WorldAutoSteel

# A case for Life Cycle Assessment
## Sport Utility Vehicle
## Executive Summary

## LCA Tells the Total Emissions Story

Life Cycle Assessment (LCA) is a methodology that considers the environmental impact of a vehicle's entire life cycle (Figure 1). LCA starts from the point where raw material is taken from the ground to when the vehicle is built (manufacturing), to the time when fuel is made and the car burns the fuel as it is driven down the road (use or driving), to the point where the vehicle is hauled to the scrap yard and all of its recyclable content is removed and the rest disposed of (end of life recycling and disposal).

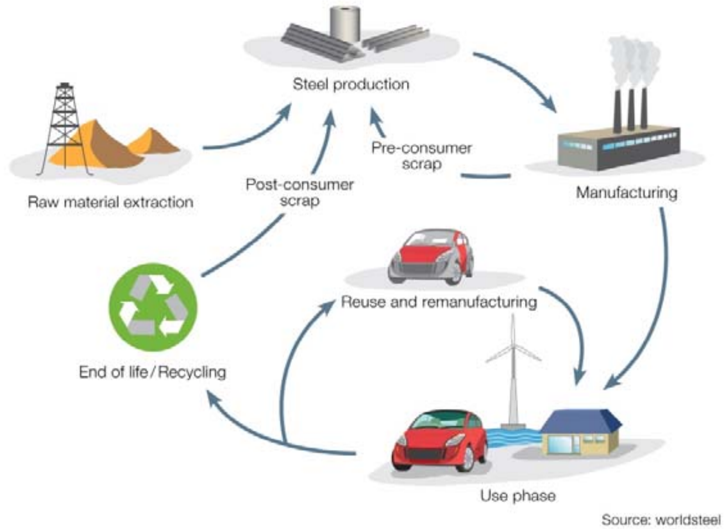


***Figure 1: Vehicle life cycle***

Current automotive emissions regulations around the world are aimed at reducing vehicle emissions, but they focus only on the driving emissions (Figure 2). Every part of the vehicle life cycle produces emissions. Consequently, driving emissions regulations only cover one part of the actual vehicle life-cycle impact. Because of this regulatory demand, automakers are led to consider other technologies, such as electrified powertrains (engines) or energy-intensive, low-density materials, which may reduce driving emissions, but can in fact increase ***total*** life cycle emissions. This could be because of the increased emissions during the manufacture of these technologies or the inability to recycle the materials at the end of the vehicle's useful life.

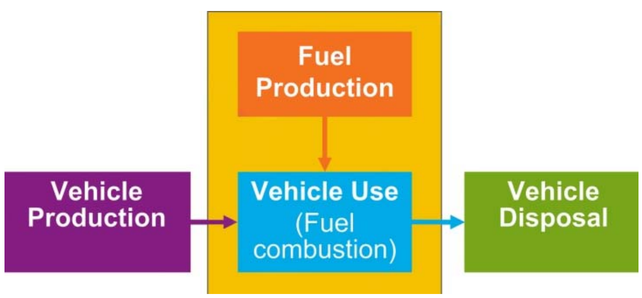


***Figure 2 – Sources of GHG Emissions in a Vehicle's Life Cycle (yellow-highlighted area comprehends current regulations)***

***Emphasis on driving emissions alone may have the unintended consequence of increasing greenhouse gas (GHG) emissions during the vehicle life.***

***Setting emissions reduction goals based on these technologies without a thorough understanding of their life cycle impact makes it impossible to know whether or not the emissions reduction goals are actually being met.***

## An LCA Case Study – Sport Utility Vehicle

Here is an example of when lightweighting with energy-intensive materials can be just such a case. Consider the following case study[1]: The manufacturer of a full-size Sport-Utility Vehicle (SUV) with an annual production of 200,000 vehicles considers changing to an all-aluminium design to reduce vehicle weight. The manufacturer expects to save 300 kg by replacing conventional steel with aluminium in the body structure, closures (doors, hood/bonnet, liftgate/boot), suspension, and subframes. Using the Automotive Materials Energy and GHG Comparison Model v4 (UCSB Model)[2], developed by the University of California Santa Barbara, a case study investigates the lifetime GHG impact of this change, and compares it to an alternative design substituting Advanced High-Strength Steel (AHSS) instead of aluminium. The aluminium-intensive components are expected to weigh 630 kg, compared to the

baseline SUV weight of 930 kg. The AHSS version of the same components is expected to weigh 698 kg, a difference of only 68 kg.

| Weight Of SUV Body Structure, Closures (Doors, Hood, Liftgate), Suspension, and Subframes in Kilograms | | |
|---|---|---|
| Baseline Conventional Steel | Aluminium | Advanced High-Strength Steel |
| 930 kg | 630 kg | 698 kg |
| | -32% lighter | -25% lighter |

Many factors affect the vehicle's performance, such as how many miles/kilometers the vehicle is driven over its lifetime, amount of fuel reduction to be expected, and the size of the powertrain. To get the best understanding of what can be expected for emissions results in this comparison, we cannot simply run one study. Rather, the UCSB Model includes an analysis that runs 5,000 different iterations, each time randomly selecting a set of different values from a predetermined range. We can then look at the whole "cloud" of results, and examine a variety of scenarios. And from these, we can select when each vehicle is achieving the best it can possibly achieve and the worst it can possibly achieve, under the given parameters, and everything in between. To keep it as simple as possible, Figures 3 and 4 show the very best and the very worst predictions.

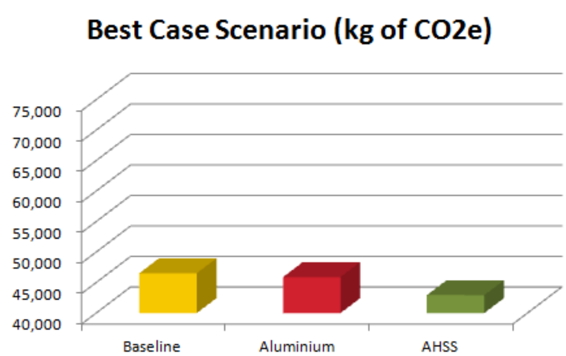


***Figure 3: Best Case Scenario—the best performance that can be predicted with the given parameters for total life cycle emissions***

In this best case scenario (lowest total emissions), which shows total life cycle GHG emissions, the SUV designer tried to reduce driving emissions by substituting aluminum for conventional steel but achieved very little (>1,000 kg) in reducing total life cycle emissions. The best scenario for the AHSS design, however, reduced total life cycle emissions compared to the baseline conventional steel vehicle by over 3,000 kg.

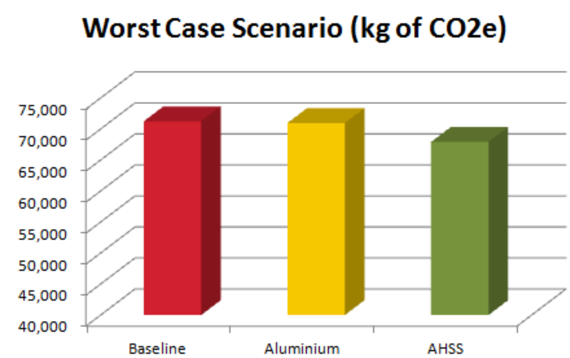


***Figure 4: Worst Case Scenario—the worst performance that can be predicted with the given parameters for total life cycle emissions***

Notice in this Worst Case Scenario graph that ALL materials showed increased emissions. When we look at the very worst of the 5,000 runs for each material, the aluminium design has achieved emission reduction of less than 300 kg over the full life cycle. But, the AHSS design still produced fewer total life cycle emissions (~3,000 kg) than the aluminium or conventional steel baseline design.

***In fact, in all of the 5,000 iterations, the AHSS-intensive design results in lower GHG emissions than the Aluminium-intensive design, 100% of the time.***

***For a fleet of 200,000 vehicles, this means an AHSS-intensive design saves approximately 600,000 metric tonnes of $CO_2$e over the aluminium-intensive vehicle.***

## Where the Rubber Hits the Road: Projected Fuel Savings

Lightweighting is about increasing fuel economy and reducing driving emissions. But, is lightweighting alone truly the road to achieve this? The UCSB Model provides a prediction on fuel economy, using the same 5,000 runs to determine the best and the worst case scenarios. Figure 5 illustrates that the Aluminium-intensive design is predicted to save 0.5 at worst to 0.9 at best liters per 100 kilometers (l/100) over the life of the vehicle, compared to the conventional steel vehicle. However, there is ***an advantage of just 0.1 to 0.2 l/100 over the AHSS-intensive design***. This means that the Aluminium-intensive vehicle owner can expect to visit the fuel pump just 2 to 4 fewer times (Figure 6) than the AHSS SUV owner***, during the vehicle's entire life time***. Consider that in the worst case scenario, the Aluminium vehicle will not only achieve minor fuel consumption improvement, but would also INCREASE total life cycle emissions.

**How Many More Liters Per 100 Kilometers
Can Be Achieved with Each Option?**

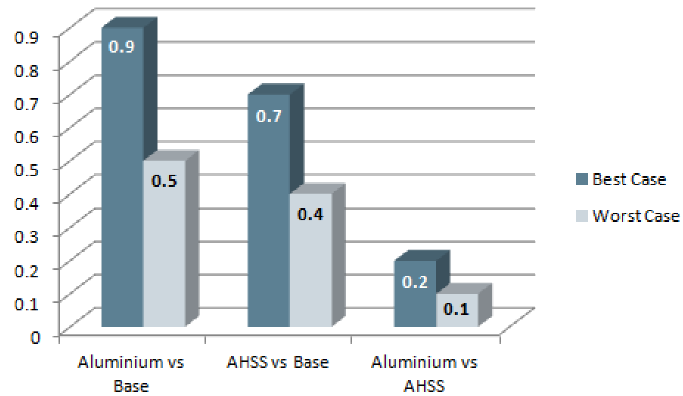



***Figure 5: Prediction of the Increase in Miles Per Gallon fuel economy (Assuming a 100-liter fuel tank)***

**How Many Fewer Trips Will You Make to the Fuel Station
Over the Entire Life of the Vehicle?**

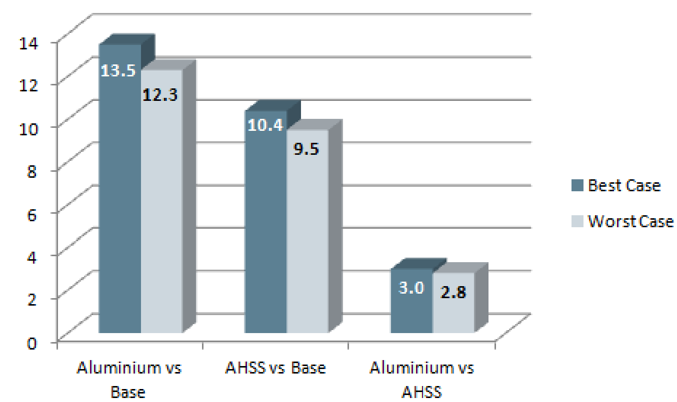


***Figure 6: Prediction of how many few times the vehicle will require refueling over its entire lifetime (Assuming a 100-liter fuel tank)***

Why does steel perform so well? The manufacture of aluminium produces up to seven times more emissions than any steel. The point is that without a life cycle assessment to guide the design decision process, automakers will make decisions resulting in unintended consequences.

## ANNOTATIONS

[1] WorldAutoSteel, *Life Cycle Assessment Case Study; Light Duty SUV Reference*, full report and model available online at www.worldautosteel.org

[2] Geyer, Roland: The Example of Mild Steel, Advanced High Strength Steel and Aluminium in Body in White Applications Methodology Report (December 2007). The Methodology Report and a free download of the UCSB Automotive Greenhouse Gas Materials Comparison Model are available at http://www.worldautosteel.org/projects/vehicle-lca-study/assessments-of-automotive-material/.