

Designing Busbars for Golf Carts, Utility Vehicles, and Warehouse Equipment

The most visible stories in electrification focus mostly on highway electric vehicles. However, another important engineering story, for anyone who builds power distribution hardware, is happening in the small four-wheel vehicles that never see a highway, such as golf carts, neighborhood electric vehicles, turf and grounds equipment, airport and campus utility carts, burden carriers, pallet trucks, counterbalance forklifts, and the autonomous mobile robots now moving inventory across distribution centers.

These platforms are compact, cost-sensitive, and built in volume. They also are increasingly involving battery chemistries, current levels, and duty cycles that wiring architectures were never designed for. This gap is where busbars play a critical role.

A quiet market with real volume

The low-speed vehicle (LSV) segment is not a niche. Global market estimates put low-speed vehicles at roughly \$10.4 billion in 2025, growing toward \$21.8 billion by 2035 at about 7.8% CAGR, with industrial utility vehicles being the largest single category at nearly 43% of 2025 value.

Material handling is on a parallel track. The electric forklift market was valued at roughly \$42.4 billion in 2025 with a projected 9.6% CAGR through 2032.

For component suppliers, the takeaway is straightforward: this is high-unit-volume OEM business with an electrical content curve that is bending upward.



Five trends changing the power path

- 1. Lithium is displacing lead-acid as the default.** Roughly 63% of new electric cart models are now reported with lithium packs, a trend that is being driven by both total cost of ownership, easy opportunity charging, and by energy density alone. Lithium packs discharge more slowly, accept higher charge rates, and can replace six loosely bolted lead-acid batteries with a smaller, structured module-and-interconnect architecture.
- 2. Voltage is climbing but still staying relatively low.** 48 V remains the practical center of gravity and is the highest nominal bus most designers will put in an operator-accessible vehicle without triggering full high-voltage engineering practice, since 60 V DC is the Safety Extra-Low Voltage (SELV) boundary under IEC/UL 62368-1. Some performance and utility platforms are pushing to 72 V and beyond. Therefore, these vehicles live in the awkward middle, where currents are high enough to demand traction-class conductors, but voltages are too low to reduce current through architecture alone.
- 3. Peak current, not average current, sets the design point.** A 5 kW motor on a 48 V bus draws over 100 A continuously and two to three times that at startup or on a grade. Regenerative braking sends that energy back through the same path and can spike bus voltage. Lift, tilt, and hydraulic functions on industrial trucks add short, peak current pulses on top of the traction load.
- 4. Accessory content is multiplying.** Lighting, heated seats, telematics, cameras, HVAC, onboard chargers, and DC-DC converters have turned a simple two-wire cart into a small distributed power network. In broader vehicle design, 48 V accessory architectures are being adopted specifically to shrink harnesses and reduce copper mass.
- 5. Regulation and safety expectations are tightening.** Street-legal low-speed vehicles must meet FMVSS 500 equipment requirements at speeds between 20 and 25 mph. Battery-powered industrial trucks fall under UL 583 for fire, shock, and explosion risk, and vehicle battery assemblies are addressed by UL 2580. Interconnect elements are explicitly in scope: cell interconnects are expected to survive vibration cycling without fracture, deformation, or electrical discontinuity.

Why cable harnesses are giving way to busbars

With 100 A to 600 A on a 48 V or 72 V bus, cable becomes the problem rather than the solution. Large-gauge cable is bulky, hard to route in a compact chassis, difficult to terminate consistently, and prone to voltage drop that a low-voltage system cannot absorb. Designers typically budget under 3% to 5% drop, and exceeding it forces either a voltage increase or a heavier conductor.

A properly engineered busbar replaces a cable harness with a defined, repeatable geometry: lower resistance per unit volume, better heat spreading, predictable assembly position, fewer connection points, and a part that installs the same way on every unit. Laminated construction goes further, reducing stray inductance and consolidating multi-conductor paths that would otherwise be a bundle of cables.

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What these vehicles require from a busbar

Ampacity sized for the real duty cycle

Design to continuous current with headroom for peaks. Typical copper current-density guidance is 2 to 4 A/mm² in still air, rising to 5 to 8 A/mm² only with forced-air or liquid cooling and validated thermal modeling. Hot warehouse environments erode margin further, where permissible current can drop 10% to 15% at 40 °C ambient.

Thermal behavior that protects the cells

Most battery busbar designs limit temperature rise to 30 to 50 °C above ambient under continuous load and keep the conductor below 90 °C to protect adjacent cells. In a sealed cart or a tightly packaged AMR, there is no airflow to rescue an undersized conductor.

The right material for the constraint

Copper delivers roughly 100% IACS conductivity; aluminum runs near 61% IACS and needs about 1.6× the cross-section to carry the same current. In space-constrained packs, copper usually wins. Where mass and cost dominate and space is available, aluminum can be the better system answer — provided the joint interfaces are managed properly.

Mechanical resilience under vibration and thermal cycling

Small vehicles operate on cart paths, dock plates, gravel, and expansion joints. Rigid interconnects that are perfectly adequate on a bench fail in service through weld fatigue, clamp loosening, and crack propagation. Practical countermeasures include expansion loops, controlled bend zones, and flexible laminated or braided links at module and chassis interfaces.

Joints and plating that hold contact resistance over years

The joint, not the bar, is where most failures originate. Vibration-induced micro-fretting, inconsistent torque, oxidized mating surfaces, and galvanic coupling between dissimilar metals all show up as localized hotspots and rising resistance. Plating selection is an engineering decision: tin is the practical default for low-voltage distribution below roughly 120 to 130 °C, nickel handles higher temperature and harsher chemistry, and silver is specified where contact resistance is critical.

Insulation, clearance, and operator safety

Even at 48 V, a 10,000 A prospective short-circuit current means an exposed conductor near a chassis member is a fire risk, not just a fault. Insulated busbars, molded covers, controlled creepage, clearance distances and integration of standoff insulators all help address what UL 583 and UL 2580 are designed to prevent, in vehicles that untrained operators service in the field.

Packaging, serviceability, and manufacturability

The busbar must fit the chassis, tolerate stack-up variation across a bolted assembly, install correctly by a line technician on the first attempt, and support inspection. Bend radii, hole placement relative to bends, realistic tolerances, clear datums, and formed-view documentation determine whether a design that works on screen becomes a part that builds consistently at volume.

Repeatability and documentation at OEM volume

These are high-unit-count programs. Material certifications, plating thickness records, dimensional inspection, and electrical test data are what make a busbar a controlled production part rather than a recurring warranty question.

How Storm Power Addresses These Requirements

Storm Power Components manufactures custom copper and aluminum busbars, flexible braided connectors, laminated busbars, and ground bars, with fabrication, electroplating, insulation, and testing performed in-house in Decatur, Tennessee. That combination maps directly onto what small-EV platforms need.

- **Material and geometry flexibility.**

Access to more than 1.5 million pounds of raw copper and aluminum inventory at mill-direct pricing supports the copper-versus-aluminum trade-off on system terms rather than on what happens to be available.

- **Rigid, flexible, and laminated in one supplier.**

Custom flexbraids are built to specified lengths, hole patterns, and ampacity requirements, the right answer at vibration-exposed module and chassis interfaces, while laminated busbars replace complex cable harnesses, reduce stray inductance, and improve thermal efficiency in tightly packaged power electronics.

- **In-house plating as an engineering choice.**

Tin, nickel, and silver finishes with both rack and barrel processing provide flexibility for plating that is tailored for joint stability, temperature, and corrosion environment, not for whatever an outside plater is running that week.

- **Validation before the field finds the problem.**

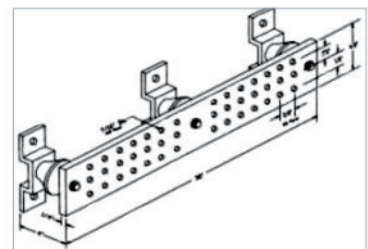
In-house HiPot, partial discharge, and ampacity testing let current rating and dielectric integrity be verified against the duty cycle rather than assumed.

- **Prototype through production.**

Prototyping and first-article capability, a 6,000-watt fiber laser that processes parts up to 20 feet with clean edge quality and no tool marks, and stock-and-release programs for high-volume OEM production support the full path from validation build to line-rate supply.

- **Quality systems that travel across markets.**

AS9100D and ISO 9001:2015 certification, ITAR registration, and HUBZone certification reflect process control developed for applications where failure is not tolerated — the same discipline applied to commercial mobility programs.



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Summary

Small electric vehicles are being asked to deliver more current, in less space, over longer service lives, in environments that punish poorly engineered connections. The conductor is no longer an afterthought at the end of the schematic; it is a structural, thermal, and safety component of the power system.

Storm Power's engineering team can review conductor material, cross-section, forming geometry, plating, insulation, and assembly requirements early in the design cycle; while changes are still inexpensive. Just bring Storm the drawing, the electrical requirements, and the operating environment, and we will help turn the electrical objective into a repeatable, production-ready busbar.

