


# Technologies in a test of endurance

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**03/06/2015** The racetrack as a proving ground for new technologies that will be used in future street-legal sports cars. This philosophy is a firm part of Porsche's DNA.

Wolfgang Hatz, Member of the Porsche AG Executive Board, Research and Development, explains: "Whether it's lightweight design, aerodynamics, downsized turbocharged engines, hybrid concepts or extending the range of electric vehicles: All of these issues are extremely important for the future of Porsche — and we test new solutions for all of them in the 24 Hours of Le Mans race and in the six-hour races in the FIA World Endurance Championship."

This especially applies to the three Porsche 919 Hybrid models that are racing in the top category of the WEC, the Le Mans Prototype 1 (LMP1) class. However, the GT works team's two Porsche 911 RSR models also serve as test laboratories on wheels for future production vehicles. "Both racing cars are perfect examples of what we call Porsche Intelligent Performance," says Hatz. The first letters of those three words also adorn all five works cars that will compete in Le Mans.

## Revolution in top motorsport

The 2014 season saw the introduction of particularly advanced technology regulations for the LMP1 category limiting the amount of energy the works cars may use in each lap. All manufacturers must also utilise at least one hybrid system. However, the rules do not specify the type of hybrid system, the method for storing recovered energy, the engine design, displacement, and power transmission concept.

Engineers are thus given a great deal of creative freedom. Nevertheless, all solutions are subject to the basic radical principle behind these regulations, namely that the more energy is deployed from the energy recovery system, the less fuel may be burnt. It was this revolutionary concept that led Porsche to return to the world of top-class motorsport. “And what a sport it is,” says Hatz. “Despite the fact that the four manufacturers in the LMP1 category each utilised totally different concepts, only a few seconds separate the winner and those behind him after six hours of racing.”

## Efficiency for street-legal sports cars

Hatz calls the 919’s 2-litre V4 turbocharged petrol engine with an output of more than 500 hp “The most efficient engine Porsche has ever built. For the combustion chambers and port design, as well as for the camshaft drive and the direct injection system, we refined materials used in Formula 1. The 919 engine is a trailblazer in terms of fuel injection and internal friction.” The Porsche engineers also used high-strength materials from the aerospace industry. As for meeting the highest demands for both the racing circuit and the road, the crankshafts used with the engines in both the latest street-legal sports car, the 911 GT3 RS, and in the 919 Hybrid Le Mans prototype, are made of the same highly resilient material.

Porsche is pursuing a three-step approach with its motorsport activities: The first step focuses on research and development, the second on testing and the third on industrialising both materials and technologies for application in production cars. Hatz is providing an additional example by saying: “Our exclusive know-how as regards the development of downsized turbocharged engines is of elementary importance for Porsche. After all, nearly all the derivatives of our iconic 911 series will soon be equipped with turbocharged engines. ”

## Porsche offers three plug-in hybrid production models

And he continues: “We also plan to move ahead further with our hybrid activities. We are currently the only sports car manufacturer in the world that offers three plug-in hybrid production models: the Panamera S E-Hybrid, the Cayenne S E-Hybrid and the 918 Spyder. Our ability to develop and build the 919 Hybrid virtually on our own in Weissach also marked a major forward-looking milestone for production and motorsport development engineers.” The cycle is completed: The development project

for the 918 Spyder super sports car was able to benefit from the knowledge of experts who had worked on the 911 GT3 R Hybrid racing car, while the 918 development engineers, for their part, supported the development of the 919 LMP1 prototype – and now the first transfer of technology to series production is about to happen.

The 919 is the only car in the WEC utilising two different energy recovery systems. The first one is already being used in a similar form in the 918 Spyder. Here, a generator at the front axle converts kinetic energy into electricity during braking phases. The second system is new and uses an additional turbine generator unit in the exhaust system that works in parallel with the turbocharger, and converts energy from the exhaust-gas stream into electricity. Thus, the Porsche 919 Hybrid is the only car that recovers energy not only when it brakes but also when it accelerates. “We also plan to adapt the exhaust-gas energy recovery system for use in production vehicles,” says Hatz.

## Energy storage technology is shaping electric mobility

A limiting factor in hybrid and all-electric drive systems is the technology for storing the electrical energy. Flywheel storage devices (Audi, Nissan), ultracaps (electrochemical supercapacitors – Toyota) and lithium-ion batteries (Porsche) are currently used in the WEC. Each manufacturer chooses the storage method that best fits its selected hybrid system. Basically, it always comes down to balancing power density and energy density. The higher the power density of the storage unit, the more energy it can absorb and deliver in a short period of time. This is a crucial factor on the racetrack because a great amount of electricity needs to be generated in the recovery systems in the shortest possible time in every lap – for example, while braking.

Ultracaps and flywheel storage units have an advantage in this regard because they can absorb large amounts of energy extremely rapidly and also release the energy very quickly. However, batteries are also a legitimate storage alternative here, because their high energy density enables them to store more electric energy for a longer period of time and thus to deploy it in a flexible manner along the more than 13-kilometre lap in Le Mans. The energy stored by the battery in the 919 Hybrid can drive the front axle via the electric motor with an output of more than 400 hp in acceleration phases, and thus complement the turbocharged engine that powers the rear axle. In this manner, the 919 is temporarily an all-wheel-drive car.

Alexander Hitzinger, Technical Director LMP1, describes the progress in the development of the battery in the Porsche LMP1, which offers the best combination of the two basic requirements (rapid energy accumulation and release, and flexible storage of large amounts of energy): “We managed to enhance the power density of the lithium-ion battery in the 919 so far that it is now almost on a par with ultracaps, yet it offers a much higher energy density than the latter. Our battery can absorb and release a lot of energy quickly, but it’s also relatively light and has a very high storage capacity.” Porsche developed the liquid-cooled lithium-ion battery for the 919 Hybrid on its own. The tightly packed individual cells are very evenly cooled and are arranged in a way that dampens vibrations. Thus, they represent a development with great potential for future hybrid sports cars.

## Top-class eight-megajoule category

Of all the Le Mans participants, only Porsche has been able to make the leap into the highest energy recovery category. The 919 Hybrid, with its total system output of approximately 1,000 hp, is able to use eight megajoules of recovered energy per lap (13.629 kilometres) in Le Mans – but may only burn 4.76 litres per lap. In a normal race, the Porsche 919 Hybrid would generate up to 1,000 kilowatt-hours of electricity over a 24-hour period. With that amount of energy, the Volkswagen e-Golf – one of the most efficient electric vehicles in the compact segment – could travel more than 6,100 kilometres, which is more than the distance between Le Mans and New York.

Some engineers at Porsche work on both motorsport and production vehicle projects. They do not just exchange information but also "tangible" things on occasion – for example, when a 919 Hybrid front axle (including the KERS, the electric motor, and the battery) was installed for testing purposes in a 911 GT3 prototype long before the first Porsche LMP1 racing car was ready to roll. Other technical achievements, in turn, whetted the appetite of production vehicle developers. For example, the most modern driving simulator in the Volkswagen Group was installed in Weissach for the LMP1 programme. This is now being used by series development teams for driving dynamics tests and further research into hybrid system set-ups and strategies.

The resulting efficiency gains enable either lower energy consumption, even if the driving style remains the same, or a sportier driving style without increasing energy consumption. Of course, Porsche is always focussing on performance as well. The 919 Le Mans prototype's nearest relative – the 918 Spyder – offers a great example of this, as the 887-hp super sports car that consumes just three litres per 100 km and can drive emissions-free holds the lap record for the North Loop of the Nürburgring (6:57) – this, not despite its powerful hybrid drive, but because of it.

## Close together: 911 racers and production vehicles

Non-hybrid racing cars from Porsche have also led to pioneering advances with production models. A comparison of the aerodynamic features of the 911 RSR with those of its street-legal cousins reveals strong similarities in everything from the shape of the front spoiler lip to the design of the cooling-air ducts, the temperature-management system, the streamlined underbody and the two rear wings.

On top of that, the 911 GT3 RS is ten kilogrammes lighter than the 911 GT3. The engine and boot lids are made of carbon fibre, the rear window consists of a thin polycarbonate and additional lightweight components are made of alternative materials. Some of these components were tested in and then derived from the 911 RSR. The new magnesium roof for the GT3 RS is also based on an idea from motorsport to lower the location of centre of gravity. The new 12-volt lithium-ion lightweight battery in the GT3 RS, which replaces conventional and significantly heavier lead batteries, was basically taken also from motorsport.

Porsche and Le Mans have shared an appreciation of efficiency for quite a long time now. In Le Mans, special ranking lists known as the Index of Performance and the Index of Thermal Efficiency were kept – and Porsche came out on top in these efficiency rankings long before the first of the brand's 16 overall victories. Back in 1955, the Porsche 550 Spyder finished on top in the rankings for fuel economy. The 917 also captured awards for economy in 1970 and 1971, when it achieved overall victories in Le Mans. Between 2007 and 2011, the 911 GT3 remained undefeated in its class in terms of fuel efficiency and also won the Michelin Green X Challenge.

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