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## **Audi R18 e-tron quattro**

### **Comeback of quattro drive in motor sport**

**Audi's first big motor sport program in 1981 was based on the quattro permanent four-wheel drive. After numerous championship wins and the banning of four-wheel drive in FIA circuit-based racing series for the 1998 season, a model from Ingolstadt and Neckarsulm with four driven wheels now returns to the race tracks – the Audi R18 e-tron quattro.**

Four-wheel drive in an LMP1 sports car: Audi, in its 30 year plus motor sport history, once again makes a pioneering step as the brand with the four rings becomes the first automobile manufacturer ever to field a diesel hybrid at Le Mans. "To develop the hybrid technology for Le Mans is at least as ambitious and challenging as our diesel project was in its early stages," explains Head of Audi Motorsport Dr. Wolfgang Ullrich. "The first test results are very encouraging and we are intrigued to see just how this technology performs in combination with our ultra lightweight technology on the race track at Le Mans."

Background of the innovation is the interaction of two factors: promising technologies for environmental protection encounter new clarity in the regulations for Le Mans Prototypes. Since 1999, the 24 Hours of Le Mans has provided an excellent laboratory for testing new, production relevant technologies for Audi. Following the first Le Mans victory for gasoline direct injection TFSI (2001) and the first diesel triumph with TDI (2006), a hybrid car now makes its debut. To this end, the regulations are not only open for new power sources and energy recovery, but also allow the use of four-wheel drive in a Le Mans Prototype for the first time. The two technologies combine in a fascinating way to create a new type of drive – e-tron quattro. This in turn has direct reference to future production line products at Audi: the first experimental vehicles with the electric four-wheel drive e-tron quattro are already being tested with a view to possible high-volume production.

Kinetic energy is recovered on the front axle during the braking phase on the Audi R18 e-tron quattro. It is fed into an electric flywheel accumulator before being retrieved under acceleration. During this procedure only the front axle is integrated. The V6 TDI power plant producing over 375 kW (510 hp) still transfers its power to the rear wheels. The two systems complement one another to create the powertrain principle e-tron quattro, a new form of four-wheel drive which in turn hails a revolution – as did the permanent quattro four-wheel drive for automobile production from 1980 thanks to Audi and, from 1981, also gave motor sport a significant technological impulse that has worked for decades.



At that time Audi became the first manufacturer to successfully offer the permanent quattro four-wheel drive in high-performance cars and later in almost every model range. It also led to two Manufacturers' and two Drivers' World Championship titles in rallying. Four-wheel drive subsequently proved a sensation in circuit racing: quattro models set new benchmarks and won numerous races and championship titles in TRANS-AM and the IMSA GTO series in the USA, in the DTM and in super touring cars.

### **e-tron quattro: the next generation four-wheel drive**

More still: Audi initiated a concept shift. From the power transmission principle, previously reserved for all-terrain vehicles, Audi developed a highly efficient system incorporating many technical innovations for passenger cars and sports cars. The competition was also forced to follow the new trend – albeit several years behind. The same was valid in motor sport: since the quattro era, it is hard to imagine rallying without four-wheel drive as a characteristic feature. The competition repeatedly followed the direction set by Audi in circuit racing – but by no means with the same level of success. Three decades ago, quattro four-wheel drive distinguished itself through its particularly compact dimensions, the correspondingly small installation space required and by its high degree of efficiency.

The e-tron quattro is now the next generation four-wheel drive and motorsport once again plays a pioneering role. The new Audi R18 e-tron celebrates its race debut on May 5 in the 6-hour race at Spa-Francorchamps (Belgium). Audi Sport Team Joest fields two cars equipped with the innovative drive system in the 24 Hours of Le Mans on June 16/17. In parallel, for the 80th running of the world's most famous endurance race, Audi Sport Team Joest sends a pair of conventionally powered Audi R18 ultra prototypes to join the grid. With the exception of the hybrid system, they are absolutely identical to the R18 e-tron quattro. "As before, we still see potential in the conventional drive – just as our colleagues in production development do," says Head of Audi Motorsport Dr. Wolfgang Ullrich. "This is why we are absolutely delighted that the ACO and FIA selection committee has accepted our entries and that we can join the grid with four cars at the commemorative running of the Le Mans race."

Audi will also follow a two-pronged approach in the FIA World Endurance Championship this year by fielding both technologies. Both R18 versions share the ultra lightweight design and construction, which only made the use of additional hybrid components possible in the first place.



## **Audi R18 e-tron quattro**

### **Dawning of a new era**

**The Audi R18 e-tron quattro is the first Audi race car no longer accelerated exclusively by a combustion engine. With its partially electrified hybrid drive e-tron quattro, the prototype hails a new era in LMP1 sports cars.**

Revolution in 18 months: the project e-tron quattro for motor sport started in February 2010. Only 18 months passed from the initial conceptual ideas to the first test. "This is a relatively short cycle for a technology that has never been tested in motor sport and which still doesn't even exist in production," stresses Dr. Martin Mühlmeier, Head of Technology at Audi Sport.

The first big hurdle on the threshold of a new era was defining the concepts. As so often the case in the past, Audi also aims to play a pioneering role in this technology. With the R18 e-tron quattro "Vorsprung durch Technik" means the development of an independent hybrid system including complete networking, control, software, algorithms and interfaces. As in other areas Audi Sport also cooperates with external manufacturers during the manufacture of components for the hybrid system. Development partner for the accumulator is Williams WHP, for the Motor Generator Unit (MGU) long-standing technology partner Bosch.

Audi adopted a flywheel accumulator system since the requirements at Le Mans differ slightly to those in everyday life. "A high power density is crucial during energy recuperation," states Christopher Reinke, Technical Project Leader LMP. "The accumulator must be capable of absorbing a lot of energy within a few seconds during the braking stage."

The system integrated into the front axle is comprised of two drive shafts, the Motor Generator Unit including planetary gears, an electronic flywheel accumulator alongside the driver, an insulation monitoring unit for high voltage safety and the control system. The process of energy recuperation is explained relatively easily, the technical implementation is, in contrast, extremely challenging. The recuperation of energy occurs during braking. In the process, the wheels drive the MGU. The braking zones permitted are defined by the organizer. The Motor Generator Unit accelerates electrically a carbon-fiber flywheel, which runs in a high-vacuum. After the corner is taken and the driver accelerates again the system delivers the energy to the front axle. The regulations allow 500 kJ of energy to be transferred to the front wheels between two braking phases. The planetary gears adapt the transmission ratio during acceleration and braking. The two independently powered axles on the e-tron quattro are synchronized exclusively via electronic control strategies.



This control occurs automatically without driver intervention. The entire charging process (recuperation) is controlled by two parameters: the deceleration of the car, meaning the braking process, and subject to the accumulator's state of charge. The energy emission process (boost) is defined by the minimum speed of 120 km/h stipulated by the regulations, the race strategy selected, the throttle pedal movement and acceleration of the car.

### **The ideal compromise – a challenge**

“The greatest challenge was to find the ideal compromise,” reasons Wolfgang Appel, Head of Vehicle Development at Audi Sport. “It was a question of weight, performance, hybrid concept, regulation constraints and the packaging, which means perfectly balancing the distribution of all the components in such a way that no appreciable disadvantages arise in the conventional vehicle since both cars are absolutely identical, with the exception of the hybrid system, in design and construction.”

A warning lamp and sticker stipulated by the regulations are the only external differences between the R18 e-tron quattro and the R18 ultra. The driven front axle and the coolers are covered by the bodywork. Only an operating panel below the normal dashboard in the cockpit identifies the e-tron quattro. According to driver comments the additional front wheel drive is, however, clearly noticeable dynamically.

Audi Sport has worked on the e-tron quattro project since February 2010. Initial component tests were completed on board a road going R8 sports car in 2010. Circuit testing of the R18 e-tron quattro has been underway since the beginning of October 2011. The race debut follows on May 5 in the 6-hour race at Spa-Francorchamps (Belgium).



## **Audi R18 ultra**

### **ultra light evolution of a Le Mans winner**

**Audi takes a two-pronged approach this year in the 24 Hours of Le Mans and the newly created FIA World Endurance Championship (WEC) – the 2012 Audi R18 is available with and without hybrid drive. The trick: the base of both cars is completely identical, which is why the additional logistical effort is kept to a minimum for Audi Sport and the race team.**

When Audi Sport designed the R18 TDI for Le Mans 2011, the technicians already had the future electrification in the back of their minds. It was not foreseeable that the new, smaller power plants would be subject to further limitations by the regulations after their first season. From the very inception of project 'R18' Audi Sport focused on a compact 3.7 liter V6 TDI with innovative architecture and equipped with a mono-turbocharger. This specifically now pays dividends: the engine is very compact and plays its role in compensating for the hybrid system's additional weight. In spite of the latest restrictions imposed by the Automobile Club de l'Ouest (ACO) Audi Sport still extracts over 375 kW (510 hp) and a maximum torque exceeding 850 Nm from the power unit thanks to the efficiency of the overall concept.

At first sight the R18 ultra does not look much different to last year's Le Mans winning R18 TDI. However, under the guidance of Technical Director Dr. Martin Mühlmeier the Audi Sport engineers have done a great job and left hardly a single area of the car untouched. The result is a largely new LMP1 prototype – including a modified carbon-fiber monocoque, which continues to excel through its one-piece construction.

“To compensate for the weight, the subject of lightweight design and construction was the focus throughout the entire car,” says Christopher Reinke, Technical Project Leader LMP at Audi Sport. “We have systematically and logically pursued ultra lightweight design and construction without compromising the aspects of safety and reliability. The same applies to the monocoque just as it does for the engine, gearbox and other components.”

Almost every component in the V6 TDI engine was completely reworked and adapted to suit the new regulations, which targeted a reduction in engine power of around seven per cent, which was achieved in the form of a smaller engine air intake restrictor (45.8 instead of 47.4 mm diameter) and a reduction in the maximum the boost pressure from 3.0 to 2.8 bar. In addition, the fuel cell volume was reduced from 65 to 60 liters and even 58 liters for the diesel hybrid.



“The target was to compensate for this as best as possible, for example through the reengineering of the combustion process and the optimization of the gas exchange – and we are extremely satisfied with the result,” says Ulrich Baretzky, Head of Engine Development at Audi Sport. “We also succeeded in making a significant weight reduction so that our 3.7 liter V6 TDI is now lighter than the 3.6 liter V8 TFSI of ten years ago – and this for approximately the same engine power, substantially more torque and considerably less fuel consumption. This is remarkable progress when you consider that diesel engines are often regarded as being inherently heavier due to greater component load. This once again emphasizes Audi’s technical expertise.”

### **Innovation in the power transmission area**

There is a genuine innovation in the area of the transmission: a new carbon-fiber composite gearbox housing was developed for the R18 – a premiere in endurance racing. Innovative materials and manufacturing processes to reduce mass are also used in the suspension area. The electromechanical steering, which gives the drivers even more precise feedback, is completely new.

The extremely advanced aerodynamic configuration from 2011 was initially adapted to suit the new regulations, which stipulate openings above the wheel arches. Additionally, the product concept catalogue also specified a further significant reduction in aerodynamic drag despite the increased cooling requirements for the hybrid components. Vision out of the closed cockpit was also improved through detailed optimization in the area of windshield cleaning and the area illuminated by the full LED headlights.

Fundamentally, the hybrid drive results in a slightly longer front section which also has positive effects on the overall balance of the conventionally powered twin brother that more than lives up to its model name ‘R18 ultra’: it is the lightest Le Mans prototype that Audi Sport has ever built. Accordingly, the engineers can position the additional ballast weight exactly where it is required – even if both cars have exactly the same overall weight. The regulations for LMP1 cars stipulate 900 kilograms.

“The new R18 ultra is a distinct evolution of last year’s Le Mans race winning car,” summarizes Head of Audi Motorsport Dr. Wolfgang Ullrich. “Our drivers’ impressions were positive from the first moment. Without the weight optimized R18 ultra we would have not been capable of realizing the R18 e-tron quattro which is absolutely identical with the exception of the hybrid system.”



Just like its electrified twin brother, the conventionally powered R18 ultra makes its race debut on May 5 in the 6-hour race at Spa-Francorchamps (Belgium).

The way in which Audi Sport names its prototypes and projects also changes with the introduction of the 2012 models: the brand's future closed LMP1 sports cars will all carry the model designation 'R18'. This means, Audi Sport mimics road car production as the basic name of a car does not change with the model year.





## Technical data Audi R18 e-tron quattro / ultra (2012)

Version: February 2012

Model	Audi R18 e-tron quattro / ultra (2012)
<b>Vehicle</b>	
Vehicle type	Le Mans Prototype (LMP1)
Monocoque	Carbon-fiber composite with aluminum honeycomb, tested according to the strict FIA crash and safety standards
Battery	Lithium ion batteries
<b>Engine</b>	
Engine	Turbocharged 120° V6, 4 valves per cylinder, DOHC, 1 Garrett turbocharger, mandatory intake air restrictor of 1 x 45.8 mm diameter and turbo boost pressure limited to 2.8 bar absolute, diesel direct injection TDI Fully stressed aluminum cylinder block, diesel particle filter
Engine management	Bosch MS24
Engine lubrication	Dry sump, Castrol
Displacement	3,700 cc
Power	Over 375 kW / 510 hp
Torque	Over 850 Nm
<b>Hybrid system*</b>	
Type of accumulator	Electric flywheel accumulator, max 500 KJ, WHP
Motor Generator Unit (MGU)	MGU on the front axle, water cooled with integrated power electronics, 2 x 75 kW
<b>Drive / transmission</b>	
Type of drive	Rear wheel drive, traction control (ASR), four-wheel drive e-tron quattro from 120 km/h*
Clutch	Carbon clutch
Gearbox	Sequential, electrically activated 6-speed racing gearbox
Differential	Limited-slip rear differential
Gearbox housing	Carbon-fiber composite with titanium inserts
Driveshafts	Constant velocity sliding tripod universal joints
<b>Suspension / steering / brakes</b>	
Steering	Electrical assisted rack and pinion steering
Suspension	Front and rear double wishbone independent suspension, front pushrod system and rear pull rod system with adjustable dampers
Brakes	Hydraulic dual circuit brake system, monobloc light alloy brake calipers, ventilated carbon disc brakes front and rear, infinitely manually adjustable front and rear brake balance
Wheels	O.Z. magnesium forged wheels
Tires	Michelin Radial, Front: 360/710-18, rear: 370/710-18
<b>Weight / dimensions</b>	
Length	4,650 mm
Width	2,000 mm
Height	1,030 mm
Minimum weight	900 kg
Fuel tank capacity	58*/60 liters

\*Different specification for R18 e-tron quattro



## quattro history in motor sport

### **With four-wheel drive to the fore**

**Audi has been writing motor sport history for 31 years. A revolution heralded the beginning: Audi made four-wheel drive perfect for motor sport use for the market launch of the quattro sports car model range. A look back over the most important chapters.**

With the advent of the high-performance quattro sports car a new era quite literally imposed itself in rallying: the winner's advantage was not measured in seconds, but in fact in minutes. The Audi quattro makes its debut in the hands of Franz Wittmann/Dr. Kurt Nestinger in the Jänner Rally in 1981, a round of the European Rally Championship, and wins by 20 minutes and 50 seconds. Audi also celebrates its first victory in a World Championship rally four weeks later in Sweden: Hannu Mikkola/Arne Hertz beat their closest rivals by 1 minute 53 seconds.

These first trophies for the relative production based Audi quattro signal the beginning of a success story. As early as 1982 Audi wins the Manufacturers' Championship in the World Rally Championship. Michèle Mouton/Fabrizia Pons make quite a splash: the Audi factory drivers celebrate three overall victories in Portugal, Greece and Brazil and fight for the World Championship crown to the end before clinching runner-up spot in the Drivers' Championship.

Twelve months later Audi is also able to celebrate victory in the Drivers' World Championship: Hannu Mikkola/Arne Hertz are named Rally World Champions in 1983. Audi concludes its most successful rallying season in 1984 with two titles: Stig Blomqvist/Björn Cederberg win the Drivers' Championship and Audi the Manufacturers' Championship in the WRC.

Time for new impetus: Audi also aims high with the quattro in the all important US market. Storming up the summit during the Pikes Peak hillclimb proves to be a sensation: Audi scores a hat-trick between 1985 and 1987 in Colorado with Michèle Mouton, Bobby Unser and Walter Röhrl at the wheel of different versions of the Audi Sport quattro. In the sporadically contested World Rally Championship the final victory conquers a previously barren hunting ground: Hannu Mikkola/Arne Hertz win the 4,600 kilometer long Safari Rally through East Africa in April 1987 with a production based Audi 200 quattro.

The next task in the USA is even more difficult: in the 1988 TRANS-AM Series the Audi 200 quattro should also demonstrate its superiority in circuit racing. American Hurley Haywood wins the series at the first attempt. A year later the Audi also makes a strong impression in the IMSA



GTO Series with the 90 quattro: seven race wins, including five one-two finishes, are the reward. Producing almost 530 kW (720 hp) the IMSA Audi is the most powerful quattro ever.

Soon after, the German fans finally get to see quattro four-wheel drive on the race tracks: the Audi V8 quattro cleans up big time on its DTM debut. The touring car series, already very popular at this time, is won at the first attempt in 1990 by Hans-Joachim Stuck. In the following season budding talent Frank Biela repeats last year's success at the wheel of the V8 quattro. Never before has a manufacturer fielded the champion two years in succession.

### **Audi's know-how advantage**

To conclude, quattro four-wheel drive confronts the toughest proof of its competitiveness: the concept was extremely useful along rallying's natural tracks and in high-performance cars on the race tracks, but super touring cars with not even 220 kW (300 hp) pose completely other demands from 1993. Pure traction alone does not suffice with these relatively low powered engines. Some competitors who also back four-wheel drive learn the hard way. Efficiency from Ingolstadt is the key: the original quattro concept of a hollow shaft gearbox without separate drives represents low frictional losses, compact installation space, low weight and corresponding maximum efficiency. The results are crowned by seven championship titles in the 1996 season. The national championships in Australia, Belgium, Germany, Great Britain, Italy, Spain and South Africa go to the Audi A4 quattro. In addition, Frank Biela wins the Touring Car GP in Macau. Other manufacturers also join the four-wheel drive fraternity in super touring cars but are not successful – Audi's know-how advantage is simply too great.

After the 1996 winning streak racing touring cars with four-wheel drive are classified significantly worse by the regulations. From 1998 the FIA prohibits such systems completely. In privateer hands, such as in the American SPEED series, the S4 and also the S6 continue to demonstrate their abilities years after.

Even though the ban is hard, Audi continuously optimizes the four-wheel drive for its customers. Motorsport and production repeatedly benefit from the technological findings each department makes. For instance, Audi tests the self-locking Torsen differential for the first time in 1985 in the rally Sport quattro model. Audi customers also profit from the design's safety benefits in regular road traffic since 1987. It enables the engineers to combine the ABS system with quattro permanent four-wheel drive for the first time.

With the Audi R18 e-tron quattro, a factory entered Audi equipped with four-wheel drive returns to motor sport for the first time since 1997. In this case, for the first time the front and rear axles are



not connected mechanically via a conventional transmission. In reality the drive occurs on one axle – with the R18 e-tron quattro on the rear axle – through the combustion engine. The energy recuperated electrically during the braking phase is only fed through the front axle. Similar concepts are also gaining importance in production: first studies like the e-tron Spyder reveal a comparable load distribution between the front and rear axles even though the recuperation strategy for road traffic is different. In addition, with the A5 e-tron a production based prototype is already running in the experimental stage under extreme conditions. It prepares the future of electrified four-wheel drive at Audi. Fascinating possibilities of new dynamics in handling open up through targeted torque input.

### **A new path for sporting dynamic and efficiency**

Audi e-tron quattro signals the arrival of the next generation four-wheel drive: the partially electrified four-wheel drive combines sporting dynamic and efficiency in a new, fascinating manner – in both racing and production. One axle is driven by a combustion engine or a hybrid system comprised of a combustion engine and electric motor, the second axle by electric.

In turn, for the future many possibilities open for synergies between motorsport and production – as is the case since 1980 as Audi customers have very clearly benefited from the motorsport successes of quattro four-wheel drive.



**Interview with Head of Audi Motorsport Dr. Wolfgang Ullrich**

## **“The diesel hybrid is particularly interesting”**

**Dr. Wolfgang Ullrich (61) has been Head of Audi Sport since November 1993. Under his guidance Audi dominated the super touring car scene in the 1990s and has since won the 24 Hours of Le Mans ten times.**

**Dr. Ullrich, for the first time an Audi race car is no longer powered exclusively by a combustion engine. Are we standing on the threshold of a new era?**

It's clear that here at Audi Sport we are dealing with a completely new subject: the electrification of the drive, an issue in which our colleagues from production are also totally absorbed. In this respect a new era has in fact started – and as always Audi is involved as pioneer from day one and, as a result, is trendsetter.

**Audi last appeared at Le Mans with two different concepts in 1999. At that time it was primarily a question of the bodywork, today the drive. Why the decision to bring two types of car to the grid in 2012?**

Quite simply, the TDI engine invented by Audi is still the most efficient drive in the world. We've also proved this at Le Mans since 2006. It's not a coincidence that turbo diesel engines are unbeaten there for six years now, even though the diesel cars were repeatedly limited. We are convinced that the TDI has even more potential. This is why Audi not only supports the hybrid in motorsport and production, but in parallel also the further development of the conventional drive. The combination of TDI and hybrid is, however, without doubt particularly interesting and very promising. This is exactly what the new Audi R18 e-tron quattro stands for.

**The R18 e-tron quattro is only at the beginning of its development. In your view how much potential is combined with the energy recuperation?**

The potential is certainly very big, since the entire subject of hybrid is still in its infancy. There are many obstacles, the weight of an energy storage system suitable for mass production for example. At the moment we still benefit enormously from the groundwork done by our colleagues in the production advance development, who have been studying the subject for a little longer. However, in this case I also think that motorsport can accelerate development of a new technology. Over the last few months many good ideas have already emerged, which we want to implement in the future.



**Motor sport was never a means to an end for Audi, but rather always served the technical development of its product range. What contribution will the R18 e-tron quattro be able to make?**

That is correct. Audi has always consciously selected championships and categories in racing that have a close relationship to production and therefore have technical relevance for Audi customers. quattro, TFSI and TDI are three excellent examples of how motor sport has stimulated production development. A similar tendency is apparent with the e-tron quattro: we test a completely new technology on the race track before it's introduced to the Audi production line. Efficiency and lightweight design and construction are particularly important in motor sport. It's exactly this aspect of a hybrid vehicle that provides so much development potential, where one or the other point could possibly be exploited a bit faster due to our Le Mans involvement.

**Progress must also be welcomed – and from those who draft the regulations. What chances and risks does the current classification of the R18 e-tron contain?**

The ACO and FIA are faced with a very difficult task here. The more different technologies there are in the game the more difficult it becomes to correlate them all. The biggest problem is that the Audi and Peugeot diesel cars were in a class of their own over the last few years – and not just because the TDI is the world's most efficient engine, but also because no other competitor developed an LMP1 car with a gasoline engine to a similar level of detail and know-how. For this reason the diesel was trimmed again for the 2012 season, so that from our point of view the diesel is now at a real disadvantage on paper. We are, however, prepared to face this challenge and are convinced that the ACO and FIA will make the right decisions for the future. As far as the hybrid issue is concerned we can easily assess the pros and cons through our two-pronged approach, since the base of the R18 ultra and R18 e-tron quattro really is identical. The hybrid system alone makes the difference. The ACO and FIA will receive particularly meaningful data from us.



## Hybrid and e-tron

### The future at Audi started a long time ago

**Audi is working under high pressure on holistic solutions for CO<sub>2</sub> neutral mobility of the future. The brand is developing a broad portfolio of hybrid and electric vehicles. This year, the model range already offers three hybrid vehicles and a high-performance sports car.**

The requirements of the customers keep developing very differently on the global markets. To offer everyone the right solution, Audi is working on a wide variety of technology concepts. Each of them is tailored precisely to its purpose – from a compact electric vehicle with range extender for the city traffic to the hybrid car for long distances, which is already on sale.

Audi differentiates between two groups of vehicles for electromobility. Full hybrid vehicles belong to the first. With their high-performance batteries they cover a distance of various kilometers electrically. All other concepts use a high-energy battery for greater distances. In this case it is a question of plug-in hybrids, range extender vehicles and pure electric vehicles. Audi calls them 'e-tron'.

The brand with the four rings looks back to more than 20 years of experience in hybrid technology. In 1989 the technology concept car Audi duo made its debut with a combination of gasoline engine and switchable electric motor. Another test vehicle followed two years later. In 1997, Audi produced the Audi duo, based on the A4 Avant, in low quantities – the first-ever European hybrid car. It was already designed as a plug-in hybrid and was powered by a 1.9 liter TDI engine with 66 kW (90 hp) and an electric motor producing further 21 kW (29 hp).

In November 2011, Audi introduced its first series production hybrid model, the Q5 hybrid quattro. Its 2.0 liter TFSI engine and the electric motor produce a total of 180 kW (245 PS) system power and very sporty driving performance. The consumption is on average less than seven liters per 100 kilometers. Over the next few months, the Audi A6 hybrid and the A8 hybrid will arrive on the streets. They use the same parallel hybrid concept as the performance SUV while having front-wheel drive.

The next step will be Audi's plug-in hybrid cars like the technology study Audi A3 e-tron concept. Its 1.4 TFSI delivers 155 kW (211 hp), the electric motor adds 20 kW (27 hp), both driving the front wheels. With a power capacity of 12 kWh the lithium-ion battery provides an electrical range of about 50 kilometers.



The Audi e-tron Spyder presents another technical alternative. Its 3.0 liter TDI rear-engine drives the rear wheels with 221 kW (300 hp), two electric motors with a total of 64 kW (87 hp) act on the front wheels. The concept of dividing the forces of the combustion engine and the additional drive to the axles, has great potential: the LMP1 prototype R18 e-tron quattro follows this as well as the e-tron quattro study based on the Audi A5. The 2.0 TFSI engine in the front of this car is supplemented by two electric motors – one for the front axle, the other for the rear axle.

The e-tron A1, which is currently completing a fleet trial in Munich, is again a very unique way – as an electric car with range extender it is a specialist for urban areas. Its e-machine sends up to 75 kW (102 hp) to the front wheels. An ultra-compact rotary rear-engine with 15 kW (20 hp) allows cross-country tours by recharging the battery.

The high-performance sports car R8 e-tron, which was presented for the first time at the 2009 IAA 2009 in Frankfurt am Main, however gets its 230 kW (313 PS) exclusively from strong electric motors and a large lithium-ion battery that stores 53 kWh of energy. Audi will introduce the two-seater at the end of the year in a small series for the road. With the technology study Q5 HFC the brand finally investigates the potential of fuel cell propulsion.





## **Audi at Le Mans**

### **Ten victories in record time**

**No other manufacturer has won the 24 Hours of Le Mans so often in such a short space of time after its debut. The classic on the Sarthe has been staged since 1923. Audi has competed with great success since 1999.**

Audi is in the fast lane: the Le Mans winner presents itself with an outstanding sporting record to coincide with the 80th running of the endurance classic. Between 2000 and 2011 the Audi Sport team from Ingolstadt and Neckarsulm has accepted the winners' trophy ten times. With 13 starts since 1999 this results in a victory rate of almost 77 per cent. More still: no other manufacturer has posted such an impressive series directly after its Le Mans debut. In the all-time winners' list Audi has overhauled Ferrari and now stands alone in second position.

The figures are even more remarkable if the year 2003 is included: at that time the group brand Bentley won. The drivetrain technology in the British sports car was co-developed by Audi Sport. As a result, the engineers from Ingolstadt and Neckarsulm have contributed to eleven victories so far.

The roots for the Le Mans project are established in the brand's genes: whoever claims 'Vorsprung durch Technik' must also prove it – with its products in sport. Audi therefore uses motorsport since the inception of the rally project in 1980 to test technologies for the benefit of the end user.

The Le Mans project started when there was nothing more to prove for the Audi's most successful invention: the permanent four-wheel drive quattro had won everything from the World Rally Championship via the DTM to TRANS-AM and numerous super touring car championships. When the FIA, Fédération Internationale de l'Automobile, generally banned four driven wheels in circuit racing at the end of 1997, Audi found a new challenge in the shape of Le Mans.

Several decisive advantages make the endurance race attractive: the winner completes a distance of more than 5,000 kilometers. 24 hours are required for this at Le Mans. In Formula 1 this distance is distributed over almost an entire year. Second advantage: the endurance racing regulations are open enough to allow the most diverse technical concepts. Open or closed sportscars, Otto or diesel engines with or without energy recuperation, two or even four driven wheels are not only theoretically possible, but are used in practice.



Audi won a trophy on its debut in a strong field of starters. An Audi R8R finished third first time out in 1999. A year later Audi was able to celebrate overall victory for the first time. The newly developed Audi R8 claimed a one-two-three finish on its debut.

### **Greater range with less fuel**

Audi set the next milestone in 2001. The victorious R8 was equipped for the first time with a TFSI engine with gasoline direct injection. Its advantages: excellent power modulation, especially in the rain, and particularly economical use of fuel. In this way Audi went further on a single tank of fuel than any other competitor. Although the trophy was conceived as challenge cup Audi was able to keep it for the first time after Frank Biela/Tom Kristensen/Emanuele Pirro claimed a third consecutive victory with Audi Sport Team Joest.

In 2004 and 2005 win numbers four and five followed for the R8 sports prototype. During this time the rules turned against it: its engine power was systematically reduced by a total of 74 kW (100 hp), its rear wing also became smaller and smaller. Tom Kristensen was at the wheel of the R8 for all of its five victories. The Dane is lonely record holder at Le Mans with no less than eight overall victories.

The 2006 season remains a special chapter in the history books: a diesel sports car won for the first time on the Sarthe. The Audi R10 TDI of Frank Biela/Emanuele Pirro/Marco Werner was not only in front on the premiere. After another victory in the following year, Dindo Capello/Tom Kristensen/Allan McNish scooped the TDI hat-trick in 2008. In 2010 the historians leafed frantically through the history books: when the R15 TDI driven by Timo Bernhard/Romain Dumas/Mike Rockenfeller triumphed Audi had exceeded the 39 year old distance record by 75.4 kilometers. With Audi ultra lightweight technology, a compact and highly efficient V6 TDI power plant and many other innovations Marcel Fässler/André Lotterer/Benoît Tréluyer recorded Audi's tenth victory last year with the R18 TDI.



## **Audi in the WEC**

### **Worldwide challenge for Audi**

**Audi competes in a World Championship for the first time since 1987. Prototype racing has found a new home in the FIA World Endurance Championship (WEC).**

A gap was closed when the FIA, Fédération Internationale de l'Automobile, and the Le Mans organizer Automobile Club de l'Ouest (ACO) presented the World Endurance Championship during the 24 Hours of Le Mans week in 2011. "It took a long time before sports cars – one of the most technically challenging categories in motor sport – found this home," says head of Audi Motorsport Dr. Wolfgang Ullrich. "At Audi we have been of the opinion for a long time now that the Le Mans Prototypes deserved a World Championship, which reflects this important class of car." The cooperation of two important organizations accompanied the announcement: the FIA organizes the championship, while the ACO takes over also the marketing.

#### **Calendar covers most important markets**

The calendar includes the important regions worldwide: in Europe the sports cars compete at Silverstone (GB) and Spa (B) on two traditional race tracks. The 24 Hours of Le Mans in France is, as the world's most important endurance race, the championship's jewel in the crown. With Sebring (USA) and Interlagos (BR) the series shows its colors in the North and South American markets. In the Middle East the WEC stops in Bahrain. Asia is even represented three times on the calendar: Fuji in Japan and Shanghai on the Chinese mainland conclude the season in October. With regards to sales China is now the most important single market for Audi.

#### **Diverse race formats, attractive class structure**

Six, twelve and 24 hours – these are the race distances in the World Endurance Championship. As a result, the two traditional events – 12 hours of Sebring and 24 Hours of Le Mans – retain their typical character, while the remaining races are staged over a common distance. On top of this comes a special highlight to Le Mans: at the test day two weeks before the 24-hour race fans get to see the latest generation of prototypes at the Sarthe for the first time. While the LMP1 prototypes like the Audi race car fight for dedicated driver and manufacturer titles, the smaller prototype class LMP2 as well as GTE cars are also admitted. They also compete in their own classification. The organizers reserve the right to admit additional vehicle categories if innovative technologies are used in them. However, these models are not eligible to score points.



### **Point system brings excitement to the championship**

Points are awarded in line with an essentially well established pattern, with exceptions however: As in other FIA championships points are awarded as follows to the first ten finishers – 25-18-15-12-10-8-6-4-2-1. All other cars classified at the finish receive half a point. Double points are awarded for the 24 Hours of Le Mans. Another point is awarded for the pole sitter in every class. This is awarded to the manufacturer recording the fastest time and each of the drivers entered in the car. In the manufacturers classification only the best placed car of any automobile manufacturer is eligible. The best six results including the 24 Hours of Le Mans count promising excitement all the way to the finale in Shanghai.

### **Audi on the grid with different concepts**

Audi uses the World Endurance Championship as platform to present new technologies – and this with three different models: the Audi R18 ultra impresses through its uncompromising ultra lightweight design and construction. The Audi R18 e-tron quattro is the brand's first Le Mans Prototype with four-wheel drive. Audi still relies on last year's Le Mans winning R18 TDI at the season opener in Sebring.

### **Most successful Le Mans team contests all races**

Audi Sport Team Joest fields all the Audi sport prototypes mentioned in every round of the World Endurance Championship 2012. The successful race team from the Odenwald region has been Audi partner since 1999. Up to today the team behind the two Managing Directors Reinhold Joest and Ralf Jüttner has won the 24 Hours of Le Mans no less than twelve times. A total of twelve drivers form the driver squad for Le Mans and the WEC – including Le Mans record winner Tom Kristensen (DK) and last year's winners Marcel Fässler (CH), André Lotterer (D) and Benoît Tréluyer (F). New to the team are former test driver Marco Bonanomi (I), Oliver Jarvis (GB) and last year's Sebring winner Loïc Duval (F).



## **WEC driver teams 2012**

17/03 12 hours Sebring (USA)

#1 Marcel Fässler (CH)/André Lotterer (D)/Benoît Tréluyer (F), Audi R18 TDI

#2 Dindo Capello (I)/Tom Kristensen (DK)/Allan McNish (GB), Audi R18 TDI

#3 Timo Bernhard (D)/Romain Dumas (F)/Loïc Duval (F), Audi R18 TDI

05/05 6 hours Spa-Francorchamps (B) as well as

16/06 24 Hours of Le Mans (F)

#1 Marcel Fässler (CH)/André Lotterer (D)/Benoît Tréluyer (F), Audi R18 e-tron quattro

#2 Dindo Capello (I)/Tom Kristensen (DK)/Allan McNish (GB), Audi R18 e-tron quattro

#3 Timo Bernhard (D)/Romain Dumas (F)/Loïc Duval (F), Audi R18 ultra

#4 Marco Bonanomi (I)/Oliver Jarvis (GB)/Mike Rockenfeller (D), Audi R18 ultra

All other WEC races after Le Mans:

#1 André Lotterer (D), Audi R18 e-tron quattro\*

#2 Allan McNish (GB), Audi R18 ultra\*

\*The other drivers will be named at a later date based on the Sebring line-up



**From Akrapovič to TAG Heuer**

## **Audi Sport partners in the WEC**

**Audi Sport Team Joest can rely on strong partners in the 2012 FIA World Endurance Championship (WEC) and at the 24 Hours of Le Mans.**

**Akrapovič** supplies the exhaust systems for Audi's sport prototypes since 2009 and is an official Audi Sport partner for the first time in the 2012 season. Around 500 employees produce high-quality exhaust systems for motorbikes and sporty automobiles at the state-of-the-art facility close to Ljubljana.

Established in 1963, **Alpinestars** is the world-leader in high performance motorsports apparel, footwear and safety gear, equipping all of Audi's sports car team and drivers. As a global technical apparel and clothing brand, Alpinestars' unique motorsports heritage is also the foundation for a distinctive range of casual street-wear for a young and dynamic audience.

The **Robert Bosch GmbH** is a leading international technology and service company and has been an Audi Sport partner for the sport prototypes for many years. Bosch supplies the complex electronics, telemetry system and the Motor Generator Unit (MGU) for the Audi R18 e-tron quattro.

Since the company was founded in 1899, Castrol represents innovation and superior product quality, in turn the new product family **Castrol EDGE** for the best engine oil that Castrol has to offer. Castrol EDGE is the engine oil for Audi Sport.

As leading global development partner to the automobile and engine industry **MAHLE** provides unique system expertise in the field of combustion engines and peripheral engine components, which Audi Sport has used for years – also for the sport prototypes that are equipped with MAHLE pistons.

Enhancing the mobility of people and goods is Michelin's corporate mission. Automobile and motorcycle racing have always played a major role in furthering this objective. Because the Racing environment is so demanding, it provides an exceptional laboratory for developing new materials, optimizing suspension systems and wheel assemblies and measuring the tires against the competition. Audi Sport has relied on **Michelin** since the beginning of the sport prototype program.



Over the last 40 years success in motor sport was an important factor in making the Italian wheel manufacturer O.Z. to international market leader. **O.Z. Racing** produces high-quality aluminum wheels for the most important race series' (Formula 1, DTM, sport prototypes, rallying and IndyCars) and is OEM supplier for the most exclusive automobiles and motorbikes.

The renowned Swiss watchmaker **TAG Heuer** is partnering Audi Sport, placing its logo on the Audi sport prototypes. This partnership continues TAG Heuer's history in endurance races which started in 1970 with US actor Steve McQueen in the 'Le Mans' movie."

**Other partners in the WEC:**

Audi Top Service, Hofmühl, Gerolsteiner



## History of the World Sports Car Championship

### Technology pioneer in important eras

**For the first time since 1992 the Fédération Internationale de l'Automobile, FIA, stages a World Championship for sports cars. In its heydays the predecessor of the new FIA World Endurance Championship (WEC) was frequently more popular than Formula 1. A look back over the World Sports Car Championship's checkered history.**

History is revisited when the starting flag drops for the WEC on March 17, because almost exactly 59 years ago, on March 8, 1953, the first running of a sports car world championship celebrated its premiere with the 12-hour race around the circuit in Florida. As a result, endurance racing also received World Championship status three years after Formula 1. The seven rounds in the debut season generally numbered among the toughest tests in automobile racing. Whoever prevailed in the races in Europe and North and South American wrote motorsport history. 1,000 kilometers on the world's most demanding race track, the Nürburgring Nordschleife, the 24 Hours of Le Mans, the five day long Carrera Panamericana across Mexico or the 1,000 mile Italian tour Mille Miglia – the races and their victors quickly attained legend status.

The new series immediately proved to be a complete success. Not only because several hundreds of thousands of spectators streamed to the race tracks. The championship was also extremely popular among the manufacturers. Alfa Romeo, Ferrari, Maserati, Mercedes-Benz, Jaguar or Aston Martin – the participants in the World Sports Car Championship, in which there was originally only a constructor's title, represented the who's who of the automobile industry. The fact that drivers like Alberto Ascari, Stirling Moss or Juan Manuel Fangio, the best Formula 1 drivers, also competed in sports cars contributed to the rapidly growing popularity of the series.

#### Faster than Formula 1

Up to 1965 the championship was largely dominated by Ferrari. The Italians clinched the title in every season apart from 1955 and 1959. When a new technology race started in the mid 1960s as new manufacturers entered and developments in the areas of tires and aerodynamics rapidly increased resulting in ever faster race cars, the automobile federation reacted: From 1968 it limited the previously unrestricted engine displacement of sport prototypes to three liters. Alternatively, manufacturers could field sports cars with a displacement of up to five liters, of which at least 50 examples had to be produced. When this quantity was halved in 1970, two sports cars, the Porsche 917 and Ferrari 512, were developed that were faster to a certain extent than Formula 1 cars. The battle between the two brands went down in motor sport history. At Le





Mans in 1971 Porsche set a speed and distance record that was only broken in 2010 by the Audi R15 TDI. During the 1,000 kilometer race at Spa in the same year the winner's average speed was 249.069 km/h – even today this race is regarded as the fastest sports car race ever. To slow down the cars the displacement was restricted to three liters from 1972 onwards. In the throes of reorganization in 1976 the sports car sector was split into two series by the FIA: into a World Sports Car Championship, which was cancelled again after two years due to a lack of participants, as well as a Manufacturers World Championship for the so-called Group 5 silhouette race cars.

### **The Group C with consumption formula generates new impetus**

At the beginning of the 1980s when manufacturers' interest for the Manufacturers' World Championship also waned, the FIA proposed a series from 1982 onwards for so-called Group C prototypes. To make the championship interesting for as many manufacturers as possible the engine regulations permitted many different designs. However, to prevent engine power from escalating a consumption limit was introduced for the first time ever. In the years that followed the limit was constantly tightened. The regulations contributed to a new sports car boom, which attracted numerous manufactures, in the mid 1980s. Simultaneously it drove technical progress for the benefit of efficient drive concepts.

### **Expensive Formula 1 technology leads to demise of World Championship**

When the engine regulations were aligned with those of Formula 1 at the end of the decade many manufacturers withdrew, however, because the new, high-revving 3.5 liter normally aspirated engines represented a step backwards and the costs almost spiraled out of control. After the 1992 season, during which less than ten cars started in some races, the Sports Car World Championship was not staged again with world championship status before its rebirth in 2012. The sports prototype renaissance is due to the Automobile Club de l'Ouest (ACO) and American businessman Don Panoz who, in 1998, founded the American Le Mans Series (ALMS) in which Audi proved so successful between 2000 and 2008. From the Intercontinental Le Mans Cup (ILMC), which was held for the first time in 2010, emerged the FIA World Endurance Championship (WEC) which is co-organized by the ACO and FIA.



## **Audi in motor sport 2012**

### **Two ambitious programs**

**Dawning of a new era for the Audi ‘factory’ motor sport program: a new age starts in 2012 in the DTM, while for LMP sports cars the FIA World Endurance Championship (WEC) is staged for the first time. As result, Audi tackles two particularly ambitious programs and these with numerous clashing fixtures.**

The 2011/2012 motor sport year will probably go down in Audi Sport history as the toughest period: for the DTM Audi developed and tested a completely new car – the A5 DTM. In parallel two new versions of last year’s Le Mans race winning LMP1 sports car were created: the Audi R18 ultra and the Audi R18 e-tron quattro, the first race car in Audi Sport history not to be driven exclusively by a combustion engine.

#### **New safety concept for the DTM sets standards**

After twelve years the DTM changes its look completely: the previous touring cars make way for a new, far more economical vehicle concept. The spectacular acoustic signature of the race cars is, however, maintained and visually the A5 DTM exudes an even more thrilling appearance. At the same time, however, the considerably greater number of standard parts for every manufacturer in the DTM helps to reduce costs by up to 40 per cent. The central component is an innovative carbon-fiber monocoque with a steel cage. The design sets new standards in racing touring car safety. In the event of a side impact the central carbon-fiber component withstands a multiple of previous load values. Consequently the DTM once again assumes a pioneering role: no other racing touring car is as safe as the latest DTM car generation.

Audi started to develop the new A5 DTM for the 2012 season in May 2010. The Coupé made its maiden outing in July 2011. The sporting goals in the new year remain the same: after five championship titles with the Audi A4 DTM (2004, 2007, 2008, 2009 and 2011) the A5 DTM should continue this winning momentum.



## **Double development program with the sports cars**

Audi developed two closely related sport prototypes for the 2012 season: the Audi R18 ultra represents the logical development of the innovative R18 TDI. In parallel to this a hybrid car was also designed and built for the first time: the Audi R18 e-tron quattro uses the possibility of recovering kinetic energy to increase efficiency further still. Sophisticated electronics allows the intelligent networking of recuperation and four-wheel drive: while the rear axle is driven by the V6 TDI, the system feeds the energy recuperated electrically during the braking phase exclusively to the front axle. Highly complex, automatic control strategies are a concept feature. Audi Sport has never before developed such a sophisticated race car.

Both car concepts are raced at the beginning of a renaissance in the sports car sector: for the first time in almost 20 years a sports car series with FIA World Championship status is staged again in the form of the World Endurance Championship (WEC). The WEC calendar 2012 contains eight races and with rounds in North and South America, Europe, the Middle East and East Asia it covers the most important regions worldwide. The new Fédération Internationale de l'Automobile, FIA, World Championship follows on from the Intercontinental Le Mans Cup as highest caliber international sports car series.

The 24 Hours of Le Mans is the crown jewel in the calendar. After Audi won this endurance classic again for the tenth time last season, the focus of attention this year is once again victory in the world's most important endurance race. Marcel Fässler/André Lotterer/Benoît Tréluyer took overall victory in 2011 with an Audi R18 TDI equipped with many pioneering developments. In addition to the ultra lightweight technology and an innovative V6 TDI power plant the winning car also shone with full LED headlights.

“Le Mans remains a laboratory that is ideal for developing new technologies,” emphasizes Head of Audi Motorsport Dr. Wolfgang Ullrich. “Of great importance for Audi is always the relevance for production cars. With the World Endurance Championship and DTM we pursue two particularly ambitious goals as factory team in 2012.”

Furthermore, Audi contests the two 24-hour races at the Nürburgring and at Spa-Francorchamps as ‘factory’ with the new R8 LMS ultra. Audi Sport customer racing, the third element of Audi in motorsport since 2009, expects more than 70 examples of the R8 LMS, R8 LMS ultra and R8 GRAND-AM to be racing worldwide in the 2012 season.



## **Schedule: Audi 'factory' events 2012**

### **FIA World Endurance Championship (Audi R18)**

17/03	12 hours Sebring (USA)
05/05	6 hours Spa-Francorchamps (B)
03/06	Test day 24 Hours of Le Mans (F)
16–17/06	24 Hours of Le Mans (F)
26/08	6 hours Silverstone (GB)
15/09	6 hours São Paulo (BR)
29.09	6 hours Bahrain (BRN)
14/10	6 hours Fuji (J)
27/10	6 hours Shanghai (CN)

### **DTM (Audi A5 DTM)**

29/04	Hockenheim (D)
06/05	Lausitzring (D)
20/05	Brands Hatch (GB)
03/06	Red Bull Ring Spielberg (A)
01/07	Norisring (D)
15/07	Show event Olympic Stadium Munich (D)



19/08	Nürburgring (D)
26/08	Zandvoort (NL)
16/09	Motorsport Arena Oschersleben (D)
30/09	Valencia (E)
21/10	Hockenheim (D)

**GT3 endurance races (Audi R8 LMS ultra)**

19–20/05	24 hours Nürburgring (D)
28–29/07	24 hours Spa-Francorchamps (B)