Life Cycle Assessment
Battery Electric Vehicle:
Aluminium vs. AHSS

WorldAutoSteel

Material Matters: A Case Study

As the emissions resulting from driving the car (tank-to-wheels) are reduced with more efficient powertrains, there will be a greater chance that use-phase only regulations could result in unintended consequences. It is predicted that by 2020, emissions from the vehicle production phase could dominate over the use phase. It is a shift that is already occurring and needs to be addressed. Life Cycle Assessment (LCA) is the most comprehensive methodology to account for all phases of the life cycle. LCA is a methodology that considers a vehicle's entire life cycle, from the manufacturing phase (including material production and vehicle assembly) through the use phase (including production and combustion of fuel) to the end of life phase (including end of life disposal and recycling). It helps ensure that design and engineering choices made to reduce vehicle emissions in one phase of vehicle life results in a total life cycle emissions reduction.

An example of examining production emissions choices is the impact of material choices on life cycle GHG emissions. Consider the following case study: Virtually every automaker is adding Battery Electric Vehicles (BEV) to their fleets to meet the new emissions regulations. Structural lightweighting has become a key focus to increase battery range with the current offerings of vehicle battery technology. Without a life cycle assessment strategy in place, material decisions may be made that result in an increased environmental impact.

We compared two BEVs, one made of aluminium and one using Advanced High-Strength Steel (AHSS), using the University of California Santa Barbara Automotive Energy & Greenhouse Gas (GHG) Model (UCSB Model), to determine the material choice impact on each vehicle's total life cycle energy usage, from manufacture, to powering the vehicle during use, to recycling it at the end of its useful life.

Considering a fleet of 1,000,000 BEVs of equivalent range, whose body structures are made 100% aluminium or 100% AHSS, the UCSB Model can calculate the energy required over the total vehicle's life, from manufacture to recycling. The table provides the results, using global data (with the exception of China for a more conservative assumption) for energy usage in producing the primary material:

| Number of BEVs produced: 1,000,000	Aluminium Megajoules (MJ)	AHSS Megajoules (MJ)	
Life Cycle energy demand per vehicle:	383,000	347,000	
Total Life Cycle energy demand:	383,000,000,000	347,000,000,000	
	Total energy savings with AHSS:	**36,000,000,000 MJ (or 10,000,000 kWh)**	

This means that, with the energy it would take to produce 1,000,000 aluminium-intensive vehicles, you could manufacture, power and recycle 1,000,000 AHSS BEVs plus have enough leftover energy to power an additional 170,000 BEVs *for their entire useful lives,* or *supply the total energy demand to 77,000 U.S. households for 12 years (based on publicly available 2015 data).*

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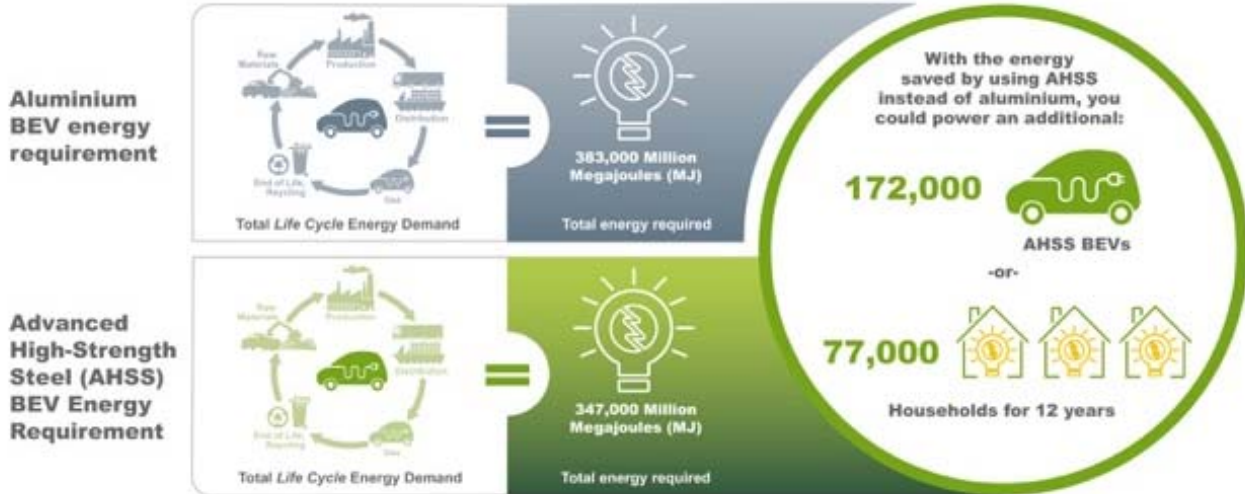
Why? Because of the much more complicated extraction and refining process, aluminium production takes almost eight times as much energy per kilogram as the production of steel.

This must be taken into consideration when deciding whether to use aluminium to lightweight vehicles. While the aluminium-intensive vehicle may save some energy in the use phase, it is important to understand how much savings is achieved through its total life. Even if lightweighting and/or energy savings during the use phase are realized, the aluminium-intensive vehicle in this case study example would require approximately 30% more energy over its life than the vehicle made primarily from AHSS.

Why Life Cycle Assessment?

Sources of GHG Emissions in a Vehicle's Life Cycle
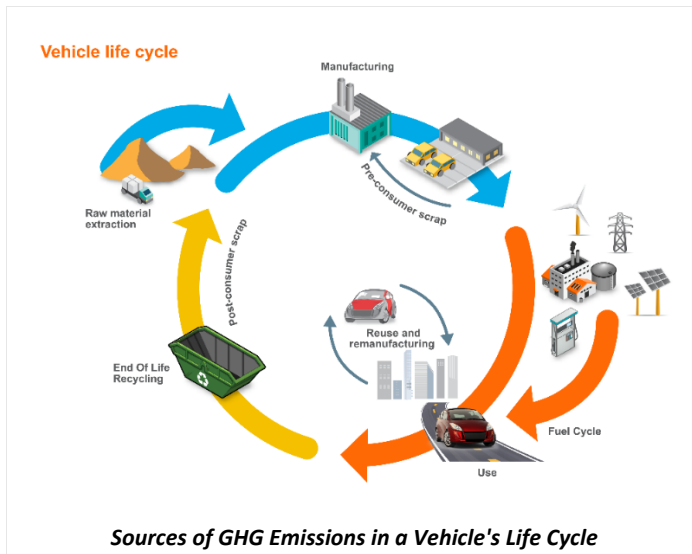
Current automotive emissions regulations around the world are aimed at reducing Greenhouse Gas (GHG) emissions of automobiles, but focus only on tailpipe emissions, which are only a part of the actual life-cycle impact of an automobile.

Emphasis on the tailpipe alone may have the unintended consequence of increasing GHG emissions during the vehicle life. For example, many automakers, to comply with increasingly stringent tailpipe emissions regulations, are turning to new materials to reduce mass. By reducing the mass of a vehicle, it is possible to reduce the fuel consumption or energy requirements and, consequently, reduce emissions. However, many of these materials can have impacts in the other life cycle phases that outweigh any advantage that may be gained in the use phase. This means that,

contrary to the stated objective of reducing the GHG emissions of automobiles, tailpipe-only regulations may have the unintended consequence of actually *increasing* the GHG impact. Therefore, WorldAutoSteel is participating in the development of LCA tools and methodology and encouraging the use of LCA in the formulation and implementation of automotive emissions regulations.

UCSB Automotive Energy and Greenhouse Gas Model Version 5.0

The UCSB Model is designed to quantify the energy and GHG impacts of automotive material substitution on a total vehicle life cycle basis, under a broad range of conditions and in a completely transparent fashion. The model methodology has been peer-reviewed by members of the LCA community and the aluminum industry.

This case study analyzed C-Class BEV vehicle body structures. The Worldwide Harmonized Light Vehicles Test Procedure Class 3b driving cycle was used. Lifetime vehicle mileage was assumed at 150,000 km/93,226 miles. The powertrain was resized for equivalent performance due to lightweighting.

The UCSB Model Version 5.0, including a comprehensive User Guide, is available for free download at www.worldautosteel.org. If you have questions about how this case study was configured, please contact us at steel@worldautosteel.org.

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Do you want to know more about Life Cycle Thinking?

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To learn more about Life Cycle Thinking in vehicle regulations, download papers written by Dr. Roland Geyer, developer of the UCSB Model, and Dr. Matthias Finkbeiner of the Technical University of Berlin from our website at www.worldautosteel.org/life-cycle-thinking/implementing-lca-in-regs/.