EXECUTIVE SUMMARY

Electric Vehicle Lightweighting 2030

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Executive Summary

Battery electric vehicles (BEVs) are the future of the passenger vehicle, but there's still an open question about how much lightweighting will be necessary in the future.

Our analysis finds that in order for lightweighting to be a cost-effective way of increasing range compared to increases in battery pack size, it must cost less than roughly $5 per kilogram removed. However, lightweighting isn't necessary for BEVs to have sufficient range – so it must save cost as well as weight to be adopted.

This analysis means that there will only be modest changes to the materials used in vehicles over the next decade. Clients should expect a reduced focus on lightweighting overall and focus on integrating novel materials with the design needs of BEVs.

Component	Weight Savings	Adoption
Structure	High	Low
Bumpers	Medium	Medium
Body Panels	Medium	Low
Windows	Medium	Low
Seating	Medium	High
Battery Packs	Low	High
Interiors	Low	High
Insulation/NVH	Low	High

BEV lightweighting is fundamentally different from combustion engine vehicle lightweighting

In the past, lightweighting has been a key tool for improving the fuel economy of internal combustion engine (ICE) vehicles. However, the transition from ICEs to BEVs changes both the goals and the design considerations around lightweighting. The key changes include:

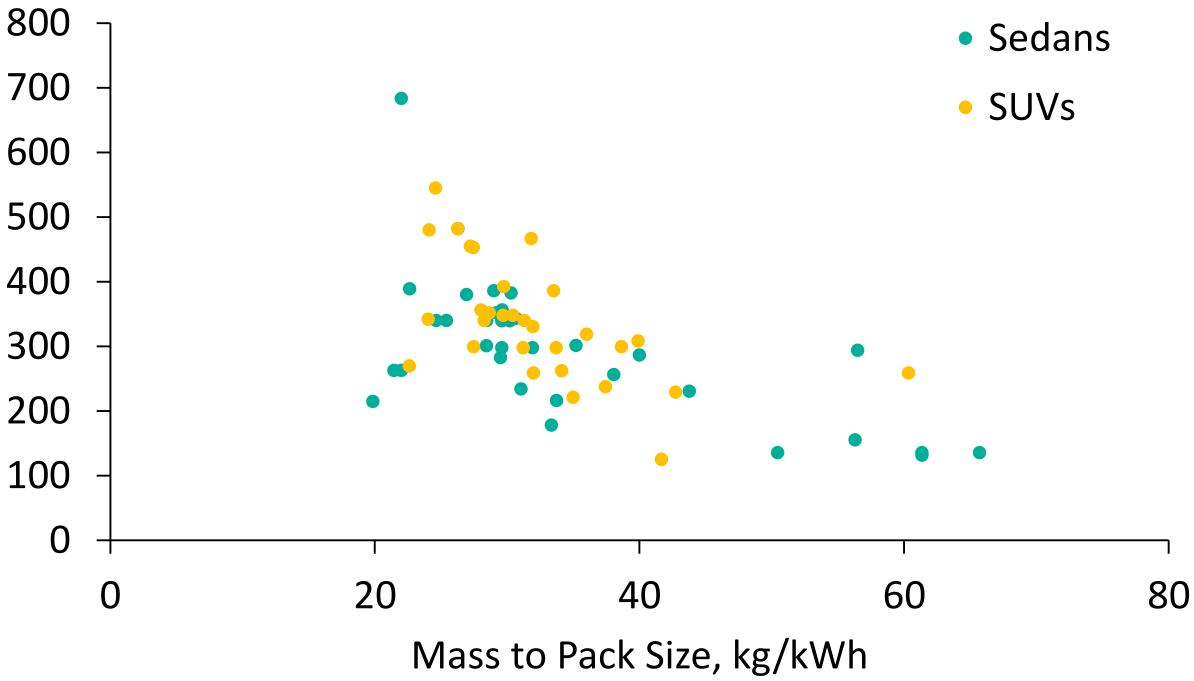
- **Range:** BEVs are overwhelmingly more efficient than ICE vehicles due to regenerative braking and more efficient motors. BEVs' main weakness is range; most midprice BEVs have a limited range of 200 km to 400 km. Much of the drive to lightweight BEVs comes from a desire to extend range.
- **Platform design:** BEVs are increasingly being designed around shared rolling frames or platforms that contain the batteries, drive systems, and in some cases structural elements of the cars. Decisions around lightweighting these elements – such as battery packs – will have a major impact across all BEVs produced by an OEM, heightening the importance of collaborating on these platform designs.
- **Mass distribution:** BEVs have predominantly located their batteries in a low, flat container on the floor of their vehicle. This mass, combined with the removal of the ICE, means BEVs naturally have very low centers of gravity, and their mass is much more evenly distributed front to back. These conditions are highly favorable for tight control, enabling even midprice BEVs like the Model 3 to handle extremely well. The consequence, however, is that performance-driven lightweighting is far less necessary.

We used the aggregate data of 64 BEVs to determine the relationships between vehicle mass, pack size, and range

We collected data on 64 model year 2019 BEVs to build a data set on BEV range and performance. We separated them into two categories: sedans, which also includes hatchbacks and other small cars, and SUVs, which includes vans and utility vehicles. We then compared the range of the vehicles to the ratio of total mass to battery pack size. This data is presented at right, with each dot representing a specific vehicle.

Taken together, this data suggests that as vehicle pack sizes go up and vehicle mass comes down, range increases – an expected result. The data at right was used to calculate how much of an impact an increase in pack size or a decrease in vehicle weight would have on the range of a generalized BEV. This was then used as the basis of the forecasting of the future BEV.

Lower vehicle mass and larger pack size generally increase BEV range



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The lightweighting benchmark shows that lightweighting must cost under $5/kg to be cost-effective in 2030

For each BEV, we modeled two scenarios – optimizing for range or optimizing for cost. For each scenario, we calculated the cost of adding 1 km of range via increased pack size versus the amount of weight reduction needed to increase the range by 1 km. By comparing the cost of increasing range with batteries to the weight reduction needed to make the same change, we calculated a lightweighting benchmark.

Lightweighting must cost less than this benchmark to be an effective way to increase range – otherwise, it will make more economic sense to simply increase pack size. While there is some variation, **the cost of lightweighting in 2030 must be less than $5 per kilogram saved on average.**

2030 Vehicles

	Sedan		SUV	
Scenario	**Optimize Range**	**Optimize Cost**	**Optimize Range**	**Optimize Cost**
Mass (kg)	1,401	1,377	1,750	1,721
Pack size (kWh)	51.75	45	64.5	56
Price	$29,920	$29,050	$34,854	$33,760
Calculated range (km)	330	305	367	339
Lightweighting benchmark ($/kg)	$5.33	$4.43	$5.15	$4.28

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What are the opportunities for lightweighting?

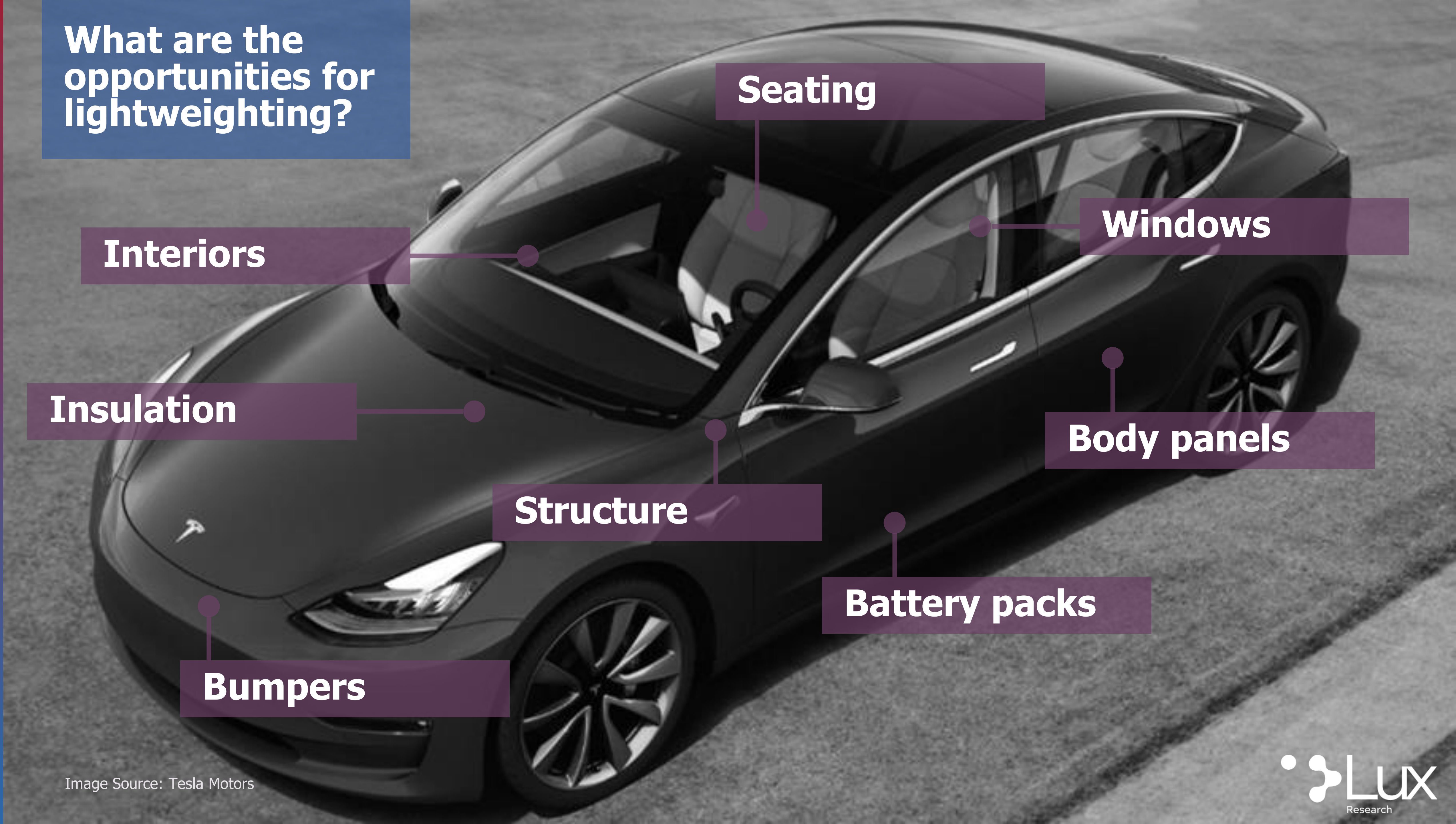

Image Source: Tesla Motors

LIGHTWEIGHTING ANALYSIS

Structure is an opportunity for high-strength steel and aluminum

BEVs have a fundamentally different architecture than combustion engine vehicles, with large battery packs as the dominant feature rather than a large engine bay. The need to secure a large, heavy battery pack at the bottom of the vehicle and the desire to use one platform for multiple vehicles will drive the automotive industry back into a body-on-frame arrangement for BEVs.

This body-on-frame structure favors high-strength steels and aluminums as the primary structural elements, as the extra weight of these metals (relative to composites) will mostly be at the bottom of the vehicle, where it will have a minimal impact on performance. Moreover, there's a wealth of expertise in forming high-strength frames from the trucking space, making this approach highly cost-effective. Composite structural lightweighting will be limited to luxury vehicles.

Potential weight savings: **High**

Likeliness of adoption: **Low**

Material opportunities: **Steel, aluminum, glass fiber, carbon fiber, thermoplastics**

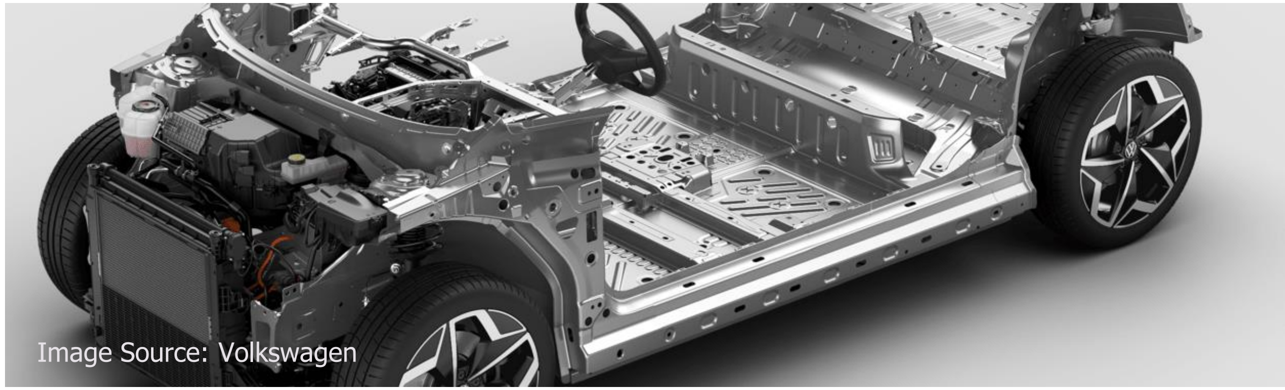
Image Source: Volkswagen

CASE STUDY: Volkswagen MEB

Volkswagen's MEB – a shared battery architecture it plans to use for its BEV fleet – doesn't necessarily guarantee any specific structural material. However, the design choices made in the MEB will set the tone for Volkswagen's structural designs for the next decade and align strongly with continued use of metal systems. Clients need to understand the design assumptions used in the platforms in order to build around those specifications.

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LIGHTWEIGHTING ANALYSIS

Seating is a prime opportunity for composite lightweighting

Seats are complex multimaterial components, making them a prime candidate for composite lightweighting. The ability of composites to consolidate components is particularly important here, as it can lead to both reduced production costs and easier assembly of components. While structural frames are perhaps the best-suited for lightweighting, there are opportunities in the foams as well: Don't expect a breakthrough, but incremental increases in the performance of foams from players like Adient will help reduce weight. Seating will also benefit from bio-based materials – not just in composites, but potentially from advanced materials like bio-based leather and novel textiles.

Potential weight savings: **Medium**

Likeliness of adoption: **High**

Material opportunities: **Steel, aluminum, composites, thermoplastics**

CASE STUDY: Faurecia composite seat shells

The shells, designed in collaboration with Lanxess, use polyimide/CF composite to shave off more than 45% of the mass of a steel component. These materials are expensive – it's no mistake that they were adopted in the Audi A8 – but the design approach, which includes multiple built-in features and consolidated components, is applicable across all price ranges.

Outlook

1

BEVs don't require more lightweighting than ICEs
Despite the issue of range, advancements in battery tech and the use of regenerative braking will limit the need for lightweighting.

2

Battery tech has far more runway than materials tech.
Ambitious targets from groups like Tesla show that batteries could end up costing substantially less than our forecasts. The imperative for materials innovation to save costs in their own right is crucial given the level of opportunity for battery cost reduction.

3

Software and manufacturing tools will be crucial areas for investment.
Advances in design are crucial, and by 2030, techniques like generative design and advanced simulation will dominate. Materials companies need to make software plays to stay relevant.

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