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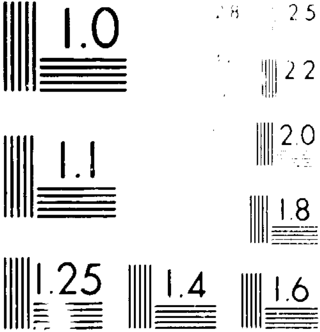
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PRESENT AND FUTURE OF THE ALUMINIUM INDUSTRY IN THE ARAB WORLD *

by

B. Balkay **

Prepared on behalf of the Metallurgical Industries Section,
Division of Industrial Operations
UNIDO

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Preface

Ever since the oil price hike of 1973, the man in the street in Europe and elsewhere has had a tendency to envy the Arab nations for their oil riches. The more thoughtful observer of the scene, however, knows full well that, in keeping with the parable of the happy workingman's shirt, riches have their own problems. How to use oil wealth best to let the future generations also benefit from it, as is their right, is a headache in every petroleum-rich country, and not just the Arab ones. Investing the petrodollars, and investing them in ways that are more lucrative, safer and more conducive to a country's self-realisation than other possible options is a difficult and, many would say, an intractable problem.

As it will be documented below, the Arab nations constitute a highly varied group economically, however much they may have in common in the cultural-spiritual sphere. Yet industrialisation seems to be a top priority with all of those nations, and mineral resource-based industrialisation with at least a considerable majority of them. They have chalked up considerable progress in petroleum refining and petrochemicals making, and have gone in for ferrous and non-ferrous metallurgy, fertiliser manufacturing, cement making and the like. One of the aims which has been realised by several of these countries and has been seriously considered by most of them is the establishment or expansion of an aluminium industry.

The aim of this paper is to serve as a thinking guide to those Arab decision-makers whose competence it is to transform these serious considerations into reality. It has been felt that, even though the author had once been of the aluminium industry, it is only honest to present the industry complete with warts and all. This aim, it is felt, has been realised rather fully - it is hoped not so as to frighten away would-be investors.

The central message of the paper is that the aluminium industry is never a <u>must</u>, but always only one of many development <u>alternatives</u>. In order to choose among these alternatives, the decision-makers must be familiar with the other options, and must also possess a sophisticated understanding of how the world economy works. Space has not permitted to go into the details, exploring which should in any case be the reader's right and burden. It is hoped, nevertheless, that the reader will have no difficulty connecting up the argument expounded here with his own world economic awareness.

It is hoped further that those at whom this paper is aimed will have found it helpful in the discharge of their duties.

Budapest, July 1983.

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Executive summary

/1/ Its present plight notwithstanding, the world aluminium industry may be expected to grow rather faster than per caput gross world product at least up to the year 2000.

/2/ The much-predicted shift of aluminium smelting from the developed market-economy countries to the developing world is gathering momentum. The process may be expected to continue up to and beyond the year 2000.

/3/ One target area of this shift in smelting geography is the Arab world, thanks to its abundant un-tied-down sources of energy. A conservative estimate of export-oriented smelter capacity increment that might be sited in the Arab world /that is, new capacity in addition to existing capacity and to the capacity needed to satisfy intra-Arab consumption/ is 1.3 million tpy between 1985 and 2000, but even twice that is not out of the question.

/4/ Whether or not it is worthwhile for the Arab countries to go in for aluminium smelting depends on several factors.

/4.1/ Inputs. The Arab countries do not, possibly with the single exception of Saudi Arabia, have any economically viable aluminium ore deposits. This, however, is no major obstacle as long as the world market functions at all normally, the less so since concluding satisfactory long-term contracts with suppliers /developed market-economy - Australia - or developing - India, Guinea, Jamaica/ seems to be unproblematic. Whether Arab aluminium smelters should import bauxite or alumina is a matter for a detailed cost-benefit analysis in any particular case.

/4.2/ Returns on investment. While it is entirely justified to expect aluminium prices to improve out of their current depressed state, the rates of return on aluminium industry investment are liable, up to the turn of the millennium, to be on average below the market-economy world's average returns on industrial investment, being similar in this respect to other natural-resources-based industries such as petroleum refining, bulk petrochemicals, nitrogen fertiliser, cement or steel.

/4.3/ Power pricing. The major comparative advantage of the hydrocarbon-producing countries is that they have the means of generating cheap electric energy for aluminium-smelter use. This, however, may be expected to appeal to them only if they find no other, more lucrative outlet for their energy resources. As a very general rule of thumb, exporting natural gas looks more lucrative than aluminium smelting until the gas market saturates. It may be reasonably expected, however, that the gas market will not take off all the gas available /and partly being wasted/ in the Arab world. Several industries may be expected to queue up for the remainder. Among these, aluminium may be expected to occupy a fair but not outstanding position /cf. also para 4.2 above/. - The same consideration holds, mutatis mutandis, for any other fuel or form of energy.

/4.4/ In summary, there is a comparative advantage to be found in aluminium smelting by those Arab countries that produce fuels in abundant quantities and are ready, willing and able to supply them to the aluminium smelters cheap enough to keep those internationally competitive.

/5/ The economics of semi-fabrication, which is not energy-intensive and which may be profitable even on a very small scale, is different; it splits up in two, according as the country possessing or envisaging a semis facility imports aluminium metal or produces its own.

/5.1/ For a country smelting aluminium, going in for semi-fabrication is a fairly straightforward option because semis achieve a comparatively great value-added at comparatively low cost /although this is partly offset by the fact that most major importing countries impose higher customs tariffs or semis than on ingot/.

/5.2/ For a country having no smelter of its own, the question whether to import ingot or semis depends on whether or not it has the option to deploy its factors of production more lucratively in some other industry than in semis manufacturing. As a rule of thumb reinforced by current experience, one may assume that most countries will find it to their advantage to go in for the production of some types of semis, but few will find it to their advantage to go in for the making of a complete range.

/6/ The Arab world as a whole is a net exporter today of both aluminium ingot and semis. Its exports as a percentage of its output may be expected to increase in regard of both.

/7/ The aluminium consumption of the Arab world may be expected at a conservative estimate to grow by two kg per caput, from one to three kg, that is, by about 420,000 tpy between 1980 and 1990.

/8/ Intra-Third World and inter-Arab aluminium industry cooperation offers considerable advantages.

/8.1/ Non-Arab Third World countries should be expected to provide the bulk of those inputs scarce in the Arab world; this holds especially for bauxite/alumina but, to a certain extent, also for labour.

/8.2/ The coordinated development of the Arab aluminium industries, as exemplified by the activity of GOIC in the Gulf region, is likely to bring considerable benefits. In addition to marketing, production share-out and siting optimisation, this coordination may extend to technology and equipment procurement, design engineering, training, R and D.

/9/ At present, developing-country aluminium smelters and semi-fabricators procure their technology from the developed market-economy world. The developed centrally-planned economies are a useful alternate source. Most of the technology comes from the Big Six. The Arab countries have a much better chance to reduce this technology dependence if acting jointly rather than severally /although achieving that end will be a long hard slog even then/.

A The world aluminium industry today: a bird's eye view

The oil price shocks of 1973 and 1979 were the harbingers, if not the immediate causes, of some profound changes in the structure of the world economy. These changes have been affecting the world aluminium industry, too. World primary aluminium consumption, which had increased by some eight per cent a year /doubling every decade/ between the end of World War II and 1974, grew by a meagre 0.4 % a year between 1974 and 1981; aluminium prices, which had held up reasonably well up to 1980, then caved in to drop by more than a quarter in nominal dollar terms up to February 1983. Nevertheless, there is no doubt whatsoever about the medium- and long-term resiliency of the aluminium market; for would-be investors into the aluminium industry, provided they possess the right sort of comparative advantages, the question is not whether they should go in for a project, but when. In fact, its present plight notwithstanding, the world aluminium industry may be expected to grow faster than per caput gross world product at least up to the year 2000.

Underlying the spectacular but rather short-term changes referred to above, however, there are more profound ones that are likely to be more persistent.

/1/ What with the abundance of bauxite in the world, and what with all the major world bauxite producers except Brazil and a good many major alumina makers members of the producers association IBA, backward integration from aluminium smelting through alumina refining to bauxite mining is not perceived today as bringing any particular advantages to smelters and semifabricators. In other words, the arguments for aluminium smelting in countries which might or do have cheap electric power but no bauxite resource have improved.

/2/ As the percentage contribution of the power price to the end-user price of aluminium creeps up, the argument for locating primary metal production in or near the centres of consumption loses cogency; a big nearby aluminium market is becoming less and less of a necessity for aluminium smelters.

/3/ The market used to be dominated by the Big Six /the aluminium equivalent of the Seven Sisters: ALCAN, ALCOA, Kaiser, Reynolds, Péchiney and Alusuisse/: today, its degree of oligopolisation is declining as the Bis Six's market shares shrink. /This is a process analogous to the irruption between 1960 and 1973 of Occidental and the other "petroleum independents" onto an oil scene which used to be dominated before by the Seven Sisters./ To new entrants into the market, this is an advantage in that it facilitates entry, but also a drawback in that it removes the informal "price guarantees" inherent in an oligopolised market.+

Items /2/ and /3/ are among the reasons why the much-predicted shift of aluminium smelting from the developed market-economy countries to the developing world can gather momentum today. The process may be expected to continue up to and beyond the year 2000.

/4/ It used to be said that in the longer run the market mechanisms assured a fair average rate of return on investment to an efficient aluminium producer operating in a

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+ "Producers have lost credibility by maintaining meaningless book prices while selling spot metal at prices 40-50 % lower - they are losing control over ingot pricing." /Vic Besso, "Aluminium in the not-so-gay 90s", Revue de l'Aluminium, No. 503, November 1982, pp. 432-434./

situation of average comparative advantages. This is no longer true. What with 35 % or so of smelter capacity government-owned even in the non-socialist world, "government intervention in the aluminium industry is becoming both more noxious and more necessary", + and our above rule changes as follows: market mechanisms will ensure the average rate of return on investment minus the average government subsidy to the erstwhile efficient aluminium producer. The implication is a long-term profit-margin squeeze for the unsubsidised producer.

/5/ The introduction of an aluminium contract on the London Metal Exchange, long resisted by the world aluminium industry, is being blamed for many ills today. Vic Besso /loc. cit./, for one, submits that aluminium price movements are no longer governed by the fundamental laws of supply and demand. One may, however, counter with equal right that producers' book prices, while they dominated the market, were as little governed by supply and demand. What does matter to both producers and consumers /as opposed to brokers and speculators/ is to smooth out the fluctuations, sometimes rather hectic, of the terminal market prices. This is a technical matter more than anything else - it can be achieved by terminal-market hedging operations and by sales price formulas based upon longer-run averages of the LME price or some other terminal market price.

+ Vic Besso, loc. cit., who then goes on to write that "The [aluminium smelters] of Spain and Italy are prime examples of industries that... could not survive in a free-enterprise, survival-of-the-fittest system. Unfortunately, social and nationalistic considerations will probably keep these industries alive."

To focus now on the narrower subject of the present paper, one target area of the shift in aluminium smelting geography is the Arab world, thanks to its possession of abundant un-tied-down sources of energy. The Mining Annual Review of 1982 /p. 50/ has this to say about the Arab aluminium industry: "The newly emerging and largely state-owned producers in the Middle East, with their abundant power resources, have been remarkably successful in maintaining full production and improving product quality, and may be expected to participate in the future expansion of the industry."

All these arguments fit neatly into a comprehensive case for a gradual transference of aluminium smelting capacities from the developed world into the Third World, a case that is improving with the passing of time. Within the Third World overall, those countries that have abundant sources of cheap electric power - which includes many Arab countries - have a considerable comparative advantage working for them.

In summary, the Arab world's share of world aluminium production may be expected to grow rather considerably up to the end of the century and beyond.

B The vertically integrated aluminium industry

This paper considers four links in the vertical chain of integration of the aluminium industry:

- bauxite mining,
- alumina refining,
- aluminium smelting and
- aluminium semis manufacturing.+

The making of finished products is too manifold to be considered here, except in the most general outline.

The links of the chain are connected together as follows.

It takes from two to three and more /seldom four/ tons of bauxite to make one ton of alumina, and almost exactly two tons of alumina to make one ton of aluminium metal.

Aluminium semis are made of primary aluminium plus aluminium scrap, plus minor dosages of alloying elements. The actual apparent consumption++ of aluminium in a country is provided by the formula

primary metal use + scrap use - losses .

Losses overall are not significant as a rule, but scrap use may be anything up to 30 %, possibly more of pri-

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+ The term aluminium semis as used here comprises the unsophisticated finished products made at the smelters and semis works, such as cast aluminium door handles or power cable strands, in addition to semis in the usual sense of the term.

++ Apparent consumption equals true consumption within the country plus metal exported in the form of finished goods.

mary metal use. /In the US, scrap use ranged from 28.9 to 34.5 % of primary metal output between 1975 and 1980;+ in the non-socialist world overall, it ranged from 20.4 to 23.4 % of total consumption between 1969 and 1979.++/

Although other ways do exist, only the making of alumina out of bauxite by the wet chemical Bayer process and the smelting of alumina by the Hall-Héroult process of igneous electrolysis are considered here, because these are for the time being the only processes competitive in the world market.

B.1 Bauxite mining

This is a non-standard activity, the inputs into which depend greatly on the geological conditions, on the overburden, on whether mining is open-cast or underground etc. Another greatly variable item is the investment into and the operating cost of transportation and other infrastructure. It would therefore be illusory to try and give in the confined space available here a picture of the inputs and other cost items of bauxite mining, all the less so since, as pointed out below, bauxite mining is unlikely ever to become widespread in the Arab world.

B.2 Alumina refining

This operation is essentially the wet chemical bene-

\+ US Bureau of Mines, Industry Surveys, cited in IBA Review, Vol. 7, No. 4, April-June 1982, p. 38.

++ Metallgesellschaft AG, Metal Statistics 1969-1979, 67th Edition, Frankfurt am Main, 1980, pp. 16-19.

ficiation of bauxite. It produces calcined alumina, Al_2O_3. Technologically, an alumina plant is of about the same degree of sophistication as a wet phosphoric acid or phosphate fertiliser plant.

In addition to bauxite, of which, as we have seen, two to four tons are required, depending on bauxite quality, to make one ton of alumina, the alumina refinery typically requires 90 to 180 kg of caustic soda /NaOH, 100 per cent base/ per ton of alumina, 0 to 15 kg of burnt lime, about 0.3 to 0.6 ton of liquid hydrocarbon fuel or an equivalent volume of gas. The process further requires 15 cu. m makeup water per ton of alumina, of which 5 cu. m for technology and the rest for flushing and cooling. Electric energy consumption is 250 to 350 kWh per ton of alumina, including the power consumption of the air compressors. The compressed air requirement is 450 normal /atmospheric/ cu. m, at a pressure of about 5 kg per sq. cm /70 psig/.

Manning in a 1,000,000 tpy alumina plant is approximately as follows.

	Operation	M[illegible]nce
Manager, deputy managers, dispatchers	32	
Masters and foremen	80	32
Skilled	480	480
Semiskilled	288	160
Total	880	672

The first two items would be expatriates at first. It would take about three years at a minimum to phase out expatriate masters and foremen and another three at a minimum to phase out the managerial staff shown in the top row.

Material costs of maintenance amount to about 2.5 % a year on the first cost of the equipment and piping. Another 0.5 per cent should be added for sundries.

Alumina-plant investment costs are shown below.

Capacity, '000 tpy	100	300	600	1000
Investment cost, $ million /without infrastructure/	100	220	350	460

The alumina plant produces a waste called red mud at the rate of from one to two /seldom three/ tons per ton of alumina. Red mud disposal is a nuisance everywhere and may be costly where environmental protection regulations are strict and/or industrial land space is confined.

B.3 Aluminium smelting

The smelting of aluminium out of alumina is a process of igneous electrolysis, in a molten bath of alumina and fluorine /plus possibly lithium/ salts, through which a strong /70,000 to 230,000 amp/ low-voltage /4-5 V/ current is led. The bath is in a carbon-lined steel vessel or cell /pot/; the current is introduced through carbon anodes hanging into the bath from above. In the Söderberg system, "green" anode paste is gradually lowered into the cell and baked to resist the bath temperature by the heat of the bath proper; in the prebake system, anode paste is baked into blocks before immersion, in a separate anode shop.

The high-voltage alternating current received from the power generating facility must be transformed and rectified. In the smelter, certain numbers of cells are connected up in series and fed from a common rectifier unit. The cells so connected constitute a potline.

The aluminium metal collecting at the cell bottom is tapped off at intervals and cast into a variety of shapes, unalloyed or alloyed. Modern smelters tend to incorporate cast-rolling facilities which make rod, coarse wire or strip direct out of the molten metal.

In addition to alumina, the smelter consumes a great deal of electric power /about 13,500 kWh d.c. per ton of metal in the most modern cells; up to 17,000 in some of the old ones; see also below/. Other consumptions per ton of metal used to be:

Fluorine salts including artificial cryolite	60 kg
Petroleum coke	450 kg
Pitch	170 kg

Recent technological development has about halved this for fluorine salts /thanks to fluorine recovery from the smelter gases/ and reduced it by up to 30 % for petroleum coke or pitch or both.

Investment costs in some selected recent Australian smelter projects have been estimated at $US2,800 to $US2,920 /1980/+ per ton of metal produced.

Manning for a 100,000 tpy smelter is roughly the same as for the 1,000,000 tpy alumina plant above.

In an aluminium smelter, water consumption for the needs of the personnel is a major item. Cooling in the casting shop is of the same order of magnitude.

+ IBA Review, Vol. 7, No. 4, April-June 1982, p. 38.

B.4 Semi-fabrication

This is another rather non-standard, multifacetted set of activities. It produces

- cast and pressure-cast products,
- hot- and cold-rolled products: plate, sheet, coil, foil, can-stock, can-top stock etc.,
- extruded products in a great variety of profile shapes /some of them very complicated/, including tube and pipe,
- wire and cable,
- powder and paste,
- collapsible-tube stock.

For the uses of each of these products, the reader is referred to the relevant special literature.

Semifabricating plants range from small semi-artisanal foundries /a few hundred tpy output/ to large complex facilities whose output is on the order of 100,000 tpy, and which produce all or most of the above-enumerated types of goods.

For the consumption pattern of an Arab country, past and forecast, consider Egypt's in the table on the facing page.+

+ A. Rambaud, "L'industrie de la transformation en Egypte", Revue de l'Aluminium, No. 509, Sep. 1982, pp. 321-323.

thousand tons	1974	1978	1982	1985	1987
collapsible-tube stock	5.2	6.6	8.3	9.9	11.1
sheet and plate	1.0	1.3	1.6	1.9	2.1
foil	1.2	1.6	2.1	2.6	2.9
extruded goods	2.8	7.4	9.4	11.0	12.5
wire and cable	6.0	9.4	14.9	20.9	26.2
pressure-cast goods	0.4	0.8	1.7	3.0	4.3
other cast goods	1.2	1.6	2.2	2.8	3.3
totals	17.8	28.7	40.2	52.1	62.4

For the highly variable other inputs of semifabrication /of which scrap, where available, is the most important/, for investment costs, manning levels etc. the reader is again referred to the relevant special literature.

B.5 Power supply

Although not a link of the vertical aluminium-making chain, the supply of electric power to the aluminium smelter is inseparable technologically from that chain. In 1980, the smelting of one ton of primary aluminium took an average 16,950 kWh of electric power as measured at the smelter's receiving terminals.+ This means that a 100,000 tpy smelter, say, requires roughly 200 MW of power, reckoning with smelter cells being run 365 days a year, 24 hours a day. Since the smelter must in fact run uninterrupted the year round if

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+ This was the average over the smelters reporting to IPAI, the International Primary Aluminium Institute /which include most of the smelters in the non-socialist world/. Cf. Revue de l'Aluminium, Vol. XVI, No. 508, Aug.-Sep. 1981, pp. 273-275.

the costly freezing of the metal is to be avoided, a switch-over facility to an alternate power station or to a standby generator must be provided.

C Endowment of the Arab world with the factors of production required by an aluminium industry

C.1 Natural-resource inputs

C.1.1 Bauxite

The Arab world is about as poor in bauxite as it is rich in petroleum and rock phosphate.

The only known significant bauxite deposit[+] of the Arab world has been discovered recently in Saudi Arabia. The estimated reserve is 134 million tons. The ore grades 58.5 % Al_2O_3 and 6.6 % SiO_2,[++] which is fair but not excellent. Its extractable aluminium metal content is 30 million tons at a very rough estimate. Economically, it probably rates worse or, at least, no better than bauxite of the same grade imported by big /100,000 deadweight tons or above/ ore carrier ship from a deep-water port in a tropical country to a deep-water port in the Gulf region.

According to the present state of bauxite geological awareness, further significant finds of bauxite in the Arab world are unlikely albeit not impossible.

For all we know, non-bauxitic ores of aluminium may be abundant in the Arab world, but the use of these cannot, in a normally operating world economy, be considered economically justified.

[+] Although bauxite indications in Egypt, Sudan and the Yemen PDR are mentioned by UN Expert Dr Rajendra Singh, quoted in "Aluminium: Idcas report on Arab industry", Metal Bulletin Monthly, September 1979, p. 71.

[++] Mining Annual Review, 1982, p. 481.

Aluminium making in the Arab world should therefore be based overwhelmingly on imported raw material.

C.1.2 Water

Alumina plants use much water. Whether to build an alumina refinery and import bauxite or whether to import alumina instead in the first place thus largely depends on the availability of water. Alumina making may be a viable option for the countries on the Nile and those on the Tigris/Euphrates, and a conditionally viable one for the Maghreb countries. But even these countries may well prefer to import alumina.

The other links in the vertical aluminium-making chain are no more sensitive to the availability of water than the average heavy industry.

C.1.3 Fluorine

Morocco and Tunisia possess significant percentages of the world fluorspar reserve /1.3 and 1.1 %, respectively/. Their output likewise approximately equals one per cent each of world fluorspar production.+

More importantly, fluorine is being economically recovered from phosphate rock in several countries. The very abundant phosphate rock reserves of the Arab world may thus acquire a considerable importance for world fluorine supply.

Production of aluminium fluoride started in 1977 at Gabes in Tunisia /22,700 tpy/. Iraq has contracts for a cry-

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\+ US Department of the Interior, Bureau of Mines Bulletin 671, Mineral Facts and Problems, 1980 ed.: Fluorine by David E. Morse, pp. 303 et seq.

olite plant /6,500 tpy/ and an aluminium fluoride plant /11,000 tpy/.+

C.1.4 **Petroleum coke**

For any country with a major petroleum refining capacity, petroleum coke is a likely by-product. As far as information is available, most existing Arab smelters use domestically produced petroleum coke, and the same is being envisaged for the smelter projects now on the drawing board. Over and above all this, the Arab countries are also exporters of petroleum coke and anode.

C.1.5 **Pitch**

The pitch normally used in preparing the anodes of aluminium smelters is a coal distillation product, and as such, it is not a likely product for most Arab countries. It may, however, be replaced by petroleum distillation by-products.

C.1.6 **Electric power generation**

Hydroelectricity. According to the 1980 edition of the UN Yearbook of World Energy Statistics /ST/ESA/STAT/SER. J/24/, most Arab states have no hydroelectric potential. The figures given are 16,654 Terajoule per year for Sudan and 1,152 Terajoule per year for Syria; no figure is given for Egypt, Iraq and Tunisia. Of these, the potential of Egypt is rather considerable /roughly one-fourth that of Sudan/. The aluminium smelter of Egypt, at Nag Hammadi, is in fact being

+ UN Expert Dr Rajendra Singh, loc. cit.

supplied with hydro power from the Aswan High Dam.

Gas-based electricity. This is where the Arab world has an outstanding potential comparative advantage. One should keep in mind that

- round one-eighth of the natural gas produced in the world is being flared; Saudi Arabia is the greatest flaring country in the world, and Algeria is third /Nigeria being second/;+
- the Dubai and Bahrain smelters are run on gas-based electricity and, as far as the information is available, gas is being considered as a fuel also for the Abu Dhabi smelter, the Libyan smelter project and the tentative Algerian smelter.

Other sources of electric power. The use of refinery residues instead of natural gas to generate electricity is not unlikely in the countries which have refineries.

Several Arab countries /the Maghreb ones; also Egypt and Saudi Arabia/ have coal deposits; some produce coal. Yet, where comparatively cheap hydrocarbons are available, coal-fueled electricity generation is not a natural choice.

C.1.7 Alumina plant fuel

For steam raising and calcination in an alumina plant one would, in an Arab context, probably use either natural gas or a refinery residue for a fuel.

+ Petroleum Economist, August 1980, p. 337.

C.2 Other factors of production

C.2.1 Labour. Alumina making is not labour-intensive; smelting is even less so; semifabrication is more so but still below the average of manufacturing. Personnel with the requisite skills is in short supply in all the Arab countries; this can be helped in the medium to long term by appropriate general education and training. A long-term concept of aluminium industry development /and of industry development in general/ must include setting up appropriate industry-specific training and educational facilities.

It is the conversion of aluminium into final products, and semi-fabrication to a minor extent, that are liable to come up against a workforce bottleneck in those countries which have a labour shortage problem. It is not so much the absolute shortage of labour that matters as the competition among the industries for the available /skilled/ workforce.+

The implication is that, economically, export-oriented aluminium smelters and semifabricating plants of the less labour-intensive type may make good economic sense for labour-short countries rich in fuels, whereas the making of finished goods and of the semis requiring an abundant labour supply might be taken up by the countries with an unemployment problem. The two types of approach might be joined un-

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\+ There is of course a certain flexibility of employment even in an aluminium smelter. For example, the Nag Hammadi smelter of Egypt, in 1978 when its rated capacity was 100,000 tpy, employed 2300 people on the potlines alone, whereas the Dubai smelter, of 135,000 tpy rated capacity, plus the power station and the desalination facility, employ just 1430 between them. /Metal Bulletin Monthly, July 1979, p. 83, and January 1982, p. 48./

der a system of regional cooperation.

C.2.2 Land as such is not short, but industry siting in congested priority development areas may be something of a problem. So may the burden on the environment caused by the large volumes of red mud produced by an alumina refinery, although, as regards red mud, recent UNIDO-sponsored development based on research carried out in Hungary has led to important new progress in the use of this nuisance by-product. Using mainly silica-containing additives, red mud can be converted into building ceramics, tiles, building blocks, decorative flooring elements and the like, to be fashioned after the construction habits and tastes of the country where the plant is to be sited. This implies that, these days, the feasibility study for an alumina refinery should include as a matter of course a market study concerning the building materials that may be so produced and, in connection therewith, the tonnage of red mud that may be so consumed.

Pollution by aluminium smelters has been reduced to tolerable levels by recent technological developments.

For importing bauxite or alumina, a deepwater port site is a considerable economic advantage. The alumina refinery consuming the bauxite /or the smelter consuming the alumina/ should be sited next to the port. The Dubai smelter, part of the Jebel Ali industrial complex, located next to the deepwater port of the same name, is a good example. Landlocked countries are not recommended to go in for making aluminium out of any imported raw material.

C.2.3 Capital. It is usual to divide up Arab countries into capital-surplus and capital-short ones. Investing into an export-oriented aluminium industry is a more likely option for the former, provided they have abundant fuel to spare, but even in those countries the aluminium industry with its extremely high capital intensity will of course have to queue up in competition with the other potential uses of capital /domestic investment, social as well as productive; capital exports, including both direct and portfolio investments abroad/. Some of the capital available may be invested in the upstream stages of the aluminium industry somewhere abroad, in order to secure inputs /bauxite, alumina/. Securing access to markets and technology may also justify investments abroad.

C.3 Technology

Access to the most modern aluminium-making, semi-fabricating and processing technologies, plant operating know-how and marketing expertise is still largely contingent today upon cooperation with one of the world aluminium majors /ALCAN, ALCOA, Kaiser, Reynolds, Alusuisse, Péchiney/, although there are other sources as well /e.g. British Smelter Constructions and National-Southwire Aluminium for Dubal/. These tend to insist on more or less of an equity participation in the facilities to be built with their assistance. This is no drawback if the cooperation with them is carefully managed by a government aware of the country's best interests and endowed with suitable legislation. Both conditions seem to be better satisfied in the Arab countries than in most other countries of the developing world.

The European socialist countries are an alternative source of aluminium technology. As contrary to the Western sources of technology, the aluminium companies of these countries do not insist on equity participation in the aluminium facilities built with their assistance.

D Present state of the Arab aluminium industry

D.1 Bauxite mining; alumina refining

There is no bauxite mining or alumina refining going on at the present time in any Arab country.

The fate of the recently discovered bauxite deposit in Saudi Arabia is uncertain as yet. It is likely to face strong competition from imported bauxite/alumina.

A pre-feasibility study has been reported to exist for a big /two million tpy?/ alumina plant to be built in the Gulf area under the aegis of GOIC,+ to be fed with Indian, Australian or possibly Saudi Arabian bauxite.++ The tendering has been entrusted to the supervision of Kaiser Engineers of the US.

D.2 Aluminium smelting

The ALBA smelter of Bahrain, the first to be built in the Arab World, went onstream in 1971 with a capacity of 57,500 tpy. It attained the output of 120,000 tpy in 1974 and 170,000 tpy in 1982. It is 57.9 % Bahraini government-owned; 20 % of the shares is held by the Saudi government, 17 % by Kaiser Aluminium and 5.1 % by Breton Investments

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\+ GOIC is the Gulf Organisation for Industrial Consulting, whose membership includes Saudi Arabia, Iraq, Kuwait, Bahrain, Qatar and the United Arab Emirates. It is essentially an industrial development coordinating body.

++ Mining Journal, No. 7681, Nov. 5, 1982, pp. 331-332. Cf. also "Le développement d'une industrie productrice d'aluminium dans les pays du Moyen-Orient" by M. Hugueney, Revue de l'Aluminium, No. 503, February 1981, pp. 44-47, and "Gulf Alumina Refinery Study", in Mining Journal, No. 7691, Jan. 14, 1983.

/Eckartwerk/. It is supplied with current from a gas turbine power station, and with alumina by imports under a long-term contract with Western Aluminium Co. /Gove, Australia/. A 75,000 tpy anode plant belongs to the unit. The cells are 100,000-amp ones, with prebake anodes. Much of the output is exported, although recently there have been marketing difficulties and a sizeable inventory has built up.+

It is intended to expand the ALBA smelter to a final size of 250,000 tpy.

The second smelter to be set up in the Arab World was the Egyptian one at Nag Hammadi. Built with technical assistance and part-financing from the USSR, it came onstream in October 1975, with a capacity of 33,000 tpy out of 150,000-amp Söderberg cells. It was subsequently expanded, to 100,000 tpy in 1976-77 and to 133,000 tpy in 1979. It receives power from the Aswan High Dam and alumina from Nabalco /Gove, Australia/, which is hauled 250 km by road from the Red Sea port of Bur Safaga. The smelter has its own anode paste factory.++

The smelter was to have attained the capacity of 166,000 tpy by June 1982 and been converted to the use of sandy alumina /likewise from Gove/ as of January 1982.

Some 60 % of the output is being exported.

Third in line was the Jebel Ali smelter of Dubai. It is owned as to 80 % by the Dubai government and 20 % by an entity called Aluminium Smelter Holdings, which is to be

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\+ Revue de l'Aluminium, loc. cit.; Mining Annual Review 1982, p. 55; p. 479; Mining Journal, No. 7686, December 10, 1982, p. 419; Revue de l'Aluminium, No. 502, January 1981, p. 9.

++ Revue de l'Aluminium, No. 503, pp. 44-47, op. cit.

bought out successively by the government. First onstream in October 1979, it produced in 1981 142,000 tons of metal for a rated capacity of 135,000 t. It has a gas-fuelled power station which also feeds a sea water desalination unit. The smelter has its own prebake facility of 92.500 tpy capacity, and receives alumina under a long-term contract from Alcoa of Australia. Plans call for an expansion to 180,000 tpy by 1985.[+]

For the Gulf region as a whole, GOIC has envisaged an aluminium production capacity of one million tpy by 1990, but before going ahead with this undertaking, serious consideration must be given to the marketing of the output.

Algeria's 132,000 tpy M'Sila smelter, to have been built with assistance from the USSR, is said to have been shelved by one source,[++] although another[§] puts its start-up into 1984, with assistance from a Japanese consortium headed by C. Itoh and Co.[§§]

Abu Dhabi's smelter construction is said to be at an advanced stage.[□] The initial capacity will be around 50,000 tpy; this is to be expanded to 150,000 tpy.

In Libya, the project of a 120,000 tpy smelter is in the tendering stage. The "Zuwarah Complex", which is to in-

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+ Revue de l'Aluminium, loc. cit. Also Mining Annual Review, 1982, p. 55 and p. 479.

++ Mining Annual Review, 1982, pp. 467-468.

§ Afrique Industrie, Vol. 12, No. 256, June 15, 1982, p. 64.

§§ Erzmetall, Vol. 36 /1983/, No. 1, p. 1.

□ Brace, A.W., "Aluminium industry developments", Metal Bulletin Monthly, January 1982, p. 37.

clude a 759 MW power station and a 75,000 tpy petroleum coke facility, partly export-oriented, is to cost $1.3 billion. It is to be set up in partnership with Energoinvest of Yugoslavia. Kaiser Engineers and Contractors have prepared the tender documents for the project, for which they will also provide construction management assistance.[+]

All in all, the Arab world already has 850,000 tpy or so of aluminium smelter capacity well in sight: in view of our Arab consumption forecast /cf. Section E.1/, much of this will have to be earmarked for export.

D.3 Semi-fabrication[++]

In Algeria, the M'Sila smelter project envisages producing at the smelter 20,000 tpy of rod, wire and cable strand. A hot-rolling mill of 70,000 tpy and a cold-rolling one of 40,000 tpy output and a 1,000 tpy foil facility at Bordj Bou Arrédidj have also been envisaged, for completion in 1984. Domestic demand for aluminium semis may attain 60,000 t by 1985 and 150,000 t by 1990.[§]

In Bahrain, Bahrain Atomizers International produces 3,000 tpy aluminium powder; Bahrain Aluminium Extrusions Co. produces 10,000 tpy extrusions; Midal Cables produces 15,000

[+] Erzmetall, Vol. 35 /1982/, No. 6, p. 281, and No. 10, p. 484, and Vol. 36 /1983/, No. 3, p. 107; Mining Annual Review, 1982, pp. 469-470.

[++] For much of the information in this section, the writer is indebted to Mr István Gazda of ALUTERV-FKI of Hungary, and his "A világ aluminiumipara" /Aluminium Industry of the World/, Budapest, 1982, mimeo.

[§] "Algérie - 20 ans après l'Indépendance", Afrique Industrie, Vol. 12, No. 256, June 15, 1982, pp. 64 et seq.

tpy wire and cable. Bahrain also plans a 40,000 tpy rolling mill, to be co-owned with Saudi Arabia, Iraq, Qatar and Kuwait, to come onstream in 1985. It is to be built by Kaiser Engineers and Contractors.

In Dubai, Gulf Extrusions Ltd has an extrusion press of 3,000 tpy capacity.+ Ziba Metals Establishments is a scrap processor. Dubai Cable Co. makes 500 tpy of aluminium cable.

Egypt has a comparatively well-developed semifabricating industry.□ Producers include three 100 % state-owned units: Egyptian Copper Works, The Helwan Works /also called Military Factory No. 63/, Electro Cable, and some private or partly private companies: Alumisr, Arab Aluminium Co., Egyptian General Metals Co., Al Saad Co. etc. The Nag Hammadi smelter itself produces 10,000 tpy wire rod. Aggregate capacities are as follows:

thousand tons	1979	planned expansion /1985?/
cold-rolling	16	45
hot-rolling and cast-rolling	37	50
foil	2.7	3.9
extruded products	15	20
tube	1.5	1.5
cast products	22	22
wire and cable	16	16
totals, rounded	110	160

+ For a description see the Dubai feature in Metal Bulletin Monthly, February 1980, pp. 15-21.

□ Cf. e.g. A. Rambaud, "L'industrie de la transformation en Egypte", Revue de l'Aluminium, loc. cit.

Egyptian semis consumption per caput was one kg in 1982, and is supposed to attain 1.4 kg by 1985 /to increase from 40,000 t in 1982 to 52,000 t by 1985 and 65,000 tpy by 1990/. As shown, semis production capacity may attain 160,000 tpy by 1985. More than half of semis output is being exported today.

Iraq has a semis works of 32,000 tpy capacity at Nassiriyah. It incorporates a rolling mill of 15,000 tpy capacity, an extrusion shop of 3,000 tpy capacity and a wire rod shop of 10,000 tpy capacity. It is slated to produce wire, cast products and foil in addition. There is also a cable factory in Iraq. The Nassiriyah plant is to be expanded by 5,000 tpy of extruded-goods and 25,000 tpy of rolled-goods capacity.

In Jordan, Arab Aluminium Ind. Co. has a 5,000 tpy extrusion plant.

In Kuwait, an aluminium cable maker - Gulf Cable and Electric Ind. Ltd - is known to operate. The Arabian Light Metals Co. has an extrusion plant of 4,500 tpy nominal capacity. ALEXCO runs a foundry and a press.

In Lebanon, Scial and Sidem, both of Beirut, used to produce 5,000 and 15,000 tpy respectively of extrusions and rolled goods. Both are part-owned by Péchiney of France.

In Morocco, Manufacture Marocaine d'Aluminium is a maker of sheet and tube. Aluminium du Maroc S.A., part-owned by Péchiney of France, is a maker of profiles and irrigation pipe.

In Saudi Arabia, Kawneer Co. and Aluminium Products Co. of Dammam are both extruders. The investment of two extrusion plants is in course. A small cold rolling plant of

6,000 tpy capacity is also being built.

Syria has envisaged the construction of a 20,000 to 30,000 tpy semis plant, but we have no information as to the fate of it.

E The economics of aluminium from an Arab viewpoint

E.1 An Arab aluminium consumption forecast

This forecast, by the nature of things, must be very tentative. Not only do the Arab countries cover an extremely wide range of sizes, per-caput and absolute-terms GDPs etc. /as a glance at Table 1 overleaf will reveal/, but also, aluminium consumption is likely to evolve quite otherwise in a country where aluminium is abundant and its substituents are scarce than in a country where the suppy situation is the other way round.

The forecast given here is based upon a method detailed in "The Economic Uses of Aluminium /based on the Hungarian Experience/" by A. Bokor, A.B. Domony and I. Varga, UNIDO/IOD.335, 28 January 1980. Let us reproduce here Table 3 of that paper.

GDP per caput in relation to aluminium consumption

GDP, $ per caput	Aluminium consumption	
	kilogramme per caput	kilogramme per $1,000 of GDP
300	0.50	1.66
500	1.00	2.00
1,000	2.60	2.60
2,000	6.75	3.38
4,000	17.50	4.38

Table 1

Essential economic indicators of the Arab world

	Population mid-1980	GDP per caput 1980	GDP total, 1980	Growth rate of GDP 1970-79	Contribution to GDP of industry	Contribution to GDP of manufacturing
	thousand	$US	$US bn	%/year	%	%
Algeria	18,919	1,920	36.32	2.8	57	14
Bahrain	422	5,560	2.35	0.7	..	..
Djibouti	352	170	0.06	-4.7	..	..
Yemen PDR	1,903	420	0.80	..	28	14
Egypt	39,773	580	23.07	5.3	35	28
Iraq	13,072	3,020	39.48	9.3	73	6
Jordan	3,244	1,420	4.61	6.0	32	16
Kuwait	1,353	22,840	30.90	1.4	79	6
Lebanon	2,700+	..	..	..	..	..
Libya	2,978	8,640	25.73	-1.6	72	4
Mauritania	1,634	320	0.52	-0.7	33	8
Morocco	20,182	860	17.36	3.5	32	17
Oman	891	4,380	3.90	3.8	..	..
Qatar	231	26,080	6.02	-1.2	..	..
Saudi Arabia	8,960	11,260	100.89	9.6	78	4
Sudan	18,371	470	8.63	1.5	14	6
Somalia	3,914	160+	0.63+	..	11	7
Syria	8,977	1,340	12.03	4.6	27	21
Tunisia	6,354	1,310	8.32	5.7	35	13
UAE	893	30,070	26.85	2.4	77	4
Yemen A.R.	5,812	460	2.67	..	16	6
Sum/Average	158,235§	2,219	351.14	..	..	..

+ estimated; § without Lebanon; .. not available or applicable

Sources: List of countries: as per UNIDO usage. Population and GDP per caput: 1981 World Bank Atlas, IBRD, Washington, US, 1982. GDP calculated from population and GDP per caput. Others: World Development Report 1982, Oxford University Press for IBRD, 1982.

As a verification of these rule-of-thumb figures for the Arab world, we have calculated current consumption for five groups of countries, representing GDP-per-caput ranges of US$ /1980/ less than 400, 400 to 750, 750 to 1500, 1500 to 3000 and more than 3000. These ranges straddle the limits in the left-hand column of the table on p. 29. The estimate on the kilogramme per caput basis provides for the Arab World a 1980 consumption of 827,000 tons, whereas the estimate on the $1000 of GDP basis gives 1,339,000 tons. In fact, however, actual aggregate consumption in the Arab World is on the order of 160,000 tons per year, off target by a factor of almost ten!

What is the reason for this discrepancy? The estimated per caput consumptions in the table are of course on the high side, but are not all that far wrong. Prof. R.F. Kumar for example[+] gives per capita consumption figures of 11.90 kg for Qatar and 14.12 kg for Dubai. Yet the estimates in the table of page 29 hold for developed rather than developing aluminium consumers Hence, the figures there turn out to be misleading for the Arab countries whose GDPs are tied up differently with their levels of development /as cf. Saudi Arabia's per caput consumption of 1.42 kg, which by the table should be somewhere around 30 kg per person/. Also, the Arab region is, as a whole, undersaturated in aluminium: consumption has not caught up yet with actual financial strength in many of these countries.

Undersaturation is not, or at least not primarily,

+ The semi products aluminium industry in some developing countries, UNIDO, 1980.

due to a supply shortage: in 1981, the three Arab aluminium-smelting countries, Egypt, Bahrain and Dubai between them produced 390,000 tons of primary aluminium, much of which was exported outside the Arab world.

Clearly, another approach to forecasting should be sought for. The following one is offered for consideration.

- The average GDP per caput in the Arab world, weighted with the size of the countries' GDP in 1980, grew at 5.8 % per year between 1970 and 1979. Let us assume that this rate of per caput growth is to persist up to 1990.
- Between World War II and 1973, the average annual growth rate of world aluminium consumption was about twice the average annual growth rate of gross world product per caput. While admitting that aluminium consumption may be expected to grow somewhat slower nowadays world-wide /albeit still faster than the per caput GDP/, let us assume that, in the Arab world, which, as we have seen, is an undersaturated market, it will keep growing at twice the growth rate of GDP per caput. /This assumption rests on the hypothesis that the Arab market will receive plentiful supplies of metal to boost consumption./
- The growth rate of aluminium consumption in the Arab world is therefore estimated, up to 1990, at 11.6 % per year in per caput terms. This is tantamount to a trebling of consumption, from one to three kilogrammes per caput, between 1980 and 1990.
- Neglecting population growth as a slower-growing

factor, that is, assuming Arab World population to stay constant at 160 million as a rough first approximation, we obtain that the consumption within the Arab world will, at a fairly conservative estimate, grow by at least 320,000 tpy between 1980 and 1990, from 160,000 t to 480,000 t per year.

- Taking into account population growth also,+ we obtain a consumption increase of 420,000 tpy between 1980 and 1990, from 160,000 t to 580,000 t per year.

E.2 Other markets

Since World War II, the world aluminium market has been characterised by a more or less persistent slight oversupply, except during the Korean and Vietnam wars. The present oversupply is likely to be flipped over into a transitory shortage by even a moderate upswing in the OECD economies. In the longer term, a rough balance leaning towards a slight oversupply may be expected to prevail. In the world market, then, any export-oriented Arab aluminium industry to be set up will have to compete on its comparative advantages which, even though they do exist, may be considerably less clear-cut than those of petroleum, petroleum-product or natural gas exports.

World aluminium production today is on the order of 16 million tpy; assuming it to grow by only 4 % per year, which is on the conservative side, the capacity increment

+ According to the IBRD World Development Report 1982, pp. 142-143, the population of the Arab World will attain 210 million by 1990 /and 270 million by 2000/.

required between 1985 and 2000 would be some 13 million tpy. Assuming that only 10 % thereof would be corralled by the Arab World, which seems entirely feasible /over and above the capacity needed to supply the domestic market, as outlined above/, the resulting 1.3 million tpy is on the order e.g. of current Japanese capacity. If held together by the right sort of efficacious cooperation agreement, such a productive capacity could well project the image of a single major aluminium producer, the more so since, on a less conservative estimate, aluminium smelter capacity in the Arab World may well reach twice that figure by 2000.

E.3 Should Arab countries opt for the development of an aluminium industry?

The principal point is that, as long as the world market functions normally, there is no prima facie case either against the importation of aluminium metal or semis or for their exportation, provided, of course, that potentially idle factors of production can be allocated to other industries of similar lucrativity. The advantages and drawbacks of the one or the other approach must therefore be determined country by country by a detailed analysis that pays due attention to all the society-wide opportunity costs and benefits involved. One should add that

/a/ The usual argument of setting up an aluminium industry so as to increase the value added to a domestic bauxite resource does not apply to the Arab world, which is short of aluminium ore.

/b/ The argument of higher value added to a fuel /natural gas or refinery residues/ is two-edged because the world fuel market /the natural gas market above all/ will probably be more of a sellers' market in the medium to long term than the aluminium market, with the Arab countries' advantages more clear-cut. Thus aluminium is seen to have an advantage only where it can function as an outlet for fuels not used otherwise /unexportable, flared gas; unexportable refinery residues not consumed by other, more lucrative industries, if any/.

/c/ Providing employment for unemployed labour in the more densely populated countries. This argument is weakened by the comparatively low labour intensity of most aluminium industry phases.

E.4 The case for semifabrication

According to R.F. Kumar /op. cit., p. 160/, "The aluminium semi fabrication industry is neither as energy nor as much capital intensive as the primary metal industry. Being amenable to relatively small scale operation, it can be advantageously established in a number of developing countries to meet their own national and intra-regional demands such as now seems to be the case amongst the Arab countries... The establishment of semi production industry is expected to achieve a number of national goals simultaneously. It would generate /i/ additional direct and indirect employment; /ii/ decrease the value of imports as now the metal would be imported as ingots and the value adding technological operations would be carried out within the country of consumption and /iii/ increase the value of exports in case of those countries who are presently exporting primary metal."

These views are endorsed fully by the present writer, with the riders that /1/ the Arab countries in fact seem to have grasped these ideas fairly early on, and /2/ the development opportunities for semis manufacturing are more widespread in the Arab world than those for aluminium smelting, the inputs required being more widely available: this is reflected by the current distribution of these two aluminium industry phases, and is expected to be a feature of ongoing development, too.

All in all, aluminium semifabrication may be expected to develop at least in step with, and probably faster than, aluminium smelting in the Arab world.

E.5 Intra-Third World and inter-Arab cooperation in the aluminium industry

The scope for cooperation between Arab aluminium makers and other developing countries is quite clear-cut because, as we have seen, the Arab aluminium makers will have to import outside ore, in the form of either bauxite or alumina. True, the procurement of both is possible from, say, Australia, but India would be another viable option,+ and so would Guinea and Jamaica. Arab cooperation may e.g. assist Guinea in its long-pursued aim of building a second alumina refinery in the country.++

+ According to a news item in the specialised press, Algeria and Iraq each have options on 150,000 tpy alumina from a plant to be built in India. /M. Hugueney, "Nuages sur le développement...", Revue de l'Aluminium, No. 510, October 1981, pp. 357-359./

++ In the labour-short Gulf-states, an important percentage of an aluminium-industry workforce may come from non-Arab developing countries. The Dubal smelter's workforce already includes many workers from Pakistan, India and the Philippines, and so do the workforces of Gulf Extrusions and of cable maker Ducab.

What scope is there for <u>inter-Arab cooperation</u> in the aluminium industry?

Arab countries pursue a variety of economic policies, different as to their openness to the world economy. Their aluminium industries, inasmuch as they exist, reflect these different policies.

For the economically open countries, going in for collective self-reliance in the aluminium sphere is unlikely to look like a reasonable option. Those which have excess production may sell it as favourably on the world market at large as to other Arab countries; those which are net importers may cover their demand as favourably from the world market as from Arab producers. Indeed, the Maghreb countries, e.g., may /and in fact do/ find importing from Western Europe geographically preferable to importing from the Gulf region.

Those countries which pursue less open foreign-trade policies may on their part prefer to set up aluminium supply agreements of a collective self-reliance type between them.

It should be remembered in this context that, at times of market depression, the policies even of the open traders may turn less open. In such situations, Arab importers may prefer buying Arab metal, not saleable for the time being outside the Arab world, to purchases from other suppliers.

Another area of cooperation may involve joint supply schemes. The alumina refinery envisaged for the Gulf region might be a case in point. This is because long-term marketing agreements are much more important for alumina refineries /and bauxite mines/ than for smelters or semis plants. Several smelters may thus invest jointly into an alumina plant /or several alumina makers into a bauxite mine/, pledging to take off most or all of its output between them. But there is no a priori reason for all these participants to be Arab companies or governments.

In the Gulf region, GOIC's role of industrial development and marketing coordination seems to fetch most of the benefits of regional cooperation while avoiding most of the pitfalls. It is an interesting question whether its activities could be extended to the non-Gulf Arab countrics.

Within the aluminium industry proper, on the other hand, GOIC might expand its sphere of activities also within the Gulf region, notably to other aspects of aluminium development.

At present, as far as we are aware, each Arab aluminium-related company /regardless of whether or not it is state-owned/ buys in its technology and all but a very minor percentage of its machinery and equipment direct from a motley variety of sources, sited in developed market economies in their bulk, in centrally planned ones on occasion. It would make a great deal of sense for the Arab companies/governments to set up joint technology reception/development facilities, with the aim of expanding them into project design/engineering centres. The argument behind this idea is that, whereas the aluminium industry of each Arab country taken in itself is minor, all these industries taken together are quite important even today, and, in ten years or so, may attain or surpass the size of e.g. the Japanese industry, becoming big enough to serve as a basis for self-sustained R and D and engineering. Such joint aluminium industry centres would be apt to facilitate very greatly the intra-Arab production of aluminium industry machinery and equipment /starting, say, with smelter cells and alumina plant boilerwork/. They would likewise facilitate /and given the problems inherent in the Arab language, greatly simplify/ the training of manpower for projects under construction.

E.6 The economics of gas as an aluminium smelter fuel

This is what S.J. Ross-MacDonald, General Manager of Bahrain Aluminium, had to say about gas and the aluminium industry in the Arab world:+ "The Alba smelter in Bahrain is fired by produced gas which could be left in the ground, while 20 miles across a shallow channel enough Saudi Arabian associated gas is flared to smelt 6m tpy of aluminium. Additionally a smelter is nearing completion in Dubai to be fired by waste gas, the supply of which is now said to be far from certain. Not 200km away vast quantities of flared gas testify to Abu Dhabi having the highest gross national product per head in the world."

The use of gas in the aluminium industry of a gas-exporting country may be costed very roughly on the following consideration.

/1/ In the year ending 30 June 1982, the average power price paid by smelters reporting to IPAI was 1.7 US cents per kWh.++

/2/ Let us assume for simplicity that the conversion efficiency of thermal energy into electric power in a gas

+ "Aluminium in the year 2000", Metal Bulletin Monthly, July 1979, pp. 57-61.

++ Cf. IBA Review, Vol. 8, No. 2, Oct.-Dec. 1982.

turbine power plant is 0.33. This implies that the fuel equivalent of three kWh must be burned to generate one kWh of electric power.

/3/ Let us assume, likewise for simplicity, that the conversion of gas into electric power is fraught with the same capital and operating costs as the exportation of LNG.

Hence, the IPAI-average price of 1.7 US cents per electric kWh corresponds to 0.5667 cents per thermal kWh. Now since one kWh equals 0.00341214 million BTU, the power-plant-gate gas price equivalent to the IPAI-average power price is $1.66 per million BTU, or about half the netback price written into the average current international gas sale contract.

It must be repeated that this is a very rough calculation indeed. Yet it is quite accurate enough to show that, for the generation and the sale of electric power to an aluminium smelter to break even with LNG exports /assuming that the smelter must be internationally competitive/, the IPAI power price average would have to double approximately. Now even though there is a consensus of sorts that power costs will go on rising irreversibly in the medium and longer term, their doubling in real terms before the end of the century /which is tantamount to a real-terms rise of slightly less than four per cent per year/ is unlikely, not the least because such a rise would seriously impair the competitiveness of aluminium vis-à-vis many other materials. In the final reckoning, then, the gas-producing Arab countries will have an inbuilt comparative advantage in aluminium smelting only either if they are ready to supply the gas to the power generating facility at a lower price than that for which they can sell some of it abroad, or if international gas prices decline in real terms /which, after a transitory fuel price shakeout in 1982-1984, is none too likely/.

Even without going into the details of price forecasting for other natural gas products, such as nitrogen fertiliser, bulk petrochemicals, direct-reduction steel, cement or the like /let alone into the details of the pricing of the gas needed to make them competitive/, the overall pattern is fairly clear-cut: all these potential users of gas /including exports/ will queue up for the gas available, and government /both in its role as the owner of the gas and as the instance responsible for industrial development policy/ will have to decide its preferences or priorities. Development priorities will depend, in addition to the view government takes of the future markets of these products, also on the way this or that industry fits into the development concept of the country, its factor endowments, market access etc. It would accordingly be overweening to try and make any comprehensive suggestions here as to government priorities. It seems likely, however, that, in a very general way, up to the end of the millennium at least, the exportation of natural gas will fetch better returns than aluminium smelting, while the making of nitrogen fertiliser, basic petrochemicals, cement or direct-reduction steel seems to have no a priori advantage or disadvantage vis-à-vis aluminium smelting. The question that remains, of course, is how much gas can in fact be exported.

F Envoi

Held together by strong bonds of race, language and cultural heritage, the Arab world is highly inhomogeneous as to richness/poverty, economic sophistication and economic policy attitudes. Accordingly, what is economically good for one Arab country is not necessarily good for the next one, let alone for all. This is true of the aluminium industry in particular as well as for investment projects in general.

In a world where the key inputs into economic development are fuels and capital, the aluminium industry is no shining light, just one of many development options. Decision-making in each country seriously considering entry into, or expansion in, the aluminium branch must be based upon a balanced consideration of both the country's individual features and its situation relative to the world economy of the metal.

It is hoped that the present paper will have contributed usefully to the taking of those decisions.