The evolution of off-highway electric vehicles

TRANSITIONING FROM INTERNAL COMBUSTION ENGINES TO ELECTRIC MOTORS

With new innovation comes new challenge

The off-highway market's move towards electric vehicles is accelerating at pace.

But this seismic shift is not without its challenges.

So, how can the off-highway sector make a smooth transition from internal combustion engine (ICE) platforms to the new generation of electric motor (EM) equivalents?

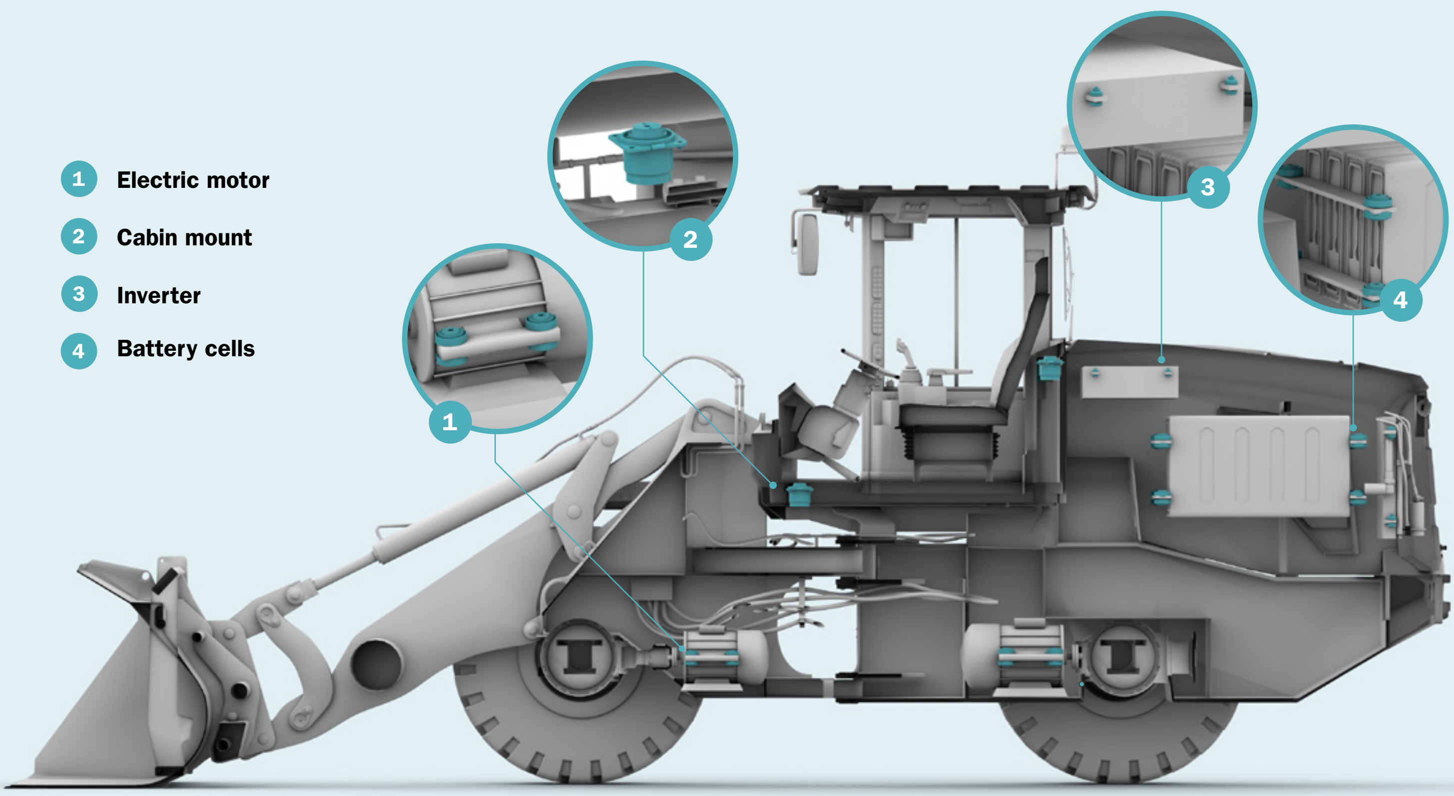
And how can we ensure that vehicle comfort, safety, longevity and performance levels are not only maintained, but improved?

The solution
Protecting performance with mounting excellence.

Electric off-highway vehicle challenges

- New isolation issues
- A new range of excitations
- A shift in perceivable vibrations

Mount examples on front wheel loader



Noise and vibration

Get your motor running

It would make sense to assume that once an ICE is eliminated from a vehicle, a reduction in noise and vibration results. However, this isn't necessarily the case.

Research shows that although off-highway ICEs and EMs function in very different ways, their operating speeds are actually quite similar, at around 0-7,000 RPM.*

But importantly, the delivery of torque at these low speeds is very different.

The speed at which an EM rotates is governed by the electrical frequency and signal supplied from the energy storage. Converters and inverters are used to switch the current type from AC to DC, and vice versa.

This process of inverting and converting has an unwanted byproduct – **structural vibration.**

The large amount of torque created by EMs can create extra movement in rubber mounts if they're not optimized to increase in load or force. An example of this is the phenomena of torque ripple.

Low-frequency movement and rumbles can be very **uncomfortable for vehicle operators.**

Equally, the high frequencies of electrical equipment vibrate or 'excite' other parts of the vehicle, emitting **hums and tonal noises** that range from 500 Hz to 15 kHz.

Structural vibration and high-frequency noise can be uncomfortable, frustrating and distracting for machine operators.

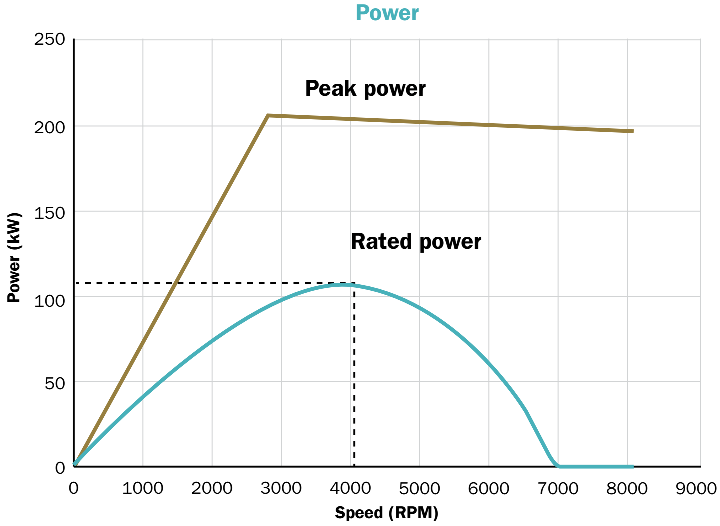
A simple but profound solution

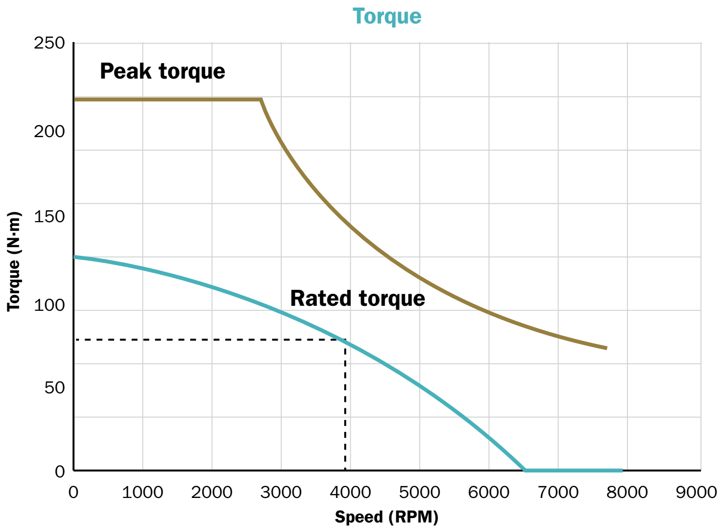
While the external excitations and transient loads may stay the same for an EV platform, the change in powertrain and ancillary equipment results in new structural stiffnesses, and shifts in natural frequencies.

Isolation of these frequencies is an important consideration when optimizing your EV platform. The use of rubber damped components will significantly contribute towards the creation of a market-leading vehicle.

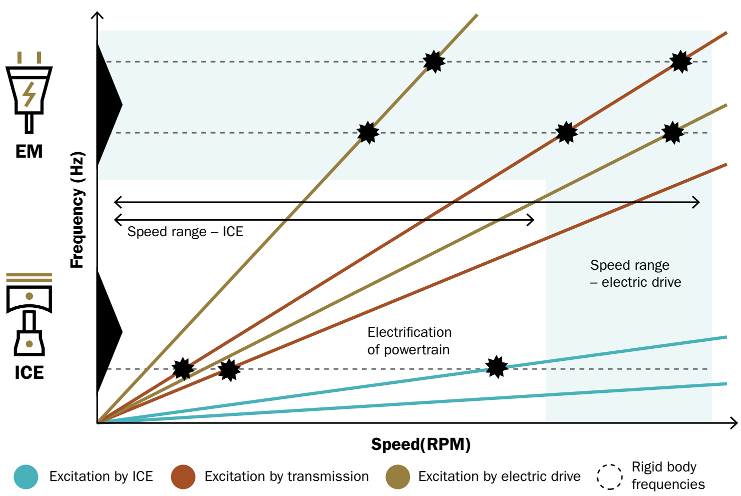
* Dependent on use case and connected gearboxes

Parker GVM310 electric motor, torque and power curves relative to RPM





Example relative distribution of orders between ICEs and EMs



Damage to ancillary equipment
Protecting your best assets

Removing the traditional ICE power source, and consequently adding a battery and electric motor has a knock-on effect on the setup of all other equipment on the electric vehicle. This might include inverter requirements, for example, or the replacement of electric hydraulic pumps.

Ancillary equipment will now need to be mounted in such a way as to minimize shock and vibration damage coming from external sources. Therefore, mount design, and the type of material used will play a vital role in future-proofing your investments.

Battery health and longevity
Powering progress

The effects of dynamic loads and vibrations on the batteries of electric vehicles are also significant.

A recent study* revealed that when off-highway EV batteries are tested to recognized industry standards** the majority experience degradation.

Importantly, even though the degradation is limited enough for the batteries to pass minimum requirements, the study also concludes that these **batteries will continue to deteriorate over time.**

Such vibrational fatigue tests highlight **a vital need for isolators,** in order to prolong the life of your batteries.

Research indicates that current lithium-ion battery testing standards are wide sweeping, and don't reflect the unique environmental forces faced by off-highway vehicles.

Standards and legislation
Tried. Tested. Trustworthy?

While there ***are*** standards for EVs, these tend to be less applicable to their off-highway counterparts.

What's more, standards seem to refer to the ways in which hardware is tested ***in isolation***, not once it's mounted onto vehicles. There is scant reference made to the effect that mounting (or lack of) has on components, and little consideration given to any form of vibration or shock isolation.

For example, equipment is often rigidly mounted to the vehicle chassis or sub-frame. But this can decrease longevity and efficiency. In contrast, mounting equipment correctly can extend and enhance its lifecycle, decrease vibration and ultimately increase the comfort of the operator.

Very few current testing standards reflect the environmental conditions faced by off-highway vehicle components **once in situ.**

* Hua, X. and Thomas, A. (2021), 'Effect of Dynamic Loads and Vibrations on Lithium-ion Batteries', Journal of Low Frequency Noise, Vibration and Active Control (Vol 40).
** The United Nations UN 38.3 T3 (vibration) and T4 (mechanical shock) testing standards.

So where do we go from here?

Our decades of experience in the ICE off-highway market have taught us there is no such thing as a one-size-fits-all solution.

And the same applies to EM platforms.

So it's important that manufacturers work with a partner that not only understands the market in which you operate, but one that will take the time to understand your organization's specific needs and requirements.

When creating the optimal solution for protecting against noise, vibration and harshness (NVH), make sure your provider considers the following:

- Equipment mass and centre of gravity (CoG)
- Mounting points/space envelope
- Operating speeds and engine frequencies
- Subsystem frequencies
- Environmental conditions (temperature and exposure)
- Bespoke isolator design.

The right solutions – whether motor, transmission, inverter, battery, cabin or HVAC mounts – delivered by a trusted and world-leading provider like Trelleborg, will prolong the life of your EV fleet, while significantly increasing productivity when on the job.

- Reduce noise, vibration and harshness
- Extend the lifetime of your vehicles
- Increase reliability
- Reduce downtime
- Provide enhanced operator safety and comfort
- Achieve environmental objectives
- Meet your business goals.

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