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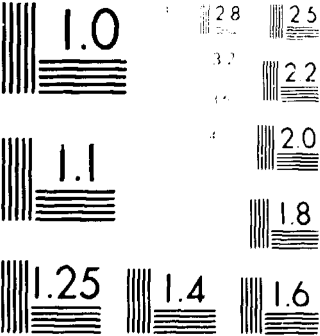
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org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United Nations Industrial Development Organization

THE DEVELOPMENT OF ALUMINIUM SALES UP TO 1990 *

Analysis and Forecast of the Aluminium Consumption in Selected Markets and Industries

conducted by
a working team
of
PROGNOS AG, Basle (Switzerland)

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THE DEVELOPMENT OF ALUMINIUM SALES

UP TO 1990

Corrigendum

Page 38, paragraph 2, line 5

delete "(Iran and Turkey - cf. Chapter 6)"

Page 61, Table 13

For "Explanation of signs: cf. page 58"
read "Explanation of signs: cf. page 62"

Page 85, Table 18

For "Legend: cf. page 58" read "Legend: cf. page 62"

Page 101, Table 21

For "Legend: page 58" read "Legend: page 62"

Page 116, Table 27

For "Legend: page 58" read "Legend: page 62"

Page 124, Table 31

For "Legend: page 58" read "Legend: page 62"

Page 133, Table VI

Change heading of table to read "Consumption of metallurgical and remelt aluminium by application areas in the United Kingdom 1960 - 1990"
Change sub-heading to read "Consumption in 1000 kg"

Page 134, Table VI

Change heading of table to read "Development of selected economic sectors and their aluminium consumption in the United Kingdom 1960 - 1990"
Change sub-heading to read "Absolute value in £ million [1) 2)]"

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FOREWORD

According to various forecasts aluminium will probably be the fastest growing non-ferrous metal during the next decade and aluminium consumption growth rates of 6 % average per year do not seem unrealistic. Whilst the growth rates in industrialized countries may be comparably lower, developing countries are expected to increase their share at a higher percentage. The growth of aluminium consumption is mainly due to the fact that the metal has become more and more competitive with other metals and materials and increasing substitution by aluminium can be reported in many sectors where other metals and materials used to be predominant. The areas of aluminium application are diversified: the transport sector, the construction industry, packaging, machine building and apparatus manufacture, and last but not least electrical engineering, which is especially relevant to developing countries.

Aluminium may become a particularly valuable replacement material for countries with insufficient availability of heavy non-ferrous metals.

Taking due consideration of this "boom" in aluminium consumption, UNIDO has published a number of documents aimed at assisting developing countries that possess the necessary raw material and/or energy resources to establish their own aluminium industry.

A recent publication "The Economic Use of Aluminium (based on Hungarian experience), UNIDO/IOD.335 of 28 January 1980" is describing the main reasons for using aluminium, with examples and methods of use, including potential sources of technology; it found a particularly positive echo by readers from both developed and developing countries.

The present study can be regarded, to some extent, as complementary to the above and elaborates on the development of aluminium sales up to 1990. Although the study is mainly based on the present situation and future outlook in industrialized countries it may be considered a useful guide to planners and decision makers (both private and governmental) in developing countries wishing to promote aluminium consumption in various sectors and possibly also considering export of semi finished and finished aluminium products.

The secretariat of UNIDO

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1. INTRODUCTION

(1) This study was carried out by PROGNOS AG, Basel, Switzerland on behalf of UNIDO, Metallurgical Industries Section, Industrial Operations Division. It is based on a previous study of similar contents, which was updated with information and statistical data up to early 1980. However, oil price increases of December 1979 and their repercussions on aluminium production and consumption could not be taken into account due to lack of reliable figures.

(2) The primary issue of the study is to define the future consumption of aluminium by industry sectors and to show fundamental technological change that may influence the demand for aluminium.

(3) Unfortunately, very little information on developing countries were available for the analysis with the result that mainly the development on markets and in industries in industrialized countries was taken into consideration.

2. RAW MATERIAL SUPPLY

2.1. Bauxite mining

(1) Since the expertise on the 'Limits of Growth' elaborated by the Club of Rome, the importance of raw materials and the dangers inherent in their wasteful exploitation have for the first time been brought to the attention of a larger public.

Taking into account only the entire amount of aluminium contained in the earth's crust, the resources of this element which is ranking third with 8.2 % after oxygen and silicium - give little rise to concern regarding any impending scarcity.

The real difficulty lies in the fact that aluminium occurs only in silicates, feldspars (magmatites) or micas. The most interesting forms for the extraction of aluminium - since according to current systems the cheapest - are the silicates of the kaolinite and bauxite group formed through weathering.

Clays and clayslate rich in kaolinite - i.e. above all kaolinite itself - contain between 20 and 40 % of Al_2O_3 (alumina), and bauxites even between 40 and 65 % of aluminium oxide which up to now has been exclusively used for the extraction of pure aluminium using the Hall-Héroult method of decomposition.

For the production of aluminium oxide, mainly various kinds of bauxites are actually used today, such as BOKE (60 % Al 0/Guinea), WEIPA (68 % Al 0/ Australia), JAMAICA bauxite (50 % Al 0), to mention only the major ones. Apart from these, however, also alunite and nephelite are extracted - probably above all in the Soviet Union - and, among other uses, are also decomposed into alunimium oxide.

Since within the foreseeable future, i.e. for the next 10 to 15 years, practically only bauxites will be used for aluminium extraction - for reasons of profitability and of the processing capacities existing today - bauxites resources have to be regarded as one of the main factors of influence for the supply of aluminium.

(2) Areas with potential bauxite deposits are such regions in which at one time lateritic weathering processes have taken place. While pre-tertiary bauxite deposits in silicate rock in all probability have already been largely exploited, the deposits known today and the frequency areas which so far are unexplored are to be found in the extended regional shield of the tropical belts, i.e. not farther than approx. 150 km inland from the coast.

Current estimates[1)] of worldwide bauxite reserves fluctuate between 18 billion and 30 billion tons. In the first case, the assumed resources are distributed as follows:

1) OECD Industrial adaptation in the Primary Aluminium Industry, Paris 1976

Regions with bauxite deposits	in millions of tons	
Africa		7,600
of which Guinea	5,500	
Cameroon	1,100	
Australia		5,500
America		3,300
of which Brazil	950	
Jamaica	900	
Surinam	700	
Europe		800
Asia		1,000
worldwide		18,200

(3) During the past period 1960 - 1978, worldwide bauxite production was accelerated by annually 6.8 % on average (cf. Table 1). For an assessment as to how long the bauxite reserves known today are going to last, future extraction would also have to become more dynamic. This would result in the life span as listed below of the above-mentioned bauxite reserves amounting to around 18 billion tons:

	Acceleration of growth in % p.a.			
	6.0	8.0	10.0	12.0
life span of bauxite resources worldwide (years)	49	40	34	30

Since it can be assumed that beyond the reserves of 18 billion tons which are known today a considerable number of hitherto unexplored deposits exist and that up to the year 2000 technological development in the field of alu-

Table 1: Production of bauxite[1], 1960 - 1978

Thousands of metric tons	1960	1966	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	Av.Gr 60-78 (%p.a.)
EC	2,386.6	2,912.1	3,056.3	3,239.3	3,377.3	3,488.1	3,327.8	2,982.9	2,989.9	2,354.5	2,393.3	2,002.0	- 1.0
FRG	3.8	3.9	2.3	3.0	2.9	2.0	1.6	1.4	0.8	0.2	-	-	-
France	2,067.3	2,663.8	2,812.6	3,008.7	3,183.6	3,401.9	2,970.2	2,949.9	2,562.9	2,330.1	2,088.8	1,977.8	- 0.2
Italy	315.5	244.4	241.4	228.6	190.8	84.2	58.0	31.6	22.2	24.2	34.5	24.2	- 13.3
Greece	883.7	1,274.0	1,688.9	2,292.2	2,800.7	2,488.5	2,748.4	2,782.7	3,008.6	2,581.1	2,882.1	2,530.0	+ 6.2
Jugoslavia	1,025.0	1,574.0	2,131.0	2,099.0	1,988.0	2,197.0	2,167.3	2,378.0	2,306.0	2,033.0	2,344.3	2,566.3	+ 5.2
Austria	25.0	-	-	-	-	-	-	-	-	-	-	-	-
Spain	2.6	4.2	4.8	5.0	5.4	6.1	8.2	9.2	8.5	13.5	9.6	10.0*	+ 7.8
Europe[2]	4,323.9	5,794.3	6,863.0	7,688.5	8,282.4	8,088.7	7,946.4	8,144.8	7,916.0	6,982.1	7,083.0	7,208.0	+ 2.9
India	387.4	708.7	708.5	1,374.0	1,517.1	1,682.1	1,251.0	1,071.1	1,004.2	1,449.0	1,518.7	1,662.9	+ 8.4
Indonesia	396.7	688.3	908.2	1,229.2	1,237.6	1,276.0	1,229.6	1,298.0	992.6	940.3	1,301.4	1,007.7	+ 5.3
Malaysia	480.2	866.7	880.6	1,139.3	977.9	1,076.0	1,142.9	947.5	703.6	608.2	616.2	618.1	+ 1.6
Pakistan	0.6	-	-	0.9	0.3	0.8	0.1	0.3	0.4	0.0*	0.4	-	-
Sarawak[3]	280.4	137.3	-	-	-	-	-	-	-	-	-	-	-
Turkey	-	10.3	23.6	52.1	153.3	471.6	332.2	664.9	588.2	463.0	567.1	449.0	+ 33.7[5]
Asia[2]	1,532.3	2,398.3	2,629.8	3,798.5	3,886.2	4,516.3	3,975.6	3,973.8	3,340.0	3,512.9	4,083.8	3,724.7	+ 5.1
Rep. of Guinea	1,378.0	1,600.0	1,639.2	2,490.0	2,630.0	2,600.0*	3,800.0	7,600.0	7,640.7	10,297.3	10,940.8	12,084.6	+ 12.8
Ghana	193.8	319.3	351.0	342.0	328.6	342.3	348.8	343.3	321.6	298.7	275.4	329.5	+ 3.0
Mozambique	4.8	5.7	5.9	7.1	7.7	5.4	5.6	5.4	5.2	0.3	2.3	-	:
Rhodesia		1.6	2.0*	2.0*	2.0*	2.0*	2.0*	2.5*	2.5*	2.5*	-	-	-
Sierra Leone		207.3	334.5	440.0	598.5	583.9	683.0	672.0	716.0	560.0	746.0	716.0	+ 10.0[5]
Africa	1,576.6	2,133.3	2,332.6	3,288.1	3,588.8	3,641.6	4,847.6	8,640.7	8,681.9	11,217.9	11,863.2	13,110.5	+ 12.5
United States[4]	2,330.1	1,688.5	1,680.5	2,115.4	2,039.9	1,841.1	1,908.2	1,980.2	1,800.4	1,989.4	2,013.0	1,668.4	- 1.1
Brazil	120.3	188.0	302.9	500.8	566.4	764.5	840.2	868.5	960.0	998.4	1,382.1	1,224.8	+ 13.7
Dominican Republic[2]	688.6	941.8	983.0	1,086.0	1,031.7	1,087.2	1,146.5	1,196.6	771.3	621.2	576.0	577.9	- 1.0
Guyana[4]	2,510.8	2,918.7	3,381.4	4,417.2	4,233.6	3,668.4	3,621.4	3,806.0	3,828.2	3,107.6	3,344.3	3,450.0	+ 1.8
Haiti[4]	346.5	382.6	378.8	686.8	764.5	782.8	743.1	688.5	522.1	733.2	686.3	630.0	+ 3.5
Jamaica[4]	5,837.0	8,661.0	9,386.4	12,008.7	12,543.4	12,988.8	13,599.8	15,327.6	11,570.3	10,296.6	11,433.3	11,738.8	+ 4.0
Surinam	3,455.0	4,388.0	5,466.3	6,022.0	6,718.0	7,777.0	6,976.0	6,864.0	4,749.0	4,586.0	4,866.0	5,288.0	+ 2.4
America	14,988.8	19,122.6	21,986.2	26,816.9	27,877.6	28,989.8	28,874.1	30,491.4	24,210.3	22,330.4	24,260.0	24,584.9	+ 2.8
Australia	70.5	1,186.4	4,203.6	9,256.3	12,732.7	14,437.0	17,596.9	19,994.3	21,083.5	24,082.5	26,086.4	24,300.5	+ 30.3
Western Countries	22,492.1	30,608.5	37,644.2	50,812.3	56,285.6	59,604.4	63,298.4	71,246.0	65,170.7	68,086.8	73,292.6	72,928.6	+ 6.8

* Estimates by the Metallurgical Society

1) In this table the officially published figures of each country in question have been recorded. It has therefore not been taken into account that bauxite occurs in ranging compositions and has varying moisture contents

2) without "Eastern countries"

3) from 1966 onward contained in the production figures of Malaysia

4) Dry weight

5) GR 66/78

From: Metal Statistics 1960 - 1970 and 1968 - 1978, Metallurgical Society, Frankfurt 1979, page 12 minium production, on the one hand, and higher costs of extraction of the still existing deposits, on the other, will have come to such a point as to make non-bauxite resources - such as clay and clayslate, anorthsites and nephilites - interesting raw materials for the extraction of aluminium, no scarcity of aluminium supply seems likely even under long-range aspects.

(4) As can be seen from Table 1, the entire bauxite production in 1978 - with the exception of the Eastern Bloc countries - was nearly 73 billion tons, with the four main producing countries

- Australia
- Jamaica
- Guinea
- Surinam

accounting for over 70 % of total mining. Accordingly, the large producing countries could increase their share as compared with 1965 by another 10 %. During this period known resources have also increasingly shifted in favour of the tropical countries due to Australia's further push. With bauxite mining in Brazil and Cameroon, the share of this group of countries will continue to grow.

(5) At the following locations, for instance, the establishment of new bauxite mining capacities is planned: Table 2.

Table 2: Planned bauxite mining capacities

Location	Manner of investment	Al_2O_3 content	Planned mining capacity (millions of tons)	Estimated Resources (millions of tons)
Brazil				
. Paragominas	New capacity	52	-	approx. 700
. Trombetas	New capacity			
. Amazonas	(mining since 1978)	-	8 t p.a.	several 1000's
Australia				
. Weipa, Qld.	Extended capacity	58	20 t p.a.	-
. Kimberley	Extended capacity	-	1.2 t p.a.	-
Kamerun				
. Northern part of the country	New capacity	39.2 - 43.7	10 t p.a.	approx. 1000
South Africa				
. Prov. Natal	New capacity	-	-	-
Guinea				
. Debelé	Extended capacity	48	poss. 2.5 t p.a.	41[1]
. Tougue	New capacity	-	8.0 t p.a.	2-4,000 Guinea total
. Dabola	New capacity	-	3.0 t p.a.	1,500 8,000[2]
. Boké	Extended capacity (up to 1979)	60	9.0 t p.a.	
- Aye Koye	New capacity	-	-	-
Zaire	New capacity (carried out by Reynolds Metals Co.)	-	-	-
Jugoslavia				
. Niksic	Extended capacity	-	1.0 t p.a. (1980) 1.5 t p.a. (1985)	-
Indonesia				
. Tayan/ West Borneo	New capacity	-	-	-
India				
. East Coast	New capacity	-	-	approx. 400

1) Only main storage

2) According to information received from Guinea' Minister of Economics, Touré, in 1975

Source: Press releases from the Metallurgical Society
Interpretation of dailies and technical journals.

(6) Starting out from 1975 conditions, the price of 1 ton of metallurgic alluminium is more or less composed as follows:

bauxite	approx.	10 %
alumina production	approx.	27 %
aluminium production	approx.	63 %
of which capital costs approx. 40 %		
energy costs approx. 35 %		
wages approx. 25 %		
1 metr. ton of metallurgic aluminium		100 %

As compared with the situation prevailing up to 1973 - which changed through the introduction of a bauxite tax in Jamaica calculated as percentage of the price per aluminium ingot - the share of bauxite in total costs rose by nearly 4 %, i.e. from 6.2 % to 10 %.

It will be the major objective of the bauxite mining countries united in the International Bauxite Association to achieve a uniform bauxite cartel price. From Guinea, the major promoter of the 'IBA', a system of calculation based on a currency 'basket' composed of US $, DM, and Sfr. is suggested for the sale of metallurgical bauxite and calcined alumina. Guinea has been applying this system from the very beginning and it seems to have proved successful up to now. Whether all the IBA countries will join the common pricing seems doubtful as seen from today's perspective - mainly because the new government in Canberra has repeatedly voiced its objections. From this fact however it cannot be inferred that Australian bauxite will be cheaper than bauxite from other mining countries.

It can be summarized that - apart from some special contracts as for instance between Alcoa and Surinam - the price of bauxite, too - comparable to that of other raw materials - has increased more than 1 1/2 times between 1973 and

1976. Although the aluminium industry does not expect a similarly marked increase in the future it must be expected all the same - be it after the example of Guinea or that of Jamaica - that the price of bauxite for the aluminium industry located outside the mining countries will no longer be below 11 - 12 % of the price of the metallurgic aluminium.

2.2 Production of aluminium oxide

(1) The production of the aluminium oxide Al_2O_3 which has been extracted from bauxite with the help of the Bayer decomposition method could be accelerated between 1966 and 1978 - outside the Eastern Bloc countries - from 11.5 billion metric tons to 25.6 billion tons, i.e. an average annual growth of 6.9 % (cf. Table 3).

While bauxite has still mostly been mined in developing countries - with the exception of Australia - over 78 % of alumina production in 1978 was accounted for by the industrialized countries of Western Europe, the USA, Japan, and Australia. Apart from Australia, alumina production also exists in the bauxite countries of Jamaica and Surinam, but the shares in total production with 8 % or 5 % are lagging behind the shares in worldwide bauxite extraction.

(2) When studying the capacities indicated below, even 78 % of total production are accounted for by the industrialized countries mentioned above. According to IPAA surveys, this structure underwent only insignificant changes up to 1978, i.e. by an extension of Australian capacities at the expence of Western Europe and the USA.

In the long run, however, it must be expected that especially with production plants for alumina capacities will be shifted to the bauxite producing countries. In favour of this are frequently existing potentials of hydro-energy, the fact that transport costs of alumina are below those of bauxite. Moreover, the bauxite mining countries are strongly interested by means of further developing this branch of industry to improve the infrastructure of their country.

Table 3: Production of aluminium oxide (alumina) 1966 - 1978

Thousands of metric tons	1966	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	av.GR 66/78 annual percent.
EC	1,717.3	1,838.7	2,074.6	2,145.6	2,234.6	2,617.1	3,198.4	3,114.3	3,240.2	3,421.3	3,685.1	+ 6.6
FRG	602.9	633.4	757.1	836.9	916.4	921.8	1,307.4	1,246.1	1,333.4	1,463.9	1,555.6	+ 8.2
France	844.9	919.8	1,004.2	1,046.1	1,111.9	1,112.1	1,107.5	1,088.6	1,013.0	1,080.7	1,220.9	+ 3.1
Italy	269.5	285.5	313.3	262.6	206.3	486.3	688.8	697.1	797.8	788.2	814.7	+ 9.7
Great Britain	119.0	135.3	107.1	99.1	116.1	96.9	94.7	82.5	96.0	98.5	94.0	- 1.9
Norway	14.8	15.5	-	-	-	-	-	-	-	-	-	-
Greece	72.9	180.9	312.5	463.8	466.2	470.4	498.0	475.3	461.6	474.2	477.6	+17.0
Jugoslavia	95.3	101.4	125.1	123.4	126.0	274.7	272.7	283.1	465.3	499.3	494.0	+14.7
Europe 1)	2,019.3	2,271.8	2,619.3	2,831.9	2,943.1	2,362.2	3,969.1	3,872.7	4,157.1	4,394.8	4,656.7	+ 7.2
India	170.0*	200.0*	327.0	362.0	363.0	350.0*	299.2	337.0	442.0	386.6	479.7	+ 9.0
Japan	662.3	709.8	1,284.9	1,603.2	1,644.4	1,987.1	1,800.5	1,565.0	1,411.4	1,784.7	1,767.1	+ 8.5
Taiwan	35.0*	31.1	42.0	43.0	53.0	65.0*	45.0	46.4	47.7	51.0	51.3	+ 3.2
Turkey	-	-	-	-	84.0	109.4	123.7	81.7	139.1	170.3	74.0	+ 2.1
Asia 1)	867.3	940.9	1,653.9	2,008.2	2,144.4	2,501.5	2,268.8	2,030.1	2,040.2	2,392.6	2,372.1	+ 8.7
Africa (Guinea)	525.3	530.0	610.0	661.0	663.3	615.0	636.0	639.1	652.0	562.0	621.6	+ 1.4
Brazil	68.3	86.9	118.6	167.0	192.0	201.0	240.0	267.5	303.0	340.8	352.1	+14.6
Guyana	301.7	273.2	317.0	305.2	265.3	269.3	316.0	294.0	285.0	277.3	239.5	- 1.6
Jamaica	803.8 2)	837.8 2)	1,797.4	1,876.3	2,087.3	2,506.9	2,737.4	2,242.4	1,622.6	2,036.0	2,141.9	+ 8.5
Canada	900.0	1,000.0	1,105.0	1,140.0	1,148.7	1,133.5	1,264.7	1,133.7	490.0	1,060.8	1,053.6	+ 1.3
Surinam	407.0	741.0	1,036.0	1,277.0	1,378.1	1,380.0	1,185.0	1,148.0	1,162.0	1,215.0	1,260.0*	+ 9.9
United States	5,310.0	5,582.0	6,051.0	5,937.5	6,113.5	6,662.4	6,884.6	5,134.7	5,806.0	6,032.8	6,166.4	+ 1.3
America	7,790.8	8,520.9	10,425.0	10,703.0	11,184.9	12,152.1	12,627.7	10,270.3	9,668.6	10,962.7	11,223.5	+ 3.1
Australia	307.0	854.4	2,172.2	2,712.6	3,068.1	4,088.9	4,899.5	5,128.9	6,205.8	6,659.2	6,775.7	+29.4
Western countries	11,509.7	13,118.0	17,460.4	18,916.7	20,003.8	22,719.7	24,401.1	21,891.7	22,623.7	24,971.3	26,649.6	+ 6.9

* estimates by the Metallurgical Society

1) without 'Eastern countries'

2) exports

Sources: Metal Statistics 1968 - 1978, Metallurgical Society, Frankfurt
PROGNOS calculations

Table 4: Production capacities for aluminium oxide by selected regions, 1973 - 1978

	1973	1974	1975	1976	1977	1978
			in 1000 t			
Western Europe	4,417	4,587	4,572	4,690	4,695	4,695
North America	8,292	8,292	8,362	8,412	8,412	8,497
Latin America	4,564	4,564	4,889	5,075	5,075	5,075
Far East	2,451	2,511	2,511	2,775	2,775	2,776
South East	514	686	755	755	755	755
Africa	700	700	660	660	660	660
Oceania	4,938	5,638	6,038	5,838	6,938	6,938
Total	25,876	26,978	27,787	29,105	29,310	29,395
			in %			
Western Europe	17	17	16	16	16	16
North America	32	31	30	29	29	29
Latin America	18	17	18	17	17	17
Far East	9	9	9	9	9	9
South East	2	2	3	3	3	3
Africa	3	3	2	2	2	2
Oceania	19	21	22	24	24	24
Total	100	100	100	100	100	100

Western Europe: Federal Republic of Germany, France, Great Britain, Greece, Italy; North America: USA, Canada, Virgin Islands; Latin America: Brasilia, Jamaica; Far East: Japan, Chinese Republic; South East Asia: India; Africa: Guinea; Oceania: Australia.

Source: IPAA, London, State as per June 30, 1975

Guinea, Jamaica, Brazil, Australia, and India for instance - to mention only the most important ones - have made a series of contracts with large aluminium conglomerates with the aim of swapping the know-how of the aluminium producers against fixed deliveries of alumina from the bauxite mining countries after manufacturing plants have been erected. The endeavours of the bauxite countries to manufacture alumina in their own country can easily be read from the growth rates: apart from Turkey - whose bauxite extraction and alumina production still are on a very low level - the bauxite countries Australia, Greece, Jugoslavia, and Brazil registered the highest growth rates (29.4 % - 14.6 % p.a.).

2.3 Production of metallurgic aluminium

In Table 5, the production of metallurgic aluminium outside the Eastern Bloc countries is depicted. The development took a comparable course to that of bauxite extraction and alumina production and reached an average annual growth of 6.7 % between 1960 and 1978.

Of total production of 11,601 billion tons in 1978, 50.1 % were accounted for by the Americas (USA 37.6 %) and 30.4 % by Europe.

On the continents of Asia and Australia, growth was most remarkable, on the one hand, due to a way above average extension of existing capacities (Australia and Japan), and on the other, to the installation of completely new capacities (Bahrein, New Zealand, and Iran).

Broken down according to countries it is shown that the largest annual outputs come from the countries listed below:

Market share in total production 1978	
1. USA	37.6 %
2. Japan	9.1 %
3. Canada	9.0 %
4. Federal Republic of Germany	6.4 %
5. Norway	5.7 %

Table 5: Production of metallurgic aluminium, 1960 - 1978

Thousands of metric tons	1960	1966	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	G.R. 60/78 (% p.a.)
EC	487.7	699.0	774.0	911.9	1,063.9	1,150.2	1,508.8	1,834.9	1,316.2	1,372.1	1,987.3	2,007.2	+ 8.2
FRG	168.9	234.4	252.9	309.3	427.5	444.4	532.7	688.9	677.1	687.2	741.8	739.6	+ 3.6
France	235.2	340.5	361.2	381.1	383.6	393.7	358.9	393.3	382.6	385.1	398.8	391.4	+ 2.9
Italy	83.6	124.1	127.8	146.5	136.4	149.5	184.2	212.2	190.1	206.5	260.1	270.8	+ 6.7
Netherlands	-	-	32.1	75.0	116.4	162.6	181.4	247.4	257.6	248.9	236.9	259.2	+ 20.9[3]
Great Britain	29.4	36.2	39.0	39.6	119.0	171.4	251.6	293.1	308.3	334.5	349.7	[illegible]	+ [illegible]
Norway	170.7	275.6	361.0	522.3	530.2	597.4	618.1	648.6	594.3	617.6	637.0	656.9	+ 7.3
Greece	-	-	71.5	87.5	116.0	129.7	143.3	146.6	135.2	134.0	129.7	143.9	+ 5.6[3]
Iceland	-	-	-	38.7	41.9	45.7	72.0	69.6	61.8	65.3	72.8	73.3	+ 8.4[4]
Jugoslavia	25.1	38.8	44.6	47.7	46.6	72.7	98.8	147.1	166.3	182.6	176.5	180.0*	+ 11.5
Austria	68.0	78.7	78.7	90.0	90.7	84.0	88.1	91.6	89.1	88.7	91.8	91.3	+ 1.7
Sweden	16.0	29.6	33.4	66.2	75.5	77.6	82.8	82.5	78.0	81.5	82.6	82.0	+ 9.5
Switzerland	39.0	67.1	72.3	91.1	94.0	82.9	88.4	87.2	79.0	78.2	79.8	79.5	+ 4.0
Spain	29.3	51.9	78.2	119.9	125.8	144.9	160.4	189.6	210.4	214.2	211.8	212.2	+ 11.6
Europe[1]	865.2	1,276.9	1,582.7	2,014.9	2,303.6	2,516.5	2,850.7	3,237.7	3,230.9	3,334.2	3,469.3	3,526.7	+ 8.1
Bahrein	-	-	-	-	10.2	62.7	102.6	118.0	116.3	122.1	121.4	122.8	+ 42.7[5]
India	18.2	63.7	96.4	161.1	178.3	179.1	154.3	128.1	166.8	208.5	183.8	205.4	+ 14.4
Iran	-	-	-	-	-	6.5	33.7	49.0	45.5	30.6	21.1	25.5	+ 25.6[5]
Japan	133.2	292.1	379.3	727.3	887.1	1,009.1	1,096.8	1,118.4	1,013.3	919.4	1,188.2	1,057.7	+ 12.2
South Korea	-	-	-	16.8	17.6	15.2	16.6	17.7	17.6	17.6	17.3	[illegible]	+ 0.7[4]
Taiwan	8.3	18.9	15.4	27.0	26.5	32.1	38.1	31.3	28.1	25.5	29.8	49.9	+ 10.5
Turkey	-	-	-	-	-	-	-	1.9	16.5	35.5	47.2	32.0*	- 102.5[7]
Asia[1]	159.7	374.7	491.1	932.8	1,119.7	1,304.7	1,439.1	1,464.4	1,404.4	1,360.2	1,612.9	1,511.0	+ 13.3
Egypt	-	-	-	-	-	-	-	-	2.0	59.0	90.0	100.4	- 268.9[8]
Ghana	-	-	57.5	113.0	111.1	132.8	152.2	157.2	143.2	151.1	154.1	113.5	+ 7.6[3]
Cameroun	43.9	50.5	48.3	52.4	50.7	46.2	44.1	46.8	51.9	48.7	46.2	41.3	- 0.2
Rep. of South Africa	-	-	-	-	29.4	52.9	52.8	75.0	75.9	78.4	78.0	81.1	+ 15.6[5]
Africa	43.9	50.5	98.8	166.4	191.2	231.9	249.1	279.0	273.0	337.2	368.3	336.3	+ 12.0
USA	1,827.5	2,498.8	2,366.8	3,607.1	3,560.9	3,739.8	4,108.7	4,448.4	3,519.0	3,856.8	4,117.5	4,357.9	+ 4.9
Argentina	-	-	-	-	-	-	-	0.7	22.0	43.1	49.9	49.2	+ 189.5[7]
Brasilia	18.2	30.4	29.7	56.1	80.6	97.4	111.7	113.6	121.4	139.2	167.5	186.4	+ 13.8
Canada	691.3	753.4	873.9	962.5	1,002.1	907.1	930.0	1,023.9	878.1	628.1	973.1	1,048.5	+ 2.3
Mexico	-	19.2	21.5	34.0	39.9	39.5	39.2	41.1	39.9	42.4	42.7	43.1	+ 6.4[9]
Surinam	-	3.5	31.1[2]	54.9	54.2	49.5	51.5	57.0	35.0	46.0	56.0	56.9	+ 23.9[9]
Venezuela	-	-	2.4	22.4	22.4	23.0	25.1	41.5	49.7	46.5	43.3	71.1	+ 36.1[3]
America	2,537.0	3,305.3	3,924.4	4,737.0	4,768.1	4,866.3	5,256.2	5,762.2	4,666.1	4,802.1	5,450.1	5,813.1	+ 4.7
Australia	11.8	87.8	92.8	206.6	223.6	205.8	207.2	219.1	214.2	232.3	247.6	263.4	+ 18.8
New Zealand	-	-	-	-	22.4	87.7	116.7	110.3	108.6	139.8	145.1	151.1	+ 31.4[illegible]
Australia and Oceania	11.8	87.8	92.8	206.6	246.0	293.5	323.9	329.4	322.8	372.1	392.7	414.5	+ 21.9
Western Countries	3,617.6	5,096.2	6,159.8	8,055.7	8,620.6	9,202.9	10,129.0	11,096.0	9,896.2	10,206.8	11,293.3	11,601.6	+ 6.7

1) Without Eastern Bloc countries
2) Exports
3) G.R. 1967/78
4) G.R. 1970/78
5) G.R. 1971/78
6) G.R. 1972/78
7) G.R. 1974/78
8) G.R. 1975/78
9) G.R. 1966/78

Source: Metall Statistics 1960 - 1970 and 1968 - 1978, Metallurgic Society, Frankfurt, page 14. PROGNOS Calculations.

2.4 Production of remelt aluminium

(1) Table 6 indicates the production of remelt aluminium in Western countries. Remelt aluminium is composed of new scrap metal stemming from production in remelting plants, from semi-products, from casting, and from processing, as well as from old scrap metal, i.e. aluminium reclaimed from scrapped products.

While the ranking order in absolute figures is the same as that of the production of primary aluminium - with the exception of Canada and Norway - the relation of remelt aluminium production to primary aluminium production shows that most of the European countries and Japan have in the past paid greater attention to this energy-saving reclamation of aluminium than the USA. The average share of remelt production in total melting plant production in the major European countries is around 50 %[1], while in the United States it is only 34 %.

Remelt production has in the past most strongly accelerated in Japan, Brazil, Spain, and Sweden.

Of all the countries with a high share in remelt production, the extension of this branch of the aluminium industry has recently been most effectively promoted in Japan. Other countries which recorded considerable growth - such as Sweden, Spain, and Brazil - are still below the average level of more advanced industrialized countries.

1) With the exception of Norway which has only a comparatively small remelt capacity, owing to the relatively ample availability of hydro-energy.

Table 6: Production of Remelt Aluminium 1960 - 1978

In thousands of metric tons	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	Av.G.R. 60 / 78 (% p.a.)	Percentage of total product. of metallurgic. aluminium
EC	230.5	318.4	353.7	508.9	531.0	576.2	856.2	923.0	796.5	976.5	1,067.5	1,073.2	+ 8.9	-
FRG[1]	135.7	202.9	185.5	258.5	275.7	294.0	328.4	324.1	285.5	344.6	390.1	412.6	+ 6.4	65.8
Belgium-Luxembourg	2.8	3.2	1.5*	2.0	2.2	2.9	7.1	5.9	2.7	2.6	3.6	4.0*	+ 2.0	only US-Prod.
France	44.0	50.2	62.7	87.4	97.0	111.9	123.5	127.7	107.1	143.7	154.3	160.8	+ 7.5	41.1
Italy	42.0	61.0	102.0	154.0	150.0	164.0	192.0	209.0	151.0	190.0	225.0	222.0	+ 9.7	82.0
Netherlands	6.0	1.1	2.0	7.0	8.3	3.4	23.6	31.3	34.3	30.5	40.6	44.0	+ 11.7	17.0
Denmark	3.3	4.5*	7.1	7.3	7.5	9.3	9.1	9.6	8.6	10.8	11.9	10.7	+ 6.8	only US-Prod.
Great Britain	111.4	178.0	178.5	201.4	181.6	184.8	189.3	188.9	176..	206.8	200.8	193.8	+ 3.1	56.0
direct use of scrap	17.2	11.6	14.3	19.6	24.5	31.0	23.2	26.7	31.3	32.5	31.1	29.3	+ 3.0	-
Norway	2.3	3.2	3.4	4.2	4.0	4.4	4.7	4.3	4.0	3.9	4.0	4.0	+ 3.1	0.6
Finland	-	2.2	3.3	3.5	4.3	4.0	4.0	5.3	4.5	6.1	7.4	7.0	+ 9.3[4]	only US-Prod.
Austria[2]	3.0	3.8	6.4	7.2	7.1	6.3	8.6	7.2	6.2	8.5	10.6	9.5	+ 6.6	10.4
Sweden	2.7	10.0	13.0	20.0	20.0	22.0	24.0	24.7	23.0	24.0	24.5	24.6	+ 13.1	30.8
Switzerland	6.6	13.0	13.0	15.0	13.5	13.9	16.6	17.2	15.6	17.8	20.1	17.9	+ 5.7	22.5
Spain	2.6*	12.0	14.3	27.0	29.0	32.9	37.0	46.0	34.5	40.0	40.3	39.1	+ 16.6	10.4
rest of Europe[6]	-	-	-	-	1.2	1.5	1.8	3.6	4.0	17.1	22.0	16.7*	+ 45.7[5]	-
Europe total	378.5	556.6	606.1	814.0	826.7	886.4	992.8	1,031.3	888.4	1,093.9	1,186.4	1,182.0	+ 6.6	33.8
Japan	49.5	123.7	181.2	322.1	349.2	411.0	536.9	517.3	424.0	525.9	574.5	635.6	+ 15.2	60.1
rest of Asia	7.5	15.0*	22.0	22.1	24.2	25.0	34.2	36.6	41.3	35.7	41.0*	39.0*	+ 8.6	-
Asia total	57.0	138.7	203.2	344.2	373.4	436.0	571.1	553.9	465.3	561.6	613.2	674.6	+ 14.7	-
Africa	2.7	5.0*	6.0*	7.0	8.0	8.5	8.6	8.5	10.0	9.8	10.0	11.0	+ 8.1	-
USA[3]	401.4	774.3	821.6	937.1	1,003.0	1,021.6	1,120.4	1,163.0	1,121.3	1,334.5	1,456.0	1,468.5	+ 7.5	33.7
Canada	8.3	21.4	31.2	31.8	33.7	31.6	36.3	29.9	38.9	40.0	45.0	45.0	+ 9.8	4.3
Brasilia	3.0	3.0	3.7	6.0	7.5	13.0	18.5	22.4	20.6	28.4	33.5	35.5	+ 20.9[4]	19.8
rest of America*		4.0	6.0	20.6	21.4	28.0	28.2	33.3	28.8	23.6	20.5	24.0	+ 14.8[4]	-
America	412.7	802.7	862.4	995.5	1,066.4	1,094.3	1,203.4	1,248.6	1,209.6	1,426.5	1,555.0	1,574.0	+ 7.7	-
Australia and Oceania*	4.5	8.0	10.0	18.9	21.0	21.5	30.6	38.4	26.5	34.0	26.4	25.0	+ 10.2	6.2
Western countries	856.4	1,511.0	1,687.7	2,180.6	2,296.4	2,447.6	2,807.4	2,881.7	2,599.8	3,126.6	3,391.0	3,477.6	+ 8.1	-

* Estimate by the Metallurgical Society

1) Including production in West Berlin

2) Only production of remelt aluminium

3) Production volume from domestic and foreign scrap, including direct use of scrap in processing plants

4) G.R. 1965/78

5) G.R. 1971/78

6) Jugoslavia and Portugal

Source: Metal Statistics 1960 - 1970 and 1968 - 1978, Metallurgical Society, Frankfurt 1979, page 18.
PROGNOS calculations

(2) Above all in countries with high aluminium consumption, the volume of old and new metal is rising; the remelt plants processing it are mostly located in the vicinity of processing industries. It is likely that the growing significance of energy saving will force many West European countries as well as the USA and Canada - which so far were among the net exporters of aluminium scrap - to become net importers.

(3) On the ratio yield of old scrap: aluminium end use, unfortunately data exist for only a few countries. According to them. the shares are:

Great Britain	15.2 %
Italy	9.8 %
FRG	9.6 %
France	8.3 %
USA	4.2 %

Apart from the level of per capita aluminium consumption, the yield of old scrap mainly depends on the structure of aluminium consumption. Above all, reclamation of aluminium from garbage is still unsatisfactory which is why in countries with widely spread use of aluminium tins, constant efforts are being made to improve this situation.

3. THE TECHNOLOGY OF ALUMINIUM SUPPLY

(1) Three factors pertaining to the methods used up to now in aluminium production will in the future be subject to increasing restrictions which are, either due to the raw material situation or to social reasons:

1. high demand, mainly for electric power
2. air pollution during the second production stage in the form of fluor vapour emission
3. the fact that bauxite resources are diminishing, though only slowly.

(2) For the production of 1 ton of aluminium, approximately the following amount of energy is needed:

	electric power (kwhr)	thermal and mechan. energy (1000 kcal)
Bauxite extraction, processing and transportation	100	1,000
alumina production	400	4,500
electrolysis	14,000	5,500
founding	100	2,000
Production total	14,600	13,000

For the entire production process up to aluminium semi-products, approximately 14,600 kwhr and 13.0 million kcal of thermal energy are accordingly used - provided the secondary production stage is up-to-date and efficient.

If the requirements of thermal energy would for the sake of comparison also be expressed in terms of electric energy, the equivalent would be approx. 15,100 kwhr. This shows that from the extraction of bauxite to the production of semi-products, nearly 50 % of energy requirements are accounted for by electric power and approx. 68 % of total energy consumption alone are needed for the reduction of alumina to primary aluminium.

It is understandable that at a time of increasing energy scarcity, the aluminium industry is getting under pressure from the government as well as from its own market to reduce the amount of energy used hitherto. The US aluminium industry, for instance, has obligated itself to the Government to reduce power consumption up to 1981 by at least another 10 %. Power consumption for the electrolyses could already be reduced from 25 kwhr to approx. 14 kwhr/kg aluminium during the past 25 years.

(3) In order to lower the high energy consumption in the reduction of Al_2O_3, at best two new procedures can at the present time be regarded as candidates for industrial application:

- the $AlCl_3$ system of Alcoa
- the thermal reduction process according to Toth

The Alcoa system seems to be the furthest developed one. While in principle it is also an electrolytical process, the decomposition does not - as in the Hall-Héroult method - proceed via the fluor-containing cryolite but via coal and chlorine gas to aluminium cloride, which is split into liquid aluminium and chlorine by means of electrolysis.

Although the procedure with the chloride process requires one step more than the Hall-Héroult method, Alcoa claims energy consumption to be only 8.9 kwh/kg[1)]

1) K. Grjotheim, Oslo u.a.: Aluminiumherstellung aus Aluminiumchlorid, a critical comment on the Alcoa and Toth process on ALUMINIUM, 11/1975.

aluminium which would mean energy savings of 25 - 30 % as compared with the latest Hall-Héroult plants. According to the structure of the procedure, this can only be due to the electrolysis unit being a highly concentrated production unit with large production per reactor volume. Further advantages of the process are said to lie in its resistance to power failures and in more flexible operations as well as in the avoidance of nonpersistant fluorides provided the problem of chloridized hydrocarbon can be solved.

Alcoa has set up (1975) and is operating a test plant for this process in Palestine, Texas, with an annual production of 15,000 tons of aluminium.

(4) Information available on the Toth process - which was announced in 1973 by the Applied Aluminium Research Company of New Orleans, Louisiana (USA) - is not as detailed. Here, too, the aluminium is produced through the formation of aluminium chloride, however, not electrolytically but through an indirect carbothermic reduction of aluminium chloride through mangane. Uncertainty still seems to reign as to pollution of the aluminium through mangane and as to the reclamation of mangane and chloride which is necessary for cost reasons. Apart from this, the lower energy consumption - according to the inventor only 5 % of that of the Hall-Héroult process - will be compensated by a much higher consumption of carbon.

Another important advantage of the Toth process - apart from energy saving - seems to be the low requirements as to the purity of the aluminium oxide which would also permit the use of the widely spread kaolins.

A test plant for the Toth process with a projected annual output of approx. 50 tons of aluminium is at present being erected in New Orleans by the development company mentioned above.

(5) The other persistently critical point regarding the Hall-Héroult process which is generally applied today is the formation of fluor water due to the addition of cryolite and the resulting emission of gaseous HF and dust containing fluorides. The US organisation EPA (Ecological Protection Authority) has therefore charged the aluminium melting plants with reducing the content of fluor in the exhaust air before emission from the chimney from 95 to 75 %.

To avoid this air pollution, a dry absorption process has recently been developed in the USA which works by retaining the fluor hydrogen through fluidized alumina. After a certain concentration has been reached, the alumina which contains fluoride can be passed into the electrolysis furnace. This avoids the loss of fluor in the calcium sludge which may occur during wet absorption. This decontamination process is said to have proved its worth-while, on the other hand, it requires considerable standards of construction.

(6) As demonstrated in Chapter 2.1 - bauxite resources can be expected to last as long as approximately to the year 2010, even on the assumption of a market rise in aluminium consumption by for instance 8 % p.a. On the other hand, the growing dependence of aluminium consuming countries on only a few bauxite countries, as well as the uncertainty with regard to the profitability of the bauxite depots which are so far only presumed to exist, makes the question of the decomposition of other aluminium compounds increasingly urgent.

Of the principally applicable process variants - the dry-basic, as well as the dry-acid and wet-acid methods - new decomposition technologies seem very strongly to tend in the direction of the wet-basic method.

At present, for instance, three test plants for the production of alumina are operated in the USA, i.e.

- decomposition of clays and slate using nitric acid

- decomposition of clays and slate using hydrochlorid acid, and
- decomposition of anorthite by means of a calcium-soda sinter technique.

They are joint ventures of the US Bureau of Mines and eight US aluminium concerns.

Up to now, however, the greatest progress with view to industrial materialization of a replacement of the Bayer method used hitherto seems to have been achieved by Péchiney and Alcan with their H+ process. This is a two-phase acid process using concentrated sulfuric acid for a first, still comparatively impure decomposition, followed up by a second phase transforming the obtained aluminium sulfate into aluminium chloride by means of hydrochlorid acid. The next step, re-crystallization, results in a purification of the $AlCl_3$ and the final calcination in the reclamation of the hydrochlorid acid and the formation of aluminium cloride.

The advantage of this process lies in the use of impure aluminium compounds in clays, loams, and natural slate, as long as the impurities in the first line concern the silicate content and to a lesser degree the iron content (10 % maximum) or calcium content (3 % maximum). Anorthite can accordingly not be used.

In spite of the more reasonably priced sulfuric acid, the repeated acid decomposition raises the costs, and Péchiney himself sees the point where this method becomes profitable in comparison with bauxite decomposition according to the Bayer process at the earliest at that moment when the Al_2O_3 content of bauxite is below 40 % and the locations are deep inside unexplored country. Above all the energy costs which are nearly 50 % higher than with the Bayer process (approx. 7 million kcal/t aluminium) have a very negative impact.

4. COST AND PRICE DEVELOPMENT OF ALUMINIUM SUPPLY

(1) Aluminium prices[1] have developed as set out below since 1960, in US cents/lb for 99.5 % aluminium ingots:

1960	1965	1970	1971	1972	1973	1974	1975	1976	1977	1978	av. Gr. 60/78 (% p.a.)
26.0	24.5	28.7	29.0	26.4	25.0	34.1	39.8	44.3	51.3	53.1	+ 4.0

Between 1960 and 1976, aluminium prices accordingly rose less than steel (+100 %) and copper (+85 %). Whether this slight price increase continues to apply in the future as compared with the major substitutes steel, copper, and plastics, seems doubtful, since the industry strongly depends on energy. A comparison of the structure of total costs of the production of primary aluminium which was undertaken at a meeting of the National Association of Recycling Industries early in 1975 in New York indicates the growing weight of energy and capital costs:

	Percentage of total costs[2]	
	1965/69	1975/79
bauxite/alumina	30	30
capital costs	17	27
energy	15	23
wages	35-40	20

1) Annual average figures from the metal statistics (Primary source: E & M/J and Metals Week)

2) Source: Press releases on metal markets, Metallurgical Society, Frankfurt, January 1975

Between 1966 and 1976, capital and energy costs have tripled, bauxite and alumina doubled in price, and wages rose by 50 % in real terms. Outlays for raw materials and energy now account for more than half of the entire production costs. This situation also explains the policy adopted by the aluminium producers during the 1974/75 recession rather to curb the output than to lower prices or build up stocks.

(2) Since the end of 1979, everything seems to indicate that worldwide demand for aluminium will by the early '80s exceed supply. By 1979 in the Western world alone aluminium consumption has risen to 12.4 million tons. In this branch of industry, growth rates which may even reach 6 % are expected for the years to come. Production capacity, on the other hand, has gradually decreased, owing to the consciosly adopted policy of the worlds aluminium producers to throttle production. Accordingly, the growth of production was already below that of consumption in 1979. Due to the enormous rise of investment costs it can at most be expected that the capacity of aluminium melting plants will grow by approx. 1.5 % annually making the price increase of metallurgical aluminium during the first half of the '80s apparently inevitable.

(3) In the past, aluminium prices in the Western world were mainly determined by the North American large conglomerates of Alcoa, Kaiser, Reynolds, and Alcan.

Between scheduled prices and market prices differences of 20 % and more, however, frequently occurred due to granted rebates. Since this phenomenon has been observed especially often in recent years, the possibility of an officially controlled aluminium exchange has been played up again.

This tendency towards a pricing system independent of the 5 or 6 market leaders will in our opinion get stronger with the growing share of the (bauxite and OPEC) developing countries.

(4) Apart from the sources of raw materials, the growing price of fossile energy will also help to strengthen the present structure of energy used in the primary aluminium industry and will grant considerable advantages to the developing countries with regard to location.

Structure of energy sources in the Western primary aluminium industry

Water	53.5 %
Coal	21.0 %
Oil	12.3 %
Natural gas	10.6 %
Nuclear energy	2.3 %
others	0.3 %
	100.0 %

Source: Revue de l'Aluminium, February 1974
State at the time of the survey as per January 1, 1974.

As this listing shows, over 50 % of energy used up to now was in the form of hydroelectric power. The table below, on the other hand, demonstrates that the potential of hydroelectric power in Western Europe and North America has largely been exploited already, taking into account that for ecological reasons the level of utilization can hardly be extended by more than 50 %.

Hydroelectric power potential and present level of utilization

	Total potential[1] (1000 MW)	Developed capacities (1000 MW)	(%)
Africa	437	8	2
Asia (excepting USSR)	684	47	7
South America	288	19	7
Europe (Excepting USSR)	215	104	48
North America	330	90	30

1) referred to annual mean

Source: World Energy Conference 1974

Not only within the sense of a forward intergation - bauxite countries becoming aluminium producers - but also in view of lower production costs, the developing countries will gain more weight within the ranks of the primary aluminium industry[1].

For the reasons outlined above, a marked shift of supply in the direction of the developing countries will take place within the period under survey. The offer of primary aluminium coming from the industrialized countries will be exposed to heavy price competition. Accordingly, seen in the long run, the price growth which accelerated towards the end of the '70s can rather be expected to decrease.

1) Only for the sake of completion, the 1.2 million tons of projected smelting plant capacity of the Arab countries ought to be mentioned in this context:

Country	Annual melting plant capacity in tons
Abu Dhabi	150,000
Algeria	150,000
Iran	300,000
Iraq	150,000
Kuweit	150,000
Saudi Arabia	300,000

Source: Aluminium 4/75.

5. THE DEVELOPMENT OF FINAL CONSUMPTION OF ALUMINIUM

5.1 Branches of industry and countries under survey

(1) This chapter represents the main part of the study, focussing on the development of the final consumption of aluminium, i.e. the demand by selected economic sectors and countries.

The following sectors have been identified as predominant for ultimate consumption of aluminium:

- transport
- construction
- manufacture of packaging material
- machine building industry
- manufacture of apparatus
- electrical engineering

(2) The analyses and forecasts by economic sectors are presented in two parts. The first part provides a quantitative background, analysing the development of the individual sectors and their sub-groups, according to available data series. The shares of castings and semiproducts in total demand are calculated and commented on in this part, as well as the main elements of demand in the past. The forecasts of aluminium consumption are based on demographic and economic indicators which are forecast and published in the annual 'PROGNOS euro-report': preceding regression analyses showed a significant relationship between the long term trend of GDP (GNP) and the total con-

sumption of aluminium (cf. Table 7 and diagrams 8 and 9).

In the second, qualitative part the information gained from interviews with experts is evaluated to show the qualitative trends within the particular economic sectors and specific characteristics in the different countries.

(3) The original emphasis was on investigating aluminium consumption in the following industrialized countries:

- European Community (FRG, France, Great Britain, Italy, Netherlands, Belgium/Luxemburg, Denmark)
- Spain
- USA
- Japan

and in the following developing countries:

- Brazil
- Iran
- Turkey

Denmark is the only European country for which no forecast was made due to the lack of statistical data. Alumnior is the sole producer of aluminium in Denmark, and a publication of production figures would allow direct conclusions as to its business situation.

Concerning Non-European countries, we received information[1)] only from Brazil, whose Aluminium Association sent data for the year 1972. We attempted to forecast the future aluminium demand by relating to the overall economic development.

1) According to several interview partners, even this information has to be interpreted with caution.

The least information could be gained from Turkey, where neither structural data on total aluminium consumption nor time series existed to forecast the sectoral economic development (data only in Tables I - III).

For Iran, statistics on aluminium consumption do not yet exist; the magnitude of future demand is to be related to the aluminium-consuming branches of industry and to the past total aluminium consumption. It is questionable however as to whether a relation to demand is important for these countries (Iran and Turkey - cf. Chapter 6), because - at least according to our interview partners - this can not be considered as a limiting factor for business growth.

Table 7: GNP-development and consumption of aluminium in the United States and the FRG

	USA							FRG						
Year	GNP (nom.) (current prices) US $ billions	GNP (nom.) (at 1970 prices) US $ billions	aluminium consumption[3] (1000 kg)	Population (mill.)	per capita GNP (current prices) US $	per capita aluminium consumption (kg)	ε aluminium consumption / GNP	GNP (nom.) DM billions	aluminium consumption (1000 kg)	population (mill.)	per capita GNP (nom.) US $	per capita aluminium consumption (kg)	GNP (nom.) (at 1970 prices) DM billions	ε aluminium consumption / GNP
1954	363.1	526.0[1]	1.524,900	163.0	2,228	9.4		168.6[2]	190,600	51.9	729	3.7	260.0[2]	
1955	398.0	578.4[1]	1.886,600	165.9	2,399	11.4	2.379	181.4[2]	230,300	52.4	821	4.4	291.3[2]	1.736
1956	419.2	600.0[1]	1.917,600	168.9	2,482	11.4	0.440	200.5[2]	231,800	53.0	900	4.4	312.5[2]	0.089
1957	441.1	611.9[1]	1.642,600	172.0	2,565	9.6	-7.236	218.5[2]	239,600	53.7	968	4.5	330.2[2]	0.593
1958	447.3	604.5	1.596,700	174.9	2,558	9.1	2.300	234.3[2]	251,900	54.3	1,033	4.6	342.5[2]	1.378
1959	483.7	643.1	2.171,800	177.8	2,721	12.2	5.633	254.9[2]	290,400	54.9	1,113	5.3	367.5[2]	2.095
1960	503.7	659.1	1.838,300	180.7	2,788	10.2	-6.192	302.3	361,000	55.4	1,309	6.5	425.3	1.547
1961	520.1	671.3	2.087,000	183.7	2,831	11.4	6.945	332.6	352,300	56.2	1,480	6.3	448.3	-0.445
1962	560.3	716.0	2.430,900	186.5	3,004	13.0	2.613	360.1	356,200	56.8	1,586	6.3	466.3	0.276
1963	590.5	744.6	2.679,700	189.2	3,121	14.2	2.557	384.0	366,300	57.4	1,583	6.4	482.4	0.823
19[illegible]	632.4	785.3	2.988,700	191.9	2,396	15.6	2.111	420.9	449,500	58.0	1,824	7.8	514.5	6.823
1965	684.9	834.9	3.436,600	194.3	3,525	17.7	2.373	460.4	474,000	58.6	1,961	8.1	543.3	0.873
1966	749.9	889.4	3.831,700	196.6	3,814	19.5	1.763	490.7	484,300	59.1	2,065	8.2	559.1	0.747
1967	793.9	912.5	3.760,100	198.7	3,996	18.9	-0.719	495.5	447,900	59.3	2,092	7.6	558.0	36.135
1968	864.2	954.9	4.233,600	200.7	4,306	21.1	2.708	540.0	575,400	59.5	2,252	9.7	590.7	3.893
1969	930.3	980.6	4.450,100	202.7	4,590	22.0	1.902	605.2	682,500	60.1	2,532	11.4	648.0	2.259
1970	976.4	976.4	4.059,000	204.9	4,765	19.8	20.583	685.6	700,600	60.7	3,063	11.5	685.6	0.458
1971	1,050.4	1,008.6	4.461,600	207.0	5,074	21.6	3.011	761.9	720,200	61.3	3,537	11.7	706.1	0.937
1972	1,158.0	1,071.0	5.179,100	208.8	5,546	24.8	2.706	826.0	757,300	61.7	4,203	12.3	726.3	1.000
1973	1,294.9	1,134.1	6.235,600	210.4	6,154	29.6	3.462	918.6	855,800	62.0	5,548	13.8	761.8	2.661
1974	1,397.4	1,109.8	5.750,300	211.9	6,595	27.1	3.632	987.1	811,500	62.1	6,137	13.1	766.0	-9.389
1975	1,526.5	1,100.3	4.132,300	213.5	7,149	19.4	32.871	1,031.8	718,400	61.8	6,782	11.6	750.1	5.627
1976	1,695.0	1,161.0	5.402,800	214.6	7,897	25.2	5.573	1,126.6	898,000	61.5	7,264	14.6	791.7	4.600
1977	1,878.8	1,216.3	5.728,500	216.8	8,665	26.4	1.266	1,198.5	881,600	61.4	8,408	14.4	813.8	-0.658
1978	2,098.7	1,264.9	-	217.9	9,631	-	-	1,284.1	903,100	61.3	10,423	14.7	838.8	0.798

1) Estimates based on the 'Index of Consumer Prices', International Financial Statistics, Washington 1972

2) Saarland and Berlin not included

3) 1954 - 1959: estimated values

Sources: PROGNOS euro-report 80
OECD, Metal Statistic

Diagram 6: <u>Development of Σ aluminium consumption/GNP in the FRG 1955 - 1978</u>

average Σ (excluding 1967): 1.3

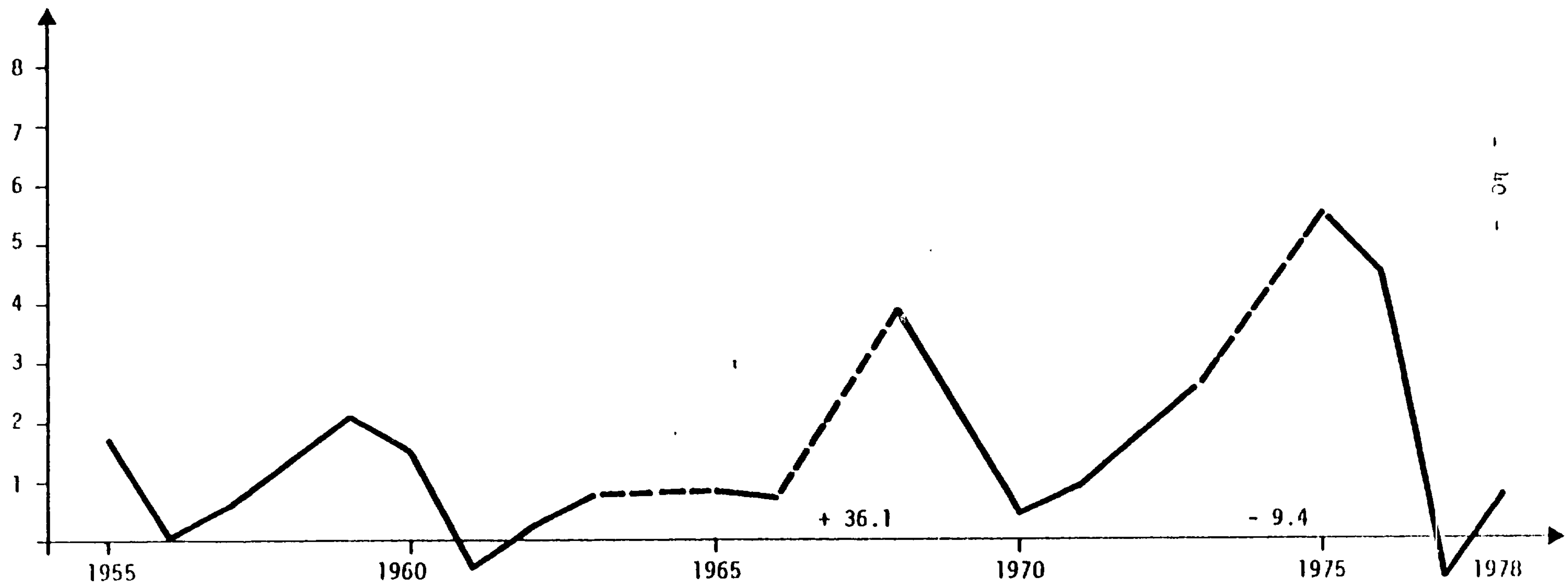
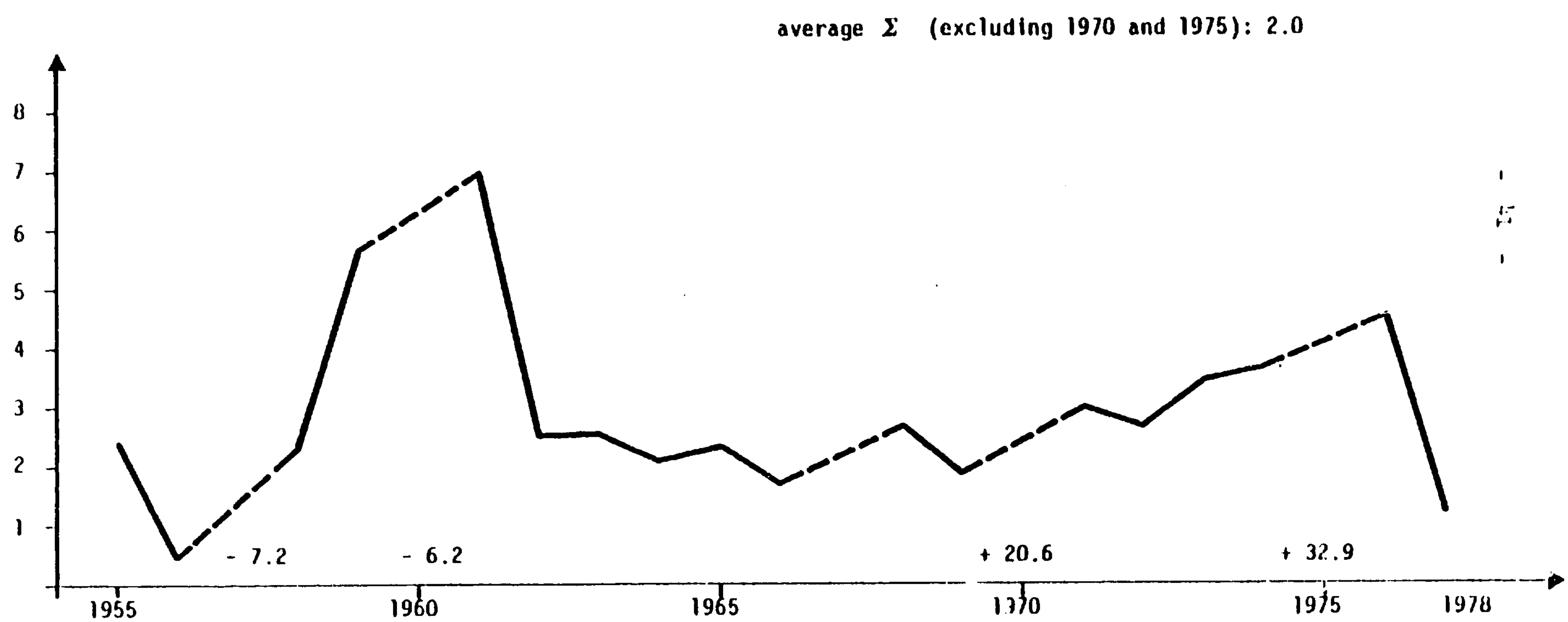


Diagram 9: Development of Σ aluminium consumption/GNP in the United States 1955 - 1978



5.2 Aluminium consumption in the transport sector

A. Analysis of recent trends and quantitative basic forecast

(1) Depending on the importance of the manufacture of motor vehicles in each individual country, between 5 % and 35 % of total aluminium consumption is concentrated on this economic sector. The major part (from 75 % to over 90 %) of total consumption is used for castings (see Table 10); semiproducts, i.e. rolled products and profiles, at the most amount to a share of 22 % of total aluminium consumption in the transport sector (FRG).

(2) The most important products in the transport sector that are produced partly or completely out of aluminium, are:

- passenger cars
- freight cars for various usage
- buses
- caravans
- military motor vehicles
- aircraft
- ships

(3) A trend analysis for recent years shows that in all European countries with a marked production of passenger cars - except in the United Kingdon -, the rate of increase in aluminium consumption has been below the overall sectoral development.

We could verify this fact by constructing a model for the FRG. In this country, the specific input of aluminium per unit (passenger car) dropped from 26 kg to 21 kg between the years 1968 and 1973. In 1974, the input raised

Table 10: Production of cast aluminium: transport sector (1000 tons)

	1969	1970	1971	1972	1973	1974	av. GR 69/74 (annual perc.)
FRG	129.9	143.8	139.4	148.8	154.9	134.7	0.7
France	94.1	101.7	110.2	121.0	131.8	126.7	6.1
Great Britain	76.1	74.6	75.0	77.1	85.2	76.8	0.2
Italy	77.5	95.3	99.3	112.0	140.0	129.7	10.8
USA	302.7	276.9	290.5	356.9	373.2	315.2	0.8
Japan	-	-	237.5	261.1	288.8	278.4	-
	Cast aluminium production: percentage share of total aluminium consumption						
FRG	14.8	16.3	15.2	15.3	13.6	11.8	
France	20.6	20.7	23.2	23.7	22.5	21.2	
Great Britain	12.8	12.4	14.6	12.7	12.4	11.3	
Italy	20.3	22.7	24.7	18.4	20.4	19.1	
USA	6.3	6.3	5.9	6.7	6.0	5.1	
Japan	-	-	21.1	17.2	15.3	17.6	

Sources: Organisation of European Aluminium Smelters
Metal Statistics
PROGNOS calculations

above 21 kg again for the first time.

A comparison of the different countries investigated showed the following results, allowing for biases due to lack of comparable data:

- in the US and Japan, the specific aluminium consumption has increased already in the past: according to American studies[1] from 28 kg on the average in 1965 to 38 kg in 1974[2];

- also in European countries there were specific divergencies: highest was the Italian car production with 28 kg per vehicle in 1974, lowest was the United Kingdom with approximately 16 kg in 1974;

- also between different brands and even between models within the same series (i.e. not taking into account special vehicles) divergencies of up to 300 % were registered.

Summing up it can be stated - what has also been confirmed in our interviews - that, at least within the private motor vehicle sector attempts have been made by individual producers to raise the aluminium content; a comprehensive survey for Europe on the other hand shows, that less rather than more aluminium has been used since 1970.

Detailed statistical data concerning the aluminium input in other transport vehicle types are not available, yet from a collection of indices it can be stated that for

- trucks
- buses
- caravans
- rolling stock

more aluminium has been used than in previous years: the share of semiproducts

1) Estimates by Kidder, Peabody & Co. Inc.

2) In Japan, the average aluminium input per passenger car was 29.5 kg.

Table 11: FRG: Manufacture of aluminium semiproducts in the transport sector, 1968 - 1975

	Rolled products tons		Rods tons		Profiles tons		Tubes tons		Wires tons		Pressed and forged parts tons		Conducting material tons	av.GR 68/75 (ann. perc.)	Market share of total in %			
															- 5%	5% 10%	10% 20%	+ 20%
Rolling stock	40.3	23.9	4.3	0.9	60.9	69.9	1.8	3.6	0.2	0.1	2.5	1.6	-	+5.1		x		
Passenger cars and station wagons	43.5	46.7	2.6	1.7	39.2	37.7	8.3	4.1	0.0	0.0	6.4	9.8	-	-4.0				x
Commercial vehicles	54.1	31.8	2.3	0.5	38.9	63.3	2.1	0.5	0.1	-	2.6	3.8	-	+6.4				x
Caravans	57.8	69.4	2.1	-	34.6	29.7	2.6	0.9	0.5	-	2.5	-	-	+11.9		x		
Military vehicles	11.8	16.1	1.5	0.4	20.7	22.0	13.6	6.6	-	-	52.4	54.9	-	+17.7	x			
Bicycles and motorcycles	18.4	10.3	22.7	25.5	36.5	21.3	0.6	0.6	16.5	34.0	5.3	8.2	-	-6.7	x			
Other road vehicles	63.7	19.6	7.2	1.1	27.3	74.9	1.5	4.3	0.2	0.1	0.1	-	-	-8.5	x			
Other accessories, single and spare parts	46.1	44.0	9.3	9.0	19.8	26.9	0.6	8.9	0.0	-	24.3	11.2	-	-4.8	x			
Road vehicles total	45.6	40.0	4.1	2.1	36.9	44.8	5.7	2.9	0.9	1.1	6.9	9.3	-	0.0				x
Water vehicles	55.1	62.2	3.3	3.0	34.8	27.2	3.0	5.6	0.6	0.4	3.6	1.6	-	-2.6	x			
Air and space craft	65.7	58.0	6.9	5.2	16.5	17.3	2.1	2.6	0.0	-	8.7	17.0	-	-2.7	x			
Containers (above 3 m^3)	19.2	7.7	0.8	2.2	79.6	89.0	-	-	-	-	0.4	1.1	-	-7.8	x			
Other transport vehicles	88.2	86.9	3.7	1.4	2.7	6.1	3.0	4.8	2.1	0.8	0.3	0.1	-	+4.9	x			
total	47.5	41.7	4.1	2.1	38.3	44.0	5.1	3.1	0.8	0.9	6.2	8.2	-	+0.2				

Sources: 'Aluminiumhalbzeugverband', Düsseldorf
PROGNOS calculations

for the vehicles has risen continuously since 1968 in the FRG (cf. Table II). The countries in Western Europe which are not producing passenger cars have a higher growth rate of aluminium consumption in the transport sector; finally, the trend to increased aluminium usage was confirmed by our interview partners, above all for specialized commercial vehicles (tank trucks, dump trucks, furniture removal vans) and rolling stock.

(4) In the case of the transport sector, we considered not only, as usually done, the real sector development as main determinant, but in addition the foreseeable development of the specific aluminium input. Starting with the functional relationship between the real development of the value of production and total aluminium consumption, i.e.[1)]

$$PV = PQ \, . \, P/U \qquad PQ = \frac{PV}{P/U}$$

$$AI = PQ \, . \, AI/U \qquad PQ = \frac{AI}{AI/U}$$

we come to the following correlation

$$\frac{PV}{AI} = \frac{P/U}{AI/U}$$

$$AI = PV \, . \, \frac{AI/U}{P/U}$$

$$AI = \frac{PV}{P/U} \, . \, AI/U$$

As the forecast of the value of production of transport vehicles is made on the basis of comparable prices, aluminium consumption can be directly derived from the development of the real sector value and the expected increase of aluminium consumption.

---

1) PV = value of production PQ = quantity of production
P/U = price per unit AI/U = aluminium input per unit

A study carried out in 1974 by the American motor car ancillary industry in the form of a Delphi-analysis with experts from industry, universities and state authorities[1)] stated that by 1990 the percentage of aluminium parts in a car would rise from 2.1 % to approximately 7.5 %.

Taking into account the average car weight, we forecast an average annual growth rate of aluminium input of 6.6 % until 1990 for American and of 5.5 % for European and Japanese passenger cars[2)].

According to the findings of our interviews, a future growth of aluminium consumption similar to that of passenger cars can be expected for non-American commercial vehicles. As the two groups together represent 80 - 85 % of total aluminium consumption in the transport sector and as the other 15 - 20 % cannot be analyzed due to lack of statistical data, we continued to use the two influential factors 'real growth of production of the overall transport sector' and 'development of specific aluminium input for passenger cars' in the first approach to the forecasting model.

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1) T.R. Funke, 'Hochbeanspruchte Aluminium-Schmiedestücke im Fahrwerk' paper presented at The International Symposium 'Aluminium and cars' Dusseldorf, March 1976.

2) Leaving aside the effect of the development of the real value of production and the effect of the specific aluminium input, total aluminium consumption can further be influenced by a quality effect which is embedded in the P/U-ratio (e.g. overproportionate rise of the selling-price in relation to the input costs, due to an increasing quality of the car which due to environmental protection impositions). Substantiated estimations which consider a price increase due only to qualitative reasons as an autonomous development were not possible to consider within the given limits of this study, but could be the subject of a more detailed analysis. On the other hand, the data for the past development of the price effect generated by statistical-mathematical methods, differ significantly from each other and can therefore only be considered as approximative values. Based on these calculations we estimated an annual 2 % quality-stipulated price increase to discount for the aluminium consumption, according to the above mentioned functional relationship.

(5) The country-to-country comparison in Table 12 shows, that until 1990 the highest growth in aluminium consumption will be likely in Spain and Japan. Despite an overproportionate material substitution - in comparison to other countries under survey - necessitated by the great weight of the passenger cars, the 7.7 % increase in the U.S. is only ranking fifth. This is due to the fact that the sectoral development is only slightly positive (cf. Table I in the appendix), and as the aluminium penetration into other segments of the transport sector - above all in commercial vehicle construction - is already much further advanced than in other countries under survey.

B. Evaluation of interviews

Passenger cars

(1) In passenger car construction aluminium can be utilized for the following parts:

1. Engine with auxiliary units
2. under-frame
3. automobile body
4. electrical equipment
5. wheels

Ad 1.

Although the three motor companies Peugeot - Renault - Volvo have in a joint venture developed an apparently satisfactory pure aluminium engine, the majority of our interview partners expect only a gradual change to aluminium because of the existing gray iron production capacities. In the first case it is the high investment costs and the risk involved in the change of production, that in the commercial vehicle industry present substantial handi-

Table 12: Final aluminium consumption: Transport sector (1000 tons)

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av.GR 60/78 ann. perc.	av.GR 78/90 ann. perc.
FRG	97.7	141.8	113.9	191.6	184.0	187.6	208.0	174.4	171.0	220.2	242.0	255.9	300.1	375.8	470.5	5.5	5.2
France	67.3	93.1	102.6	144.9	145.0	163.3	156.5	154.0	138.2	172.8	174.0	182.6	221.7	306.7	422.2	5.7	7.2
Great Britain	111.4	121.6	124.4	134.0	127.8	131.8	158.2	143.7	117.2	123.7	115.0	103.6	122.2	134.2	147.5	-0.4	3.0
Italy	57.0	75.0	114.0	140.0	138.0	145.0	133.6	145.3	112.6	150.2	168.4	177.0	210.7	324.2	496.5	6.5	9.0
Netherlands	2.5	5.5	5.0	7.0	7.5	(7.8)*	(7.7)*	-	-	-	-	-	-	-	-	-	-
Belgium	1.2	2.4	1.9	2.9	3.1	3.1	3.8	4.3	1.7	2.6	2.7	2.4	2.8	4.0	5.9	3.8	7.8
Denmark	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spain	-	-	-	38.0	38.5	48.8	57.9	62.1	55.8	61.6	65.3	63.4	82.3	143.0	247.6	6.6 1)	12.0
USA	-	848.2	046.9	734.3	867.3	1,066.4	1,356.3	1,169.4	816.5	1,163.0	1,349.0	-	2,019.7	2,953.9	3,525.3	3.9 2)	7.7 4)
Japan	-	86.1	104.7	256.6	269.7	309.9	344.1	325.1	312.8	370.9	413.2	462.4	563.5	958.1	1,585.7	15.0 3)	10.8
Brazil	-	-	-	-	-	27.4	-	41.2	-	-	-	-	-	-	-	-	-

1) GR 1970/78
2) GR 1965/77
3) GR 1965/78
4) GR 1977/90

* calculated values in parenthesis

Sources: Metal Statistics
European Aluminium Statistics
Anuario Estatistico da Associaçao Brasileira do Aluminio
PROGNOS calculations

caps to a speedy change. Many of the present engine block series have a service life of 20 or more years and can also by negligible variations be adapted to new specifications. Although by die-casting - above a production quantity of approximately 100,000 - possibilities of rationalisation against traditional methods exist, the P-R-V group - because of the higher material prices - always ended up -2 % higher than those of a comparable gray iron engine. Another disadvantage of the aluminium engine was the higher noise intensity, that made additional soundproofing elements necessary. Contrary to the U.S.A., many European and Japanese cars had already used cylinder-heads and cylinder-head covers made of aluminium because of their better performance. An extension of this trend is generally expected.

Under the motto 'use of aluminium whenever suitable as substitute material' the development of aluminium radiators is viewed very optimistically, as its price is not expected to rise as much as that of copper, and an aluminium radiator is approximately 50 % lighter than a copper one. Previous difficulties with joints (welding, glueing) can, in the opinion of our interview partners, be eliminated. In addition to this, the production costs of an aluminium radiator - primarily the pipes - are still higher today than those of conventional radiators. Other auxiliary units, such as heat exchangers and oil coolers are also regarded as future aluminium products. On the other hand, it must be taken into consideration that certain less stress bearing parts, such as the waterpump will in the future be manufactured from synthetic materials and not from aluminium.

Ad 2.

The usage of aluminium for the under-frame is very convenient: its advantages over the use of gray iron are clearly demonstrated by the anticorrosion requirements, the relatively high weight of the latter and the lower investment risk as compared to the engine block. In advanced car models of today gear covers, cardan gear housings, stearing-gear boxes, clutch housings and transverse tractions are all manufactured from die-cast aluminium, as are, in the most ordinary car, at least the acessory covers and relatively small parts such as brake-shoe holders. According to our information it seems therefore that the second most essential new application area of aluminium in future cars - after the aluminium radiator will be the under-frame.

Ad 3.

While the weight factor is of great interest for the automobile body the use of aluminium is rather problematic in this sector. It is well known that General Motors in their 'Vega' model had constructed parts of the automobile body of aluminium: it seemed not to be a satisfactory solution, due to the high 40 % part rejects rate and a 20 % share of production usable only after touching up - not to mention the necessary cost comparison. The specific disadvantages of the forgeable alloys that can be used for parts of the automobile body are listed below:

- deformability
- limited strength (in many parts the necessary strength can be introduced only by subsiduary strengthening or by the use of a 40 % stronger aluminium plate)
- the technical problems of jointing (e.g. three times more energy input is necessary than in steel plate welding, repeated examination of the electrodes, material distortion in mixed steel-aluminium structures, less tolerance than with steel sheets for the same part reject rate).

The aluminium industry appears to be aware of these deficiencies and serious efforts are being made to improve the material prerequisites in this sector by new developments (Péchiney - alloy $Al-Cu_2-Mg-Si$ as standard business classification CP 485, two new Alcoa-forgeable alloys for application in automobile body construction). Now General Motos and Ford also want, as Citroen, for their expensive models (Cadillac, Lincoln) to use aluminium for the roof, motor hood and for the engine and trunk area.

Ad 4.

Comparable to the aluminium radiator the electrical layout is an application area that derived directly from the features of aluminium, viz. its relatively low price and its relatively good conductivity. It was seen by most interview partners as a growth area in car production. With the substitution of copper conducting materials through aluminium, a 25 % - 50 % excess demand in space and iron weight ensues, if the same performance is to be achieved. More problems occur because of the non-conductivity of the oxide layer with electrical connections. For this reason no screw or clip connections, but upset- or lap weldings with fluxing agent or Cu-network are used. Eventually aluminium windings are also used in engine starters. Considering the technological and economic incentives, the manufacturing companies (Bosch) expect that the previously small power units to 0.8 kW can be further developed in the years to come.

Ad 5.

More for the sake of fashion than is economically justifiable, the number of passenger cars with aluminium rims has risen considerably in recent years. A further increase - at least in the short term - should be reckoned with.

Our interview partners had divergent opinion concerning aluminium-made shock absorbers. Although some models - in Europe upon request - are equipped with aluminium shock absorbers, the majority of the experts believe that synthetic materials have better prospects.

Door-, window- and chassis edgings, today predominantly made of aluminium, will, in the view of our interview partners, also be lost to synthetics as substitute materials.

Commercial vehicles

(2) The aluminium input for commercial vehicles differs from one country

to the other, almost as it differs for passenger cars by model, product and country.

The highest percentage of aluminium input can be found in the United States, where 20,000 commercial vehicles out of 2.8 mill. produced in 1974 have already been equipped with aluminium chassis, and approximately 60,000 to 70,000 driver's cabs out of 140,000 commercial vehicles with a total weight of 15 tons have been equipped with aluminium. In addition, aluminium is used in the U.S. as raw material for forged rims for commercial vehicles and, to a major extent, for tail boards and custom-built bodies.

According to the information we received, in this area of the transport sector efforts made by industry and government are also increased to save energy by reduction of weight. Hence, a more widespread use of aluminium expecially as chassis-material seems to be essentially a question of the development of the costs of aluminium in relation to the price of energy.

In Europe, the commercial vehicles in Switzerland, Sweden, and in the U.K. have the highest share of aluminium. Custom-built bodies for tank lorries, tipping trucks, refrigerator trucks, tractor trucks for different use and the sides of the tail board are predomenantly made of aluminium. On the other hand still little use is yet made of aluminium for driver's cabs, chassis and rims.

For custom-built superstructure a further increase of aluminium input is not expected, due to the already high percentage of market penetration; but Péchiney and Alusuisse[1)] are at present making strong efforts to introduce aluminium into serial production of commercial vehicles. But according to information given by commercial vehicle producers, any substantial progress, i.e. use of aluminium for cab or chassis, can not be expected because the

1) e.g. production of an all-aluminium-commercial vehicle at the commercial vehicle exhibition in Geneve 1974.

cost difference to steel sheets and steel-supports is still too large.

In addition, several leading commercial vehicle producers have recently invested in installations for the production of steel driver's cabs, which means a commitment for approximately 10 years. We discovered that in this respect no fundamental disagreement exists among the producers, because our interview partner of MAN has a joint marketing organization together with SAVIEM and thus was also informed about the activities of the 'Club of the Four' (DAF, Volvo, Saviem, KHD).

New possibilities of an input of aluminium can be seen and are increasingly realized in the sector of loading ramps, due to a steady price increase of the Brazilian pine which is used for platforms (including trailers), and for compressed air containers because these are particularly affected by corrosion; this latter possibility is nevertheless still in an experimental stage.

For the rest, there is already a larger amount of die cast parts in use, for commercial vehicles as well as for passenger cars, like oil sump, clutch housing, flywheel housing, cover plate of the rear-axle, switch cover for gear and lever support, to name the most important.

An introduction of chop-forged rims failed until now due to the costs that amount to more than 200 percent of the price of steel rims.

The situation in Europe is thus largely different from that in the United States, where aluminium made frames, driver's cabs and rims are already partly in use. This difference can be explained by the different mentality of processing (argular driver's cabs of the U.S. commercial vehicles with rivetted joints) as well as by the comparatively stronger position of the U. S. aluminium industry.

Other vehicles for road transport

(3) There is a trend towards a more intense use of aluminium not only for passenger cars and commercial vehicles, but also for motorcycles and bicycles. Concerning this market we were, in particular, informed that tubular frames could be made in the future of aluminium instead of steel and - especially for motorcycles - the traditional spoke rims could be replaced by aluminium rims.

Finally, the so-called 'motor-homes'[1] in the U.S. play an important role in the aluminium consumption within the group of vehicles for road transport, because the application of aluminium die cast and profiles reduces the average weight from the 6 to 7 t standard to 5 t. Outside the United States, these 'motor homes' are at best comparable to caravans (but without an engine). In spite of astonishing growth rates in the past, they play a comparatively negligible role.

Rolling stock

(4) According to Table 11, between 1968 and 1975 less than 10 % of total aluminium consumption in the transport sector accounted for by rolling stock in the FRG; on the other hand, aluminium producers consider this area as a typical growth sector.

Because of its low weight, aluminium is perfectly qualified for the body and underframe of local traffic and express trains. The use of aluminium reduces the weight of an underground - or suburban train carriage by 30 % to 40 %.

As the costs of the material only amount to a very small share of the total costs of a carriage, its costs increase only by 3 %, although aluminium

1) not to be confounded with 'mobile homes' (see 5.3)

is three times as expensive as sheet steel, and about 40 % below the price of stainless steel. The reduction of weight results in lower energy consumption for the frequent acceleration and braking, which more than compensates the higher costs of suburban trains. For this reason the aluminium alloys 7020 and 6061 have been used for the recent extension and replacement of wagon fleets for suburban trains. To achieve a reduction in welded and riveted joints, carriage construction has increasingly used large profiles. Having at its disposal the capacities to produce these large sections, the Swiss company Alusuisse suceeded in obtaining the order from the Metro Company in Paris to deliver new carrage units.

The use of aluminium in the construction of express train carriages has the advantage that the loading weight on the roadbed caused by high speed, can be reduced more than by the use of steel sheets.

In addition to all-aluminium carriages for passenger traffic, which turned out a success in practically all industrialised countries, Switzerland and the USA also have all-aluminium freight cars. By improving the jointing techniques, by the application of large extruded sections in the sides, a reduction of the great variety of extruded sections and prefabrication of larger car body elements, some progress in fulfilling operating requirements towards a reduction of the price differential against steel versions have already been achieved. Nevertheless, in the conviction of the user, yet further progress must be made.

The application of aluminium constructions also benefits from the trend to special goods wagons (cf. the use of aluminium for bulk material wagons in the USA).

Finally, the trend which is already noticeable in several European countries towards inside fittings of aluminium for the wagons will accelerate.

1) Compare Revue de l'Aluminium, 3/75.

Shipbuilding

(5) The shipbuilding market can be divided into:

1. Private boats, mostly of small to average size
2. Commercial boats for various purposes.

Ad 1.

In small to average sized private boats the application of aluminium is limited to the superstructure. The hull is produced predominantly of synthetics, reinforced by fibreglass.

In addition, there has recently been a growing supply of boat engines - petrol and expecially diesel - made of die-cast aluminium. Their previous problems concerning power delivery, can almost certainly be surmounted.

Ad 2.

An especially interesting new field of application for aluminium has emerged in the growing number of tankers for liquified natural gas. The majority of these newly introduced tankers is fitted out with the Moss-Rosenberg spherical tank system and has an average aluminium input of 60 t - 100 t/1000 m^3, i.e. a tanker of a totally conventional volumetric capacity of 125,000 m^3 of natural gas, already requires about 10,000 t of aluminium sheets.

Aircraft construction

(6) In aircraft construction, aluminium is already the material most used (85 %). Aluminium producers therefore do not expect any acceleration in this sector. It is, on the contrary, possible that parts of the present aluminium application, as for example interior fittings, will possibly be ceded to synthetic materials. A further though at present not very probable development in this direction in the near future - would be the substitution of aluminium

outer sheets through Titan[1]. This would be the case if more supersonic aircraft were introduced into the commercial sector.

A possibility to sell more aluminium in this sector at least in Europe, could ensue from the success of the current efforts of West European aircraft manufacturers (Airbus A 3000, multipurpose combat aircraft etc.) to gain a larger share of the world market.

The alloys needed for such purposes represent a highly developed technology making sales highly profitable. On the other hand, it should be taken into account that Alcoa, as the main supplier to the American companies of Boeing, Douglas and Lockheed, occupies a very strong position in this sector and therefore is ready to market this know-how with the European aircraft manufacturers.

C. Summary of the findings

As a result of the quantitative analysis and of the information gained from our interviews concerning future aluminium consumption in the transport sector, we can state the following:

(1) Examination by sector

- With an average - unweighted - 8.2 % annual growth of consumption the transport sector (together with electrical engineering[2]) leads all the other substantial consumer sectors.
- The strong increase in aluminium consumption is predominantly caused by the expectation of an average rise in specific aluminium input per passenger car of 5.5 % in Western Europe and Japan and 6.6 % in the USA.

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1) Compare, however, as new development the so-called 'Saphibres', an aluminium oxide fibre with 1,800° C heat resistance, produced by Alcoa.

2) cf. Chapter 5.7

- The largest increase will be accounted by die-cast aluminium (underframe, engine parts in passenger and commercial cars, axle-tree bed bolsters for rolling stock, motorcycle frames); in addition there is also an increasing demand for sections (superstructure trucks and railroad wagons) rolled products (driver's cabs for trucks, plates for liquified natural gas tankers) and - for the time being only in the higher classes of vehicles - parts of the automobile body for passenger cars and forged products (rims for road vehicles and motorcycles).

- Conducting material will experience the strongest proportionate increase, while only slightly rising by volume.

(2) Examination by country

- The strongest growth of aluminium consumption in the transport sector is expected for Brazil, Spain, Japan and the USA, as -

  . in Brazil there is an expected 7.7 % growth of the overall economy, it is a very large country and one of the actual economic priorities is given to the development of a transport system; moreover the Brazilian car industry has at present secured a 3.8 % share of the gross domestic product, the highest share of any country we examined;

  . Spain with an expected sector growth of 6.6 % lies far above the average of West European countries;

  . Japan has still - despite an already highly developed car manufacturing industry - a very high 6 % annual growth potential of the overall economy - compared to other industrialized countries - and will in the future be in a position to exploit export markets more easily than the West European countries or the USA;

. The USA will, despite a very low annual sector growth of only 2.4 % until 1990, achieve a relatively high rise in aluminium consumption of the transport sector, as the legal standards to reduce gasoline consumption of passenger vehicles, together with the simultaneous weight increase due to safety and environmental precautions, can only be satisfied by a very consistent weight reduction in all other vehicle parts.

Table 13: Products with growing aluminium use in the transport sector

	EC - countries	Spain	USA	Japan	developing countries
Passenger cars					
- engine parts (C)	1976: P 1985: I	1976: P 1985: I	1976: - 80:P 85:I	1976: P 1985: I	1985: I
- radiators (M)	1976: A 1980: F	ref. EC	ref. EC	ref. EC	ref. EC
- under-frame parts (C)	1976: P 1980: I	ref. EC	ref. EC	ref. EC	ref. EC
- automobile bodies (F)	1976: - 1980/85: P	ref. EC	ref. EC	ref. EC	ref. EC
- electrical system (CM)	ref. USA	ref. USA	from 1977: B 80/85: I/B	ref. USA	ref. USA
Commercial vehicles					
- bodies (F/M)	1976-1990: P	ref. EC	ref. EC.	ref. EC	ref. EC
- tail boards (F/M)	1976: F 1980: I	1976: - 1980: I	1976: P 1980: I	1980: I	-
- under-frame parts (C)	1976: P 1980: I	ref. EC	ref. EC	ref. EC	-
- driver's cabs (F)	1976: - 1985: F	ref. EC	1976: P 1980: I	-	-
- frame construction (M)	1976: - 1985/90: P	ref. EC.	1976: P 1980: I	ref. EC	-
- rims (FR)	n.u.	n.u.	1976: P 1980: I	-	-
- compressed air containers (M)	1976: A 1978: F 1980/85: B	ref. EC	1976: F 1980: B	-	-
Motorcycles					
- frames (C)	1976: n.u. 1980/85: F	ref. EC	ref. EC	ref. EC	-
- rims (C/FR)	1976: n.u. 1980/85: F	ref. EC	ref. EC	ref. EC	-
Bicycles					
- frames (C)	1976: n.u. 1980/85: B	ref. EC	ref. EC	ref. EC	-
Local trains/ Express trains					
- bodies (F/M)	1976: F 1980: B	ref. EC	ref. EC	ref. EC	ref. EC
- chassis (C)	1976: F 1980: B	ref. EC	ref. EC	ref. EC	ref. EC
- wagons for special goods (F/M)	USA	USA	1976: P 1980/ 85: I	-	-
Shipbuilding					
- bodies (small boats) (M)	1976: P	ref. EC	1976: P	-	-
- small engines (C)	1976: F 1980/ 85: B	ref. EC	ref. EC	ref. EC	-
- liquified natural gas tankers (F)	1976: F 1980: B (small market)	n.u.	1976: F 1980: B	ref. USA	-

Explanation of signs: cf. page 58

LEGEND REFERRING TO TABLES

A	=	Aluminium product in the stage of development
F	=	First application of aluminium
P	=	Partial use of aluminium
I	=	Increased partial use of aluminium
B	=	Use of aluminium on a broad basis
n.u.	=	No use of aluminium
Index	-	Without brackets: view of majority
Index	-	In brackets: disputed view
	=	Following upon the development indicated for the region in question at longer or shorter intervals
-	=	No specific information available
R	=	Rolled products (sheets, foils)
M	=	Molded products (profiles, rods)
D	=	Cold drawn products (screw-top tubes)
FR	=	Forged products
C	=	Cast products
CM	=	Conducting materials

5.3 Aluminium consumption in the construction industry

A. Analysis of the past and basic quantitative forecast

(1) During the last 15 years, construction was the second largest user of aluminium. On the average of the countries examined (cf. Tables IV - XIV), its share amounted to approximately 20 %, however with substantial differences between individual countries. A share of aluminium usage of only 10 % in construction in France and Great Britain shows that evidently no breakthrough has taken place in those countries. Contrary to this, the Japanese and Belgian construction industries had the greatest share of overall aluminium consumption (34 % and 31 % respectively in 1978). This fact is even more noteworthy for Japan, because the high capita aluminium consumption in the construction sector does not lead to relative shortages in the supply of other consumer sectors.

(2) The widely diverging market shares of aluminium in the construction sector also reflect the individual growth rates of aluminium consumption. Between 1960 and 1978, annual consumption increase by 23 % and 16 % respectively (cf. Table 16) was by far the highest for Japan and Spain, ahead of Italy and the FRG. With a per capita consumption of 6 kg for the construction sector alone, Japan was second behind the USA (6.3 kg) in 1978.

Already this analysis of past development indicates the different prerequisites of the application of aluminium in the construction sector. In the USA and Japan, the construction of commercial buildings as well as of residential housing are both qualified for the use of aluminium. The rapid industrialization of both countries stimulates the usage of aluminium products for façade design and interior fittings of office and administrative buildings. Concerning residential construction, aluminium has to meet relatively few - to European standards - specifications which results in a greater variety of uses (e.g. aluminium covering on the exterior of appartment blocks); on the other hand, countries like Japan, Spain and Italy will accept - due to their small reserves of wood - the use of aluminium more readily than the countries in middle- and northern Europe.

The aluminium market was not attractive in France and the United Kingdom: the average disposable income in these countries did not permit a massive use of aluminium for decoration in administrative and residential buildings. In these two countries, the traditional wooden window is also preferred to a plain version of an aluminium window. However, sales conditions for this market sector are expected to improve, particularly in France.

(3) Contrary to the transport sector, in construction, the share of cast products in total consumption[1)] (cf. Table 14) is very low, amounting to 3 % - 5 % on the average. The only exception is Italy with a share of 20 % for cast products. This fact can partly be explained by the exceptional high share of aluminium fittings in Italy.

(4) The aluminium products listed below are used in the construction sector:

- doors
- windows
- prefabricated façades
- exterior coverings
- fittings
- sunshade installations
- heating and ventilation equipment

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1) Estimates of the share of cast products are based on the production of cast aluminium, due to a lack of consumption data in this sector. As the balances of trade are relatively small in this sector, the assertion is only insignificantly influenced.

Table 14: Development of the production of aluminium castings: Construction sector (1000 tons)

	1969	1970	1971	1972	1973	1974	av. GR 69/74 annual perc.
FRG	6.9	6.5	7.7	7.3	7.4	7.7	2.2
France	0.8	1.8	3.0	2.7	3.3	2.5	25.6
Great Britain	2.4	2.2	1.9	1.6	1.6	1.6	-5.9
Italy	6.9	8.1	8.0	17.0	27.6	26.9	31.3
USA	53.1	32.1	70.1	64.0	70.8	53.5	0.2
Japar	-	-	-	-	-	-	-
	Production of castings: share of total aluminium consumption in the construction sector (%)						
FRG	0.8	0.7	0.8	0.8	0.6	0.7	
France	0.2	0.4	0.6	0.5	0.6	0.4	
Great Britain	0.4	0.4	0.4	0.3	0.2	0.2	
Italy	1.8	1.9	2.0	3.7	5.2	4.7	
USA	1.1	0.7	1.4	1.2	1.1	0.9	
Japan	--	-	-	-	-	-	

Sources: Organisation of European Aluminium Smelters
Metal Statistics
PROGNOS calculations

The 1974 and 1975 statistics of the European Wrought Aluminium Association show more detailed data on the consumption of semiproducts in the FRG, France and the United Kingdom. Hence, the structure of consumption of aluminium semiproducts in the construction sector can be analyzed as follows:

- the market segment 'doors, windows and prefabricated façades' (represented by the item 'architecture' in Table 15) has by far the largest share: in all three countries, this segment's share is over 50 % of the total market; expecially in the countries with a lower share (France and United Kingdom), a rising tendency to reach almost 70 % can be observed.

- the market segment 'roof and wall coverings, panels, façade elements and the necessary accessories' follows in second place; in the FRG and France this sement had a share of about 10 % of the consumption of aluminium building materials; in the United Kingdom the share fell from 25 % to approximately 15 %.

A comparison of these findings with the FRG - Semiproducts - Statistics (which cover the preceding eight years) shows that the average annual 10 % increase in the consumption of aluminium products in the construction sector was not only caused by a growing demand for doors, windows and separating walls, but also by a substantial market growth of the segments 'other Above-Surface Construction', 'other products of the construction industry and interior fittings'.

The considerable growth of the segment 'other above-surface construction' was mainly influenced by prefabricated buildings for commercial and residential use.

The segment 'interior fittings' includes very heterogeneous products such as radiators, balconies, garage gates, locks, etc. According to our interviews, the use of aluminium radiators has led to an overproportionate growth of this segment.

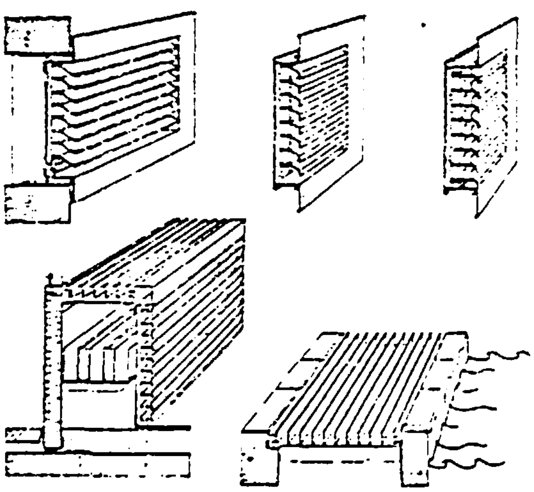
Table 15: Aluminium semiproducts for the construction sector in the FRG 1960 - 1975

	rolled products tons	rods tons	profiles tons	tubes tons	wires tons	pressed and forged parts tons	av.GR 68/75 ann. perc.	Market share in total group (%) - 5%	5% - 10%	10% - 20%	+ 20%
Architecture	6.5 13.3	2.2 0.5	89.9 85.6	1.1 0.6	0.1 0.0	0.2 -	+11.2				x
Sunshade install.	19.5 14.0	1.0 0.4	73.9 83.9	5.7 1.7	- -	- -	+4.1	x			
Roof and wall coverings	75.5 71.4	0.4 0.0	23.2 28.5	0.8 0.1	0.0 -	- -	+5.9			x	
Inside fittings	41.6 52.7	3.3 0.8	47.3 42.8	5.1 3.6	0.1 0.0	2.6 -	+14.4		x		
Other above Surface construction	8.4 23.7	0.4 0.2	68.3 67.2	22.6 8.9	0.1 0.0	0.2 -	+26.5		x		
Above Surface construction, total	20.7 23.8	1.8 0.4	74.8 74.3	2.3 1.5	0.1 0.0	0.3 -	+11.0				x
Heating, ventilation and sanitary facilities equipment	50.0 43.0	1.1 0.4	37.6 50.2	9.1 4.0	0.7 0.8	1.5 1.7	-2.1	x			
Engineering	18.0 9.3	2.3 0.8	49.2 83.3	9.7 4.4	0.6 1.6	20.3 0.6	-0.4	x			
Road equipment	39.6 9.4	0.1 0.4	44.6 39.0	8.4 50.6	0.3 -	7.0 0.6	-10.5	x			
Mining and below-surface construct.	2.1 1.0	5.6 3.1	32.7 7.9	44.2 60.6	0.2 -	15.2 19.5	-5.0	x			
Other construction	27.6 23.0	1.2 1.1	53.7 72.0	4.7 2.6	2.7 1.1	10.1 0.3	+25.0	x			
Total	22.0 23.6	1.9 0.5	70.0 73.1	4.1 2.5	0.1 0.1	1.8 0.2	+10.0				

Sources: Aluminium Semiproduct Association Düsseldorf
PROGNOS calculations

The segment 'other construction' has, compared to the other segments mentioned, the smallest share, but - with 25 % - one of the highest growth rates. This development seems characteristic to us for aluminium consumption on the whole in this sector: while no further large increases are expected, especially in the FRG, for the overall sector, diversification is accelerating. Thus it happens that products that had hitherto not been made of aluminium significantly influence the growth of the overall segment as soon as their production is taken up.

The case of EBS-Bauelemente, Stuttgart shows how, by use of standardized units, such product diversification can lead to an advantageous sales offer: from a supporting cross-beam and a clamped-on profil all the products for the construction sector shown in the illustration below have been developed.



Standardized units made from extruded profiles

- lattices and grates traversable by pedestrians or vehicles
- ventilation grates
- radiator coverings
- sun shades
- man-hole coverings

(5) Furthermore, Table 15 shows that profiles definitely dominate among the different types of semiproducts, with the exception of roof- and wall coverings and heating and ventilation equipment. These results have been improved since 1968 with the newly introduced aluminium products which are registered under the item 'other construction'.

(6) As a result of our quantitative forecast (cf. Table 16) we can denote Brazil, Japan and Spain as countries where the largest market expansion of aluminium products for the construction sector can be expected. Even without being able to make an exact aluminium forecast under the given circumstances, we also consider for instance Turkey and Iran as countries with a comparable growth rate, due to the forecast of the overall construction sector and to the level of aluminium consumption which is still low today.

For the USA we still expect an annual growth rate of nearly 6 % even for the forecast period, although they are already today in a leading position; this is explained by a slight growth of the overall construction sector during the forecast period as well as by the above mentioned favourable circumstances for aluminium usage.

Among the EC-countries, Italy and France achieve a relatively good increase, due to different reasons:

- in Italy, aluminium is very well suited as building material, due to technical and climatic reasons, although standardization in residential construction is not yet very advanced; in addition, construction will during the forecast period increase as compared to the past;

- a slight decrease of the construction sector is expected for France, but this country has - besides Greece - the largest backlag demand concerning the usage of aluminium in the construction sector.

Table 16: Aluminium end consumption: Construction Sector (1000 tons)

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av.GR 60/78 ann. perc.	av.GR 78/90 ann. perc.
FRG	24.4	47.5	80.8	112.2	137.2	149.3	172.6	144.9	137.4	183.2	168.0	176.2	175.8	245.4	331.5	11.6	5.2
France	15.3	23.7	28.7	33.4	33.6	42.3	53.3	53.3	41.6	56.4	55.0	54.0	65.8	92.7	130.7	7.3	7.6
Great Britain	31.5	36.7	34.5	36)	34.4	42.2	54.9	62.0	51.5	59.8	55.6	59.1	64.7	88.6	121.4	3.6	6.2
Italy	14.0	20.0	26.0	53.0	48.0	58.0	93.7	115.5	79.5	110.0	111.3	117.6	140.0	190.9	249.5	12.6	6.5
Netherlands	5.0	10.0	14.5	23.0	26.0	(23.4)*	(23.4)*	(19.5)*	-	-	-	-	-	-	-	-	.
Belgium	3.1	8.7	11.9	16.1	11.0	12.0	16.1	17.4	14.3	15.8	14.0	12.3	13.5	19.4	27.9	8.0	7.0[1)]
Denmark	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	..
Spain	-	-	-	18.3	20.8	25.7	29.5	44.2	38.9	52.5	65.5	61.5	85.6	125.8	176.5	16.4[3)]	9.2
USA	-	848.2	846.4	1006.4	1242.4	1417.9	1626.2	1363.1	1000.1	1331.3	1360.8	-	1730.1	2207.8	2871.8	4.0[4)]	5.9[6)]
Japan	-	45.0	69.7	297.9	348.9	459.3	654.3	546.0	516.5	668.0	621.5	687.5	879.4	1461.9	2259.6	23.3[5)]	10.4
Brazil	-	-	-	-	-	30.1	-	39.0	-	-	-	-	-	-	-	-	..

* (calculated values in brackets)

1) cf. explanation in the text 2) GR 1972/30 3) GR 1970/78 4) GR 1965/77 5) GR 1965/78 6) GR 1977/90

Sources: Metal Statistics
European Aluminium Statistics
Anuario Estatistico da Associaçao Brasileira do Aluminio
PROGNOS calculations

- our calculation of future aluminium consumption in Belgium seems to us too high by 0.5 % - 1.0 % since today's per capita consumption in the-construction sector is already 1.8 kg; in addition, a decrease of the sector's activity has to be considered. The higher, quantitative result of the forecast stems from the high growth rate at the beginning of the period under observation.
- with a 2.9 kg per capita consumption in the construction sector the FRG is heading the European countries. Considering this fact as well as the expectation of a substantial decrease of the construction sector by 1990, the prospective annual growth of 5.2 % of consumption in this sector is relatively low.

B. Interview results and qualitative trends of demand for aluminium in the construction industry

(1) The construction sector has to be regarded as the most heterogenous and complex market, especially if it is taken into account that conditions differ from one country to the other.

In the following it will therefore be attempted, on the one hand, to represent the different possibilities of application of aluminium products as far as general statements can be made and, on the other, to clarify specific preconditions for successful marketing and selling.

(2) In the construction sector, aluminium is mainly used in the form of the products listed below:

- above surface construction: windows
  roofs

	exterior paneiling
	doors
	prefabricated façades
- Construction equipment	balconies, railings
	ceilings
	fittings
	garage and industrial gates
	heating, ventilation, airconditioning
- Public facilities and equipment:	road equipment
	equipment of ports, airports and railways
- Prefabricated houses:	single family homes
	nursery schools
	shools
	multi-purpose halls, hangars etc.

(3) For these products two important application segments exist within the field of above-surface construction:

- institutional construction
- housing construction

The major influential factors for aluminium consumption in institutional above-surface construction are volume and structure of industry, while in housing construction it is the private quality standards of the owners or tenants of the homes or apartments.

(4) Quite generally, the best prospects of aluminium application are in institutional above-surface construction, i.e. in the erection of office or administrative buildings, of representative buildings, but also of shools

or nursery schools. The reason is that here the type of light construction resulting from system building concept leads to considerable cost saving.

The possible uses of aluminium in institutional above-surface construction are varied; the major ones are windows, separating walls, prefabricated ceilings and façades.

Prefabricated façades are made from aluminium sheets and profiles with eloxated, stove-enameled or plastic-coated surfaces. They can be produced as custom-made models if they are made in larger metal-working plants with the necessary experience and if the architect wishes to be a little more free in his design, or else as unit system by the semiproduct producers. Smaller metal-working plants too, can normally mount such unit system façades without any difficulty.

Another possibility of façade design is the use of panels or cast plates. Cast plates and shaped casting elements are increasingly used on especially exposed surfaces, where they are popular on account of their varied surface structure and can be applied as building elements giving an artistic effect.

The use of aluminium as a cold façade in combination with synthetics can serve the stabilization or changed effect of a surface; aluminium panels are furthermore used in combination with several forms of aereated plastics (polyurethane, polystyrene, or phenole hard foams) as fully insulating façade elements.

The future development in the surface treatment of aluminium façades is assessed very differently. Although anodizing (fewer but larger facilities), painting and plastics coating be further developed to the same extent, many construction engineers prefer stove enameling or synthetic coatings because anodization may suffer damage during the finishing process.

On the other hand, for surface painting and for synthetic laminates, further improvements are also requested, expecially with regard to

- environmental features, i.e. substition of the lead-soluble varnishes through water-soluble ones
- durability of the laminates

Another improvement that would be most desirable is

- less proneness to corrosion at intersections.

(5) In competition with synthetic materials the major competitors within the institutional area, aluminium can claim the advantages of

- better anti-corrosion features
- less color fading (in spite of the progress made in the meantime in this field with synthetics)
- a lower modulus of extension
- superior functionality

The disadvantages of aluminium in this context would be

- poorer insulating qualities
- higher price (only negligibly though)

Which of these features will tip the balance with regard to future prospects of application will partly also depend on the country in question.

In Germany, France, and Italy, for instance, better prospects were definitely seen for aluminium within the institutional sector while in Holland, and especially in Great Britain, competition from the side of synthetics seems to be much keener.

Aluminium products cannot only be replaced by pure synthetic products but also by aluminium-synthetics compounds, e.g. a synthetic-coated aluminium core. For these compound materials, our interviewees saw substantial possibilities of further development, while this does not apply as much to aluminium-wood combinations.

Another substitution trend which the aluminium producers should look out for is the coated light steel for façades originating from the USA. The construction system using light steel seems to be the major impediment against a breakthrough of aluminium as a load-bearing construction element on a broader basis.

Even more divergent than in the institutional sector are the conditions in the countries under survey with regard to the housing industry: it is therefore advisable to describe the present situation and the expected development country by country.

FRG

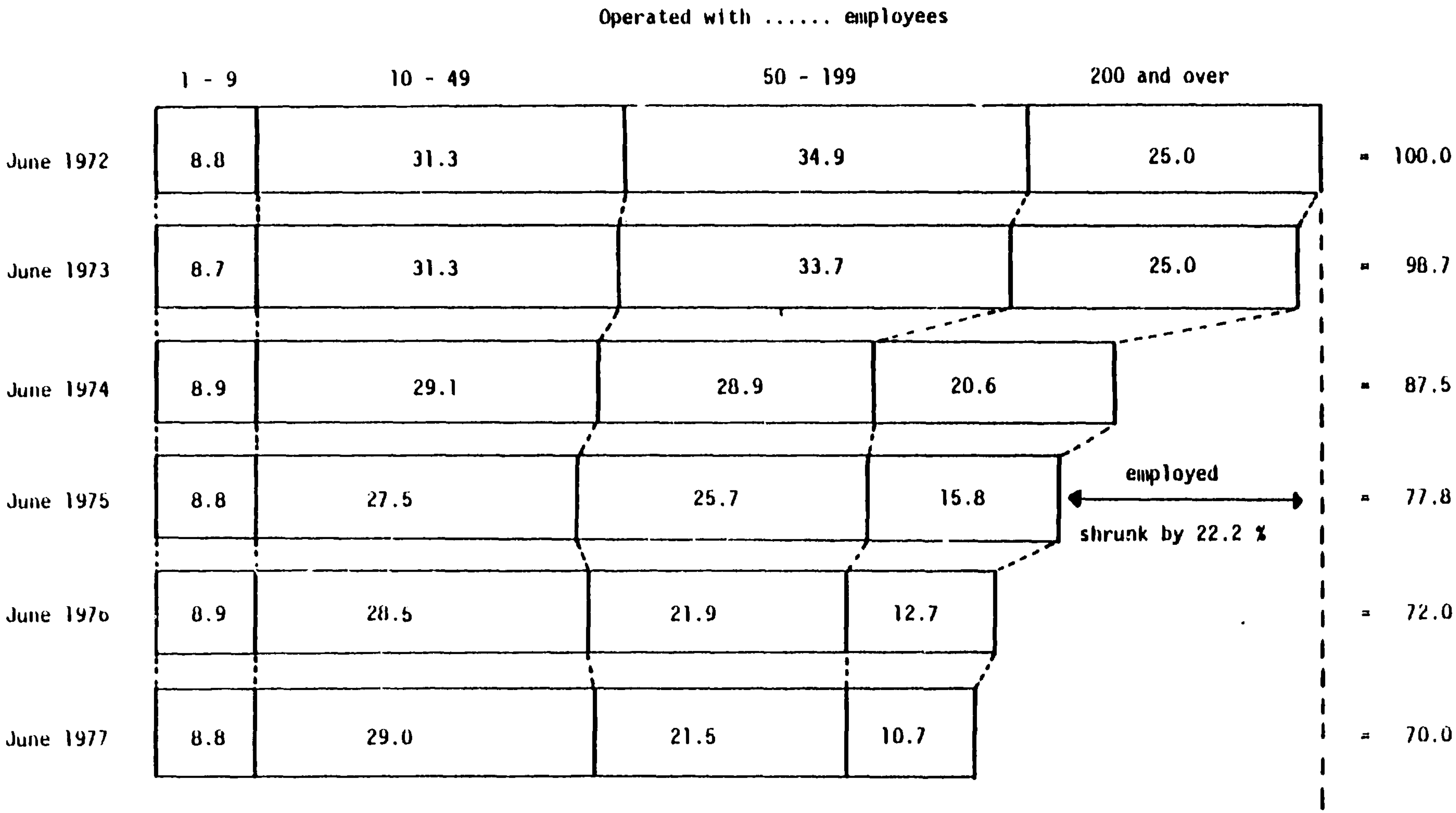
(6) The housing market in the FRG is primarily marked by a shrinking process which became necessary after the over-capacity in the 1970's. Following upon a record of 714,000 housing starts in 1973, the volume fell back to 600,000 units in 1975. In the long run, i.e. up to 1990, the market will grow at an annual rate of 1.3 %. It must, moreover, be taken into account that due to the boom in the early 1970's, a great density of suppliers ensued. The concurrence of recessional and structural conditions resulted in a mass shutdown especially of smaller building companies and metal working plants which is still continuing.

The housing market in the FRG is moreover characterized by the following criteria:

- with a per capita 2.87 kg aluminium consumption, the FRG is heading the list of all EC countries.

- standardization is not much advanced in comparison with other European countries, i.e. apart from a share of originally one-third and now already nearly 50 % of single-family homes, approximately 2000 societies are sharing in housing subsidized by public funds. This widely spread

Diagram 17: <u>Structure and Development of the Construction Industry 1972 - 1977 in the FRG</u>



Source: Institut für Baumarktforschung Zimmermann system of commissioning is reflected in the employment structure of the construction industry (cf. diagram 17: Structure and development of the general building industry 1972-1977). In terms of aluminium only 25 %[1] (approx.) of the major product - the aluminium window[2] is standardized. For the rest, the profile systems of the semiproduct manufacturers and larger metalworking plants prevail, according to which the user can select the most suitable system for his particular requirements.

- Medium-sized enterprises, which dominate the scene in the FRG, however provide good prospects for the use of aluminium windows since the advantages of wooden window frame production count much less in manual production than in industry.

Per capita turnover and wage share*)

	wood	alu	synth.	steel
Handicraft				
a) per capita TDM	80 - 110	120 - 140	80 - 100	? (70-80)
b) wage share (%)	33.7	24.6	35.5	42.7
Industry				
a) per capita TDM	170 - 220	110	100	50-70
b) wage share (%)	16.4	29.1	32.0	53.0

*) Wage share on DM 32,000.- per capita as standard value for 1975.

Source: Institut for Baumarktforschung Zimmermann.

1) By comparison, the standardization quota for aluminium windows in the USA is nearly 95 %, in France and Great Britain between 50 % and 70 %.

2) According to an estimate by Cégédur-Péchiney, the market for aluminium windows in the FRG in 1971 - which should more or less correspond with the situation in 1975 - reached 50,000 tons of aluminium or nearly 2.5 million units.

- The most important market segment for aluminium windows in the FRG in any case is that of owner-occupied houses. In subsidized housing construction it is expected - mainly for cost reasons, that wooden windows will increasingly be replaced by synthetics.

Summing up, it can be stated for the FRG that with a very low growth rate of the market in the next 14 years there will rather be an excess supply of traditional aluminium products. As in the case with publicly subsidized housing construction, the renovation sector - which is as much of interest in Germany as it is in other countries - does not offer as many prospects to aluminium as it does to sythetics. Moreover, a better penetration of the market would - if at all - be only possible via a participation in a metal-working plant. Only those, for one matter, have the direct contact to the customers and, for another, the relations to semiproduct manufacturers as subcontractors are mostly based on tradition and would not be easy to dissolve; it should furthermore be taken into account that mainly in Germany, the made-to-order business plays an important part and the services offered in conjunction with the order, i.e. consulting and know-how transfer bring the greatest profit.

Some interesting sales segments for aluminium products in the construction sector might at most be opened up in detail by offering some of the items listed below:

- prefabricated houses
- exhibition buildings and stalls
- edges of flat roofs
- door steps and window sills (only 2 suppliers, but certain distribution problems)
- façades for pre-war buildings under renovation
- prefabricated suspended ceilings in the institutional sector
- radiators (only 4 European producers in Italy and France, all-European standardization. 60 % of the market volume is accounted for by pre-war renewals)
- sewer covers.

France

(7) The aluminium situation on the French housing market differs clearly from that in the FRG:

- the construction market is largely still in the state of expansion which is reflected in the greatest annual acceleration among the EC countries (2.8 % p.a.).
- The use of aluminium in the construction sector (1.01 kg) is at the tail end of the EC countries, together with Great Britain (1.06 kg).
- Due to the strong influence of the government on societies (subsidized housing), the market is much more standardized than for instance in the FRG or in Italy.
- Analogously to the overall more marked centralization of economy and administration, there are fewer but larger building companies (they often look after as many as 500-600 rows of single-family homes).
- Metal-working plants, too, are larger than in the FRG with an average of 100 employed, and accordingly operate at greater cost advantage.
- Apart from the market for new constructions, the renewal of pre-war houses too is expected to create a demand for aluminium products, such as windows, window sills, and doorsteps.
- In France, the difference in market penetration of aluminium is very marked between large agglomerations and the rest of the country. The projected decentralization is to give special promotion to industry outside the Paris area; this growing industrialization on a broader basis is believed to give further impetus to the use of aluminium in the institutional construction sector.

- The market for radiators is comparatively less promising, since- at least at the present time electrical heating is strongly propagated by Electricité de France.

In spite of these generally favourable preconditions[1)] it is not easy for an importer on account of the close traditional relations between customers and suppliers and due to the comparatively marked government influence to penetrate the relatively closed French market. It would be important in any case to be in a position to offer a complete system of one's own. The prospects of such endeavours would be greatly improved by establishing some direct contact to influential representatives of government or industry.

Great Britain

(8) The use of aluminium in Great Britain - as in France - is very poorly represented in comparison with the rest of Europe (per capita consumption was only 1.06 kg in 1978). The British producers therefore expect a high market growth rate in this sector, i.e. mainly in the housing construction sector. The situation can be described in detail as follows:

- the entire construction market will expand only slightly - parallel with the economic development.

- in the institutional construction sector, keen competition from the side of synthetics is feared, mainly for cost reasons.

- On account of the much narrower window frames used in British houses - as compared with the Continent - synthetics alone are not suited as window material (they would have to be reinforced). The prices of wood and aluminium however will become increasingly close from which stronger

1) As late as in 1974, the'Révue de l'Aluminium' (9/74) assessed the development prospects of aluminium consumption in the French construction industry so favourably that - assuming a consumption of 66,000 tons per year - an acceleration to more than 200,000 tons, i.e. an average annual growth of nearly 12 %, were expected.

demand impulses for aluminium are deduced for the future. Including replacements for older buildings, a growth rate of approximately 10 % p.a. is expected over the next 5 - 10 years (!) at the expense of windows hitherto made of steel or wood. Since this market is largely standardized it is served by large companies with industrial production as well as by small metal-working plants which are working together with Baco and Alco in franchise. On account of the advanced standardization, Japanese imports are feared - and this development is already under way. The windows will - for reasons of energy cost saving - become rather smaller than larger. The introduction of heat breakers is expected and there is some hope of a growing share of double windows with noise and heat insulation.
The introduction of aluminium windows is a marketing problem since the market share up to now was very low.

- Prefabricated aluminium façades will not be able to penetrate the institutional construction market on account of their high price.

- The housing sector in Great Britain - comparable to that in France - is largely concentrated on large building companies; these are the decision making partners for companies seeking orders.

- Last but not least, the construction industry in this country is regarded as one of the most interesting future markets for aluminium.

Italy

(9) Italy has in the past registered a very impressive expansion of aluminium in the building sector and achieved a per capita consumption of 2.07 kg in this sector in 1978.

In the course of a slight decrease of building activities within the period under survey of 2.3 % p.a. to an average 1.5 %, growth is expected to decline further. According to the estimates of our Italian interview partners regarding the share of the construction industry in total aluminium end use have continuously been slightly retrograde.

In spite of the fact that the parcelling out of builders is comparable to the FRG, the made-to-order aluminium product is not ranking first in Italy, but instead standardized mass production. Apart from the use as façades in institutional building, suspended ceilings and roofs, aluminium windows and radiators as well as fittings have found wide use in the housing industry.

Italy is the only country where aluminium is also given a chance of application as constructive building units.

The Netherlands

(10) The Netherlands are in many respects taking an intermediate position between Great Britain and the FRG with regard to aluminium end use in the construction sector:

- with a per capita consumption of 1.43 kg in 1974, they are distinctly above the British rate, while they are yet considerably behind the FRG (2.34 kg).
- The development of the construction industry with an average annual rate of 2.0 % up to 1990 it is also receding but still higher than in Great Britain or in the FRG. As to the structure, a better development is expected in institutional building than in housing construction.
- For housing construction, however, a pent-up demand for aluminium products may ensue since up to now - as in Great Britain - steel and wood have been used as materials; the quality level was below that of the FRG, Switzerland or Sweden.
- In addition to the unexploited aluminium potential a growing demand for

renovation will arise which above all will result in a demand for

. windows
. doors
. door steps

- As in France and Great Britain, the housing industry is dominated by a small group of large companies. The largest of these account for 25 % of the total volume. The standardization of building elements is accordingly relatively advanced, without however catching up with Great Britain or France. The size of metal-working plants is about the same as in France, i.e. approximately 100 employed on average.

- Foreign firms have been successful with imports to the Netherlands of

. profiles for hothouses
. roof edge profiles, roof edges
. rods for awnings

Spain

(11) Spain must be regarded as the big newcomer among West European aluminium users. With a per capita consumption of 1.65 kg, there still is enough development potential left.

Apart from this, the aluminium construction market is marked by the following criteria:

- per capita wood consumption in the Spanish construction industry is very low.

- with an average overall economic growth rate of 6.9 % Spain is heading the list of all the European countries under survey. This is a favourable prerequisite for institutional above-surface construction and for housing construction.

- private housing construction is government sponsored
- in Spain, the building companies are also very concentrated, with approximately 5000 housing units to one company per year. Important contacts for those seeking contracts are banks and insurance companies.
- Particularly interesting with regard to the profit per unit seem to be
  - . sunshades
  - . roller blinds,

  which are high-quality end products with rising follow-up costs.

Table 18: Products with growing application of aluminium in the construction industry

	EC countries	Spain	USA	Japan	Developing countries
Housing construction					
- edgings of flat roofs (M)	1976: F	-	-	-	-
- sunshades (M)	-	from 1977 onwards	-	-	-
- window sills/ doorsteps (M)	1976: I	ref. EC	-	-	-
- radiators (M)	1976: I (exc.F)	ref. EC	-	-	-
- fittings (C/FR)	from 1977 onwards B (Italy)				
Renovation of houses					
- windows (M)	1976: F (exc.FRG)	-	-	-	-
- window sills/ doorsteps (M)	1976: F	-	-	-	-
- façades (F/M/C)	from 1977 onwards P (FRG)	-	-	-	-
Prefabricated houses (F/M)	1976: I	-	1976: P	1976: P	-
Exhibition buildings (M)	1976: I	-	1976: I	-	-
Sewers (M)	from 1977 onwards F	-	1976: F	-	-
Mobile homes (F/M)	-	-	1976: B	-	-
Solar energy systems (M)	1976: A 1980: FP 1985: I	-	1976: F 1980: I	ref. USA	-
Airconditioning (M)	1976: F 1980/85: B	ref. EC	1976: F 1980: B	ref. USA	ref. USA
Concrete silos (M)	1977: F 1980/85 B	ref. EC	-	-	-

Legend: cf. page 58

5.4 Aluminium consumption for packaging purposes

A. Analysis of past development and quantitative forecast

(1) Aluminium consumption for packaging purposes is among the major sectors of application in nearly all the countries under survey. Its share is fluctuating between 6.8 % in Japan and 22.8 % in the Netherlands.

Apart from the more or less domestic importance of this market, which of course also depends on the importance and consumption of other sectors, per capita consumption is another key figure which can provide information as to the existing development potential.

An analysis of aluminium consumption for packaging shows the ranking order of the countries under survey (per capita):

USA	5.81 kg (1977)
Netherlands	1.77 kg (1974)
FRG	1.53 kg
Italy	1.06 kg
Japan	0.99 kg (1977)
France	0.94 kg
Great Britain	0.88 kg
Belgium/Luxemburg	0.70 kg
Spain	0.65 kg
Brazil	0.13 kg (1974)

As one can see already from this list, there is such a great difference between the United States and the other countries under investigation that it is impossible to ascribe it alone to a higher per capita income. To anticipate the qualitative trend factors which are described in the next chapter we can state already here that the mobility due to the vast expanse of the United States has resulted already very early in one-way (non-returnable) packages which in many cases replaced glass bottles. Another important influential factor is the large amount of convenience and instant foods, which mainly resort to aluminium foils for packaging. Another influential factor of great weight is the special significance of soft drinks in the USA, which was also the first sector that could be conquered by the 'can' of sheet steel or aluminium. Alcoholic drinks are not identified with glass containers, a point particularly applicable to beer, since the consumption of wine is of no quantitative consequence.

(2) The analysis of the development of aluminium consumption for packaging purposes shows that - with the exception of France[1], where the packaging sector has advanced parallel with the development of overall consumption - the growth rate of the packaging sector has between 1960 and 1978 throughout been above that of total consumption. This was particularly marked in the countries listed below:

Japan	23.5 %
USA	12.8 %
Belgium	12.0 %
Spain	10.5 %
Italy	8.7 %

With the exception of the United States and Belgium, these are mainly countries whose per capita income has risen considerably during this period.

(3) If one attempts a more detailed breakdown of the whole sector of packaging in accordance with the existing semiproduct statistics[2] (cf. Table 19), the dominating use of the use of foil becomes apparent. In most European countries,

1) and Brazil

2) Apart from Semiproduct Associations, in most of the countries Associations of the aluminium-working industry exist, whose turnover accounts for 80 % of packaging materials.

its share is around 80 %. In the USA, the situation deviates somehow since aluminium consumption in this country is strongly affected by the use of cans.

(4) For the forecast of aluminium consumption for packaging purposes no immediate industrial reference figure could be used as basis. Theoretically, the packaging industry would be thinkable as an explanatory variable, but in all the national statistics the necessary figures on the development are lacking. As an alternative, the per capita gross domestic product offered a possibility to circumscribe the level of affluence of a country.

On this basis, the strongest growth of 16.3 % or 10.6 %, respectively was obtained for Spain and Belgium (cf. Table 20).

B. Qualitative tendencies and results of the interviews

(1) While in the years 1960/78, aluminium consumption for packaging purposes grew at an annual rate of 13 % in the USA and nearly 6 % in Europe, the increase in both regions for synthetic for packaging purposes in 1960/74 was nearly 12 % p.a.; the use of tin plate during the same period slightly receded. Aluminium is today altogether ranking fifth as packaging material, after paper, glass, synthetics, and tin plate (by weight).

Nearly all aluminium packaging materials are in some correlation with all packaging materials. These interrelations span a range from a rational complementation to keen competition.

As compared with synthetics, aluminium is of greater importance wherever high standards of light or gas tightness or taste neutrality are to be met by the

Table 19: Aluminium semiproducts for packaging and containers in the FRG 1968 - 1975

	rolled products tons		rods tons		profiles tons		tubes tons		wires tons		molded and forged parts tons		annual percent. 68/75 GR	Market share in total group (%)			
														- 5%	5% 10%	10% 20%	+ 20%
Pitchers and pails	99.0	20.0	-	-	1.0	70.0	-	-	-	-	-	10.0	-31.1	x			
Barrels	92.5	86.1	0.6	-	1.0	6.6	0.0	-	-	0.4	5.8	6.9	-9.2	x			
Cases and similar containers	70.6	42.4	1.5	1.9	23.1	55.4	4.3	-	-	-	0.5	0.3	-1.7	x			
Tin cans and lids made from alu sheets	100.0	100.0	-	-	-	-	-	-	-	-	-	-	+28.6			x	
Tubes and other extrusion molded parts	98.5	100.0	1.4	-	0.0	-	0.0	-	0.0	-	0.0	-	+0.9		x		
Bottle tops	100.0	100.0	-	0.0	-	-	-	-	-	-	-	-	+11.9	x			
Foils	100.0	100.0	-	-	-	0.0	-	-	-	-	-	-	+2.6				x
Other types of packaging	31.5	56.3	0.1	-	5.9	2.5	0.1	-	59.5	37.2	2.8	4.0	+1.5	x			
Total	98.7	99.1	0.2	0.0	0.3	0.5	0.1	-	0.5	0.3	0.2	0.1	+3.9				

Sources: Aluminium Semiproduct Association Düsseldorf
PROGNOS calculations

Table 20: Aluminium end consumption: Packaging (1000 t)

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	Av. GR 1960/78 (% p.a.)	Av. GR 1978/90 (% p.a.)
FRG	34.6	42.7	53.6[1)]	69.2	73.7	83.9	92.0	91.4	79.7	93.4	91.9	93.6	112.0	144.3	181.6	5.7	5.7
France	21.8	26.5	27.2	39.0	42.2	44.9	46.3	50.8	42.0	47.8	49.6	50.2	58.3	75.9	98.7	4.7	5.8
Great Britain	29.2	29.5	30.9	35.1	33.9	38.3	47.7	54.0	43.1	45.3	50.5	49.1	54.1	70.1	91.2	2.9	5.3
Italy	13.5	16.5	23.0	35.0	35.0	42.0	58.0	54.0	36.3	52.4	52.4	60.5	66.4	89.3	118.4	8.7	5.8
Netherlands	5.0	9.5	11.5	17.0	17.6	(20.3)*	(22.4)*	(24.1)	-	-	-	-	-	-	-	-	-
Belgium	0.9	3.2	3.8	5.0	3.4	8.1	3.9	6.6	5.8	9.1	8.9	6.9	8.0	13.6	22.9	12.0	10.6
Denmark	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spain	-	-	-	11.0	12.6	16.2	19.[illegible]	21.7	19.1	24.9	29.9	24.4	33.2	70.0	148.9	10.5[2)]	16.3
USA	-	297.6	335.7	665.4	686.7	823.7	932.6	1,027.4	907.7	1,166.7	1,259.6	-	1,613.4	2,316.2	3,143.7	12.8[3)]	7.3[5)]
Japan	-	8.8	12.7	20.3	21.0	23.5	28.3	83.0	71.1	103.7	111.1	136.7	143.6	234.5	449.5	23.5[4)]	10.4
Brasilia	-	-	-	-	-	13.2	-	15.2	-	-	-	-	-	-	-	-	-

* (estimated values in brackets)

1) 1968

2) GR 1970/78

3) GR 1965/77

4) GR 1965/78

5) GR 1977/90

Sources: Metal Statistics
European Aluminium Statistics
Anuario Estatistico da Associaçao Brasileira do Aluminio
PROGNOS Calculations

packages. Wherever requirements are low, considerations of price are given preference in selecting suitable materials[1]. In other cases, individual packaging parts are made of aluminium, as for instance lids of tin plate cans or tops of glass bottles or synthetic containers. In addition, aluminium-synthetics compounds are increasingly used, offering a sensible mutual complementation of individual features of the two materials.

(2) The main competitor among stiff packages still is tin plate, since this is the most tonnage-intensive sector of cans for drink and food.

In the United States aluminium had in 1974 - after a continuous rise during the preceding years, reached a consumption of 700,000 tons for 'cans'. This represents a share of over 10 % of the total tonnage of 6.7 million. Alone the share of cans used for drinks (total nearly 43 billion units) was estimated at approximately 30 % in 1974.

In Europe, the situation has up to now not taken half as favourable a development for aluminium. From several studies[2] it can be seen that after an aluminium share of cans in 1971 of

2.1 % (7,500 tons) in the FRG
1.5 % (6,490 tons) in France
1.6 % (9,200 tons) in Great Britain

no basic change of the situation is expected. With an assumed average annual growth of 5.2 % in the FRG, 3.8 % in France, and 1.5 % in Great Britain, the shares accounting for food and drink cans in this sector will change only insignificantly:

---

1) Therefore the share of aluminium in simple packaging is low.

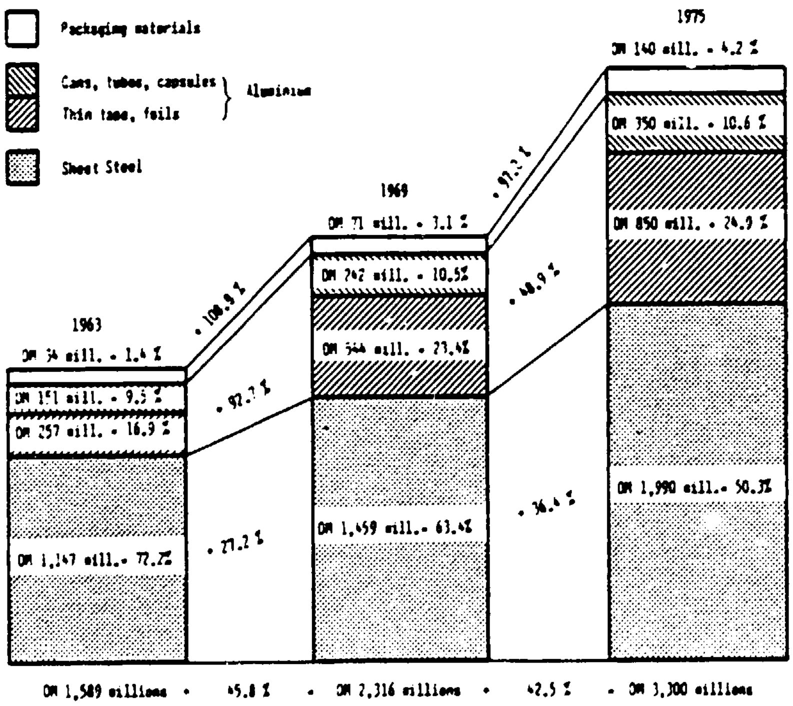
2) The collection, disposal and recycling of non-biodegradable packaging, SEMA, Paris, October 1974.

FRG	2.4 % (12,400 tons)
France	2.3 % (13,250 tons)
Great Britain	6.9 % (41,600 tons)

In view of the fact that the total market[1)] for aluminium cans in the FRG had already reached 13,000 tons in 1975, this forecast seems to us too pessimistic for the FRG and for France.

Which course the development of the aluminium packaging market took as compared with that of sheet steel on the total packaging market in the FRG since 1963 is depicted in the diagram below:

<u>Development of the aluminium packaging market as compared with that of steel sheet packaging in the FRG</u>



Source: Aluminium 5/76

1) The total market includes beverages and food cans, cans for pharmaceutical products.

This not very encouraging development of the aluminium can has been confirmed in most of our interviews, while Alcoa - hoping to follow up the success it had in the USA in Western Europe as well, is at present erecting a plant for the manufacture of aluminium cans in Wales/GB, most European aluminium producers point out the entirely different situation in Europe as compared to that in the USA:

- The steel industry in West European countries - by tradition as well as due to the existing capacity, with the exception of Switzerland - has a much stronger footing in the market which is not the case in the USA.
- The steel industry, producing one of the basic materials, enjoys much stronger support by West European parliaments than the aluminium industry does.
- Apart from its strong position, the steel industry has in the past reacted fast and flexibly to innovations introduced by aluminium producers (e.g. 'easy open ends' of cans for drinks, or two-part cans made of cold drawn steel).
- On account of longer distances, the net weight plays a more important role in the USA than it does in Europe.
- In the USA, the system of the breweries to supply pubs and restaurants themselves is unknown. This situation leads to greater demand.

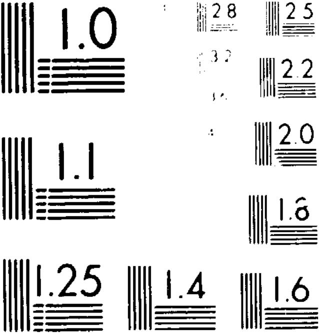
Even taking into consideration the above arguments against an increase of the market share of aluminium cans for drinks in Europe it seems that the question of whether cans for drinks will have a similar success in Europe as in the USA depends more on the price development of the two competing products and on the marketing (e.g. information of the can producers about technical production advantages of the aluminium can and transfer of the relevant know-how) of the can producer Alcoa who is dominating the US market. In any case, the skepsis against a further market penetration of aluminium cans for drinks was already much less apparent in Great Britain than it was on the Continent.

In this context, it should not be forgotten that the use of cans for beer in Japan has increased quite exceptionally since 1970: of the 800 million beer cans, none was made of aluminium in 1970, while in 1973, there was a share of approximately 2.4 % or 890 million cans in the total of beer containers (total beer can market = approximately 2.5 billion). In 1975 already, total sales of more than 2 billion beer cans were made of aluminium.

Last but not least, Table 19 indicates that aluminium cans in preceding years registered an average annual increase by more than 28 % in the FRG, thus achieving the strongest growth of all aluminium products in the packaging sector. This market expansion has, moreover, taken place more or less continuously and was not even interrupted in the recession year of 1975.

With the outline given in the foregoing we have tried to show that the development of the aluminium can is assessed very differently by the experts in question, especially by European producers (Péchiney, Alusuisse, VDM). Due to the traditional consumer behaviour and the prices, the development is seen rather pessimistically[1]. According to our opinion, the aluminium can for soft drinks and for beer will also penetrate the European market in a development going from the north to the south, reaching an average annual growth rate of approximately 10 %, provided the price development can be kept within about the same range as that of tin plate cans. It should also be possible to bring the cans back into circulation by re-cycling.

1) In Denmark, the introduction of aluminium beer cans which has already taken a satisfactory course was countermanded again by a government decree which was to serve environmental protection.


1.0
2.8
2.5
2.2
1.1
2.0
1.8
1.25
1.4
1.6

Much more difficult than in the sector of drinks will it be to push the aluminium can for foods since the anodyzed layer of aluminium cans is much less resistant to acids than the tin or tin plate cans. Furthermore, it will have - depending on the filling - to take a stand against other innovations, such as tinless steel sheet cans or synthetic cans.

(3) Another product of considerable weight on the market sector of packaging are the extrusion molded packaging types, i.e. tubes and extrusion molded aerosol cans; their share in total aluminium consumption for packaging purposes in France[1] is nearly 13 %, in the FRG nearly 9 % (no figures are available in Great Britain). Apart from the experience that the market for extrusion-molded aluminium products has not expanded any more during the last 6 years, our interview partners also saw <u>no greater prospects of development</u> for these products, since

- the tubes (for toothpaste, foodstuffs, pharmaceuticals, chemical-technical fillings) will, for price reasons, be exposed to constantly growing competition by laminate-coated aluminium products (in the USA, toothpaste is today already sold in glanimate tubes, a synthetic-aluminium-paper compound);

- the aerosol cans will probably be attached for price and also environmental reasons (probable destruction of the ozone layer in the atmoshere through the fluor hydrocarbon propellant) and will most likely be subject to growing competition from the side of the plastic can.

(4) The greatest importance as to share and volume of packaging materials in France, the FRG, and in Great Britain is ceded to flexible packaging, i.e.

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1) Boxal introduced the first aerosol can to the market

foils. Their growth has in the past not been excessively high with only 2 %, but their producers had to suffer much less from recession effects. This is probably explained by the fact that foodstuffs react only relatively weakly to cyclical movements.

The foil market differs from the other aluminium products in the packaging sector in many respects: production requires a highly developed technology and high capital intensity: the customers furthermore expect intensive consulting by the producer. At the same time, quality standards differ greatly from one country to the next. It is difficult for instance for US producers to sell their products in Europe.

These market conditions have resulted in a very oligopolistic structure of foil supply, with some countries reaching up to 50 % of the export share (FRG). Due to the relatively small growth of the market share, mainly in the field of household foils, competition has become keener and has forced Alcoa in 1974 to close down the entire production of household foils (market share in the USA 18 - 19 %). The market leader is Reynolds with a share of over 50 %.

Seen from a technological point of view, some additional impulses can however be expected for the household foil. The development in the sector of containers of drinks, foods and pharmaceuticals are moving increasingly in the direction of compounds, of which aluminium is a necessary component on account of its

- neutrality
- density
- low permeability of
  . atmospheric oxygene
  . humidity
  . smelling substances
  . micro-organisms

In view of the market volume however, no higher growth rates are expected.

The production of industrial foils - on account of the very great services they offer - seems to be much more profitable according to the statements of our interviewees. The application areas reach from the building sector via transport and machine building to electrical engineering. The largest part, however - for heat insulation purposes - is probably accounted for by the construction industry.

A more recent development within this area should be mentioned is the enamelling of aluminium foils which results in an improvement of anticorrosion features, resistance against weather and temperatures (within the range of - 40^0 - + 500^{0}C) and colour fastness.
Possible application areas are:

- pressed and foamed plates
- façade elements
- rolling escalators and lift coatings
- wagon and container inner coatings
- school blackboards
- crash barriers for traffic
- signboards.

(5) Mainly in order to meet increased requirements as to tensile strength, the use of thin aluminium tape has found wider use in the foodstuff sector. By developing such compounds from aluminium tape and synthetic foil it has become possible to sterilize convenience food in light packages and to keep fish or meat products for months at temperatures of up to 50^0.

The hope of the manufacturers is to have these semi-stiff packages as multi-sectional containers for several food portions, for instance in hospitals, factory canteens etc. They also want to use them for deep-frozen goods in tropical countries which now still offer problems.

(6) As surface treatment of foils and thin tapes, painting or dyeing can be used. This serves the following purposes:

- protection of the surface
- application of an enamel layer with hot-sealing properties
- the achievement of good adherence of printed colours
- decorative designs of metal surfaces by means of colour pigments.

While for foils mainly physically dry enamels are used, thin tapes mostly need chemically dry enamels which are used for stove-enameling which provides excellent protection. The enamelling is immediately followed by a drying process through evaporation of the solvants, i.e. a chemical drying process.

(7) Competing materials for the use of aluminium foils and thin tapes for packaging purposes, mainly of synthetic foils with vapour-applied aluminium and coextruded synthetic foils. For the rest, the future application of aluminium foils and tapes will also be of importance where durability of the packaged goods is sought or requested.

On the whole, the foils and thin tape producers are facing the situation that after a disastrous price competition which frequently was the result of oligopolistic conditions, the supply capacity has in the meantime to a large extent reached the level of demand. In the USA there has already been a temporary overlapping. The foil industry, on account of its high capital intensity, the low labour requirements, and its highly developed technology probably is that part of the aluminium industry which will be the last to be considered by developing countries with high economic ambitions. Export prospects into faster developing countries will therefore be maintained the longest in this sector.

(8) Apart from the packaging products made of aluminium discussed so far, the glass and bottle tops had in the last 8 years a very favourable development with nearly 12 % annual growth rate in the FRG (cf. Table 19). It must be taken into consideration however that preconditions for this expansion were particularly favourable because the mineral water industry in the years 1969/70 has changed over its entire stock of bottles from spring tops to screw-on tops of aluminium. A direct comparison of the years 1970 and 1974 accordingly shows that consumption has even slightly dropped. The structure between narrow- and wide-necked bottle tops in 1975 was around 10 : 3. The producers therefore mostly hold the opinion that on the whole market saturation has been achieved.

The comparison of France and Great Britain with the situation in the FRG largely shows conformity. The market volume of aluminium bottle tops - according to the estimates made by French enterprises - was around 10 % and that in Great Britain around 20 % above that in the FRG.

(9) Summing up, we think to be in a position to say on the basis of the statistical material at our disposal and the information collected during the interviews that

- aluminium consumption in the packaging sector in West European industrialized countries will up to 1990 expand by 5 % on average
- Spain, the USA, Japan, and Brazil will achieve a growth rate of approximately 8 - 10 %;
- growth of European aluminium consumption within this sector will largely depend on the fact whether the aluminium can will succeed to penetrate the market against the competition from the side of conventional containers and of other competiting containers made of metal (a slow positive development starting from Great Britain and Scandinavia is likely in spite

of the high investment required for bottling plants, provided the generally expected environmental impositions can be met and the price of aluminium will develop comparably to that of steel sheet.)[1];

- the market for foils and thin tape application will continue to expand considerably but that the aluminium foil will increasingly be used as compound material or will lose market shares to newly developed synthetic foils;

- the market for aerosol packaging and tubes will hardly expand any further.

1) cf. also section (2)

Table 21: Packaging products which increasingly use aluminium

	EC - countries	Spain	USA	Japan	developing countries
tins for beverages (F)	1976: P 1980: I	ref. EC	1980: B	1976: I 1980: B	-
industrial foils (F)	1976: P 1980: I	ref. EC	ref. EC	ref. EC	-
narrow tape for packaging purposes (F)	1976: P	réf. USA	1976: P 1980: I	ref. USA	1980: P 1985: I

Legend: page 58

5.5 Aluminium consumption in the machine building industry

A. Analysis of past development - quantitative basic forecast

(1) The international consumer groups combined under this heading constitute a very heterogeneous conglomerate of application areas. While the statistical surveys of EWAA partly take these circumstances into account, these detailed records have only been available since 1973. And even they still are only fragmentary since Belgium had to be left out again in the 1975 statistics and Great Britain, on the other hand, records only global figures on 'general engineering' which more or less means the same thing as machine building.

For a longer period (8 years) therefore only the figures recorded internally by the German semi-products industry are at our disposal (cf. Table 23).

All the same we want to try to work out different developments as far as they can be derived or have been mentioned during the technical interviews.

(2) The analysis of the past reveals that in all the countries under survey - with the exception of Great Britain, Italy and Belgium, the growth rate of aluminium consumption in machine building was below that of the total aluminium market. On the other hand, the importance of this sector with a share of 4.5 % (Spain) and 7.1 % (Italy) - in 1978 - was relatively small (cf. Tables 24 and II).

Compared with the development of the whole branch of industry (machine building), aluminium consumption was ± 2 % above or below the general development; This information therefore does not permit any specific interpretation.

Also the share of cast aluminium consumption (cf. Table 22) in total aluminium consumption for the machine building industry does not seem to have undergone any grave changes - excepting the USA where since 1970 a drop from nearly 34 % to approx. 25 % was registered (cf. also Part B of this chapter).

(3) If the whole sector - according to the information available as put down in Table 23 - is broken down into

- machinery and equipment for certain industries (textile, paper/printing, agriculture and forestry, food, beverages and tobacco)
- machine tools
- precision mechanics and optical products
- general machine building
- other aluminium products for the printing and paper industry

it already becomes apparent that markets with a formerly considerable demand for aluminium are stagnating or even receding (the first three buyer groups), while other segments are steadily growing in importance.

These phenomena are partly due to market conditions, partly however also caused by the application of substitution products. On the other hand, the positive results stem from a quite specific application of aluminium due to the particular characteristics of this material.

(4) The quantitative forecast was also based on the development of the major factor of influence, the machine building industry. The results however were rather intended to indicate approximate dimensions and to make a comparison of specific developments in the countries in question possible.

Table 22: <u>Development of cast aluminium consumption: machine building (in 1000 tons)</u>

	1969	1970	1971	1972	1973	1974	av. GR. 69/74 (%)
FRG	43.4	42.5	38.7	41.3	49.8	50.8	3.2
France	10.0	15.1	11.8	15.0	16.5	18.4	13.0
Great Britain	11.5	12.6	10.9	11.1	11.0	10.9	-1.0
Italy	7.9	12.0	12.0	10.5	11.7	12.9	10.3
USA	90.1	84.8	78.7	97.6	96.5	101.3	2.4
Japan	-	-	40.5	40.3	50.3	50.2	-
	Share of cast production in total aluminium consumption in machine building industry						
FRG	65.8	67.8	67.5	67.6	66.8	64.5	
France	37.9	48.1	43.2	41.5	49.1	49.9	
Great Britain	37.5	44.5	45.5	44.4	30.2	26.2	
Italy	32.9	48.0	52.2	40.4	29.3	30.2	
USA	30.5	33.9	29.3	31.2	24.1	24.6	
Japan	-	-	57.7	59.9	57.9	60.9	

Sources: Organisation of European Aluminium Smelters
Metal Statistics
PROGNOS Calculations

Table 23: **Aluminium Semiproduct Production for Machine Building (incl. precision mechanics, printing and paper industries) in FRG 1968 - 1975**

	Rolled products tons		Rods tons		Profiles tons		Tubes tons		Wires tons		Molded and forged parts tons		av. GR. 68/75 ann. perc.	Market share in total group (%)			
														5%	5% - 10%	10% - 20%	20% +
General machine building exc. apparatus	21.3	27.3	7.4	6.8	44.9	46.4	7.0	5.3	3.0	1.6	16.4	12.6	+9.6				x
machine tools	56.2	41.9	5.6	10.8	27.1	27.1	8.0	8.4	0.7	3.3	2.5	8.4	-7.6	x			
MFA* for textile and clothing industry	16.3	4.5	6.6	2.2	5.1	18.1	31.8	30.8	0.0	-	41.3	43.3	-13.8		x		
MFA* for paper, printing, and office machinery	32.1	3.4	7.0	2.2	41.5	87.6	15.8	5.4	0.1	-	3.6	1.4	+1.7		x		
High-speed and large scales, automates	40.5	29.2	5.3	2.8	37.6	59.3	8.5	3.4	0.4	-	7.7	6.3	-6.0	x			
MFA* for agro and forestry industry	46.1	11.0	2.4	2.1	12.2	29.1	21.0	37.6	0.0	-	18.2	20.2	-3.7	x			
MFA* for food and beverage industry	66.4	30.5	2.5	2.6	28.3	45.2	2.6	14.5	-	-	0.3	7.2	+1.4	x			
Precision mechanical and optical products	34.2	10.7	23.6	22.4	11.0	31.1	26.0	24.8	0.0	0.6	3.6	2.4	+0.0				
Printing and paper industry	95.9	98.5	1.0	0.2	0.8	0.7	2.3	0.6	-	-	0.0	-	+22.1			x	

* MFA = Machinery, Facilities and Appliances

Sources: Aluminium Semiproduct Association Dusseldorf
PROGNOS calculations

Table 24: Aluminium end consumption, machine building including precision mechanics and optics (in 1000 tons)

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av.GR. 60/78 (ann. perc.)	av.GR 78/90 (ann. perc.)
FRG	44.2	58.1	56.9 1)	62.7	57.3	61.1 2)	74.5	78.8	55.3	71.4	74.5	73.9	77.0	85.5	94.9	2.9	2.1
France	20.0	23.1	25.1	31.4	27.3	36.1	33.6	36.9	29.6	32.0	35.5	28.6	32.9	41.9	56.9	2.0	5.9
Great Britain	26.7	26.6	25.4	28.3	23.9	25.0	36.5	41.6	31.3	34.9	30.9	23.8	25.7	33.0	42.5	-0.6	5.0
Italy	9.5	14.0	20.0	25.0	23.0	26.0	40.0	42.7	25.4	37.9	42.1	39.8	42.0	58.9	81.0	8.3	6.1
Netherlands	2.6	6.5	4.5	6.0	6.0	(6.4)*	(6.8)*	(7.4)*	-	-	-	-	-	-	-	-	-
Belgium	0.9	1.6	0.5	1.4	1.1	1.6	2.9	4.5	1.6	1.9	1.6	1.7	1.8	2.9	4.2	3.6	7.7
Denmark	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spain	-	-	-	7.0	8.0	10.0	11.4	11.7	10.1	11.3	13.1	11.3	13.4	18.6	26.1	6.2 3)	7.2
USA	-	247.7	252.2	250.4	268.5	312.5	399.6	411.9	261.3	374.7	351.1	-	393.7	524.5	705.2	2.9 4)	5.5
Japan	-	26.7	42.0	71.7	70.2	67.3	86.8	82.4	60.0	82.5	82.7	89.5	106.0	160.1	235.2	9.8 5)	8.[illegible]
Brazil	-	-	-	-	-	3.7	-	6.5**	-	-	-	-	-	-	-	-	-

* calculated values in brackets ** estimates

1) 1968 2) since changed type of survey 3) GR 1970/78 4) GR 1965/77 5) GR 1965/78 6) GR 1977/90

Sources: Metal Statistics
European Aluminium Statistics
Annuario Estatistico da Associaçao Brasileir. do Aluminio
PROGNOS calculations

This because it is likely that individual segments within this field have widely varying prospects of development on account of the heterogeneity of the sectors as we shall see further down. In the case of the FRG it should moreover be mentioned that the officially reported figures of the past (av. growth: 2.9 %)[1] may give a wrong impression since the figures base on quantitative surveys (in tons) and not on deflated turnover values.

B. Qualitative tendencies and interview results

(1) The predictable prospects for the application of aluminium in the machine building industry can - according to the opinion of our interviewees - - be described as follows:

- The present application of die cast aluminium will in many cases be challenged by injection molded plastic, since in this sector, greater progress has been achieved in the past and can still be expected for the future. The advantages of injection molding are, listed in detail:
  . γrelation aluminium-plastic = 2.4 : 1
  . lower price of plastic
  . faster dyeing (during the casting process)
  . during eloxation of the die cast, streaks occur (which one hopes to be able to eliminate through new alloys)
  . greater development potential of the material (new types of material)
  . larger varieties of plastics
- Die cast aluminium is applied[2] where large series are produced and higher standards of wear resistance are demanded, e.g. for
  . air conditioning

1) cf Table IV
2) die cast aluminium is frequently used as substitute product for cast zinc.

. casings and casing connections, anchors of electro-motors
. molds for plastic products
. mountings and casings of machine tools

on the other hand less for

. office appliances
. household appliances.

- One user sector which has already grown markedly in the past and which will continue to create large demand for aluminium are aluminium engraving plates for the printing industry,
- thick aluminium plates for the machine tool industry
- profiles as parts of household or kitchen appliances.

5.6 Aluminium consumption in apparatus manufacture (refrigeration, chemical and food industry, agriculture)

A. Analysis of past development and basic forecasts

(1) Manufacture of apparatus mainly includes - at least as far as the aluminium-related market is concerned - the following products

- equipment for industrial refrigeration systems
- vessels for the chemical industry (mainly for petroleum, natural gas, and liquified gas)
- vessels for the food, beverages and tobacco industry
- vessels and stationary as well as mobile containers for agriculture.

If the volume of aluminium consumption on the market is only compared with total aluminium consumption in the countries under survey, apparatus construction appears insignificant since its share in total sales in 1978 was only between 1.4 % (USA) and 2.3 % maximum in Italy. The growth rate achieved in this sector more or less stagnated in the EC countries FRG, France, and Great Britain since 1971. In the other countries some increase is recorded, however with partly great fluctuations (cf. Table 26).

The cause in these widely differing and fluctuating developments is to be seen in

- the greatly varying structure of demand in the user countries
  . in the FRG and in Japan, the chemical industry was the major demander (FRG 1975 = 16.8 %)
  . in countries with a higher share of primary economic sectors in Gross National Product the application in agro industry dominates, e.g. in France (1975 share = 61.5 %) as in Italy and Spain.

- the very close substitutive relations to high-grade steel:
  Already the slightest price fluctuations of aluminium or steel could - in the chemical or brewery industry - change orders for aluminium vessels into decisions in favour of fine steel.

The reason why this sector in spite of a relatively small size and marked fluctuations of demand is not without interest for the semiproduct industry is due to the large specific order volume, mainly of rolled products, which may be linked with the construction of a vessel.

(2) Table 25 shows that changes in consumption between 1968 and 1975 - at least in the FRG - fluctuated very strongly, i.e. between an annual growth of 3.7 % down to a 14.8 % drop; moreover there are obviously very marked differences from one country to the next with regard to the consumer structure[1]. As already pointed out in the chapter on shipbuilding (5.2), even greater changes have to be expected in the future. In consideration of these arguments, the regression system, as it was applied to most of the other consumer sectors, could not be regarded as a suitable forecasting system.

1) On account of the lacking statistical material these differences could however only be determined quantitatively exactly in France, the FRG and in Belgium.

Building up on specific single forecasts by country of the four major application areas of aluminium in the apparatus manufacturing industry, we have undertaken additional structural estimates wherever detailed statements on aluminium consumption were not available. The trends of development thus arrived at will be presented here in three groups (cf. Table 26).

Group 1 with an annual growth rate of 7 - 10 % up to 1990

- Spain
- USA
- Japan
- France

Group 2 with an annual growth rate of 4 - 7 % up to 1990

- Italy
- Netherlands
- Belgium
- FRG

Group 3 with an annual growth rate under 4 % up to 1990

- Great Britain

On account of the structural assumptions these can only be regarded as data for orientation; for this reason we have - contrary to general usage - refrained from stating absolute values for each individual year under survey.

B. Qualitative tendencies and results of the technical interviews

(1) Manufacture of apparatus particularly strongly depends on innovation. Both the refrigeration sector and the chemical industry contribute to this state of affairs.

Table 25: Production of aluminium semiproducts for apparatus manufacture in the FRG 1968 - 1975

	Rolled products tons	Rods tons	Profiles tons	Tubes tons	Wires tons	Molded and forged parts tons	av.GR. 68/75 (ann. perc.)	Market share in total group (%) 5%	5% 10%	10% 20%	20% +
apparatus manufacture for chemical industry	86.6 90.8	4.1 1.1	3.2 4.1	4.5 2.8	0.2 0.3	1.4 1.0	- 3.2			x	
apparatus manufacture for food and beverages industry	81.1 40.1	1.5 1.7	17.0 50.9	0.4 7.3	0.0 -	0.0 -	-14.8	x			
apparatus manufacture for agro and forestry industry	24.4 62.7	- -	1.6 31.3	9.2 6.0	- -	64.9 -	+ 3.7	x			
Isolating sheets and strips	99.3 97.3	0.1 -	0.2 1.8	0.2 0.9	0.1 -	- -	- 2.5	x			
other apparatus manufacture	79.7 56.6	3.3 3.2	8.0 18.2	6.7 19.1	0.4 0.1	1.9 3.9	- 2.8			x	
total apparatus manufacture	84.2 77.4	3.2 1.7	6.0 10.8	4.5 8.2	0.2 0.2	1.8 1.8	- 3.9				x

Sources: Aluminium Semiproducts Association
PROGNOS calculations

Table 26: Aluminium end-consumption: Chemical and food industry and agriculture (1000 tons)

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	av.GR. 60/78 (ann. perc.)	av.GR. 78/90 (ann. perc.)
FRG	12.8	15.1	15.6 1)	22.4	19.7	17.8	10.0	18.9	13.8	14.8	14.0	10.5	- 1.1	4.0 > 7.0
France	4.3	5.4	7.6	7.4	10.5	9.5	11.4	11.7	9.7	13.4	10.0	10.9	5.3	7.0 >10.0
Great Britain	5.5	9.1	8.7	15.3	13.1	10.8	7.2	7.6	5.7	3.7	3.9	3.4	- 2.6	> 4.0
Italy	1.5	2.5	4.0	7.0	6.0	7.0	9.8	10.4	5.0	10.9	13.2	13.1	12.8	4.0 > 7.0
Netherlands	0.3	0.7	0.5	1.0	-	-	-	-	-	-	-	-	-	-
Belgium	1.4	0.8	1.3	1.1	1.0	1.6	1.9	1.4	0.7	1.0	0.6	0.8	- 3.1	4.0 > 7.0
Denmark	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spain	-	-	-	2.0	2.7	4.0	6.1	7.0	6.1	8.1	10.5	9.7	21.8 2)	7.0 >10.0
USA	-	24.9	27.7	36.7	36.3	35.4	46 7	73.9	44.9	49.9	80.3	-	10.2 3)	7.0 >10.0
Japan	-	8.8	16.7	33.0	38.4	48.8	69.8	39.6	28.4	38.2	34.3	35.2	11.0 4)	7.0 >10.0

1) 1968 2) GR 1970/78 3) GR 1965/77 4) GR 1965/78

Sources: Metal Statistics
European Aluminium Statistics
PROGNOS calculations

For industrial refrigerating facilities, aluminium sheets of large width and thicknesses are needed for inner coatings; therefore, relatively large demand for aluminium arises with the erection of one single plant.

Moreover, aluminium is also used for the cooling vanes of the plants themselves. The Vereinigte Deutsche Metallwerke (VDM) were the first to introduce a system using cooling vanes with inserted steel and were remarkably successful on the market.

(2) The chemical industry mainly uses vessels for liquids and also tubing made of aluminium. As already mentioned in the foregoing, substitution through rustproof steel is threatening here since the price ratio dropped from 1 : 2 to only 1 : 1.5.

Seawater desalting plants can also, in a wider sense, be attributed to the chemical industry. In view of a markedly rising worldwide demand, considerable growth of consumption of rolled aluminium sheets and profiles can also be expected.

A third application area with a large growth potential are liquid gas containers (mainly on tankers), since apart from oil drilling, a more complete utilization of this source of energy can be expected.

(3) Similar to the chemical industry, the brewery industry, too, requires large containers for storage and fermentation. Some enterprises which had been specializing in the manufacture of welded aluminium containers, have got into great straits through constantly rising aluminium prices. It should be considered to negotiate for long-range contracts with them, provided a fixed price would be granted for a relevant period as an equivalent. This is particularly true against the background of growing capacity utilization of

the container and vessel producers on account of large scale orders for the Near East and Africa.

Table 27: <u>Products which increasingly use aluminium within the sector manufacturing of appartus</u>

		EC - countries	Spain	USA	Japan	Developing countries
Refrigerating plants	(P/M)	1976: P 1980: B	ref. EC	ref. EC	ref. EC	ref. EC
Seawater desalting plants	(P/M)	-	-	-	-	1976: A 1980: B
Liquid gas containers	(P/M)	1976: P 1980: B (small market)	n.u.	1976: P 1980: B	ref. USA	-

Legend: page 58

5.7 Aluminium consumption in the electrical engineering sector

A. Analysis of past development and basic forecasts

(1) The variety of the product fields and the countries to be surveyed resulted in an agreement with the Client to the end that electrical engineering as sector of aluminium consumption will not be discussed.

On the other hand, it was obvious that in the technical interviews which were to serve the determination of

- product areas with great growth prospects and/or profitability
- countries with a great demand potential for aluminium products based on market or structural conditions,

all those sectors should be discussed in which aluminium could possibly find profitable application areas on account of its special characteristics. Since these preconditions to a great extent apply to electrical engineering, we shall in the following also present a short outline of the development of this sector.

(2) Within the scope of the analysis of past development it was found that electrical engineering - with a share fluctuating between 5.6 % in Italy and 17.0 % in France - in general was the fourth largest sector of aluminium consumption in 1974, after transport, construction, and packaging.

In Table 28, it can be seen that the share accounted for by blocks fluctuates between approx. 10 % (USA) and 40 % (Italy), depending on the structure of production. The fact that the share of cast steel in the FRG grew from

22 % in 1972 to 36 % in 1973 is connected with the changes in statistical classification: according to recommendations from OECD, the sector of electric consumer equipment and electric refrigerators (cf. Table 29) was detached from electrical engineering as from 1973 and placed in category G of OECD 'household appliances and office supply'.

In the varying growth rate of aluminium blocks for electrical engineering as shown in Table 28, the changing importance of the electrical engineering industry and its specific aluminium demand in each country is reflected: In the FRG, the USA, and above all in Great Britain it is receding, while in Italy, Japan, and France it is of growing importance.

(3) As shown in Table 30, the growth of total aluminium consumption in this sector in the highly industrialized countries (USA, FRG, The Netherlands, Great Britain) between 1960 and 1978 was rather weak, if compared with the development of the electrical engineering branch of industry as such.

(4) In this instance, too, the forecast was based on the method of approximation the main determinant, i.e. electrical engineering. The selection of this method was undertaken on account with the results of the interviews[1].

As a result of this manner of procedure the purely quantitatively statement can be made that aluminium consumption will in the future take a proportionate - in some countries even overproportionate - development as compared with that of electrical engineering (mainly in Italy, Japan).

1) With the exception of the USA where we had to resort to time series regressions due to the lack of basic figures. As regarded from our qualitative stage of information, the future development appears to us to be too low by approx. 3 % (cf. interview results).

Table 28: Development of cast aluminium production: Electrical engineering (1000 tons)

	1969	1970	1971	1972	1973	1974	av. GR. 69/74 annual percent.
FRG	27.5	26.6	24.1	24.1	26.9	26.4	-0.8
France	12.0	11.5	11.9	12.9	14.2	15.9	5.8
Great Britain	18.1	17.3	16.3	13.9	12.9	12.9	-5.1
Italy	7.9	10.0	10.0	10.5	13.2	12.1	8.9
USA	80.1	66.3	65.1	74.9	81.8	75.8	-1.1
Japan	-	-	25.5	27.9	35.8	32.8	8.8 1)
	Percentage of casting in total aluminium consumption in electronics (%)						
FRG	26.8	25.8	23.2	22.2	36.4	35.5	
France	19.4	2.3	2.5	2.5	18.3	20.2	
Great Britain	29.9	2.9	3.2	2.3	19.7	16.5	
Italy	28.2	2.3	2.5	2.3	45.5	36.0	
USA	1.7	11.5	1.3	1.4	10.5	9.7	
Japan	-	-	17.4	1.8	15.8	20.1	

1) 1971-1974

Sources: Organisation of European Aluminium Smelters
Metal Statistics
PROGNOS calculations

Table 29: Production of Aluminium semi products for electrical engineering in the FRG 1968 - 1975

	Rolled products tons	Rods tons	Profiles tons	Tubes tons	Wires tons	Molded and forged parts tons	Conducting material total tons	av.GR. 68/75 ann. perc.	Market share in total group (%)			
									- 5%	5% - 10%	10% - 20%	20% +
Generation and transformation of electricity	46.4 14.8	19.1 10.7	3.9 23.0	0.9 7.5	27.4 14.3	2.3 18.5	- 11.2	+ 2.4	x			
Distribution of electricity	0.9 1.5	3.1 0.1	0.7 0.8	0.7 0.1	93.4 0.5	1.2 0.5	- 96.6	+ 4.3				x
Electric appliances	68.4 38.6	5.1 1.9	15.8 47.4	7.8 7.0	0.7 0.5	2.2 0.5	- 4.1	+ 2.1	x			
Electric refriger-ators and freezers	04.9 91.3	0.6 0.2	7.3 4.2	7.0 4.2	0.2 -	0.0 0.1	- -	- 3.1		x		
Telecommunication and high frequency technology*	63.9 51.4	6.2 3.5	11.9 26.7	14.7 11.6	2.8 4.5	0.5 1.0	- 1.4	- 5.5		x		
Electric lamps	63.2 56.3	1.2 0.8	29.7 38.7	5.2 4.1	0.6 0.2	0.1 -	- -	+11.4	x			
Other electro-technical products	49.9 26.4	4.5 1.1	25.4 6.2	4.0 1.4	5.7 2.1	10.6 1.0	- 61.8	+32.2		x		
total	24.2 17.1	3.6 0.7	4.5 6.5	3.5 1.7	63.0 1.1	1.2 0.9	- 72.0	+ 4.0				

* Telecommunication and high frequency technology, electric measuring and control system

Sources: Aluminium Semiproduct Association Düsseldorf
PROGNOS calculations

Table 30: Aluminium end consumption: Electrical Engineering (1000 tons)

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av.GR. 60/78 (ann. perc.)	av.GR. 78/90 (ann. perc.)
FRG 1)	60.9	72.6	89.7 2)	103.0	104.1	108.5	73.0	74.4	67.2	67.8	54.4	61.5	81.9	92.2	101.8	0.1	4.3
France	31.0	30.4	44.2	56.7	65.3	66.4	77.5	78.7	73.2	85.0	85.0	90.2	100.6	135.9	184.4	6.1	6.1
Great Britain	35.3	59.3	62.6	64.6	56.0	56.0	65.4	78.2	66.1	63.1	54.6	53.1	59.6	79.7	114.4	2.3	6.6
Italy	10.5	[illegible]	17.0	34.0	31.0	37.0	29.0	33.6	28.0	27.7	29.5	31.1	37.7	57.7	89.7	6.2	9.2
Netherlands	3.0	6.5	4.5	6.0	6.5	(6.8)*	(7.3)*	(7.6)*	-	-	-	-	-	-	-	-	-
Belgium	0.6	1.1	2.0	5.0	5.6	4.8	6.5	6.7	6.3	6.6	5.1	5.5	6.2	8.9	12.3	13.1	7.0
Denmark	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spain	-	-	-	18.0	18.0	21.5	19.9	42.2	37.8	39.0	37.4	34.5	41.9	84.6	172.5	8.5 3)	14.4
USA	-	468.6	552.5	574.2	598.3	640.0	781.1	780.2	513.0	554.8	584.2	-	688.0	894.9	1,169.6	1.9 4)	5.5 6)
Japan	-	44.6	87.1	155.8	146.1	166.2	226.2	163.0	123.4	178.5	190.9	209.8	276.9	473.0	779.3	12.6 5)	11.6
Brazil	-	-	-	-	-	47.3	-	56.3	-	-	-	-	-	-	-	-	-

* calculated values in brackets

1) up to 1972 incl. office requirements 2) 1968 3) GR 1970/78 4) GR 1965/77 5) GR 1965/78 6) GR 1977/90

Sources: Metal Statistics
European Aluminium Statistics
Anuario Estatistico da Associaçao Brasileira do Aluminio
PROGNOS calculations

B. Qualitative tendencies and results of the interviews

(1) The semiproducts table 29 alone illustrates the fact that consumption of conducting material is way above that of all other semiproducts; according to OECD classification, i.e. without electric household appliances in France, the FRG, and Great Britain it even was approx. 80 %. Since in some countries, aluminium cables are today used as conducting material for voltage ranges up to 50 kV, this sector offers good market prospects - especially in countries with larger cabling projects, such as Japan and the developing countries.

It can moreover be assumed that aluminium - which has replaced copper as open-air transmission lines for some time already - will in the years to come quite generally displace copper in the cable sector too. Estimates of the current share are fluctuating, depending on the voltage group (1 kV to 50 kV) between 60 and 100 %.

On the other hand, it must also be expected that aluminium as coating material will largely or even entirely be substituted by plastics; in the same way, paper, now used as insulating and coating material of communication cables, will be largely substituted by plastics which are more resistant[1].

Apart from high tension cables, growing substitution of copper communication cables through aluminium is also to be expected within the period under survey. After Bell Telephone in the USA has decided for cost reasons (one-third cost saving) to carry out replacement investment in existing telephone lines with aluminium cables, this realization is spreading among European telephone companies (e.g. new investments of the British Post Office).

1) in this context it should be mentioned that France has recently bought large lots of 'Properzi' wire.

(2) A further penetration of aluminium in house cabling is moreover to be expected, to begin with mainly in the form of bus-bars. By means of copper plating according to the principle of ASEA, Västerås (Sweden) a practically equally good conductivity as that of copper is given, taking the skin effect into account. Some problems arising in clamping of aluminium lines are today no longer regarded as grave handicaps.

(3) A third application area which also promises a great increase in volume of aluminium conducting materials is seen in the use of aluminium in electric motorcar fittings. The clamping problems which will still have to be overcome here appears to be more serious, and more insulation would be necessary in the case of copper substitution, due to the larger diameter of the cables. It must be considered however that research efforts in this sector are very intensive on account of the existing and probably even strongly increasing costwise advantages.

(4) In former classifications, household appliances - as already mentioned - were also recorded in the electro-technical sector. Although this is no longer the case today it should all the same be pointed out that aluminium profiles, sheets and piping are increasingly used in household refrigerating equipment.

Table 31: Products of electrical engineering with growing application of aluminium

		EC - countries	Spain	USA	Japan	Developing countries
Open-air transmission lines	(CM)	no special growth	cf. EC	cf. EC	cf. EC	since 1977: B
Cables	(CM)	since 1977: I 1980: B	1980: B	1976: B	since 1977: B (market growth)	since 1977: B
Communication cables	(CM)	1980: B	-	since 1977: B	since 1977: B	-
House cabling	(CM)	1976: F 1985: B	cf. EC	cf. EC	cf. EC	-
Electric motorcar equipment	(CM)	cf. USA	cf. USA	since 1977: F 1980/85 : I/B	cf. USA	-
Household appliances	(M)	1976: P 1980: I	cf. EC	cf. EC	cf. EC	-

Legend: cf. page 58

APPENDIX OF TABLES

Table 1: Development of population (millions of inhabitants)

Country	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av.GR 60/78 ann. perc.	av.GR 73/90 ann. perc.
FRG	55.43	58.62	58.29	60.65	61.30	61.67	61.98	62.05	61.83	61.51	61.40	61.34	60.75	59.56	58.30	0.6	-0.4
France	45.68	48.76	49.55	50.77	51.25	51.70	52.13	52.49	52.74	52.92	53.12	53.28	53.53	54.12	54.60	0.9	0.2
Great Britain	52.56	54.38	54.93	55.52	55.71	55.89	56.02	56.05	55.96	55.93	55.85	55.82	55.71	55.45	55.25	0.3	-0.1
Italy	50.20	51.99	52.67	53.66	54.01	54.41	54.90	55.41	55.81	56.19	56.45	56.72	56.99	57.67	58.30	0.7	0.2
Netherlands	11.49	12.29	12.60	13.03	13.19	13.33	13.44	13.55	13.65	13.77	13.85	13.94	14.04	14.29	14.55	1.1	0.4
Belgium	9.15	9.45	9.56	9.64	9.67	9.71	9.74	9.77	9.80	9.83	9.83	9.84	9.84	9.85	9.87	0.4	0.0
Denmark	4.58	4.76	4.84	4.93	4.96	4.99	5.02	5.05	5.06	5.07	5.09	5.11	5.11	5.13	5.14	0.6	0.0
Spain	30.35	32.06	32.73	33.78	34.13	34.49	34.86	35.60	36.03	36.46	36.89	37.30	37.73	38.79	39.80	1.2	0.5
USA	180.68	194.30	198.71	204.88	207.05	208.85	210.41	211.90	213.54	214.65	216.82	217.90	220.47	227.18	234,70	1.0	0.6
Japan	93.40	98.30	100.40	103.70	105.30	107.00	109.70	110.16	111.57	112.77	113.86	-	114.10	118.10	122.30	1.2	0.7
Brazil	69.70	80.60	85.40	93.10	95.60	98.20	102.20	106.40	109.40	112.40	115.60	-	122.90	139.90	159.90	3.0	2.6
Iran	21.60	25.20	26.80	29.40	30.30	31.20	32.20	33.20	34.10	34.70	35.40	-	30.30	43.10	48.50	2.9	2.4
Turkey	27.50	31.10	32.70	35.20	36.20	37.00	37.90	38.90	39.80	40.70	41.70	-	43.60	47.90	52.60	2.5	1.9

Sources: PROGNOS Euro-Report
Annual Statistics of the countries under survey
PROGNOS calculations

Table II: Total Aluminium consumption (1000 tons)

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	av.GR 60/78 ann.percent.
FRG	428.7	585.5	587.2	881.0	918.3	969.6	1,140.8	1,145.5	957.4	1,263.7	1,251.6	1,336.4	6.5
France	240.2	310.4	374.8	491.6	475.2	510.2	504.6	596.7	513.0	629.3	675.6	683.0	6.0
Great Britain	481.3	528.7	530.8	602.9	613.3	608.0	687.6	681.2	665.2	617.7	588.2	567.6	0.9
Italy	143.0	195.0	281.0	420.0	402.0	458.0	532.0	579.0	445.0	590.0	636.0	668.0	8.9
Netherlands	20.0	20.3	28.0	69.8	72.8	89.0	114.6	120.1	93.8	130.2	142.5	138.7	11.4
Belgium	66.3	117.8	134.7	176.9	193.1	203.8	225.7	238.7	180.9	246.8	238.9	256.6	7.8
Denmark	-	-	12.3	16.5	16.6	10.0	12.4	12.6	13.5	17.0	17.9	18.0	3.5 3)
Spain	25.0	76.0	92.7	156.1	179.4	204.1	223.1	262.7	252.4	266.7	290.8	272.8	14.2
USA	1,942.6	3,626.1	3,940.7	4,425.4	4,930.8	5,320.3	6,196.6	6,290.5	4,386.3	5,825.0	6,212.0	6,445.4	6.9
Japan	200.0	403.8	692.9	1,187.4	1,125.7	1,514.5	1,975.1	1,638.3	1,484.0	1,956.7	1,809.8	2,164.0	14.1
Brazil	-	54.6	81.7	90.2	114.1	150.8	176.1	207.6	229.8	246.3	283.4	282.2	13.5 1)
Iran 2)	-	3.0	3.9	5.8	5.8	7.0	17.7	26.3	27.3	38.6	43.5	53.4	24.8 1)
Turkey 2)	-	2.4	9.3	13.7	27.7	28.7	36.7	52.2	60.1	68.1	78.0	45.0	25.3 1)

1) av. GR 65/78

2) Consumption of metallurgic aluminium

3) av. GR 67/78 annual percentage

Sources: Metal Statistics 1968 - 1978
European Aluminium Statistics 1978
PROGNOS calculations

Table III: Per capita consumption of aluminium (in kg)

country	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	av.GR 60/78 ann. percent.
FRG	7.2	9.1	8.8	13.7	14.6	15.3	17.6	16.4	14.6	19.3	18.9	19.5	5.7
France	4.9	5.5	6.4	8.8	8.9	9.8	11.3	11.3	9.2	12.0	11.8	11.5	4.9
Great Britain	7.8	9.0	8.8	11.1	9.7	11.2	12.3	12.1	9.8	11.2	10.8	11.0	1.9
Italy	2.9	3.6	5.2	7.5	7.1	7.9	9.4	10.5	7.5	9.8	10.7	11.0	7.7
Netherlands	3.4	2.9	3.9	6.0	7.1	6.8	8.5	11.0	8.4	13.2	11.4	11.4	7.0
Belgium	3.2	3.7	5.0	7.3	7.7	8.1	10.1	10.7	6.5	11.2	9.2	10.2	6.7
Denmark	4.3	6.5	-	9.9	9.6	-	10.9	10.8	8.2	11.3	10.6	11.3	5.5
Spain	-	-	-	4.0	4.2	5.4	6.0	7.2	6.6	7.0	7.8	7.1	7.4 1)
USA	10.8	18.6	19.0	20.4	22 2	25.3	29.5	27.4	20.3	26.0	27.4	29.7	5.8
Japan	2.0	3.9	6.5	11.2	11.7	14.7	16.9	14.5	12.2	16.1	15.8	19.0*)	13.3
Brazil	-	0.7	1.0	1.0	1.2	1.5	1.6	2.0	2.1	2.2	2.5	-	11.2 2)
Turkey	-	0.07	0.28	0.39	0.77	0.78	0.97	1.34	1.51	1.67	1.87	-	31.5 2)

1) av. GR 1970/78 annual percentage

2) av. GR 1965/77 annual percentage

*) estimate

Sources: European Aluminium Statistics
PROGNOS calculations

Table IV: DEVELOPMENT OF SELECTED ECONOMIC SECTORS AND THEIR ALUMINIUM CONSUMPTION IN THE FRG (1960 - 1990)

	1960	1965	1968	1970	1971	1972	1973	1974	1976	1976	1977	1978[4)]	1980	1985	1990	av.GR 60/78	av.GR [illegible]4/90
	absolute value in DM 100 millions[1) 3)]																
- Transport equipm.	(127)	172	185	247	246	247	270	246	260	297	314	314	323	346	370		
- Machine building industry	(227)	262	281	322	320	316	340	349	324	329	347	351	372	427	481		
- Electrical ind.	(154)	194	220	289	293	308	350	379	351	399	421	428	472	597	732		
- Construction ind.	(353)	535	525	582	626	665	667	611	574	594	606	651	668	710	743		
GDP	4,260	5,461	5,940	6,788	7,007	7,263	7,618	7,660	7,601	7,917	8,138	8,388	8,847	10,083	11,382		
	av. GR over preceding period (annual percentage)																
- Transport equipm.	-	-	12.1	11.8	-0.4	0.4	9.3	-8.5	[illegible]	14.3	6.6	0.0	1.4	1.4	1.4	6.2	1.4
- Machine building industry	-	-	8.5	-2.1	-0.6	-1.3	7.6	2.6	-7.1	1.4	6.6	1.0	2.9	2.8	2.4	2.5	2.7
- Electrical ind.	-	-	17.0	10.3	1.4	5.1	13.6	8.3	-7.3	13.4	6.6	1.7	6.0	4.8	4.1	5.8	4.6
- Construction ind.	-	-	-0.1	6.2	7.6	6.3	0.2	-8.3	-6.2	3.6	1.8	7.7	1.3	1.2	0.9	3.6	1.1
GDP	-	-	6.3	6.0	3.2	3.7	4.9	0.6	-2.1	6.6	2.8	3.1	2.7	2.6	2.5	3.8	2.6

Table IV (cont.): Consumption of metallurgical and remelt aluminium by application areas in the FRG 1960 - 1990

	1960	1965	1968[2]	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av. GR 60/78	av. GR 70/90
	Consumption in 1000 kg																
Transport	97,700	141,800	145,200	191,600	184,800	187,600	208,000	174,400	171,000	220,200	242,000	265,900	300,100	376,800	470,500		
Machine building incl. precision and optical instruments	44,200	58,100	55,900	62,700	57,300	61,100	74,600	78,800	55,300	71,400	74,600	73,900	92,000	126,000	183,400		
Electr. engineering	60,900	72,600	89,700	103,000	104,100	108,500	74,000	74,400	67,200	67,800	54,400	61,600	81,900	92,200	101,800		
Construction	24,400	47,500	80,800	112,200	137,200	149,300	172,600	144,900	137,400	183,200	168,800	176,200	175,800	245,400	331,600		
Packaging	34,600	42,700	53,500	69,200	73,700	83,900	92,000	91,400	79,700	93,400	91,900	93,600	112,000	144,300	181,600		
Others	99,200	111,300	149,300	161,900	163,100	166,900	234,700	247,600	207,800	262,000	249,900	242,000					
Total	361,000	474,000	575,400	700,600	720,200	757,300	855,800	811,600	718,400	898,000	881,600	903,100					
	av. GR over preceding period (annual percentage)																
Transport	-	7.7	0.8	14.9	-3.5	1.5	10.9	-16.2	-1.9	28.8	9.9	5.7	8.3	4.6	4.6	5.5	5.2
Machine building incl. precision and optical instruments	-	5.6	-0.7	5.0	-8.6	6.6	21.9	5.6	-29.5	29.1	4.3	-0.8	11.6	6.6	7.8	2.9	7.9
Electr. engineering	-	3.6	7.3	7.1	1.1	4.2	-31.8	0.5	-9.7	0.9	-19.8	13.1	16.4	2.4	2.0	0.1	4.3
Construction	-	14.3	19.4	17.8	22.3	8.8	15.6	-16.0	-5.2	33.3	-7.9	4.4	-0.1	6.9	6.2	11.6	5.4
Packaging	-	4.3	7.8	13.7	6.5	13.8	9.7	-0.7	-12.8	17.2	-1.6	1.8	9.4	5.2	4.7	5.7	5.7
Others	-	2.3	10.3	4.1	0.7	2.3	40.6	5.5	-16.1	26.1	-4.6	-3.2				5.1	
Total	-	5.6	6.7	10.3	2.8	5.2	13.0	-5.2	-11.5	25.0	-1.8	2.5				5.2	

1) at 1970 prices

2) For the FRG, 1968 figures were used instead of those of 1967 in coordination with the semiproducts statistics

3) Estimated values in brackets

Sources: OECD, Metal Statistics
PROGNOS Euro-Report 76
PROGNOS calculations

Table V: DEVELOPMENT OF SELECTED ECONOMIC SECTORS AND THEIR ALUMINIUM CONSUMPTION IN FRANCE 1960 - 1990

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990		
	absolute value in Ffrs. billions 1) 2)																
- Transport equipm.	(13.8)	(17.9)	(18.6)	25.8	28.9	32.2	34.3	32.8	32.8	40.2	41.6	41.7	44.0	60.2	66.8		
- Machine building industry	(15.2)	(18.2)	(22.0)	29.9	33.4	33.7	36.6	39.7	38.3	39.4	39.1	40.1	43.6	53.1	64.0		
- Electrical ind.	(7.2)	(11.9)	(15.0)	18.9	21.0	22.7	26.3	28.6	28.3	31.0	32.2	32.9	37.2	60.3	67.3		
- Construction ind.	(44.7)	(46.8)	49.8	58.3	69.8	63.1	61.9	64.1	66.6	63.8	63.3	62.6	66.0	76.8	87.0		
GDP	444.6	589.5	653.3	783.0	825.6	872.2	920.7	950.2	953.3	997.4	1,027.9	1,064.1	1,136.6	1,333.1	1,662.9		
	av. GR over preceding period (annual percentage)															av. GR 60/78	av. GR 78/90
- Transport equipm.	-	5.4	1.9	11.6	12.0	11.4	6.5	-4.7	0.0	22.8	3.3	0.4	2.8	2.7	2.2	6.3	2.6
- Machine building industry	-	3.7	9.9	10.7	11.7	0.9	8.3	8.8	-3.9	2.8	0.6	2.4	4.1	4.1	3.8	5.6	4.0
- Electrical ind.	-	10.5	12.2	7.9	11.1	8.1	15.9	8.0	-0.8	9.4	3.9	2.4	6.3	6.2	6.0	8.8	6.1
- Construction ind.	-	0.8	3.5	5.4	2.6	5.5	-2.1	3.7	2.3	-2.7	-0.8	-1.3	2.8	2.8	2.8	1.9	2.8
GDP	-	5.8	4.4	5.8	5.4	5.6	5.6	3.2	0.3	4.6	3.1	3.5	3.3	3.3	3.1	5.0	3.2

Table V (cont.): Consumption of metallurgical and remelt aluminium by application areas in France 1960 - 1990

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av. GR 60/78	av. GR 78/90
	consumption in 1000 kg																
Transport	67,314	93,132	102,555	144,975	145,000	163,269	166,494	153,990	138,188	172,822	174,033	182,600	221,700	306,700	422,200		
Machine building incl. precision and optical instruments	20,024	23,100	25,144	31,393	27,290	36,128	33,580	36,905	29,596	32,016	36,474	28,600	32,900	41,900	56,900		
Electr. engineering	30,998	30,399	44,193	56,742	65,329	66,434	77,473	78,672	73,200	85,036	85,046	90,200	100,600	135,900	184,400		
Construction	15,296	23,708	28,720	33,448	33,565	42,253	53,341	53,252	41,691	56,412	54,967	54,000	66,800	92,700	130,700		
Packaging	21,796	26,488	27,225	38,979	42,204	44,893	46,317	50,704	42,031	47,769	49,537	50,200	68,300	75,900	98,700		
Others	62,966	69,658	79,863	87,379	95,462	97,151	112,141	130,577	107,357	126,107	119,667	124,300	-	-	-		
Total	218,394	266,485	307,700	392,916	408.850	450,118	489,346	504,095	431,863	520,162	518,603	529,900					
	av. GR over preceding period (annual percentage)																
Transport	-	6.7	4.5	12.2	0.0	12.6	2.0	-7.5	-10.3	25.1	0.7	4.9	10.2	6.7	6.6	5.7	7.2
Machine building incl. precision and optical instruments	-	2.9	4.3	7.7	-13.1	32.4	-7.1	9.9	-19.8	8.2	10.8	-19.4	7.2	5.0	6.3	2.0	5.9
Electr. engineering	-	0.4	20.6	8.7	15.1	1.7	16.6	1.5	-7.0	16.2	0.0	6.1	5.6	6.2	6.3	6.1	6.1
Construction	-	9.2	10.1	5.2	0.3	25.9	26.2	-0.2	-21.9	35.6	-2.6	-1.7	10.4	7.1	7.1	7.3	7.6
Packaging	-	4.0	1.4	12.7	8.3	6.4	3.2	9.5	-17.1	13.6	3.7	1.3	7.8	5.4	5.4	4.7	6.6
Others	-	2.0	7.1	3.0	9.3	1.8	15.4	16.4	-17.9	17.6	-6.2	4.0				3.9	
Total	-	4.1	7.5	8.5	4.1	10.1	8.7	3.6	-14.8	20.4	-0.3	2.2				5.0	

1) at 1970 prices

2) estimated values in brackets

Sources: OECD, Metal Statistics
PROGNOS Euro-Report 76
PROGNOS calculations

Table VI: DEVELOPMENT OF SELECTED ECONOMIC SECTORS AND THEIR ALUMINIUM CONSUMPTION IN THE UNITED KINGDOM 1960 - 1990

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av.GR 60/78	av.GR 78/90
	absolute value in £ millions 1) 2)																
Transport	111,374	121,047	124,414	134,000	127,809	131,825	158,190	143,682	117,233	123,741	114,969	103,600	122,200	134,200	147,500		
Machine building incl. precision and optical instruments	26,652	26,559	25,401	28,300	23,946	24,994	36,467	41,588	31,323	34,930	30,871	23,000	26,700	33,000	42,500		
Electr. engineering	35,274	59,289	62,648	64,600	66,006	66,012	65,378	78,158	66,105	63,126	54,621	53,100	69,600	79,700	114,400		
Construction	31,526	36,692	34,476	36,000	34,416	42,238	54,907	61,979	61,602	69,820	65,682	69,100	64,700	88,600	121,400		
Packaging	29,235	29,537	30,931	35,100	33,954	38,290	47,719	53,991	43,118	45,341	60,478	49,100	54,100	70,100	91,200		
Others	117,369	129,604	123,905	157,000	142,444	169,670	161,772	160,733	129,773	158,070	164,476	164,900					
Total	351,430	402,728	401,775	455,000	418,575	453,029	524,433	540,131	430,754	485,027	470,987	463,600					
	av. GR over preceding period (annual percentage)																
Transport	-	1.7	1.4	2.5	-4.6	3.1	20.0	-9.2	-18.4	5.6	-7.1	-9.9	8.6	1.9	1.9	-0.4	3.0
Machine building incl. precision and optical instruments	-	-0.1	-2.2	3.7	-15.4	4.4	45.9	14.0	-24.7	11.5	-11.6	-22.9	7.9	5.2	5.2	-0.6	5.0
Electr. engineering	-	10.[illegible]	2.0	1.0	-13.3	0.0	16.7	19.6	-16.4	-4.5	-13.6	-2.8	5.9	6.0	7.5	2.3	6.6
Construction	-	3.[illegible]	-3.1	1.5	-4.4	22.7	30.0	12.9	-16.9	16.2	-7.1	6.3	4.6	6.5	6.5	3.6	6.2
Packaging	-	0.2	2.3	4.3	-3.3	12.8	24.6	13.1	-20.2	5.2	11.3	-2.7	5.0	5.3	5.4	2.9	5.3
Others	-	2.0	-2.2	8.2	-9.3	12.1	1.3	-0.6	23.3	22.1	4.1	0.3				1.9	
Total	-	2.8	-0.1	4.2	-8.0	8.2	15.8	3.0	-7.7	10.5	-2.9	-3.7				1.4	

Table VI (cont.): Consumption of metallurgical and remelt aluminium by application areas in the United Kingdom 1960 - 1990

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978 3)	1980	1985	1990	av. GR 60/78	av. GR 78/90
	consumption in 1000 kg																
- Transport equipm.	(1,479)	1,579	1,550	1,645	1,612	1,678	1,692	1,653	1,650	1,509	1,539	1,508	1,545	1,642	1,739		
- Machine building industry	(1,192)	1,545	1,649	1,868	1,870	1,775	1,931	1,993	1,994	1,916	1,914	1,914	2,030	2,309	2,811		
- Electrical Ind.	(747)	546	1,105	1,253	1,286	1,380	1,575	1,650	1,433	1,390	1,452	1,495	1,692	1,862	2,177		
- Construction Ind.	(2,112)	2,712	2,869	2,855	2,938	2,909	3,048	2,731	2,601	2,642	2,627	2,720	2,789	2,996	3,335		
GDP	38,592	45,163	47,209	50,794	52,127	53,404	57,622	56,591	55,608	57,601	58,264	60,292	62,728	69,257	76,465		
	av. GR over preceding period (annual percentage)																
- Transport equipm.	-	(1.3)	-1.3	-3.7	-2.0	4.1	0.8	-2.3	-5.7	-3.1	2.0	-2.0	1.2	1.2	1.2	0.1	1.2
- Machine building industry	-	(5.3)	0.5	3.1	0.1	-5.1	8.8	3.2	0.1	-3.9	-0.1	0.0	3.2	3.2	3.3	2.7	3.3
- Electrical Ind.	-	(4.8)	7.1	3.0	2.6	7.3	14.4	-1.8	-7.5	-3.0	4.5	3.0	3.2	3.2	3.2	3.9	3.8
- Construction Ind.	-	(4.4)	3.8	-1.9	2.9	1.7	2.0	-10.4	-5.5	-1.5	-0.6	7.6	1.3	1.4	2.2	1.4	1.7
GDP	-	3.2	2.6	2.6	2.6	2.4	7.9	-1.8	-1.7	3.6	1.2	3.5	2.0	2.0	2.0	2.6	2.0

1) at 1970 prices
2) estimated values in brackets

Sources: OECD, Metal Statistics
PROGNOS Euro-Report 76
PROGNOS calculations

Table VII: DEVELOPMENT OF SELECTED ECONOMIC SECTORS AND THEIR ALUMINIUM CONSUMPTION IN ITALY 1960 - 1990

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av. GR 60/78	av. GR 78/90
	absolute value in Lit. billions[1) 2)]																
Transport	57,000	75 000	114,000	140,000	138,000	145,000	133,600	145,300	112,600	150,200	168,400	177,000	210,700	324,200	496,500		
Machine building incl. precision and optical instruments	9,500	14,000	20,000	25,000	23,000	26,000	40,000	42,700	25,400	37,900	42,100	39,800	42,000	58,900	81,000		
Electr. engineering	10,500	11,000	17,000	34,000	31,000	37,000	29,000	33,600	28,000	27,700	29,500	31,100	37,700	57,700	89,700		
Construction	14,000	20,000	26,000	53,000	48,000	58,000	93,700	115,500	79,500	110,000	111,300	117,600	140,000	190,900	249,500		
Packaging	13,500	16,500	23,000	35,000	35,000	42,000	58,000	54,000	36,300	52,400	52,400	60,500	66,400	89,300	118,400		
Others	32,100	35,000	50,100	87,900	81,500	92,700	113,400	119,000	100,850	124,350	137,100	133,400					
Total	136,600	171,500	250,100	374,900	356,500	400,700	467,700	510,100	382,650	502,550	540,800	559,400					
	av. GR over preceding period (annual percentage)																
Transport	-	5.6	23.3	7.1	-1.4	5.1	-7.9	8.8	-2.3	2.7	1.0	0.5	9.1	9.0	8.9	6.5	9.0
Machine building incl. precision and optical instruments	-	8.1	19.5	7.7	-8.0	13.0	53.8	6.8	-4.6	3.7	1.0	-0.5	2.7	7.0	6.6	8.3	6.1
Electr. engineering	-	0.9	24.3	26.0	-8.8	19.4	21.6	15.9	-1.6	-0.1	0.6	0.5	10.1	8.9	9.2	6.2	9.2
Construction	-	7.4	14.0	26.8	-9.4	20.8	61.6	23.3	-3.3	3.0	0.1	0.5	9.1	6.4	5.5	12.6	6.5
Packaging	-	4.1	18.1	15.0	0.0	20.0	38.1	-6.9	-3.5	3.4	0.0	1.3	4.8	6.1	5.8	8.7	5.8
Others	-	1.7	19.6	20.6	-7.3	13.7	22.3	4.9	-1.5	1.9	0.9	-0.2	-	-	-	8.2	
Total	-	4.7	20.8	14.4	-4.9	12.4	16.7	9.1	-2.6	2.5	0.7	0.3	-	-	-	8.1	

Table VII (cont.) Consumption of metallurgical and remelt aluminium by application areas in Italy 1960 - 1990

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978 3)	1980	1985	1990	av.GR 60/78	av.GR 78/90
	consumption in 1000 kg																
- Transport equipm.	(487)	650	880	1,070	1,070	1,110	1,230	1,280	1,200	1,300	1,360	1,518	1,637	1,954	2,231		
- Machine building industry	(913)	930	1,340	1,570	1,620	1,490	1,700	1,990	1,800	1,970	2,000	2,072	2,258	2,770	3,267		
- Electrical ind.	-	530	710	990	940	580	1,090	1,220	1,150	1,200	1,240	1,266	1,408	1,818	2,254		
- Construction ind.	(3,054)	4,000	4,250	4,910	4,676	4,718	4,861	4,969	4,599	4,566	4,539	4,601	4,749	5,167	5,485		
GDP	33,660	43,390	49,135	57,937	58,836	60,689	64,905	67,660	65,320	69,072	70,226	71,630	76,992	87,754	99,771		
	av. GR over preceding period (annual percentage)															av.GR 60/78	av.GR 78/90
- Transport equipm.	-	5.9	7.3	18.9	0.0	3.7	10.8	4.1	-6.3	8.3	4.6	11.6	3.8	3.6	2.7	6.6	3.3
- Machine building industry	-	0.4	16.5	13.8	-3.2	-2.0	14.1	17.1	-9.6	9.4	1.6	3.6	4.4	4.2	3.4	4.7	3.9
- Electrical ind.	-	-	20.3	20.7	-5.1	4.3	11.2	11.9	-5.7	4.3	3.3	2.1	5.6	5.2	4.4	6.9 3)	4.9
- Construction ind.	-	5.5	5.7	-1.2	-4.8	0.9	3.0	2.2	-7.4	-0.7	-0.6	1.4	1.6	1.6	1.4	2.3	1.5
GDP	-	5.2	6.4	5.7	1.6	3.1	6.9	4.2	-3.6	5.7	1.7	2.0	3.0	2.9	2.6	4.3	2.8

1) at 1970 prices
2) calculated values in brackets
3) estimated values

Sources: Annuario Statistico Italiano, Edizione 1975
OECD, Metal Statistics
PROGNOS Euro-Report 76
PROGNOS calculations

Table VIII: DEVELOPMENT OF SELECTED ECONOMIC SECTORS AND THEIR ALUMINIUM CONSUMPTION IN THE NETHERLANDS 1960 - 1990

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av.GR 60/78	av.GR 78/90
	absolute value in Fls. 10 millions[1) 2)]																
- Transport equipm.	(123)	(156)	(169)	218	230	233	231	207	201	195	191	182	187	200	212		
- Machine building industry	(294)	(411)	(460)	547	550	552	580	623	575	596	607	595	618	681	751		
- Electrical ind.	(163)	279	308	433	452	465	-	-	-	-	-	-	-	-	-		
- Construction ind.	(464)	(639)	(570)	820	861	852	845	707	771	755	801	806	838	925	1,021		
GDP	6,850	8,685	9,408	11,458	11,959	12,428	13,161	13,714	13,590	14,199	14,537	14,900	15,777	18,183	20,876		
	av. GR over preceding period (annual percentage)																
- Transport equipm.	-	(4.9)	(4.0)	(8.9)	5.5	1.4	-0.9	-10.4	-2.9	-3.0	-2.1	-4.7	1.4	1.4	1.1	2.2	1.3
- Machine building industry	-	6.9	5.8	6.0	0.5	0.5	5.1	7.4	-7.7	3.7	1.8	-2.0	1.9	2.0	2.0	4.0	2.0
- Electrical ind.	-	11.3	5.1	12.0	4.4	2.9	-	-	-	-	-	-	-	-	-	-	-
- Construction ind.	-	(6.6)	(8.3)	(3.0)	5.0	-1.0	-0.9	-6.9	-2.0	-2.1	6.1	0.6	2.0	2.0	2.0	3.1	2.0
GDP	-	(4.9)	4.1	6.8	4.4	3.9	5.9	4.2	-0.9	4.5	2.4	2.5	2.9	2.9	2.8	4.4	2.9

Table VIII (cont.): Consumption of metallurgical and remelt aluminium by application areas in the Netherlands 1960 - 1990

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av.GR 60/74	av.GR 74/90
	consumption in 1000 kg[2]																
Transport	2,500	5,500	5,000	7,000	7,500	(7,776)	(7,690)	(6,674)					11,442	16,168	19,999		
Machine building incl. precision and optical instruments	2,600	6,500	4,500	6,000	6,000	(6,383)	(6,776)	(7,398)					8,726	10,724	13,167		
Electr. engineering	3,000	6,500	4,500	6,000	6,500	(6,752)	(7,268)	(7,608)					11,317	16,071	20,144		
Construction	5,000	10,000	14,500	23,000	26,000	(23,403)	(23,403)	(19,479)					29,938	36,199	43,682		
Packaging	5,000	9,500	11,500	17,000	17,500	(20,277)	(22,423)	(24,078)					40,134	60,895	92,339		
Others	11,900	16,650	12,500	21,000	20,800	(27,772)	(32,157)	(40,473)									
Total	30,000	54,650	62,500	80,000	84,300	(92,362)	(99,171)	(105,702)									
	av. GR over preceding period (annual percentage)																
Transport	-	17.1	-4.7	11.9	7.1	3.7	-1.1	-13.2					9.4	6.8	6.7	7.3	7.1
Machine building incl. precision and optical instruments	-	20.1	-16.8	10.1	0.0	6.4	6.2	9.0					2.8	4.2	4.2	7.7	3.7
Electr. engineering	-	16.7	-16.8	10.1	8.3	3.9	7.6	4.7					6.3	6.9	6.0	6.9	6.3
Construction	-	14.9	20.4	16.6	13.0	-10.0	0.0	-16.8					7.4	3.9	3.8	10.2	6.2
Packaging	-	13.7	10.0	13.9	2.9	15.9	10.6	7.4					8.9	8.7	8.7	11.9	8.8
Others	-	6.9	-13.4	18.9	-1.0	33.5	16.8	25.9									
Total	-	12.7	-2.0	15.1	5.4	9.6	8.0	6.0									

1) at 1970 prices

2) calculated values in brackets

Sources: OECD, Metal Statistics
PROGNOS Euro-Report 76
PROGNOS calculations

Table IX: DEVELOPMENT OF SELECTED ECONOMIC SECTORS AND THEIR ALUMINIUM CONSUMPTION IN BELGIUM (INCLUDING LUXEMBURG) 1960 - 1990

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990		
	absolute value in B.Frs. billions[1) 2)]																
- Transport equipm.	136	193	212	276	304	326	354	335	354	392	387	400	423	486	560		
- Machine building industry	175	265	264	304	286	301	349	392	377	373	380	376	406	489	576		
- Electrical ind.	208	280	280	365	368	403	449	600	491	527	521	630	583	734	908		
- Construction ind.	(632)	762	820	886	897	915	965	1,009	1,007	1,071	1,099	1,105	1,150	1,272	1,406		
GDP	8,245	10,119	10,841	12,809	13,339	14,110	15,023	15,736	15,398	16,273	16,489	16,753	17,739	20,445	23,471		
	av. GR over preceding period (annual percentage)															av.GR 60/78	av.GR 78/90
- Transport equipm.	-	7.3	6.5	5.7	10.1	7.2	8.6	-5.4	5.7	10.7	-1.2	3.2	2.8	2.8	2.9	6.2	2.8
- Machine building industry	-	8.7	-5.4	5.2	-5.9	5.2	15.9	12.3	-3.8	-1.1	1.9	-1.2	3.9	3.8	3.3	4.3	3.6
- Electrical ind.	-	6.1	1.4	8.3	0.8	9.5	11.4	11.4	-1.8	7.3	-1.2	2.8	4.8	4.7	4.3	5.3	4.6
- Construction ind.	-	3.8	3.9	12.5	1.2	2.0	5.4	4.6	-0.3	6.4	2.6	0.6	2.0	2.0	2.0	3.2	2.0
GDP	-	4.1	4.0	6.3	4.1	5.8	6.5	4.7	-2.1	5.7	1.3	1.6	2.9	2.9	2.8	4.0	2.8

Table IX (cont.): Consumption of metallurgical and remelt aluminium by application areas in Belgium (incl. Luxemburg) 1960 - 1990

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av.GR 60/78	av.GR 78/90
	consumption in 1000 kg																
Transport	1,160	2,421	1,903	2,885	3,135	3,063	3,867	4,295	1,688	2,634	2,686	2,409	2,779	4,046	6,944		
Machine building incl. precision and optical instruments	869	1,604	504	1,417	1,149	1,642	2,948	4,482	1,639	1,909	1,646	1,720	1,756	2,904	4,169		
Electr. engineering	632	1,149	2,032	5,003	5,636	4,831	6,496	6,662	6,298	6,503	5,120	5,456	6,188	8,926	12,344		
Construction	3,138	8,749	11,869	16,139	11,000	12,024	16,124	27,443	14,260	15,809	14,010	12,363	13,641	19,440	27,909		
Packaging	939	3,231	3,794	4,989	3,364	8,120	3,877	6,588	5,762	9,077	8,937	6,879	8,024	13,643	22,989		
Others	5,397	16,797	10,994	18,298	28,872	17,589	20,243	13,339	8,956	19,283	10,326	10,766					
Total	12,135	33,951	31,096	48,731	53,156	47,269	53,545	62,809	38,693	55,296	42,724	39,682					
	av. GR over preceding period (annual percentage)																
Transport	-	15.9	-11.3	14.9	8.7	-2.3	25.9	11.4	-60.7	56.0	2.0	-10.3	7.4	7.8	8.0	4.1	7.8
Machine building incl. precision and optical instruments	-	13.0	-43.9	41.1	-18.9	42.9	79.6	52.0	-63.4	16.5	-13.8	4.6	1.0	10.6	10.6	3.9	7.7
Electr. engineering	-	12.7	33.0	35.0	12.7	-14.3	34.6	2.6	-5.6	4.5	-22.2	6.6	6.6	7.6	6.7	12.7	7.0
Construction	-	22.8	16.5	10.8	-31.8	9.3	34.1	8.2	-18.2	10.9	-11.4	-11.8	4.7	7.5	7.5	7.9	7.0
Packaging	-	28.0	8.4	9.6	-32.6	141.4	-52.3	69.9	-12.7	57.8	-1.6	-23.0	8.0	11.2	11.0	11.7	10.6
Others	-	25.5	-19.1	18.5	57.8	-39.1	15.1	-34.1	-32.9	116.3	-46.5	4.3				3.9	
Total	-	22.8	-4.3	16.2	9.1	-11.1	13.3	-1.4	-26.9	43.3	-22.7	-7.4				6.8	

1) at 1970 prices

2) calculated values in brackets

Sources: OECD, Metal Statistics
PROGNOS Euro-Report 76
PROGNOS calculations

Table X: DEVELOPMENT OF SELECTED ECONOMIC SECTORS AND THEIR ALUMINIUM CONSUMPTION IN DENMARK 1960 - 1990

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av.GR 60/78	av.GR 78/90
	absolute value in D.Kr. 10 millions 1) 2)																
- Transport equipm.	(90)	99	102	93	105	126	127	122	108	115	117	117	118	119	119		
- Machine building industry	(154)	235	278	387	385	392	411	424	397	441	444	466	490	584	602		
- Electrical Ind.	(97)	130	156	199	208	206	220	229	212	240	246	264	274	330	393		
- Construction Ind.	(615)	889	1,087	1,163	1,201	1,302	1,244	1,119	1,013	1,126	1,132	1,137	1,192	1,334	1,466		
GDP	7,289	9,420	10,413	11,907	12,197	12,856	13,531	13,608	13,445	14,292	14,656	14,700	15,626	17,741	20,013		
	av. GR over preceding period (annual percentage)																
- Transport equipm.	-	(1.9)	-10.8	-6.3	13.6	18.9	1.6	-4.3	-11.7	7.1	1.9	0.0	0.2	0.2	0.0	1.6	0.1
- Machine building industry	-	(8.8)	1.8	17.1	-0.6	1.9	6.0	3.2	-6.6	11.1	0.7	2.7	3.7	3.6	3.2	6.2	3.4
- Electrical Ind.	-	(6.0)	7.0	7.7	4.5	-1.1	6.9	4.0	-7.7	13.6	2.3	3.4	3.9	3.8	3.6	5.6	3.7
- Construction Ind.	-	(7.6)	7.9	3.9	3.3	8.4	-4.6	-10.0	-9.6	11.0	0.7	0.4	2.4	2.3	1.9	3.6	1.7
GDP	-	5.3	4.6	2.6	2.4	5.4	5.2	0.6	-1.2	6.3	1.8	1.0	2.8	2.7	2.4	4.0	2.1

Consumption of metallurgical and remelt aluminium by application areas

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av.GR 60/78	av.GR 78/90
	Consumption in 1000 tons																
total	-	-	12.3	16.5	16.6	10.0	12.4	12.6	13.6	17.0	17.9	18.0					
	av. GR over preceding period (annual percentage)																
total	-	-	-	10.3	0.6	-39.8	29.0	1.6	7.1	25.9	6.3	0.6				3.4	

1) at 1970 prices
2) calculated values in brackets

Sources: OECD, Metal Statistics
PROGNOS Euro-Report 76
PROGNOS calculations

Table XI: DEVELOPMENT OF SELECTED ECONOMIC SECTORS AND THEIR ALUMINIUM CONSUMPTION IN SPAIN 1960 - 1990

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978 2)	1980	1985	1990		
	absolute value in Ptas. 100 millions 1)																
- Transport equipm.	-	645	897	1,236	1,174	1,632	1,817	1,929	1,935	1,936	2,601	2,640	2,920	4,094	6,488		
- Machine building industry	-	181	190	289	309	353	436	549	496	535	576	590	684	974	1,298		
- Electrical ind.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
- Construction ind.	-	1,529	1,717	2,080	2,057	2,247	2,437	2,647	2,432	2,371	2,336	2,277	2,493	3,114	3,857		
GDP	10,965	18,871	21,316	25,745	26,976	29,274	31,730	33,418	33,636	34,327	35,146	36,200	39,229	47,820	57,623		
	av. GR over preceding period (annual percentage)															av. GR 60/78	av. GR 78/90
- Transport equipm.	-	-	4.7	14.6	-5.0	30.5	18.5	6.2	0.3	0.0	29.3	1.6	7.2	7.0	6.0	11.1 3)	6.6
- Machine building industry	-	-	-6.2	0.3	6.9	14.2	23.5	25.9	-9.7	7.9	7.5	2.6	7.7	7.3	5.9	9.5 3)	6.8
- Electrical ind.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Construction ind.	-	-	5.1	3.0	-1.1	9.2	8.5	4.5	-4.6	-2.5	-1.5	-2.5	4.6	4.5	4.3	3.1 3)	4.4
GDP	-	-	4.3	6.0	4.8	6.5	8.4	5.3	0.7	2.1	2.4	3.0	4.1	4.0	3.8	6.9	3.9

Table XI (cont.): Consumption of metallurgical and remelt aluminium by application areas in Spain 1960 - 1990

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av.GR 70/78	av.GR 78/90
	consumption in 1000 kg																
Transport				38,000	38,500	48,800	57,900	62,100	55,800	61,600	65,300	63,400	82,300	143,000	247,600		
Machine building incl. precision and optical instruments				7,000	8,000	10,000	11,400	11,700	10,100	11,300	13,100	11,300	13,400	18,600	26,100		
Electr. engineering				18,000	18,000	21,500	19,900	42,200	37,800	39,000	37,400	34,500	41,900	84,600	172,500		
Construction				18,300	20,800	25,700	29,500	44,200	38,900	52,500	65,500	61,500	85,600	125,800	176,500		
Packaging				11,000	12,600	16,200	19,500	21,700	19,100	24,900	29,900	24,400	33,200	70,000	148,900		
Others				24,000	25,200	38,000	47,100	59,600	51,900	55,700	63,600	55,000					
Total				116,300	123,100	160,200	185,300	241,500	213,600	246,000	274,800	250,100					
	av. GR over preceding period (annual percentage)																
Transport				-	1.3	26.8	18.6	7.3	-10.1	10.4	6.0	-2.9	13.9	11.7	11.0	6.6	12.0
Machine building incl. precision and optical instruments				-	14.3	25.0	14.0	2.6	-13.7	11.9	15.9	-13.7	9.1	6.7	7.0	6.2	7.2
Electr. engineering				-	0.0	19.4	-7.4	112.1	-10.4	3.2	-4.1	-7.0	10.2	15.1	15.3	8.5	14.4
Construction				-	13.7	23.6	14.8	49.0	-12.0	35.0	24.8	-6.1	18.0	8.0	7.0	16.4	9.2
Packaging				-	14.5	26.6	20.4	11.3	-12.0	30.4	20.1	-18.4	16.6	16.1	16.3	10.5	16.3
Others				-	5.0	50.8	23.9	26.5	-12.9	7.3	14.2	-13.5				10.9	
Total				-	5.8	30.1	15.7	30.3	-11.6	14.7	12.2	-9.0				10.0	

1) at 1970 prices
2) estimated values
3) GR 1965/78

Sources: OECD, Metal Statistics
PROGNOS Euro-Report 80
PROGNOS calculations

Table XII: DEVELOPMENT OF SELECTED ECONOMIC SECTORS AND THEIR ALUMINIUM CONSUMPTION IN THE USA 1960 - 1990 (Present System)

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av. GR 65/78	av. GR 78/90
	absolute value in $ 100 millions 1) 2)																
- Transport equipm.	-	230	253	220	235	251	276	244	227	266	288	311	326	366	411		
- Machine building industry	-	212	251	251	236	264	311	334	304	336	362	387	425	537	676		
- Electrical ind.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
- Construction ind.	-	477	499	478	476	480	486	426	426	456	486	490	494	502	502		
GDP	-	8,422	9,168	9,812	10,096	10,676	11,266	11,110	11,003	11,610	12,163	12,649	13,409	15,505	17,088		
	av. GR over preceding period (annual percentage)																
- Transport equipm.	-	-	0.8	-16.2	3.1	6.8	10.0	-11.6	-7.3	16.7	8.7	8.0	2.4	2.3	2.3	2.3	2.4
- Machine building industry	-	-	0.8	-5.6	-6.1	11.9	17.8	7.4	-9.3	10.5	7.7	6.9	4.8	4.8	4.7	4.7	4.7
- Electrical ind.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
- Construction ind.	-	-	0.8	-6.6	-0.4	0.8	1.3	-2.1	-10.6	7.0	6.6	0.8	0.4	0.3	0.0	0.2	0.2
GDP	-	-	2.7	-0.1	2.9	5.7	5.4	-1.3	-1.0	5.5	4.8	4.0	3.0	2.9	2.9	3.2	2.9

Table XII (cont.): Consumption of metallurgical and remelt aluminium by application areas in the USA 1960 - 1990

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av. GR 65/77	av. GR 77/90
	consumption in 1000 kg																
Transport		848,200	846,900	734,300	867,300	1066,400	1356,300	1169,400	816,480	1163,030	1348,398		2019,712	2953,906	3526,294		
Machine building incl. precision and optical instruments		247,700	252,200	250,400	268,500	312,600	399,600	411,900	261,274	394,674	361,084		393,784	524,490	705,203		
Electr. engineering		468,600	552,600	574,200	598,300	640,000	781,100	780,200	613,022	664,763	584,233		687,903	894,913	1169,616		
Construction		848,200	846,400	1006,400	1242,400	1417,900	1626,200	1363,100	1008,806	1331,316	1360,791		1738,124	2207,792	2071,846		
Packaging		297,600	335,700	665,400	686,700	823,700	932,600	1027,400	907,654	1166,762	1269,639		1613,376	2316,209	3143,723		
Others		726,300	926,400	828,300	798,400	918,600	1139,800	998,300	626,0[illegible]	813,269	823,732						
Total		3436,600	3760,100	4059,000	4461,600	5179,100	6235,600	5750,300	4132,297	5402,794	5728,477						
	av. GR over preceding period (annual percentage)																
Transport	-	-	-0.1	-4.6	18.1	23.0	27.2	-13.8	-30.2	42.4	16.0		14.4	7.9	3.6	3.9	7.7
Machine building incl. precision and optical instruments	-	-	0.9	0.2	7.2	16.4	27.9	3.1	-36.6	43.4	-6.3		3.9	5.9	6.1	2.9	5.5
Electr. engineering	-	-	8.6	1.3	4.2	7.0	22.0	-0.1	-34.2	8.1	5.3		5.6	5.4	5.6	1.9	5.5
Construction	-	-	-0.1	5.9	23.4	14.1	14.7	-16.2	-26.0	32.0	2.2		8.5	4.9	5.4	4.0	5.9
Packaging	-	-	6.2	25.6	3.2	20.0	13.2	10.2	-11.7	28.4	8.1		8.6	7.5	6.3	12.8	7.3
Others	-	-	12.9	-3.7	-3.6	15.1	24.1	-12.4	-37.4	30.1	1.3					1.1	
Total	-	-	4.6	2.6	9.9	16.1	20.4	-7.8	-28.1	30.7	6.0					4.4	

1) at 1970 prices
2) calculated values in brackets

Sources: OECD, Metal Statistics
PROGNOS Euro-Report 76
PROGNOS calculations

Table XIII: DEVELOPMENT OF SELECTED ECONOMIC SECTORS AND THEIR ALUMINIUM CONSUMPTION IN JAPAN 1960 - 1990

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990	av. GR 60/74	av. GR 74/90
	absolute value in Yen millions [1]																
- Transport equipm.	713	1,160	1,558	2,286	2,278	2,495	2,488	2,814					4,112	6,845	8,103		
- Machine building industry	763	1,118	1,510	2,919	2,710	2,632	3,281	3,282					5,210	7,811	11,377		
- Electrical ind.	783	1,040	1,537	2,642	2,620	2,799	3,170	2,903					4,934	7,366	10,687		
- Construction ind.	1,424	2,643	3,391	5,162	5,157	6,198	6,799	6,234					10,651	15,744	22,833		
GDP	25,923	39,966	56,493	72,207	74,699	81,925	89,376	87,732					130,192	180,901	246,532		
	av. GR over preceding period (annual percentage)																
- Transport equipm.	-	10.2	15.9	13.6	-0.3	9.5	-0.3	13.1					6.6	7.3	6.8	10.3	6.8
- Machine building industry	-	7.9	16.2	24.6	-7.2	-2.9	24.7	0.0					8.0	8.4	7.8	11.0	8.1
- Electrical ind.	-	7.1	21.6	19.8	-4.6	11.1	13.3	-8.4					9.2	8.3	7.7	10.3	8.6
- Construction ind.	-	13.2	13.3	15.0	-0.1	20.2	9.7	-8.3					9.2	8.3	7.7	11.1	8.6
GDP	-	9.0	12.4	12.7	3.3	9.8	9.1	-1.8					6.8	6.8	6.3	9.1	6.6

Table XIII (cont.): Consumption of metallurgical and remelt aluminium by application areas in Japan 1960 - 1990

	1960	1965	1967	1970	1971	1972	1973	1974	1975	1976	1977	1978	1980	1985	1990		
	consumption in 1000 kg																
Transport	-	86,109	104,710	256,661	269,657	309,961	344,085	325,125	312,821	370,937	413,197	462,360	663,600	958,100	1586,700		
Machine building incl. precision and optical instruments	-	26,657	41,966	71,698	70,214	67,282	86,836	82,309	60,043	82,639	82,748	89,632	105,902	160,096	235,233		
Electr. engineering	-	44,626	87,088	155,816	146,104	166,187	226,205	163,034	123,367	178,492	190,927	209,785	276,968	473,031	779,293		
Construction	-	44,959	69,969	297,862	348,905	459,261	634,306	545,954	616,521	667,993	621,645	687,460	879,382	1461,893	2259,640		
Packaging	-	8,785	12,739	20,263	21,022	23,493	28,281	83,033	71,073	103,710	111,077	136,717	143,638	234,502	449,637		
Others	-	142,942	291,425	338,142	343,907	426,653	521,628	309,900	332,006	440,499	395,074	417,232					
Total	-	354,078	607,624	1140,442	1199,809	1452,837	1861,341	1589,435	1406,821	1844,170	1814,568	2003,084					
	av. GR over preceding period (annual percentage)															av.GR 66/78	av.GR 78/90
Transport	-	-	10.3	34.8	5.1	14.9	11.6	-5.5	-3.8	18.6	11.4	11.9	10.4	11.2	10.6	13.8	10.8
Machine building incl. precision and optical instruments	-	-	25.5	19.5	-2.1	-4.2	29.1	-5.1	-27.1	37.6	0.3	8.2	8.8	8.6	8.0	9.8	8.4
Electr. engineering	-	-	39.7	21.4	-6.2	13.7	36.1	-27.9	-24.3	44.7	7.0	9.9	14.9	11.3	10.5	12.6	11.6
Construction	-	-	24.5	62.3	17.1	31.6	42.5	-16.6	-5.4	29.3	-7.0	10.6	13.1	10.7	9.1	23.3	10.4
Packaging	-	-	20.4	16.7	3.7	11.8	20.4	193.6	-14.4	45.9	7.1	23.1	2.5	10.3	13.9	23.5	10.4
Others	-	-	42.8	5.1	1.7	24.1	22.3	-25.3	-14.8	32.7	-10.3	5.6				8.6	
Total	-	-	31.0	23.4	5.2	21.1	28.1	-14.6	-11.5	31.1	-1.6	10.4				14.3	

1) at 1970 prices

Sources: OECD, Metal Statistics
PROGNOS Euro-Report 76
PROGNOS calculations

Table XIV: DEVELOPMENT OF SELECTED ECONOMIC SECTORS AND THEIR ALUMINIUM CONSUMPTION IN BRAZIL 1960 - 1990

	1960	1965	1969	1970	1971	1972	1973	1974	1980	1985	1990	av.GR 60/74	av.GR 72/90
	absolute value in Cruz. 100 millions[1)]												
- Transport equipm.	-	-	164.1	149.6	-	216.7	-	-	430.6	643.1	914.7		
- Machine building industry	-	-	113.8	132.2	-	190.7	-	-	376.8	566.6	849.4		
- Electrical ind.	-	-	117.2	101.1	-	141.6	-	-	323.0	520.6	827.6		
- Construction ind.	-	-	-	348.1	-	429.4	-	-	807.4	1,225.0	1,960.1		
GDP	2,625.9	3,273.0	4,261.7	4,704.2	5,235.3	5,779.3	6,438.1	7,054.2	10,765.8	15,312.5	21,779.3		
	av. GR over preceding period (annual percentage)												
- Transport equipm.	-	-	-	-8.8	-	20.4	-	-	9.0	8.4	7.3	9.7	8.3
- Machine building industry	-	-	-	16.2	-	20.1	-	-	8.9	8.5	8.4	18.8	8.7
- Electrical ind.	-	-	-	-13.7	-	18.3	-	-	10.9	10.0	9.7	6.5	10.3
- Construction ind.	-	-	-	-	-	11.1	-	-	8.2	8.7	9.9	11.1	8.8
GDP	-	4.5	6.8	10.4	11.3	10.4	11.4	9.6	8.1	7.3	7.3	7.3	7.7

Table XIV (cont.): Consumption of metallurgical aluminium by application areas in Brazil 1960 - 1990

	1960	1965	1969	1970	1971	1972	1973	1974	1980	1985	1990	av.GR 60/74	av.GR 72/90
	consumption in 1000 kg												
Transport						27,400		41,192	83,236	164,719	270,242		
Machine building incl. precision and optical instruments						3,700		6,504*	12,904	25,730	50,196		
Electr. engineering						47,300		56,368	142,691	266,407	490,830		
Construction						30,100		39,024	85,863	161,728	318,282		
Packaging						13,200		1[illegible],176	28,295	43,535	67,292		
Consumer goods						14,933		45,528					
Others						24,700		13,008					
Total	33,000	54,600	90,500	90,200	114,100	146,400	167,600	216,800					
	av. GR over preceding period (annual percentage)												
Transport								22.6	14.9	13.2	11.8		13.6
Machine building incl. precision and optical instruments								32.6	16.9	14.9	14.3		15.6
Electr. engineering								9.2	14.8	13.3	13.0		13.9
Construction								13.9	14.0	13.6	14.6		14.0
Packaging								7.2	10.0	9.0	9.1		9.5
Consumer goods								74.6					
Others								16.4					
Total	-	10.6	13.5	-0.3	26.5	28.3	14.5	29.4					

* estimated value

1) at 1970 prices

Sources: Anuario Estatistico de Associaçao Brasileira do Aluminio
OECD, Metal Statistics
PROGNOS Euro-Report 76
PROGNOS calculations