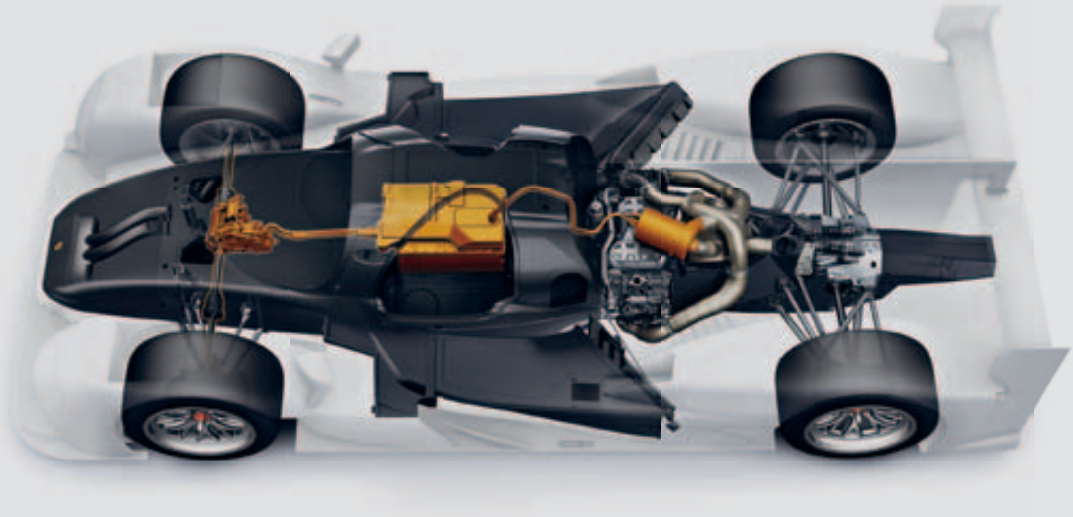
Battery Development for the 919 Hybrid

In the course of development activities for the return to Le Mans, Porsche opted to conduct battery development internally. Porsche Engineering has carried out a number of successful battery projects in recent years and took over the battery development for the new LMP1 race car—from the mechanical structure to the entire system control and testing.

By Michael Fürstner



Two recuperation systems make the 919 Hybrid a true Porsche. The exhaust energy recuperation enables charging of the liquid-cooled lithium-ion battery not only when braking, but also when accelerating.

The development of energy storage for the 919 Hybrid presented the engineers with various challenges:

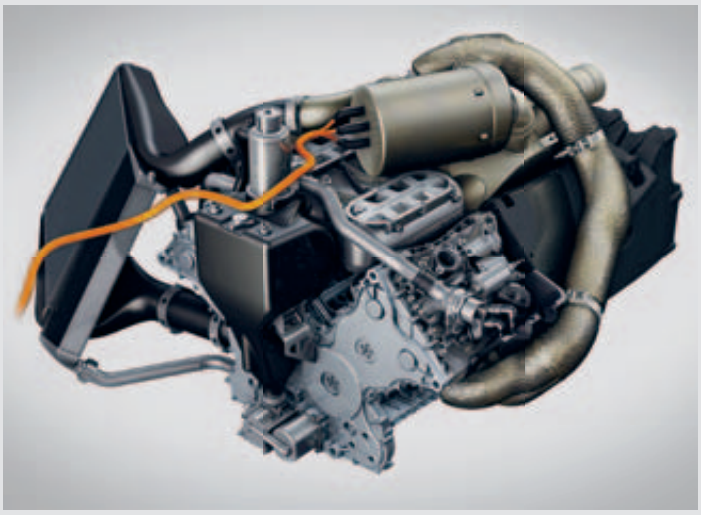
Weight problems and lack of space

Low system weight is always an important requirement and is therefore at the top of the priority list in motor racing as well. The very limited space within the vehicle also posed great challenges for the engineers. For safety reasons, the entire system is located next to the driver in the monocoque—in the crash-protected area with just millimeters separating it from neighboring components. It was therefore necessary to develop a highly compact, extremely small and lightweight battery without compromising electrical system performance. After all, the drive motor on the front axle of the LMP1 lays down 220 kW (300 hp) and naturally requires a sufficient and reliable power supply to perform its function.

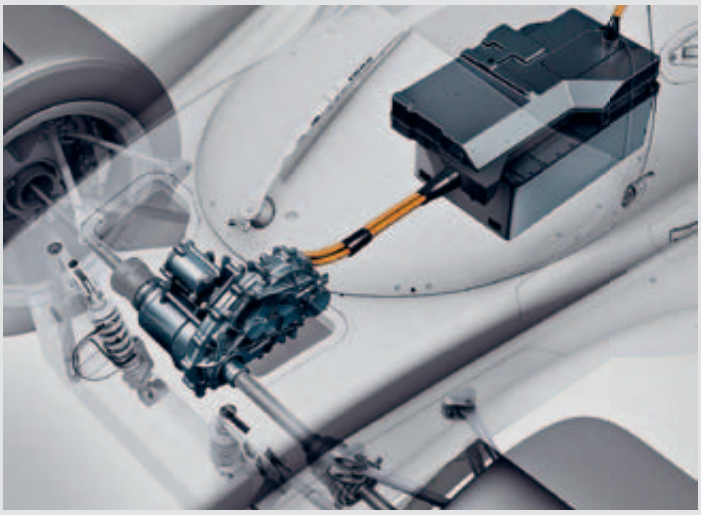
High voltage

The electrical energy is stored in lithium-ion cells from A123 Systems which were specially developed for this motor racing application and combined into compact modules using a special welding procedure. Each individual module has less than 60 volts. This modular construction is important not least for safety reasons when assembling the overall system since, in DC applications, the hazardous high-voltage range begins at 60 volts.

The overall system voltage of the 919 Hybrid is significantly above the 300–400 volts normally found in conventional electric vehicle applications. Higher voltages allow the load current-bearing components to have smaller diameters, which in turn results in lower weights. However, the components required for the development of the battery control were not immediately available from suppliers—the system voltages in this range are found in locomotives, for example, which for reasons of traction are designed with a high unit weight in mind. So all of the required components had to be individually developed and manufactured.



Performance and efficiency: a V4 with direct gasoline injection, turbocharging and exhaust recuperation system for the Porsche 919 Hybrid.



The single electric motor distributes its power as needed via a differential on both front wheels; the state-of-the-art battery energy control center is positioned in the center of the vehicle.

Durability

The cooling system is of major importance for the durability of the battery. In the 919 Hybrid, the Computational Fluid Dynamics (CFD) based fluid cooling system dissipates the waste heat so effectively that even at full throttle only very small temperature differences are detectable across the entire battery. The thermal and electrical loads on the individual cells in the system are evenly balanced, which has a positive effect on the durability of the battery as a whole.

Testing to the limit

The mechanical loads on every component in a race car are enormous. Due to the extreme total system drive forces of the current LMP1 hybrid cars and the all-wheel drive used in the 919 Hybrid, the vehicle accelerations before, during, and after every corner are at nearly Formula One levels due to the extreme grip. In terms of top speeds, the LMP1s are even a bit above that level, with top speeds of over 330 km/h achieved at this year's Le Mans.

While in operation, all components must withstand the vibrations passed on by the extremely rigid monocoque, including the vibrations from the drive motor and those caused by unevenness of the road surface. The curbs present in many corners have centimeters-high transverse grooves that rattle any car driving over them to the core. For this reason, the mount of the battery had to be designed to provide maximum damping for precisely these stresses while still taking up as little space as possible and weighing next-to-nothing.

To ensure functionality, the newly developed system was ultimately put on the test bench. There it had to withstand hours on the hydraulic shaker with maximum vibrations. In addition, in the course of the homologation process, the placement and fastening of the battery was checked and assured.

System control and monitoring

A significant component of the system is the integrated control unit. This includes various components, e.g. crash and current sensors, relay for switching off the system and individual components, resistors and interfaces for the power electronics, back-up and battery management system (BMS). The BMS monitors the entire battery system from the temperature and voltage values of the individual logical cells to the calculation of the charge level by means of special algorithms to evaluation of the crash sensor signals. ■