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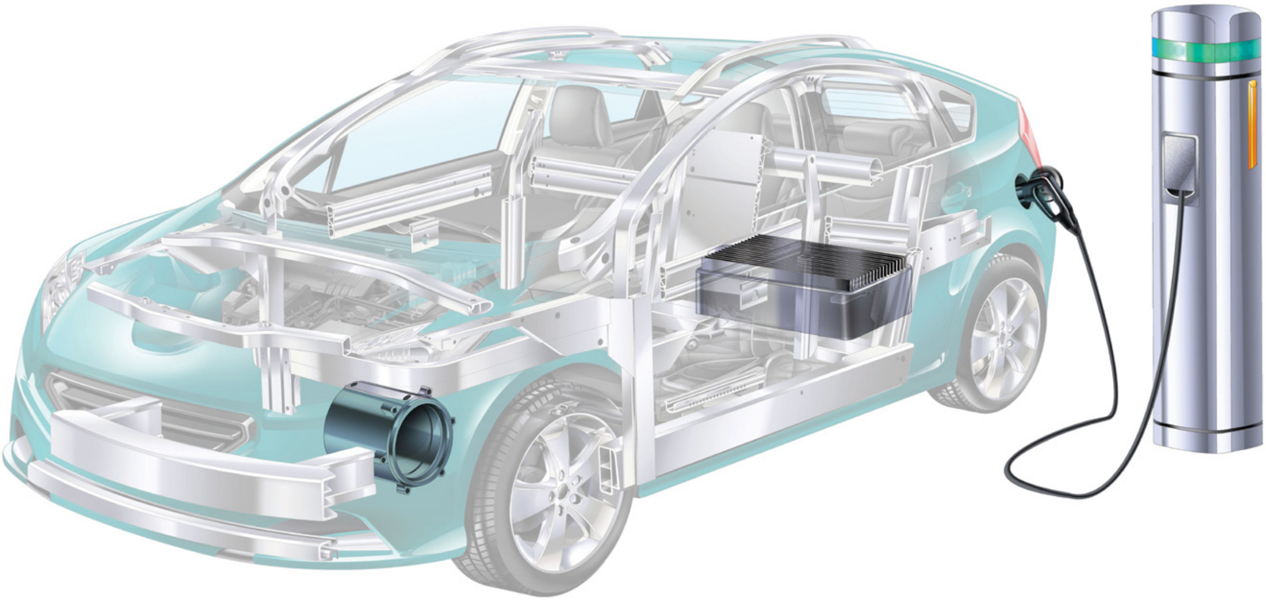
ALUMINIUM REDUCES THE COST OF ELECTRIC VEHICLES

Source: Pininfarina-Bolloré Bluecar

1 INTRODUCTION

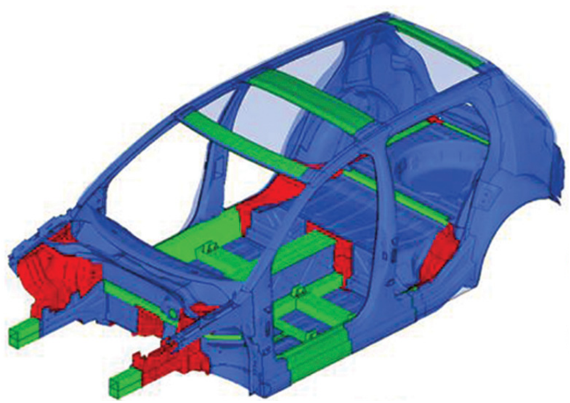
Electric vehicles today are more expensive than traditional vehicles, mainly because of the cost of batteries. It is therefore important to make electric cars as energy efficient as possible. Lightweighting is one of the most effective options to improve the energy efficiency of any vehicle, including electric ones. Lightweighting comes at some cost however, as the material used is often slightly more expensive than heavier classical materials. A study was consequently launched to investigate whether the cost of lightweighting a car with the intensive use of aluminium could be compensated for by a reduction in the cost of the batteries. The study was conducted and published by the Forschungsgesellschaft Kraftfahrwesen GmbH Aachen (fka).



2 DESIGN OF AN ALUMINIUM ELECTRIC VEHICLE

A compact class reference vehicle with steel body and internal combustion engine was chosen as the basis for this study. The mass and crashworthiness properties of this vehicle were analysed in four Euro NCAP and FMVSS[1] 301 high-speed load cases, designated as the benchmark for the various vehicle designs within the project. Both electric vehicles (steel-based and aluminium-based) should at least be as safe as the crash reference vehicle.

Reference vehicle	Electric reference vehicle	Electric aluminium vehicle
Steel body	Steel body	Aluminium body
Gasoline vehicle	Battery electric	Battery electric
Range > 700 km	Range = 200 km	Range = 200 km



• sheet • extrusion • casting

As a first step, the reference vehicle was converted into an Electric version using a conversion design strategy. This means that the original steel body structure was conserved and only minor changes were made in order to adapt the structure around the battery pack for safety reasons. In a second step the car was converted to a full aluminium-bodied electric vehicle. The shape of the outer skin of the vehicle was kept identical to that of steel vehicles. A combination of extrusion parts, complex casting nodes and sheet parts were used. The following illustration shows the various manufacturing methods used in the aluminium body structure[2] design.

[1] Federal Motor Vehicle Safety Standards
[2] Body without hang-on parts and without crash management system

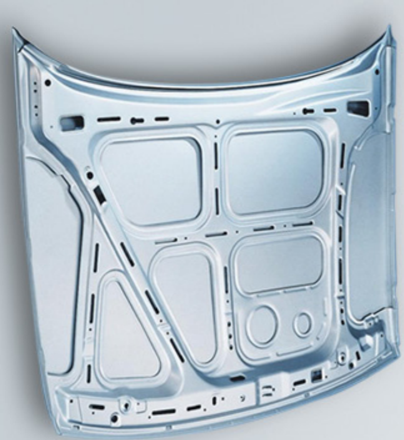
3 RESULTS

REDUCED VEHICLE WEIGHT

While reaching the defined crashworthiness targets, the weight of the total body has been reduced by 162 kg compared to the electric reference steel body. Due to this weight saving, the battery system capacity could be downsized by 3.3 kWh (which is approximately 9% of the system capacity) while still maintaining the intended driving range of 200 km. This also meant an additional weight reduction of 25 kg[3], making **the aluminium electric vehicle in total 187 kg lighter than the steel electric vehicle.**

	Electric reference vehicle	Electric aluminium vehicle	Difference	
Vehicle body	375 kg	213 kg	-162 kg	-43%
Battery system	232 kg	207 kg	-25 kg	-11%
Other parts	720 kg	720 kg		
Total vehicle weight	**1,327 kg**	**1,140 kg**	**-187 kg**	**-14%**

[3] Assuming battery technology features available in 2015



> "Producing the electric vehicle in aluminium saves 635 € compared to the reference vehicle"

REDUCED PRODUCTION COSTS

The cost implications were then quantified using the fka's cost assessment tool. Assuming a production volume of 100,000 vehicles per year, the aluminium electric car can be produced at additional part and joining costs of 1,015 € per vehicle. This additional cost should be compared to the cost reduction related to the battery capacity downsizing of 3.3 kWh. Assuming energy-specific battery system costs of 500 €/kWh for the year 2015, the reduction in total battery system costs is 1,650 €. If we compare the additional costs of the lightweight design with the reduction in battery system costs, it can be concluded that the savings on battery costs more than outweigh the additional costs for the lightweight aluminium vehicle. According to these assumptions, **producing the aluminium electric vehicle is 635 € cheaper than the reference electric vehicle.**

In order to achieve a complete aluminium design, some parts represent a somewhat high specific lightweight cost (Euro per kg saved). This increases the average specific lightweight cost. Hence, even with a lower battery price in the future, the lightweighting of a large number of parts will still be cost-efficient.

REDUCED OPERATION COSTS

During the use phase, the aluminium vehicle saves 1.2 kWh of electricity per 100 km compared to the reference vehicle. Assuming an electricity cost of 0.19 €/kWh, **the aluminium electric vehicle saves 345 € over 150,000 km.**

To clear up some uncertainties about several powertrain cost-influencing factors, a cost tool was developed to enable the impact of a wide variation range of each factor to be evaluated. The cost tool can be found on the EAA website www.alueurope.eu/publications-automotive/

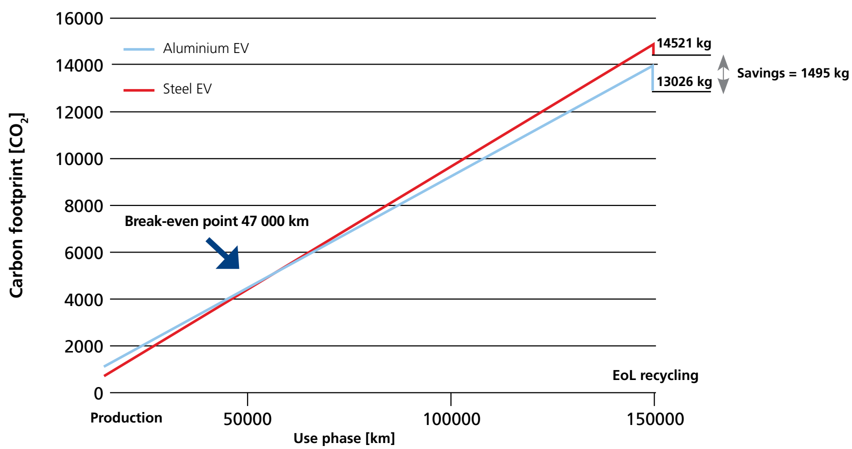
GHG intensity for the two vehicles (kg CO_2-equiv)	Steel electric reference vehicle	Aluminium electric vehicle
Production of the car body and batteries		
Metal production	735	1405
Credits for end of life recycling of metals	-300	-980
Battery production (only difference)	0	-300
Sub total	**435**	**125**
USE PHASE[4]: electricity to drive 150,000km	**14086**	**12901**
TOTAL	**14521**	**13026**
Savings		**-1495**

[4] Based on EU grid mix

ENVIRONMENTAL BENEFITS

Finally, life cycle assessments of both vehicles were carried out, revealing that the **aluminium electric vehicle emits 1.5 tons of greenhouse gases less over its complete life-cycle.**

LCA over the complete life cycle



4 CONCLUSION

While keeping the same crash performances, the study demonstrates that lightweighting through aluminium reduces both the production and the operating costs of electric vehicles since a lighter car needs fewer batteries and less electricity to travel the same distance. Therefore, lightweighting should be encouraged as it is key to improve the market uptake of electric vehicles.

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