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From REEV to Hyper-REEV

- Enhancing the Driving Pleasure of Electrified Sports Cars -

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The electrification of road transport is advancing, particularly in regions with robust power grids and abundant charging stations, leading to an increase in battery electric vehicles (BEVs) among new registrations.

In areas with inadequate charging infrastructure, weak power grids, unfavorable climates, or specific user behaviors that hinder BEV usage, Range Extended Electric Vehicles (REEVs) offer a promising alternative. REEVs feature a smaller battery and an integrated combustion engine that charges the battery via a generator, allowing ranges exceeding 1,000 km without intermediate charging. Despite being powered solely by electricity, these vehicles are classified as series hybrid vehicles.

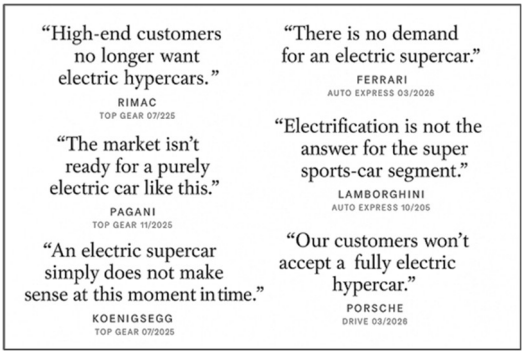

Fig. 1: *Summary statements from company representatives of various supercar OEMs regarding the relevance of BEVs in this segment*

While BEVs have gained acceptance in conventional passenger and light vehicle segments, the sports car and hypercar segments show different trends. Figure 1 presents statements from sports car manufacturers, highlighting potential buyers' reluctance towards electric super sports cars. Reasons for low acceptance include the lack of an emotional driving experience, perceived synthetic driving feel, poor value retention, and loss of brand identity for established manufacturers like Lamborghini and Ferrari.

Electric powertrains, with their higher efficiency, should gain importance in high-performance sports cars. The Hyper-REEV approach offers significant potential to boost acceptance of battery electric powertrains in the super and hypercar segment.

Integrating range extender powertrains in sports cars presents significant packaging challenges, as highlighted at the 47th International Vienna Motor Symposium. New vehicle platforms are primarily developed for electric vehicles, offering limited space for powertrain integration due to compact electric powertrains. This favors increased passenger compartment space with longer wheelbases and shorter overhangs. Sports cars, with their flat silhouettes and mid or rear-engine concepts, face even greater packaging challenges compared to standard passenger cars.

For REEVs derived from BEVs, the battery placement limits the height available for integrating an internal combustion engine (ICE). A potential solution involves integrating an inline engine with two to six cylinders in a horizontal or slightly tilted orientation (Figure 2). This requires adapting the oil circuit and cooling system to ensure proper lubrication and cooling without oil accumulation or stagnation. The wet sump lubrication system remains in use to optimize cost and space, with modifications to the oil pan and crankcase ventilation. Maintenance components like the oil filter are repositioned for accessibility. The new engine position allows for a compact exhaust layout and potential turbocharger space. The oil pump is integrated into the deeper oil pan, electrically driven, and protected by a filter screen. Adjustments to the cylinder head and gasket are feasible with existing production equipment.

Thermal management for REEVs based on BEVs requires comprehensive adjustments to accommodate additional cooling needs. A separate thermal management system for the combustion engine-generator unit, with an additional radiator, offers a simplified and cost-effective solution.

The genset unit for REEV applications integrates an electric machine, power electronics, and interfaces, optimized for high-power generator operation. The Interior Permanent Magnet Synchronous Machine (IPMSM) topology ensures superior torque and power density. Thermal regulation is achieved through a water-jacket cooling system, maintaining a compact profile for direct-drive integration. The electronic subsystem employs a consolidated control unit, maximizing cost-efficiency and spatial optimization. The inverter accommodates high-voltage, low-current regimes, employing compact modules for spatial optimization. Thermal management is achieved via a water-cooled heat sink system, ensuring electrical stability and noise suppression. All control and communication functionalities are managed by the integrated control unit, facilitating signal transmission through a dedicated interface.

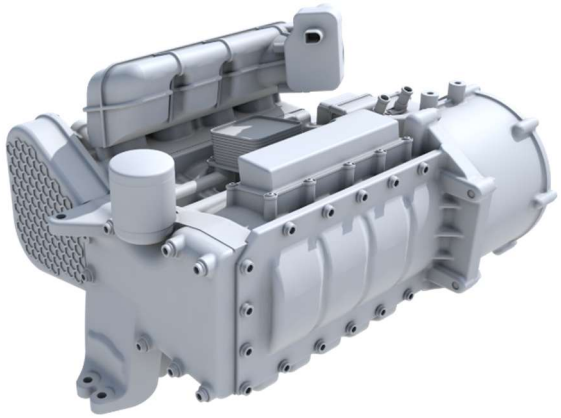

Fig. 2*: Horizontal positioned ICE, in this case derived from an inline 4-cylinder engine for standard vertical mounting in transversal orientation with the Genset*