Constellium Aluminium for automotive parts Life Cycle Assessment summary: Crash Management Systems

Introduction

This document aims at describing the results of Constellium internal Life Cycle Assessment (LCA) work on aluminium automotive parts, focusing on an aluminium crash management system (CMS) for illustration purpose. It also contains a comparison with a steel part.

This study respects ISO14040/44 standard for LCA. A previous study of an aluminium car hood and the resulting report underwent a critical review by independent third parties (led by Quantis with a contribution from French CETIM). The CMS study is based on a similar framework, and differs only on some specific items (average mass saving of 32%, extrusion process data instead of rolling, alternative primary source (for billets instead of slabs).

The document structure is as follows:

- Scope of the study: description of scope and main assumptions.
- Results: disclosure of results, with a specific focus on climate change (greenhouse gas emissions). Full study was performed on a wider range of indicators.
- Sensitivity analysis: study and discussion of main parameters influencing the results
- Conclusions

Scope of the study

A key issue is the definition of the scope of the study, notably to exclude unsuited comparison or data extrapolation. Comparison should make sure that it addresses the same scope.

This study's scope is a car Crash Management System (CMS), based on an actual model that can be produced either out of aluminium parts machined at Gottmadingen, thus based on this site specific performance and metal sourcing, or from steel, then using public data from literature and standard LCA database (from GaBi LCA software).

The figure hereunder summarizes the system boundaries (i.e. life cycle steps that are included or excluded from the scope) and material flows. Investigated life steps included primary metal elaboration, metal transformation (extrusion and forming operations, including scrap recycling), car use phase and end-of-life (including recycling).

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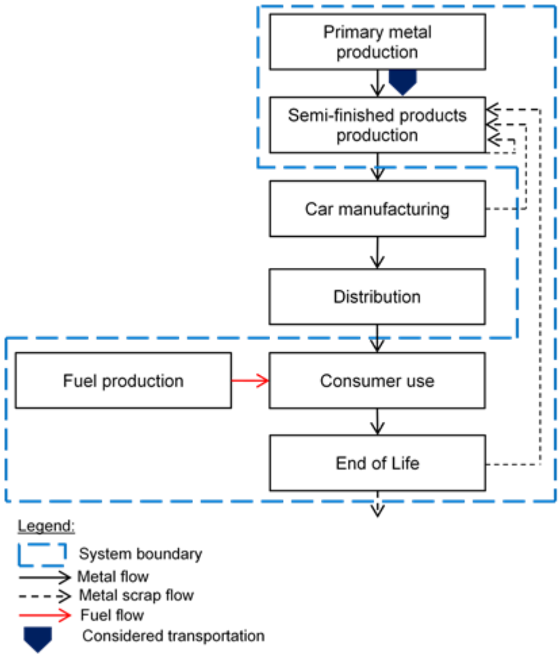
LCA Summary



As illustrated on the figure on the left, two life cycle steps are excluded from the scope.

- Car manufacturing, due to missing data
- Product distribution

Other steps were included, from metal production (from bauxite mining to electrolysis) to product use and end of life.

Are included in the model transportation of billets and extruded parts, along with transformation scrap production and recycling. Due to the lack of data related to steel, production and recycling of scrap related to the car part manufacturing was not included. In the study, its effect was investigated only for aluminium.

Main assumptions:

- Metal according to Constellium Extrusion 2014 sourcing.
- European average car consumption from GaBi software database (diesel, but gasoline case was also investigated, showing too small changes to alter study conclusions).
- 100 % primary metal input, as recycling credits were considered using the avoided impact (= end of life) approach.
- Mass of the aluminium car CMS: 6.13 kg, with 32% mass saving over steel CMS.
- Effect of 100 kg mass saving on fuel consumption: 0.28 l / 100 km[1]
- Multi components design: cross member, towing eye-nut, crash boxes (2) and insert.
- Average distance ran by the car: 200,000 km.
- Car end of life: according to European statistics, 84% of cars are being collected and recycled in Europe. The remaining 16% were assumed to experience an extra 50,000 km of use before being landfilled (worst-case approach for end of life).
- Recycling rate of steel: 97%[2] for the 84% collected fraction of end-of-life cars.
- Recycling rate of aluminium: 91%[2] for the 84% collected fraction of end-of-life cars.

[1] C. Koffler and K. Rohde-Brandenburger, “On the calculation of fuel savings through lightweight design in automotive life cycle assessments,” The International Journal of Life Cycle Assessment, vol. 15, no. 1, pp. 128-135, January 2010
[2] Internal calculation based on actual shredding campaigns within French IRT M2P program.

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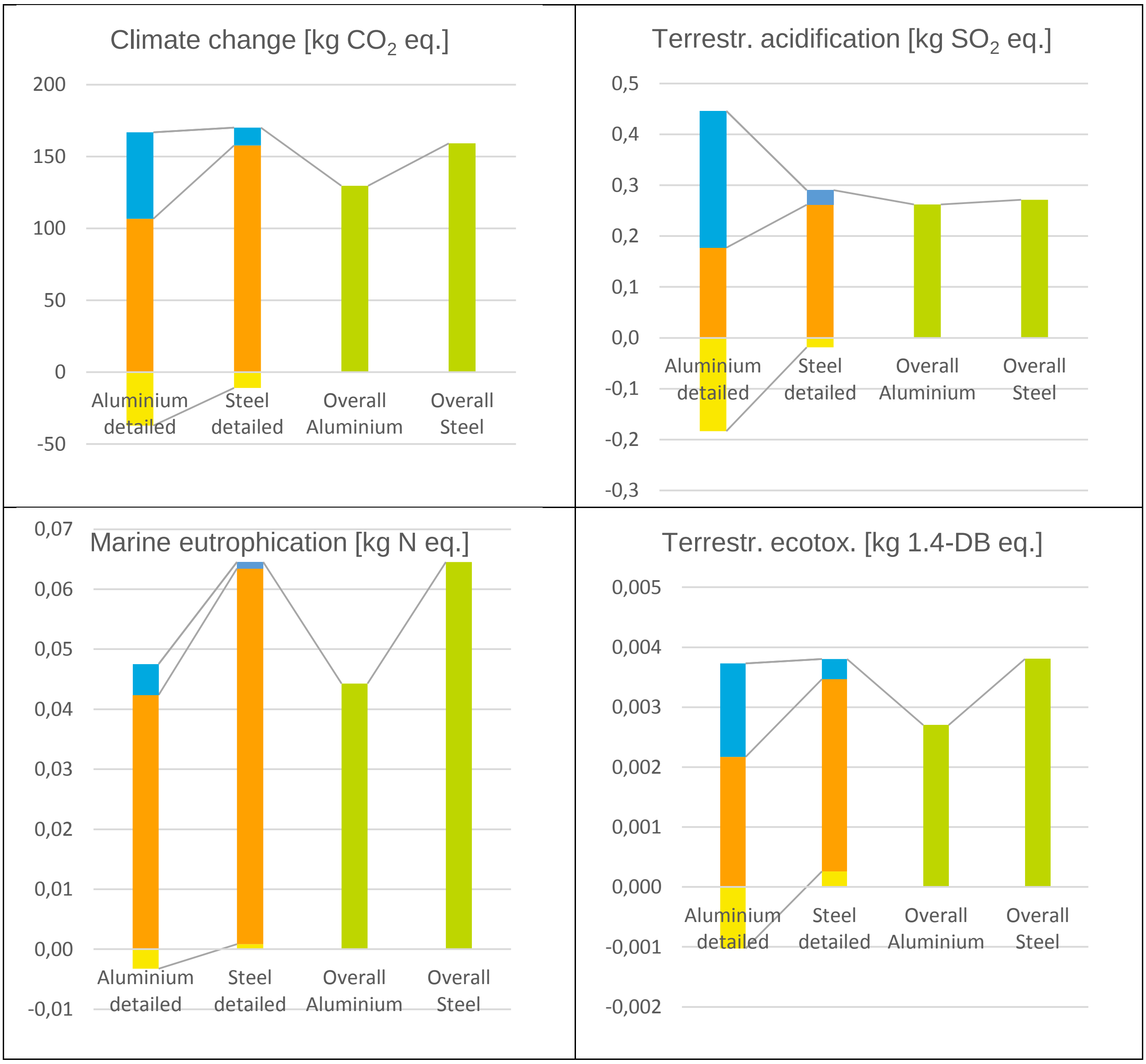
Results:

This section briefly describes Life Cycle Assessment (LCA) calculation results.
Figures below compare steel and aluminium CMS and detailed contribution of main life cycle step for 4 indicators: climate change (= greenhouse gas emissions), terrestrial acidification, marine eutrophication and terrestrial ecotoxicity.

Contribution of different life cycle phases are provided according to the corresponding color codes:
[Green "Overall" bars display summarizes added contributions from all life cycle phases detailed on the left two bars of each graphs.]

- Overall
- Metal production
- Use
- End of life



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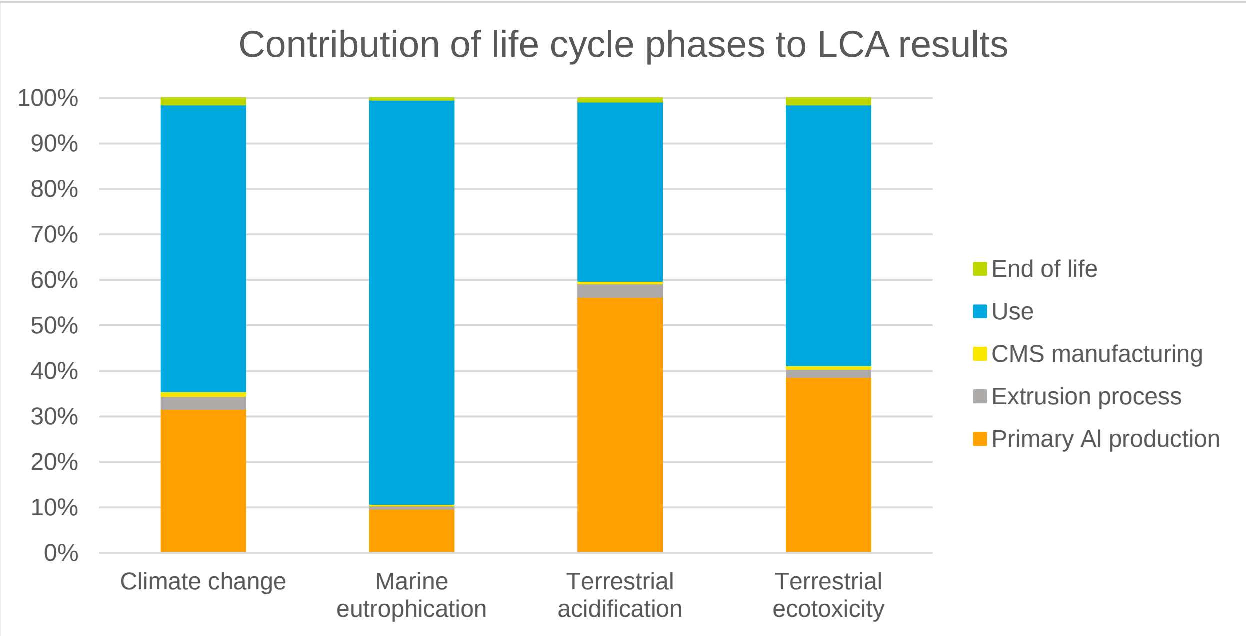
For Climate Change, Marine Eutrophication and Terrestrial ecotoxicity the main contribution comes from product use phase (mostly from associated fuel consumption). The overall impact of the aluminium CMS is also lower than for steel CMS.

Metal production comes second, mostly due to primary metal production. End of life contribution provides a net reduction of the overall impact. The negative value (= credit) is justified by the reuse of recycled aluminium in another product, thus replacing primary metal with a lower environmental impacts.

For terrestrial acidification, metal elaboration is the main contributor, with a higher importance than the use phase. The overall impacts for the aluminium CMS and for its steel equivalent are very close (3% lower for Aluminium CMS).

A more detailed analysis of the different life cycle phases for the aluminium CMS is shown below.



Comparatively to Use and Primary metal production, extrusion process and CMS manufacturing provide limited contributions (1% to 4%) to the overall impacts. This remains true in all considered impact categories.

Similar results were not available at this level of detail for steel parts, as only aggregated (from mining to extrusion) data are available for steel production.

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Analysis of the effect of main parameters on the results

This section covers the interpretation and discussion of the results.

Due to its lower weight, the aluminium CMS exhibits lower emissions during its use phase. Consequently, for indicators where the vehicle use phase is an important contributor to the environmental performance, the overall result of Aluminium CMS exhibits a significantly lower impact than the steel one. This is the case for all four indicators considered in this document.

The influence of recycling rate and average mass saving on the climate change impact were investigated in the case of a European average metal sourcing[3].
To evaluate metal sourcing sensitivity, an alternative sourcing of metal actually produced with electricity from renewable sources was also investigated.

Graphs below display the combination of mass saving and aluminium part recycling rate for which aluminium performs better (green area) or worse (orange area) than steel. The black boundary corresponds to an equal performance of both materials regarding this indicator.

Note: the sensitivity analysis has been performed by making the aluminium part recycling rate fluctuating while keeping the steel's one constant.

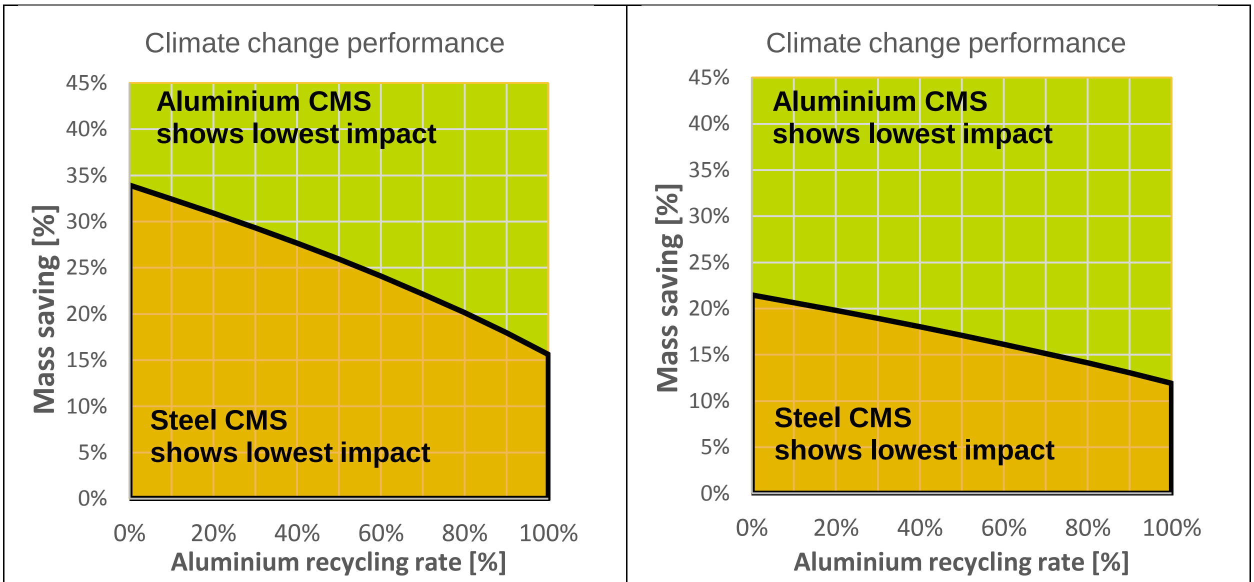

Fig. A: European average primary metal sourcing | Fig. B: Primary metal based on renewable electricicy

[3] Average impact for « aluminium used in Europe », from EAA environmental profile report 2013.

The main conclusion is that in the worst case (no recycling at all for aluminium, while steel is still 97% recycled), the aluminium part shows lower impact than steel when lightweighting reaches 34% (when we consider European Aluminium (EA) average primary metal, on Fig. A) or 21% (when considering Constellium'specific sourcing based on renewable electricity on Fig. B).

With more realistic assumptions (aluminium CMS recycling rate of 90%), aluminium CMS performs better for any mass saving ratio above 18% (Fig. A, when we consider EA average metal sourcing) or 13% (Fig. B, when considering Constellium's specific sourcing based on renewable electricity).

These results potentially apply to any CMS manufactured by any Constellium European CMS production plant, as no CMS-specific data was used to calculate the results. For sites located out of Europe, further evaluation of the metal sourcing influence might be necessary to provide accurate results.

Other parameters were also investigated, that showed no significant change over the results and conclusions. This is notably the case of motor size, gasoline / diesel, 150 000 or 200 000 km lifetime, recycling or landfilling of end-of-life cars not collected in Europe, steel production process (blast furnace or electric arc furnace).

Conclusions:

The aluminium CMS environmental performance assessed by LCA shows by up to 30% lower impacts, compared to a steel CMS through several indicators, notably climate change for which the gap is 19%.

Main contributions come from use phase and metal elaboration. The aluminum CMS shows better performance in the use phase thanks to its lower weight.

Recycling is an important parameter, along with mass saving compared to the steel part.

Metal sourcing mainly influences the importance of the gap between aluminium and steel but does not alter the conclusions.