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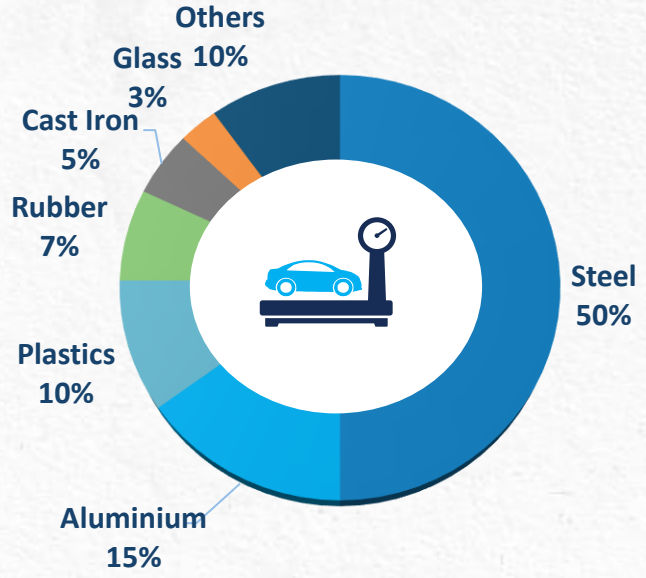
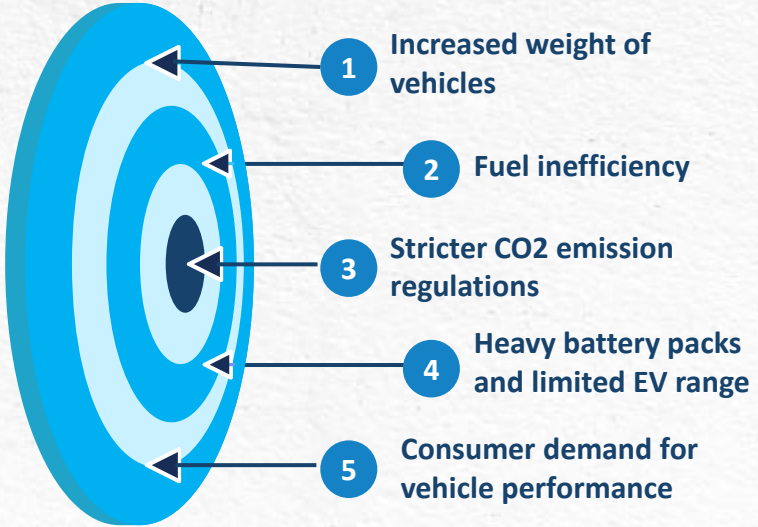
GLOBAL AUTOMOTIVE LIGHTWEIGHTING MARKET

WHY LIGHTWEIGHTING IS IMPORTANT

Traditional Materials Content as % of Total Vehicle Weight (2024)



Challenges faced



A 10% weight reduction is expected to improve EV range by 4% to 6% and improve fuel efficiency in ICE vehicles by 6% to 8%

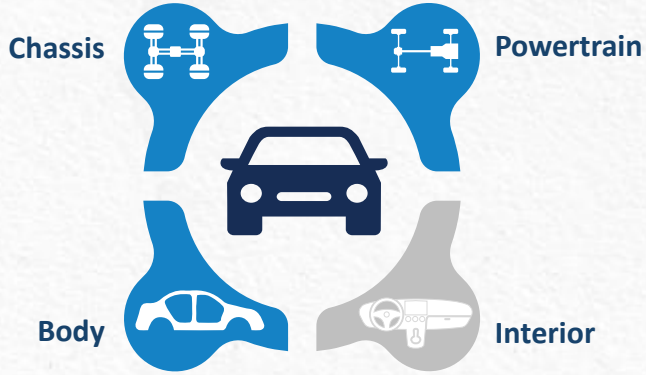
Source: Frost & Sullivan

LIGHTWEIGHTING FOR IMPROVED FUEL EFFICIENCY

Standard Approach

With subsequent generations, vehicles are expected to reduce weight for improved fuel efficiency.

Key Lightweighting Zones



Current Average Weight

1000-
2500 kg

Weight Reduction Potential

8-15%

Favored Materials

HS Steel

Aluminum

Key Segments

Hatchback

Sedan

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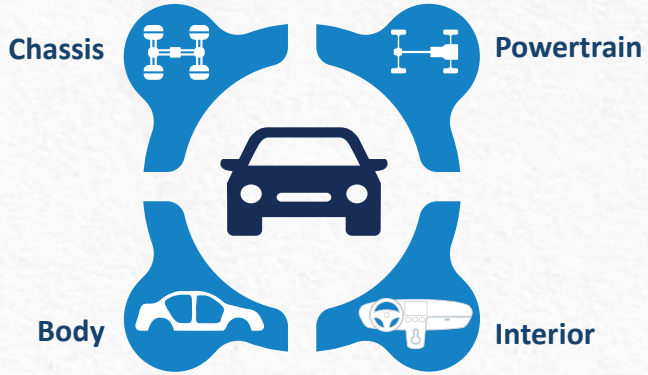
Source: Frost & Sullivan

LIGHTWEIGHTING FOR ENHANCED PERFORMANCE

Performance Approach

Lightweighting to offset the battery pack weight and heavy weight components which in turn increases the vehicle range, efficiency and performance.

Key Lightweighting Zones



Current Average Weight

1500-
2300 kg

Weight Reduction Potential

10-15%

Favored Materials

- Titanium
- CFRP
- Aluminum
- Magnesium

Key Segments

- Sedan (Full-size/Luxury)
- Crossover/SUV (EV/PHEV)
- Sports/Convertibles
- Supercar

KEY REGULATIONS/TAX IMPACTING THE NEED FOR LIGHTWEIGHTING

Region	Govt. Announcements	Vehicle Segments covered	Mandate requirements
NORTH AMERICA 	EPA Greenhouse Gas Emissions Standards	Economy-wide emissions (incl. transportation sector)	CO2 emission limits phased in for 2030; Could be eliminated in future
	Corporate Average Fuel Economy (CAFE) Standards	Light-duty vehicles (passenger cars & light trucks)	Industry-wide fleet average of 50.4 miles per gallon (mpg) by MY 2031; No penalties attached
EUROPE 	CO_2 Emissions Regulations	Passenger cars, vans	Fleet-wide CO2 emission target is 0g CO2/km from 2035
	Weight Penalty Tax ("malus au poids" in France)	Passenger cars	Penalties applies for emissions above 113 grams CO2/km and vehicle mass above 1600kg
ASIA PACIFIC 	China Corporate Average Fuel Consumption (CAFC)	Passenger cars	Fleet-wide fuel consumption targets
	BS VI Emission Norms (India)	All vehicle types	Stricter tailpipe emission controls in vehicles
	Tonnage Tax in Japan	All types of automobiles	$17/0.5t/year (= base rate) for cars EVs are exempt; Qualifying gas/LPG/clean-diesel models will be exempt or up to 50% reductions

KEY OEM TRENDS IN AUTOMOTIVE LIGHTWEIGHTING

Building lightweight and high-strength materials
Performance cars adopts CFRP for structural components such as roof panels, side frames etc.

Structural battery integration
Potential weight savings up to 20kgs per vehicle

Battery weight optimization
Building high-performance and lightweight battery packs, which are up to 40% lighter

Sustainability
Increase in usage of recycled materials (Plastics, aluminum) contributing to lightweighting and circular economy

Replacing with aluminum parts
Use of aluminum-intensive body structures, which weigh up to 45% less than steel-intensive vehicles

Modular chassis platform
Adapted across ICE, EV, and PHEV vehicles, thereby reducing the number of individual parts

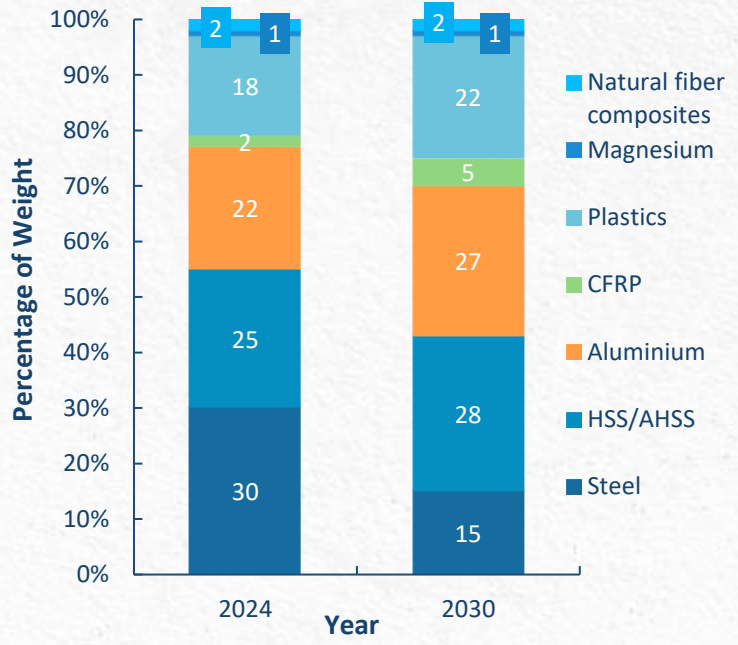
Hot stamping
A combination of heating and forming to make lightweight and strong vehicle parts from sheet metal

Giga casting technology
Production of large vehicle parts (E.g., rear underbody) instead of multiple smaller parts

Weight reduction
Reduction in the weight of vehicle components using HSS, multi-materials, and advanced molding technology

MATERIALS DISTRIBUTION IN VEHICLES

Automotive Lightweighting: Material Composition and Weight Distribution, Global, 2024 and 2030



Highlights

- Traditional steel usage is decreasing, while HSS remains essential for safety-critical components. Advanced HSS (AHSS) can reduce a vehicle's structural weight by 25%
- EVs require lighter materials to offset battery weight, making aluminum a prime candidate. Many OEMs (Tesla, Ford, and Audi) are shifting towards aluminum-intensive designs.
- In high volume vehicles, cost-effective mass reduction will be achieved using different grades of high-strength steel and selective use of aluminum
- Both synthetic and recycled plastics are expected to gain traction due to sustainability efforts and weight savings, increasing to 22% by 2030.
- Current usage of carbon fiber composites, such as CFRP, is limited. However, by 2030, usage is expected to grow in high-performance and luxury vehicles.

Source: Frost & Sullivan

ALUMINUM – INDUSTRY STRATEGY

OEM Components Approach

OEM*	Audi	Lucid	Mercedes-Benz	Toyota	Lexus	Lexus	Nissan
Examples	Q6 e-tron (2024)	Air (2024)	AMG GT Coupe	GR86 Yuzu Edition	RZ (2024)	TX (2024)	Nissan Z (2024)
Components HSS is used in	Front suspension strut mounts, front hood, tailgate	Aluminum body shell	Composite aluminum body structure	Hood, front fenders and roof panel	Hood, eAxle motor mounting bracket	Hood, front fender	Hood, doors, hatch, wheels, rear suspension, subframe, brake calipers

Key Points

Key suppliers for automotive: Alcoa, Novelis, Constellium, Norsk Hydro ASA, SAG México

Aluminum is mainly used in body panels and structural components of vehicles, for lightweighting, extended battery range (EVs), and enhanced vehicle performance.

Automotive examples:

Ford F-150 utilized aluminum for its entire body-in-white, reducing its weight by up to 700 pounds.

Novelis developed aluminum-intensive EV battery enclosures for reducing battery weight while maintaining high energy capacity.

Aluminum will emerge as a critical material for lightweighting in EVs, with its good strength-to-weight ratio. It is also closed-loop recyclable, making it sustainable.

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*Only an indicative list of OEMs is provided.

Source: Frost & Sullivan

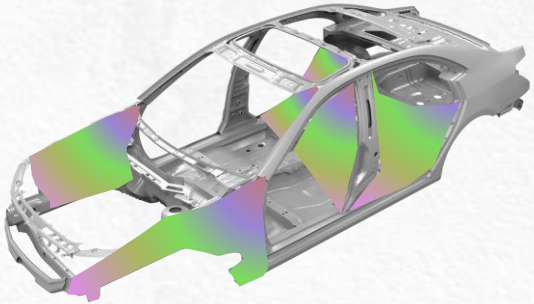
SELECT OEM INITIATIVES AND LIGHTWEIGHTING BENEFITS OBSERVED

OEMs*	Vehicle Segment	Model	Lightweight materials used
Maruti	Hatchback	Swift (2024 model)	Usage of AHSS improved by 17% and UHSS by 4%; Achieved weight savings of 100kgs compared to the 1st gen model
Suzuki	Hatchback	Alto (10th gen 2026 model)	Increase use of AHSS; Target weight savings of 100kg
Toyota	Pickup Truck	Tacoma (2024 model)	HSS used throughout chassis; Aluminum for upper body, tailgate etc.
Kia	Sedan	EV4	Lightweight aluminum brackets in the motor support structure
Mercedes-Benz	Sedan	E-Class (E 350)	Extensive use of aluminum, HSS, UHSS for body structure to enhance rigidity while reducing weight
Range Rover	SUV	Sports SV Edition (Edition 2)	Carbon fibre wheels, carbon-ceramic brakes (OPT), carbon fibre bonnet; 76kg weight savings
Aston Martin	SUV	DBX S	Carbon fibre roof + removal of roof rails, together the combination saves 18kgs
Porsche	Sports car	911 GT3 RS	CFRP for doors, front wings, roof, bonnet and rear lid; Key contributor to curb weight of 1450kg
BMW	Sports Car	M2 CS (2026 model)	Carbon fibre body; Carbon back-bucket seats; carbon-ceramic brakes (OPT)

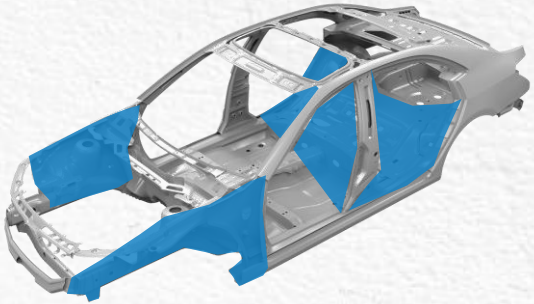
*Only an indicative list of OEMs is provided.

Source: Frost & Sullivan

GIGACASTING IN AUTOMOTIVE MANUFACTURING



Model 3 Body Structure
171 pieces of metal highlighted



Gigacasted Model Y Body Structure
2 pieces of metal highlighted >1600 fewer welds

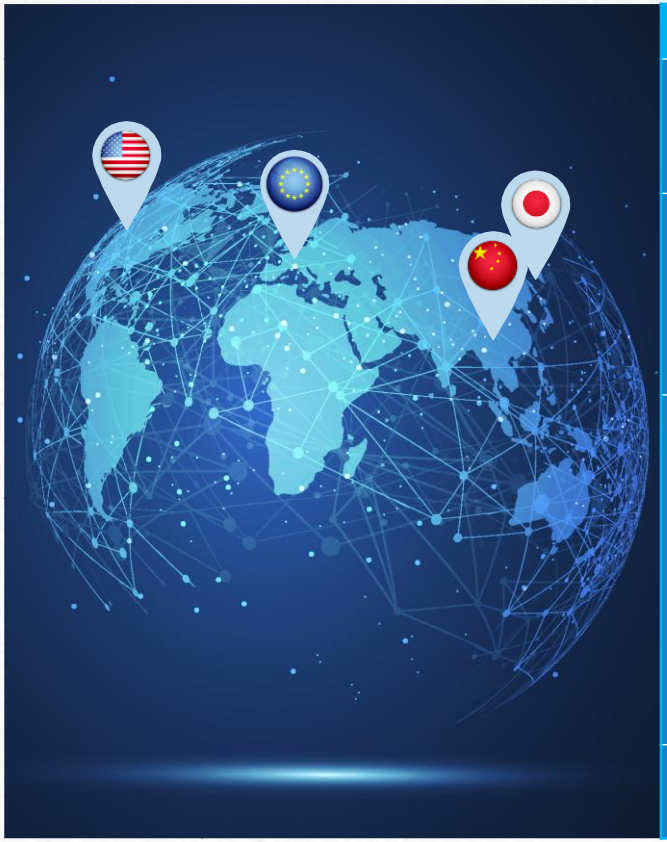
Key Challenges

- Damages in a gigacasted structure require full component replacements
- Increased repair costs
- Investing in gigacasting machines and infrastructure is capital-intensive

Tesla Approach

- Model Y utilized two gigacastings using 6000-9000 Giga Press machines
  - Rear Underbody (RUB) → Reduced from 70+ parts to 1 piece; Front Underbody (FUB) → Reduced from 100+ parts to 1 piece
  - This technology allowed Tesla to reduce Model Y's manufacturing costs by 40% and provide a lightweight chassis
- Tesla also uses aluminum gigacasts for the front and rear bodies of its Cybertruck electric pickup

GIGACASTING IN AUTOMOTIVE MANUFACTURING: INDUSTRY INITIATIVES



Region	OEMs	Location	Machine Details	Gigacasted Components
USA	Honda	Anna Engine Plant in Ohio	Six 6,100T giga-presses	Intelligent Power Unit (IPU)
	General Motors	NA	NA	Shock towers and underbody castings in Cadillac CELESTIQ
Europe	Volvo	Torslanda, Sweden	2 8400T giga-press machines	Rear floor of their EVs
	Volvo	Košice, Slovakia	Two 9000T giga-press machines	NA
	Volkswagen	Kassel plant in Germany	4400T machine	Rear underbody and structural battery housings
China	Xpeng	Guangzhou plant	12,000T giga-press machine	Rear underbody of X9 model
	Huawei	Chongqing	9000T giga casting machine	Single rear body units of Aito M9 model
	XIAOMI	Beijing	9100T machine	Casting rear underbody of EVs
	Toyota Lexus	Shanghai	9,000T die casting machines	Develop modular vehicle structures split into front, center and rear sections of LF-ZC
	Honda	Chongqing	12,000T giga press	Partnered with GHT to manufacture battery trays
Japan	Toyota	Aichi prefecture	9,000T	Rear and front section of its EVs

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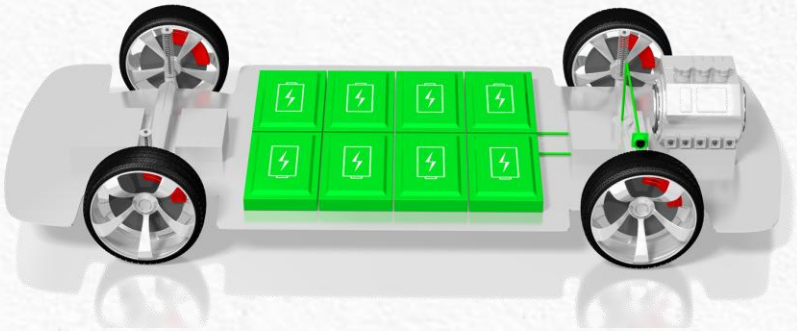
*Only an indicated list of OEMs are displayed

EV BATTERY STRUCTURAL INTEGRATION

- Traditional EVs have a separate battery pack with modules and cells integrated, housed in the vehicle floor or undercarriage with its own casing and supporting structure
- **Structural batteries are built directly into the vehicle's frame, especially the underbody, removing the need for extra weight**



Tesla Approach

- Tesla's structural battery pack acts as a body structure, linking front and rear underbody parts.
- It has 4,680 battery cells, which are larger and more energy-dense.
- This, combined with the gigacasted front and rear underbody, allowed Tesla to **eliminate 370 parts in the Model 3.**
- **Benefits:** Reduced manufacturing costs and weight savings
- **Challenges:** Not easily serviceable, minor collisions can make it unusable

Other OEMs Adopting Structural Battery Integration in EVs

- **BMW's in-house developed Gen6 cylindrical batteries** will be integrated into the structural floor of Neue Klasse (all-electric architecture) vehicles. **Benefits offered**: Reduced vehicle weight; 30% increased driving range; 20% more energy density, and 50% cheaper to build
- **BYD pioneered cell-to-body technology in the SEAL model**, which used the upper shell of the battery pack to replace the body floor. Through this, a volume utilization rate of 66% can be achieved. However, no direct vehicle weight savings were observed.

COMPARATIVE ANALYSIS OF EV BATTERY LIGHTWEIGHTING STRATEGIES

Lightweighting Strategy	Structural Integration	Lightweight Chemical Composition	Lightweight Materials for EV Batteries	Cell-to-Pack (CTP) Technology
EV Weight Reduction Potential	~10-20%	~30-40%	~10-15%	~10-20%
Manufacturing complexity				
Cost implications				
Industry Examples	• Tesla Model Y/Cybertruck • BYD Seal • Hyundai & Kia – filed patent	• **Stellantis** – Investing in lithium-sulphur batteries • **Mercedes-Benz** – Road testing of solid-state batteries	• **Kautex Textron** – received an order from an EV OEM for thermoplastic composite battery housing units	• **NIO** - Lithium Iron Phosphate (LFP) 75 kWh battery in CTP structure • **Tesla** – Prismatic LFP cells in CTP structure in Model 3s and Model Ys

Source: Frost & Sullivan

KEY TAKEAWAYS

Tax Burden and Regulatory Pressures Fuels Lightweighting Push
Globally, CO2 emission reduction standards and strict fuel efficiency targets are driving automakers to prioritize lightweighting. While there are no direct restrictions on heavy cars, hefty charges are applied during registration, inspection, and parking in many countries, thereby making lightweighting more crucial

Balanced Mix for Optimal Lightweighting
A mix of HSS and aluminum is predominantly preferred in high-volume vehicle segments to deliver cost-effective mass reduction. Increasing **use of carbon fiber composites is seen in premium and sports vehicles** where performance and weight optimization is key.

North America Will See Slowdown In Automotive Lightweighting
Rising tariff pressures are disrupting global supply chains, prompting OEMs in the region to scale back lightweighting efforts and adjust strategies to reduce tariff exposure.

LINK TO THE STUDY

AUTOMOTIVE LIGHTWEIGHTING MARKET, GLOBAL, 2024-2030

Subscriber: Link to Download

Non-Subscriber (Store): MHC8 Link to Purchase

Global Automotive & Transportation Research Team at Frost & Sullivan

Appendix

How does your organization identify and prioritize Growth Opportunities?

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