



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).

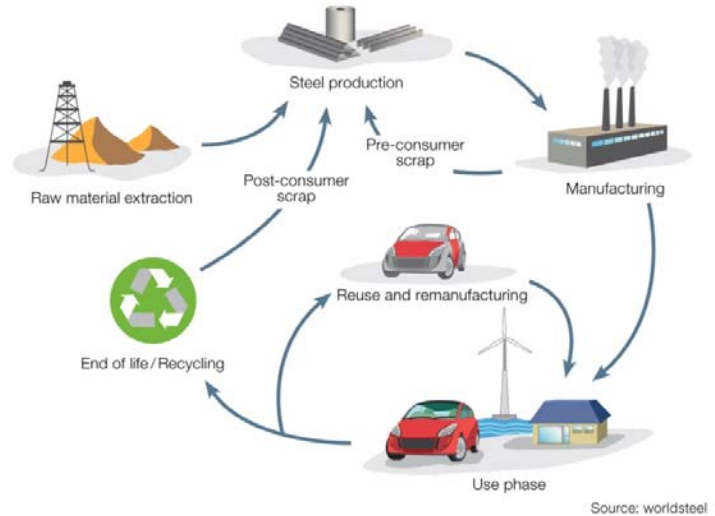


Figure 1: Vehicle life cycle

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.

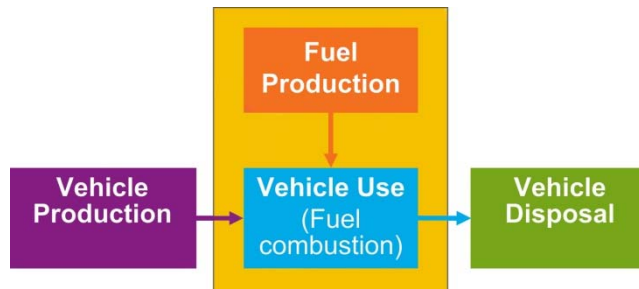


Figure 2 – Sources of GHG Emissions in a Vehicle's Life Cycle (yellow-highlighted area comprehends current regulations)

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 – Light Duty Truck

Here is an example of when lightweighting with energy-intensive materials can be just such a case. Consider the following case study¹: Increasingly stringent driving emissions regulations have forced the manufacturer of a full-size Light Duty Truck with an annual production volume topping 700,000 vehicles, to consider changing to an aluminium-intensive design in order to meet the future U.S. fleet average, which sets fuel consumption at 54.5 miles per gallon. 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 truck structural skeleton (the body structure), its closures (doors, hoods/bonnet, tailgate/boot) and the truck bed are expected to weigh in at 446 kg, compared to the baseline Light Duty Truck weight of 686 kg. The AHSS version of the same components is expected to weigh 515 kg, a difference of just 69 kg.



Weight of Truck Body-In-White (BIW), Closures (Doors, Hood, Tailgate) And Truck Bed in Kilograms		
Baseline Conventional Steel	Aluminium	Advanced High-Strength Steel
686 kg	446 kg	515 kg
	-35% lighter	-25% lighter

Many factors affect the vehicle's performance, such as how many miles/kilometers the vehicle is driven, 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 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.

Best Case Scenario (kg of CO₂e)

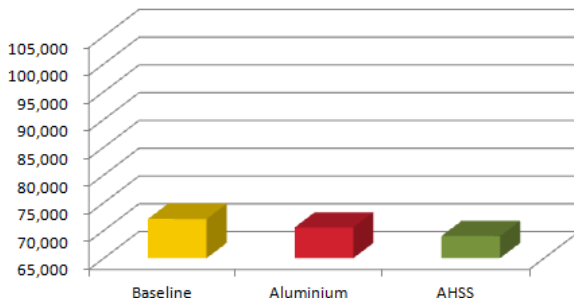


Figure 3: Best Case Scenario—the best performance that can be predicted with the given parameters for total life cycle emissions

In this best case scenario (lowest total emissions), which shows total life cycle GHG emissions, the truck designer tried to reduce driving emissions by substituting a lighter weight material but only reduced the total life cycle emissions by 1,500 kg. The best scenario for the AHSS design, however, reduced emissions compared to the baseline by over 3,000 kg.

Worst Case Scenario (kg of CO₂e)

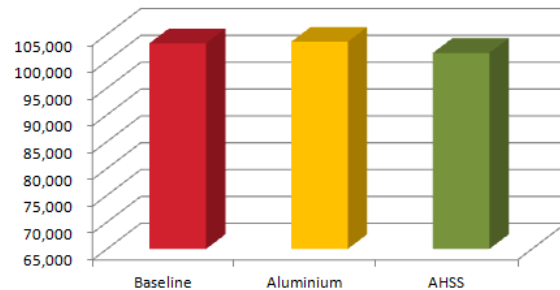


Figure 4: Worst Case Scenario—the worst performance that can be predicted with the given parameters for total life cycle emissions

Notice that ALL of the materials showed increased emissions in the Worst Case Scenario. When we look at the very worst of the 5,000 runs for each material, the aluminium design achieved no reduction in life cycle emissions. In fact, it increased emissions slightly by 298 kg. But, the AHSS design still produced fewer total life cycle emissions (-3000 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 700,000 vehicles, this means an AHSS-intensive design saves approximately 1 million metric tonnes of CO₂e 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 0.6 at worst to 1.5 at best miles per gallon (mpg) over the life of the vehicle, compared to the conventional steel vehicle. However, there is ***an advantage of just 0.2 to 0.4 mpg 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 truck owner, ***during the vehicle's entire life time***. Consider that in the worst case scenario, the Aluminium vehicle will not only achieve minor fuel economy improvement, but would also INCREASE total life cycle emissions.

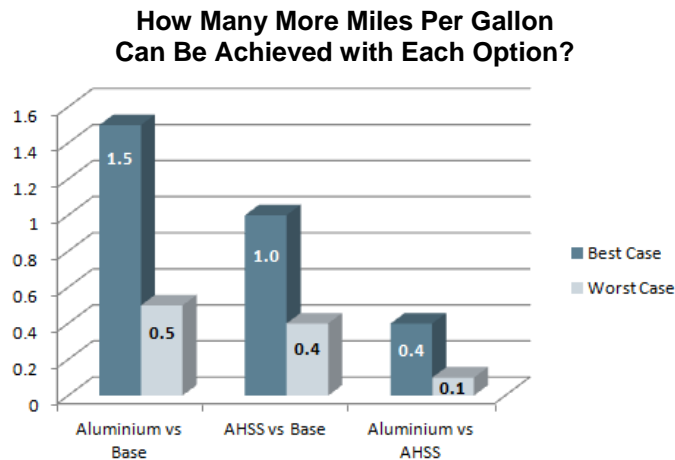


Figure 5: Prediction of the Increase in Miles Per Gallon fuel economy (Assuming a 26-gallon Fuel Tank)

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

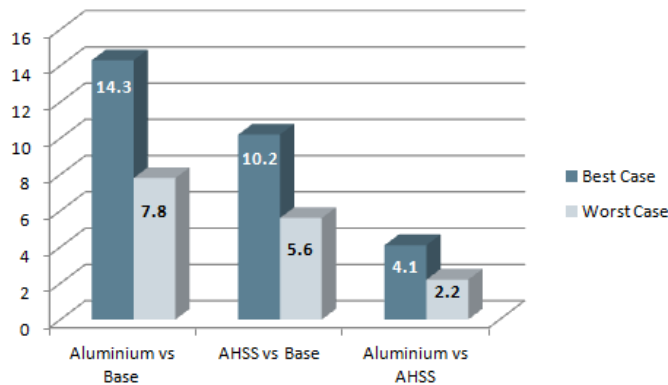


Figure 6: Prediction of how many few times the vehicle will require refueling over its entire lifetime (Assuming a 26-gallon Fuel Tank)

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 Truck Reference*, full report available 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/>.