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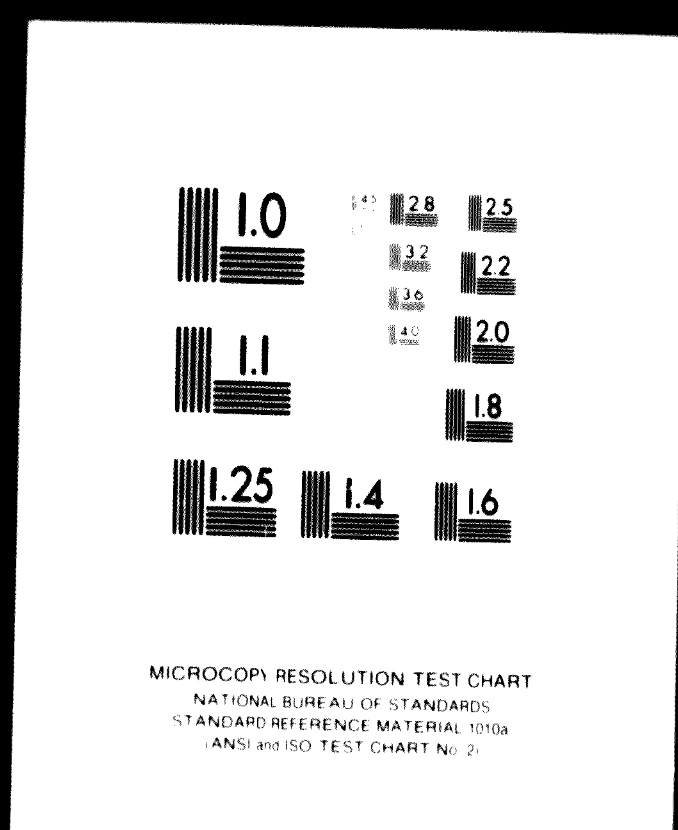
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CENTRE OF INDUSTRIAL STUDIES
FOR THE MAGHREB

Restricted Distribution
WP 1970/V1/1
June 1970 No. 226
Original: English

A PRELIMINARY STUDY ON THE POSSIBILITIES OF ESTABLISHING AN ALUMINIUM METAL PRODUCTION IN ALGERIA AND/OR LIBYA BASED ON NATURAL GAS AS SOURCE OF ENERGY,

by

F. Szakel, United Nations Expert
Khalil El Hattab, Maghrebian Counterpart

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P. Szakal, United Nations Expert
Khalil El Muttawa, Maghrebian Counterpart

This report is not an official document of the United Nations, but a study especially made for the Governments of the Maghreb, by the "Centre of Industrial Studies for the Maghreb", with the assistance of UNIDO and the United Nations Special Fund.

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FOREWARD, INTRODUCTORY REMARKS

This study tries to give an answer to the question, if it is possible and reasonable to start aluminium production in one of the Maghreb countries. Secondly: if the natural gas available in these countries can serve as a source of cheap electric energy for this possible production of aluminium.

In the course of this work we had to apply up-to-date information on aluminium production techniques and economy to the local realities, covering also aspects of raw material supply and evaluation of the metal market. At the same time we tried to follow a coherent line of ideas, on explaining briefly the more important basic notions.

The above ramifications of this study resulted in two disadvantages:

1. The study became lengthy compared to its preliminary character:
2. It was difficult to secure the easy comprehensibility for the average reader without general knowledge of the specific field.

We tried to avoid all details, which might be found in textbooks, on the other hand, we wished to concentrate into the text allbasic ideas and possibly also data and information which seem important for decision making in this matter. These are founded partly on own experience and are partly otherwise not accessible through published papers. Therefore, we feel that our work, exceeding its basic task, can serve two main purposes:

/....

1. It offers a recent summary of the situation in the involved countries from the point of view of aluminium production and consumption. As to our knowledge, at present, no other recent similar work on this topic is available.

2. It may serve as a compendium for those who are involved in the future smelter project investment management.

We should like to express our thanks to all governmental and company officers who helped us with their advice and granted interviews for the purpose of this study.

1. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

1) It seems possible and reasonable to establish an aluminium smelter in Algeria. The practical steps, which have been taken on this matter by Societe Nationale de Siderurgie seem correct and reasonable. The preference for Algeria vs. Libya is founded by the following main arguments:

a) The quantities and the duration of natural gas supply are here more clarified. For Libya the certainty of duration for only 15 - 20 years has been indicated;

b) In Algeria there exists electric energy generation, based on natural gas and this is to be extended, whilst in Libya only oil-firing exists and no other fuel is visualized;

c) Algeria itself affords a considerable inland market potential. From the point of view of the whole Maghreb area as a market of aluminium, it has a favourable central situation. On the other hand, Libya's geographic situation, especially that of the Gulf of Sirte, which seems the most probable site for a possible smelter, would imply remarkable additional freight costs.

d) Algeria will dispose from 1973 of a domestic production of petroleum coke, an important auxiliary material of aluminium production. In Algeria and in neighbouring Morocco and Tunisia, as well, there are significant deposits of fluorspar. This raw material basis, and the possible utilization of fluorine by-products of the phosphate fertilizers production, offer an ample basis for domestic production of cryolite and aluminium fluoride, other important ingredients of aluminium smelter operation. In Libya these materials are not available;

e) The problem of recruiting skilled manpower can be more easily solved in Algeria, whilst in Libya the existing labour is bound to projects of higher priority.

f) In Algeria, there exists already some tradition of aluminium foundry and rolling-mill practice.

A Final, definite decision can be taken only after the evaluation of the detailed feasibility studies which are being undertaken and concerning smelter economy, unit price of electric energy and aluminium market and fabrication and planning of future development.

2) The smelter should be fed with purchased alumina, to be secured by favourable, long-term contracts. Construction of an integrated alumina plant does not seem reasonable. Later on, participation in a common venture for alumina production might be of interest.

3) The smelter should be equipped with an own anode-carbon plant, tobe based on domestic petroleum coke as raw material.

4) The initial capacity of the smelter might be reasonably between 30,000 and 50,000 tpy. Higher figures would be justified only in the case of association with a partner, who guarantees the sales or the consumption of the excess metal.

5) Preliminary estimates of power price and aluminium production costs seem to corroborate the favourable economy of future smelter.

6) Opinion on pre-investment decision factors has been expressed and is recommended to the attention of the future investor. (Chapter 4).

7) A global evaluation of the aluminium market in the Maghreb countries on the basis of statistical data and taking into consideration macro-economic relationships shows the following present situation:

a) The market, except Libya, is very undersaturated with aluminium. The average consumption per capita of the four countries in 1967 was 0.23 kg., whilst the world average totalled 2.5 kg /capita.

b) In the latest period, aluminium imports of the four countries are increasing by about 16.5% per year (1965-68). The volumes of imported aluminium goods for the four countries totalled 12 million dollars for 1968, corresponding to 10,500 tons.

c) There is practically no exchange of aluminium products between the four countries. The mutual deliveries in 1968 totalled 2(two) tons. On the other hand, there exist significant idle fabrication capacities for certain products (e.g. welded tubes in Morocco). Mutual information and co-ordination of commerce policy seem here desirable.

d) It is a general phenomenon that there is no conscious or organized strive to promote economic application of aluminium. The most striking example for this is the amazingly high proportion of copper cables production and use.

It is advisable to study this situation on a regional basis and take co-ordinated practical steps, in order to promote more sound development.

Therefore, we recommend the following:

a) To establish in the involved countries production facilities for the most important semis, such as -

- sheet, possibly also foil
- extrusions
- wire rod
- castings

It is important that the quality of the visualized products should be equivalent to those from developed industrial countries and, therefore, proper regional standards should be established. The problem of economic scrap-processing deserves special attention.

b) The developments indicated above under a) should be implemented in a co-ordinated way, on the basis of mutual understanding.

c) Special efforts should be made to facilitate the broad application of aluminium, using available up-to-date foreign experiences. This is especially important in the field of electrical industry and electrification. It seems rational to exert these efforts in a joint way, using all means of common technical information.

d) When amending the customs tariff systems of the countries, or the relevant bilateral agreements, it should be kept in mind to promote mutual trade in aluminium goods between the countries of the Maghreb.

It exceeds by far the scope of this study to outline an optimal set-up for the coming semis production. However, on the basis of our findings, it can be suggested as a preliminary proposal for consideration:

- To set up, jointly with the future smelter, a cast/rolling mill for wire rods with a capacity of about 20,000 tpy (corresponding Properzi 7B type);
- To set up, in the most important industrial regions, two or three cast/rolling units for about 5 - 8,000 tpy each, in order to cover the requirements in
  - rounds for production of household goods
  - ondulated sheet for roofs and other purposes
  - sheet and strip, in general
  - set up, in one of the countries, an extrusion mill, which might supply mainly:
    - profiles for construction;
    - small diameter tubes.

In order to promote these developments in an optimally rational way, we suggest to prepare a detailed study concerning both

a) market analysis and forecast of aluminium semis and finished goods;

b) alternatives for development of semis production in the Maghreb countries.

(Quoted from Chapter 8.22)

8) A rough forecast calculation shows the following aluminium absorption capacities in the Maghreb countries:

	expected consumption in tons per year	
	total	produced in the Maghreb
1975	27,000	16,000
1980	46,000	28,000
1990	105,000	75,000

9) In the case the projected production should substantially exceed the above quantities, it is advised to make arrangements for guaranteed sales, possibly at 'list' prices.

10) It has been found that in three Maghreb countries there exists a realistic possibility to produce fluorine products, among others, cryolithe and aluminium fluoride. This possibility is based partially on significant deposits of fluorspar (CaF_2), and, on the other hand, on possible fluorine recovery from the production of phosphate fertilizers for domestic use and exportation.

We recommend to study the relevant situation on a regional basis and to elaborate a co-ordinated plan of action for a survey and development plan in this field.

2. GENERAL INFORMATION ON THE ALUMINIUM INDUSTRY

2.1 Th<u>e importance of aluminium.</u> The production of aluminium, though it has begun on a commercial scale only at the end of the 19th century, developed spectacularly and has quantitatively outstripped the other non-ferrous metals.

Figure 2 - I
World Production of Aluminium

Year:	1900	1910	1920	1930	1950	1960	1965	1970
1000 mt	5.8	44.9	125	269	1509	4630	6530	over 10,000 (forecast)

There is indication that during the next decade the consumption of aluminium metal will further increase by a yearly rate of 6 to 8%. Substantial additional production capacities are at this moment under construction all over the world.

The above development of consumption and production is due to the favourable chemical, physical and mechanical properties of this metal, which enabled its broad application in important fields, such as power transmission, transport, packaging, construction, etc. In such a way, aluminium became an essentialingredient of all developed economies

2.2 Bauxite. The production of aluminium is mainly based on bauxite ore as a raw material. As a sole exception, commercial quantities of other ores, such as alunite and nepheline are processed in the USSR, but with the present bauxite supply possibilities, these might be economically justified only under special conditions.

From the geological genetic point of view, two basic types of bauxite are known:

a) those in connection with magmatic base rock (laterite-type)

and b) those in connection with sedimentary rocks (carstic-type).

Regarding the mineralogical character and chemical composition, the most important features are the following:

The aluminium oxide may be present in the ore in the form of trihydrate $Al_2O_3 \cdot 3H_2O$ or monohydrate $Al_2O_3 \cdot H_2O$. This latter, again, may occur in two different forms: boemite and diaspor. The processing of monohydrate bauxite, especially of diasporic type, is more expensive than that of the trihydrate (gibbsite or hydragillite)type.

The bauxite contains the following main components:

Al_2O_3	between	40	-	60%
Fe_2O_3	"	2	-	20%
SiO_2	"	1	-	8%
TiO_2	"	1	-	8%
H_2O	"	12	-	30%

The active SiO_2 content in the ore is of great importance, since during the alumina production, caustic soda and Al_2O_3 losses are proportional to the content of active silica.

Development work in attempting to improve the economy of low-grade bauxite processing is at present carried out.

The investment cost for the establishment of bauxite mining facilities might be of 10 to 25 US $ per annual metric ton capacity.

The main producing countries of bauxite and their capacities are indicated in Figure 2 - II (ref. No.1).

Figure 2 - II

Bauxite Producing Countries

Country		Capacity in 1,000 metric tons (1966)
Western Hemisphere	USA	1800
	Brazil	250
	Dominican Rep.	900
	Guyana	3400
	Haiti	400
	Jamaica	13250
	Surinam	6000
Europe	France	2560
	Greece	2250
	Italy	275
	Yugoslavia	about 2500
	Hungary	" 2000
	USSR	" 6000
	Roumania	" 100

	Country	Capacity in 1,000 metric tons (1968)
Asia	India	350
	Indonesia	1900
	Malaya	1300
	Sarawak (in Malaysia)	300
	China	about 500
Africa	Ghana	750
	Guinea	3250
	Sierra Leone	350
Australia		4250
World Total		about 64200

In Western Africa there are important deposits of bauxite which, up till now, have not been sufficiently exploited (e.g. Guinea, Ghana, Ivory Coast, Congo, Mali).

2.3 Production of alumina. To-day all aluminium is produced in two main technological steps:

a) production of commercial aluminium oxyde (Al_2O_3) i.e. alumina;

b) production of the metal from the oxyde, by high temperature electrolysis (smelter process).

This way may be regarded at present as the only economic way. Recent efforts in some countries to attain principally new ways of production have not proved fruitful. This statement is also supported by the fact of the world-wide vigorous construction activity in the field of alumina plants and electrolytic smelters according to the classical processes.

The most economic and mostly used process for the production of alumina from bauxite is the wet-alcaline or so-called Bayer process. This process has several varieties and the design should be carried out individually, depending on the characteristics of the bauxite. Technology and equipment were significantly developed after the Second World War. The most important features of modern plant: large equipment units, respectively production lines, application of continuous processes, automatic control, new types of equipment, sophisticated heat and caustic soda economy and recovery, utilization of by-products.

The production of alumina is a mostly heat-energy intensive industry, it needs also big quantities of caustic soda and industrial water. The main consumption figures per one metric ton of alumina are:-

bauxite, t 2.2 - 3.0
caustic soda, t 0.06 - 0.18
steam, t 1.5 - 3.0
electric power kwh. 230 - 300
fuel oil, kg. 110 - 120

The above data are much depending on the bauxite characteristics, and should be regarded only as indicative. The water demand per t of alumina is about 20 to 30 m^3/t. In some cases lime, as an ingredient, is also needed.

The main effluent is "red mud", an alcaline waste, containing mostly Fe_2O_3, TiO_2, SiO_2, Al_2O_3, Na_2O. Vanadium and gallium may economically be recovered as by-products. A breakthrough in economic processing of the red mud on a commercial scale has not yet materialized.

For the economic size of a new alumina plant, a capacity of 200,000 to 300,000 metric tons per year seems to be the minimum. Big producers tend to visualize one million t/year plants (Australia, Jamaica, Pechiney's new plant in Europe).

The specific investment cost of alumina plants is between 165 and 220 US$ per metric ton annual capacity.

Main factors influencing selection of the site was until now mostly the proximity of a bauxite mine, availability of transport (harbour) facilities and thermal energy. In some cases, integrated alumina/aluminium facilities have been constructed. New developments in cargo shipping and the availability of big quantities of ore, especially the Australian bauxite with granular structure, facilitating bulk transport, are again influencing in the sense of this latter philosophy; keeping in view also the proximity of the metal markets.

It should be mentioned that, for the production of one ton of metal, roughly two tons of alumina are needed. This determines the capacity proportions.

2.4 Production of primary (virgin) aluminium metal

The essential technological performance in the aluminium smelter is to obtain the metal from the oxide (alumina).

This is done by an electrolytic process at a temperature about 940 C° and in a medium consisting of molten fluoride-salts.

This process is performed at a high current intensity (D.C.) up to 100,000 Amperes and more. Aluminium smelting is a highly electric-energy intensive industry; for the production of one ton of metal about 15,000 kwhs are needed.

The production of the smelter is primary or virgin aluminium metal, which is shipped in ingots, slabs, billets or, if applying up-to-date cast-rolling technologies, partly in the form of Properzi rod or wire/or cast-rolled strip.

As this study is concerned with just the possible establishment of aluminium smelter(s), the relevant technical and economic information will be presented in the next chapter, separately and in detail.

2.5 Secondary aluminium. This is produced by processing and remelting aluminium scrap. As the production of secondary aluminium is generally economic and the secondary metal can be advantageously applied, especially for castings, its turnover quantity attains, in some developed industrial economies, about 20% of the total metal demand. The investment cost per metric ton per year secondary smelting capacity is about 100 US$.

2.6 Production of semis, fabrication, casting shops.

The industries manufacturing aluminium products such as

- plate, sheet, strip, foil (rolled products)
- extrusions (e.g. profiles, rods, tubes, flats)
- forgings
- wire, cable, ACSR (aluminium cable, steel reinforced)
- powder, paste
- welded tubes
- drawn tubes

are generally classified as semis fabrication. An important part of the semis is made of alloys. The production of castings is regarded generally as a separate group of industry. A further link in the line is the production of aluminium finished products (e.g. construction elements, hollow-ware, chemical industry equipment, etc.)

Considering the establishing of new aluminium industries, it should be kept in mind that:-

a) The metal can penetrate the domestic or other visualized markets only when the necessary capacities of semi-fabrication and finished goods will be available at the same time.

b) The economy of aluminium industry is the more favourable, the more the metal production can get integrated towards manufacture of semis and finished goods.

3. THE ALUMINIUM SMELTER INDUSTRY

3.1 Technology, equipment, structure of the plant.

The technology generally applied is the classical Hall-Heroult process, using an electrolysis high temperature of about 930-950 C°. The electrolyte is molten cryolithe ($3NaF_3 \cdot Al_3$), usually with some excess Al_3 content. The alumina is dissolved in this flux. The cathode is the cell electrode carbon lining itself, respectively the surface of the molten aluminiumlayer at the cell bottom. The carbon anodes are immersed into the electrolyte and are consumed by electrolytic oxydation. The cells are electrically bound in series called potline. The amperage of commercial potlines very between 40,000 and about 150,000 A. The cell average voltage is about 4.0 - 4.5 V, The potlines are fed by D.C., converted in silicon rectifyer stations. These have efficiencies up to over 98%. The D.C. voltage of the rectifier station determines the number of the cells. It is usually between 750 and 1100 V,

In such a way, the production capacity of a potline is determined by two factors:

a) the current intensity,

b) the D.C. voltage of the rectifier station, by which the number of cells is determined.

The basic groups of equipment for an aluminium smelter respectively, the main plant departments are the following:

- electric sub-station, including switchgear and transformers,
- rectifier station,
- transformer and distribution system for A.C. consumers (melting furnaces, motors),

- the electrolytic cells and their busbar system,
- electrolysis service and auxiliary equipment (cranes for mounting, for anode-manipulations, crustbreakers, alumina-hoppers or other feeding devices, tapping crucibles, special machinery for the purpose of replacement and cleaning of steel conductor studs in the case of Soderberg anodes, etc.)
- station for unloading and storage of alumina,
- ventillation system for the cellhouses, gas purification and cryolite-recovery, if any,
- foundry shop equipment (holding and melting furnaces, equipment for the casting of ingots, slabs, billets, cranes and other handling equipment and transport facilities for the above, saw for ingots, milling machinery for scalping sheet-ingots,)
- possibly equipment for direct casting of rods and strips, (Properzi mill, respectively strip-rolling casting mill with auxiliaries),
- auxiliary services (compressor, vacuum systems, if any, water supply, etc.),
- repair shop (with special regard to requirements of smelter maintenance),
- anode plant (with storage),
- laboratory,
- general stores,
- offices, welfare establishments, etc.

3.2 Electrolytic cell types and their comparison

Large scale aluminium producers developed their own specific cell design. The most important feature of the cell design is the selection of the anode system. Concerning this, four basic types are used at present:

1) continuous, self-baking Soderberg anodes with horizontal studs (studs are slightly conical steel rods, which convey the electric current to the anode carbon),

2) Soderberg anodes with vertical studs,

3) pre-baked anodes,

4) continuous pre-baked anodes.

The application of the different anode systems has varied dramatically in the last three decades.

During World War II, European practice was much in favour of horizontal studs Soderberg. The fifties brought a breakthrough of the vertical Soderberg, culminating with the establishment of Kitimat in Canada and Nogueres in France. The sixties brought again an overwhelming return to classical pre-baked anodes. Even Pechiney, one of the previous champions for vertical Soderberg designed INTALCO (in the USA), DISTOMON (in Greece) and SLATINA (Rumania) with pre-baked anodes.

The continuous pre-baked anodes system is a special development of VAW in the GFR. Until now, it has been applied exclusively in German plants.

The recent picture, though much in favour of pre-baked anodes, is altogether not unambiguous. The quantitatively very significant smelter industry in the USSR uses almost exclusively both types of Soderberg. A lot of new projects elsewhere are also designed with Soderberg. Some examples:

Saramenha (extension)	Brazil	horizontal	Soderberg
Seydishehir	Turkey	vertical	"
ALNOR	Norway	vertical	"
Koyna	India	vertical	"
Madras Aluminium Co. (extension)	India	vertical	"
Belgaum	India	horizontal	"
Korba	India	vertical	"

Advantages and disadvantages of the different anode systems are still under discussion, even within the technical staff of large scale producers.

On selecting the type of anode system, the following main pattern of characteristics of the two main varieties (pre-baked and Soderberg) might serve as a guideline (Ref. No.2).

Pre-Baked	Soderberg
Power consumption lower (by about 1000 kwh/t).	Anode plant, cheaper.
Flux consumption lower (cryolithe + aluminium fluoride).	Slightly less manpower needed.
Less atmospheric polution (no tar distilling from anodes)	

As to specific investment costs: with smaller plants, Soderberg is cheaper, but in the case of large smelters, pre-baked is the more economic. Regarding the production cost, the picture is similar.

Exact comparative figures for specific investment costs and production costs, and their variation as a function of plant capacities, can be determined only in the case of specific cost factors, e.g. construction price levels, prices of electric energy and raw materials.

These factors will also determine the more specific parameters of potline design, especially the current densities to be selected for the anodes and the busbars. High power prices justify lower current densities, which afflict again an increase in specific investment costs. Optimizing calculations for these factors should be an element in a relevant Feasibility Study.

3.3 Features of up-to-date smelter techniques.

As to the cell size, and current intensities of the potlines, large production units are set up with cells of 100,000 A and above (see Ref. No. 3 and 4): e.g. USSR to 150,000 A, Pechiney about 130,000 A. Smaller plants, especially in developing industries, are still constructed, however, with current intensities from 50,000 A to about 70,000 A. The advantages in this case are : simpler, cheaper busbar system, the cell operation is easier, there are less possibilities of troubles in operation.

Electrical equipment and busbar systems are constructed in a way to minimize electric energy losses. High efficiency (up to about 98.4%) silicon rectifiers and all-welded busbar systems are here the main features.

Cellhouse operations are widely mechanised. (Crust-breaking, feeding of alumina, tapping of the metal, regulation of interpolar distance, manipulations concerning replacement of the anodes, and the contact studs for Soderberg-anodes.) Here special devices are applied, e.g. by Pechiney, aiming at an extreme economy in manpower.

Plant-scale automation is, quite recently, developing. In some projects, just under construction, automatic control of periodic crust-breaking and feeding of the cells with alumina and regulation of the interpolar distances will be foreseen as well. Cathode lining life should be about 4 years.

For purposes of their foundry shop, most smelters apply two-stage furnace systems. The tapped metal is collected in a mixer, gets transfused into a holding furnace and is poured either into ingots (using chain-moulds) or to slabs or billets (using direct casting of several pieces simultaneously). Here, proper degasification of the metal, avoiding of chutes, as well as maximal mechanization and automation in the casting process, are among the main features of up-to-date technology. For the production of wire, the Properzi-mill is widely applied (capacity of type 7B about 20,000 tons/year).

In the production of anodes or anode paste total mechanization, automation and a totally closed system for materials handling are characteristics of an up-to-date plant. Here it is disputed, if in the critical process of mixing a continuous or a batch method is the more preferable. Some big producers are still in favour of the batch process, which affords more security in avoiding big scale failures of the granular composition.

In the production of pre-baked anodes, another recent achievement is the application of the vibration technique instead of pressing. Before considering its application, thorough references on plant-scale experience should be obtained, however, especially in relation to the qualitative characteristics and plant behaviour of the product.

3.4 <u>Product-pattern of the smelter.</u>

Metal quality. This is generally mainly depending on impurities in alumina and anode carbon. The purity of the metal should be in the average over 99.6%. The main, generally accepted classes of purity are: 99.0, 99.5, 99.7 and 99.8%. It is important that, for the purposes of electrical conductors (wire, cable, busbars, etc.) extra qualities used to be specified. Here, one great producer's specifications require minimum 99.5% Al, maximum 0.15% Si, respectively, 0.01% Ti + V (for titanium and vanadium). The corresponding specific resistance is 0.02763 ohm. mm^2/m for rolled rod, and 0.-28-35 ohm. mm^2/m for drawn wire.

It is also usual to furnish alloy ingots. The composition respectively other quality requirements are usually defined in this case by the customer.

As to the physical shape of the product, the main varieties are:

a) Ingots for remelting. Usually in pieces from 15 kg. upwards. Their shape should facilitate stacking, storage, handling, loading and unloading manipulations. Big producers developed their own system (e.g. ALCAN's TRI-LOCK, ALCOA-S BAR-LOK).

b) Extrusion -, sheet - and wire ingots.
These are used directly for semis-fabrication purposes. Some exemplary data on usual dimensions:

- Extrusion ingot (cylindric form) diameters 140-400 mm.
  length up to 2640 mm.
- Sheet ingot, called also rolling slabs (oblong form):
  thicknesses 170-620 mm. width 730 - 2200, length 1500 - 4500 mm.
- Wire ingot (rectangular section rods) 102 x 102 mm.
  153 x 153 mm.

c) Directly cast and rolled rod (Properzi-rod). Here 7.6, 9.5, 12 and 15 mm. are usual diameters.

d) Directly cast and rolled strip. Here width up to about 1200 mm. is feasible.

e) In some cases it is justified to deliver the metal in molten, slightly superheated state directly to the consumer. Examples for this are in the USA and UK and Italy (see Ref. No. 6). This is justified only in the case that quantities of several thousand tons per year are transported.

3.5 Factors and conditions of investment.
<u>Considerations on selecting the plant site.</u>

Know-how, engineering. A partner, respectively contractor, with proven experience should be contacted. Only cell constructions with favourable long-term results, which could be demonstrated in full plant-scale, should be accepted, especially for new producers. Fees used to be undisclosed, but should be of the order of 1.5 million US$ for a 50,000 tons per year plant (know-how and basic engineering).

Some key factors of investment. Equipment weight is about 0.35-0.40 tons per ton annual capacity. Total weight, including cathode linings and anodes should be of the order of 0.75-0.80 t per ton/year. As to construction work, the main buildings are the pot-rooms with lengths up to about [illegible] m. The specific pot-room area for 1 ton capacity per year (on basis of some recent projects) is between 0.35 and 0.65 m^2. The relevant figures for pre-baked anodes are here generally on the lower side. Additional buildings need further 20-30% of this area. Potrooms with two rows of cells have proven to be the most advantageous.

Power-plant capacity. Electric load factors are very favourable, since the load is almost uniform, e.g. for a capacity of 50,000 tpy the peak is at 95 MW. For 100,000tpy, the peak is [illegible] MW. and the average 184 MW. The security of power supply is of extreme importance. Connections with the network for emergency supply or stand-by capacity in the power plant are necessary. Failures of power supply exceeding one hour may inflict heavy damages and even cause total close-down of production.

Specific investment costs. Authentic published data are rare and should be regarded with caution, especially because only overall figures used to be given, without indicating what is included. The regular increase in price levels is another distorting factor. Some published figures, without commentary, see in table 3 - I.

Figure 3 - I

Examples of Investment Data of Aluminium Smelters

No.	Capacity mt/y	Startup Year	$/t	Remark
1	44,000	1963	750	Europe
2	57,000	early sixties	610	"
3	105,000	1967	860	Africa
4	228,000	1968	570	U.S.A.
5	22,000	1969	680	Europe
6	90,000	1970	1030	Africa
7	90,000	1971	800 (inc.power?)	Bahrain
8	84,000	1971	820-910	Europe
9	90,000	1970?	710	Asia
10	100,000	after 1970	890	Europe
11	50,000	1974	880	Europe

In general, it can be stated that the figures are now between 700 and 900 US $ per ton. Comparative data, calculated on the basis of identical price factors, have shown the influence of capacity on specific investment cost as follows:

capacity t/year	$/t
20,000	880
30,000	830
50,000	740
100,000	650

Realistic values and breakdown of the investment cost can be calculated only for specific cases, design and cost factors. This should be the task of a Feasibility Study or a Preliminary Technical Project. The following data, based on calculations for purposes of a 50,000 tpy smelter with Soderberg anodes might indicate the proportions of main cost items.

<u>Figure 3 - II</u>

Rough breakdown of investment cost factor of smelters.

	$ tpy	%
Construction and buildings	200	28
Machinery and equipment [1]	210	30
Busbars	74	10
Rectifier Station [2]	30	5
Cell linings and first filling-up	70	10
Carbon paste plant [3]	34	5
Others	balance	balance
Total	740	100

1) A thorough purification system for exit gases can alter the picture.

2) Current prices of equipment are 8-12 $/kw.

3) Figures up to 88 $/t (Al) are quoted recently for pre-baked anode plant.

Equipment for production of cast/rolled semis is relatively not an important cost item.

Requirements on site. The necessary area is of the order of 20 hectars for 50,000 tpy and 30 hectars for a 100,000 tpy unit.

Ground water level should be possibly low, the terrain should be even. Water should be available. Informative data of quantities required.

	30,000 tpy	1 00,000 tpy
Industrial water		
peak m^3/min.	3	8
average/min.	1.5	4
drinking water		
peak m^3/min.	0.4	1
average/min.	0.17	0.4

Recirculation of industrial water is possible.

Other requirements on site.

It should be accessible for transport. In case of non-integrated unit, the alumina will be received by cargo vessels. For this purpose, vessels with 30,000 t load weight are usual. Corresponding harbour facilities are necessary, which are also used for unloading of carbon electrode raw materials and the possible loading of produced metal to be shipped.

It should be possible to construct nearby (but at least about 1 km. from the plant) the housing colony for plant personnel.

It should be mentioned that fluorine and tar-containing exhaust gases may cause damage in the nearby area. Vegetation and animal farming may be severely affected, unless very expensive precautions, respectively captive systems are involved. Taking this into view, less cultivated areas should be preferred in some cases.

Time scheduling of construction. It is general practice to construct the smelters in several stages, by potlines or even by parts of potlines.

Some examples concerning the duration of construction:

- NORF-smelter, W. Germany, 44,000 tpy, the construction lasted 18 months.
- A 30,000 tpy smelter in India needed 2.5 years.
- The 90,000 tpy ALBA-smelter should begin start-up about 29 months after final decision and put into full capacity operation 4 years after final decision.

3.6 Factors of Production

Electric energy. The bulk of consumption is the D.C. energy which is used for metal production and covering the heat losses of the cells. Some factual figures:

	Pre-Baked	Soderberg
Pechiney, 1968 Jan-Feb. (Ref. No. 3)	13,635 kwh/t	14,405 kwh/t
Hungarian plant 30,000 tpy, 1969	-	14,763 "

Under favourable conditions, with skilled personnel, a consumption of respectively 13,500 kwh/t and 14,500 kwh/t should be attained. Some additional consumption is caused by losses in rectifying (about 2%) and because of motoric consumers. This latter may become significant in the case of strong ventillation combined with gas capitation. A slight peak margin should be foreseen, especially because of the periodic "flashing" of the cells, causing a temporary increase of about 40 volts on the D.C. side.

In newer plants, power consumption is usually slightly higher because of lack of training.

Materials. The main specific consumption figures kg. per ton of metal -

Alumina: about 1910 - 1920

Anodes

Paste for Soderberg: 515 - 560

Pre-baked electrodes, net: about 440

Cryolite and aluminium fluoride:

Expressed as F for pre-baked: 28

for Soderberg: 38

Remark: F-content of cryolite is about 54%, of aluminium fluoride about 61%.

Factual figures for a Hungarian Soderberg smelter (1969):

26.1 kg/t cryolite	-	14.1 kg F
21.8 kg/t Al fluoride	-	13.3 kg F
		27.4 kg F

Carbon electrodes are produced on the basis of petroleum respectively pitch-coke, with low ash- and sulphur content. Special coal pitch is needed as binder. The quantities needed (for 1 t of anode paste):

about 750 kg. calcined coke

about 300 kg. pitch

The exact specifications for these materials comprise an essential chapter of the know-how.

Manpower Here a broad diversity exists, depending on size, technical level of the plant, respectively the salaries and labour policy of the country. Man-hours per ton are the usual index for comparison. Here again, two main indices should be discerned, namely:

a) net electrolysis workers manpower. This means practically personnel for cell operations, metal tapping and anode replacement operations. Here the best figures are between 2.8 and 4.7 man-hours per ton.

b) Total manpower of the plant, including maintenance. The best figures are for this case 14-15 man-hours per ton. This would mean about 750-800 men for a 100,000 tpy smelter. Relevant specific figures for new plants, small plants in developing countries used to be higher.

The importance of the human factor is prelevant, because of the extensive character of production (a great number of small production units). Due training and efforts aiming at conservation of skilled manpower are indispensable conditions of normal work.

Working capital: Its exact exigencies depend on a lot of factors, among others on the method of alumina supply. When alumina is shipped by big cargo vessels, large quantities of that raw material are to be stored and increase the assets significantly. In the practice, roughly 15% of annual metal production value can be taken into consideration (about 2.5 million dollars per 30,000 tpy). This includes also the value of molten metal, which is kept constantly in the cells.

4. CRITICAL REVIEW OF THE MAIN TECHNICAL PREINVESTMENT DECISION FACTORS

The basic decision on the establishment of a possible smelter and the timing of the investment will depend on complex basic factors such as:

- availability and price of electric energy,
- if it is possible to acquire alumina under favourable conditions,
- evaluation of absorption capacity of the Maghreb market, and final evaluation of possible foreign markets,
- availability of financial means for the project,
- results of a detailed feasibility study, including the profitability of the project,
- availability of technical staff and skilled labour,
- considerations of general industrial development policy, also with respect to regional collaboration.

The relevant chapters of this study furnish some preliminary information and opinion which can contribute to the formulation of the above.

Here, we should like to summarize our opinion and recommendations concerning some technical aspects of the project, keeping in view the local conditions in Algeria.

Site. Power, harbour, water, cheap development possibilities for the infrastructure should be available.

The sites visualized by S.N.S. in Algeria, though basically favourable, seem to have two disadvantages

1) between the harbour and the plant there is a distance of several kilometres. This necessitates double storage facilities of alumina and also a permanent additional expenditure on local loading, plus transport and unloading of the alumina, using cistern-trucks or railway wagons;

2) they are surrounded by valuable agricultural areas, which might be exposed to severe damage, as mentioned above.

Further investigation and detailed comparative calculations are therefore necessary.

Capacity. Decision on this will depend basically on the general marketing concept. Here the two extremes are possible

1) evaluating the market cautiously, being sceptical on Maghrebian commercial integration, regarding the outside markets with scepticism, insisting on going alone;

2) relying upon Maghreb market integration, being optimistic as to the foreign, mostly European, market, trying to find some strong partner or partners to guarantee sales of the bulk of metal, hard line on co-ordinated efforts for substitution of heavy non-ferrous metals by aluminium, and general promotion efforts for aluminium application.

Conclusion: to construct up to 100,000 tpy.

Life, as usual, will possibly lead here also to some compromise, e.g. combining caution with efforts in sales promotion in the Maghreb countries.

It should also be mentioned that here specific investment costs will, of course, have an important say in favour of big capacities.

Starting with relatively small units has also some advantages, e.g. that the after-start in-plant training of the personnel is much easier. Such a plant can serve for "breeding" of cadres for later more bold developments. Examples of this philosophy can be found in practice in some developing countries, as in Brazil and India.

We have been informed by S.N.S. that they investigate only possible capacities of 50, 100 and 150,000 tpy. We recommend to extend these also to alternatives composed of 25-30,000 tpy potline units. These correspond to cells under 80,000 Ampere and just this range offers also advantages from technical and investment-cost points of view (no difficulties with magnetic fields, cheaper busbar systems).

Investment stages. Stepwise construction is usual practice. The total potline voltage should possibly be used soon, but this is not a rigid rule. Potlines should be possibly uniform. Simultaneously, with the first stage, it is reasonable to instal workshops and the laboratory for full capacity. The ingot-casting shop can be extended stepwise. The anode plant should be constructed for full capacity. The excess production can be sold easily on the market.

Type of cells. This will depend partly on decisions for visualized capacity steps. In the case a longer period with smaller production (up to about 50,000 tpy) is probable, both Soderberg and pre-baked may come into the picture. From the point of view of environmental damages, pre-baked might be more favourable. Any cell type with good references of long-term plant experience might be acceptable.

Integration. Under the given circumstances, it is not indicated to construct an alumina plant for an aluminium smelter. Production of anode carbon should be foreseen. It is indicated to develop a significant production of cryolite and aluminium fluoride, in the Arab countries, but this venture should be integrated into a complex of fluorine compounds production, separately from the smelter.

Production pattern. The smelter should dispose of ample capacity, which enables flexibility in production of:

- ingots for remelting
- extrusion, wire and sheet ingot (alloy type according to desire)
- cast-rolled wire rod (minimum unit capacity about 20,000 t/y)

   and possibly also
- cast-rolled strip (unit capacity about 5000 t/y).

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5. POWER SUPPLY, THE PRICE OF ELECTRIC ENERGY

5.1 Requirements. Besides alumina, electric energy is the main factor of aluminium production. As it has been indicated in Chapter 3, the demand of "technological" electric energy is under ideal circumstances 13 500 kwh/t in case of prebaked, and 14 500 kwh/t in case of Soderberg anodes. The overall specific consumption is higher, because of

- transformation and rectification losses,
- demand for auxiliary plants and equipment, such as the anode plant, the casting shop, the smelter operation, ventilation. This last item itself may attain, in the case of total purification of exhaust gases and strong ventillation, values up to 600 kwh/t.

Besides this it is inevitable that new smelters operated by freshmen have slightly higher consumption figures. For purposes of power source design, values between 15 500 and 16 500 kwh/t can be regarded as realistic.

The bulk of the power, serving the purposes of electrolysis will be converted into direct current by silicon rectifiers. The primary voltage of the rectifier station does not exceed 30 to 35 kV, so a step-down transformation is usually necessary and even inevitable, because for cases of emergency the smelter power supply has to be secured from the high-voltage network system.

The smelter has a practically constant load. Differences between peak and average loads are in the case of a 50 - 100 000 tpy smelter of the order of 3 - 3,5 %. Operation time is practically 8760 hours per year. Dropouts exceeding one hour may cause severe damage to the cells.

5.2 Power prices for aluminium production. These are usually expressed in mills (0,001 US $ per kwh). The price levels in some important areas of aluminium production (Ref. No. 1):

	mills		mills
USA	2 - 4	Germany (Fed.)	5 - 7
Canada	2 - 3	France	5 - 7
Norway	2 - 3	Italy	7
Ghana	2,6	Japan	8 - 10
Iceland	2,5 - 3		

The new smelters in Germany will use power at near 5 mills/kwh, in the USA power at 4 mills is available in any amount.

Nuclear power enables to set the smelter right into the market area. Example for this will be the STADE smelter of Reynolds, to be constructed near Hamburg, with a starting capacity of 100 000 tpy, to be supplied by a 660 MW atomic power station.

The cost of nuclear power became competitive, at least under European circumstances (Ref. No. 2). Some comparative data (600 MW, 6000 hours operation per year):

Fuel	Cost per kwh	
	DPf	mill
Coal	3,2	8,7
Brown coal	2,3	6,3
Nuclear power	2,3	6,3

Besides cheap hydro-power and traditional fuels, natural gas has become one of the important sources of electric energy for aluminium production. In the US Kaisers, Chalmette, La. smelter, Reynolds' Corpus Christi smelter are based on gas fuel.

Pechiney and Ugine have set up their Nogueres and Lannemezan smelters on the basis of the Lacq gas field. Here a 375 MW thermal generation plant has been set up. The relevant power price has been estimated by Bloch and Moment (see Ref. No. 3) at 4,5 mills per kwh. The gas price has been set at 25 ¢ per 1000 cuft, only there are factors of calculation, which do not permit a direct calculus of power cost on the basis of this gas price.

The price of Groningen natural gas in Netherlands was 34 ¢/1000 cuft (data of 1964).

Recent developments in gas turbine power generation offer an interesting alternative for investors (see Ref. No. 7). Cheaper investment, quick construction, possibilities of easy replacement are enticing advantages of this system. However its economics can be utilized totally if, simultaneously with electric energy, heat energy finds also consumption. However, extremely low fuel prices may compensate this factor.

5.3 Electric energy generation in the Maghreb countries. This study should clarify, if it is possible (or reasonable) to establish an aluminium smelter on the basis of supposed cheap electric energy to be produced from natural gas in Algeria and/or Libya.

A thorough, detailed study of the possible sources of energy, which should involve detailed and specific calculations of the investment costs and production costs of the visualized power stations, taking into account all factors, which may influence the fuel price, and the cost impact of infrastructural accessories will be inevitable and exceeds that field of metallurgical and marketing considerations, which has been set as the main purpose to the present Study. As we have been informed in ALGERIA by Société Nationale de Sidérurgie, the Algerian Government entrusted SONELGAZ with the elaboration of such a study for the case of three alternative plant sites (Arzew, Skikda, Bedjaja). Accordingly, before the end of this year a realistic power price calculation will be available for a possible Algerian smelter. Similarly, it was not possible to establish a realistic power-price, and not even a realistic price of natural gas in Libya. In this situation, as cost of electric energy is one of the most important items in aluminium production cost, we had to attempt ourselves a rough, preliminary calculation. At the same time, we tried to cover all essential information and data, available to us at this moment.

The final issue of this investigation should give a clear picture on the competitiveness of production cost of aluminium metal in the Maghreb. Shipping this metal to Europe, will mean a transport cost of the order of 1,2 - 1,5 ¢/kg (for comparison: Cameroon to cif Europe, EEC 1,10 ¢/lb, Ghana to cif U.K. 1,30 ¢/lb). Advantage by cheap power cost should compensate at least for this drawback. This would mean a minimum difference between European and Maghreb power prices of 1,25 - 1,55 mill. Therefore, only from this point of view, a price of maximum 4,0 - 4,25 mills p. kwh would be desirable.

5.4 Electric energy on the basis of natural gas in Algeria.

Regarding quantities and availability, natural gas does not seem to be any problem. The reserves of the country have been quoted at 2800 . 10^9 m^3, of which the gas field of HASSI-R'MEL represents about 2000 . 10^9 m^3. A 580 km long pipeline from HASSI-R'MEL to SKIKDA should transport 13 . 10^9 m^3 per year, in order to supply the Eastern region (Ref. No. 4). Natural gas has been already widely applied in electric energy generation. In 1968 in Algeria generated about 46 % of its electric energy on the basis of natural gas (see Ref. No. 5).

All newly planned power stations will use natural gas as fuel.

Station	Units (MW)	Year of completion
Oran	60 + 60	early 1972
Annaba	50 + 65	late 1972
Skikda	125 + 125	1973

The unit fuel cost for natural gas has been indicated by Murgatroyd (Ref. No. 5 p. 64) as 19,9 US ¢/1000 cuft or 0,703 US ¢ per m^3. As average generation cost for Algeria, in the case of a typical existing modern steam power station (ALGER Port II., with 360 823 GWh sold) he indicates 0,961 ¢/kwh, of which the fuel cost is 0,340 ¢. (9,6 or 3,4 mills respectively).

The values given to us by Société Nationale de Sidérurgie on 28 May 1970 were:

- Price of electric energy (from existing sources) 0,045 - 0,1 DA per kwh, i. e. 9 - 20,2 mills.
- Price of natural gas (9600 kcal per Nm^3) 0,03 DA/m^3 = = 0,606 US¢ per m^3.

On the basis of this latter gas price we made a rough calculation of the electric energy cost both for the case of a traditional thermal power station and a power station applying gas turbines.

The result was:

5,5 mills p. kwh for steam-generation power and
3,8 - 4,5 mills p. kwh for gas turbines.

The approximate character of these results should be stressed here again. The details of the calculations are submitted in Appendix No. II. For purposes of cost estimation we used 4,5 mills, being of the opinion, that in the worst case this should be assured by governmental gas and power tariff policy. Taking into consideration the excellent load factor, this would be justified.

5.5 Electric energy on the basis of natural gas in LIBYA.

Electric energy generation on basis of natural gas does not exist at this moment and is not planned. There is a big production of gas. According statistics (see Ref. No. 6) in 1969 72 . 10^9 m^3 was the yearly production (corresponding about 220 . 10^6 m^3/day). According to what we were told the main problem is the difficulty of gas transport. On the other hand, though at this moment large quantities are flared uselessly, the oil producers claim, that maybe lateron repressuring of significant quantities of gas will be necessary to keep the level of oil production in the fields.

On answering to a questionary for the purpose of this study, the Ministry of Petroleum says as follows (letter of 3rd June, 1970): "Natural gas quantities between 0,35 and 1,12 . 10^6 m^3/day may be furnished. We think that such quantities may be transported through an existing gas pipeline if the site of your supposed project is in the Gulf of Sirte. The duration of the natural gas delivery may be estimated between 15 and 20 years (here it was asked if a constant gas delivery for at least 25 years seems possible to be guaranteed?). Natural gas price can be negotiated after the supposed project is officially proposed, studied and agreed upon by the Libyan Government."

We would like to add, that at present, concerning utilization of natural gas, liquefaction, petro-chemical uses and production of carbon black are visualized as having priorities. Non-officially we have heard about a gas price for petrochemical production which would be very attractive.

As a conclusion, we think that at this moment it is not possible to foresee any founded or exact price of power. At the same time, we think that those rough calculations, which we made for ALGERIA, will basically be applicable also for Libya. 15 - 20 years as duration for the fuel supply is on the low side and in the case of later possible reconsideration of the complex, this circumstances will require more specific investigation.

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6. SUPPLY OF ALUMINA AND OTHER RAW MATERIALS

6.1. Quantity of alumina: The alumina consumption per ton of metal is about 1920 kg (new plant) to 1910 kg (skilled personnel, less loss by dusting). This means that supplies should by foreseen for about the double weight of the metal to be produced.

6.2. Quality of alumina: The exigencies, respectively exact specifications should be suggested by the donor of know-how. It is important that content of impurities affecting electrical conductivity of the metal (e. g. Si, Ti, V) should be low. As an example, two commercial specifications (figures indicate %):

Figure 6 - I

Examples of alumina quality characteristics.

		I	II
Al_2O_3	min	99,00	98,5
Loss on ignition	max	1,0	1,0
$Si\ O_2$	"	0,040	0,020
Fe_2O_3	"	0,040	0,030
$Ti\ O_2$	"	0,010	0,003
Na_2O	"	0,750	0,950
Na_2O soluble	"	0,300	0,020
Zn O	"	0,008	
Ca O&	"	0,100	0,050
V_2O_5	"	0,010	0,002
Mn O	"	0,002	
Other impurities	"	0,020	

The physical structure of the alumina should be in harmony with the cell construction and technology (sandy, floury, intermediary types).

6.3. Method of transport of alumina: Rail transport is [illegible] almost the exclusive way applied. For this purpose, special railway cisterns are used. Sea transport is getting effected by cargo ships with about to 30 000 tons net load. Unloading facilities have been constructed for several smelters, situated at the seaside. The impact of unloading and possible additional storage of alumina on investment and production costs have not been published and should be calculated for the foreseen case in the feasibility study stage.

6.4. Possible sources of alumina supply.

6.4.1. An own alumina plant. In order to consider this way of solving the problem, it should be taken into consideration:

- the minimum economic size of an alumina plant can be considered for the coming years as between 300 000 and 600 000 tons per year;

- this would mean an additional investment of the order of 45 - 100 million US $ which may still increase by further about 30 %, because of accessory investments;

- whilst, as it has been mentioned, it is technically feasible to construct relatively small smelter capacities, from about 25-30 000 tpy which can be extended in an almost continuous way and so easily adapted to the exigencies of a moderately starting but slowly increasing market demand, as it might be expected for a Maghreb smelter, this is not possible with an alumina plant, because modern alumina production technics apply big-size, continuously working production lines of 200 000 - 300 000 tpy capacity each. These are indivisible and their work under nominal load would, of course, not be reasonable.

Taking the above into consideration, an own alumina plant for exclusive purposes of the possible smelter in one of the Maghreb countries does not seem reasonable and might be recommended only when other partners which are also interested in the long-term purchase of alumina, and dispose of the proportional capital for the investment, would be ready to participate. To find such possible partners is already a task of the executive work. It might be suggested, however, to consider a discussion of this problem, among others, with the UAR Government, as according informations, this Government considers also the establishment of a smelter near Aswan dam. In the area of Gebel Abu Churuk bauxite should be also available here, according literature. Similar combinations concerning possible partners might involve:

a) governments and/or companies in the Mediterranean area (e. g. Yugoslavia, Greece) and in Western Africa (e. g. Guinea, Ghana, Congo, Sierra Leone, Ivory Coast), which dispose of bauxite deposits;

b) big aluminium producers in Europe, including the East-European countries.

<u>6.4.2. Purchased alumina.</u> It is characteristic, that the bulk of alumina is used by the producers themselves. According to L.A. Harvey [x], the surplus (+) or deficit (-) of alumina capacities in the non-socialist countries is as follows (1000 metric tons):

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x Lawrence A. Harvey: World alumina picture. In "Integration in Aluminium", a Metal Bulletin Issue - Winter 1969, p. 79 - 84.

Companies, including affiliates	Surplus (+) or deficit (-) of alumina capacity 1968 (December)	1973 (estimate)
ALCAN Aluminium	+ 283	+ 110
ALCOA	+ 1175	+ 1430
KAISER	+ 594	+ 345
REYNOLDS	+ 88	- 149
PECHINEY - UGINE	- 78	- 175
ALUSUISSE	- 488	+ 53
Smaller private companies	- 124	- 1190
Non-socialist government authorities	- 224	+ 205
Total, non-socialist world	+ 1226	+ 629

If we compare these figures with the alumina capacities:

1968, end of December	15 750 000 t
1973, foreseen	22 600 000 t

it can be seen that:

a) the bulk of production does not appear in the sales,

b) the surplus capacity of alumina plants (alumina production capacity minus smelter capacity equivalent) totalled altogether 8 % in 1968 and will shrink to an even more modest 3 %.

The opinion in the industry is that the alumina supply situation, especially in the European area will be tight, at least up to 1976.

Under these conditions, the supply for a new smelter cannot be based on case - to case spot deals. Long-term contracts for cash, barter of metal for alumina under long-term agreements are both usual practice. This has been the basis of alumina supply for Ardal og

Ardal og Verk, the Canadian British Aluminium Company and the ALNOR smelter in Norway. Similar agreements exist between the Hungarian Aluminium Corporation as supplier of alumina, and the Polish and Soviet smelters.

In order to locate a possible supplier it may be of interest, to review the surplus respectively deficit in alumina supply according geographical regions. Here again Harvey should be cited (Figure 6-II.).

Figure 6 - II.

Non-socialist world surplus (+) or deficit (-) of alumina capacity, 1000 metric tons

Region	End of 1968	End of 1973
Non-socialist countries, total	+ 1223	+ 625
North America (excluding Jamaica)	- 1240	- 3150
Jamaica	+ 1110	+ 2570
South America	+ 1250	+ 1230
Western Europe (excl. Yugoslavia)	- 1292	- 2380
Middle East (incl. Turkey & Iran)	--	- 191
Africa	+ 208	+ 134
Asia (excl. Turkey & Iran)	- 173	- 488
Australia & New Zealand	+ 1360	+ 2900

The figures indicate, that Western Europe and the Near East will be deficit areas.

The socialist countries, except Yugoslavia, cannot be taken into consideration as possible suppliers. Poland, GDR are importers of alumina, Rumania (partly), Czechoslovakia (totally) depend on imported bauxite. The USSR is to some extent importer of bauxite, respectively alumina, Hungary's excess bauxite, respectively alumina is sold out by long term agreements.

A geographically favourably located new producer of alumina, depending on Australian bauxite will be the new plant to be constructed in Sardinia. According to published data, the initial capacity will be 600 000 tpy and this should attain till end of the seventies about 2 million tons. The competent company will be EMALUMINA, an affiliate of ALSAR (55 %), COMALCO (25 %), and Metallgesellschaft (20 %). ALSAR again is owned by EFIM (52 %), MONTEDISON (24 %), and by TRACTION ELECTRICISE (Belgian) (24 %).

The possibilities, respectively conditions of a possible long-term deal can be clarified only by direct discussions between the concerned parties.

<u>6.5. Price of alumina:</u> Here the long-term character of the contract will have a decisive role. Whilst spot-purchases may attain levels over 90 $/t Fob European ports, in the case of a deal with an overseas supplier for 10 up to 15 years Fob prices between 50 and 55 $/t seem realistic. European prices are higher. Even long-term deals are here in the range between 70 and 75 $/t. This latter picture will probably change favourably, when the new big, economic plants will come into being (Sardinia, Péchiney - Kaiser's plant, ALCAN'S European plant). The production cost will stay here, however, about by 10 $/t higher than overseas prices, simply because of bauxite transport's additional cost (Australia - Mediterranean ports about 4,5 $ per ton of bauxite).

Sea transport costs of alumina will also depend on factors, such as size of the vessels. A factual figure of 4,5 $/t for North African port to East European port may be regarded as a good medium. In such a way for purposes of calculation we suggest a cif North Africa price of 65 $/t in the hope that this will reflect also the cost of [illegible] for coming up-to-date production on the European coast line.

6.6. Supply of cryolite and aluminium fluoride: The necessary quantities for current production of one ton of metal roughly 30 kg commercial cryolite and 30 kg commercial aluminium fluoride are consumed. These proportions may vary depending on technologies and/or the quality of these materials. Thus for a 100 000 tpy capacity about 3000 tons of cryolite and 3000 tons of aluminium fluoride per year are necessary. In the case of smaller capacities, the quantities will vary in a linear proportion.

Before start up, a significant quantity of cryolite is needed for the filling-up of the cells with electrolyte, i. e. about 6500-7000 tons in the case of a 100 000 tpy smelter.

The price of synthetic cryolite Fob South European harbour is 180-200 $/t, that of aluminium fluoride 220 $/t. The mine of natural cryolite in Greenland does not cope with the immense quantity requirements of today's market.

In the Maghreb countries there is at present no production of cryolite and aluminium fluoride, but the raw material situation for this is very favourable. It might be suggested to study this problem separately and to elaborate a detailed proposal for coordinated action in this field.

A short summary of the raw material situation in the countries:

ALGERIA. There are three recently discovered fluorspar (CaF_2) deposits:

a) HOGGAR area (transport not economic)

b) ICHMOUL near BATNA

c) MAGHNIA

Quantity data are not available.

In the processing of phosphate rock, which contains about 3,5 % fluorine, there is at present no recovery of fluorine but at the request of a possible buyer, SONATRACH would be prepared to go ahead in developing a line of by-product fluorine compounds.

MOROCCO. El-Hamma deposit (near Meknes) counts now 2.10^6 t fluorspar rock (45 % CaF_2). Here a flotation dressing plant with 50 000 tpy capacity (96 % CaF_2) will start up to 1972 (it will be run as a joint venture of BRPM and OMNIUM NORD AFRICAIN).

In the production of phosphate fertilizers there is now no fluorine recovery at all. At the SAFI complex, however, where the input is of about 600 000 tpy phosphate rock, there might be a recovery of about 8 - 10 000 tpy fluorine (corresponding to about 15 - 20 000 tpy cryolite) possible. This could be implemented in the phosphoric acid concentration step, only an economic process, starting from NaF would be needed by the plant for this purpose.

TUNISIA. Hammem Zriba deposit (near Zeghouan) has an established reserve of 2.10^6 t of fluorspar and possibilities of further quantities. Here a flotation plant with a yearly capacity of 29 000 t product (97 % CaF_2) exists. It is under consideration to double the output of this plant and to establish production of fluorine compounds and, among others, of cryolite and aluminium fluoride. For these both products about 20 000 tpy have been suggested, corresponding to about 10 000 tpy HF (hydrogen - fluoride) as intermediary product.

Fluorine recovery in the phosphate fertilizer production is not foreseen. With the SIAPE process, most of the fluorine content of the rock is lost in the gypsum wastes. However, this possibility should be studied again. In Figure 6-III. we indicate a rough estimate of recoverable fluorine quantities as by-product of phosphate fertilizer production.

Figure 6 - III.

Production estimates for phosphate fertilizers production in the Maghreb. (Based on data from: T.S. Abida, K.M. Muttawa, K. Shantz: Preliminary Investigations into the Fertilizer Situation in Algeria and Morocco, Centre of Industrial Studies for the Maghreb, Tripoli, April 1969). 1000 tons P_2O_5.

Figure 6 - III.

	1970 estimates		1975 estimates		1980 estimates	
	produ.	capacity	produ.	capacity	produ.	capacity
Morocco	204	210	197	210	290	372
Algeria	18	19	180	181	204	208
Tunisia	178	207	257	303	257	310
Libya	-	-	-	-	-	-
Maghreb total	400	436	634	694	751	890
Recoverable fluorine (F) estimate 1000 t	12		19		22,5	
Corresponding quantity of cryolite 1000 t	24		38		45	

Remark: In average a rock with 30 % P_2O_5 and 3 % F has been supposed. Fluorine recovery should be about 30 %.

Summarizing, it can be stated that exceeding by for the consumption of a possible Maghreb smelter, there could be a significant excess output in fluorine products for export purposes.

It seems advisable to realize the concerning investments in some coordinated way.

Efforts for producing recovered cryolite from anode gases of the cells did not prove economic on plant scale and the cryolite quantities obtained by this way are not very significant.

6.7. Supply of carbon electrodes and cell linings.

The quantities of carbon anode materials required:

In case of Soderberg anodes: 520 - 560 kg anode paste per ton of metal. This means about 400 kg/t calcined petroleum - or pitch coke and 150 kg/t special coal pitch as components of paste production.

In case of prebaked anodes 510 kg/t of metal overall and 410 kg/t net consumption is normal (net figures do not contain the weight of recoverable anode stumps). Accordingly, for a 100 000 tpy metal production 52 - 56 000 tpy electrode paste, or 51 000 tpy prebaked anode blocks are necessary.

This again means, that annually more than 40 000 tpy calcined, ash-free coke and about 15 000 tpy special quality pitch will be consumed. The filling-up of the anodes before starting necessitates again a big lot of material. In the case of a 100 000 tpy plant with Soderberg-anodes the required quantity will be about 12 000 tons.

The cathode linings of the cells are usually built of prebaked electrode-carbon blocks made of anthracite, respectively by using stamping electrode paste, which is made partly of a mixture of anthracite and foundry-coke grains, partly contains also some graphite. For the construction of a 100 000 tpy smelter about 5 000 t cathode blocks and roughly 5 500 t stamping pastes are used.

Some relevant price data:

anode paste Fob South European harbour about 80 $/t,
prebaked anode blocks about 140 $/t,
cathode blocks 210 $/t,
the cathode paste price may be in the average less than 80 $/t,
petroleum coke Fob Gulf Coast harbour: about 35 $/t.

In the Maghreb area the main raw material will be soon available. In Algeria, SONATRACH will start its 100 000 tpy calcined petroleum coke production till late 1973. For some characteristics see figure 6-IV.

Figure 6 - IV.

Characteristics of petroleum coke to be produced in Algeria.

Sulphur	less than 1 %
Vanadium	less than 80 ppm
Ashes	maximum 0,5 %
Less on ignition	less than 0,5 %
Real density	2,06 - 2,08

In Libya, at this moment there is no intention to establish production of petroleum coke.

If necessary, the pitch as binder can be easily purchased from Europe or other sources. In this way, the establishment of an own electrode production seems indicated and feasible.

Cathode blocksshould be purchased from an experienced supplier. Lateron, only the annual repairs of the linings require further, more modest quantities of cathode carbon (about 1500 tpy for a 100 000 tpy smelter).

The cathode stamping pastes can be produced in the anode plant. The relevant recipes should be requested from the supplier of the know-how.

7. Attempt of production cost analysis

The purpose of this chapter is to estimate the production cost for the future smelter. Comparing the estimated cost with the product prices gives an idea on the profitability of the venture. As a significant part of the product has to be shipped and at the same time part of the raw materials will be imported, the impact of transport cost should not be neglected.

The general structure of aluminium production cost in the Western world is roughly :

Alumina + power	45%
Other raw materials	15%
Labour	10%
General expenses	10%
Capital charges	20%

In the following, we shall apply the categories of cost factors according to Lewis (see Ref. No. 1), namely :

- alumina
- fluorides
- carbon
- operating and maintenance supplies
- power
- labour
- miscellaneous and general expenses
- capital charges, as depreciation and interest on fixed capital

A complete analysis should involve several variants, so that the detailed costs for cases of prebaked and Soderberg and these again for different capacities, should be elaborated. We feel that such calculus would require a quite specific and detailed calculation of the investment cost and of the production cost for all cases. Such detailed data will not be available before the stage of Feasibility Study. Here,we confine ourselves for cases of 30.000, 50.000 and 10.000 tpy as these are the most probable ones and have derived the data only for the case of Soderberg-cells. For prebaked we calculated merely for the case of the bigger capacity. Even so, the figures should be sufficient to indicate the overall rentability of a possible project.

Supposition and initial data :

We have kept in mind a location in Algeria.

Alumina : Specific consumption 1920 kg/t; price CIF Algerian harbour 65,0 $/t, additional local transport to plant has been neglected.

Fluorides : The specific consumption figures : cryolite 32 kg/t with Soderberg, 26 kg/t with prebaked.
Aluminium fluoride : 32 kg/t with Soderberg, 26 kg/t with prebaked.
Prices : cryolite, CIF Algerian harbour 205 $/t, aluminium fluoride 225 $/t.

Carbon : Specific consumption 520-560 kg/t Soderberg -

paste (we counted 54o), or 440 kg/t prebaked net, respectively 510 kg/t gross weight. Price, respectively cost of anode paste, when of own production, should not be more than 60 $/t, that of prebaked anodes maximum 90 $/t.

We operated with these figures, at the same time the differences in investment cost of the carbon plant have been neglected, being supposed, that the respective capital charges of the carbon plant are contained in these cost figures.

Operating and maintenance supplies : This we estimated as 20,0 $/t, based on data Ref. 1, corroborated by known actual figures.

Power : Specific consumption (overall) in case of Soderberg 16.000 kwh/t, in case of prebaked 15.000 kwh/t. Price of power : supposed 4,5 mills.

Labour : We supposed per ton the following overall numbers of man-hours :

30.000 tpy	20 man-hours/t
50.000 tpy	18 " "
100.000 tpy	16 " "

Wages 10 DA per hour, i.e. 2 $/hour.

Miscellaneous and general expenses : These include insurance, supervisory, technical and clerical personnel and contingencies. Here we assumed 2,5 percent of fixed capital plus 30 percent of labour cost.

<u>Capital charges</u> : Fixed investment assumed as follows :

30.000 tpy	28,65 m/$	955 $/t/y
50.000 tpy	42,55 m/$	851 $/t/y
100.000 tpy	74,7 m/$	747 $/t/y

Differences in investment cost factors between the two anode types have been neglected. Life of equipment has been assumed at 12,5 years, of buildings at 20 years. Interest rate 6 percent.

The results of the calculus can be found in Figure 7 - I.

Figure 7 - I

Average production cost estimate of aluminium ingot
(in US dollars per metric ton of product)

Item	Soderberg 30.000 tpy	Soderberg 50.000 tpy	Soderberg 100.000 tpy	Prebaked 100.000 tpy
Alumina	125	125	125	125
Fluorides	14	14	14	11
Carbon	32	32	32	46
Operating and Maintenance supplies	20	20	20	20
Power	72	72	72	68
Labour	40	36	32	32
Miscellaneous and general expenses	36	32	28	28
Capital charges :				
1) Depreciation	68	61	53	53
2) Interest on fixed capital	57	51	45	45
TOTAL	464	443	421	428

To compare the production costs with those of [illegible] [illegible], we consulted the annual report of ALCAN for [illegible] which reveals as average ingot sales prices :

for 1968   23,7 ¢/lb - 523 $/t

for 1969   24,8 ¢/lb - 548 $/t

This means that a profit margin up to 70 - 110 $/t [illegible] possible.

On selling the ingot to Europe, a transport cost of 12 $/t might be realistic.

It is important to clarify in advance and unequivocally the questions of trade barriers, as these can attain in the case of EEC countries 5 to 9% for aluminium delivered from outside the EEC area. Discounts for simultaneous compensation of additional freight and customs duties would curtail the profit margin very sensibly and render the economy dubious.

The main possible sources of error in the above consideration can be :

- the unit price of alumina, where a favourable long term purchase agreement is an inevitable condition;
- miscellaneous and general expenses, where local taxation might cause unexpected increases,
- the volume of fixed capital, for which definite, final figures will require a complete detailed calculation, taking full account of realistic, local cost factors.

References for Chapter 7

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6. ALCAN annual report 1969.

8. MARKETING OF ALUMINIUM METAL

8.1 General background. Comparative figures on metal consumption

Recent estimates of world aluminium production capacities, with a forecast for the period up to 1974 is shown in Figure 8 - I. Accordingly, the world capacity, estimated at about 11 million metric tons/year for 1970 will be extended according known projects up to 1972/74 by roughly 27% up to about 14.3 million.

For purposes of a preliminary and global evaluation of the aluminium consumption, specific consumption figures, expressed in kg per capita per year are widely used. It is also expedient to compare these figures with the relevant data of Gross National Product (or G.D.P., respectively Net N.P.) per capita and year. Figure 8 - II indicates these figures for some countries. (1)

Though the scatter diagram of the consumption index values versus Net National Product (kg Al per 100 $ N.N.P.) show no coherent correlation function, it can be established that 0,30 seems to be a reasonable minimum value in the range of 200 - 600 $ G.N.P. per capita, that might be expected for the Maghreb countries in the next two decades. (See Figure 8 - III).

(1) Based partly on undisclosed data sheet of the Hungarian Aluminium Application Centre.

FIGURE 8 - I

WORLD ALUMINIUM PRODUCTION CAPACITIES AND THE EXTENSION PLANS FOR THE PERIOD UP TO 1972 - 1974 (Ref. No. 1).

	Capacity. 1000 metric tons	
Country	1970	1972-1974 estimated
United Kingdom	39	300
Australia	104	187
Austria	96	96
Belgium	-	66
Brazil	58	130
C.S.S.R.	60	60
South Africa	-	42
South Korea	-	15
France	369	408
Ghana	104	104
Greece	72	90
Netherlands	32	90
India	120	223
Indonesia	-	20
Iran	-	50
Iceland	-	45
Jamaica	30	45
Japan	548	902
Yugoslavia	104	200
Kamerun	52	59

Country	Capacity, 1000 metric tons	
	1970	1972-1974 estimated
Canada	1084	1200
China	about 175	about 200
Poland	96	110
Hungary	65	80
German D.R.	79	79
Norway	514	691
German F.R.	270	430
Italy	145	232
Rumania	75	150
Spain	84	134
Surinam	72	72
Switzerland	74	74
Sweden	50	50
U.S.S.R.	1830	2095
Taiwan	33	36
Turkey	-	30
U.S.A.	4172	4830
Venezuela	20	25
Others	about 400	about 600
Total	about 11026	14310

FIGURE 8 - I.

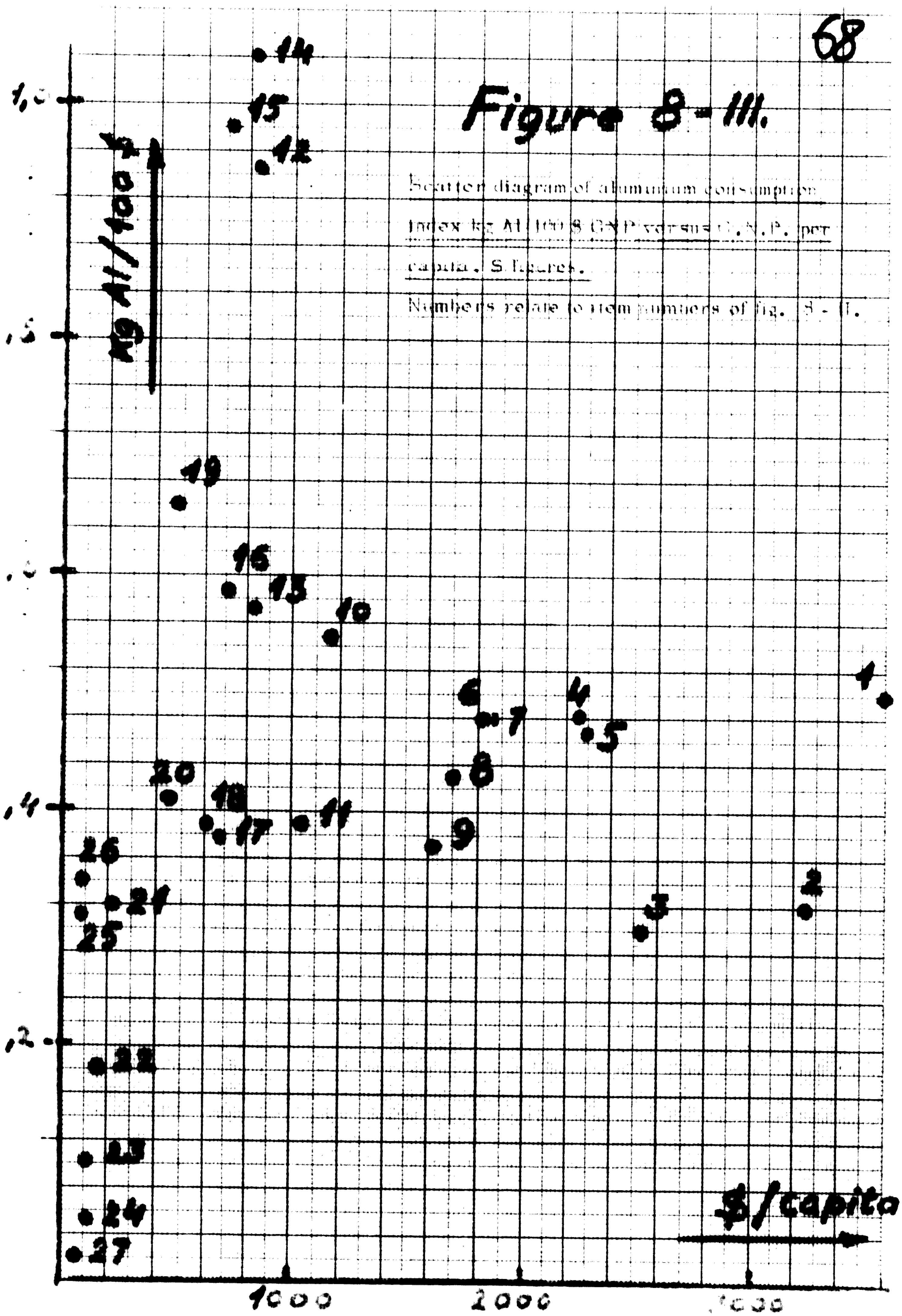
COMPARATIVE DATA ON ALUMINIUM CONSUMPTION AND NATIONAL PRODUCT PER CAPITA FIGURES AND THEIR INTER-RELATION

Country	Year	N.P. per capita, $	Al consumption per capita kg/year	Consumption index kg Al 100 $ N.P.
G.N.P./c. over 2000 $ per year				
1. USA	1968	4280 (GNP)	21.4	0,50
2. Sweden	1968	3340 (GNP)	10.8	0.32
3. France	1968	2510 (GNP)	6.3	0,25
4. Switzerland	1966	2250 (GNP)	10.7[1)]	0,46
5. German Fed. Rep.	1968	2280 (GNP)	10.7	0,47
G.N.P./c. between 1000 and 2000 $ per year				
6. United Kingdom	1968	1830 (GNP)	8.8	0,48
7. Canada	1965	1825 (NNP)	8.9	0,48
8. Norway	1966	1710 (GNP)	7.3[1)]	0,43
9. Australia	1965	1620 (NNP)	6.0	0,37
10. Austria	1966	1150 (GNP)	6.3[1)]	0,55
11. Italy	1966	1030 (GNP)	4.0[1)]	0,39
G.N.P./c. between 500 and 1000 $ per year				
12. German Dem. Rep.	1965	840 (NMP)	8.0	0,95
13. U.S.S.R.	1965	820 (NMP)	4.7	0,57
14. Hungary	1968	810 (GNP)	8.4	1,04
15. Czechoslowakia	1965	715 (NMP)	7.0	0,98
16. Japan	1965	695 (NNP)	4.1	0,59
17. Greece	1966	660 (GNP)	2.5[1)]	0,38
18. Spain	1965	594 (NNP)	2.3	0,39

Country	Year	N.P. per capita,$	Al consumption per capita kg/year	Consumption index kg Al 100 $ N.P.
G.N.P./c. between 250 and 500 $ per year				
19. Poland	1965	465 (NNP)	3.1	0,66
20. Bulgaria	1965	438 (NNP)	1.8	0,41
G.N.P./c. less than 250 $ per year				
21. Brazil	1965	217 (NNP)	0.7	0,32
22. UAR	1966	160 (GNP)	0.3	0,18
23. Sudan	1966	100 (GNP)	0.1	0,10
24. Uganda	1966	100 (GNP)	0.05	0,05
25. India	1965	86 (NNP)	0.27	0,31
26. Tanzania	1966	80 (GNP)	0.27	0,341
27. Ethiopia	1966	60 (GNP)	0.01	0,02

1) Data for 1967
Source of 1966 GNP data : Marches Tropicaux et Mediterraneens, No. 1248, October 1969.

Figure 8-III.



Scatter diagram of aluminum consumption index kg Al/100 $ GNP versus G.N.P. per capita. $ figures.

Numbers relate to item numbers of fig. 8 - I.

The main sectors of aluminium fabrication and their quantitative proportions on the basis of European statistics for the period 1960 - 1965 are indicated in Fig. 8 - IV(2). Here, the input proportions were : virgin metal 80%, secondary metal 20%.

Figure 8 - IV

PROPORTION OF ALUMINIUM FABRICATIONS

(Period 1960 - 65)

Products	%
Rolled (sheet, strip, foil)	45
Extruded	15
Drawn	10
Forged	2
Castings	25
Powder, paste, granules	3
	100

Some comparative data concerning percentual brakdown of aluminium consumption according to the main fields of end uses, have been revealed in Figure 8 - V.

FIGURE 8 - V

PERCENTUAL BREAKDOWN FIGURES OF ALUMINIUM CONSUMPTION ACCORDING TO THE MAIN CATEGORIES OF END-USE

		G.F.R. 1965	Hungary 1965	India 1968	Italy 1965	Switzer-land 1965	USA 1965
	Consumption kg/cap	8,25	5,76	0,30	3,97	7,83	17,54
1.	Construction of vehicles	29,6	18,9	12,0	43,7	8,1	23,8
2.	Machinery	12,2	4,0	-	8,7	20,4	6,4
3.	Electrical ind.	15,2	38,5	55,0	6,5	10,8	13,2
4.	Construction	10,1	4,1	6,5	12,0	24,5	24,2
5.	Chemical, food, agriculture, packaging	12,5	10,1	7,6	9,9	19,6	10,0
6.	Household goods	3,7	6,7	12,0	7,6	5,3	10,0
7.	Powder and siderurgy	6,0	3,6	-	3,6	1,3	4,7
8.	Mass products and others	10,7	14,1	6,9	8,0	2,8	7,4
	Total	100,0	100,0	100,0	100,0	100,0	100,0

8.2. Marketing possibilities of aluminium to be produced in the Maghreb area.

8.2.1 The aluminium market within the Maghreb. The present situation.

Because of the preliminary character of this study and the limitations of available time we have confined ourselves to a global quantitative evaluation of the present situation. The fact-finding was founded basically on official data of foreign trade statistics and interviews with government officials and officers of involved enterprises as well.

The Figures 8 - VI to 8 - IX reflect the recent situation, respectively the available global data on import and export of aluminium, respectively aluminium products. On calculating the consumption figures, we took the difference of the imported and exported weight. We related consumption per capita figures also to the G.N.P., respectively G.D.P. per capita values. This analysis, though it should be regarded only as a first, simplistic attempt of market capacity evaluation, reveals that, the market - apart from Libya - is evidently under-saturated with aluminium.

While the world average consumption per capita for 1965 was 1,85 kg and for 1967 2,5 kg, here the per capita figures were :

ALGERIA	1966	0,70 kg
	1967	0,10 "
	1968	0,20 "
LIBYA	1966	1,36 kg
	1967	1,70 "
	1968	1,65 "
MOROCCO	1965	0,11 kg
	1966	0,09 "
	1967	0,16 "
	1968	0,15 "
	1969	0,20 "
TUNISIA	1966	0,20 kg
	1967	0,24 "
	1968	0,28 "

Though, as it has been said, there is no direct correlation between G.N.P. per capita and the specific aluminium consumption, it should be mentioned that relevant figures for the Maghreb are also far under the 0,30 kg per 100 US $ value, which fact also corroborates our opinion that the aluminium consumption, respectively application in these countries is by far not in compliance with up to date economic proportions, even considering their developing status.

		kg aluminium per 100 $ G.N.P.
ALGERIA	1966	0.028 x
	1967	0.041 x
	1968	0.08x
LIBYA	1966	0.0146
	1967	0,159
	1968	0.149

		kg aluminium per 100 $ G.N.P.
MOROCCO	1965	0.055
	1966	0.051
	1967	0.084
TUNISIA	1966	0.140

x) per 100 $ G.D.P.

Remark : The above figures are not exactly comparable with those under Figure 8 - II, partly based on Net N.P. data. As the difference between G.N.P., N.N.P. and G.D.P. are not too great in the case of these countries, the above indexes can serve however, as indicative.

The values of present imports and exports have been indicated in Figure 8 - X. It is a promising fact, that imports of aluminium in the four countries has grown between 1965 and 1968 by about 16,5% per year.

We scrutinized also, to what extent there exists a commercial interchange of aluminium goods between the Maghreb countries. The findings are reflected in Figure 8 - XI, in kg per year and indicate,that this traffic is practically nil. This fact seems to be contradictory to the existing and only poorly used fabrication capacities for some products. (See Appendix I).

FIGURE 8 - VI

GLOBAL ALUMINIUM CONSUMPTION FIGURES IN ALGERIA DURING 1966 - 1968

Year	1966	1967	1968
Import, t	1540,7	1997,5	3523,8
Export, t	704,3	686,8	813,6
Net, for consumption, t	836,4	1310,7	2710,2
Population, 1000	12 150	12 969	13 358
G.D.P. market price, 10 000 D.A.	1488 000	1576 000	-
G.D.P. market price, 10^6 US $	3006	3184	-
G.D.P per capita, US $	247	245	250 1)
Al consumption, kg/capita	0,069	0,101	0,203
Index kg aluminium per 100 $ GDP	0,028	0,041	0,08 1)

1) estimate

FIGURE 8 - VII

GLOBAL ALUMINIUM CONSUMPTION FIGURES IN LIBYA DURING 1966 - 1968

Year	1966	1967	1968
Import, t	2278,9	2959,0	2949,3
Export [1], t	-	-	-
Net for consumption, t	2278,9	2959,0	2949,3
Population, 1000	1677	1738	1790
G.N.P. market price, 10^6 L£	557,4	665,9	-
G.N.P. market price, 10^6 US $	1560,7	1864,5	1976,4 [2]
G.N.P. per capita, US $	928,9	1072	1104 [2]
Al consumption, kg/capita	1,36	1,70	1,65
Index kg aluminium per 100 $ GNP	0,146	0,159	0,15

Remarks : 1) Export of scrap possible, only the relevant figures were available for nonferrous metals, globally

2) estimated

FIGURE 8 – IX

GLOBAL ALUMINIUM CONSUMPTION FIGURES IN TUNISIA DURING 1966 – 1968

Year	1966	1967	1968
Import, t	1519,5	1229,3	1446,4
Export, t	191,5	142,8	138,5
Net, for consumption, t	1328,0	1086,5	1307,9
Population, 1000	4470	4527	4654 1)
G.N.P. market price, 10^6 Dinars	493,3	–	–
G.N.P. market price, 10^6 US $	948,6?	–	–
G.N.P. per capita US $	212	215 1)	220 1)
Al consumption kg/capita	0,297	0,24	0,28
Index kg aluminium per 100 GNP	0,140	0,111	0,127

1) estimated

FIGURE 8 - X

VOLUMES OF VALUE, ALUMINIUM IMPORTS AND EXPORTS OF THE MAGHREB COUNTRIES

(on basis of official statistics data on foreign trade)

A (Imports, 10^6 US Dollars)

Year	1966	1967	1968
Algeria	1.823	2.359	4.241
Libya	1.974	2.386	3.266
Morocco	2.285	2.537	2.801
Tunisia	1.563	1.327	1.732
Total 10^6 US $	7.645	8.609	12.040
Imports total (t)	7.235	8.945	10.536
Average price, $/t	1.056	962	1.142

B (Exports, 10^6 US Dollars)

Year	1966	1967	1968
Algeria	0.249	0.241	0.260
Libya	...	...	-
Morocco	0.201	0.147	0.151
Tunisia	0.058	0.044	0.043
Total 10^6 US $	0.508	0.432	0.454
Exports total (t)	1.490	1.308	1.742
Average price, $/t (including scrap)	341	330	260

FIGURE 8 - XI

INTERCHANGE OF ALUMINIUM PRODUCTS BETWEEN THE MAGHREB COUNTRIES

QUANTITIES IN KG PER YEAR.

		Imports from			
		Libya	Morocco	Tunisia	Total
ALGERIA	**1966**	-	433	15	448
	1967	-	2473	220	2693
	1968	-	417	-	417

		Imports from			
		Algeria	Morocco	Tunisia	Total
LIBYA	**1966**	-	52	1878	1930
	1967	-	-	331	331
	1968	-	-	531	531

		Imports from			
		Algeria	Libya	Tunisia	Total
MOROCCO	**1966**	-	-	-	-
	1967	-	-	-	-
	1968	-	-	-	-

		Imports from			
		Algeria	Libya	Morocco	Total
TUNISIA	**1966**	-	-	-	-
	1967	-	-	-	-
	1968	1065	-	-	1065

Remark: In case of contradictory data, we used the higher ones.

We have also attempted to furnish more specific data on the breakdown of aluminium goods, which are imported at present in the four countries, according to the main product groups. Similarly, we collected some information on the visited enterprises which are dealing with fabrication or application of aluminium metal. See [illegible] in Appendix [illegible] to this Report.

<u>On observing the present situation, the following main features are conspicuous :</u>

1. The market, as it has been indicated above, can be regarded as strongly undersupplied with aluminium. The present demand in the range of 10 000 t/y could be increased significantly.

2. The low consumption figures are partly due to strong conservatism as to the use of heavy non-ferrous metals, especially of copper [illegible] from the point of view of the individual national economies and might deserve attention of the Governments. [illegible] to foster up-to-date light metal application techniques should be [illegible] co-ordinated.

3. The commercial activities aiming at exportation and importation of aluminium and aluminium products are practically completely extraverted from the point of view of the Maghreb area. Deals between the countries at present are practically nil. The causes of this situation are mainly the following :

a) The fabrication and assembling facilities have been developed parallel in the four countries, without coordinated planning, in such a way basically there is no complementary character of demand respectively supply between the countries.

b) The present customs tariff regulation system generally does not favour the interchange of goods between the four countries v/s other suppliers. Here the official general tariffs act sometimes even adverse, especially because of special relations of the countries with some European countries and/or the EEC. The pattern of this situation is however complicated and changing, due to recent bilateral special regulations within the Maghreb area.

c) Because of lack of metal and semis production facilities there is practically no remarkable export potential in these countries at present. The existing ones, such as MMA's (Morocco) excellent tube-welding plant and pressure cooker production are used only to a very limited extend.

8.2.2 The aluminium market within the Maghreb. Future outlook.

A detailed and profound market-expectations forecast would require a thorough analytic market study going into details for each sort of products to be investigated in correlation with relevant other industrial and consumption forecast figures, etc. The special situation of the involved countries where in rural areas traditional civilisation environment still exists, parallel with the striving development in urban and industrial areas, would justify also a specific analytic approach to get more realistic figures. This would, however, by far exceed the purpose and scope of this work.

We may, therefore, recommend that such a study is prepared separately. It would be most reasonable to combine this task with a detailed fact-finding analysis of the present aluminium fabrication situation in the Maghreb countries and the elaboration of a proposal concerning coordinated development of aluminium semis fabrication industries and a possible reasonable collaboration in the turnout of aluminium finished products.

Coming back to our present tasks, we felt that it would be satisfactory to draw a first-glance global forecast for aluminium metal consumption. For this, we applied simple regression based on population and G.N.P. expectations. In this attempt we started from the following suppositions :

a) A slightly optimistic approach, expecting that economic aluminium application and consumption will be stimulated also by governmental means, making use of organized methods, like application consulting services. This is reflected in the supposed kg Al per 100 $ G.N.P. or (G.D.P.) figures, for which we have projected values approaching 0,30 up to 1990.

b) The following uniform growth rates have been supposed for the whole time-period (percent per year) :

Population :	ALGERIA	3 (1980-90 2,5%)
	LIBYA	3
	MOROCCO	2,8
	TUNISIA	2,5
G.N.P.: respectively	G.D.P.	
	ALGERIA	7
	LIBYA	6
	MOROCCO	5
	TUNISIA	6,5

Figure 8 - XII shows the global results of this calculus.

The target for 1975 would need some effort, but the figures for 1980, respectively 1990 can be easily achieved and reflect even some conservative caution. In support of this statement it should be considered, that the forecast kg/capita figures are still below the 1965 world average (1,85 kg) or even the present Libyan level (about 1,7 kg). The average annual growth rate of metal absorbtion would be 11,7% per year, starting from 1968.

In round figures the above assessment says, that total Maghreb need for aluminium would be :

1975	27.000 t/year
1980	46.000 t/year
1990	105.000 t/year

It might be supposed that about 40% and 30% in 1990 of these quantities will be required in such dimensions or special qualities, for which there will be no production

FIGURE 8 - XII

ALUMINIUM DEMAND FORECAST

FOR THE MAGHREB, TONS PER YEAR.

	1967	1975	1980	1990
Algeria	1 310	8 220	15 400	46 000
Libya	2 960	7 420	11 900	21 000
Morocco	2 280	7 940	12 800	25 000
Tunisia	1 090	3 370	5 700	13 000
Total	7 640	26 950	45 800	105 000
Total kg Al per capita	0,23	0,64	0,95	1,65

facilities in the area or which will be covered [illegible] supplies because of commercial reasons. This estimated proportion is in compliance with the breakdown of present [illegible] according to main product groups as in Appendix I [illegible] In this way, the purchasing capacity of the involved countries, i.e. the <u>internal net absorbing capacity of the market may be [illegible] roughly at</u> :

for 1975	16.000 t/year
for 1980	28.000 t/year
for 1990	75.000 t/year

The above picture may, of course, change basically in case the fundamental political and economic conditions develop in a way that the present trend rates of growth are modified. However, even the indicated levels of consumption suppose the following measures :

a) To establish in the involved countries production facilities for the most important semis, such as

- sheet, possibly also foil
- extrusions
- wire rod
- castings

It is important, that the quality of the visualized products should be equivalent to those from developed industrial countries and therefore, proper regional standards should be established. The problem of economic scrap-processing deserves special attention.

b) The development indicated above under a) should be implemented in a coordinated way, on the basis of mutual understanding.

c) Special efforts should be made to facilitate the broad application of aluminium, using available up-to-date foreign experience. This is especially important in the field of electrical industry and electrification. It seems rational to exert these efforts in a joint way, using all means of common technical information.

d) When amending the customs tariff systems of the countries, or the relevant bilateral agreements, it should be kept in mind to promote mutual trade in aluminium goods between the countries of the Maghreb.

It exceeds by far the scope of this study to outline an optimal setup for the coming semis production. However, on the basis of our findings it can be suggested as a <u>preliminary proposal for consideration</u> :

- To set up jointly with the future smelter a cast/rolling mill for wire-rods with a capacity of about 20 000 tpy (corresponding Properzi 7B type);
- To set up in the most important industrial regions two or three cast/rolling units for about 5 - 8 000 tpy each, in order to cover the requirements in
    - rounds for production of household goods
    - ondulated sheet for roofs and other purposes

  - sheet and strip in general
- To set up an extrusion mill in one of the countries which might supply mainly :
  - profiles for construction
  - small diameter tubes

In order to promote these developments in an optimally rational way, we suggest to prepare a detailed study concerning both

a) market analysis and forecast of aluminium semis and finished goods,

b) alternatives for development of semis production in the Maghreb countries.

8.2.3 The aluminium metal market outside the Maghreb

On this, hardly more can be said than general statements, that are of lasting value for a prospective vendor. The con- annual growth of the demand on the European Market, which evidently is the most interesting in this case, is estimated between 7 and 10%. The construction of production facilities for the period up to 1975 has been planned taking into consideration the more ambitious figures. Therefore, it exists the possibility of the danger, that - in case of non-fulfillment of market expectations - significant idle smelter capacities which may attain on world scale 1 million tpy, might be available. Competition on behalf of other materials, adversities of the political and economic climate may affect these developments significantly. Europe, as a whole, is at present importer of primary aluminium. Figure 8 - XIII indicates on the basis of Wohnlich's data (Ref. No. 8 - 3) the general picture, according to the situation by the end of 1968.

The aluminium consumption of the Western European countries is put by Domony (Ref. No. 4) for 1969 at a level of 1.907,000 tons. Existing smelter capacities of the whole European area, except the Soviet Union, according to 1970 figures amount to 2 224 000 tpy. These capacities should increase, taking into view scheduled projects to 3.475,000ton per year up till 1974. (See also Ref. No. 4). This corresponds to an annual growth rate of about 11,5%. (For details, see Figure 8 - XIV).

Taking into account all these figures and also the unknown factor of Soviet metal export, further the potential of future capacities outside Europe, but with a product destination to the European countries, like the ALBA-smelter in Bahrein, it seems clear that Europe cannot be regarded for 1975 as an area to be undersaturated by primary metal.

Integration efforts and growing internationalization of the big producers is characteristic on world-scale and also in Europe. Another important feature of the seventies seems to be to favour smelter sites near or within the markets, contrary to the previous decades, where the proximity of cheap electric power was often the determining factor.

The European aluminium market should be regarded as an organized one. The "Aluminium Club", a cartel-like association

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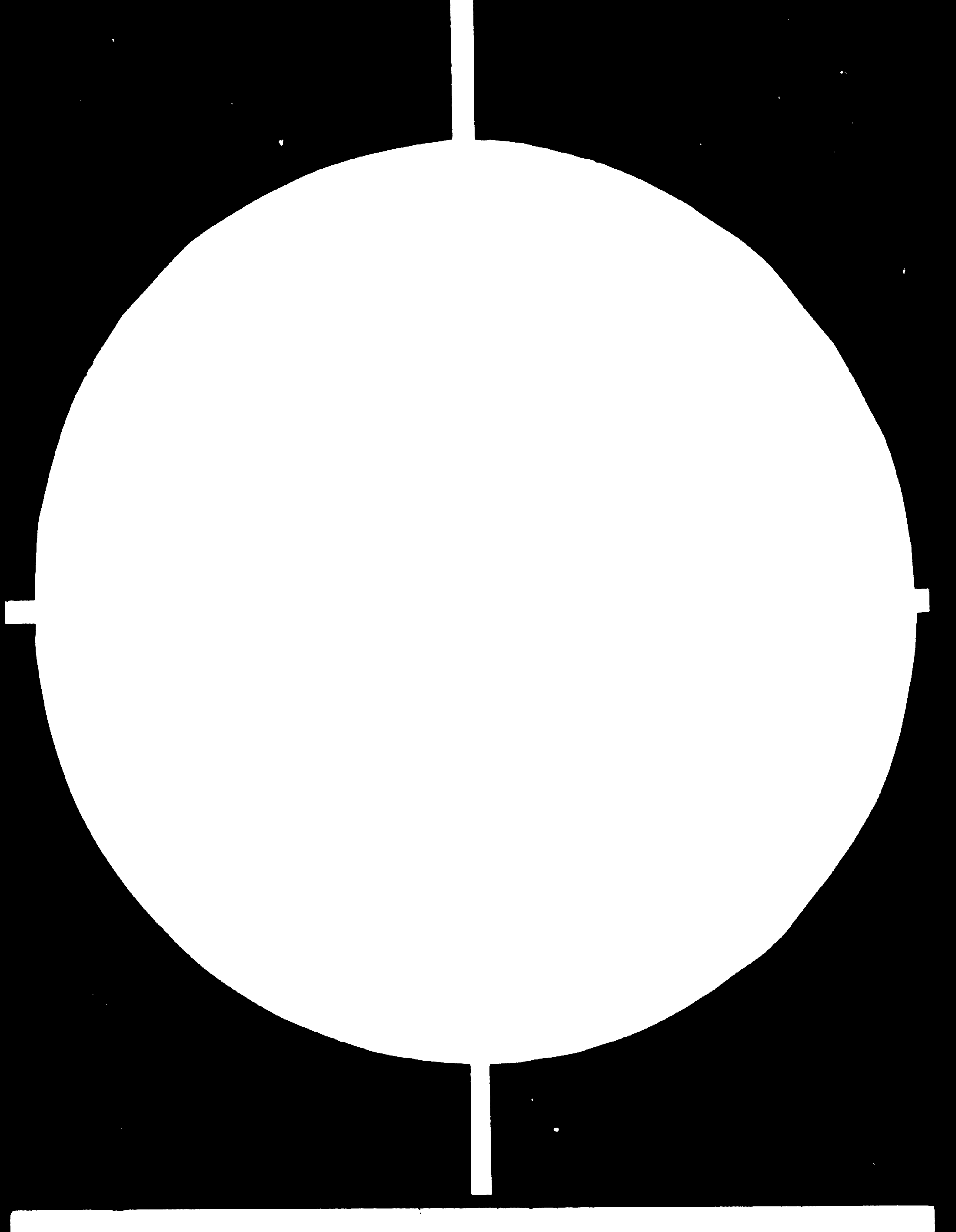

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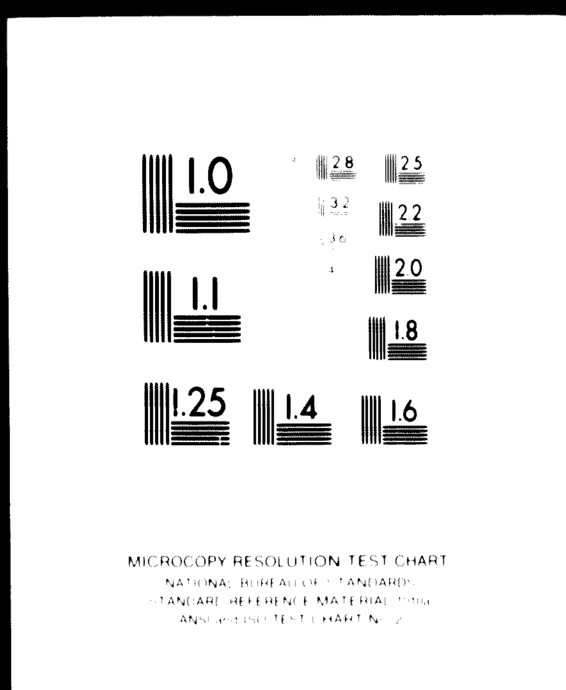
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FIGURE 8 - XIII.

PRIMARY ALUMINIUM PRODUCTION AND CONSUMPTION BALA[illegible] IN EUROPE BY THE END OF 1968, IN 1000 [illegible]

EEC	Production	Consumption	Balance of import (+) and export (-) by countries, [illegible]
Fed. Germany	257	539	+ 2[illegible]
France	366	294	- 8[illegible]
Italy	142	205	+ 61
Netherlands	47	30	- 11
Belgium	-	145	+ 152
EEC total	812	1113	+ 3[illegible]2
EFTA			
Norway	474	45	- [illegible]13
Austria	85	69	- 17
Switzerland	76	70	- 8
Sweden	57	65	+ 9
United Kingdom	38	397	+ 341
Denmark	-	8	+ 8
Finland	-	12	+ 11
EFTA total	730	656	- 69
OTHERS	203	191	
Europe altogether	1745	1960	+ 313

Remark: The formal deficit of 1960-1745 = 215 t and the commercial [illegible] of 313 t differ, probably because of changes in stocks, the n[illegible] accounted items in group "others", etc.

FIGURE 8 - XIV

EXISTING AND PLANNED SMELTER CAPACITIES IN THE EUROPEAN AREA, 1000 TONS PER YEAR.

	Capacity 1970	Capacity to be attained up to 1972 - 74
United Kingdom	39	300
Austria	96	96
Belgium	-	66
Czechoslovakia	60	60
France	369	408
Greece	72	90
Netherlands	32	90
Iceland	-	45
Yugoslavia	104	200
Poland	96	110
Hungary	65	80
German Dem. Rep.	79	79
Norway	514	691
German Fed. Rep.	270	480
Italy	145	232
Rumania	75	150
Spain	84	134
Switzerland	74	74
Sweden	50	60
Turkey	-	30
Total	2224	3475

... main producers determines practically the price ... the main participant in this arrangement which practically exists since early sixties are ALCAN, ALUSUISSE, PECHINEY, VAW, the Austian public-sector smelter RANSHOFEN . The USA companies are hindered in overt participation by the Anti-Trust Law, however, as they already have and further develop significant positions in Europe, a coordination of their action is evident. Similarly, the state-owned export companies of East-Europe have to take into account the realities of the situation.

The power of the association is based on the fact, that they do not only command the bulk of primary metal production but dispose also of significant semis capacities themselves. For the "independent" semis fabricator important price reductions are granted, if he is a regular customer. The producers have their quotas of supply.

It seems inevitable for a new producer who desires to sell to Europe, to make proper arrangements in due time with the "Club".

On the other hand, just in order to diminish the risks possible sales difficulties, it is indicated to select, for the initial period of production, a modest - though still economic - capacity, say between 30.000 and 60.000 tpy.

Flexible accomodation to market exigencies require that product quality should be on the usual up-to-date level and some transformation possibilities into semis, e.g. wire rods should also be available.

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APPENDIX I.

SOME DATA AND INFORMATION ON THE PRESENT STATE OF ALUMINIUM APPLICATION AND FABRICATION IN THE MAGHREB COUNTRIES.

Eaoh country is covered by a chapter. These chapters contain figures, indicating the breakdown of imports and exports (if any) according the main groups of products.

On the basis of interviews and plant-visits also some basic data on existing enterprises in this field of industries have been compiled. It should be stressed, that these informations and datashould not be regarded as oomplete. The oorrectness of intimated data could not be controlled. Some data for 1965 and before rely on the Study of Societe Tunisienne de Banque (Ref. No. 8/10).

Figure A-VIII gives the overall import breakdown data for the four countries, based on 1968 figures.

ALGERIA

FIGURE A - I.

BREAKDOWN OF IMPORTS OF ALUMINIUM PRODUCTS TO ALGERIA ACCORDING MAIN GROUPS OF GOODS.

(metric tons)

Year	1965	1966	1967	1968
1. Ingots	332	195,0	145,1	321,2
2. Rods, bars, profiles	280	201,0	200,2	572,7
3. Sheet, plates, foil, over 0,15 mm thickness	212	171,9	277,2	954,5
4. Foil, under 0,15 mm thickness	508	493,1	600,0	570,2
5. Constructions and their parts	138	15,5	20,0	354,5
6. Household goods 1)	367	152,4	453,8	280,6
7. Cables, ropes, wire	-	0,2	-	-
8. Tubes, accessories of tubes, hollow bars	17	140,8	84,1	173.5
9. Others	49	170,8	217,2	296,6
Total	1903	1540,7	1997,5	3523.8

1) Including also some sanitary goods.

ALGERIA

FIGURE A - II.

BREAKDOWN OF EXPORTS OF ALUMINIUM GOODS FROM ALGERIA

(metric tons)

Year	1966	1967	1968
1. Ingots	70,3	-	...
2. Scrap	597,5	570,1	622,7
3. Household goods 1)	0,2	0,15	0,8
4. Others	36,3	116,5 2)	190,2 3)
Total	704,3	686,8	813,6

1) Including sanitary goods

2) Including 107,2 t bars and profiles

3) Including 186,9 t bars and profiles

INTERVIEWED AND VISITED PRODUCERS IN ALGERIA.

Smelter project of S.N.S. (Societe Nationale de Siderurgie)	Capacity between 50 - 150 000 tpy. Site probably ARZEW or SKIKDA. In stage of feasibility study. Possible beginning of construction during Four Years Plan period (before [illegible]).
ALUMAF (Alger)	Rolling mill for strip and production of household goods. Present metal output 350 tpy. Projects of modernization and extension are under consideration. These should be realized up to 1973. Rolling mill capacity may attain up to [illegible] tpy.
SONELEC (Alger)	Production of non-isolated and isolated cables. Their production programme for 1970 is 800 t aluminium cable, 800 t ALMELEC cable. They use imported 9,5 mm Ø Properzi rod. Aluminium consumption for 1973 will be about 3 000 tpy.
ALLAL (Societe l'Aluminium Algerois) Alger	They produce household goods from imported discs. Metal input in 1969 was 312 tons. They [illegible] of [illegible] capacity.

CHAPTER II.

LIBYA

FIGURE A - III.

BREAKDOWN OF LIBYA'S IMPORTS OF ALUMINIUM PRODUCTS ACCORDING TO MAIN GROUPS OF GOODS.

(metric tons)

Year	1964	1965	1966	1967	1968
1. Ingots	0,4	-	18,8	-	10,0
2. Rods, bars, profiles	11,8	53,8	61,3	366,6	117,7
3. Sheet, plates, foil, over 0,15 mm thickness	291,3	321,4	501,8	371,8	245.6
4. Foil, under 0,15 mm thickness	72,3	51,5	106,9	172,2	[illegible]
5. Constructions and their parts	266,8	290,6	234,4	509,9	625,[illegible]
6. Household goods	92,9	64	177,8	216,6	294.[illegible]
7. Cables, ropes, wire	40,3	1,1	-	-	[illegible]
8. Tubes, accessories of tubes, hollow bars	298,9	641,9	1103,9	1301,9	[illegible]
9. Others	130,6	107,0	74,0	20,1	165,8
Total	1205,3	1561,3	2278,9	2959,0	2949,3

INTERVIEWED AND VISITED PRODUCERS IN LIBYA.

LABOPLEX Tripoli	Assembling aluminium window-frames, doors, partitions, ceilings, decorations, etc. Metal turnover about 50 tpy.
MHAISSY Tripoli	Production of household goods from purchased discs. Metal turnover 60 - 125 tpy.

CHAPTER III

MOROCCO

FIGURE A - IV.

BREAKDOWN OF MOROCCO'S IMPORTS OF ALUMINIUM PRODUCTS ACCORDING TO MAIN GROUPS OF GOODS IN 1965-1969.

(metric tons)

Year	1965	1966	1967	1968	1969
1. Ingots	5,9	6,3	3,5	3,4	21,1
2. Rods, bars, profiles	560,9	385,3	1308,0	551,3	[illegible]
3. Sheet, plates, foil, over 0,15 mm thickness	725,9	909,3	815,8	[illegible]	1667,7
4. Foil, under 0,15 mm thickness	166,5	205,8	233,3	362,2	386,5
5. Constructions and their parts	10,4	17,1	2,2	[illegible]	15,2
6. Household goods	33,1	69,9	57,9	66,6	[illegible]
7. Cables, ropes, wire	256,4	2,1	40,4	1,9	[illegible]
8. Tubes, accessories of tubes, hollow bars	13,4	13,8	82,7	79,0	[illegible]
9. Others	187,9	285,2	215,9	213,5	[illegible]
Total	1960,4	1894,8	2759,3	[illegible]	[illegible]

MOROCCO

FIGURE A - V

BREAKDOWN OF EXPORTS OF ALUMINIUM GOODS FROM MOROCCO

1965-1969 (metric tons)

Year	1965	1966	1967	1968	1969
1. Ingots	51,6	7,9	39,7	-	-
2. Scrap	447,4	573,7	436,5	488,3	650,2
3. Household goods	0,5	0,3	2,0	0,5	0,4
4. Others	16,7	12,0	-	0.2	5,8
Total	516,2	593,9	478,2	489.0	656,4

INTERVIEWED AND VISITED PRODUCERS IN MOROCCO

MMA (Manufacture Marocaine de l'Aluminium) Mohammedia

Foil processing, they stopped their own small foil plant as uneconomic. They import about 250 t foil per year.

Welded irrigation tubes. Can be produced in diameters 3,4,5,6 inches. The capacity is 500 tpy. The production between 30 and 65 tpy.

Ondulated sheet. Their production, starting from imported sheet is about 300 tpy. Their capacity is about 3000 tpy.

Corking capsules are made of imported thick foil

Metallic yarns. They are made for use in brocade tissues. They are produced of imported strip.
Two types are made :

- INOXOR yarn from aluminium foil between two plastic layers,
- NC 13 yarn from plastic foil, metallized in vacuum.

Pressure cookers. The capacity is 30 000 pcs per year, while the production is 8 000 pcs per year.

They produce also other, traditional household goods.

The consumption of discs is about 8 - 900 tpy. Production of collapsible tubes will start 1970. Their overall aluminium consumption is now about 1500 tpy.
They intend to set up a cast-rolling mill with a capacity of about 5000 tpy.
The technical level of the plant and the quality of the products are excellent.

C.G.E. (Compagnie Generale d'Electricite)
Plant : Mohammedia,
Head office; Casablanca

Production of isolated and non-isolated cables. This latter are produced with galvanized steel-rope core (ACSR) and also with ALUMOWELD core. The raw material is 9,5 mm Ø rod. They use about 900 tons of aluminium per year. (At the same time about 1500 tpy copper).

A.C.M. (Africaine de Constructions Metalliques)
Casablanca

They are producers of steel and aluminium constructions. For this latter purpose they have set up recently a separated neat workshop and an affiliate : AFCOAL. Use of aluminium is at the level of 100 tpy.

HALCO Casablanca	They are affiliates of ALCOA in the field of metal constructions. They claim to be the most experienced and strongest enterprise of this kind of aluminium application in the country. They use about 250 tons of imported metal per year.
TABOR (Has not been visited) Casablanca	Production of castings. Aluminium consumption 5 - 8 tpy.
CHIMICOLOR (Has not been visited)	Use and mix imported aluminium powder into paints.
TIMSIT (Has not been visited)	Production of household goods.

CHAPTER IV

TUNISIA

FIGURE A - VI

BREAKDOWN OF TUNISIA'S IMPORTS OF ALUMINIUM PRODUCTS ACCORDING TO MAIN GROUPS OF GOODS IN 1965-1968

(metric tons)

Year	1965	1966	1967	1968
1. Ingots	13,5	16,3	14,1	36,7
2. Rods, bars, profiles	56,5	51,6	151,6	78,9
3. Sheet, plates, foil, over 0,15 mm thickness	128,1	55,4	296,9	282,2
4. Foil, under 0,15 mm thickness	315,9	283,1	103,8	115,9
5. Constructions and their parts	28,5	26,5	32,1	61,1
6. Household goods	18,7	32,7	17,0	35,9
7. Cables, ropes, wire	670,8	768,5	512,1	747,1
8. Tubes, accessories of tubes, hollow bars	8,4	9,1	12,8	41,0
9. Others	43,0	276,4	88,9	47,6
Total	1283,4	1519,5	1229,3	1446,4

TUNISIA

FIGURE A - VII

BREAKDOWN OF EXPORTS OF ALUMINIUM GOODS FROM TUNISIA
1966-1968 (metric tons)

Year		1966	1967	1968
1.	Ingots	186,4	94,3	96,5
2.	Scrap	3,0	46,9	41,2
3.	Household goods	-	0,1	-
4.	Others	2,1	1,5	0,8
	Total	191,5	142,8	138,5

INTERVIEWED AND VISITED PRODUCERS IN TUNISIA

AL MAADEN S.A. TUNIS	Start in 1970 production of collapsible tubes, to be made from imported discs.
SOFOMECA (Societe de Fonderies et de Mecanique Tunis)	The main field of activities is steel and iron casting. Aluminium casting is only an accessory branch in their production. During 1968 they produced 14 tons of aluminium castings.
Societe de Matiere Electrique CHAKIRA Tunis	Production of insulated cables up to 1000 V. They should like to use aluminium, however at present the electricity supply companies still insist using copper.
SOTAL (Societe Tunisienne de l'Aluminium)	Production of household goods, especially vessels. They produce also enamelled and galvanised steel goods. 350 tons of aluminium strip are used per year.
IMEL Tunis	Assembling of building and construction elements of aluminium (e.g. window-frames, doors, portals, boxes etc. They cover about 90 % of this kind of production in Tunisia. Their alumini product output is 80 - 120 tpy.

TABLE VIII

SUMMARIZED [illegible] OF MAGHREB ALUMINIUM IMPORTS IN 1968

		Algeria t	Libya t	Morocco t	Tunisia t	Total t	Total %
1.	Ingots	321,2	10,0	3,4	36,7	371,3	3,5
2.	Rods, bars, profiles	572,7	147,7	551,3	78,9	1350,6	12,8
3.	Sheet, plates, foil over 0,15 mm thickness	954,5	245,6	1334,8	282,2	2817,1	26,7
4.	Foil, under 0,15 mm thickness	570,2	409,3	362,2	115,9	14[illegible]7,6	13,8
5.	Constructions and their parts	354,5	625,1	2,5	61,1	1043,2	9,9
6.	Household goods	280,6	294,4	68,6	35,9	679,5	6,4
7.	Cables, ropes, wire	-	64,5	1,9	747,1	813,5	7,7
8.	Tubes, accessories of tubes	173,5	986,9	79,0	41,0	1280,4	12,1
9.	Others	296,6	165,8	213,5	47,6	723,5	7,1
	Total	3523,8	2949,3	2617,2	1446,4	10536,7	100,0

APPENDIX II

DETAILS OF ELECTRIC ENERGY COST ESTIMATION CALCULATIONS

1. ALGERIA, Traditional thermal power plant, gas fuelled.

Suppositions, respectively initial data :

Installed capacity	200 MW
Specific investment cost	150 $/kw
Interest loss factor for construction period (intercalar factor)	1,37
Interest and amortization	8,5 % per year
Maintenance and repair cost factor	2 % per year
Salaries (average) 8 DA per hour, corresponding	3330 $ per year
Number of employees	200
Overheads and management cost factor	30 %
Availability factor of installed capacity	74 %
Operation time	8760 hours per year
Specific heat consumption	2500 kcal/kwh

Specific cost of fuel heat energy 0,6312 $/Gcal

(0,03 DA per 1 m^3 gas of 9600 kcal per Nm^3 heat value.

This means 0,00605 $ per m^3, respectively 0.606 ¢ per 9600 ..

Ergo : 1 Gcal = 10^6 Kcal will cost 63,12 ¢

$C_o = C_o + C_c$

$C_c = B\frac{1}{100}(i.\ a + b) + P$

$C_v = L.T.g.A.\ 10^{-3}$

Explication of symbols :

- C_o - overall costs, \$ per year
- C_o - constant costs, \$ per year
- C_v - variable costs, \$ per year

- B - investment cost of the power plant \$
- i - intercalar fa tor (interest losses during construction period)
- a - capital services (depreciation + interest) % per year
- b - cost factor of repair and maintenance, in proportion to capital investment % per year
- P - cost of personnel and management \$ per year
- L - average operating capacity (capacity load factor x nominal capacity) MW
- T - operation time hours per year
- g - average specific heat consumption kcal/kwh
- A - specific fuel heat energy price \$/Gcal

$C_o = C_o + C_v$

$C_o = B\frac{1}{100}(i.a + b) + P + L.T.g.A.\ 10^{-3} =$

$= 200\ 000 \times 150\frac{1}{100}\ (1{,}37 \cdot 8{,}5 + 2) +$

$+ 200 \times 3880 \times 1{,}3 + 200 \times 0{,}74 \times 8760 \times 2500 \times 0{,}624 \cdot 10^{-3} = 4{,}09 \cdot 10^6$

$+ 1{,}01 \cdot 10^6 + 2{,}05 \cdot 10^6 =$

$= 7{,}15 \cdot 10^6$ \$ per year.

Power production : $148\ 000 \times 8760 = 1{,}3 \cdot 10^9$ kwh/y

Unit cost of power : $\frac{7{,}15 \times 10^6}{1{,}3 \times 10^9} = 0{,}0055$ \$/kwh, that is 5.5 mills.

2. ALGERIA, power plant, applying gas turbines.

Suppositions, respectively initial data :

Installed capacity	200 MW
Specific investment cost	105 $/kw
Intercalar factor	1,14
Interest and amortization	8,5 % per year
Maintenance and repair cost factor	2,5 % per year
Salaries, average, as under 1	
Number of employees	80
Overheads and management cost factor as under 1	
Availability factor	95 % of installed capacity
Operation time	8760 hours per year
Specific heat consumption	3300 kcal/kwh
Specific cost of fuel heat energy as under 1	

$$C_o = C_c + C_c =$$

$$= 200\ 000 \times 105 \frac{1}{100} \ (1{,}14 \cdot 8{,}5 + 2{,}5) +$$

$$+ 80 \times 3380 \times 1{,}3 +$$

$$+ 200 \times 0{,}95 \times 8760 \times 3300 \times 0{,}6312 \cdot 10^{-3} =$$

$$= 2{,}50 \cdot 10^6 + 0{,}40 \cdot 10^6 + 3{,}47 \cdot 10^6 =$$

$$6{,}37 \cdot 10^6 \ \$$$

Production of energy $= 190\ 000 \times 8760 =$

$= 1{,}66 \cdot 10^9$ kwh per year

Unit cost of energy : $\frac{6,37 \cdot 10^6}{1,66 \cdot 10^9}$ =

= 0,00384 $ per kwh, that is 3,84 mills.

In case of less favourable load factors, this might deteriorate.
So for 80 % :

Production of power 160 000 × 8760 = 1,401 . 10^9 kwh

Unit cost $\frac{6,37 \cdot 10^6}{1,401 \cdot 10^9}$ =

= 0,00454 $/kwh (4,54 mills)

[illegible] III

LIST OF [illegible]
[illegible] COURSE OF INTERVIEWS.

ALGERIA

Centre d'Industrie et de Technologie 126 Bis A, rue Didouche Mourad B.P. 99, Plateou Fauliere IVe Etage	M. Akrouf, Director M. El-Ass, Acting Project Manager
Ministry of Industry and Energy "Colisee", rue Zephirin Roccas	Mr. Hacini (was not present) Mr. Boudjemline (Adviser)
S.N.S. (Societe Nationale de Siderurgie) 2, rue de Chenoua, Hydra Tel : 601 544 Alger	Mr. Hocine Mr. Budin Mr. Hadjad
ALUMAF Gue de Constantine KOUBA, Alger	Mr. Ould Hamou Brahim Director
SONELEC Gue de Constantine Kouba, Alger Tel : 766 865, 765 525	Mr. Ali Khaled, Directeur Laminoir et Trefilerie
ALLAL (Societe l'Aluminium Algerois) Plant : 19 Victor Hugo Hussien Dey, Alger	Mr. A. Bismuth, Director (was not present)

LIBYA

Industrial Research Centre P. O. Box 3633 Tripoli	Mr. A. Sharri Director
Ministry of Petroleum	Mr. Abdulhamid Sif-Elnaser Chief of Personnel and Training Affairs Mr. Abdulhy Ben Omran Director of Technical Department
LIPETCO Tripoli, Mitchell Cotts Building	Deputy Managing Director
Ministry of Planning Tripoli	Mr. Shmila, Director of Economic Department Mr. Gerger, Chief, Technical Department Mr. Bashir Ramadan Mr. Khiary, Engineers, Technical Department
LABOPLEX Suani Road, 1 km Tel : 32224 - 39681 Tripoli	Mr. Arafat Saad, Manager
NHAISSY, Manufacture of household goods Tripoli, Suani Road, 1,5 km	

MOROCCO

Ministry of Commerce and Industry Tel : 27 511	Mr. Moumni, Deputy Director of the Department of Mines and Geology Mr. Estel (Geologist), University Paris, working for bauxite survey Mr. Senhagi, Direction du Commerce Mr. Belkhayat, Director of Industries Mr. Houel, Director of Bureau d'Etudes Mr. Laraki, Engineer of the Bureau d' Etudes
Ministry of Planning	Mr. Echiguer, Director of Coordination of Technical Assistance
Ministry of Foreign Affairs	Mr. Mounir Mr. Cherkaoui Tahar (Assistance technique multilaterale
M.M.A. (Manufacture Marocain de l'aluminium) Mohammedia, rue Fatima Zahra 24.97/98	Mr. Galice, Directeur
CGE, Maroc (Compagnie Generale d'Electricite) Plant : Mohammedia Head Office : 68, Bd de la Resistance, Casablanca	M. Deunzelles, Director (was not present) Mr. Christian Veron
A.C.M. (Africaine de Constructions Metalliques) Ain Sebaa, Casablanca Av. Khalid Bnou Loualid Tel : 48061	Mr. Y. H. Gabbay Administrateur - Directeur

MOROCCO

MALCO (Moroccan Aluminium Company, S.A.) 1., rue de Puzancy, Casablanca Tel : 416 12, 405 25	Mr. A. Berrada, Director Mr. S. F. Nimr, (from ALCOA International)
O.C.P. (Office Cherifien des Phosphates)	Mr. Ouajjou Hassan
Maroc-Chimie (Address : Service de developpement. Complex Maroc-Chimie de Safi, Maroc)	Mr. Lepage Chief de developpement Section (by telephone)

TUNISIA

Permanent Consultative Committee of the Maghreb 1, Rue de Grece Tunis	Mr. Chadli Tnani Vice Chairman Mr. Belkhodja Mr. Moktar Anegay Economic Expert
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Ministry of Economy and Planning Kasba, Tunis	Mr. Radhouane Ghozzi Chief Engineer, Chief of Chemical Industries Division Tel : 260 874
Al Maaden S.A. 6, Rue Jean Jacque Rouseau	(President : Mr. Tawfik Chaibi)
SOFOMECA (Societe de Fonderies et de Mecanique)	Manager, Mr. Komoon Mahmoud Technical Manager (Metallurgist)

TUNISIA

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