THE FUTURE OF AUTOMOTIVE ALUMINIUM

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Abstract

This paper presents different possible developments for aluminium in automotive applications describing the resulting impact on aluminium production and recycling. Based on detailed process chain modelling, the use of aluminium in the German car industry is analysed along the entire life cycle chain. To identify major innovations in the automotive industry several life periods of cars have to be covered, which was achieved by choosing 2040 as the target year. A variety of parameters influence the demand of metal (primary and/or recycled) and the availability of aluminium scrap. Investigated are market developments of automobiles in general, and design strategies for car components differentiating between conventional and aluminium-intensive constructions. For the analysis the automotive aluminium is classified into casting or wrought alloys, which have to be distinguished with regard to recycling aspects.

Introduction

The growth of aluminium and the automotive sector is closely connected. The transport sector was the biggest end use sector of the European aluminium industry in 2000 accounting for 29% of demand. And it will become even more important. Within this sector the automobile plays the domination role (95% of the metal demand). Beside, the growth rate of the future automobile market, though moderate, the specific amount of aluminium used in cars is expected to increase much faster.
The entire German aluminium industry is affected by the developments. Using more and more extrusions and rolled products beside castings, the automotive sector covers the variety of production paths.
The facet of greatest concern for this paper is the availability of primary and recycled aluminium. This is strongly influenced by the car industry being the biggest old scrap-producing sector and the biggest user of new and old scrap at the same time. In 1997 about 40% of the total amount of scrap (without in-house scrap) was reused in the automotive sector.
This paper points out the effects various developments of the use of aluminium in the automotive sector will have on the German aluminium industry with regard to production of primary aluminium and the use of scrap up to the year 2040. Using a scenario technique the differences between an increasing use of aluminium in conventional cars concepts and in aluminium-intensive vehicles (AIV) are shown. According to the scenario technique, the results should not be interpreted as a prediction of the automotive market in the future but rather as 'what would happen if' case studies for the aluminium supply chain.

The "automotive aluminium" scenario

Looking a good way into the future the amount of produced and used cars, the automotive design and therefore the amount of aluminium used in cars will change. Additionally, the supply of primary and recycled metal, whether domestic or imported, will alter. To show the impact of different possible developments on the German production situation a scenario technique is used. The investigations consider the aluminium supplying industry with semi-finished products and castings, and also the existing recycling industry for end of life vehicles (ELV). For the chosen example, the changes of primary and recycled aluminium both in demand and supply and the resulting import situation is modelled. To show different developments the scenario approach is carried out in three steps:

1. Base case 1997 (**1997**): The case shows the domestic market supply for Germany for the base year 1997 (including import and export of primary and recycled aluminium, its pre-products and the recycling of automotive aluminium).
2. Conventional concepts 2040 (**2040**): For the second case an increasing use of aluminium in cars for the target year 2040 is assumed, considering the conventional steel-based concepts utilized today. Nevertheless, the proportion of aluminium components is much higher than today.

3. Aluminium-intensive vehicles 2040 (**AIV**): The third case reflects a widespread use of aluminium-intensive vehicles also including new concepts.

The results of all three cases are compared resulting in conventional and aluminium intensive demand and supply situations for primary and recycled aluminium in a long-term time frame.
The investigated aspects comprise 'German car market', 'Aluminium use in cars', 'Wrought and cast products', 'Primary and recycled material'.

The overall German aluminium system in 1997

To analyse the material and energy flows of aluminium a process chain model has been developed [1]. Within this model production, use and recycling of aluminium products is divided into individual processes which are represented by technology-specific and location-independent modules. They can be seen as entities of a production system, each of which has specific inputs and outputs of materials, energies, emissions and products taking distinct natural and technical properties into account. The process chain model describes the aluminium flow from bauxite mining to the production of aluminium products including primary smelting and recycling of fabrication and post-consumer scrap.
Considering the high metal demand of the German aluminium manufacturing industry, it is obvious that the metal supply is strongly import-dependent. In 1997 casting alloys had an import rate of 38%, alloyed primary aluminium 47%, and unalloyed primary aluminium 55%, respectively.
The main exporting countries for alloyed wrought material used in the investigated system are Norway (43%), UK (26%), Iceland (10%), France (8%), Russia (7%), Canada and Brazil less than 5 %. Only for alloyed aluminium imported from the UK and France is a recycled content of 43% estimated. The other countries produce alloyed material mainly from primary aluminium with added alloying elements.

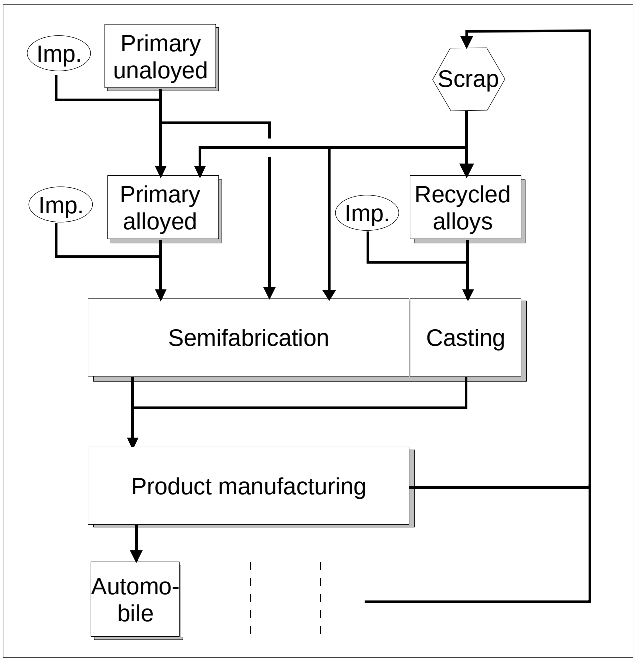


Figure 1: Schematic German aluminium system and its implications for the automotive market

For the explicit analysis of the German automotive system only a few of the technology modules available in the process chain model are necessary. Nevertheless, the overall material flow of aluminium for domestic use and export has to be considered. The total metal demand in 1997 was about 2.5 million tonnes and domestic end-use more than 1.3 million tonnes. Figure 1 characterises the interconnections of primary and recycled materials which are representative of the automotive sector as well as for every other application. Changes in any of the application areas will have an influence on the overall system and therefore affect the supply situation as well.
New scrap or alloying elements are added to unalloyed primary aluminium produced from bauxite in primary smelters and either cast into rolling slabs for strip and sheet production, extrusion billets or used for primary casting alloys (see also figure 2). Another group of wrought alloy producers are the remelters using mainly fabrication scrap and primary ingots. Strip and sheet production is done by conventional hot and cold rolling. Extrusion processes are used to produce the various extrusion products (forgings are not considered exclusively and are included in the extrusion process flow). The picture for wrought alloys, however, is quite complex, due to the different scrap supply for low, middle and high alloyed materials. In particular, for 1997, the following recycled contents have been calculated from German industry and literature data: extrusion and forging alloys 47%, low alloyed rolling material 35%, middle 80% and high 65%. Unalloyed material usually has no recycled content.
A third group, the secondary smelters (refiners), use old and new scrap, turnings and dross as raw materials to produce casting alloys, so that the recycled content of these alloys is nearly 100%. On the other hand, primary casting alloys are made of 100% primary metal. The cast processes considered are die and mould casting.

The German automotive system

In 2000 German automotive production was the third biggest worldwide only outnumbered by the USA and Japan [2]. As a consequence, the German supplying industries are quite big as well. First the modelled system, including the assumptions for the base case 1997, is presented.

Production of semi-finishes and castings for car components

Automotive aluminium applications cover nearly the whole range of semi-finished products and castings, figure 2.
In 1997 the main material for automobile components was casting alloys with a share of 78%. 80% of which is produced from recycling material by the refiners. The remaining 20%, the so-called primary casting alloys, are supplied by primary smelters.
The most widely used casting alloy for nearly all kinds of automotive applications is the AlSi9Cu3 alloy with a share of about 50% of all castings. In addition, that the eutectic AlSi12 and the AlSi10Mg are the most important alloys with a share of 16 and 12%, respectively. The latter has nearly doubled in the last 4 years.

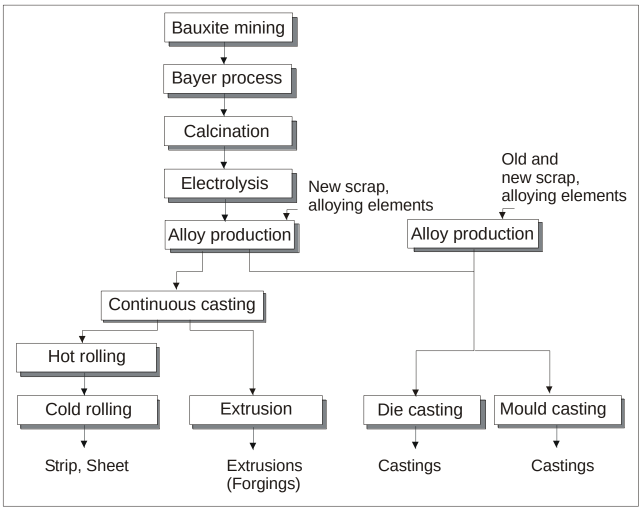


Figure 2: Production scheme for semi-finishes and castings for the automotive sector

In the case of the primary casting alloys there is an increasing application of the AlSi7Mg alloy for safety components like wheels and brake parts. Table I shows some typical automotive alloys and their application share [3-5].

Table I Alloy composition of automotive aluminium

Alloy type	AA No.	Notation	Share
casting alloys (78%)	A 359	AlSi9Cu3	48%
	A 356	AlSi7Mg	20%
	A 361	AlSi10Mg	12%
	-	AlSi12Cu	9%
	A 413	AlSi12	7%
	A 332	AlSi12CuNiMg	4%
wrought alloys (22%)			
of which - extrusions	6060	AlMgSi0.5	35%
- forgings	6082	AlMgSi1	11%
- rolled	3003	AlMn1	10%
products	5182	AlMg4.5Mn0.4	9%
	5754	AlMg3	14%
	6016	AlSi1.2Mn0.4	15%
	7020	AlZn5.4Mg1	6%

Table I also shows the most representative wrought alloys used for example for radiators (3003), forged wheels (6082), bumper beams (7020), internal (5182, 5457) and external (6016) structural parts [4-8]. The wrought alloys used for the calculation are divided into extrusions (46%), low alloyed rolled products (25%) and high alloyed rolled products (29%).

Recycling of cars

In 1997 3.4 million cars were deregistered, of which only 40% remained in Germany for recycling (figure 3). The rest was exported mostly to Eastern Europe for further use [9]. After removal of all fluids the cars are partly dismantled. Tyres together with rims, batteries and the catalysts are removed. The rims are sold directly to the secondary smelters. About 60% of the partly dismantled cars are completely dismantled. The other 40% partly dismantled and the dismantled bodies, power trains and radiators are then shredded. Except the radiators, whose copper-aluminium mix is directly used as alloying material in recycling plants, the other shredder outputs are further processed in a subsequent heavy-media separation to reclaim the aluminium. So far no distinction between wrought and cast alloys can be made. All fractions can then be smelted either for closed loop production of new automobile casting components (8%) or casting products of other aluminium systems.

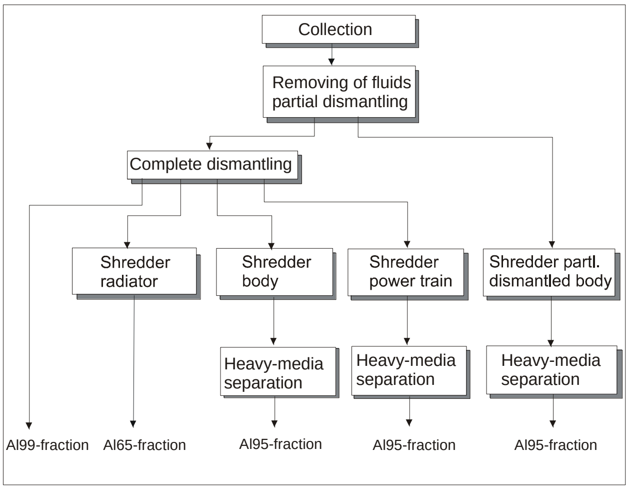


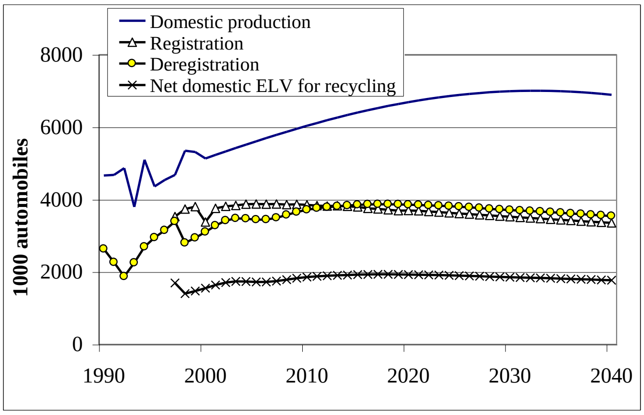
Figure 3: Recycling system of ELV in Germany

Development of metal demand and supply

The main parameters of the metal demand in the car industry are car production itself, the average aluminium content per car, the share of wrought and cast alloys, and the share of primary and recycled material.

Development of the German car market

Figure 4 gives an overview of the current development of the German car market and a projection up to 2040. In 1997 domestic production of cars amounted to 4.7 million, 3.5 million cars from domestic production and imports were registered in Germany and 3.4 million cars were deregistered.



Source: VDA Statistics [2], own calculations

Figure 4: Development of German car market

Studies of the German automobile market covering the time horizon to 2040 are not available. To develop figures necessary for the analysis, assumptions for automobile production, registration,

deregistration and recycling of ELV were worked out, based on plausible economic and demographic projections and existing studies with shorter time horizons [10]. Nevertheless, the figures should be used with caution and should not be interpreted as a prediction, because in the long time span until 2040 different developments are possible.
The assumptions for car market development are as follows:

- Domestic automobile production growth, but decreasing growth rates up to 2040;
- Decreasing population;
- Decreasing registrations after 2010;
- The technical lifetime of cars is normally distributed with a median of 12 years;
- In 1997 the net domestic supply of cars for recycling after export of complete cars or car bodies equals 40% of deregistered cars, because of the high quality level of used German cars and the resulting export potential. It is assumed that this rate will not change until 2040, although recently initiatives to change the regulations of ELV in the European Union have been undertaken.

For the year 2040 domestic production of cars is assumed to be 6.9 million. 3.4 million cars from domestic production and imports will be registered and 3.5 million cars will be deregistered, representing only a minor shift from the 1997 situation. Resulting net domestic supply of cars for recycling will therefore be 1.4 million. This assumed development will be the same for the conventional case and for the AIV case.

Development of aluminium use in cars

Looking at the average annual growth rates of aluminium used in conventionally designed cars (figure 5) it is obvious that in the ongoing decade the highest average growth rate of 7.4% can be expected. This is due to the current trend for car manufacturers to use, besides aluminium castings for engine, gear box, chassis and suspension, more and more wrought alloys for hang-on parts of the bodywork. For the AIV case the growth rates show a similar trend only with higher values (8.8% in 2000 - 2010).

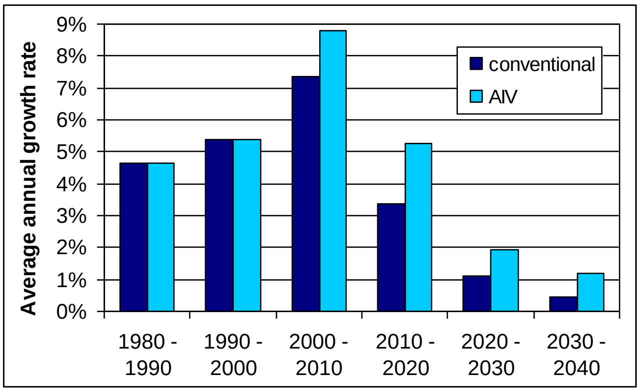


Figure 5: Estimated development of average annual growth rates of aluminium used in cars (own calculations)

The absolute amounts of aluminium used in cars for the conventional case in figure 6 underlines the current trend of growth rates described above. Especially the high growth rate between 2000 and 2010 is obvious. The average aluminium content of a passenger car will increase from 100 to 250 kg from today's amount within the next few decades, while the share of castings will decrease from about 75% to nearly 50% in the same period. The figures were assembled from the end-use statistics of GDA up to 2000 [11] and many different estimations from the aluminium industry (Pechiney, VAW, Alcan-Alusuisse, EAA, GDA) and the car industry (PSA Peugeot Citroen, Audi, Ford) [12-16].

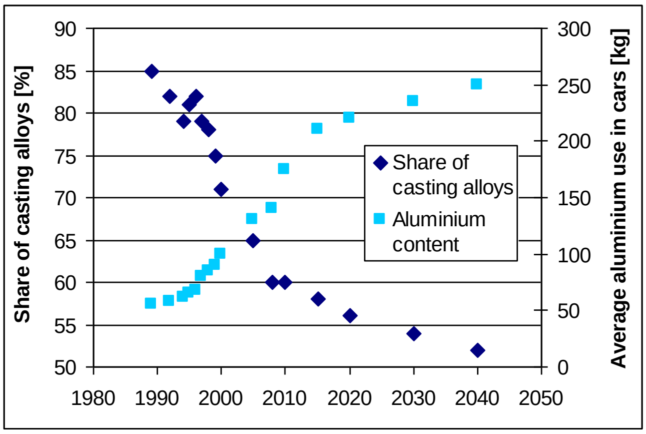


Figure 6: Development of aluminium used in cars for the conventional case

Development of wrought and cast products

The amount of 250 kg per car for the 2040 conventional case seems to be achievable considering a total potential of aluminium parts of about 300 kg for a conventional steel-based car, of which 160 kg are casting alloys and 140 kg wrought alloys [5, 8, 16]. The smaller amount of 250 kg assumed is due to the fact that especially many small cars will not reach this high aluminium content. The share of other concepts already existing (such as space frame) is considered to stay the same. They have a significantly higher amount of aluminium.
For the AIV case the average aluminium weight of a car is assumed to be 400 kg, whereby the amount of castings remains constant at 130 kg. Using more aluminium for body and frame, the share of wrought alloys increase to 67.5% in that case.
A comparison of statistics and the calculations of metal demand show that about 80% of the metal supply of the automobile industry can be found as aluminium products in the car itself. The other 20% is mainly necessary because of the occurrence of fabrication scrap during end-product manufacturing and the supplementary production of spare parts. This ratio is assumed to remain constant in spite of improved production technologies, because the increasing share of wrought alloys application with higher scrap rates will compensate this trend.
The particular German metal demand is then obtained by multiplying the adapted specific demand per car by the annual production figure, figure 7. Due to the increasing share of wrought product use the growth of the semi-fabricated products demand is higher than for the castings, reaching nearly the same value of 1,100,000 tonnes at the end of the calculation in the year 2040 for the conventional case. This means a factor of 3 of growth for castings and a factor of 10 for rolled, forged and extruded products in 40 years.
In the AIV case the demand for semis reaches 2,330,000 tonnes. While the growth for castings stays constant at the threefold amount, the wrought products increase by a factor of 22, overtaking casting demand in 2015.

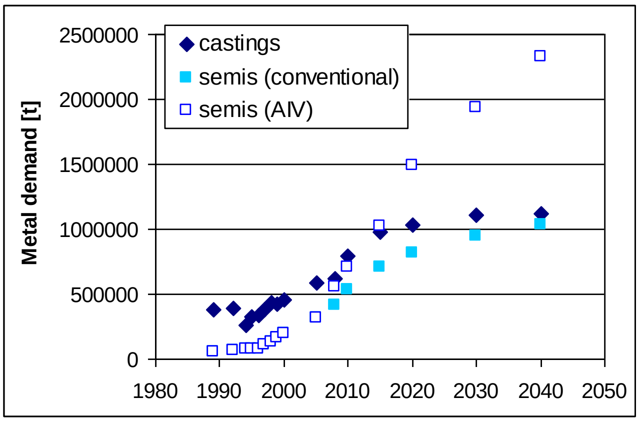


Figure 7: Development in aluminium demand of German car manufacturers

Development of primary and recycled material supply

German primary aluminium production is assumed not to exceed 700,000 t in 2040 due to the lack of raw materials and cheap (hydro) power for both the conventional and the AIV case. Further demand for unalloyed and alloyed material has to be met by a higher share of imports.

The supply of recycled material will change significantly by 2040. The improvement of the collection quotas of post-consumer scrap and the metal yield of sorting, material processing, and smelting will increase the average recycled content of aluminium alloys for the domestic market supply from 46 to 56% (54% AIV) [17]. For 2040 no imports and exports of recycled cast aluminium are considered due to the fact that the production is met by the German supply of new and old scrap. For both 2040 cases the share of primary (20%) and secondary casting alloys (80%) are kept constant at that of 1997. To satisfy the secondary casting demand, besides the total cast scrap amount, which can only be remelted into casting alloys, additional wrought scrap has to be used. For automotive alloys the latter is taken from end of life vehicles. Using improved sorting technologies wrought and cast material will be obtained separately.

Table II summarises the chosen main assumptions, which determine the overall aluminium system in general as well as the automobile system in particular.

Table II Main system assumptions

	1997	2040	AIV
1. Cars produced [million cars]	4.7	6.9	6.9
2. Aluminium content per car [kg]	79	250	400
3. Share of casting alloys in automotive application [%]	78	52	32.5
4. Share of primary casting alloys in total foundry production [%]	20	20	20
5. Material spare parts, scrap [%]	80	80	80
6. Import share of recycled aluminium [%]	37	0	0
7. Export share of recycled aluminium [%]	12	0	0
8. Primary smelter production [1000 tonnes]	570	700	700
9. Collection quota of ELV [%]	40	40	40

Results

Taking all the described developments of the various parameters into account the impacts on the system can be determined. Changes of the automobile system cannot be described without discussing their impact on the overall aluminium system. Therefore, the effects on the overall aluminium market are described first before the specific impacts on the automobile system are shown. The various connected results are then described.

Resulting demand of material for the German automobile market

If the German aluminium industry in the sector of semi-finished products remains strongly export-oriented as it is today the production of these products in the overall aluminium system will increase from 1.8 to 5.7 million tonnes by 2040 and to as much as 7.1 million tonnes in the AIV case, while the castings production arises from 0.5 million to 1.5 tonnes in both cases.

The metal demand for the automotive system is mainly determined by the assumptions of car development and the amount of aluminium in cars (see table II). Table III shows the resulting demands for aluminium products.

Table III Comparison of 1997 and 2040 systems parameters and calculated demand for wrought and casting products

		1997	2040	AIV
Casting products	%	78	52	32.5
	1000 tonnes	359	1,121	1,121
Wrought products	%	22	48	67.5
	1000 tonnes	105	1,035	2,329
Total demand	1000 tonnes	464	2,156	3,450

464,000 tonnes of aluminium products were necessary for the production of 4.7 million cars in Germany in 1997, bearing in mind that 20% of the material is either scrap from end product manufacturing or used for spare parts production. With the estimated production of 6.9 million cars in 2040 the material demand for the two cases varies between 2.2 and 3.5 million tonnes of aluminium because of the different aluminium content of the cars. While in both 2040 cases the demand for castings increases from nearly 360,000 tonnes in 1997 to 1,121,000 tonnes, the situation for wrought material differs. The demand increases from about 100,000 tonnes in the base year to 1,035,000 tonnes in the conventional case and to 2,329,000 tonnes in the AIV case.

Resulting supply of wrought and casting alloys for the automobile market

The domestic supply of the German market in 2040 will be determined by the production capacity of primary smelters and the supply of scrap for secondary smelters. Since, like the market for automobiles, the other aluminium markets will increase the total scrap amount available in Germany will increase as well.

For secondary castings it is assumed that no imports of cast products will take place because the German demand can be satisfied by these amount of scrap. This implies that the 1997 German production must be nearly tripled by 2040 from 430 to 1,180 thousand tonnes.

At the same time, the amount of surplus scrap which goes to the remelters increases significantly and substitutes primary metal. The supply increases from 190 thousand tonnes in 1997 to 950 thousand tonnes for the conventional case, and 1,660 thousand

tonnes for the AIV case, respectively. This yields a higher recycled content of wrought material produced in Germany because the production of primary metal is assumed only to increase slightly from 570 to 700 thousand tonnes.
For the 1997 base case, it was possible to determine the recycled content differentiating between the various wrought alloy groups (low/medium/high alloyed, rolled/extruded) (table IV). The detailed information necessary to obtain the different amounts is not available for the 2040 cases. Therefore only overall results for wrought products are obtained, considering the German primary production and scrap supply. Table IV shows the various recycled contents of wrought products, due to the small growth of primary capacity and significant increase in fabrication and post-consumer scrap.

Table IV Recycled content of wrought material for the German aluminium system in %

	1997	2040	AIV
Rolled (low)	35		
Rolled (medium)	80		
Rolled (high)	65		
Extruded (low)	47		
Average	43	78	85

These are the average shares of recycled aluminium for the entire German wrought aluminium system. The specific values for the automobile production or other applications cannot be separated. It is assumed that the supply from the German system to the automotive sector is prorated according to the share of demand.
Besides the changing demand, the described developments of the automobile systems also yield different amounts and qualities of old scrap. Table V shows the estimated old scrap from the automobile sector for the different 2040 cases, considering car production itself, the lifetime of cars, and the amount of aluminium used in cars.

Table V Old scrap from the automobile sector in 2040 in 1000 tonnes

	2040	AIV
Casting scrap	258	258
Rolled scrap	124	243
Extrusion scrap	96	194

As described earlier, the wrought old scrap from the automobile sector is used to fill the gap between the demand for cast alloys and the supply of cast new and old scrap. For both 2040 cases this gap is 234 thousand tonnes. For the conventional case, wrought old scrap just meets this amount. Looking at the scrap supply of the German secondary smelters [18], turnings and dross are also main input materials and can only be handled by the smelters. Consequently the old scrap has to be separated into cast and wrought scrap. Without strictly differentiated sorting into wrought and cast alloys there would just be mixed scrap only reusable to produce cast alloys. The German demand for secondary castings would not be high enough to handle the resulting amount of old scrap plus turnings and dross. The oversupply of cast alloys would have to be exported, but at the same time more wrought alloys would have to be imported. With a higher wrought alloy amount in cars for the AIV case this separation becomes even more essential.

Resulting import shares for the automobile market

While the German castings demand will be met by the German scrap supply, wrought unalloyed and alloyed material has to be imported to satisfy demand. The import rates will increase from 55 to 79% for unalloyed primary aluminium, and from 47 to 69% for alloyed primary aluminium, and 76% for AIV, respectively, for the overall German aluminium sector. The share of recycled content for the exporting countries France and UK will also increase to 50% while the other countries will still produce the alloyed aluminium at primary smelters.
Looking exclusively at the automotive sector, a separate picture emerges. Mainly alloyed components are used for car production. Figure 8 shows the import shares for the 1997 system but also those for 2040 resulting from the assumed production capacities for primary and recycled aluminium and the demand for car production.

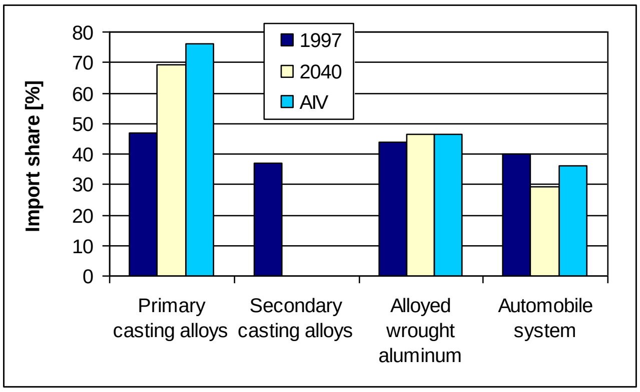


Figure 8: Import shares for the 1997 and the 2040 cases in % for materials used in German automobile system

German primary aluminium production is assumed not to follow the increasing demand. Therefore the import shares for the production of primary castings produced at primary smelters must increase in the same way as the imports of primary alloys. For secondary castings no imports were assumed in the future. To determine the import share for alloyed wrought aluminium besides the change in the import situation of primary alloyed material the increasing supply of scrap on the German market has to be considered. The import share, however, still has to increase less than for primary alloys. It can be seen that for the total automobile system the import share decreases by 2040 (from 40 to 29%) for the conventional case because the domestic produced secondary castings are still dominant. In the AIV case the wrought alloyed components with their high share of 67.5% cause a smaller decrease of the import share (36%).

Material flows of the total automobile system today and in the future

So far the impacts of the assumed developments on the overall aluminium system and the automobile system in particular have been described. Using the process chain model material flows of the total automobile system are obtained. Therefore, changes of the German automobile system and the adapted import situation must be combined. In table VI the shares of recycled aluminium from the domestic German automotive system are compared to those including the necessary imports.

Table VI Recycled content for the 1997 and 2040 cases in % for the Germany automobile system with and without and imports

	1997		2040		AIV	
	FRG	Incl. Imp	FRG	Incl. Imp	FRG	Incl. Imp
Primary castings	0	0	0	0	0	0
Secondary castings	100	100	100	100	100	100
Wrought alloys	43	26	78	41	85	44
Total autom. system	79	70	88	64	90	58

The situation for Germany and the countries which export primary castings to Germany are similar with no recycled content. In 1997 secondary castings are produced by using exclusively scrap in all countries considered. The two 2040 cases have no imports and exports for secondary castings, so that the German situation equals the overall casting system. For the wrought alloys recycled content including the imports is smaller than the German one due to the fact that more than 65% of the countries exporting wrought alloys to Germany produce their alloys only from primary metal. Looking at the total automobile system in Germany, the recycling share increases due to the higher amount of available scrap and only a moderate increase in the production of primary metal. Also including imports the effects are reversed. The increase of scrap cannot compensate the increasing demand due to the time lag in occurrence, so that wrought aluminium has to be imported (with low recycled content). Assuming that the production of recycled aluminium needs less energy, an increase in aluminium in cars would yield in a reduced specific energy demand for the domestic German system but a rising specific energy demand for the total automobile system, due to the import countries.

The absolute amounts of primary and recycled alloys of the automobile system in Germany and the import countries are shown in table VII for all three cases. The growth rates for primary or recycled material vary for the different subsystems (Germany/import countries). While the German increase of a factor of 5.9 from 1997 to the AIV case is mainly due to increasing scrap availability, for the import countries the growth of 6.2 can only be met by higher primary production.

Table VII Demand of primary and recycled aluminium for the automobile system from the German market and resulting imports in 1000 tonnes

		FRG	Imports	Total
Primary alloyed	1997	80	115	195
	2040	200	750	950
	AIV	250	1,400	1,650
Recycled alloyed	1997	300	150	450
	2040	1,500	150	1,650
	AIV	2,000	250	2,250
Total automobile system	1997	380	265	645
	2040	1,700	900	2,600
	AIV	2,250	1,650	3,900

The total automobile system considering Germany and the import countries has a growth rate of 4 for the conventional case und 6 for the AIV case. While the automobile system had a total demand of 645,000 tonnes in 1997 in Germany and those countries which supply Germany with alloyed material, the system needs 2,600,000 tonnes for the conventional steel-based concepts in 2040. Aluminium-intensive vehicles would even yield a demand of 3,900,000 tonnes. In contrast to the calculated demand for products in table III, fabrication scrap of the entire processing chain is included here.

In figure 9 it can be seen that the German system increases more than that of the import countries. This is expected because the additional amount of scrap is supplied only to the domestic system.

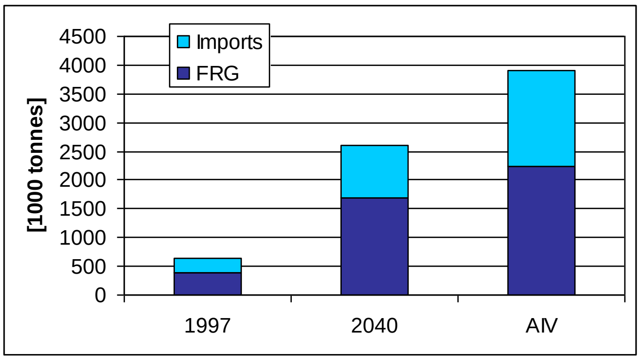


Figure 9: Total amount of material for the German automobile sector including imported material

This is also obvious in figure 10 where the particular primary and recycled amounts are shown for the domestic and the import situation for the three cases. It also shows the dimension of the necessary extension of capacity, especially for the German refiner and remelter industry. However, the additional demand for primary alloyed material of 635 thousand tonnes for the conventional case or as much as 1,285 thousand tonnes for the AIV case cannot easily be satisfied by the existing system. With recently implemented new smelters having a capacity of about 300 thousand tonnes that would mean between 2 to 4 additional new smelters entirely used to supply the German automobile market. Keeping the growth rates in mind (figure 5), this capacity expansion has to happen within the next 10 – 15 years.

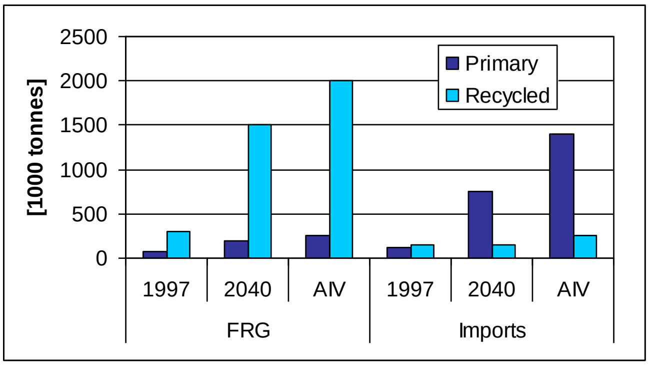


Figure 10: Primary and recycled material for the automotive system distinguishing between domestic and foreign supply

Conclusion

Different developments in the use of aluminium in cars are possible. A scenario approach has been used to show the effects various concepts would have on demand and on also the supply of wrought and casting alloys in the German aluminium industry in general and the automotive industry in particular. A differentiation was made between the conventional steel-based and an aluminium-intensive concept. By choosing 2040 as the target year it was ensured that enough time for changes within the system was considered. The development of the main parameters, car production itself, the average aluminium content per car, the share of wrought and cast alloys, and the share of primary and recycled material had to be described first.

The increasing production of automobiles from 4.7 to 6.9 million cars and the different concepts will yield a higher demand of aluminium products in 2040 rising from about 460 at present to 2,160 and 3,450 thousand tonnes. At the same time the scrap amount usable for the German system will increase. Nevertheless, with an increasing share of aluminium-intensive vehicles an improvement in sorting technology is necessary to separate wrought and casting alloys because the absolute amount of old scrap is higher than the casting demand. While the higher scrap availability benefits the German market, the recycled content of the overall system decreases. The demand for wrought alloys is increasingly satisfied by imports.

The total automobile system will grow fourfold for the conventional case and sixfold for the AIV case. This can only be met by extending both the secondary smelting system in Germany and the primary production in countries exporting to Germany.

The results should be considered to show trends and orders of magnitude for automotive metal demand based on the scenario technique used. They should not be misunderstood predictions.

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