RCMOS – Multidisciplinary Scientific Journal O Saber. ISSN: 2675-9128. São Paulo-SP.

Year VII, v.2 2026 | submission: 04/28/2026 | accepted: 05/08/2026 | publication: 06/19/2026

Battery mass as a vector for chassis reconfiguration in electric vehicles and its effects on suspension, brakes, and structure

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ABSTRACT
The electrification of automobiles and light commercial vehicles concentrated a significant portion of the vehicle's total mass in the energy storage system, with consequences that go beyond the issue of range and affect the chassis design as a whole. This article examines, through a narrative review of technical and scientific literature complemented by elementary analytical analysis, how the increase and redistribution of mass associated with traction batteries affect suspension, tires and wheels, brake systems, and the body structure of battery electric vehicles. The review brings together reference works in vehicle dynamics and chassis engineering, empirical studies on energy consumption and non-exhaustive emissions, research on battery mechanical safety, and recent regulatory frameworks such as Regulation (EU) 2024/1257 and Law No. 14,902/2024. The results indicate that the additional mass triggers cascading side effects, which require resizing of springs, shock absorbers, wheels, discs, and calipers, reduces the available installation space, and turns the battery pack into an element to be protected and, increasingly, integrated into the structure. Regenerative braking reduces the stress on friction brakes but does not exempt sizing for the most severe condition and introduces new corrosion and electronic integration problems. It is concluded that mass reduction should be treated as a systemic design requirement, with direct repercussions on energy efficiency, road safety, and environmental performance.
Keywords: Electric vehicles. Vehicle mass. Suspension. Regenerative braking. Vehicle structure.

1 INTRODUCTION

The progressive replacement of the internal combustion engine by the electric powertrain changed one of the most basic parameters of automotive design, which is the vehicle's mass. In a battery electric car, the traction battery pack is usually the heaviest individual component of the set, and its mass is not limited to electrochemical cells. König et al. (2021) show that the gravimetric energy density measured at the package level is significantly lower than that of cells, because cooling systems, cabling, housings, and fasteners add mass and volume without storing energy. Weiss, Cloos, and Helmers (2020), analyzing 428 electric vehicles from different categories, confirmed that battery capacity and vehicle mass are strongly correlated and that doubling the mass raises certified energy consumption by about 60%, while doubling the motor's rated power raises it by only about 5%.

For chassis engineering, this additional mass is not a neutral datum. Suspension, steering, brakes, wheels, tires, axles, and subchassis are sized based on the loads the vehicle imposes on the ground

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and the accelerations it will be subjected to, so that any relevant mass increase propagates through practically all subsystems. Reference works such as those by Reimpell, Stoll, and Betzler (2001) and Heißing and Ersoy (2011) describe the chassis as a tightly coupled system, in which decisions made for a component affect kinematics, elastokinematics, comfort, and overall safety. Nicoletti et al. (2020) demonstrated, in parametric modeling applied to electric vehicles, that mass variations in the early stages of development cause secondary changes in mass and volume in wheels, discs, and tires, even compromising the available installation space on the front axle.

Given this framework, this article aims to analyze how the mass and position of traction batteries condition the design of suspension, tires and wheels, brake systems, and body structure in battery electric vehicles, as well as to discuss the implications of this condition for road safety, non-exhaustive emissions, and regulation. The text is organized into six thematic axes, preceded by a description of the method and followed by final considerations. It is based on the premise, supported by the reviewed literature, that mass has ceased to be just a project result and has come to function as a structuring variable in engineering decisions, which requires integrated approaches from product conception.

2 METHODOLOGY

The study adopts a narrative literature review approach, qualitative in nature and exploratory and descriptive, suitable for topics where distinct disciplines converge, such as vehicle dynamics, materials engineering, battery safety, environmental science, and regulation. Unlike a systematic review, which requires a closed search protocol and statistical aggregation criteria, narrative review allows articulating sources of diverse nature, such as reference books, peer-reviewed articles, technical reports from government agencies, and normative texts, around a defined engineering issue. This choice is consistent with the purpose of the work, which is not to estimate an average effect, but to understand the mechanisms by which battery mass is converted into chassis design requirements.

The selection of sources was carried out from databases and repositories of recognized reliability, including ScienceDirect, SpringerLink, MDPI, SAE Mobilus, PubMed Central, and the official legislative portals of the European Union and Brazil. Descriptors in Portuguese and English related to the mass of electric vehicles, battery energy density, suspension and vertical dynamics, tire loads, regenerative braking, brake wear, non-exhaustive emissions, battery impact and protection and structural batteries were used. The inclusion criteria favored works published in indexed journals, classics widely cited in automotive engineering, and official documents, with individual verification

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of authorship, year, volume, pagination, and digital identifier of each reference. Commercial promotional materials and texts without authorship or traceable origin were excluded.

Additionally, an elementary analytical analysis was performed based on consolidated physical relationships, such as the expression of kinetic energy, the natural frequency of a mass-spring system, and lateral load transfer, with the purpose of making explicit the order of magnitude of the effects discussed. The values presented in this analysis are illustrative and do not represent specific vehicles, serving only to demonstrate the proportionality between mass and mechanical stresses. The limitation of the method is recognized as the absence of proprietary experimental data and the dependence on results obtained in different test and fleet contexts, which is why conclusions are formulated in terms of trends and mechanisms, rather than universal values.

3 THE BATTERY MASS AND THE NEW VEHICLE ARCHITECTURE

The first consequence of electrification on the chassis is architectural in nature. In vehicles developed on dedicated platforms, the battery pack normally occupies the floor between the axles, forming a large mass concentrated in a low position. König et al. (2021) observe that the difference between the energy density of the cells and that of the pack arises from indispensable peripheral elements, such as modules, thermal system, connectors, and casing. The authors also note that direct integration of cells into the package, known as cell-to-pack, was announced with the purpose of eliminating intermediate modules and reducing battery mass by about 10%, although there was still no production vehicle with this solution when the study was published. Based on estimates by other researchers, the same work indicates practical limits for the gravimetric density of lithium-ion cells in the range of 350 to 370 Wh/kg, which suggests that the mass associated with energy storage will remain relevant in the near future.

The position of the package has effects that, in certain respects, are favorable. Arora, Shen, and Kapoor (2016), when reviewing mechanical design techniques and strategic battery positioning, discuss the choice of the installation location of the package as part of the overall protection strategy, taking as an example a mass-produced electric car. Underfloor installation, adopted in most dedicated platforms, also has the effect of lowering the center of gravity, whose importance can be understood by the static stability factor, defined by the ratio between the gauge and twice the height of the center of gravity. Walz (2005), in a technical report from the National Highway Traffic Safety Administration, uses this indicator to assess the tendency to roll over and shows that higher values

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correspond to vehicles less susceptible to this type of accident. A low and wide battery therefore tends to increase this factor, even if it adds mass to the set.

Mass distribution also alters moments of inertia and load transfer between wheels. Gillespie (1992) shows that lateral load transfer in curves is proportional to the product of mass by lateral acceleration and center of gravity height, and inversely proportional to the gauge. A lower center of gravity attenuates this transfer and favors the use of tire grip, but the higher total mass increases the absolute forces that tires, bushings, arms, and bearings must support. The concentration of the battery between the axles, close to the center of the vehicle, also tends to moderate the moment of inertia in yaw compared to masses distributed at the edges, which influences directional response. The result is a vehicle with potentially more stable behavior, but subjected to higher mechanical stresses on almost all components.

The most subtle, and perhaps the most challenging effect for development teams, is the chaining of secondary masses. Nicoletti et al. (2020) parametrically modeled the components of electric vehicle wheels and concluded that a primary variation of about 6% of the curb mass can reduce the available installation space on the front axle by up to 12%, depending on the adopted design strategy. The authors estimate that, for this same variation, the wheel mass increases by 0.5 to 1.5 kg per wheel in cases where there is no rim change, but that an inadequate strategy can raise this total increase to about 20 kg. In one of the cases studied, an increase of only 0.7% in the vehicle's mass made the brake disc incompatible with the smallest 19-inch rim offered, highlighting the sensitivity of the wheel and brake package to mass variations.

This chaining has a direct impact on energy performance and, consequently, on the battery size itself. Weiss, Cloos, and Helmers (2020) estimated that, in electric cars, every additional 100 kg increases consumption by approximately 0.6 kWh per 100 km. To maintain range, the designer tends to increase the battery capacity, which adds mass and repowers the cycle. Kim and Wallington (2013), in a review and harmonization of life cycle studies, demonstrated that mass reduction produces energy and greenhouse gas emission benefits throughout the vehicle's life, and Candela et al. (2024) systematized the materials and mass reduction methods used by industry, such as high-strength steels, aluminum alloys, and composites. These studies converge to the conclusion that, in electric vehicles, mass management has ceased to be a final optimization and has become a starting condition for the design.

4 SUSPENSION AND VERTICAL DYNAMICS UNDER HIGHER LOADS

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The suspension is the first subsystem to feel the increase in mass, as it supports the vehicle's static load and controls its movements over the irregularities of the pavement. Gillespie (1992) describes the vertical behavior of the suspended mass through models of a quarter vehicle, in which the natural frequency is proportional to the square root of the ratio between the equivalent stiffness of the suspension and the supported mass. Since the comfort perceived by occupants is associated with relatively narrow ranges of natural body frequency, an increase in mass requires a proportional increase in spring stiffness to preserve this frequency. In practical terms, an electric vehicle 25% heavier than its combustion equivalent requires springs about 25% stiffer to maintain the same riding behavior, which increases material stresses, supports loads, and component dimensions.

The same reasoning applies to shock absorbers. The damping ratio, a parameter that defines how quickly body oscillations are dissipated, depends on the relationship between the damping coefficient and the root of the stiffness product by mass. Reimpell, Stoll, and Betzler (2001) treat shock absorber fitting as a compromise between comfort and wheel control, which needs to be redone whenever the masses and stiffnesses of the system change. With more mass and stiffer springs, shock absorbers need to generate greater forces to maintain the same damping ratio, dissipating more energy in the form of heat. This affects the sizing of the internal valves, the diameter of the tube and the rod, as well as the durability of the seals and fixing bushings, which then operate under higher average loads throughout the vehicle's entire service life.

The variation in charge between empty and loaded conditions adds another difficulty. In automobiles, the difference between the vehicle with only the driver and the vehicle with passengers and luggage already requires compromise solutions. In light electric commercial vehicles, where the battery mass adds to the payload, this amplitude becomes critical because the suspension needs to ensure height, stability, and comfort under very different conditions. Heißing and Ersoy (2011) discuss air suspensions and leveling systems as means to keep the vehicle's height and natural frequency relatively constant under variable load, although with increased cost and complexity. The choice between progressive coil springs, spring bundles, air springs, or combinations of these solutions now depends on the battery mass as much as the vehicle's usage profile.

Unsprung mass deserves particular attention. It includes wheels, tires, hubs, discs, calipers, and part of the suspension arms, elements that move together with the wheel and are not isolated by springs. Gillespie (1992) shows that the ratio between suspended and unsprung mass influences the tire's contact with the ground and the resonance of the wheel, which is at frequencies much higher than those of the body. The increase in mass often leads to larger discs, more robust calipers, and larger

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diameter wheels, as pointed out by Nicoletti et al. (2020), which precisely raises the unsprung mass and can impair grip on uneven pavements. Proposals for motors installed inside the wheels worsen this issue, and the increase in unsprung mass is often pointed out among the factors that lead most mass-produced electric vehicles to keep the motors fixed to the body or subframe, with torque transmission via half-shafts.

Semi-active and active suspensions appear as a technological response to this set of compromises. Savaresi et al. (2010) present control methods for variable coefficient shock absorbers that allow continuous adjustment of damping to the driving condition, reducing the conflict between comfort and wheel control. The high availability of electric power on board electric vehicles generally favors the use of actuators, but the energy consumption of these systems needs to be accounted for in the range. At the same time, the absence of combustion engine noise makes the noises and vibrations transmitted by the suspension more noticeable, which gives bushings and cushions an even more important role in sound insulation. The electric vehicle suspension thus needs to support more mass, control larger load amplitudes, and transmit less noise—three requirements that do not always point in the same direction.

5 TIRES, WHEELS, AND LATERAL DYNAMIC BEHAVIOR

Tires are the only contact element between the vehicle and the ground and, therefore, directly translate the effect of mass on dynamic behavior. Pacejka (2012) demonstrates that the lateral force a tire can generate does not increase linearly with vertical load, a phenomenon known as load sensitivity. As the load increases, the effective coefficient of friction decreases, so a heavier vehicle needs tires with a larger contact area, greater structural rigidity, or higher inflation pressure to achieve equivalent levels of lateral grip. This characteristic has direct implications in the design of electric vehicles, in which the gain provided by the lower center of gravity can be partially offset by the drop in the effective friction coefficient associated with higher vertical loads.

The tire's load capacity is another limit to consider. Tires are specified by load indices associated with a reference pressure, and heavier vehicles require higher ratios, reinforced constructions, or larger dimensions. The increase in rim diameter, in turn, is often imposed by the need to accommodate larger brake discs, as evidenced by Nicoletti et al. (2020) in cases where a small increase in mass made the disc incompatible with the smallest available rim. Larger wheels and wider tires increase unsprung mass, rotational moment of inertia, and often aerodynamic drag and rolling noise. The designer needs

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to balance load capacity and grip with rolling resistance, which directly affects energy consumption and vehicle range.

In directional behavior, the mass distribution between axles largely defines the vehicle's understeering or oversteering tendency. Gillespie (1992) expresses the steering gradient as a function of the loads on each axle and the lateral stiffness of the respective tires. Since the battery located between the axles tends to bring mass distribution closer to a balanced condition, the dedicated platform electric vehicle offers the chassis engineer a favorable basis for calibrating dynamic balance. Still, the increase in total mass increases the forces the tires need to develop in emergency maneuvers, such as sudden lane changes, and demands greater attention to bushing stiffness, toe-toe and camber geometry, and calibration of electronic stability control systems.

Tire wear is a direct consequence of the combination of greater mass and high available torque from low revs. Beddows and Harrison (2021) analyzed the dependence of non-exhaustive particulate emission factors on vehicle mass and showed that emissions from tire wear, pavement wear, and dust resuspension increase with weight. Timmers and Achten (2016) reached a convergent conclusion in concluding that electric vehicles continue to emit relevant amounts of non-exhaustive particulate matter, partly because they are heavier than their combustion counterparts. From a chassis engineering perspective, these results reinforce the need for specific rubber compounds and tire structures capable of withstanding higher loads and torque without accelerated tread degradation.

Wheels and steering system complete this picture. Wheels need to support higher radial and lateral loads, which requires greater mechanical strength and often more mass, in contradiction to the goal of reducing unsprung mass. In the steering system, higher loads on the front axle increase rack forces and the torque needed to steer the vehicle, especially during parking maneuvers. Heißing and Ersoy (2011) describe electric-assist steering as a solution that allows modulation of assistance according to speed and load, but its engine, electronics, and bearings need to be sized for the highest forces. In summary, tires, wheels, and steering absorb the effects of mass interdependently, and any isolated optimization tends to shift the problem to another system component.

6 FRICTION BRAKES AND REGENERATIVE BRAKING

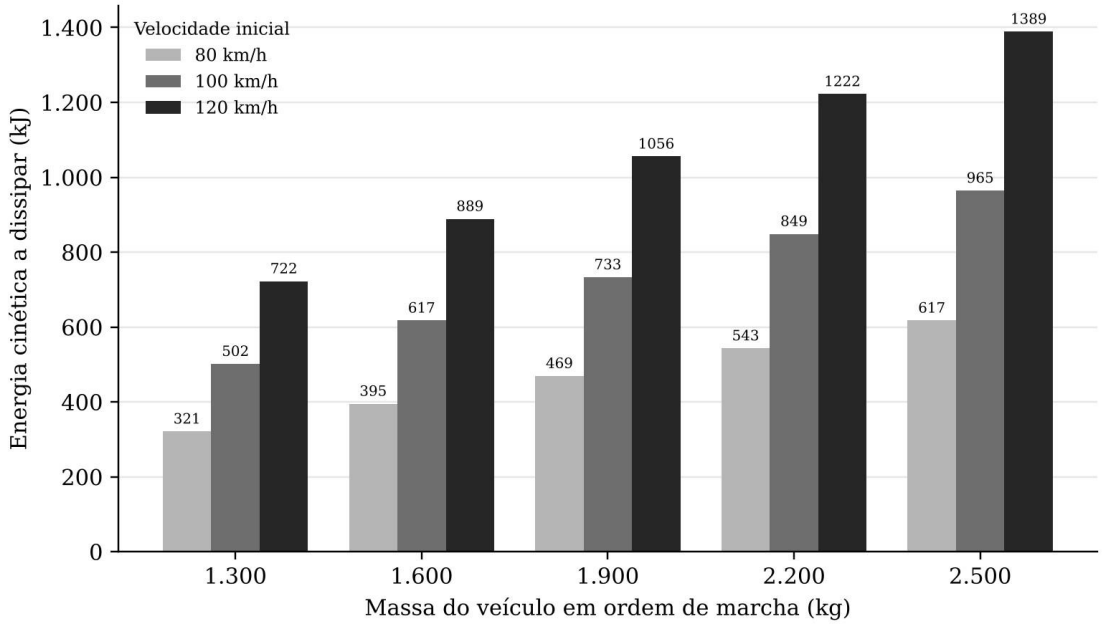
The braking system is the one in which the relationship between mass and load appears most directly. Limpert (2011) shows that the energy to be dissipated during braking corresponds to the vehicle's kinetic energy, proportional to the mass and the square of the speed, and that this energy is converted

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into heat in the discs, drums, and pads. In an emergency deceleration, practically all this heat needs to be absorbed by the thermal mass of the discs within a few seconds. Figure 1 illustrates the order of magnitude of the problem. At 100 km/h, a 1,600 kg vehicle accumulates about 617 kJ of kinetic energy, while a 2,200 kg vehicle accumulates about 849 kJ, a difference of approximately 38% that needs to be dissipated by the brakes. During repeated braking, such as on long descents, this difference accumulates and increases the risk of efficiency loss due to overheating, a phenomenon known as fading.

Figure 1 – Kinetic energy to be dissipated by the braking system as a function of the vehicle's mass and initial speed



Source: prepared by the author (2026), based on the ratio E = 1/2·m·v² presented by Limpert (2011).

The distribution of braking force between axles also depends on mass and its position. Limpert (2011) demonstrates that the ideal distribution depends on the height of the center of gravity, the distance between axles, and the static load distribution, since deceleration transfers load from the rear axle to the front. In vehicles with a battery on the floor, the lower center of gravity reduces this dynamic

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transfer and allows the rear axle to contribute more to braking, which favors the use of available grip. At the same time, the greater total mass imposes discs of greater diameter and thickness, calipers with more pistons or pistons with larger area, and fluids with greater thermal stability. As shown earlier, these choices affect the wheel diameter, the unsprung mass, and the installation space on the front axle.

Regenerative braking profoundly modifies this equation, as it allows part of the kinetic energy to be recovered by the electric motor operating as a generator. Gao and Ehsani (2001) proposed electronic braking architectures that integrate regeneration, automatic braking force control, and anti-lock system, treating the coordination between electric brake and friction brake as part of the braking system's own design. Lv et al. (2015) analyzed the energy flow of a regenerated electric vehicle, proposed two parameters to evaluate the contribution of regenerative braking to energy efficiency, and applied them in chassis dynamometer tests with typical driving cycles and three distinct control strategies. Ehsani et al. (2018) emphasize that regenerative capacity is limited by engine power, state of charge, and battery temperature, as well as reduced efficiency at low speeds.

Because of these limitations, friction brakes continue to be sized for the most severe condition, where regeneration may be reduced or unavailable, such as during an emergency stop with a fully charged battery or at low temperatures. This creates a design paradox, as the system needs to be robust enough for the worst-case scenario, but is rarely used in everyday use. Antanaitis (2010) observed that there was little published research on what the drastic reduction in friction brake use means for the brakes themselves and presented analyses and tests on corrosion, wear outside braking, and friction levels in vehicles with regeneration, proposing that the design balance of these systems be different from that adopted in conventional vehicles. This finding shifts the design focus from thermal capacity, traditionally dominant, to preserving friction surfaces over time, which involves material choice, corrosion protection, and the logic of actuating friction brakes by the control system. The environmental dimension of brakes reinforces the importance of regeneration. Grigoratos and Martini (2015), in a review on particle emissions from brake wear, indicate that this source can account for up to 55% of the mass of non-exhaustive PM10 emissions in urban environments and about 11% to 21% of total PM10 emissions related to traffic. Beddows and Harrison (2021) concluded that the balance of particle emissions from electric vehicles compared to conventional ones depends critically on the extent of regenerative braking use. This evidence was incorporated into European regulation, as Regulation (EU) 2024/1257 establishes, for cars and vans, a brake particle emission limit of 3 mg/km for purely electric vehicles and 7 mg/km for most others (EUROPEAN UNION, 2024). The

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electric vehicle brake thus ceases to be just a safety system and also becomes an object of environmental control.

7 BODY STRUCTURE AND BATTERY SYSTEM PROTECTION

The presence of a large mass under the floor transforms the relationship between the body and the energy storage system. The battery pack needs to be secured to withstand rolling vibrations, braking and cornering accelerations, and impact loads, without the cells undergoing deformations capable of causing internal short circuits. Arora, Shen, and Kapoor (2016) reviewed more than 75 sources, including dozens of patents, on mechanical protective characteristics of lithium-ion battery packs against thermal runaway, vibration, and impact, and concluded that relatively simple mechanical characteristics can reduce the risk of failure. The authors identify suitable materials for the main components of the package and, based on comparison between existing designs, outline basic requirements for a robust and reliable storage system. For the chassis, this means that the mounting points, supports, and the package shell itself become integrated into the vehicle's cargo path.

Impact on the ground represents a specific stress on the architecture with a floor battery. Xia et al. (2014) developed a methodology based on a global finite element model of a hypothetical package, complemented by detailed cell models, to analyze impacts of objects against the underside of the vehicle. The results predicted perforation of the protective plate, propagation of cracks, and local deformation of the cells, whose failure the authors associate with the risk of short circuits and thermal runaway. A parametric study allowed the extraction of general rules for the design of the protective structures of the package. For chassis engineering, this type of request requires joint consideration of ground clearance, suspension stiffness, and lower protection, since suspension travel and ride height influence the likelihood of contact.

In collisions, the battery pack requires the structure to preserve a protected volume around the cells, especially in lateral impacts against poles, where the available deformation zone is small. Zhu, Wierzbicki, and Li (2018) reviewed safety-oriented mechanical models of commercial lithium-ion batteries, highlighting the importance of properly representing the mechanical behavior of the cell components to predict the onset of short circuits under impact loads. This need translates, in the bodywork, into reinforced thresholds, underfloor crossbars, extruded aluminum profiles, and energy-absorbing structures designed to divert loads from the pack. The mass of these protections adds to the battery mass, which reinforces the mass growth cycle discussed in section 3.

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The most recent trend is to treat the package not only as a load to be protected but as an element that contributes to the rigidity of the body. In cell-to-pack solutions, mentioned by König et al. (2021), the elimination of intermediate modules increases the active mass fraction of the package, and in solutions where the package is integrated with the floor, its casing begins to function as part of the structure, increasing the torsional rigidity of the assembly. This integration can reduce mass and redundant components but shifts requirements for tightness, thermal management, and electrical insulation to the structure, as well as making repair and replacement of cells more difficult. Heißing and Ersoy (2011) point out that body rigidity is a condition for suspension kinematics to operate according to the design, which makes the structural integration of the battery a decision that directly involves chassis engineering.

In the research horizon, structural batteries propose that the material itself stores energy and supports mechanical loads. Asp et al. (2021) presented a structural battery based on carbon fibers with an energy density of 24 Wh/kg, modulus of elasticity of 25 GPa, and tensile strength above 300 MPa. Although the energy density is still much lower than that of conventional cells, the concept points to a direction in which the distinction between structural mass and storage mass ceases to exist. At the same time, Candela et al. (2024) gather the main materials and mass reduction methods adopted by the industry, such as advanced high-strength steels, aluminum alloys, and composites, which expand the alternatives to compensate for part of the mass added by the battery. These approaches suggest that the answer to the mass problem will not come from a single component, but from the integrated revision of the structure, battery, and chassis.

8 IMPLICATIONS FOR ROAD SAFETY, THE ENVIRONMENT, AND REGULATION

The increase in vehicle mass has implications that go beyond the vehicle itself and affect other road users. Anderson and Auffhammer (2014), in an econometric study published in The Review of Economic Studies, estimated that, with the vehicle's mass constant, being hit by a vehicle about 1,000 pounds (approximately 454 kg) heavier increases the risk of death by 40% to 50%, characterizing a negative externality that is not considered by the buyer at the time of purchase. Shaffer, Auffhammer, and Samaras (2021), in an article published in the journal Nature, applied this reasoning to electrification and argued that electric vehicles should be lighter to maximize their climate and safety benefits, suggesting taxation of heavy vehicles and reducing battery sizes. Mass therefore becomes a matter of collective safety and not just individual performance.

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In the environmental field, electrification eliminates exhaust emissions at the point of use, but does not eliminate non-exhaustive emissions. Timmers and Achten (2016) argued that the greater mass of electric vehicles can increase emissions associated with tire wear, pavement wear, and dust resuspension, offsetting part of the reduction provided by regenerative braking. Beddows and Harrison (2021), although they also found that non-exhaustive emissions grow with mass, reached a more nuanced conclusion regarding the final balance, according to which changes in total local particle emissions would be modest for a car that meets current emission standards, but emphasized that the result strongly depends on the degree of regeneration use. The convergence among these studies lies in the recognition that mass is the variable that connects chassis design to air quality in cities.

Regulation is already beginning to reflect this connection. Regulation (EU) 2024/1257, known as Euro 7, incorporated for the first time limits for brake particle emissions and requirements related to tire abrasion, as well as durability requirements for traction batteries, which, in the case of cars, must retain 80% of their initial capacity up to five years or 100,000 km and 72% up to eight years or 160,000 km (EUROPEAN UNION, 2024). For chassis engineering, this means that brakes and tires are also homologated for their environmental performance, which influences the choice of friction materials, disc coatings, and rubber compounds. The differentiation of brake limits between purely electric vehicles and others recognizes the role of regeneration, but also creates an incentive for control strategies that maximize energy recovery, reinforcing integration between the braking system, the powertrain, and battery management.

In Brazil, Law No. 14,902, dated June 27, 2024, established the Green Mobility and Innovation Program (Mover), aimed at decarbonization and competitiveness of the mobility industry and encouraging research and technological development in the country (BRAZIL, 2024). The law establishes mandatory requirements for the commercialization of new vehicles related to energy efficiency, recyclability, labeling and structural performance, and driver assistance technologies, and provides differentiated IPI rates according to attributes such as energy efficiency and structural performance. Since mass directly influences energy consumption and structural behavior, it also gains economic relevance for manufacturers and suppliers based in the country. Added to this are the specific pavement and usage conditions in many Brazilian cities and highways, which intensify demands on suspension, tires, and lower battery protection. The adaptation of electric platforms developed in other markets therefore requires local validation of durability and dynamic behavior, a task that falls directly on the chassis engineering teams.

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These elements indicate that the mass problem in electric vehicles is simultaneously technical, environmental, regulatory, and social. The reviewed literature suggests that the most consistent response is the incorporation of mass as a systemic requirement from the early stages of development, with parametric models capable of predicting side effects, such as those proposed by Nicoletti et al. (2020), and with the joint evaluation of battery, structure, and chassis. Ehsani et al. (2018) reinforce that electric vehicle design requires an integrated approach between powertrain, energy storage, and vehicle systems. Chassis engineering stops acting on a given mass and begins to influence the very definition of that mass, participating in decisions about battery capacity, structural architecture, and braking strategy.

CONCLUSION

This article analyzed the mass of traction batteries as a factor that reconfigures the design of battery electric vehicle chassis. The literature review showed that the mass increase associated with energy storage is not a localized effect, but a condition that propagates through suspension, tires, wheels, steering, brakes, and structure, requiring each of these subsystems to be resized and their interactions reassessed from vehicle conception.

Architecturally, it was found that installing the battery under the floor produces ambivalent effects. On one hand, it lowers the center of gravity, raises the static stability factor, and favors a balanced mass distribution between the axes. On the other hand, it increases the absolute forces on all components and triggers secondary masses that reduce installation space and feed back the growth of the total mass, as demonstrated by the reviewed parametric modeling studies.

In suspension, the need to preserve natural frequencies and damping ratios compatible with comfort imposes stiffer springs and shock absorbers capable of generating greater forces. Load variation, especially relevant in light commercial vehicles, and the increase in unsprung mass make the compromise between comfort, wheel control, and acoustic insulation more difficult, which explains the growing interest in air suspensions, leveling systems, and semi-active damping.

In tires and wheels, load sensitivity reduces the effective coefficient of friction as vertical load increases, requiring higher-capacity tires and often larger rims to accommodate more robust brakes. This chain of decisions affects rolling resistance, unsprung mass, rolling noise, and wear, which in turn relates to non-exhaustive particle emissions, a topic that has gained scientific and regulatory relevance in recent years.

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In brakes, the energy to be dissipated grows in proportion to mass, which requires larger discs and calipers for the most severe conditions. Regenerative braking relieves the daily stress of friction brakes and reduces particle emissions, but does not dispense with sizing for the
worst case scenario and creates new problems, such as disc corrosion and the need for precise electronic coordination between the electric brake and the hydraulic brake, with direct effects on the safety and durability of the system.

In terms of structure, the battery pack has become both a load to be protected and a potential structural element. Protection against undercuts and side collisions requires reinforcements that add mass, while strategies for integrating cells into the package and from the package to the body aim to reduce redundant components. Structural batteries, still in the research stage, indicate the future possibility of eliminating the boundary between structural mass and energy storage mass.

The implications of this condition go beyond the vehicle. Economic and road safety literature shows that heavier vehicles impose greater risks on other road users, and European regulation began to limit brake emissions and tire abrasion. In Brazil, the Mover Program combines incentives with criteria of efficiency and environmental performance, which also gives mass management economic and strategic relevance for the automotive industry established in the country.

It is concluded that mass reduction and management should be treated as systemic requirements of electric vehicle design, not as the final optimization stage. As a research agenda, it is recommended to deepen experimental studies on the durability of chassis components in electric vehicles under Brazilian usage conditions, quantify non-exhaustive emissions in national fleets, and develop design methods that integrate battery, structure, and chassis from the early stages of product development.

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