european aluminium association

ALUMINIUM IN CARS

UNLOCKING THE LIGHT-WEIGHTING POTENTIAL

CONTENTS

> “Excess weight kills any self-propelled vehicle... Weight may be desirable in a steam roller but nowhere else”
>
> Henry Ford 1924

INTRODUCTION

Aluminium's success in modern cars started in the early seventies, when under the strong pressure of the first and second oil crises, car manufacturers worldwide began lightweighting their cars to obtain better fuel efficiency. The first high volume applications were radiators, cylinder heads and bumper beams.

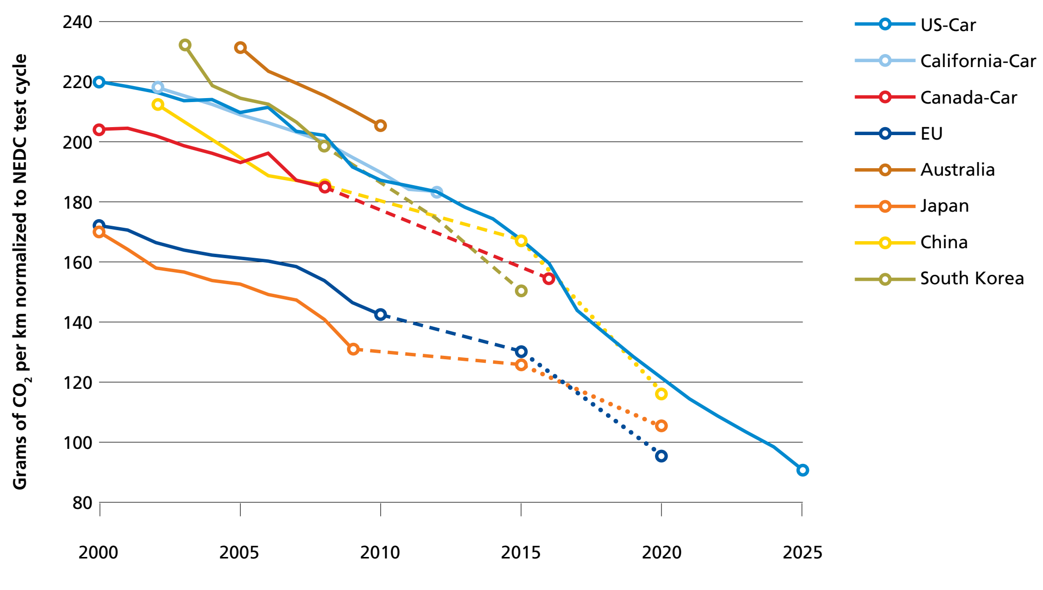
In the meantime, the average amount of aluminium used per car produced in Europe has reached 140 kg, and aluminium castings, extrusions, forgings and sheets can be found nearly everywhere, including in car bodies, closures, chassis, suspensions and wheels.

The present brochure explains why, now more than ever, reducing vehicle mass is necessary and how aluminium can be used to further improve the sustainability and the safety of future generations of cars.

1 REDUCING MASS IS NECESSARY TO REDUCE CO_2 EMISSIONS

1.1. VEHICLES MUST BE MORE FUEL EFFICIENT IN THE FUTURE

All around the world governments are imposing tougher and tougher CO_2 emission standards. From 2010 to 2020 the average CO_2 emissions from European vehicles is to decrease from 142 g/km to 95 g/km (or 3.9% per year). Figure 1 shows the CO_2 emission targets for various countries.



* China's target reflects gasoline fleet scenario. If including other fuel types, the target will be lower.

Figure 1: Declining CO_2 emission targets across the world

Source: www.theicct.org

1.2. LIGHTWEIGHTING REDUCES TAILPIPE CO_2 EMISSIONS

The relation between lightweighting and the reduction of tailpipe CO_2 emissions is quite complex. Depending on how the calculation is made, various CO_2 reduction values ranging from 3 g/km up to 13 g/km for a weight saving of 100 kg are reported. These different outcomes are all correct, as they depend on definitions and to what extent the lightweighting is exploited. It is therefore important to distinguish between two kinds of weight savings and two kinds of fuel savings.

- **Direct weight saving:** the weight reduction due to exchanging a heavier material for a lighter material in one or several components.
- **Indirect weight saving:** additional weight reduction obtained by downsizing certain components (i.e. brakes, suspension, engine, etc.) to keep vehicle performances at the same level as before. Indirect weight savings come on top of direct weight savings, and can represent up to 50% additional savings on the weight of the complete car.
- **Primary fuel saving:** fuel saved thanks to the lower energy demand related to moving a lighter mass.
- **Secondary fuel saving:** additional fuel saving obtained by optimising the drive train (i.e. gear ratio, engine electronics, displacement, etc.) to keep performances at the same level as before.

The lowest CO_2 emissions savings will be achieved by combining direct weight savings and primary fuel savings exclusively. The largest CO_2 reductions are achieved when both indirect weight-saving and secondary fuel saving are added together. The table below summarises the different options based on simulated fuel reduction data from a VW Golf VI with a 90 KW TSI engine following the NEDC driving cycle[a].

	Direct weight savings **100 kg**	Direct + Indirect weight savings **total 150 kg**
Primary fuel savings	3.6 g/km	5.4 g/km
Primary + secondary fuel savings	8.4 g/km	12.7 g/km

Table 1: Reduction of tailpipe CO_2 emissions

As indirect weight savings can only be maximized by completely redesigning cars, they are usually lower than 50% and close to 0% when only one single component is made lighter. In the latter case, a reduction of CO_2 emissions of 8.4 g/km is more realistic.

[a] On the calculation of fuel savings through lightweight design in automotive life cycle assessments, Christoph Koffler & Klaus Rohde-Brandenburger. International Journal of Life Cycle Assessment (2010) 15:128-135

European vehicles are getting heavier, but aluminium can reverse that trend.

1.3. VEHICLES ARE GETTING HEAVIER - THE WEIGHT SPIRAL

Despite its impact on fuel consumption, the average mass of European vehicles shows an increasing trend, as illustrated in Figure 2. The temporary drop in vehicle mass in 2009 was due to the economic downturn and the scrapping scheme that favoured small vehicles. In 2011 the average mass was higher than ever before. The weight increase is basically due to added safety and comfort equipment, as well as customer demand for bigger cars. This in turn has caused an increase in the weight of other components (e.g. engines, transmission, brakes) to reach the desired performance level. The inversion of the "weight spiral" is today one of the most demanding challenges for the automotive industry.

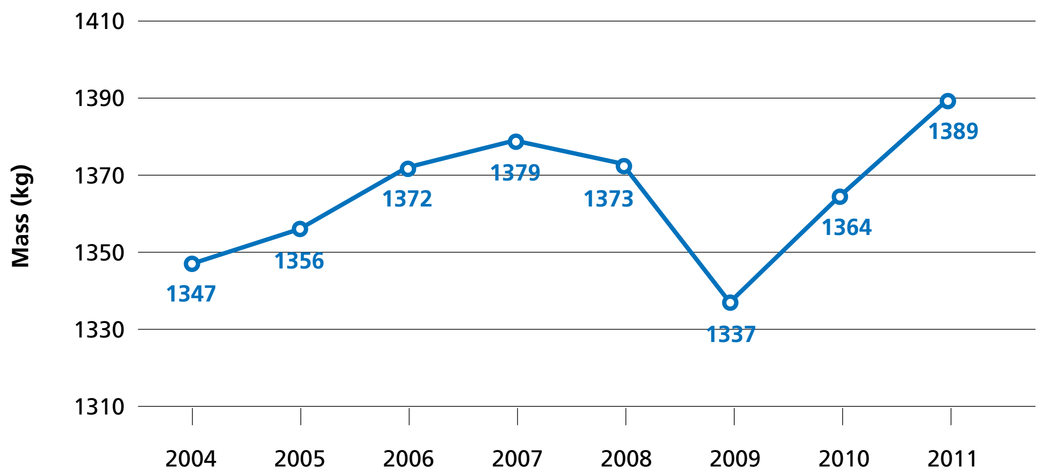


Figure 2: Evolution of the average mass of new cars registered in Europe

Source: European Environment Agency

1.4. VEHICLE MASS REDUCTION POSSIBILITIES

In order to invert this weight spiral, a reduction of the vehicle mass is a must. The fuel saving potential through reduced vehicle mass is significant. Weight reduction without any changes to the functionality or safety of the car can be realised not only by replacing heavier materials with lighter materials, but also by introducing new design and manufacturing concepts or, ideally, by a combination of these measures. It is important to realise that aluminium offers the possibility for lightweighting without downsizing and without impairing the safety of the vehicle fleet.

1.5. VEHICLE MASS DIRECTLY IMPACTS FUEL CONSUMPTION

Weight reduction directly reduces the energy consumption because the energy required for moving a vehicle is, except for aerodynamic resistance, directly proportional to its mass.

On average, 100 kg mass reduction achieved on a passenger car saves[b]:

- 0.315 litre of fuel per 100 km[c].
- 8 grams of CO_2 per km at the car exhaust pipe.

Including emissions for fuel production & supply (well-to-wheel), 100 kg mass reduction achieved on a passenger car saves:

- 9 grams of CO_2 per km.

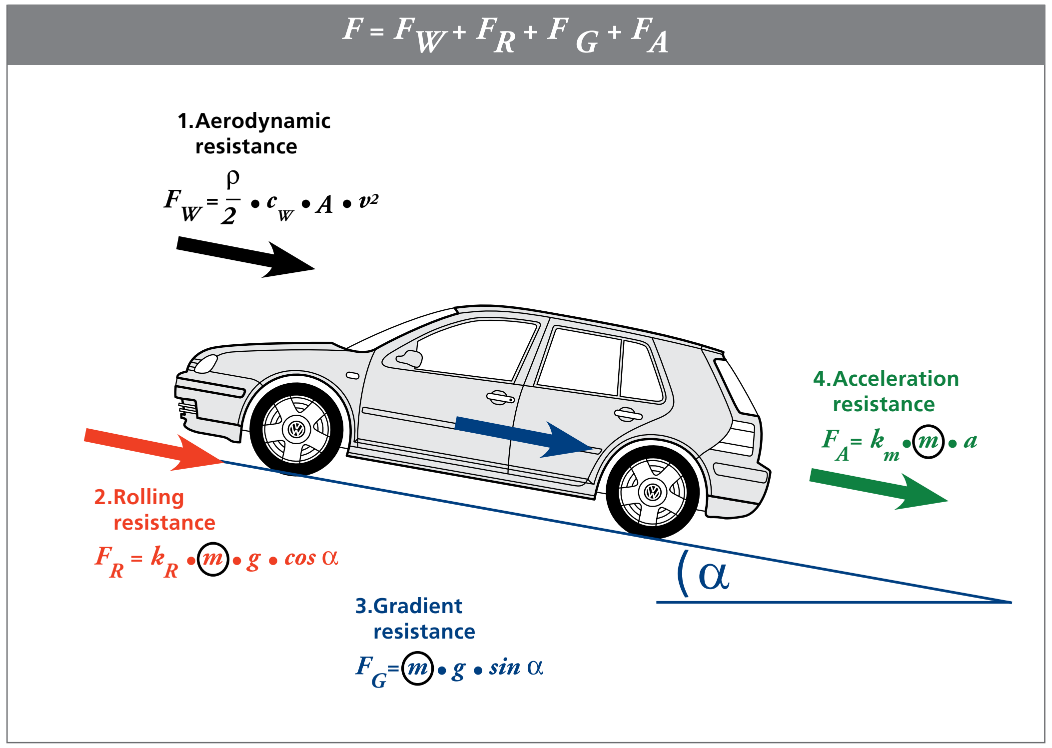


Figure 3: Resisting forces

[b] These figures are material-independent and slightly vary depending on specific factors such as vehicle type, driving cycle, etc..
They assume the following average values for petrol and diesel:
- The combustion of 1 litre of petrol emits 2.4 kg of CO_2 at the car exhaust pipe
- The combustion of 1 litre of diesel emits 2.6 kg of CO_2 at the car exhaust pipe
- 1 litre of fuel represents 2.8 kg of CO_2 from well-to-wheel

[c] On the calculation of fuel savings through lightweight design in automotive life cycle assessments, Christoph Koffler & Klaus Rohde-Brandenburger. International Journal of Life Cycle Assessment (2010) 15:128-135

2 REDUCING MASS HAS ADDITIONAL BENEFITS

2.1. ACCELERATION

Keeping the car acceleration performance constant, which is generally reflected by the power-to-weight ratio, saving weight allows downsizing of the power train (engine, transmission, axle differential etc…) and thus provides additional weight savings.

Keeping the power train unmodified, reduced weight increases the power-to-weight ratio and therefore improves acceleration.

2.2. BRAKING

Keeping braking power constant, light-weighting shortens braking distance.

Keeping the braking performance constant, light-weighting allows downsizing of the brakes, which offers further weight saving potential.

2.3. HANDLING

Road handling is improved by light-weighting in many different ways:

- Handling of a lighter car is easier in demanding driving situations.
- Reducing body weight lowers the centre of gravity, improving the car's stability and reducing the risk of roll-over.
- The optimal weight distribution between front and rear axle being 50:50 and the front axle being usually overloaded, using lightweight aluminium components for the front parts of cars is particularly beneficial.

2.4. DRIVING COMFORT AND ROAD PRESERVATION

Saving weight on unsuspended parts like wheels does not only increase a car's comfort, but also reduces the hammering effect on uneven roads, therefore reducing wear of the roads.

3 ALUMINIUM IS THE IDEAL LIGHT-WEIGHTING MATERIAL

3.1. ALUMINIUM PROPERTIES

At 2,700 kg/m³, the density of aluminium is one-third of that of steel. But such a weight reduction is seldom reached since, for a large number of parts, it is necessary to increase the average thickness of aluminium compared to steel to achieve the same part characteristics.

The most frequently encountered ratio of thickness[d] in structural applications is approx. 1.5, which means for instance that an 0.8 mm steel component can be replaced by a 1.2 mm aluminium component: in this case, the weight reduction is still 50%.

However, the relationship between the material properties and the strength, stiffness and weight of a component is very complex and can be strongly influenced by the part geometry, meaning that there is no absolute rule. In practice, it will be necessary to consider the design of each component individually to determine the actual weight reduction potential. The following section further illustrates this fact.

[d] This ratio is valid for stiffness-critical sheet applications.

3.2. DIRECT WEIGHT SAVINGS WITH ALUMINIUM

Aluminium allows a saving of up to 50% over competing materials in many applications.

Typical relative[e] and average absolute weight savings of today's main aluminium applications in mass-produced cars are given in Figure 4.

For niche models, full aluminium bodies enable a 30-40% weight saving, between 70 and 140 kg, depending on the size of the car.

It should be recalled that, as explained in Section 1.2, indirect weight savings can come on top of direct weight savings, and can represent up to 50% additional savings on the weight of the complete car.

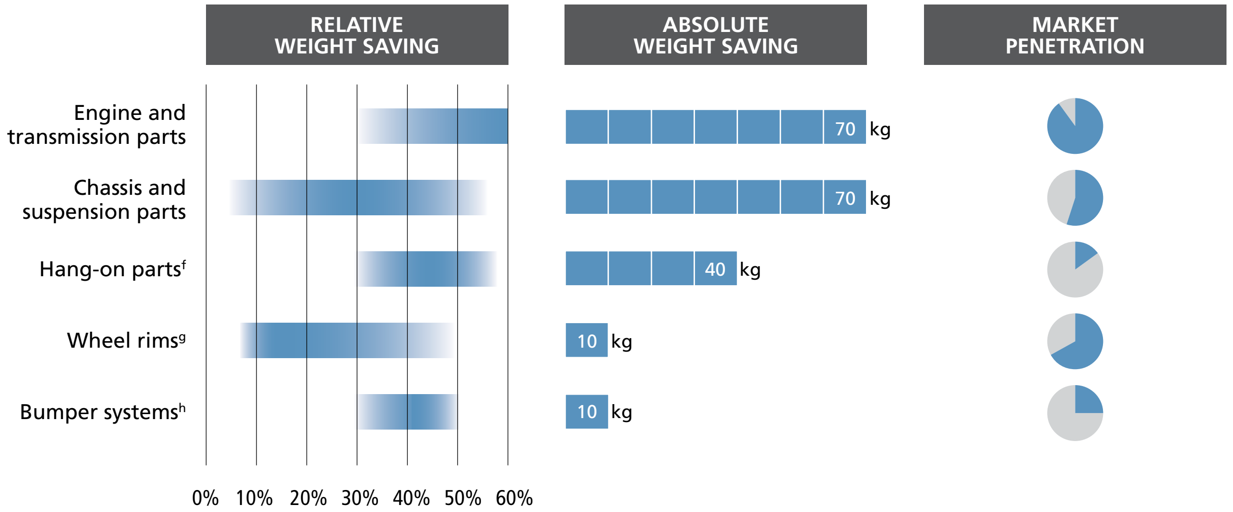


Figure 4: Aluminium's direct weight savings and market penetration

[e] Relative to the weight of substituted parts.
[f] Hang-on parts are bonnets/hoods, wings/fenders, doors, boot lids. The market penetration of aluminium bonnets is 21% in Europe.
[g] Wheel rims are presently not always weight-optimized. However, 50% weight saving is achievable.
[h] The overall market penetration of aluminium bumpers is 25% in Europe, but for front bumpers, it is close to 40%.

3.3. TODAY'S CARS CONTAIN 140 KG OF ALUMINIUM

The Audi A8, the Jaguar XJ and the Range Rover are well known for their high aluminium content, exceeding 500 kg, but all cars actually contain significant amounts of aluminium (Figure 5).

A study published by Ducker Worldwide in cooperation with the European Aluminium Association shows that the amount of aluminium used per car produced in Europe almost tripled between 1990 and 2012, increasing from 50 kg to 140 kg. This amount is predicted to rise to 160 kg by 2020, and even reach as much as 180 kg if small and medium cars follow the evolution recorded in the upper segments of the automobile industry (Figure 6).

The study is based on a detailed analysis of car models representing a European production volume of 17 million units in 2012. The distribution of the 140 kg on various parts can be seen in Figure 7.

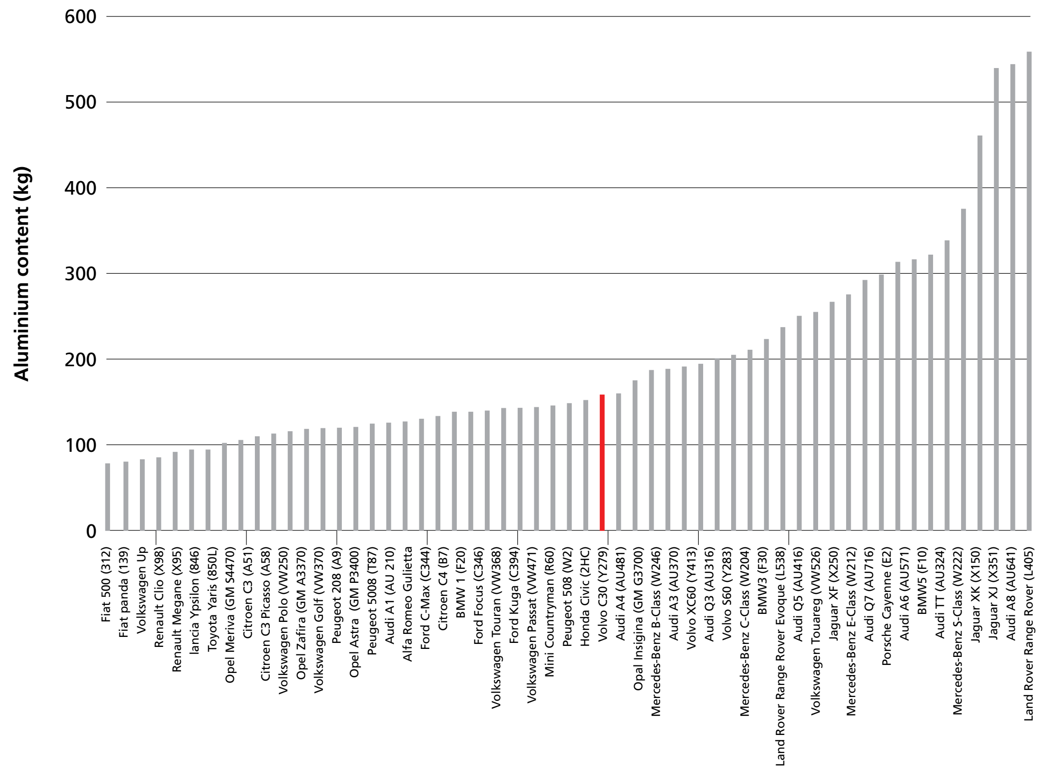


Figure 5: Aluminium content of some European cars

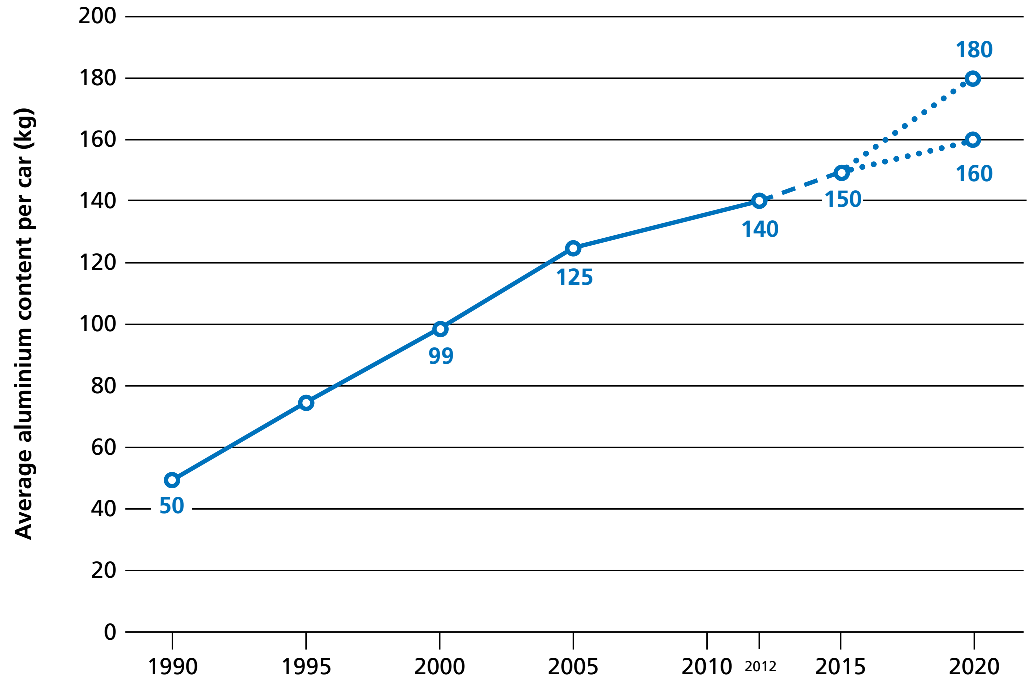


Figure 6: Evolution of average aluminium content per car produced in Europe

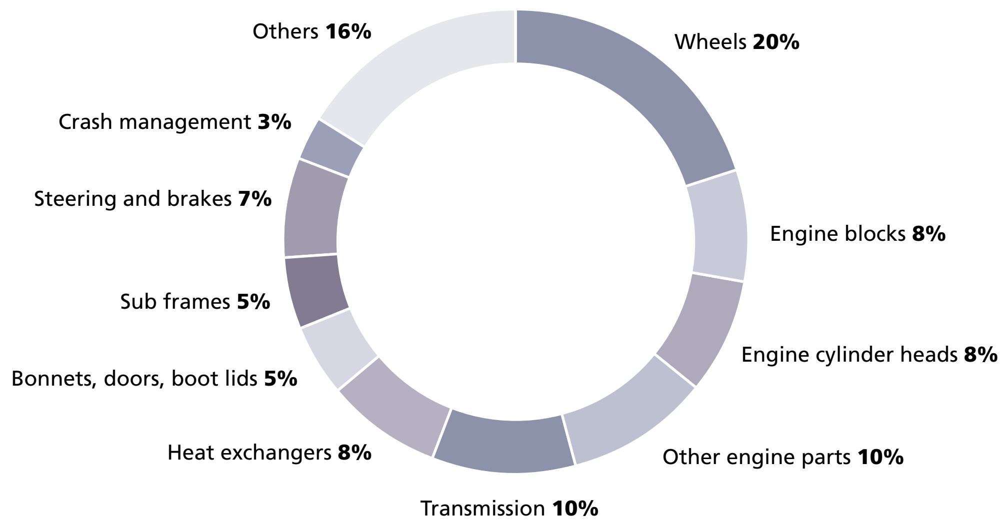
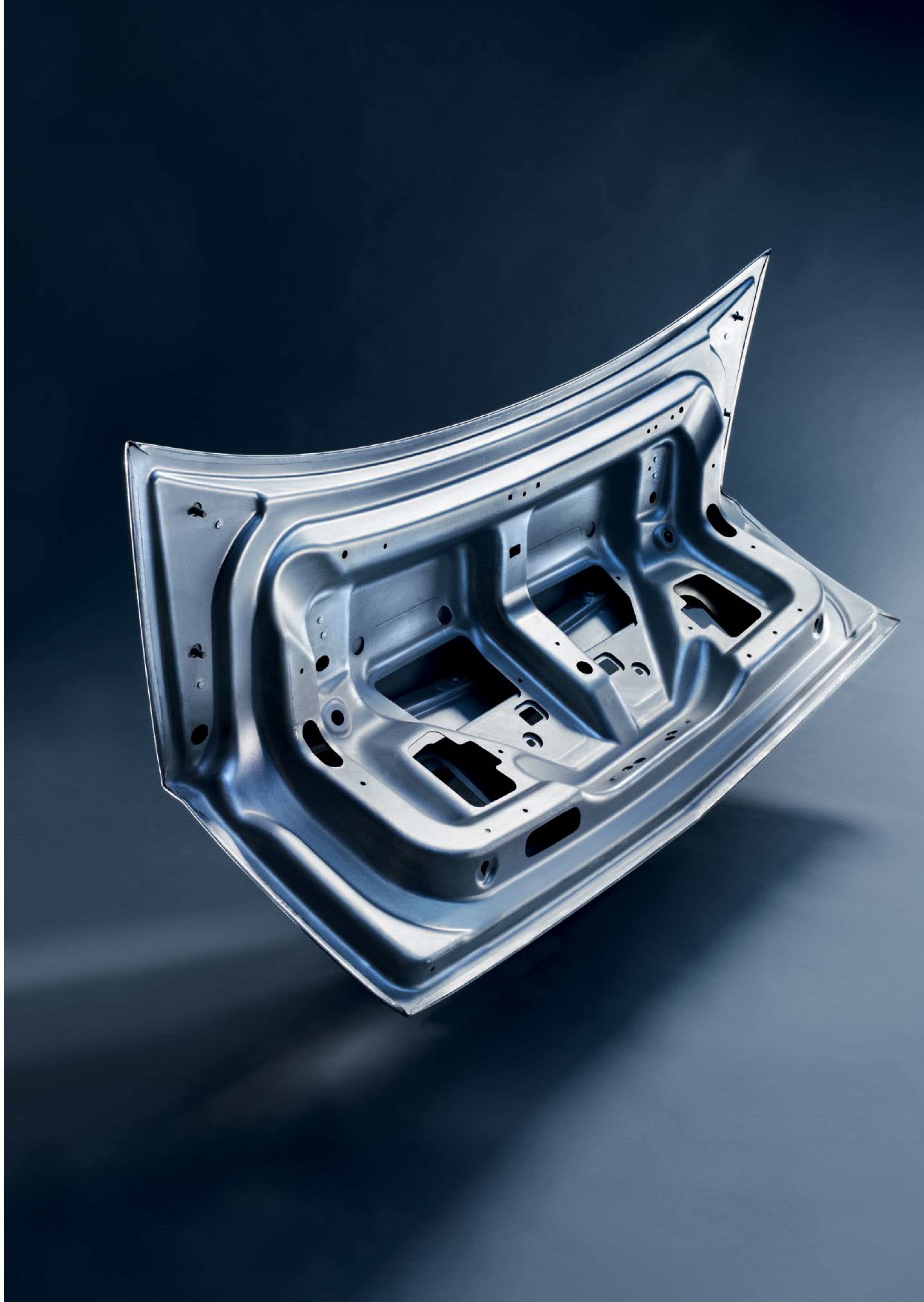


Figure 7: Distribution of aluminium in European cars



Cost-efficient aluminium solutions offer significant additional weight reduction potential.

3.4. TOMORROW'S CARS COULD EASILY BE 40 KG LIGHTER

Innovative, safe and cost-efficient light-weight aluminium bonnets, fenders, doors and bumpers can be found across all car models today. For these parts, switching to aluminium is relatively easy and does not need full re-engineering of the car. Together, their light-weighting potential exceeds 40 kg per car, but market penetration is less than 20%. This is a weight reduction potential that can be exploited immediately to reduce the average emissions from future cars by 3-4 g CO_2/km.

In practice, material substitution is generally connected to a model change where there is extensive re-designing in any case. Mixed material design does not present bigger problems, provided that appropriate design and manufacturing measures are taken. Thus, the weight saving potential could even be significantly greater.

3.5. ALUMINIUM FRONT STRUCTURES IN THE MEDIUM TERM?

Aluminium front structures are already used in sport and premium cars today.

In a study by the Institut für Kraftfahrwesen-University of Aachen (IKA)[i], aluminium front sections for medium-sized cars were examined. Numerical simulations carried out on a reference car indicate a minimum weight reduction potential of 35%. In a progressive approach, the design space was expanded as far as possible with respect to the major package components of the reference vehicle in order to allow more design freedom and encourage innovative ideas. In this case, a weight reduction potential of 41% was achieved, with a significant increase in stiffness plus improved energy absorption in the event of a crash. Thus, even if this weight reduction potential cannot be fully realised, aluminium front structures are clearly a most interesting future application for aluminium.

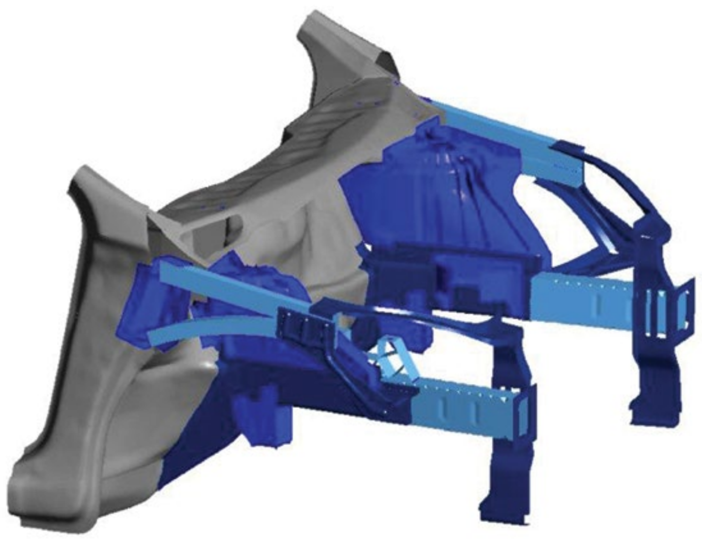


Figure 8: Aluminium front structure

[i] Optimised aluminium vehicle front section, ika-RWTH-Aachen University (2006)

3.6. AN IMPRESSIVE LIGHTWEIGHTING POTENTIAL REMAINS UNTAPPED

Total vehicle weight could be cut by one-third by means of aluminium

The Alu-maximised Car study[j] determined the weight saving potential in a car designed to make optimum use of aluminium wherever possible. The results are quite significant; the 'Alu-maximised' car is remarkably lighter than the reference model. The reference car, an amalgam of five popular small family cars, weighs 1229 kg without fuel or occupants. Based on the latest technology, the final weight of the 'Alu-maximised' car after direct and maximum indirect weight savings is just 785 kg, i.e. 36% lighter!

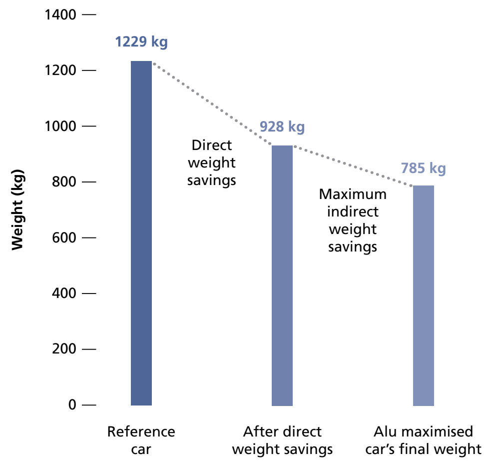


Figure 9 : Alu-maximised Car study results

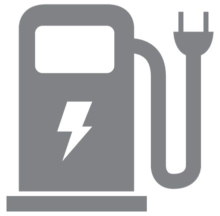
Car bodies could become 40% lighter by means of aluminium

The "Stiffness and Crash Relevance of Car Body Components" study[k] found that the use of aluminium could result in significant weight savings for the typical components of a compact class car body, ranging from 14 to 49%. Based on a state-of-the art steel reference car, the maximum weight reduction potential of aluminium in car bodies is approximately 40%.

Weight reduction potential using high strength steel was limited to a reduction of only 11%. The reason why the potential weight reduction using high strength steel is smaller is that nearly 40% of the parts analysed simply cannot be made thinner without reducing the car's overall rigidity, whereas aluminium can be used without reducing thickness or causing the car's rigidity to suffer.

Futhermore, the multi-material SuperLIGHT-Car project[l] on "Sustainable Production Technologies of Emission Reduced Light-weight Car concepts" with 38 partners, including most European carmakers, resulted in a predominant role for aluminium in a mix of proven and state-of-the-art solutions ready to make an average midsize car body 100 kg or 35% lighter.

[j] Alu-maximised Car, ika-RWTH-Aachen University (2003)
[k] Stiffness and Crash Relevance of Car Body Components, ika-RWTH-Aachen University (2009)
[l] Advanced multi-material lightweight vehicle structures, SuperLIGHT-CAR Consortium (2009)



Aluminium reduces the cost of electric vehicles since lighter cars need fewer batteries and less electricity to travel the same distance.

3.7. ALUMINIUM IN ELECTRIC VEHICLES

Electric vehicles are today rather expensive, mainly because of the cost of batteries. It is therefore important to make electric cars as energy efficient as possible. Lightweighting is one of the most obvious ways of improving the energy efficiency of any vehicle, including electric ones. Lightweighting comes at a cost, however. The material used for lightweighting is often slightly more expensive than heavier classical materials. In a study commissioned by EAA[m], it has been shown that an electric car of the VW Golf class can be made 187 kg lighter using aluminium instead of steel. The additional cost of building the car in aluminium is more than offset by the cost savings that can be made on the battery pack, since a lighter car needs less battery power to drive the same distance. The total cost of the aluminium electric vehicle is 635 € lower than that of the steel electric vehicle.

	ELECTRIC REFERENCE VEHICLE	ALUMINIUM TARGET VEHICLE	DIFFERENCE	
Vehicle body	375 kg	213 kg	-162 kg	-43.2%
Battery system	232 kg	207 kg	-25 kg	-10.8%
Total vehicle weight	1,327 kg	1,140 kg	-187 kg	-14,2%

Table 2: Aluminium in electric vehicles study results

The aluminium design was achieved by keeping the shape of the outer skin of the vehicle the same as for the original steel vehicle. For the vehicle structure, a combination of extrusion parts, complex casting nodes and sheet parts are used. Figure 10 shows the different aluminium semi-products used in the aluminium design.

In addition, a life cycle analysis of the full-steel and the full-aluminium electric vehicles shows that the aluminium electric vehicle emits 1.5 tons of greenhouse gases less over its complete life-cycle than the steel electric vehicle (including production, driving distance of 150,000 km and recycling).

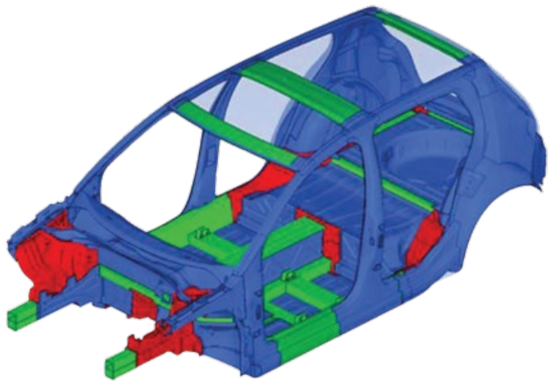


Figure 10: Distribution of aluminium semi-products

[m] Investigation of the Trade-off Between Lightweight and Battery Cost for an Aluminium-intensive Electric Vehicle, ika-RWTH-Aachen University (2012)

3.8. THE POTENTIAL OF ALUMINIUM APPLICATIONS IS ENDLESS

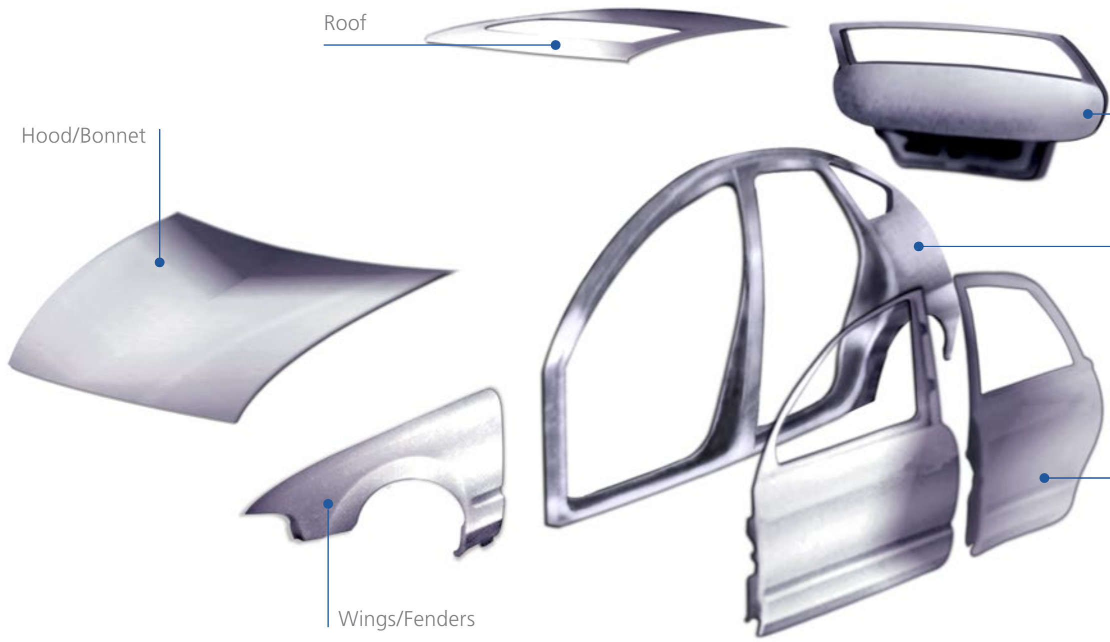


Figure 11: Aluminium hang-on parts

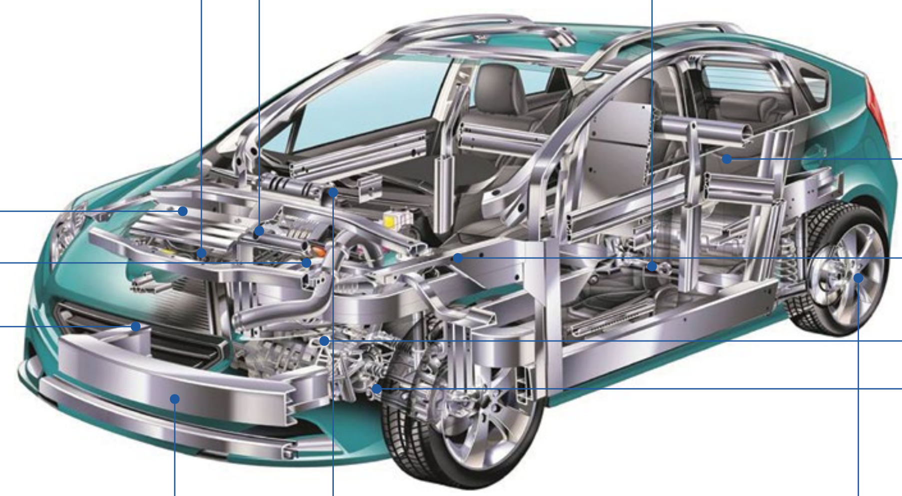


Figure 12: The endless potential of aluminium applications

Light-weighting improves safety for all road users, as it facilitates vehicle handling, shortens braking distances and reduces the severity of accidents.

4 ALUMINIUM IMPROVES VEHICLE SAFETY

Today's vehicles have to fulfil a large and increasing number of stringent safety regulations, both regarding vehicle crash management (e.g. EuroNCAP, IIHS, etc.) and pedestrian protection.

Lightweight aluminium designs offer the possibility to improve the safety performance of a vehicle and to reduce simultaneously its mass. The mass-specific energy absorption capacity of aluminium is twice that of mild steel, and also compares favourably to the newly developed high strength steel grades. But car safety is not only a question of the material used. The design applied and the manufacturing concept are even more important.

4.1. ALUMINIUM FOR SAFE CAR BODY STRUCTURES

In order to fulfil the various safety requirements, modern vehicles include a stiff, stable passenger cell to ensure the necessary survival space in the event of an accident, which is surrounded by deformation zones where the crash energy is efficiently absorbed without exceeding critical acceleration levels. In the development of the car body structure, the most important thing is to find a suitable compromise between structural stiffness, crash energy absorption capacity and further body requirements (e.g. package). Aluminium is an ideal material whereby to solve these often conflicting goals with maximum performance and lowest possible weight.

The extreme rigidity of an aluminium structure is the result of higher material thickness (aluminium components are generally about 50% thicker than comparable steel body components). Additional possibilities to increase the body stiffness are offered by the use of closed multi-hole extrusions and large, structural high quality die castings of sophisticated design. Depending on the available package space, it is therefore possible to improve the stiffness of the car body structure while maintaining a weight reduction of up to 40 – 50% compared to a steel design.

4.2. ALUMINIUM FOR CRASH MANAGEMENT SYSTEMS

In an automobile, the crash energy is primarily absorbed by the front and rear crash management systems, followed by the deformation of the longitudinal beams. Crash management systems consist of a bumper beam and two crash boxes that are designed to minimize the damage to the vehicle at low speed impacts and to absorb a maximum of crash energy by deformation at higher speed impacts. Aluminium crash management systems are generally based on extrusion designs. Proper alloy selection ensures that crash management systems deform heavily before crack formation starts. At equal energy absorption, aluminium allows weight savings of about 40% compared to steel solutions.

4.3. ALUMINIUM FOR PEDESTRIAN PROTECTION

Design for pedestrian protection requires sufficient deformation space and the use of a construction material offering a low initial peak force and closely controllable energy absorption characteristics. Proper selection of the aluminium alloy and product form enables lightweight components to be produced that fulfill all requirements. Furthermore, the potential for lightweight design with aluminium facilitates the reduction of the risk of severe knee and head injuries by the addition of lower bumper stiffeners and the use of pop-up bonnets.

4.4. LIGHTWEIGHTING INCREASES VEHICLE SAFETY

Lower weight improves vehicle handling and reduces braking distances, which are important factors in respect of accident avoidance. Furthermore, several international studies have shown that size, not weight, is the better determinant of vehicle safety[1]. Reducing vehicle weight reduces the crash forces that must be managed and the energy that must be absorbed during an accident, and this applies to all vehicles involved. If the vehicle size is reduced, both the interior survival space and the available crush space of the vehicle are reduced. Consequently, making cars lighter without making them smaller is a positive measure from a vehicle safety viewpoint.

An additional factor is crash compatibility. Large differences in vehicle weight are, of course, significantly more dangerous for the lighter vehicle. Consequently, the overall light-weighting of all vehicles while keeping their size would improve the survival rate for all road users.

[1] An Assessment of the Effects of Vehicle Weight and Size on Fatality Risk in 1985 to 1998 Model Year Passenger Cars and 1985 to 1997 Model Year Light Trucks and Vans, R.M. Van Auken & J.W. Zellner (2005), SAE Technical Paper 2005-01-1354, 2005, doi:10.4271/2005-01-1354

Sipping fuel and saving lives: Increasing fuel economy without sacrificing safety, Deborah Gordon, David L. Greene, Marc H. Ross, and Tom P. Wenzel (2007)

5 ALUMINIUM IS SUSTAINABLE

5.1. ALUMINIUM IS A PERMANENT MATERIAL

Aluminium is easy to recycle and saves 95% of the energy required to produce primary aluminium.

RWTH-Aachen analysed the aluminium recycling process and concluded that 95% of the aluminium contained in end-of-life vehicles can be recovered by mechanical processing in modern shredder and non-ferrous metal recovery plants[6].

The aluminium life cycle is described in Figure 13. Aluminium recycling from end-of-life vehicles is an established and profitable business, and the proceeds from the recycled aluminium are a most important factor in the economy of car recycling.

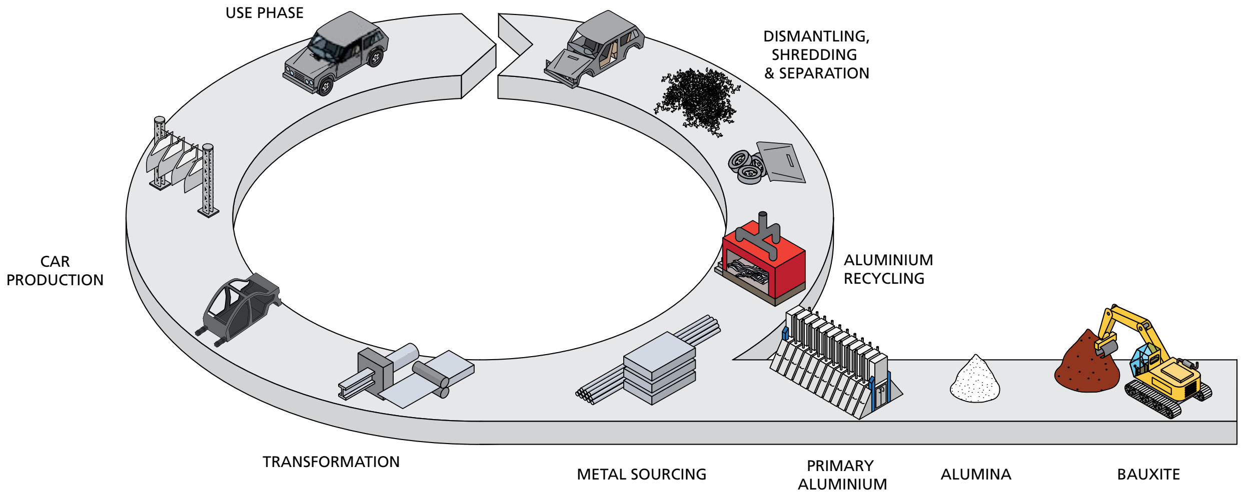


Figure 13: Aluminium life cycle

[6] This figure does not include aluminium losses within smelting and refining processes.

Cars are metal mines for future generations.

5.2. THE FULL LIFE CYCLE MUST BE CONSIDERED

Today, the use phase of vehicles is responsible for around 80% of the full life cycle emissions. With constantly improved fuel efficiency, the impact of the production of vehicles is becoming increasingly significant. It is therefore important for manufacturers to consider the full life cycle emissions when making design decisions. The best picture of the environmental footprint of a vehicle is obtained by looking at its total life cycle, in which production, use phase and end-of-life recycling benefits are all taken into account (see Figure 14).

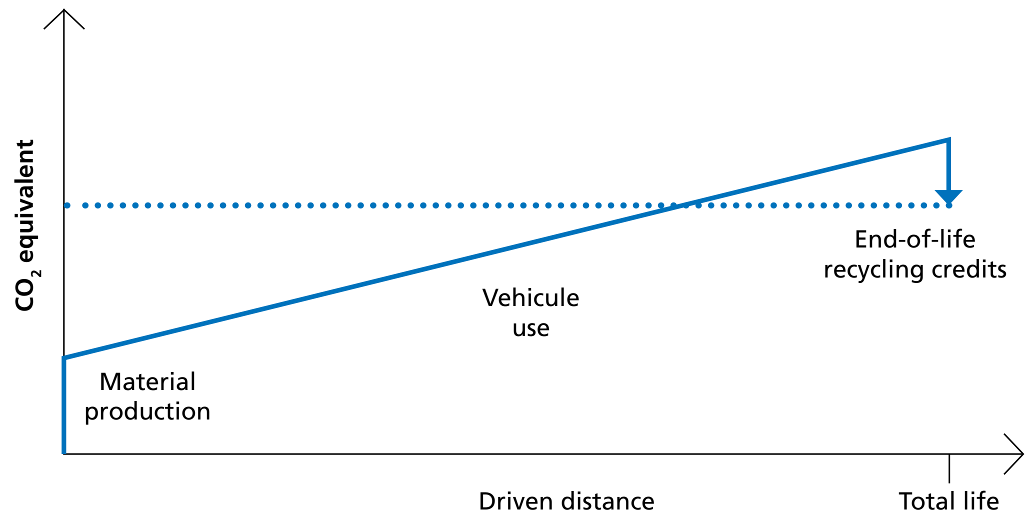


Figure 14

Some LCA studies are based on the recycled content approach. That means that the impact of the production phase is reduced based on the amount of recycled material included in the production. For aluminium, the recycled content, i.e. the scrap availability, depends on market growth, average product life span and the end-of-life recycling rate. Even if the end-of-life recycling rate is high, Figure 15 clearly shows that recycled metal cannot satisfy market demand due to market growth, increasing aluminium content in cars and the long lifespan of products.

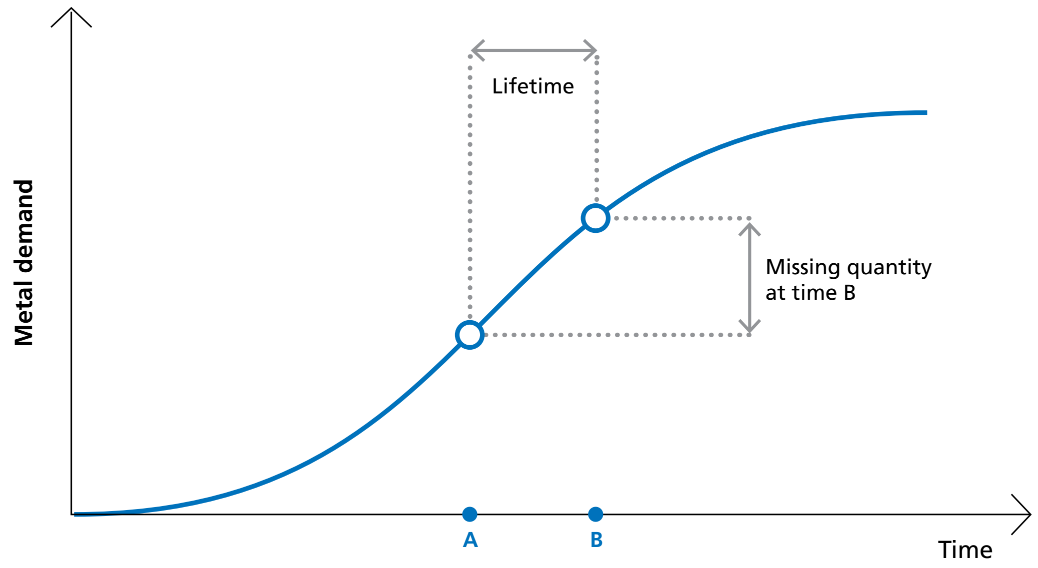


Figure 15

As can be seen, the recycled content of aluminium car components is not directly linked to its end-of-life recycling performances. Hence, it is more appropriate to use the end-of-life recycling rate to reflect and credit the recycling performances of an aluminium car component.

5.3. FULL LIFE-CYCLE CO_2 SAVINGS

Let us take an average European car containing 140 kg of aluminium and a driving distance of 200.000 km (15.000 km / year). We further assume that an aluminium component is on average 40% lighter than the replaced component (direct weight saving) and that 25% additional weight reduction is obtained by downsizing other components (indirect weight savings). We can then calculate that:

- Each kg of aluminium provides an average light-weighting of 1 kg.
- 1 kg of aluminium in a car reduces CO_2 emissions by 18 kg during its use phase.
- 1 kg of aluminium in a car reduces CO_2 emissions by 17 kg during its whole life-cycle[p].
- Based on a yearly European production of 16 million cars, this corresponds to roughly 40 million tons of avoided CO_2 emissions during their lifespan.
- 140 kg of aluminium in an average car result in an annual average fuel saving of 65 litres.

[p] An end-of-life recycling rate of 95% is assumed for aluminium and competing materials.

5.4. COST CONSIDERATIONS

Assuming an average fuel cost of 1.60 € per litre, every kilogram saved on the mass of a European car saves more than 10 € over 200,000 km, to which savings on CO_2 emissions-based national taxes and European penalties should be added.

However, today's cost premium accepted by car manufacturers generally does not exceed 5 € per kg saved on family cars[5]. This is because first car buyers are focused on purchase price and do not care enough about total life cycle cost, fuel consumption and CO_2 emissions.

However, several of today's aluminium applications are already affordable (i.e. between 2 and 4 € per kg light-weighting) and easy to apply (hang-on parts[6]), meaning that a fast upgrade to aluminium is possible.

Furthermore, the automotive and aluminium industries are working together on reducing the cost of other aluminium applications currently used in sport and luxury cars, so that these can also find their place in smaller cars.

[5] There is no fixed number; the acceptable cost depends on the type of car, the philosophy of the OEM, the location of the specific component in the car as well as the valorization of additional advantages. For example, higher cost premiums can be justified for front and roof parts in order to improve the mass balance, or for bonnets and doors to allow for easier opening.
[6] Bonnets/hoods, wings/fenders, doors, boot lids.

Europe is the world leader for aluminium in car body applications.

6 ALUMINIUM AND COMPETITIVENESS OF THE EUROPEAN INDUSTRY

The European automotive industry, in close co-operation with the European aluminium industry, has developed and introduced numerous innovative aluminium light-weighting solutions. Key success factors are the product-specific developments, the selection of the proper aluminium alloys and the consistent reproduction of the required quality level for the various product forms (sheets, extruded sections, castings, forgings, etc.). Most important of all is the full exploitation of aluminium-specific design possibilities and the introduction of manufacturing methods highly suited for the forming, machining, assembly and surface finishing of aluminium components. Intensive joint research and development activities have enabled the practical use of safe and cost-efficient light-weight aluminium concepts both in high volume production and in the manufacturing of small series and niche vehicles. These solutions can be applied with little adaptation across all car models.

The European producers have taken the global lead in the light-weighting of passenger cars with aluminium. Europe is the leader for aluminium body applications, in chassis and suspension, bumper systems, etc., to name just a few. An important element proved to be the joint R&D efforts of both the Automotive and the Aluminium industry, often facilitated by the support of the European Commission.

Figure 16 further illustrates this fact, taking the example of car body applications and crash management systems.

Europe should therefore safeguard its competitive advantage and remain the pioneer of vehicle light-weighting.

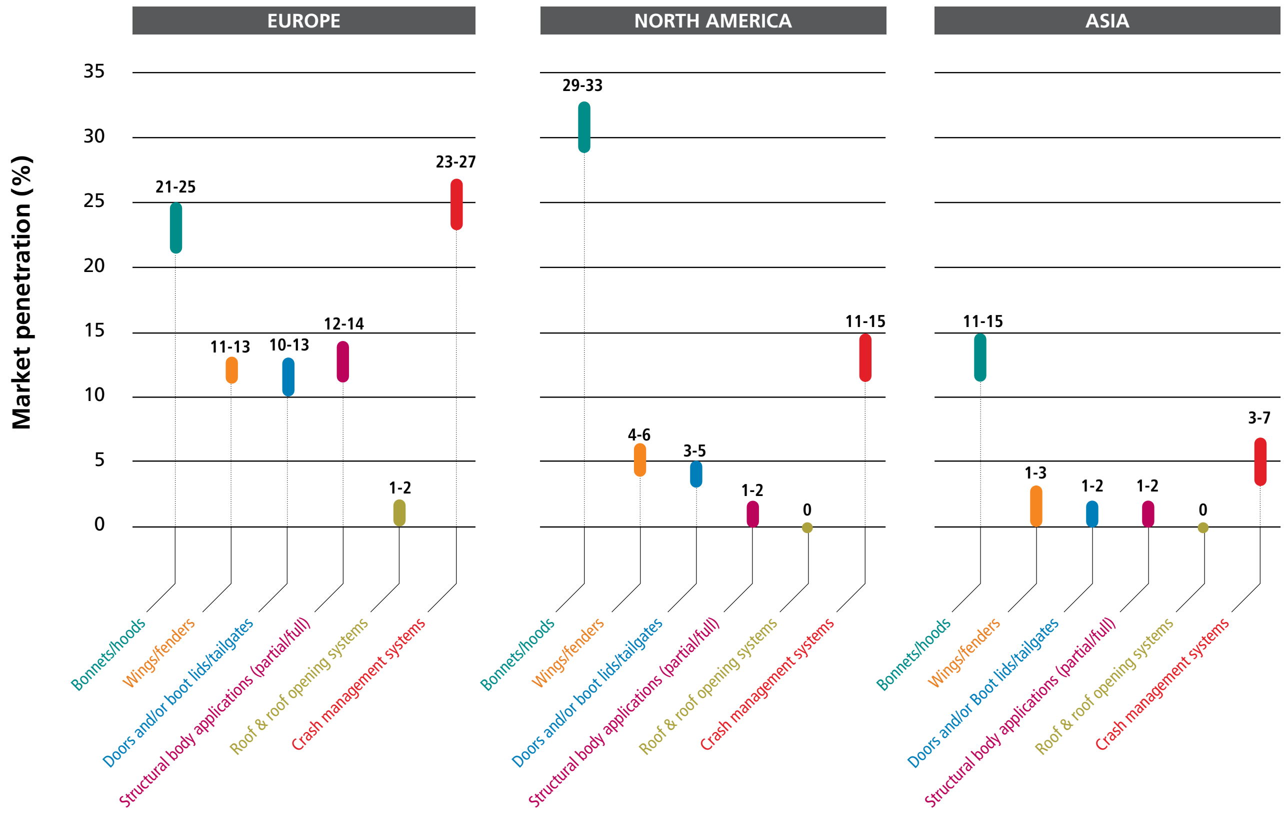


Figure 16: Aluminium penetration in car body applications

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ALUMINIUM SUPPLY

Aluminium supplies will continue to meet demand because:

- Current reserves of bauxite, used to produce primary aluminium, will last for many generations.
- The amount of aluminium available for recycling is constantly increasing and its high economic value drives the continuous improvement of recycling processes.
- The production capacity of aluminium (primary, recycling, casting, extrusion and rolling…) is ready to match the automotive industry's increasing demand.

CONCLUSION

Because the average mass of passenger cars has dramatically increased since the 70's, and because vehicle weight directly impacts fuel consumption, light-weighting is necessary now more than ever to reduce CO_2 emissions. 100 kg mass reduction achieved on a car saves 8 grams of CO_2 per km at the exhaust pipe.

Aluminium is the ideal light-weighting material, as it allows a weight saving of up to 50% over competing materials in most applications without compromising safety.

Today's European cars contain an average of 140 kg of aluminium components. In the short term, it will be possible to realise many additional aluminium applications without significant re-engineering or extensive cost impact (e.g. by the use of more aluminium hang-on parts). This could easily reduce the average weight of the cars produced in European by 40 kg.

The industry is working on reducing the cost of other aluminium applications, in particular in the body structure and for chassis and suspension parts, currently used in sport and luxury cars, so that they can also find their place in smaller cars.

As a long-term vision, an "Alu-maximised" small family car could be 30-35% lighter after direct and indirect weight savings.

Together, the European Automotive and Aluminium industries are worldwide leaders with respect to the development and application of innovative, safe and cost-efficient light-weighting aluminium solutions; they should safeguard this competitive advantage in order to remain the pioneers of vehicle light-weighting.

> "Aluminium light weighting is the enabler of future sustainable cars"

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