Styled Steel Wheels for Electrified Vehicles Advantages

Louis Belli

MAXION WHEELS
a division of IOCHPE-MAXION

GREAT DESIGNS IN STEEL™

EVs Redefine the Importance of Wheels in NVH Performance

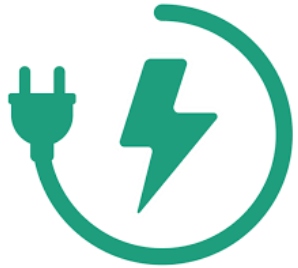
GDIS

ICE Vehicles - Dominant Noise Source:

- **Powertrain Noise**
  - Engine Combustion;
  - Transmission & auxiliaries;
  - Masks wheel-related noise.

EVs – Dominant Noise Source:

- **Road / Tire & Wheel Noise**
  - Quiet electric powertrain;
  - More sensitive to NVH;
  - Wheel design becomes critical.



EV NVH is driven by the wheel.

CO_2 Regulations Are Driving New Trade-offs in Vehicle Design

Global Context

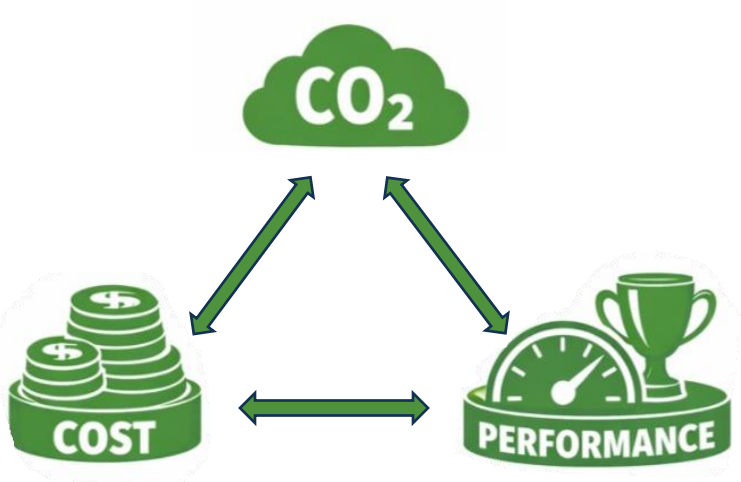
- Markets are becoming increasingly regulated regarding CO_2 emissions (e.g. Fit for 55 - EU / EPA GHG Standards – US);
- Sustainability targets are now embedded in product development decisions.

Engineering Impact

- Weight reduction remains a key lever for CO_2 compliance;
- Cost pressure increases alongside performance expectations;
- Design choices must balance **emissions, durability and total system cost.**

Implication

- Material selection now plays a central role in meeting regulatory and cost targets.



Material selection is no longer a detail – it is a strategic decision.

The Challenge for Steel Wheels in Electrified Vehicles

Current Perception of Steel Wheels

- Cost-driven & commodity component;
- Higher mass vs. alternatives;
- ICE-oriented legacy designs;
- Limited NVH & efficiency focus;
- Low association with EVs.

What EVs Demands from Wheels

- Low noise & vibration behavior;
- Weight reduction without durability compromise;
- Contribution to vehicle efficiency (range & aero);
- Lower CO_2 footprint & sustainability alignment;
- Increased demand for distinctive and modern designs.

Electrification redefines the value and relevance of wheel design.

Engineering Tasks to Meet EV Wheel Requirements

NVH-Driven Design

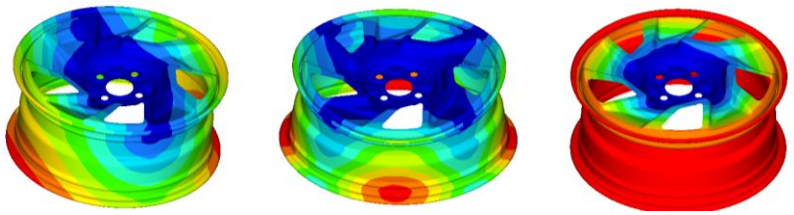
- Modal behavior optimization (natural frequency)
- Rim and disc geometry tuning;
- Interaction with tire and suspension system (entire system matters).

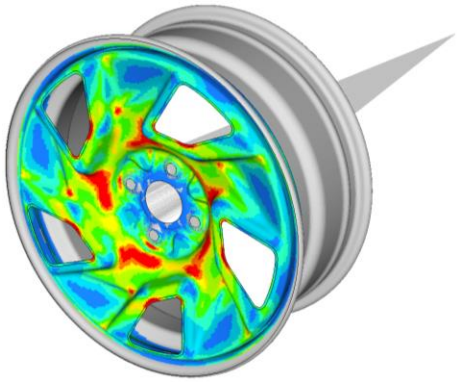
Lightweight Engineering

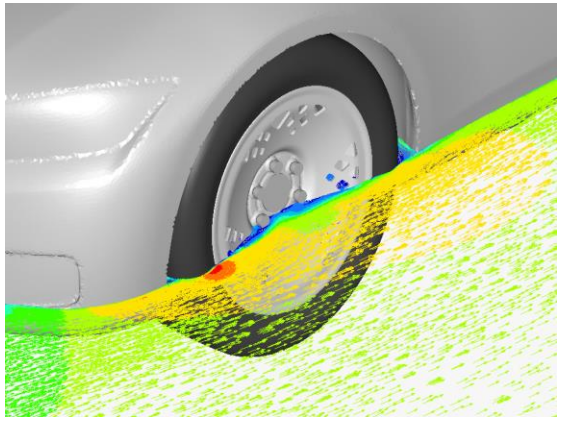
- High-strength steel application and trade-off analysis;
- ↑ stiffness, ↓ material gauging thickness;
- Mass vs. durability optimization iteration.

Vehicle Range Contribution

- Aerodynamic features integration;
- Unsprung mass reduction;
- Rolling resistance impact.



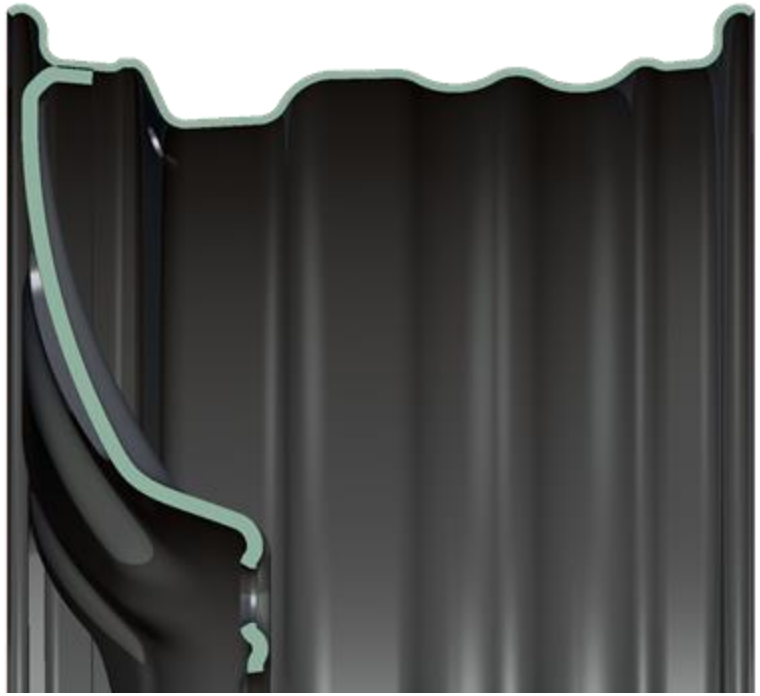




Steel wheels for EVs require a shift from cost-driven design to engineering-driven optimization.

Design Strategy for Next-Generation Steel Wheels

EV requirements push steel wheel design beyond legacy geometries.



*Patent protected - ® Maxion Wheels

Design Intent
- Focus on manufacturing feasibility;
- Customer design intent driven.

Geometric Optimization
- Topology and shape optimization;
- Material definition;
- Reach performance requirements.

NVH Tuning
- Identify critical bands (customer input)
- Mass and stiffness balance;
- Shift frequency modes.

Geometry is the primary NVH enabler.

Role of High-Strength Steels

Enabling Lightweight Steel Wheels for EVs

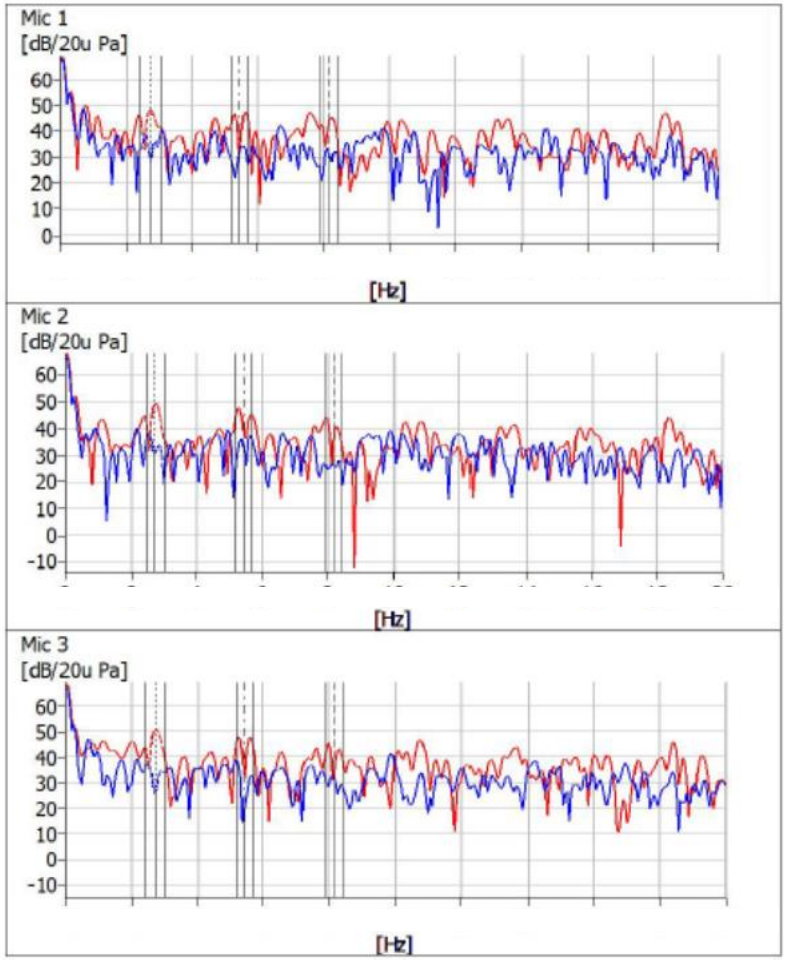
- Mass reduction through thinner sections and optimized geometries;
- Structural robustness under higher EV loads demands;
- Improved NVH behavior via increased stiffness-to-mass ratio;
- Key contributor to vehicle range, efficiency and CO_2 reduction.

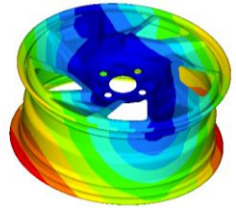
Low Carbon Steel	High Strength Steel	Advanced High-Strength Steel
• Stiffness →	• Stiffness →	• Stiffness →
• Thickness ↑	• Thickness ↓	• Thickness ↓↓
• Mass ↑	• Mass ↓	• Mass ↓↓

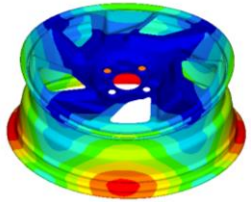
Material innovation elevates steel wheels to EV-ready solutions.

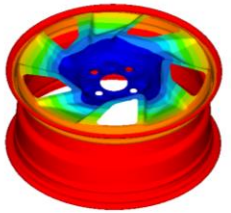
Modal Behavior Improvement

- Reduced mass combined with increased stiffness shifts natural frequency upward;
- Modal separation from excitation bands improves NVH robustness;
- Design focus moves from damping countermeasure to intrinsic NVH performance.





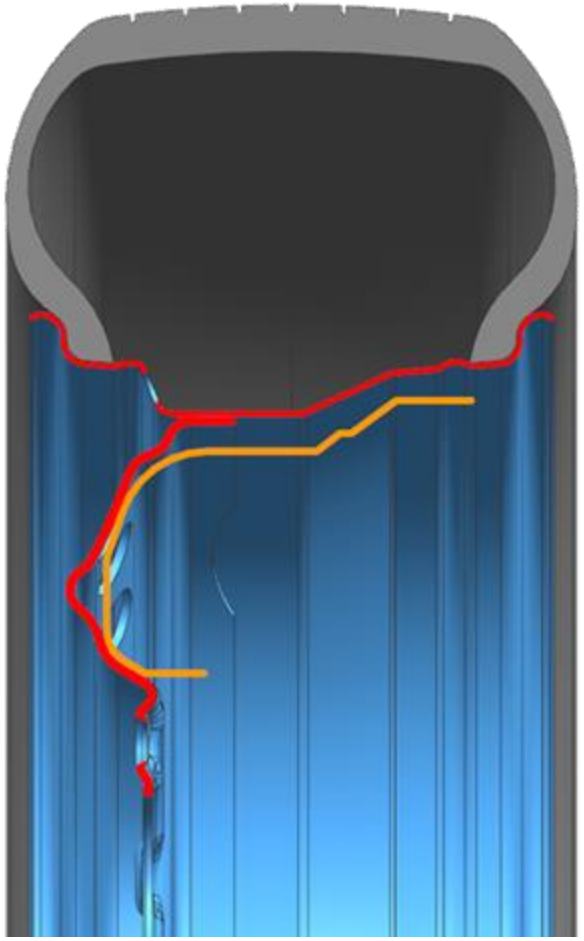




Moving wheel modes away from excitation bands is key for EV NVH performance

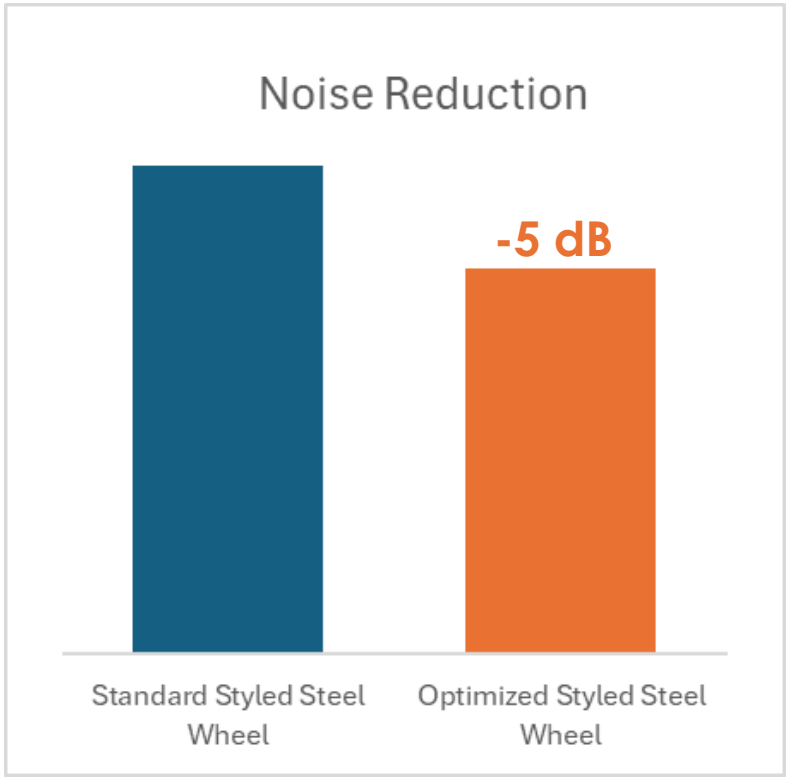
Tire Cavity Noise: A Critical NVH Band for EVs

- Tire cavity resonance typically occurs in the **150~200 Hz range**;
- This frequency band strongly influences **perceived road noise;**
- Absence of powertrain noise makes cavity noise **highly noticeable;**
- Wheel structural modes close to this band can **amplify interior noise.**



Avoiding wheel modes in the tire cavity noise band is critical for EV NVH performance.

NVH Performance Results: Optimized Steel Wheels



* 5 dB: Significant and perceptible sound level reduction;
** 10 dB: Perceived as approximately half the noise level.
Source: ABD Engineering & Design

- Field analysis highlights NVH performance across critical Frequency bands;
- Optimized steel wheels show up to 5 dB attenuation in the tire cavity noise range;
- NVH performance reaches parity – and in some cases advantage – versus aluminum wheels.

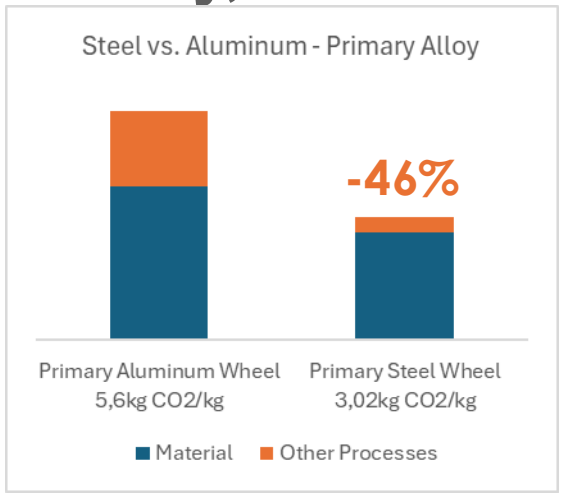
Optimized design enables high NVH performance.

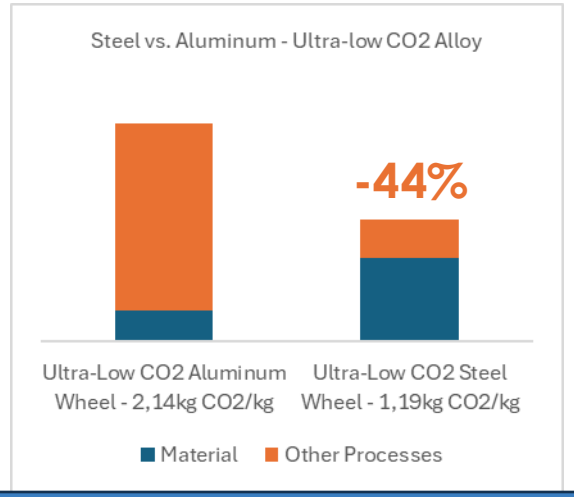
Life-Cycle Energy and CO_2 Perspective of Wheel Materials

Beyond Vehicle use-phase efficiency, material choice significantly impacts total life-cycle and CO2.

Aluminum Wheels

- High embodied energy due to primary aluminum production;
- Energy-intensive melting and recycling loops;
- Strong dependence on electricity mix.





Steel Wheels

- Lower embodied energy per kg compared to aluminum;
- Mature recycling infrastructure and high recycling rates;
- Further reduction potential with green steel pathways.

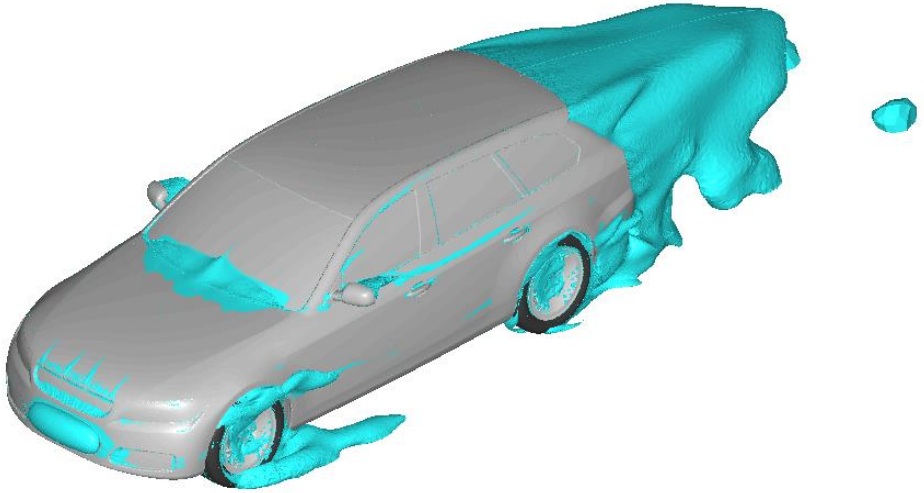
*Wheels produced at Maxion plants in 2023
**Calculated by LCA Studio Prague

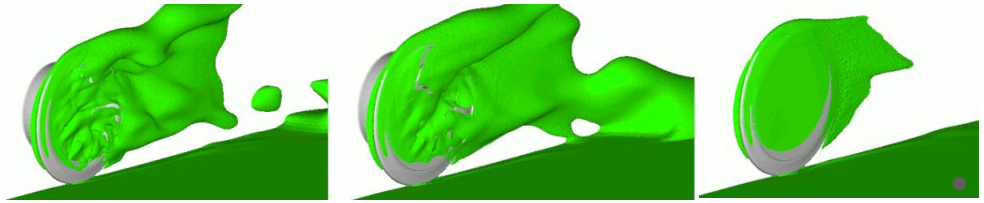
When NVH and range parity are achieved, embodied energy becomes a decisive differentiator.

Aerodynamic Wheel Design and EV Range Contribution

Aerodynamic Design Approach

- Introduction of aerodynamic surfaces and wheel covers/inserts;
- Reduction of airflow separation and turbulence around the wheel;
- Styling concepts compatible with steel wheel manufacturing





Performance Impact

CFD-based simulations: up to 18% drag force reduction (no cover) and up to 80% (full cover).

Benefit increases with Vehicle speed and duty cycle;

Do not change stiffness, NVH or durability

Aerodynamics adds a third efficiency lever to steel wheel optimization, alongside NVH and mass.

Styled Steel Wheels Deliver Balanced Value

When engineered beyond legacy constraints, steel wheels balance NVH performance, efficiency, sustainability, styling freedom and cost.

- NVH parity – and in specific cases advantage – versus aluminum
- Lightweight solutions enabled by geometry and high-strength steels
- EV range contribution via aerodynamic restyling
- Lower embodied energy and CO_2 potential at vehicle level
- Preserved cost competitiveness and manufacturing feasibility

Styled steel wheels evolve from commodity components to system-level enablers for New Energy vehicles.

Louis Belli

Product Engineering Supervisor – Maxion Wheels

Louis.Belli@maxionwheels.com

SCAN ME