ALL VEHICLES SHOULD BE MADE FROM ALUMINUM

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Aluminum makes better vehicles, great business sense, and is key to a circular economy.

It is not surprising that aluminum is the fastest-growing automotive material[1]. Automotive startups and manufacturers of electric vehicles are making aluminum their first material of choice, while legacy automakers are responding to changing habits and environmental challenges by designing tomorrow's automobiles with aluminum at their core.

The reason is obvious: aluminum makes better vehicles—more efficient, better performing, safer, and more sustainable.

Aluminum is better at durability, corrosion resistance, and energy absorption in a crash. It is fully recyclable, strong, and lightweight.

The Advantages of Lightweighting with Aluminum

This last point is essential. Lightweighting has always been an important feature of motor vehicles, for reasons that have evolved over time. Initially, automotive manufacturers used aluminum to build faster sports and race cars, or vehicles that could carry more (due to their light weight). In the 1970s, when the oil crisis hit, lightweighting became a key enabler of fuel efficiency, with a number of aluminum-intensive vehicle concepts. With the approach of the 21st century, climate change and air pollution emerged as major concerns, and governments around the world started to implement legislation targeting fuel economy improvements and emissions reductions.

Weight savings leads to better mileage for vehicles with internal combustion engines (ICEs), and less energy consumption and better range for battery electric vehicles (BEVs). For all kinds of vehicles, lightweighting means better handling (faster acceleration, more responsive steering, quicker braking), less load on brakes and suspension, and the capacity to tow and carry more. In the design phase, lightweighting can result in secondary weight savings for parts such as brakes and suspension systems, as well as smaller fuel tanks for ICEs (requiring less fossil fuels), or fewer battery cells for BEVs (requiring less mining for raw materials and chemical elements).

For ICEs, lightweighting in the use phase improves fuel efficiency and reduces carbon emissions—in other words, greater sustainability for the planet and lower costs for the vehicle owner. As Ford CEO Jim Farley told Yahoo Finance last year, "What I found about full size truck customers, you know, when we went aluminum, they loved saving [more than] 500 pounds."[2]

For BEVs, with battery size and related mass, efficiency is imperative. Because efficiency depends largely on weight, lightweighting is fundamental.

[1] https://www.greencarcongress.com/2020/08/20200813-ducker.html

[2] https://news.yahoo.com/ford-ceo-f-150-lightning-134437778.html

Cover images: Ford F-150 Lightning courtesy of Ford Motor Company, Lucid Air courtesy of Lucid Motors

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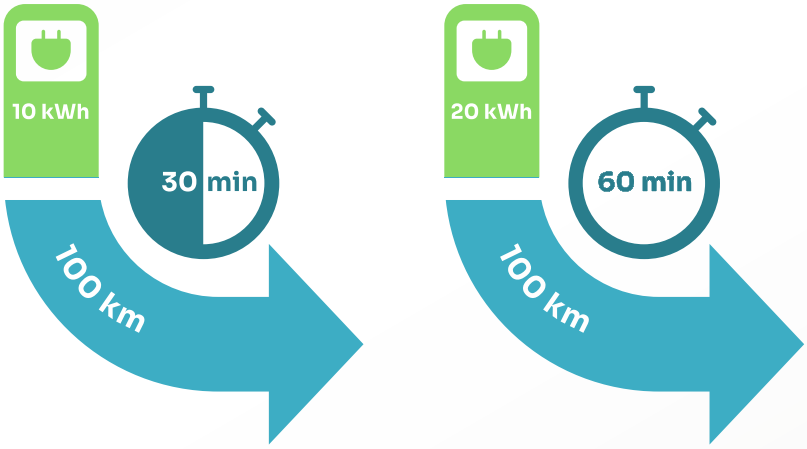
Lucid Air, courtesy of Lucid Motors

BEVs: a Game Changer for Lightweighting and Aluminum

One of the greatest factors behind automakers' switch to aluminum is the quickly growing market for BEVs. They are the vehicles of the future, a vital part of the effort to mitigate climate change. An increasing number of cities and even countries have announced targets to phase out new ICE vehicles in the coming years[3], while several vehicle manufacturers have pledged to sell only zero-emissions new cars and vans by 2040.[4]

One obstacle to consumers' widespread adoption of BEVs is recharging. While it generally takes just a few minutes to stop and fill up the tank of a gas-powered vehicle, charging an electric vehicle currently demands a larger time commitment. Lightweight BEVs are quicker to charge and have better efficiency and potentially smaller battery packs, which means they drive farther between charging stations with the same amount of energy, or can carry more passengers and cargo while maintaining range and performance.



Moreover, batteries are the most expensive part of a BEV. The heavier the vehicle, the bigger the battery, the more it costs. Dr. Thomas Rudlaff, Managing Director of Alumobility and a longtime engineering executive at Mercedes-Benz, notes, "If you can go the same distance with a smaller battery, you save a lot of money, which can pay for other features in the vehicle."

Similarly, the added mass of BEVs creates an additional challenge for engineers to manage crash safety. With aluminum's higher energy absorption and lower mass, it provides an ideal solution for components such as rockers and battery enclosures, which must withstand additional safety requirements for impact.

European regulations provide one more argument for lightweighting passenger vehicles: a legal weight restriction of 3.5 metric tons, including passengers and cargo. A standard BEV with a more than 100-kWh battery very easily weighs more than two metric tons unloaded.

[3] https://theicct.org/growing-momentum-global-overview-of-government-targets-for-phasing-out-sales-of-new-internal-combustion-engine-vehicles/

[4] https://www.gov.uk/government/publications/cop26-declaration-zero-emission-cars-and-vans/cop26-declaration-on-accelerating-the-transition-to-100-zero-emission-cars-and-vans

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The Business Case: Aluminum is the Most Cost-Effective Material

When manufacturing lightweight, affordable vehicles for mass production, automakers have two practical material options for the body-in-white: aluminum and steel. Carbon fiber is lightweight but expensive, and cannot be easily recycled. Magnesium is lightweight but expensive, and is CO_2e-intensive with today's production methods. Plastics are less weight-efficient, have a low recycling rate compared to metals in automotive, and do not offer the same performance for most structural body components.

At first glance, it might seem that steel has a cost advantage over aluminum, but this is not the case. It is true that when comparing the price of one kilogram of aluminum to one kilogram of steel, aluminum has the higher price tag. But because aluminum has one-third the density of steel with the same in-service strength, automotive manufacturers only need to use 600 grams or less of aluminum for every kilogram of steel.

Consider a vehicle roof made from a sheet of steel 0.8 mm thick. If the roof were made of aluminum, with the same stiffness and the capacity to carry an equivalent load, it would need to be up gauged to 1.2 mm, meaning the final weight savings is around 45%. Automotive manufacturers pay per kilogram, so the aluminum roof would be much closer in cost to steel.

However, the savings do not end here, especially when looking at BEVs. As we have seen, if an automaker can reduce the weight of a BEV body by using aluminum, it can use a smaller, less expensive battery for an equivalent range.

A typical steel SUV body weighs around 500 kg, including closures. A comparable aluminum body weighs ~40% less, or around 300 kg (or less). While the steel car would be built with an 80-kWh battery pack, the aluminum vehicle could travel the same distance with a 75-kWh battery. Because a smaller battery dramatically impacts the price of the vehicle, the aluminum vehicle is now the same or less expensive than the steel one, with lower energy use over the life of the vehicle and lower recycling costs at the end-of-use phase.

Aluminum offers automakers even greater cost savings and CO_2e reduction when they implement a closed-loop recycling system in production, using scrap from the press shop or recycled at the end of a vehicle's life.[5]

[5] https://alumobility.com/news/new-white-paper-closing-the-loop-on-automotive-aluminum-scrap-to-minimize-carbon-emissions/

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Aluminum is the Best Choice for Recycling

Aluminum is the most sustainable choice for automotive sheet because it is infinitely recyclable without a loss in its qualities, including lightness, durability, and formability. Unlike plastics, aluminum can be upcycled. Other non-metals, such as carbon fiber, are difficult to recycle, and the process consumes more energy.

Recycling aluminum uses ~5% the energy of producing primary metal, and reduces carbon emissions by as much as 95%. Recycling aluminum scrap in a closed-loop process is an immediate opportunity for vehicle manufacturers to reduce their carbon emissions, while end-of-life recycling offers an opportunity for the future.[6]

Aluminum also makes it possible for automakers to develop recycling-friendly subassemblies, such as battery boxes and doors.

Steel is recyclable, as well, but it melts at around 1400°C; aluminum has a much lower, less energy-intensive melting point of 650°C. When one considers that a vehicle can be manufactured with 600 kg or less of aluminum rather than one metric ton of steel, the recycling energy equation is even more advantageous for aluminum.

Although it takes less energy to produce primary steel than primary aluminum, that difference is quickly offset by closed-loop recycling of aluminum in the vehicle production phase—and with all the benefits of aluminum over other materials in the use and end-of-life phases.

[6] https://alumobility.com/news/new-white-paper-closing-the-loop-on-automotive-aluminum-scrap-to-minimize-carbon-emissions/

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Aluminum Offers Other Important Advantages

Aluminum offers many additional advantages over other automotive materials. For vehicle owners, its durability translates into cost savings, with cars that last longer and require less maintenance.

Aluminum has excellent corrosion resistance and is self-healing, forming a protective oxide barrier when cracked, dented, or deformed. It can be used blank, without paint or coatings (which also reduces vehicle weight). In comparison, steel will corrode over time, with or without a protective coating.

Aluminum has better in-service dent resistance, meaning that a stone hitting a steel panel is more likely to dent it—and will create a bigger dent—than if it hits an aluminum panel that is gauge-adjusted for the same stiffness. And because an aluminum panel is more flexible, any surface paint will flex with it, for less damage and long-term corrosion risk.

In the event of a crash, aluminum absorbs more energy than steel per kilogram, and with its superior crash crush properties can withstand multiple blows, such as a rollover. The steel industry has endeavored to reduce the weight of steel by developing high-strength alloys with a lower gauge, but at the expense of stiffness and ductility. High-strength steel does not absorb energy like aluminum. As for carbon fiber, it resists impact, but generally only once, so it is not as beneficial in real-world crash performance.

Embracing an Aluminum Future (or Being Left Behind)

As the world evolves, the automotive industry evolves along with it. For numerous reasons, aluminum has become the obvious choice for manufacturing new vehicles of all types. Legacy automakers have a greater challenge, with their long-established production sites, but the market's momentum favors the use of light weight for efficiency.

"Change is never simple," says Mark White, Alumobility's Technical Director, following a career at Jaguar Land Rover. "Going from combustion engines to electric is a major break for automakers, and even more so if they switch to aluminum. But the two are linked. If an automaker changes to BEVs but stays with steel, their cars will never reach the efficiency of an aluminum car, and in a few years, they might be outdated."

One thing is certain: in the not-too-distant future, the vast majority of vehicles on the world's roads will be high-performing, more efficient, powered by alternative energies...and aluminum-intensive.

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Alumobility is a global ecosystem of leading aluminum and downstream technology partners that supports automotive manufacturers in creating lighter, safer, smarter, and more sustainable vehicles. The non-profit association was founded to focus on technical studies to advance the adoption of aluminum automotive body sheet (ABS). Working with global automakers, Alumobility is helping to fulfill the promise of a lighter, more efficient, more sustainable mobility future.

For more information on our studies and events, visit **alumobility.com** or contact us at **info@alumobility.com**.

Acknowledgements

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