industries within the iron and steel sector, a study was med, which went beyond the guidelines set down by the European Economic Community, of pellet production plants and steel works which use processes other than electric furnaces.

Pellet production is not, strictly speaking, within the scope of iron and steel production, as it is purely a physical treatment of the ore and does not involve any chemical transformation.

In the report, however, it is indicated that certain countries would be well advised to associate a plant for the production of pellets for export with their iron and steel industry in the strict sense, in cases where that type of plant would seem to enjoy particularly favourable conditions.

Nevertheless, this theme was not developed to the extent of a feasibility study, partly because there is very little added value in the ore after such treatment, and also because this process does not fall within the scope of an iron and steel survey.

In the iron and steel sector, on the other hand, the study included iron-ore pre-reduction plants, production of cast-iron and steel, using both the electrical process and the oxygen process.

The iron-alloy sector study, however, took electro-reduction as being the only production process, in order to assess the possibilities of using large quantities of hydro-electricity in the industry, as this is readily available.

A study was made of the possible development of AASM countries of iron to steel and ferro-alloy industries.

This study specified processes, scale and production capacity, stting and, finally, investment and operational costs of the plants themselves.

The experts'reports (which are only available in French) and the final reports (which are available in German, English, Italian and Dutch) can be obtained free of charge from the following address :

Commission of the European Communities
VIII/B/1
200, rue de la loi
1040 Bruxelles (Belgique)

IRON AND STEEL PRODUCTION

The study of the iron and steel sector deals both with the production of iron and that of a number of ferro-alloys.

The studies are in 3 volumes. The first is an enquiry into iron-ore resources, energy and alloys in the AASM countries. This list has been drawn up on the basis of library research and, in the case of some countries, from the results of field missions by the experts.

The 2nd and 3rd volumes deal with demand, production processes, the choice of sites and an economic assessment of each of the production lines : iron and steel and ferro-alloys respectively.

In the iron and steel sector a study was made of pellet production plants and steel works using processes other than electric furnaces.

The study of iron-ore pelletization did not extend to a feasibility study, both because of the low added value in the ore after such treatment and because this does not come within the scope of an iron and steel survey. For steel production, on the other hand, the survey dealt with ore pre-reduction plants, plants for producing cast-iron, and steel works, both using the electric process and the oxygen process.

The ferro-alloy sector study took electro-reduction as being the only production process, so as to assess the possibility of using large quantities of hydroelectric power in this industry, as this is available under favourable conditions.

A study was made of the possible development of iron and steel and ferro-alloy industries, which specified processes, scale and capacity of production, siting and finally investment and operational costs of the plants themselves.

A. RESOURCES

As concerned the prospects of, on the one hand, setting up an iron and steel industry as such (iron-ore pelletization and electro-metallurgy) and, on the other hand, the production of iron-alloys, a list was drawn up of resources available for the development of these industries. This study was based on a considerable amount of library research and, in the case of some of the countries, on the results of field missions.

The most important characteristics of each country are summarized below : the area, the population (in 1970), mining resources and energy potential (hydroelectricity). Of the 18 countries studied, it becomes immediately apparent that the most interesting are Gabon and Ẑaire, which have larger mining and energy resources than the other associated countries. Further examination confirms a marked difference between these countries and the others with regard to the possibilities of setting up iron and steel or iron-alloy industries.

Country	Area	Population	Mining resources			Energy resources	
	10^3 km2	10^3 (1970)	(a)	(b)	(c)	(d)	(e)
Burundi	32	3.544	-	-	-	*	-
Cameroon	475	5.840	*	-	-	160	160
Central African Rep.	623	2.370	*	-	-	8	2
Congo	349	1.100	**	-	-	15	17
Dahomey	112	2.718	*	-	-	8	110
Upper Volta	274	5.076	*	**	-	-	*
Madagascar	592	7.011	*	-	-	*	consid.
Mali	1.240	5.022	**	-	-	7	175
Chad	1.284	3.600	-	-	-	-	-
Somalia	638	2.800	*	*	-	-	*
Rwanda	26	3.700	-	-	-	21	*
Niger	1.189	4.050	*	*	-	-	*
Senegal	197	3.800	**	-	**	-	20
Mauritania	1.030	1.170	**	-	-	-	*
Ivory Coast	322	5.100	**	**	*	108	180
Togo	56	1.956	**	-	*	16	*
Gabon	267	950	**	**	**	20	6.500
Zaire	2.345	21.600	**	**	**	500	40.000

(a) Iron
(b) Manganese
(c) Quartzites
(d) Hydroelectric power installed (MW)
(e) Hydroelectric power not exploited (MW)

* Negligible
** Exploitable

Energy potential in itself already constitutes a decisive element of discrimination for a primary electro-metallurgy plant planned to process 2-3 million tons/year of steel. An industry of this kind requires an installed power supply of about one thousand MW ; the only countries capable of providing this kind of energy are Gabon and Zaire.

The considerable energy potential in Zaire would make it quite possible to exploit to the fullest extent an iron deposit in a bordering country, the Congo, because this potential is centred on Inga in the South of Zaire, less than 200 km from the coast and very near the Congolese border.

Gabon

The main resources discovered in Gabon are the following :

- Iron ore for large-scale iron and steel production : the Belinga-Mekambo and Boka-Boka deposits, which are among the largest and richest in the world, both in quality and volume. Their exploitation, however, will require considerable investment (mainly in railway and port facilities) ;

- Iron ore for small-scale iron and steel production : the deposits at Tchibanga (in the South) and those of Ndjole and Kango (in the North-West of the country which are itabiritic and of average size, are well situated near the coast and/or existing or planned transport infrastructures and also near electrical energy production sites ;

- Methane gas : the quantities available at the present time appear insufficient to supply an iron and steel production industry ; moreover, collection and transportation costs are prohibitive ;

- Manganese ore : the deposit at Moanda (Franceville) is one of the largest in the world, both because of its exploitation and properties and the quality of the ore. Exploitation and enrichment do not pose any problems and new increases in the production programmes are envisaged ;

- Quartzites and silica sands : the prospects in this sphere are uncertain ; there is no - or little - industrially exploitable quartz and the quartzites are often contained in pre-cambrian structures ;

- Energy : the hydroelectric energy potential is enormous, although spread over several possible large sites. Bearing in mind the huge quantities of electrical energy necessary for the industries under consideration, some of the most promising sites are the Chutes de l'Impératrice (for which design studies have already been undertaken), the Okanda gates and the Mafoula-Matato site near the manganese deposits. Foreseeable unit costs were estimated during the initial stages of the study and are reasonable.

All in all, the prospects of transforming iron ore into steel are good. The best site for the iron and steel industry would be near the port of loading. The same applies to ferro-alloy production (silicon and/or manganese). It would be possible to site plants near a prospective iron and steel works and also in the quartzites zone at Tchibanga.

Zaire

On the other hand, the resources of Zaire are the following :

- Iron ore : the largest deposit is that in the M'bomo mountains near Kisangani (North-East). On the basis of the results obtained during the course of the study, it may be said that the M'bomo mountains contain considerable deposits of iron ore (probably 90 million tons and possibly more than 500 million) ; this ore is of good quality (63-68 %), both from the physico-chemical viewpoint and regarding content. Its use should not present any problems. Transportation to the centres where the ore is to be used (either inland or near the coast) seems possible at very reasonable cost ;

- Manganese ore : the Kisenge (Shaba) deposit has already produced 5,600,000 tons of ore between the years 1951 and 1969. The reserves are probably not less than 15 million tons at 48 % ;

- Nickel ore : before 1960, nickel prospecting was carried out in the region of Kananga. These probes, about which very little information is available, reportedly met with positive results. According to the limited information available concerning definite and/or probable finds, there is considered to be a deposit of about 100,000 tons of nickel. The largest deposit is reported to be about 60 km to the South-West of Kananga. These provisional conclusions should be studied and analysed before a 2nd stage of more extensive study is started ;

- Silica and quartzites : according to the information available, there is pure quartzite at Matadi, Inga and Monolithe (Southern Zaire). The reserves of good quality ore seem to be very large ;

- Electrical energy : in the region to the South of the central bowl of Zaire there is a large area with an abundance of waterfalls and rapids where the current is very strong. It is difficult to evaluate the natural power of all these waterfalls and rapids, because of a lack of precise data for certain regions. After subtracting from the total the power which belongs to the countries bordering Zaire, the available potential for Zaire is about 104 million KW, i.e. approwimately twice the power potential of the United States and three times that of the European part of the USSR. A large proportion of this potential is centred in Inga, where the river describes a sharp bend over 20 km and where there is an overall drop in the level of about 100 m. Bearing in mind that the river has an average rate of flow of at least 40,000 m3/sec, it is easy to calculate that this site has an energy potential which is unique in the world having a gross power of at least 40 million KW.

Harnessing this enormous potential has already started : between now and 1975, in two stages, the installed power will reach 351 MW ;

- Methane gas : it has already been mentioned in the previous section that, as concerns the western region of the country, there is little chance of finding methane fields in the area where oil prospecting is at present in progress. There is, however, a methane deposit in the North-East of the country, in Lake Kivu. According to the latest assessments, the lake contains approximately 50 km3 of methane at a depth of more than 250 m and the annual rate of formation of methane is about 2 % of this figure. Also in accordance with the preliminary calculations, the annual extraction of quantities of methane proportionate to the rate of formation would make available some thousand millions Nm^3 of CH_4 each year at suitable unit costs of extraction and concentration. Transportation of the concentrated methane gas over long distances to the centres where it is to be used could be effected by pipe-line and would not pose any particular problems.

Congo

Resources are not available in Congo in the same quantities. However, Inga is very near the Congolese coast and could supply a coastal industrial area, and especially a large-scale iron and steel works based on the ore from Zamange. The known reserves in this deposit amount to about 400 million tons.

Conclusion

As a result of the above, the possibilities of building iron and steel plants in the following countries should be studied : Gaon, Zaire, and Congo ; for each of these, the processes, the production levels and the sites most suitable for the plants will be specified.

As concerns ferro-alloys, Gabon has iron ore, quartzites and hydroelectric energy.

In Zaire, electrical energy can be provided cheaply and in large quantities by harnessing the Inga ; silicon is obtainable in Southern Zaire in the form of almost pure quartzite ; and the encouraging results of the probes for nickel ore at Kasai mean that local production of nickel alloys will doubtless be possible. As far as manganese is concerned, on the other hand, the situation is less promising. In the case of Zaire, the remoteness of the production sources from the hydroelectric sites makes the possibility of economic production of manganese alloys very unlikely, especially in comparison with other countries whose conditions are much more favourable.

The Congo, on the other hand, can benefit from its geographical position, for its ferro-alloy industry ; it is easily able to receive supplies of energy (from Zaire) and local manganece ore.

B. IRON PRODUCTION

The manufacture of steel blanks in the African countries associated with the European Community is only justified for export purposes if local conditions permit the sale to European countries of products which are of the same quality and price as those which can be obtained by European industry.

It seems improbable that transportation of steel blanks, and in particular of blooms, which could become the product most in demand in the future, would be more economical than that of the corresponding iron ore. For this reason plants which are going to be built in Africa must have the same characteristics and dimensions as those which exist at the present time or are planned in Europe.

This is why emphasis has been placed on plants capable of producing a minimum of 3 million tons of blooms per year by envisaging plants which have a unit capacity close to the maxima possible with modern technology, in order to make full use of economies of scale.

I. Demand

It is considered at present that the following are the most reliable sources of information regarding forecasts of world demand for steel :

- IISI (International Iron and Steel Institute), whose study, made in February 1972, gives forecasts which extend until 1985 ;

- the EEC, which was made a study on the many problems in the Community iron and steel industry (Memorandum on the general aims of the Community iron and steel industry during the years 1975-80, September 1971) which considers the development of the steel balance-sheet in the short term, i.e. until 1975.

The basic hypothesis of the IISI study is to accept the existence of a ratio between the individual gross national product and "steel intensity" (understood as the amount of steel, which, consumed in a particular year, engenders in that year 1 US $ of gross national product).

The aim of the EEC study mentioned does not require the provision of exact details concerning its hypothesis and method. Its aims, however, are rather different from those of the IISI study : the world steel balance-sheet is used only to define Community trade with abroad, and this on a short-term basis, i.e. for 1975.

As concerns the Community and the world total, the IISI and EEC forecasts are recorded in the table below :

Projected world balance-sheet for crude steel*

	(a)	(b)	(c)
IISI version			
Year 1975			
- Community of the Six	130,60	107,60	23,00
- United Kingdom, Denmark, Ireland	29,90	27,80	2,10
Total Community of the Nine	160,50	135,40	25,10
WORLD TOTAL	737,60	737,60	-
Year 1980			
- Community of the Six	158,40	128,80	29,60
- United Kingdom, Denmark, Ireland	35,60	32,90	2,70
Total Community of the Nine	194,00	161,70	32,30
WORLD TOTAL	939,20	939,20	-
Year 1985			
- Community of the Six	191,00	153,20	37,80
- United Kingdom, Denmark, Ireland	39,10	35,90	3,20
Total Community of the Nine	230,10	189,10	41,00
WORLD TOTAL	1.144,60	1.144,60	-
EEC version			
Year 1975			
- Community of the Six			
. poor business situation	137,10	117,10	+ 20,00
. good business situation	147,90	127,90	+ 20,00
- United Kingdom	32,50	30,00	2,50
WORLD TOTAL	778,90	778,90	-

(a) production

(b) consumption

(c) surplus of deficit

* data in millions t/year

The differences for 1975 between the IISI study and the EEC study are almost negligible : the world total for production-consumption differs by about 5 % in favour of the EEC total.

Since the aims of this study were to extend the field of alternatives offered in the long term to the Community iron and steel industry, the IISI forecasts may be adopted, as they extend to 1985, which is an appropriate limit for this study, and as they give a reasonable estimation of probable Community steel consumption compared with the EEC short-term forecasts.

According go the hypothesis of the study, the Community of Nine is the potential market for a primary iron and steel industry in one of the AASM countries ; this suggests a need to analyse this market in greater depth.

Assessment of future Community requirements of steel blooms

During 1960-1970, bloom production developed in the Community iron and steel industry at faster rates than raw steel production. This expansion occurred partly at the expense of long semi-finished products, in accordance with a now clearly-defined evolutionary process of the uses of steel. The percentage of flat semi-finished products in the 1960 total is 46.4 % and rises in a straightforward linear progression to 54.5 % in 1970.

In order to face up to the forecast 1975 demand, the investment programmes of Community companies plan to reach a production capacity of 163 million tons of raw steel.

For production in 1975, there is a difference between the value recorded by the IISI forecasts (130.6 million tons) and the EEC good business forecast (148 million tons). The difference probably corresponds to the rates of utilization of 80.1 and 90.8 %, which are in fact fairly representative of the minima and maxima reached since 1960.

Keeping this range of rates of operation and considering the IISI data as the lower production limit (corresponding to the utilization rate of 80.1 %), it is possible to define the upper production limit (corresponding to the utilization rate of 90.8 %) and the installed capacity for both 1980 and 1985.

Between 1975 and 1985, the Community primary iron and steel industry will have to install a production capacity for raw steel of about 238 - 163 = 75 million tons ; as regards blooms, capacity growth will have to be 162 - 96 = 66 million tons (between 1975 and 1985, the proportion of blooms in total steel production will increase from 59 to 68 %).

The present Community market for blooms

There is not really a market as such for blooms at the present time. There is trading over limited periods of time and for limited quantities, depending on the situation of various companies. In general, companies maintain an equilibrium between the production of semi-finished and finished products. If this equilibrium is not obtained at the level of each factory, it is so for all firms taken as a whole.

The principal intra-Community trading partners are Germany (supplier) and France (buyer) ; vis-à-vis third countries, Italy and the Netherlands have tended to be buyers, at least over the the last three years.

There is thus no real "market" for blooms at the present time which could justify action such as that under study. The way to broach the study of demand is rather to examine the Community's future bloom requirements and the industrial and social costs of the different methods of their production, including production in other countries and in particular the AASM countries.

A reasonable compromise between the costs and the many risks which exist (in particular, the risk of dependence on semi-finished products from an external source for a large share of production) would be to create a consortium of several Community companies.

Precisely because trading in blooms does not really constitute a market as such at the present time, prices largely reflect the fluctuations of the principal market steel as a finished product.

These occasional transactions hardly make it possible to escape from the price trends. It seems more useful to try to estimate the order of magnitude of the production costs of blooms by a Community manufacturer in the near future, so that this may be compared with the cost for an "African" manufacturer, rather than to adopt too imprecise a market price for purposes of comparison.

II. The solutions under consideration

The countries chosen for possible siting of primary iron and steel industries are Gabon, the Congo and Zaire.

Each of these countries has characteristics which enable it to adapt easily to the different possible industrial processes. Each has at its disposal large quantities of electrical energy, and thus the only choice to be made is which process should be adopted : i.e. electric furnace loaded with ore or pre-reduced ore and blast furnace.

Choice of processes

Gabon

The Belinga iron ore deposit has properties which permit an annual production of 10 million tons of iron ore with an average iron content of 65 %. The ore could be transported on the Belinga-Libreville railway.

If the data (which is unfortunately rather limited) concerning the possibility of building a deep-water port in the Libreville area is accepted initially, the best site for an iron and steel works for the production of semi-finished products would be near Pointe Sainte Clairette.

With an annual availability of 10 million tons of ore, it may be considered that part of this will be exported in pellet form and part in steel blanks. The manufacture of the pellets will take up the finest ore, which is estimated at about 40 % of the total. The remaining 60 % will be used as such in the local iron and steel works for the production of blooms.

The main raw materials used in the works are the following :

- iron ore from Belinga (cost free works 9.8 $/t)
- imported fossilized-coal coke (cost free works 25 $/t)
- limestone from the island of Coniquet (cost free works 1700 CFA/t)
- imported iron alloys, fluxes and scrap iron.

Since Gabon possesses a large hydroelectric potential, it was deemed necessary to check this choice by comparing the blast-furnace reduction process with electric furnaces.

Only the elements which differ between the processes were included in the comparison. The elements common to the two processes were not included.

Blast-furnace process

- coke	t	0.46 x 43.68 \$/t	\$/t	20.90
- energy	KwH	50 x 0.01 \$/KwH	"	0.50
- manpower	Hour	0.33 x 1.1 \$/hour	"	0.36
- depreciation and financing expenses	\$	$100 \times 10^6 \times 0.135/4 \times 10^6$	"	3.37
- Total			\$/t	24.33

Electric-furnace process

The comparable cost items for cast iron produced by electric furnace are all known, except the cost of the electrical energy.

- known costs :				
. anthracite	t	0.44 x 22.0 \$/t	\$/t	9.68
. manpower	Hour	1.20 x 1.1 \$/hour	"	1.32
. depreciation and financing expenses	\$	$92 \times 10^6 \times 0.135/4 \times 10^6$	"	3.11
- Total known costs			\$/t	14.11
- maximum energy cost for competitive results		24.33 - 14.11	\$/t	10.22
- energy required per ton of cast iron		2,400 kWh		
- unit cost of kWh for competitive results		10.22/2,400	\$/kwh	0.0045

Altough the price at which the kWh would have to be produced free Pointe Clairette appears very low, there is not sufficient data available at the present time to exclude its being possible. For purposes of this study, it is sufficient to examine in detail the blast-furnace solution and to leave as a subject for future research the consideration of the cost of energy coming from Okanda, which is the only hydroelectric plant capable of supplying the one thousand MW required for iron and steel production by electric furnaces.

Optimum plant size

From an examination of each installation, it can be seen that the optimum works capacity is about 4 million tons of steel per year, produced by two 37 feet blast-furnaces, three 200 t converters and five continuous casting machines with one bloom production line. Such a work uses about 6 million tons of ore per year. The 4 million remaining can be pelletized in two plants each with a capacity of 2 million tons.

The Congo

The conditions in Congo are comparable to those of Gabon, with the great difference that low-cost energy is not available. The best site for the construction of a deep-water port for exportation would seem to be Pointe Noire, which is at the end of the railway on which the iron ore should arrive and not far from the complex at Inga, to which it could be linked by a high-power energy transmission line.

The main differences compared to the Gabon plant are the following :

- adoption of electric reduction furnaces which are more economical than blast-furnaces, taking into account the price of electrical energy in Inga, which may be calculated - under favourable conditions - at 0.0035 kWh (0.0045 free Pointe Noire), i.e. at the total price-level indicated for Gabon.

- adoption of ore-briquetting plants for all the ore coming from Zanaga, including fine graded ore which cannot be loaded directly into the furnace. The availability of sinter also has the advantage of giving a better furnace performance while reducing the consumption of electrical energy.

- absence of a thermal power station as a result of the availability of energy at Inga and of the lack of coking plants, since anthracite is envisaged as the reducing agent.

The capacity of the works was fixed at 3 million tons of blooms per year so as to limit to 20 the number of electric furnaces to be installed and so as to provide three 150-ton converters which will ensure a steel production of 3.150.000 t/year.

Zaire

The Zaire iron and steel industry will use the iron ore from the Mount M'bomo deposit, near Banalia, and there are two possible solutions for the reducer :

- use of methane gas extracted from lake Kivu ;
- use of imported fossile coal.

The first solution envisages a plant in the Kisangani area using the two main raw materials available on the site : iron ore and gas.

The second solution contemplates transporting the iron ore to the coast and the construction of the plant near the loading port for the products. In this case, it would also be possible to consider exporting the iron ore as such or in pellet form.

The presence in the Inga region of power stations, either in existence or in the planning stage, which are capable of supplying large quantities of energy cheaply to an area extending to the Atlantic coast, provides a choice between a conventional iron and steel works with blast furnaces and an electri-furnace plant.

The information available concerning the M'bomo mountains deposit only permits the formulation of a simple theory on the physical state of the ore mined. This implies a further diversification of the solutions depending on the grain of the ore. The following three solutions are considered :

Zaire solution A

Transport to the coast of large quantities of powdered ore, transformation of this ore into pellets, use of part of these pellets to feed the blast-furnaces and to produce steel by means of LD converters and continuous casting, export of unused pellets.

Zaire solution B

Transport to the coast of large quantities of fine calibrated ore, briquetting of fine ore, production of kig by electric furnaces operated on sinter, production of steel by LD converters ; export of blooms and unused calibrated ore.

Zaire solution C

Transport to Kisangani of fine calibrated ore ; briquetting of the fine ore ; production of spongy iron with the whole of the ore and then transformation into steel in arc furnaces and into blooms by continuous casting ; transport of blooms to loading port.

In solutions A and B, the mine production envisaged is 10 million tons per year, with a production of 4 million tons of blooms by blast furnaces and 3 million by electric furnaces, and export of unused ore.

In solution C, the mine production is limited to about 5 million tons in order to provide for the export of 3 million tons of blooms.

The following production capacities are envisaged for the projected plants (000 t/year) :

Plants	Gabon	Congo	Zaire A	Zaire B	Zaire C
Ore-briquetting	-	4.480	-	4.500	2.300
Pelletization	4.000	-	9.300	-	-
Coking	2.156	-	2.070	-	-
Electric furnaces	-	3.110	-	3.110	-
Blast-furnaces	4.147	-	4.150	-	-
Direct reduction	-	-	-	-	2.900
Steel works	4.320	3.240	4.320	3.240	-
Electric steel works	-	-	-	-	2.700
Continuous casting	4.000	3.000	4.000	3?000	2.500

III. Feasibility study

Investments

The investments covered in the study are under the following headings :

- installation cost (engineering expertise and spare parts included)
- interest on capital during construction
- working capital and plant commissioning expenses
- expenditure on training of personnel.

The installation costs were deducted from the European costs, applying an increase coefficient to take account of transport costs, higher local assembly costs and costs for civil engineering work.

These coefficients are as follows :

- sites served by a port : 1.28
- up-country sites : 1.32.

The interest on capital during construction is calculated at 15 % of the installation cost, corresponding to about 4 years of construction at a rate of 7.5 % according to the normal staggering of expenditure.

Working capital and plant-commissioning expenses have been added to the amount of investment and assessed at 9 % of the cost of the installation. The cost of training personnel was calculated on the basis of the number of personnel envisaged, calculating a cost per person of 4,000 dollars for specialized or skilled workers and 10,000 dollars for supervisory staff.

Investments

(millions of $)

	Gabon	Congo	Zaire A	Zaire B	Zaire C
Direct investment	655	419	659	427	442
Contingent expenses	83	58	93	58	66
Engineering	83	58	93	58	66
Training expenses	40	42	40	42	30
Commissioning	62	43	62	43	45
Interest on capital during construction	110	80	127	82	86
Total	1.033	702	1.074	712	735

Operating costs

The basic operating costs adopted in the calculations are listed below :

Raw materials

The costs of the iron ores free works are as follows :

- Gabon with enrichment	$/t	9.80
- Congo with enrichment	"	8.80
- Zaire A with secondary cruhing and pipeline	"	10.55
- Zaire B with rail and river transport	"	10.90
- Zaire C to Kisangani	"	3.15

For the reference solution in Europe, the average price for ores graded at 63 % Fe was estimated at 14.50 $/ton. Coking coal was estimated at 24 $/ton in Europe and 25 $/ton in Africa. Anthracite free Africa was estimated at 22 $/ton ; limestone at 5.5. $/ton in Europe, 7 in Gabon and the Congo, where the quarries are fairly close to the plant and 7.5 in Zaire where they are a little further away.

Electrical energy

In Europe, the average cost of 0.01 $/kWh was adopted ; in Gabon, bearing in mind that energy is home-produced, a fictitious price was adopted which was equal to the European price.

The solutions proposed for the Congo, Zaire A and Zaire B use the energy supplied by Inga. The cost of a kWh refers to the "Inga 2" stage which will increase the present installed power of 300 MW by 1,100 MW. By examining the various possible ways of financing the project, it is possible to calculate the minimum and mawimum cost bracket of a kWh at 3.5 to 4.5 mills (at the power station), estimating the cost of transporting energy to Banana and Pointe Noire at 0.5 and 1 mill respectively. The corresponding energy cost range at the two sites will be 4 to 5 and 4.5 to 5.5 mills.

The Zaire C solution on the other hand would use energy from the future Lulaba power station (Kisangani) for which - on the basis of available preliminary studies - a minimum and mawimum cost bracket may be estimated for one kWh of between 5 and 6 mills (including transport).

Manpower costs

For all the countries, a single cost of 1.1 $/h was adopted for direct manpower and 50 % of the overheads being accounted for costs of staff for the maintenance services and management.

Other operating costs

As concerns other expenses, the European values taken as basis values were increased by adapted corrective coefficients.

For the five solutions under consideration and for the European reference solution, the following is a summary of the details of the operating costs :

(10^6 t/year)

Solution	Gabon	Congo	Zaire A	Zaire B	Zaire C	Europe
Raw materials	201.0	132.0	212.5	140.5	108.0	241.2
Energy	–	35.31+43.17	4.0 + 5.0	31.39+39.40	10.2+12.25	10.9
Manpower	20.5	19.1	21.5	19.1	15.1	13.6
Overheads	41.8	33.1	40.7	32.7	35.3	35.2
Total annual expenditure	263.3	219.51+227.37	278.7+279.7	223.69+231.70	168.6+170.65	273.9
Production in 10^6 t/year	4	3	4	3	2.5	4

As regards the cost of transport, on the basis of studies in course at present with a view to using specially designed ships, transport from Africa to Europe of blooms in vessels of about 80,000 dwt may be estimated at about 5 $/ton.

Receipts

If there is not really an international steel bloom market – since each producer is also a consumer and only buys and sells blooms abroad when his own production/consumption equilibrium is temporarily upset – it is not right to draw up a profitability analysis of bloom production as such. In fact, the product, which has no further uses other than as intermediary stage in production, is only profitable insofar as the finished products themselves are profitable, since it is these and not the blooms which are the object of production and sale.

The advantages and disadvantages of steel bloom production in the AASM must be considered from the point of view of production cost, by comparing this with what the European cost would be for identical production.

Solutions	Gabon	Congo	Zaire A	Zaire B	Zaire C	Europe
Unit cost $/t	102.25	108.45+111.07	105.96+106.21	111.36+113.98	117.91+118.75	92.08
Local currency	31.36	36.38	36.60+36.85	49.40+52.02	58.38+59.22	–
Foreign currency	70.89	72.17+74.79	69.36	61.96	59.53	–
Production 10^6t/year	4	3	4	3	2.5	4

In the present situation and on the basis of unit costs of production alone, it is not possible to state definitely that an export primary iron and steel industry in the AASM would be competitive with a similar European iron and steel industry. In fact, there are numerous major risks which will give cause for pessimism at the present stage of the studies and which impose on the assessment of the unit cost of the blooms produced in Africa a margin of uncertainty which could probably be as large as 10 %.

Added value

Given that it is not possible to define the amount of annual plant receipts, it is not possible either to calculate two of the elements which make up the added value, i.e. the "net profit" and "taxation". However, it is possible to estimate the other two elements: wages and salaries on the one hand, depreciation and financing expenses on the other hand.

Added value

Solutions	(a)	(b)	(c)
Gabon			
Local currency	14,381	18,225	32,605
Foreign currency	7,008	107,460	114,468
Total	21,389	125,685	147,074
Congo			
Local currency	14,986	14,355	29,431
Foreign currency	6,264	80,325	86,589
Total	21,250	94,680	116,020
Zaire A			
Local currency	17,626	18,090	35,716
Foreign currency	8,008	106,650	114,738
Total	25,714	124,740	150,454
Zaire B			
Local currency	14,171	14,715	28,886
Foreign currency	6,264	81,405	87,669
Total	20,435	96,120	116,555
Zaire C			
Local currency	11,429	14,445	25,874
Foreign currency	4,800	84,780	89,580
Total	16,229	99,225	115,454

(a) wages
(b) technical depreciation and return on capital
(c) (a + b)

The element "amortization and financing expenses" was estimated at 13.5 % of the investment cost, both in foreign and local currency. It is made up of the following :

- 5 % for technical depreciation, taking the technical life of the iron and steel complex as 20 years
- 8.5 % for return on capital.

Effects on employment

Taking account of the investments proposed and the number of personnel, it is possible to calculate the value of the relationship "investment/employment".

Solution	Gabon	Congo	Zaire A	Zaire B	Zaire C
Investment 10^6 $	931	702	924	712	735
Number of persons	5,240	5,650	6,510	5,650	4,300
Investment/person 10^6 $/person	0.177	0.124	0.141	0.126	0.170

Effects on balance of payments

The proposal for an iron and steel industry geared exclusively to export will not have an effect of "import-substitution" in the trade balance, but it will trigger a large increase in foreign trade receipts, which will be offset only in part by payments abroad in the form of financial amortization and of dividends transferred to shareholders.

C. FERRO-ALLOYS

A study of the possibilities of building plants to produce ferro-alloys in some of the Associated States is devoted to three products, all widely used in the iron and steel industry : ferro-silicon, ferro-manganese and ferro-nickel. Each of these products has certain characteristics which make it a good example of the kind of ferro-alloys which can be produced in the AASM.

The ferro-alloies sector

The ferro-alloies sector includes a whole range of products which are essentially different according to the part they play in the iron and steel industry, and by the amount of them consumed.

This study considered the kinds of ferro-alloys which have the following features :

A - products of a low technical level and widely consumed

B - products which the Community is at present obliged to import (and in all likelihood will be in the future)

C - products which use large quantities of electrical energy in their manufacturing process

D - products which use other resources, namely raw materials, which would be widely available in the AASM countries.

Thus the following were chosen : ferro-silicon, ferro-manganese and ferro-nickel.

The most important resource for the production of ferro-alloys is without a doubt electrical energy. This exists in some of the Associated States, but the information available on this subject was not always enough to allow the calculation in realistic terms of the cost price of the energy needed in the industrial manufacturing processes. Because of this, it was necessary to make certain working hypotheses as far as evaluation of this prime cost is concerned.

Ferro-silicon

In the iron and steel industry ferro-silicon acts as a deoxidising and degasifying agent in steel production (silicon can be added in the form of ferro-silicon or ferro-silico-manganese) and as a constituent element in cast-iron alloys and special steel alloys (steel for magnetic sheets, rough castings, steel alloys).

Ferro-silicon consumption is always proportionate to steel production.

Apparent ferro-silicon consumption in the Community

(000 t)

	1967	1968	1969	1970	1971
The Community of the Six	262	392	420	432	405
The Community of the Nine	477	513	543	562	512
World total	2,056	2,167	2,288	2,375	2,373

On the world level, the average specific consumption of ferro-silicon is about 4 kg per ton of raw steel for all years considered.

Statistics on world production capacities for ferro-silicon are available only for 1971, the highest installed production capacity being for 75-80 % ferro-silicon.

In 1971, the average utilization rate of plants was 75 % ; the rate registered in the Community of the Six -Great Britain, Denmark and Ireland are not producers) was 85 %.

(000 t)

	Percentage in ferro-silicon				
	45-60	65	75-80	90	Total
The Community of the Six	62	131	150	17	360
The Community of the Nine	62	131	150	17	360
World total	965	495	1,528	160	3,168

Production capacity is divided as follows among the producing countries of the Community (1971).

(000 t)

	Percentage in ferro-silicon				
	45-60	65	75-80	90	Total
Germany	17	4	23	5	49
France	31	120	80	8	239
Italy	14	7	47	4	72

Traditionally there are two areas of ferro-silicon buyers : the Community and the European socialist countries which are members of Comecon. The latter have only one supplier, the Soviet Union, while the Community calls on various suppliers the world over.

Forecasts for ferro-silicon consumption coincide solely with those for steel production. The present study adopts the forecasts made by IISI (International Iron and Steel Institute) in order to determine the approximate size of the Community's future demand for steel and deduces from this the volume of the future demand for ferro-silicon.

The forecast for ferro-silicon consumption is based on the forecasts concerning the iron and steel products incorporating ferro-silicon.

Community of the Nine - Forecasts for ferro-silicon consumption in terms of silicon at 100 %

(in tons)

	1970	1975	1980	1985
Consumption for				
- magnetic sheets	44,840	49,000	55,320	61,000
- rough castings	62,130	66,360	71,400	77,400
- stainless steel	31,000	46,600	70,000	105,400
- steel alloys	73,350	110,430	165,600	249,600
- reduced steel	165,600	192,600	232,800	276,100
Total silicon consumption	376,920	464,990	595,120	769,500

Assuming that the rate of plant utilization stays the same as in 1971, it is possible to estimate the production capacity to be established inside the Community (home production) and outside (imports). Assuming that the breakdown between the different types of ferro-silicon remains constant, the capacities to be reached for the 75-80 % type are as follows :

Production capacity required according to Community consumption forecasts (ferro-silicon 75-80 %)

(ton/year)

	1975	1980	1985
A - Installed capacity inside the Community	158,400	204,600	267,000
B - Installed capacity outside the Community	105,600	136,400	178,000
C - Installed capacity outside the Community of the Nine	169,600	215,400	272,000

Over recent years there has been a constant increase in ferro-alloy prices. The following are the Community import prices with the exception of France, whose imports are negligible.

Average import values (CIF)

Year	Germany (1)		Belgium-Luxembourg (2)		Italy (2)		Great Britain (1)	
	DM/t	$/t	FB	$/t	Lit x 1,000	$/t	£/t	$/t
1967	640	160	8,300	168	89.7	144	60.3	145
1968	628	157	8,100	162	112.6	181	66.7	159
1969	677	184	8,400	169	90.8	145	68.1	163
1970	879	241	10,100	203	123.0	198	88.2	211
1971	855	235	11,100	221	136.9	219	97.5	233

(1) Ferro-silicon 75-80

(2) Average price for each type of ferro-silicon

Ferro-manganese

The iron and steel industry creates the largest demand for manganese. Among the different forms in which manganese is used in the industry, it has been estimated that about 90 % of the manganese ore consumed in the world is used in the form of ferro-manganese.

The ferro-alloy considered in this study is "standard" ferro-manganese, i.e. with a high carbon content, which can be produced in a blast-furnace (the technique now most widespread) or in an electric furnace.

Below is a table showing world production of manganese ore for the five year period 1966-1970. Only one Community country, Italy, produces a few tens of thousands of tons, while the AASM countries are well represented by Gabon, Ivory Coast and Zaire, which together produce slightly under 10 % of the world total.

	1966	1967	1968	1969	1970
					(000 t)
Community of the Nine (Italy)	44	47	51	53	50
AASM	1,690	1,568	1,693	1,801	1,807
- Gabon	1,274	1,147	1,254	1,363	1,460
- Ivory Coast	176	150	117	127	-
- Zaire	240	271	322	311	347
World total	18,670	17,600	17,800	18,500	19,100

However, the Community as a whole is an important producer of ferro-manganese : over a million tons per year.

The trade situation for ferro-manganese is different to that for ferro-silicon : the import-export situation for the Community of the Six is practically in balance while that of the Community of the Nine is in deficit.

Evaluation of world ferro-manganese production for 1970

Belgium	140
France	540
Germany	260
Italy	28
Total Community of the Six	968
Great Britain	171
Total Community of the Nine	1.139
World total	4.135

As in the case of ferro-silicon, ferro-manganese consumption is closely linked to steel production. The same forecast of steel production and the specific ferro-manganese consumption per ton of raw steel, calculated over the period 1960-1971, enable us to estimate the capacity of plants to be constructed between now and 1985 (considering as practically installed the means of production necessary to satisfy the Community demand in 1975 and calculating on the basis of an average plant utilization factor of 75 %).

			(000 t)
	1975	1980	1985
Installed production capacity			
- Community of the Six	1,120	1,280	1,450
- Community of the Nine	1,500	1,700	1,900

Consequently, the total new production capacity to be installed between 1975 and 1985 is $1,450 - 1,120 = 330 \times 10^3$ t/year and $1,900 - 1,500 = 400 \times 10^3$ t/year for the Communities of the Six and of the Nine respectively.

It is known that until now the Community itself has tended towards home production. As a result, recourse to large quantities of ferro-manganese produced outside would be a new departure for the Community's iron and steel industry.

Until 1970 price rises in standard ferro-manganese were practically insignificant. Over the last three years prices have risen by more than 20 %, mainly between 1970 and 1971. Numerous factors have contributed to this increase, among them, for example, raw materials and labour costs. More recently (1972-1973), prices have tended to become stabilized around the 1971 level.

Year	France	Germany	Italy	Great Britain
	F/t	DM/t	Lit/kg	£/t
1972	960	590	125	67.5
1973	965	595	127	67.5

Ferro-nickel

Ferro-nickel was considered because it is, in a certain sense, an extreme case as far as the electrical energy requirements necessary for its production is concerned. This can reach more than 20,000 kwh/t for the type containing 25 % nickel. From this point of view it is a perfect "example" for studies concerning the use of concentrated quantities of electrical energy.

For this purpose one only needs to estimate the order of magnitude of the future demand for nickel as a pure element as it is of little importance whether it is the alloy or the nickel which is in fact used.

Nickel production and consumption is situated in France and Germany for the Community of the Six and in Great Brotain for the new partners.

France produces almost all the nickel of the Community of the Six ; Great Britain alone produces approximately three times as much as the Community of the Six.

In terms of consumption, however, the Community of the Six, and mainly France and Germany, is more important than Great Britain. Great Britain's consumption during 1969/70/71 was half the total of that of the Community of the Six.

Refined nickel production in the Communities of the Six and the Nine

			(t)
Country	1969	1970	1971
Germany	474	565	219
France	8,925	10,952	9,941
Total Community of the Six	9,399	11,517	10,160
Great Britain	29,965	36,709	38,713
Total Community of the Nine	39,086	48,226	48,873
Source : OECD			

Refined nickel consumption in the Communities of the Six and the Nine

			(t)
Country	1969	1970	1971
Germany	26,171	31,898	27,838
Belgium-Luxembourg	1,700	3,200	2,000
Netherlands	621	953	723
France	31,839	36,071	32,211
Italy	16,200	19,800	18,000
Total Community of the Six	76,531	91,922	80,772
Great Britain	27,174	38,323	28,794
Total Community of the Nine	103,705	130,245	109,566
Source : OECD			

The average annual growth rate in world demand for nickel over the period 1970/2000 has been estimated at between 2.8 and 4 %, and even as high as 5 %. For sake of caution the rate adopted by this study is 2.8 %.

Demand by the Communities of the Six and the Nine, their production capacity following present trends, and imported supplies of refined nickel may be estimated as follows :

	Community of the Six		Community of the Nine	
	1975	1985	1975	1985
Demand	90,000	120,000	123,000	162,000
Production	11,000	15,000	49,000	65,000
Imported supplies	79,000	105,000	74,000	97,000

Taking into account an assumed plant utilization factor of 85 %, the following means of production will have to be installed in the Community between 1975 and 1985.

Community of the Six : $\frac{105,000 - 79,000}{0.85}$ = 31,000 tons of nickel per year

Community of the Nine : $\frac{97,000 - 74,000}{0.85}$ = 27,000 tons of nickel per year

In terms of ferro-nickel at 25 % these figures become about 120,000 and 100,000 t/year respectively.

As in the cases of ferro-silicon and ferro-manganese, the problem of plant size can be solved by using technical criteria, as long as the quantities indicated are note exceeded.

Current nickel prices

At the moment the average price for pure nickel in France and Great Britain is 14,650 F and £1,400 per ton respectively (about $ 3,300 per ton).

The price of 25 % ferro-nickel can be considered as being approximately $ 825 per ton, or a quarter of the current price of pure nickel.

Construction possibilities in the AASM

The countries interested in the possible construction of an ferro-alloy plant are Zaire, Gabon and the Congolese Republic.

Zaire

The availability in the Inga area of large quantities of cheap electrical energy and of siliceous materials of adequate quality, as well as the existing transport infrastructure (railway and the ports of Matadi and/or Banana, which will soon be completed) make possible the production of ferro-silicon (of the standard 75 % type),

The sites of the plants, taking into account the considerable quantities of raw materials necessary, will be chosen near the quartzite mines, i.e. in the Lufu-Monolithe area.

As there are interesting deposits of nickel ore of seemingly suitable quality around Kananga, and as there exists in the immediate area a continuous HT power line linking the Inga installations and the consumers in the Shaba region (to be completed soon) nickel-alloy production is equally worth considering.

Gabon

As far as silicon alloy production is concerned, the only site which was considered among the various possibilities is at Mayumba.

Mayumba is an ocean port, near the Tchibanga iron and quartzite deposits and near enough to the Chutes de l'Impératrice installations (under study) to dispose of the necessary energy unburdened with excessive transport costs.

Republic of Congo

On the basis of the following considerations :

- possibility of the ready availability of the electrical energy supplied by the Inga hydroelectric installations (Zaire)
- absence of precise information on the silicon or quartzite deposits
- the availibility locally of manganese ore from Gabon which is transported from Moanda via Pointe-Noire, the study considered only ferro-manganese production.

The plant can only be built at Pointe-Noire, through which the manganese-ore has to pass.

Table of solutions considered

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)
Fe-Si 75%								
Zaire	Lufu	2 x 40,000	63	coke	loc. min.	Inga	SZLKM 1	1
"	"	"	"	"	imp. min.	"	" 2	2
"	"	"	"	charcoal	loc. min.	"	SZLHM 1	3
"	"	"	"	"	imp. min.	"	" 2	4
"	"	"	"	anthracite	loc. min.	"	SZLAM 1	5
"	"	"	"	"	imp. min.	"	" 2	6
"	"	"	"	coke	scrap iron	"	SZLKF	7
Gabon	Mayumba	"	"	"	loc. min.	ref.	SGMKM 1	8
"	"	"	"	charcoal	"	"	SGMHM 1	9
"	"	"	"	anthracite	"	"	SGMAM 1	10
"	"	"	"	coke	scrap iron	"	SGMKF	11
Fe-Mn 77%								
Gabon	Libreville	2 x 25,000	130	imported coke	loc. min.	ref.	MGLKM 1	12
"	"	"	"	local coke	"	"	" 2	13
"	"	"	"	imported coke	"	loc.	" 3	14
"	"	"	"	local coke	"	"	" 4	15
"	"	"	"	charcoal	"	ref.	MGLHM 1	16
"	"	"	"	"	"	loc.	" 2	17
"	"	"	145	coke	scrap iron	ref.	MGLKF 1	18
"	"	"	"	"	"	loc.	" 2	19
"	"	"	"	charcoal	"	ref.	MGLHF 1	20
"	"	"	"	"	"	loc.	" 2	21
"	"	"	130	anthracite	loc. min.	ref.	MGLAM 1	22
"	"	"	"	"	"	loc.	" 2	23
"	"	"	145	"	scrap iron	ref.	MGLAF 1	24
"	"	"	"	"	"	loc.	" 2	25
Congo	Pointe-Noire	"	"	coke	"	Inga	MCPKF	26
"	"	"	"	charcoal	"	"	MCPHF	27
"	"	"	"	anthracite	"	"	MCPAF	28
Fe-Ni 25%								
Zaire	Kananga	2 x 50,000	32	coke		Inga	NZKK	29
"	"	"	"	charcoal		"	NZKH	30
"	"	"	"	anthracite		"	NZKA	31

(a) site
(b) furnaces (n x kVA)
(c) production (10^3 t/year)
(d) reducing agent
(e) iron
(f) electrical energy
(g) reference code
(h) n° of solution

imp. min. = imported ore
loc. min. = local ore

electrical energy ref. = reference price
electrical energy loc. = official price

Feasibility studies

The dimensions of the plants have been fixed close to the maximum values allowes by present day technology so that the maximum economy of scale comes into play.

- ferro-silicon : two electric furnaces of 40,000 kVA to produce 63,000 t/year of ferro-silicon, 75% in Si
- ferro-manganese : two electric furnaces with a total installed power of 50,000 kVA to ensure a production of 130,000 t/year (if iron ore is used) or 145,000 t/year of standard Fe-Mn 77% (if scrap iron is used)
- ferro-nickel : two furnaces of 50,000 kVA to produce 32,000 t/year of ferro-nickel, 25% nickel.

For each proposed the study included different production alternatives based on the variation in the following factors :

- raw materials : the possibilities considered foresee the use of local imported ore or of scrap to supply the iron
- reducing agents : the choice is between coke, anthracite and charcoal
- energy : the alternatives are the prices stated officially and a very low price which could be obtained under special conditions (for Gabon exclusively).

Only the most interesting solutions under study will be explained and commented on below.

Investment costs

The following items were considered in determining net investment costs for setting up plants ready to go into service :

- plant equipment, initial stock of spare parts and various accessories for the plants
- civil engineering
- assembly
- engineering
- contingencies margin.

To evaluate gross investment costs the following items were considered :

- interests during construction, evaluated at the rate of 7.5 % of the net cost of the plants over a construction period of about 24 months (equal in all cases) according to a standard staggering of expenditure.
- commissioning expenditure, calculated as a lump sum of about 10% of annual operating costs,

- personnel training expenditure, calculated on the basis of the complexity of the plants and the number of persons employed.

- working capital, evaluated as about 4 months production costc in all cases.

The investment costs are broken down in the following table :

Investment costs

Siting	Lufu Zaïre	Libreville Gabon		Pointe-Noire Congo	Kananga Zaïre
Plant :	Fe-Si 75 %	Fe-Si 75 %	Fe-Mn 77 %	Fe-Mn 77 %	Fe-Ni 25 %
Installed power kVA	2 x 40,000	2 x 40,000	2 x 25,000	2 x 25,000	2 x 50,000
Ferro-alloy production t/year	63,000	63,000	130,000 145,000	130,000 145,000	32,000
Net investment :					
- plant equipment and initial stock, spare parts	7.01	7.01	4.70	4.70	9.49
- civil engineering work	6.50	6.32	5.13	5.13	10.60
- assembly	1.97	1.88	1.37	1.37	2.82
- miscellaneous, not given in detail	1.11	1.11	0.86	0.86	1.62
- engineering	0.94	0.94	0.68	0.68	2.05
- contingency	1.28	1.28	0.94	0.94	2.05
Total net investment	18.81	18.54	13.68	13.68	28.03
Additional expenditure :					
- interests during construction	1.32	1.28	0.94	0.94	1.88
- commissioning	0.09	0.09	0.09	0.09	0.21
- personnel training	0.13	0.13	0.09	0.09	0.17
- working capital	0.43	0.43	0.17	0.17	0.56
Total gross investment	20.18	20.47	14.97	14.97	30.85

Operating costs

The criteria used in evaluating the operating costs are the same as those used in the iron and steel sector. Electrical energy was studied in greater detail.

As stated above, Zaire uses energy from Inga ; the estimated cost per kwh refers to the "Inga 3" phase, for which the final installed power will be about 2,600 MW. On the basis of the possible schemes for financing this undertaking, a minimum cost of 3,5 mill per kwh and 1 mill per kwh free Pointe-Noire.

In Gabon it was assumed that energy from les Chutes de l'Impératrice (in the advanced study phase) and Okanda (in the preliminary study phase) would be used. For the first installation only the Gabon government authorities estimated the cost price of energy free Libreville at 8 mills per kwh, and at 12,6 mills per kwh free Maymba.

Given that these cost prices seem very high, even compared with European costs, and that they would jeopardize the profitability of possible ferro-alloy production in Gabon, it was nonetheless considered worthwhile to take as a basis for first approximate calculations prices per kwh equal to those which can be obtained at Inga.

Production factor costs

Item	Unit	Gabon	Congo	Zaire	Free	DL	DE
Raw materials							
Iron ore (63%)	\$/t	9.80	-	-	Libreville	x	
	"	8.80	-	-	Mayumba	x	
	"	-	-	10.50	Lufu	x	
	"	-	-	14.50	Lufu		x
Scrap iron	"	-	50.00	-	Pointe-Noire		x
	"	50.00	-	-	Libreville		x
	"	-	-	54.00	Lufu		x
Manganese ore (45%)	"	14.80	-	-	Libreville	x	
	"	-	16.80	-	Pointe-Noire		x
	\$/h	-	-	7.5	Lufu	x	
	"	7.5	-	-	Mayumba	x	
Reducing agents							
Charcoal (80%)	\$/t	32.00	-	-	Libreville	x	
	"	-	32.00	-	Pointe-Noire	x	
	"	-	-	32.00	Lufu and Kananga	x	
Coke (88%)	"	54.00	-	-	Libreville		x
	"	44.00	-	-	Libreville	x	
	"	-	54.00	-	Pointe-Noire		x
	"	-	-	58.00	Lufu		x
	"	-	-	62.00	Kananga		x
Anthracite (80%)	"	22.00	-	-	Libreville and Mayumba		x
	"	-	22.00	-	Pointe-Noire		x
	"	-	-	26.00	Lufu		x
	"	-	-	30.00	Kananga		x
Electrical energy	\$/Kwh	0.0045	-	-	Libreville	x	
	"	0.0084	-	-	Libreville	x	
	"	0.0045	-	-	Mayumba	x	
	"	0.0126	-	-	Mayumba	x	
	"	-	0.0045	-	Pointe-Noire		x
	"	-	-	0.0040	Lufu	x	
	"	-	-	0.0065	Kananga	x	
Others							
Lime	\$/t	14.00	-	-	Libreville	x	
	"	-	14.00	-	Pointe-Noire	x	
Electrode casings	\$/kg	0.270	0.270	0.270	-		x
Electrode solder	"	0.120	0.120	0.120	-		x

Production costs for ferro-silicon

The unit costs per ton of ferro-silicon delivered CIF European port (minimum total cost and minimum cost in foreign currency) are as follows :

($/t)

Plant in	Solution	Unit cost		
		National currency	Foreign currency	Total
Lufu				
- minimum total cost	(5)	75	117	192
- minimum cost in foreign currency	(3)	110	88	198
Mayumba				
- minimum total cost	(10)	79	112	191
- minimum cost in foreign currency	(9)	115	88	203

The two sites under consideration Lufu (Zaire) and Mayumba (Gabon) both offer as a minimum cost solution the use of local ore and imported anthracite.

The two solutions are 15% cheaper than the most unfavourable ones (which would use scrap iron and imported coke). They are not, however, the most favourable from the point of view of the breakdown of the costs in national currency and in foreign currency.

From this point of view the use of local charcoal instead of particularly expensive imported reducing agents is a decisive factor if the costs in foreign currency are to be diminished.

It should be remembered, however, that for the Mayumba solutions a first approximate estimate was used to evaluate electrical energy at a total cost of US $ 0.0045/kwh.

If, on the other hand, the official value of $ 0.0126/kwh were used as a basis, the total minimum cost of Makumba ferro-silicon would be (0.00126 - 0.00045) x 9,000 = $ 73 per ton higher than the total indicated above, i.e. a total of 191 + 73 = $ 264 per ton.
As the sail price has been fixed at $ 270 per ton it is obvious that the official estimate of the energy cost for Mayumba would exclude this site.

Production costs for ferro-manganese

Assuming a capacity of 130,000 t/year, the estimate of unit costs for the minimum and maximum solutions is as follows :

($/t)

	Solution	Unit cost		
		National currency	Foreign currency	Total
Total maximum cost	(14)	75	67	142
Total minimum cost	(22)	40	75	115
Minimum cost in foreign currency	(22)	74	47	121

For a capacity of 145,000 t/year the figures are :

($/t)

	Solution	Unit cost		
		National currency	Foreign currency	Total
Libreville				
Total minimum cost	(24)	43	70	113
Minimum cost in foreign currency	(24)	43	70	113
Pointe-Noire				
Total minimum cost	(28)	12	93	110
Minimum cost in foreign currency	(27)	30	85	115

In terms of minimum total unit costs, the solutions at 130,000 t/year and at 145,000 t/year seem to be equally valid in the case both of Gabon and of the Congolese Republic. The Congolese solution, however, offers a national/foreign currency distribution which is clearly less favourable than that of the best Gabonese solution.

Production costs for ferro-nickel

On the basis of the data available, it is impossible at present to carry out an adequate analysis of garnierite ore which would be representative of the whole of the deposits in Zaire, or to evaluate the cost of working it.

As a result of this there are two important elements in the evaluation of the ferro-alloy production costs which are imprecise : the cost of the ore to charge the furnaces (the unit cost and specific consumption are unknown) and the cost of the electrical energy consumed (the specific energy consumption, which depends on the ore, is unknown).

It can be assumed, as an initial approximation, that the other cost factors do not depend on the properties of the ore : i.e. labour, overheads, such as the maintenance of auxiliary services, the cost of reducing agents, electrode casings and solder, transport and marketing.

These costs for the three solutions under consideration, which differ according to the reducing agent used, are laid out below :

($US per year)

Solutions	NZKK 29	NZKH 30	NZKA 31
Total costs (1)			
National currency	1,563,730	2,352,210	1,563,730
Foreign currency	9,737,730	8,348,930	9,088,130
Total	11,302,460	10,701,140	10,651,860

(1) excluding energy and ore

Production receipts

The reference prices chosen for calculating the annual volume of receipts are as follows :

- $ 270/t for 75% ferro-silicon
- $ 200/t for 80% ferro-manganese
- $ 825/t for 52% ferro-nickel.

These prices are Cif European port.

Private profitability

Simple investment profitability, i.e. the relation between net operational profit and the initial investment, was used to evaluate the private investment interest.

It was only possible to calculate this for ferro-silicon and ferro-manganese. The following figures were obtained for the best solutions :

Ferro-silicon

Solutions		SZLHM1 (3)	SZLAM1 (5)	SGMHM (9)	SGMAM (10)
Receipts	$/year	17,010,000	17,010,000	17,010,000	17,010,000
Total costs	$/year	12,514,000	12,100,000	12,760,000	12,021,000
Gross margin	$/year	4,496,000	4,910,000	4,250,000	4,989,000
Gross profit rate	%	21.6	23.6	20.8	24.4
Taxes on profit	$/year	2,248,000	2,455,000	2,125,000	2,499,500
Net profit rate	%	10.8	11.8	10.4	12.2

Ferro-manganese

Solutions		MGLKM3 14	MGLAFI 24	MGLAM1 22	MCPHF 27	MCPAF 28
Receipts	$/year	26,000,000	29,000,000	26,000,000	1,900,000	1,900,000
Total costs	$/year	17,184,400	16,423,900	14,934,500	16,740,500	15,827,000
Gross margin	$/year	8,815,600	12,576,100	11,065,500	12,259,500	13,173,000
Gross profit rate	%	58.9	84.0	73.8	82.0	88.0
Taxes on profit	$/year	4,407,800	6,288,050	5,532,750	6,129,750	6,586,500
Net profit rate	%	29.4	42.0	36.9	41.0	44.0

Added value

The added value is a pointer to the interest for the collectivity in undertaking the project.

Of the two components, national currency and foreign currency, it is foreign currency which is the most important ; the ratio between the two amounts is about 1.4 for ferro-silicon and 1.3 for ferro-manganese.

Local added value (as a percentage of the investment) is high, especially for ferro-manganese. There is a slight difference between the highest and lowest ratios obtained from all the solutions studied.

Ferro-silicon

Solutions	SZLAM1 5	SZLHM1 3	SGMHM 9	SGMAM 10
Wages				
National currency	935,000	935,000	935,000	935,000
Foreign currency	960,000	960,000	960,000	960,000
Amortization and financing expenses				
National currency	437,370	437,370	437,710	437,710
Foreign currency	1,993,430	1,993,430	1,962,120	1,962,120
Taxes				
National currency	2,455,000	2,248,000	2,125,000	2,499,500
Foreign currency	–	–	–	–
Net profit				
National currency	2,455,000	2,248,000	2,125,000	2,499,500
Foreign currency	2,455,000	2,248,000	2,125,000	2,499,500
Total added value				
National currency	3,827,370	3,620,370	3,490,710	3,855,210
Foreign currency	5,408,430	5,201,430	5,047,120	5,421,620
Total	9,235,800	8,821,800	8,537,830	9,276,830
Local added value x 100 / Investment (%)	18.4	17.4	17.1	18.8

Ferro-manganese

	MGLKM3 14	MGLAM1 22	MGLAF1 24	MCPHF 27	MCPAF 28
Wages					
National currency	636,350	636,350	636,350	636,350	636,350
Foreign currency	1,106,300	1,106,300	1,106,300	1,106,300	1,106,300
Amortization and financing expenses					
National currency	318,100	318,100	318,100	318,100	318,100
Foreign currency	1,767,200	1,767,200	1,767,200	1,767,200	1,767,200
Taxes					
National currency	4,407,800	5,532,750	6,288,050	6,129,750	6,586,500
Foreign currency	-	-	-	-	-
Net profit					
National currency	-	-	-	-	-
Foreign currency	4,407,800	5,532,750	6,288,050	6,129,750	6,585,500
Total increase in value					
National currency	5,362,250	6,487,200	7,242,500	7,084,200	7,630,950
Foreign currency	7,281,300	8,406,250	9,161,550	9,003,250	9,370,000
Total	12,643,550	14,893,450	16,404,050	16,087,450	17,000,950
Local increase in value x 100 / Investment (%)	35.8	43.3	48.4	47.3	51.0

Ferro-nickel cannot be evaluated like the other two ferro-alloys because of uncertainty about the cost of the ore and energy consumption. Everything points to the possibility of achieving a modest profitability level.

Conclusions

It can be concluded from feasibility calculations that ferro-alloy production in the AASM is worth a deeper study, at least as far as ferro-silicon and ferro-manganese are concerned. Ferro-nickel is at the moment of less immediate interest because of relative uncertainty about the properties of the ore in the Kananya deposits (Zaire).

The sites studied seem more or less equal in value, both from the point of view of profitability (private interests) and of added value (collective interests). Only deeper research, particularly into energy and transport costs, would make it possible to specify exact sites.

There is very little difference in the cost prices of ferro-alloys produced in the AASM and European cost prices. As all production factors, except energy, are more expensive in Africa than in Europe, it seems quite clear that it is only electrical energy which can counteract the higher costs of African sites.

The importance of this fact is even more obvious if it is considered that in the long term the differences between the costs of production factors in Africa and Europe, such as capital and personnel, will tend to decrease as the infrastructures and the workers skills improve, while the differences between energy costs will no doubt tend to increase.

The high profit margins for ferro-manganese which exist in the AASM (40% against 10-12% for ferro-silicon) also exist in Europe, for they compensate the high risks of such an industrial undertaking, which is constantly up against the relative uncertainties of ore supply and of evaluating the economic situation of the iron and steel industry in which any change becomes apparent only over long periods.

Ferro-silicon production in the AASM is encouraging enough to attract companies or a consortium of companies operating in this sector.

Ferro-manganese production, however, seems to be the kind of operation to be undertaken by a consortium in order to spread the risks inherent to the undertaking and reduce them to an acceptable level.