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## **Innovative technologies in the new Audi R8 model family**

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Appendix: Technical data

**The equipment and data specified in this document refer to the model range offered in Germany. Subject to change without notice; errors and omissions excepted.**

Compact version

## **Innovative technologies in the new Audi R8 model family**

**At Audi, race cars and production cars have a lot in common in many technology areas – including their controls and displays. The best example is the similarity between the sport prototype Audi R18 e-tron quattro and the new production sports car, the Audi R8\*. Their steering wheels and digital displays share a lot of common features. The high-performance sports car, which will go on sale in late summer, is part of a sporty model family together with the GT race car, the Audi R8 LMS, and the battery-electric powered Audi R8 e-tron. In its latest evolutionary stage, the Audi R8 offers more power, speed and endurance.**

“Motorsport has been a part of our Audi DNA for many decades,” says Prof. Dr. Ulrich Hackenberg, Board Member for Technical Development. “Audi stands for automotive dynamism more than any other brand. This is especially true of our new high-performance Audi R8. Its concept is extremely close to that of a race car – in its controls and displays too.”

### **Steering wheels and displays: great similarities**

In the new Audi R8 V10 plus, the steering wheel has 20 controls, including four new satellite buttons – and in the LMP1 race car, the Audi R18 e-tron quattro there are as many as 33. In both cars, the driver shifts gears from the steering wheel, and color indicators let the driver know when the engine is nearing its rpm limit. Key driving dynamic parameters can be set via control buttons on the steering wheel. In both the production sports car and the race car, information – such as tire pressure and lap times – appears on a digital display.

### **Audi R8 e-tron: 340 kW of power**

In its latest development stage, the new Audi R8 e-tron, the first all-electric car from Audi, offers fascinating dynamics. Its 340 kW of power enables a 0 to 100 km/h (*62.1 mph*) sprint time of 3.9 seconds, and its maximum driving range is 450 kilometers (*279.6 mi*). This high-performance sports car serves as a mobile laboratory for developing new electrical concepts and components at Audi. The R8 e-tron will be produced in the small-scale production facility of quattro GmbH at the Audi Neckarsulm site in the Böllinger Höfe.

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## **Controls and displays in the new Audi R8 and in the Audi R18 e-tron quattro race sports car**

**The new Audi R8 and the Audi R18 e-tron quattro race car prototype exhibit great similarities in their controls and displays. Both feature a multifunction steering wheel with buttons the driver can use to control key dynamic parameters, as well as a digital display for indicators.**

The interior of the new Audi R8 illustrates the similarities between Audi motorsport and Audi production cars very well. Its defining element is the “monoposto” – the large curved section that encircles the area in front of the driver’s seat and conveys the atmosphere of a race cockpit. The driver sits on a newly developed lightweight seat that is mounted low. The operating concept focuses on the driver. Drivers can control all important functions without taking their hands off the steering wheel or looking away from the road – as in a race car.

### **New satellite buttons: the steering wheels**

The sport leather steering wheel with multifunction plus (standard in the Audi R8 V10) adds two large, round satellite controls to the buttons and roller controls of the MMI operating system. Located beneath the right steering wheel spoke is a red button for starting and stopping the engine. Beneath the left spoke there is a black button that the driver uses to select one of the four basic modes of the Audi drive select driving dynamics system – comfort, auto, dynamic or individual.

Two more buttons, the satellite buttons, are added to the performance leather-trimmed steering wheel of the Audi R8 V10 plus (optional in the V10). The right satellite button controls the exhaust flaps, while the driver uses the left button to activate the performance mode. The driver selects one of the performance modes – dry, wet or snow – by turning the rotary ring integrated in the push-button. These modes adapt systems relevant to driving dynamics to the friction coefficient of the road surface, thereby maximizing stability and driving dynamics. The performance modes each have special engine/transmission tuning.

### **Fully digital instrument: the Audi virtual cockpit**

The fully digital Audi virtual cockpit is standard in the new R8. Its TFT display has a 12.3-inch diagonal and offers a resolution of 1,440 x 540 pixels. It shows all information in remarkably sharp, bright, brilliant and contrast-rich graphics with complex, detailed effects. The needle position of the rev counter is updated 60 times per second, making its movement very fluid – even when the V10 revs up under full load. The color scheme of the display varies according to the basic menu setting – it is orange for the media menu, for instance, and green for the telephone menu.

The driver can switch between two user interfaces by pressing the “View” button. In the infotainment mode, the navigation map or lists from the Telephone, Radio and Audio areas appear in a large central window – while the rev counter and speedometer appear as small round instruments on either side of this display window. In the classic view, the instruments are approximately as large as analog instruments, and the center display window is therefore smaller.

In performance mode, the primary instrument is a large central rev counter. It also serves as a gear shift indicator – when the seven-speed S tronic is being operated in manual mode, its scale has a color background at higher engine speeds. As the rpm increases, more segments are added: green, orange and red. As soon as the engine reaches its limit of 8,500 rpm, the entire scale flashes red. The Audi R18 e-tron quattro racing car has a similar function on-board.

### **Other indicators: g meter, lap timer, power and torque**

The driver can use the multifunction push-buttons located on both sides of the rev counter to place gages that visualize the dynamics of the new Audi R8. The power and torque output of the 5.2 FSI are shown as percentages, and a g-meter, whose peak value is 1.5 g, visualizes forces generated when driving through curves, braking and or accelerating. A lap timer records up to 99 laps and compares times. As in the race car, the status of key technical parameters can also be viewed: engine oil and transmission fluid temperatures as well as air pressures and temperatures of the tires.

The Audi virtual cockpit is driven by a high-performance Tegra 30 chip supplied by Audi joint venture partner Nvidia. It is designed for low electrical consumption and has separate audio, video and image processing units.

### **Evolutionary advanced development: the Audi R18 e-tron quattro**

The Audi R18 e-tron quattro for the 2015 race season advances the operating and display concept of the previous race sports car. The switches and controls are laid out on the steering wheel and at the front of the cockpit to the left of the steering wheel. The steering wheel display and two more monitors show all key information.

The driver sits on the right side in the LMP1 race car. Various secondary switches are positioned on the front cockpit panel to the left of the driver. Under the decal labeled "E" is a switch with a guard that activates the fire extinguishing system. Beneath it are a rotary volume control for the radio communications loudspeaker and a socket for the communications cable connected to the helmet. In the area to the right are buttons for idle and reverse gear as well as the main switch for the vehicle electrical system and a switch for activating the hybrid system. The driver can de-power the high-voltage system for technical work in the pits or if there is a problem on the racetrack. Two red and two green LEDs indicate its status – green means that the system is operating error-free, while red indicates an error.

If the electronic circuit breaker box deactivates an electrical consumer in the Audi R18 e-tron quattro, the driver can attempt to re-activate it by pushing a button located in the upper front cockpit area. If a line for the data logging and transmission system is deactivated, it can be reconnected by pushing the adjacent reset button. Two rotary controls are used to make settings for the brake system and the Anti-Slip Regulation (ASR).

### **33 controls: the steering wheel in the R18 e-tron quattro**

As in a Formula 1 race car, the steering wheel in the Audi R18 e-tron quattro has a yoke design. It is made of aluminum and is therefore very light. There is an info display on the front of the steering wheel. 33 buttons, paddles and scroll wheels are arranged on the front and back of the steering wheel. The R8 V10 plus production sports car has a total of 20 such controls on its steering wheel.

As in the sports car, two paddles are used to shift gears in the R18 e-tron quattro – the left paddle is used to downshift, and the right to upshift. Four additional paddles are used to activate the clutch, fuel system and headlamp flasher. In addition, the driver has two control knobs for adjusting the brake balance.

There are four rotary switches at the center of the steering wheel – they control the windshield wipers, ASR and mapping for the V6 TDI and the hybrid system. They are enclosed by a circle of 13 buttons which are used for the pit function and the speed limit on the pit lane, for radio communications, for the starter (2 switches), windshield heating, fog lights, high-beam lights, drinking system, hybrid function, caution flag periods and for user navigation in the steering wheel display.

There are three more switches on each of the two steering wheel horns – redundant switches for the hybrid system, brake balancing and ASR. The upper border of the steering wheel integrates six green, three yellow and three red LEDs – they are gear shift indicators that replace the rev counter. When the last yellow diode lights up, the driver should shift to the next higher gear.

### **The steering wheel display: 3.0-inch diagonal**

The compact, transfective, color display with its 3.0-inch diagonal is positioned at the center of the steering wheel. It assures extremely good readability, even in bright direct sunlight. There are three views for normal driving whose layouts are similar. Each view shows all four tire pressures, the engaged gear, the ASR and brake balance settings and the current fuel strategy – they help the driver to achieve energy targets for each lap. There are also variable instruments for lap time and difference, vehicle speed, charge status of the flywheel accumulator and brake temperature.

Two more small monitors under the headlining complement the steering wheel display. An AMOLED display made of organic LEDs that works with a rear camera serves as a digital rear-view mirror. A second gear indicator appears its upper area. Another display required by the race organizer shows the flag signals posted by the race committee.

## The Audi R8 e-tron

**340 kW of power, from 0 to 100 km/h (62.1 mph) in 3.9 seconds and a driving range of up to 450 km (279.6 mi) – Audi has further developed the R8 e-tron thoroughly. The high-performance sports car combines an all-electric high-powered drive system with radical solutions in lightweight design.**

Visually, the 4.40 meter (14.4 ft) long Audi R8 e-tron is recognizable by its unique lighting solutions on the air inlets, front apron and sideblades. Its exterior skin, painted in Magnetic Blue, combines body parts made of aluminum and carbon fiber reinforced polymer (CFRP), such as the front and rear lids. Thanks to aerodynamic modifications to its cooling air inlet, rear spoiler, diffuser, underbody and sideblades, the drag coefficient (Cd) of the R8 e-tron is just 0.28. Its Audi Space Frame (ASF) is based on the multimaterial design of the V10 version, which is extended by a rear body module made of CFRP. Despite its low weight, the corrugated bulkheads that conceal the luggage compartment can absorb a lot of energy in a rear-end collision.

The T-shaped battery is structurally integrated in the middle tunnel and is mounted behind the occupant cell – this location offers a low center of gravity and an axle load distribution of 40:60 (front/rear). The high-voltage battery is based on lithium-ion technology. The liquid-cooled lithium-ion battery consists of 52 modules. Compared to the first e-tron technology platform, the energy capacity of the new 595 kg (1311.8 lb) battery system was boosted from around 48.6 kWh to 90.3 kWh without requiring any package modifications.

Thanks to the high energy density, which was increased from 84 to 152 Wh/kg, the R8 e-tron can be driven up to 450 km (279.6 mi) on just one battery charge – previously it was 215 km (133.6 mi). In the Combined Charging System (CCS) for charging with DC or AC electricity, the battery can be fully charged in well under two hours. The driver can control this process remotely by smartphone, if the user has installed the relevant Audi connect app.

### **Immense tractive power: 920 Nm (678.6 lb-ft) of torque**

The two electric motors on the rear axle each output 170 kW and 460 Nm (339.3 lb-ft) of torque. The R8 e-tron, which weighs just 1,841 kg (4058.7 lb) empty (without driver), sprints from 0 to 100 km/h (62.1 mph) in 3.9 seconds and can accelerate to an electronically governed top speed of 250 km/h (155.3 mph) while developing its unique e-sound. Targeted Torque Vectoring – a need-based distribution of drive power between the rear wheels – gives the car maximum stability and dynamism.

Intelligent energy management and an electromechanical brake system at the rear axle ensure high rates of energy recuperation. The suspension springs consist of glass fiber reinforced polymer (GFRP), and the anti-roll bar is made of CFRP.

The R8 e-tron rides on aerodynamically optimized, high-gloss 19-inch aero wheels that were specially developed for this car. At the front axle, size 225/40R19 tires enable precise steering response. Size 275/40R19 tires transfer the torque of the electric motors to the road. The tires were specially developed for the requirements of an electric supercar, and they combine sporty driving properties with efficient rolling resistance values. Extremely sporty 20-inch wheels of the production R8 are available via the Audi Genuine Accessories program.

In the finely crafted interior, the R8 e-tron offers illuminated door sill trims, folding bucket seats and a specially configured Audi virtual cockpit. A heat pump removes waste heat from electrical components for thermal management and for interior climate control – an important efficiency module of the overall concept.

Audi also uses the latest development stage of the R8 e-tron as a high-tech laboratory – it also continues to play an important role in developing electric mobility of the future. The R8 e-tron will be produced in the small-scale production facility of quattro GmbH at the Audi Neckarsulm site in the Böllinger Höfe.

## The high-voltage battery in the Audi R8 e-tron

**Electric drive at Audi is gaining momentum with the new Audi R8 e-tron. In its latest evolutionary stage, the high-performance sports car offers even more power, speed and endurance. It can be driven up to 450 km (279.6 mi) on a fully charged battery.**

The new battery cells are primarily responsible for the new performance and driving range of the Audi R8 e-tron. Audi has systematically adapted its high-voltage battery system to the specific needs of electric cars – the primary focus was on achieving an optimal ratio between power and energy. The results: The R8 e-tron has a significantly longer driving range and even more power than the previous model. In developing the high-voltage battery, the brand with the four rings followed the principle of maximum flexibility without losing sight of synergies in electrification. Its flexible cell module concept makes the Audi brand well-equipped for all future market developments, while the modular concept also guarantees Group-wide use across different car models.

The battery operates with 385 volts of nominal voltage, and its new cell module concept achieves excellent performance. The battery's energy density grew from 84 watt-hours per kilogram (Wh/kg) to 152 Wh/kg, and its nominal capacity from 48.6 kWh to 90.3 kWh. Its driving range on a full charge has more than doubled – from 215 km (133.6 mi) to as much as 450 km (279.6 mi). These values make Audi the leader among the competition.

The battery system of the Audi R8 e-tron takes on the shape of a "T". It measures 235 cm (92.5 in) long, 136 cm (53.5 in) wide and 70 cm (27.6 in) high, including the junction box on the cross-bar of the "T". This junction box is responsible for monitoring, switching and transmitting an electrical current of over 1,200 amperes. The highly complex battery system consists of over 10,000 individual parts.

The 7,488 cells are packed in 52 modules of 144 cells each. Each module weighs 7.8 kg (17.2 lb). They are arranged on two and five levels ("floors") in the tunnel battery and in the rear battery. Aluminum plates separate the "floors" from one another while creating the supporting structure for the battery.

Coolant circulates in a cooling system of aluminum shells. In a crash, high-strength floor plates and impact plates redirect the crash forces into the multimaterial ASF (Audi Space Frame) of the R8 e-tron in a defined way.

#### **40:60: ideal axle load distribution**

The 595 kg (*1311.8 lb*) battery system is joined to the ASF with bolts in the middle tunnel and behind the occupant cell, making it an integral part of the vehicle structure. Its mounting position results in a low center of gravity and an axle load distribution of 40:60 (front/rear), which is ideal for a mid-engine sports car.

The Combo 2 charging interface of the Combined Charging System in the Audi R8 e-tron enables charging with AC or DC electricity. When charging with AC from an industrial electrical outlet with 7.2 kW of charging power, a full charge is reached in just around 12 hours. Charging with DC electricity shortens the time – to just 95 minutes at a charging power of 50 kW. Audi is demonstrating charging equipment that can charge this battery system with up to 150 kW of charging power. For the driver of the R8 e-tron, this means that a driving range of around 150 km (*93.2 mi*) can be attained after just 15 minutes of charging time. The customer can manage charging remotely as well – using a smartphone on which the customer has installed the relevant Audi connect app.

## The new Audi R8 LMS

**Making its debut at the same time as the new Audi R8 production car model is the motorsport version – the new Audi R8 LMS. Engineers from motorsport and production collaborated closely in its development. As in the first generation of the sports car, the level of shared parts between the two R8 versions is around 50 percent – in addition, both cars have made significant performance gains. The body of the R8 LMS is manufactured together with the production car body at the new Audi Böllinger Höfe handcrafted manufacturing site located near the Audi Neckarsulm plant.**

The body of the GT3 race car is based on the point-reinforced multimaterial Aluminum Space Frame (ASF) made of aluminum and carbon fiber reinforced polymer (CFRP), which is supplemented by a safety cage. The Audi PS1 safety seat is solidly joined to the chassis, which increases rigidity. The steering column and pedals can be individually adjusted. A new type of CFRP element in the rear body – similar to the one used on the R8 e-tron – protects the driver in case of a rear-end collision. With the exception of the roof, the exterior skin consists of CFRP, and the homologation weight of the rear-wheel drive race car is 1,225 kg (2700.7 lb).

The V10 engine is nearly identical to the production car engine; it only lacks manifold injection. It outputs around 430 kW (around 585 hp) – depending on the specific race regulations and the air restrictor that is specified in them. The engine rebuild interval is 20,000 km (12,427.4 mi). The newly designed six-speed transmission, which is pneumatically shifted via paddle shifters, is considerably lighter than the previous unit; the clutch features electro-hydraulic activation. Classic race car wishbones guide the wheels, which are size 18-inch according to race rules. The race car also uses special steering components and wheel bearings.

One of the top qualities of the new Audi R8 LMS, which is 4.58 meters (15.0 ft) long and 1.17 meters (3.8 ft) high, is its aerodynamic efficiency. The large diffuser in the large smooth surface of the underbody panels generates strong downforce, which enables a smaller rear wing – compared to the previous model the aerodynamic drag coefficient has been reduced by 20 percent. The flow of cooling air has been improved in all areas – in the front body and in the cockpit.

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\*The collective fuel consumption of all models named above and available on the German market can be found in the list provided at the end of this Basic Info.

Today, the new Audi R8 LMS already conforms to GT3 race regulations that take effect in 2016. This year, the new race car will be put through its initial paces by the factory team at international races. The R8 LMS has already won its debut entry at the long-established 24-hour race on the Nürburgring. Audi will be offering the car to interested customer teams from the end of the season.

### **Fuel consumption of the models named above:**

#### **Audi R8**

Combined fuel consumption in l/100 km: 12.3 – 11.4\*\* (*19.1 – 20.6 US mpg*);

Combined CO<sub>2</sub> emissions in g/km: 287 – 272\*\* (*461.9 – 437.7 g/mi*)

\*\*The fuel consumption and the CO<sub>2</sub> emissions of a vehicle vary due to the choice of wheels and tires. They not only depend on the efficient utilization of the fuel by the vehicle, but are also influenced by driving behavior and other non-technical factors.