UKRAINE

OUTLINE OF A SOCIAL, ECONOMIC AND TECHNICAL AUDIT OF THE KRIVOI ROG IRON AND STEEL BASIN

Study proposal prepared with the collaboration of CERNA

JANUARY 1993
This document describes a possible framework for a social, economic and technical audit of the Krivoj Rog iron and steel basin in the Ukraine. The objective of this audit should be a contribution to the establishing of a master plan for the restructuring of the Krivoj Rog iron and steel basin.

It is our opinion that this should involve the definition of new institutional structures in order to rescue the social functions and to break-up the existing Combinates without causing huge losses of employment and social disruption. It is only if such new institutions are created, that it will possible to consider the industrial restructuring of productive functions and these are, by all standards, only a small part of the total system. The definition and implementation of new structures can only be done by nationals and therefore any audit of this nature requires the active participation of a Ukrainian counterpart.

The ideas that are given in this document result from the various contacts in relation to the Krivoj Rog iron and steel basin, in which Sofremines has been involved during 1992. One of these occasions was with CERNA, a French research organisation linked with the School of Mines of Paris; CERNA specialises in the industrial and social organisation of natural resource sectors and has recently taken part in the transformation of social and economic structures in post communist countries. In may 1992, CERNA undertook a preliminary survey of the Krivoj Rog iron and steel basin, the most significant aspects of which are summarised hereafter.

Sofresid and Sofremines also participated in the deep changes that affect the ex-eastern block countries, namely Czechoslovakia, Poland and Rumania. In Czechoslovakia and Rumania, Sofresid participated in the study and formulation of recommendations to restructure the steel industry. Sofremines participated in several missions to survey the coal mining industry of Czechoslovakia.

It will be understood that the methods discussed could apply to any socialist integrated industrial complex (for which we use the French word of Combinate), be it in any of the post communist countries, or in Africa.

In the event these ideas should be deemed relevant, Sofremines would propose to put up the most appropriate structure in order to expand the present document and establish a commercial proposal.
The Krivoj Rog iron and steel basin is an extensive industrial region that stretches 120km along the Ingulets river, a tributary of the Dnepr river. The region is approx. 400km from the mouth of the Dnepr on the black sea, opposite the island of Crimea. The basin is around 40km wide and its population is 850,000.

The economic importance of the region is due to the presence of iron-ore which was developed and exploited at large scale in the late 19th century with French and Belgian capital. After the revolution of 1917, it became a major source of supply of iron-ore to the Ukrainian steel industry. Iron ore mining operations are conducted in 9 large size open pit mines and 17 smaller underground mines. In 1990 the production of ROM ore was approx. 155 million t by surface methods and 35-40 million t by underground mining, making a total of around 190 million t.

The ore mined is low grade (32-35% Fe) and therefore needs to be upgraded to make it possible to be used in modern steel processes. The annual capacity of concentrated ore (55-60% Fe) in the present technical and economic conditions is about 90 million t.

Today as inherited from the past communist regime, the 9 open-pit mines belong to 5 Combinates and the 17 underground mines to 3 Combinates. A Combinate (GOK in Russian) is the basic economic and social institution of the communist state. It encompasses not only those production activities that are directly related to its official objectives (e.g. iron-ore, steel products, manufacturing of industrial and military equipment) but many other activities. There are activities required to support the main production e.g. engineering of most of the installations and equipment used, as well as manufacturing of spare parts and of most of the inputs (e.g. refractories). There are also all the social activities e.g. schools, hospitals, leisure centres etc.

The Combinates report to a central planning organisation at Kiev (Ukrudprom) which belongs to the ministry of metallurgy. This system plans and centralises the production of iron and steel and the allocation of resources. Formerly, the structure reported to the Gosplan and ministry of Metallurgy at central level and through this, to the Party.
The Combinate is therefore a small state within the communist state. Its purpose is not only to produce goods but to serve the "well" being of the people it employs, provide them with goods and services for consumption, education, welfare, leisure and so on. In the liberal democratic state with market economy, social and economic structure is divided into a multitude of institutions that are all linked by contractual relations governed by the laws of the country. And all these function with the consensus of all actors of the society.
Figures 1 and 2 show the structure of surface and underground production of ore, by mine and Combine.
In addition to the iron-ore Combinates, there is a steel Combine, Krivorostal, which is a vast steel complex for producing long products. This Combine which employs about 30,000 people, has 4 large pelletising plants, 9 blast-furnaces of which N° 9 is the largest in the world (14.7m diameter and 5,000m3 volume), 2 steel melting shops (1 open hearth and 1 oxygen), 3 roughing mills (blooms), 2 billet mills, 6 light section and bar mills, 3 wire & rod mills, and one hot strip mill for thick plates. The capacity of production of long products is about 12 to 13 million t. Production in 1991 was 10 million t and a further decrease is expected in 1992, i.e. down to 7 million t. Krivorostal is only one of the 8 steel Combinates of Ukraine. Ukraine’s total crude steel capacity is said to be of the order of 55 million t.

The iron-ore Combinates supply iron-ore concentrates to Krivorostal on exclusive basis, but they also supply the other steel Combinates of Ukraine. In addition, they supply iron-ore concentrates and pellets to the ex-Eastern block countries with which Krivoj Rog has special relationship, in particular for the production of pellets. In 1990, the proportions supplied to the 3 destinations were about 30 million t respectively (28 million t were exported). Figure 3 shows the exports of iron-ore and concentrates to the ex-Eastern block countries, mainly Poland, Czechoslovakia and Romania.

**Figure 3: Exports of iron-ore 1990**

(Fe ore, concentrates, pellets & sinter)

**Conversion of the Combine to a Market economy enterprise**
After the collapse of the communist state and considering the political will to convert the system to a market economy, the most difficult problem for the Combinates is to separate their different activities into institutions similar to those of the liberal democratic state with a market economy. It is therefore necessary to identify activities that can be run by monetary enterprises i.e. enterprises geared to the accumulation of capital. This constitutes a major change in post communist countries because Marxist ideology had suppressed the appropriation of capital as a means of production.

All the other activities that cannot be run as monetary enterprises have to be kept up, but they must be converted into separate institutions. A completely new system of institutions has therefore to be created, with the consensus of all social and economic actors. Only such institutions will make it possible to continue to provide the useful functions of the Combinates to the population and to the new commercial enterprises. Otherwise, chaos will occur, not market economy. But this will probably be a long process.

With respect to the population involved in the Krivoj Rog iron and steel basin, Figures 4 and 5 show personnel numbers of the open-pit and underground Combinates with indication of industrial personnel and social personnel i.e. personnel that is connected to social activities. However, the numbers that are listed as "industrial" probably include people that are not really productive as we understand in our market economy. As a reminder, the production of ROM ore in Mt is shown on the right hand scale.
The total personnel is therefore approx. 65,000 to which the 30,000 of Krivorostal are to be added, making a total of approx. 95,000 for the 9 Krivoj Rog iron and steel Combinates. Out of this total there are officially 14,000 to 15,000 people employed in non-industrial activities but probably much more in reality.

Once the transformation of the Combinate to similar institutions as in a liberal democratic state with a market economy are more clearly understood, one can examine the industrial aspects of the commercial enterprises that can be rescued. Here, the conditions are more familiar to Western economic thinking. But it must be realised that this is only a small part of the Combinates’ present problems.

**Krivoj Rog’s industrial problems**

According to our information, the Krivoj Rog iron and steel basin is confronted with the following problems:

- poor quality of saleable iron-ore mined and steel-making raw materials produced in the basin;

- dramatic decrease of the consumption and production of steel due to the collapse of the economy and particularly of military productions by industrial and military Combinates;

- dramatic increase of the cost of inputs because of their alignment to market economy conditions (freedom of prices);

- decrease of exports of saleable steel making raw materials to the ex-Eastern block countries.
The problems of quality of ore and concentrates are depicted in figure 6 and table 1 below:
TABLE 1: QUALITY CHARACTERISTICS OF Krivoj Rog CONCENTRATES, PELLETS AND SINTER PRODUCTS

<table>
<thead>
<tr>
<th>contents in %</th>
<th>Concentrates</th>
<th>Pellets</th>
<th>Sinter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>min.</td>
<td>max.</td>
<td>min.</td>
</tr>
<tr>
<td>Fe</td>
<td>62.5</td>
<td>66</td>
<td>59.31</td>
</tr>
<tr>
<td>FeO</td>
<td>27</td>
<td>28.2</td>
<td>1.16</td>
</tr>
<tr>
<td>Fe2O3</td>
<td>58</td>
<td>64.8</td>
<td>81.8</td>
</tr>
<tr>
<td>SiO2</td>
<td>7.3</td>
<td>10.9</td>
<td>7.2</td>
</tr>
<tr>
<td>Al2O3</td>
<td>0.14</td>
<td>1.1</td>
<td>0.31</td>
</tr>
<tr>
<td>CaO</td>
<td>0.16</td>
<td>0.29</td>
<td>0.42</td>
</tr>
<tr>
<td>MgO</td>
<td>0.24</td>
<td>0.82</td>
<td>0.9</td>
</tr>
<tr>
<td>MnO</td>
<td>0.03</td>
<td>0.05</td>
<td>0.02</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.007</td>
<td>0.022</td>
<td>0.005</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.024</td>
<td>0.169</td>
<td>0.002</td>
</tr>
<tr>
<td>NaO</td>
<td>0.06</td>
<td>0.16</td>
<td>0.07</td>
</tr>
<tr>
<td>K2O</td>
<td>0.10</td>
<td>0.83</td>
<td>0.11</td>
</tr>
<tr>
<td>H/O</td>
<td>7.00</td>
<td>11.00</td>
<td></td>
</tr>
</tbody>
</table>
With respect to quality, table 1 shows that Krivoj Rog concentrates and fired products (pellets and sinter) are very high in silica content. With the reservation that the percentages of iron and gangue materials correspond to ranges of variation and that they are uncorrelated, the ranges of silica and alumina are very high, the ratio of silica and alumina to base materials (CaO and MgO) is about 0.5 as compared to 2.2 which is required for blast furnace operation.

This requires large amounts of carbonates to be used at BF stage which affects BF performance unfavourably by increasing the slag rate and the coke rate. The table also suggests that the pelletising and sintering processes are not satisfactory because the pellets and sinter produced are not self-fluxing. This is because the sintering process is not used to dissociate CaCO3 into CaO and melt it with SiO2 and iron-oxides into complex but reducible melts; moreover, the heating value of the magnetites contained in the ore is not utilised.

However, it is our opinion that Krivoj Rog iron ore is naturally a raw material of rather low quality, particularly with regard to silica content; indeed, due to the genesis and depositional features of the deposits, silica is so finely disseminated in the ore types, that the removal of siliceous elements is technically difficult and costly, even in market economy conditions. Moreover, we believe that the engineers of Krivoj Rog have already done the maximum to improve the quality of their ore. Therefore, only second stage if not marginal improvements can be achieved, and Krivoj Rog will have to live with the quality of its ore. The problem is to assess the optimum usage value of the ore and concentrated materials, value of usage which combines all the factors of availability, metallurgical properties and cost.

In addition to these aspects, it must also be noted that in the communist state there was no pressure to ensure minimum quality of raw materials produced from a deposit. The material had only to be useful i.e. required by an industrial process. In particular, no economic criteria of selection of reserves was applied. The concept of an economic cut-off grade, familiar to the mining capitalist, was unknown. Also, there were no constraints of cost of transport or environment.
The first limiting factor that was encountered was environmental, because it became evident that vast areas of land were subjected to environmental disaster in the process of mining. Today and in addition, the desirable conversion to market economy conditions, are going to impose economic constraints which will affect reserves and the tonnage that can be mined economically from surface and underground mines.

Hence, the economic significance of the whole Krivoj Rog basin is likely to be changed, including the possibility of exporting concentrates and pellets to the ex-Eastern block countries and to the West (Mediterranean). Indeed, market prices of end-products, their quality characteristics as required by the market economy, the costs of inputs used in the processes of production, the resultant value added and the share of this value added that will be available for payment of productive personnel, will be the major limiting factors in the near future.

These new conditions will probably provoke pressure, first to increase the quality of saleable iron-ore and steel making products (concentrates, pellets, sintered agglomerates). From this there will result important changes in the approach to ore reserves and this, together with market demand will call for decreasing the level of production of ROM ore from the level of 190 million tonnes per annum of the late 1980s. Further upstream, in the field of ore extraction, the repercussion will be the necessity to develop selective methods of mining, as well as improved ore preparation and upgrading techniques.

In anticipation of the difficulties that will be encountered in the transition to a market economy and to avoid the social adjustments that will be necessary, the authorities of Krivoj Rog hope to maintain some of the capacity of production by marketing iron-ore and steel making raw materials (iron concentrates and pellets) in the market economies of the West, particularly in the Mediterranean basin which is nearest to Krivoj Rog. Supposing that this will be possible, considering the reduction of ore reserves and production that will result from applying economic cut-off grades, this objective will probably emphasise infrastructure problems as the transport routes, plant and equipment for handling and transporting bulk materials, as well as ports, are inadequate in capacity and state of technology. Moreover, Krivoj Rog is already committed to supplying the ex-Eastern block countries with concentrates and pellets and this constraint added to the reduction of reserves and capacity, may not enable it to supply other clients in the West.
Coal is produced in the Donbass basin which is situated some 200km away from Krivoj Rog. Similar conditions should apply to coal mining, for the quality of coking coal to produce good metallurgical coke for efficient blast furnacing. However, being separate from Krivoj Rog, but with a similar Combine organisation, we consider that the Coal Basin should be subject to a similar but separate study.
FRAMEWORK FOR A SOCIAL, ECONOMIC AND TECHNICAL AUDIT
OF KRIVOJ ROG

A social, economic and technical audit of Krivoj Rog should therefore encompass the following main aspects in a systems approach which should be conducted moving in reverse order from the social and economic structure and commercial end-products (iron concentrates and steel products; see diagram page 13):

- assessment of the existing social and economic structure of the mining and steel Combinates.

- outline of necessary transformations of the social, economic and industrial structure i.e. reallocation of the activities of the Combinates between commercial ventures, social ventures, functions that can be institutionalised and functions that can only be assured by state initiative at national, regional or local levels;

- identification of commercial and industrial activities that can be assured by a market economy type of enterprise i.e. operating autonomously from the proceeds of sales of products;

- prospective of the future market for steel long products produced by Krivoy Rog, both on domestic and export markets;

- prospective of the effect of steel market and likely market prices on main production ratios as well as technical and economic parameters i.e. steel melting, blast-furnace pig-iron, coke making;

- prospective of the effect of main production parameters estimated above, on the quality and tonnage of iron-ore required i.e. lumps concentrates, pellets and of coking coal;

- prospective of ore exports to other regions of Ukraine, and to ex-Eastern block countries and the West (Mediterranean);
- Analysis of each of the iron-ore mines with the objective of establishing the following assessment:

  - prospective evolution of mineral reserve inventories taking into account the application of economic cut-off grade concepts;
  - potential evolution of mining methods to produce ores with a quality and a capacity corresponding to revised demand at market economy prices with cost effectiveness. This should involve more selective mining based on the knowledge of zonal distribution of ore qualities (iron and gangue content);
  - prospective evolution, or confirmation of, ore upgrading techniques to reduce gangue contents and produce saleable lump ores and concentrates, both as sinter and pellet feeds; production of pellets of good physical and metallurgical quality from fine concentrates; production of sinter of good physical and metallurgical quality from coarse concentrates; prospects for the optimisation and decreased cost of blast-furnace operation obtained by the use of improved quality raw materials.
  - estimation of the value of usage of the best iron-ore raw materials that can be produced in the region, taking into account pig-iron and steel production parameters, including addition of fluxes, slag and coke rates as well as equipment productivities, all these result from the specific iron-ore material characteristics such as Fe content, basicity ratio, gangue contents, granulometry, reducibility etc.
  - based on this value of usage, estimation of selling prices of the different products, according to the method of fixing of international standard prices (US$/Fe point).
  - estimation of potential value-added by the production process and of personnel costs in market economy conditions.

More details on the contents of the following aspects are given in the next pages:

- social and economic structure
- markets
- iron-ore

A SIMILAR SOCIAL, ECONOMIC AND TECHNICAL AUDIT MAY APPLY TO THE DONBASS COAL BASIN IF REQUIRED.
SOCIAL AND ECONOMIC STRUCTURE

This major issue is dealt with in two papers published by Cerna.


These two documents are appended after page 20.

The objectives of the study should be as follows:

- to identify and describe all the component activities of each of the Combinates i.e. their functions, their inputs and outputs and their specification as goods or services, their mode of functioning;

- to identify which of the above functions can be "monetarised" for the exchange of goods and services;

- to identify which functions cannot be "monetarised" but have to be provided by state institutions;

- to identify among the "monetarisable" functions, those that can be assured by market economy type of enterprises;

- to define the rational for new relations between the enterprises and institutions (i.e. after break-up of the Combinates) and their personnel, in terms of "monetarisation" of their services;
- to define the rational for new relations between the enterprises and institutions under contractual terms;

- to identify and describe the missing functions that must also be provided by institutions or organisations e.g. training to new knowledges and skills, associations, banking etc.,

ALL THESE INVESTIGATIONS SHOULD BE CONDUCTED IN CLOSE COLLABORATION WITH UKRAINIAN COUNTERPARTS. INDEED, A NEW INSTITUTIONAL STRUCTURE CAN ONLY BE DEvised AND IMPLEMENTED BY NATIONALS AND IN THE END, IT WILL REQUIRE NATIONAL CONSENSUS TO BE FEASIBLE.

THIS APPROACH IS THE ONLY ONE WHICH CAN LEAD TO A PRODUCTIVE BREAK-UP OF THE POST COMMUNIST COMBINATES, WITHOUT PROVOKING HUGE LOSSES OF JOBS AND SOCIAL DISRUPTION, DUE TO A WILD AND UNREALISTIC INTRODUCTION OF MARKET ECONOMY CRITERIA.
In the framework of this study, the market survey should cover two main aspects:

- potential long term market of steel products produced by Krivorostal steel complex, allowing to determine its average raw material consumption.

- potential market of other consumers of iron ore raw materials, including other Ukraine steel combinates and export markets both in the ex-eastern block and in the west Mediterranean zone, according to the various products (pellets, sinter feed, concentrates...) and their quality characteristics.

This market survey should be made using statistical data and figures supplied by, and in good co-operation with, the Ukrainian counterparts. This is crucial to obtain and validate data of reliable nature.

**a) Steel products from Krivorostal steel complex**

A complete detailed market study of steel products in Ukraine would substantially exceed the possibilities of this study. Even if it should appear necessary in another context, it represents a very heavy work which should be considered in itself.

A prospective assessment of the long term market potential of Krivorostal steel complex should be made in this study, by establishing and estimating economical strong and weak points of the steel complex, according to each category of products, including a technical and economical evaluation of the corresponding production equipment’s.

This will lead to evaluate the categories of products for which Krivorostal will be in a position to increase or to maintain its market shares, in front of its competitors (both inside and outside of the Ukraine), and those for which a reduction of market share has to be envisaged. Krivorostal’s overall market should be assessed by a broad approach: this method, though not precise enough to build a short or medium term business plan, is sufficient to evaluate Krivorostal’s capacity of steel production and therefore, its probable consumption of raw materials. In addition, the approach will suggest what technical evolution of the steel complex is inevitable, i.e. a programme of capital investments required to develop competitiveness in the future with their order of priority and a programme of productions that will have to be discontinued in the future, due to the loss of market share.
Because of the small number of clients for Krivorostal’s products, it is desirable and possible to interview these clients directly.
b) Iron ore products market.

This part of the market study should be conducted taking into account existing long term contracts with steel plants in the ex-Eastern block, as well as their respective markets. Sofresid is well informed of these points, having actively participated to several studies supported by the European Community (programme Phare) in 1992 (Czechoslovakia, Romania and Poland).

To enable an economical evaluation of these existing contracts, we will need to be informed on their specific conditions by the Ukrainian Counterpart, with full assurance of confidentiality on our side. We wish to emphasise here that if one has to include in an economic evaluation, the effect of barter agreements in trade of iron-ore, one needs to be very careful, because there is a severe risk of biasing the conclusions.

The iron ore materials market study should be based on the so-called "USAGE VALUE" of the products, which eventually depends on the structure and on the equipment of the steel plant. Indeed, the economic value of any iron-ore raw material depends on the added costs that are necessary to produce steel from this particular raw material.

For example, to compensate for a high silica content, the addition of carbonates is necessary and this can be done either at the sintering, pelletising, or blast furnace stage; the cost of this addition must therefore be subtracted from the market price of an "ideal" self-fluxing ore i.e. an ore with a silica/carbonate ratio nearer to BF operating requirement.

In the same way, any factor that causes the productivity of blast furnace operation to decrease e.g. a high gangue content which increases the slag rate, or a poor reducibility of the iron-ore which deteriorates the blast furnace’s operating conditions and increases the coke rate, will increase the operating and capital costs of the steel plant. Such increases in cost should therefore be compensated by an equivalent decrease of the price of the raw material so that its cost of usage is remains competitive compared to better quality ores.
Similarly, depending on the structure of the steel plant, a variation of production and productivity caused by the raw material used, may sometimes impose to operate an additional blast furnace to maintain the production capacity of the steel plant e.g three BFs instead of two. Such a condition may therefore significantly affect the operating costs and, by increasing the capital required, the amortisation costs.

Such are the aspects that are taken into account in the concept of "USAGE VALUE", which is the only one which allows to compare rationally raw materials of different origins and quality. Based on this concept of "USAGE VALUE", it is possible to determine, by reference to standard raw materials traded on the world market, the market price of any raw material so as to make its cost competitive. It is clear that above the level of price determined by this method, there can be no trade in any market; at and below this price, the raw material is economically interesting for the steel maker, and a potential market volume can be estimated.
The objectives of the study of the iron-ore mines should be:

**a) Audit of individual mines**

- to assess the quality of the reserves, their tonnage and their distribution by grades and gangue content;

- to assess the methods of mining that are required to achieve a selective extraction of ore by grades and gangue content i.e. methods of development and of ore extraction, installations and equipment;

- to assess the possibilities and the methods of upgrading ROM ores to specifications required by national and export users or specifications normally accepted for international trade of iron-ore, with regard to iron and gangue contents; this should include the main output products i.e. lumps, concentrates for sintering (coarse) or pellets (fine), super-concentrates for pellet feed; and also the sintered agglomerates and pellets that can be produced from those concentrates.

- to assess the value of usage of the best quality iron-ore raw materials that can be produced in each mine, taking into account pig-iron and steel basic operating parameters, including the addition of fluxes, slag and coke rates as well as equipment productivities. All of these parameters result from the specific iron-ore raw material characteristics, such as its Fe content, its basicity ratio, the gangue elements and contents, granulometry of ore, reducibility etc.

- based on this value of usage, estimation of the selling prices of the different iron-bearing products, according to the method of fixing of international standard prices (US$/Fe point).

- estimation of the value added by production based on variable costs only, standard selling prices of the different iron-ore products on the international market and costs of inputs corrected to reference economic conditions;
b) Elaboration of a master plan

- considering quantities and qualities of iron required by market based scenarios, and their distribution by types of products (lumps, concentrates sinter feed or pellet feed, super-concentrates, fired sinter or pellets), establish the rational basis for a distribution of tonnage’s and qualities of ROM ore among the different sites, on the basis of reserves and their quality characteristics, and of value added by production.

- based on all the above findings, outline a master plan for the production of iron-ore in 3 scenarios centred on the prospective markets (Krivorostal, other Ukraine steel plants, ex-Eastern block steel plants, West (Mediterranean) steel plants).

- in conjunction with the studies conducted on the social and economic aspects, in particular with regard to the separation of non productive activities of each of the combinates, establish a prospective outline of the personnel of each mine of the master plan. From this, derive operating margins by deducting cost of personnel from expected value added. Finally, establish a prospective evolution of personnel productivity, in the case of the central scenario, in order to show a trend of progressing towards market economy standards.