

**Communications Model Lines, Innovation  
and Technology**

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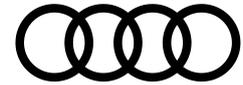
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**PRESS INFORMATION**

## **Audi e-tron: Aerodynamics**

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## **Sophisticated aerodynamics for high efficiency and range**

**With a drag coefficient of  $c_d$  0.27, the Audi e-tron achieves a top figure in the SUV segment. The highly developed aerodynamics make a major contribution to the range and affect virtually all areas of the car. The finishing touches begin with the battery bolting points on the underbody and run through to the virtual exterior mirrors with small cameras. These mirrors are being used for the first time on a volume-production model.**

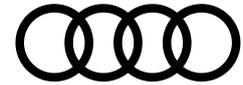
### **Rethinking electric mobility**

Weight is far less important for power consumption on an electric car than on a similar model powered by a combustion engine. In town, a heavy electric car is also efficient because it can recover a large part of the energy, which it uses to accelerate, when running up to the next red traffic light. The situation is, however, totally different on long journeys where the Audi e-tron is perfectly at home: Here from speeds of around 70 km/h (*43.5 mph*) the rolling resistance and the inertia take second place to aerodynamic drag irrespective of the type of car. The energy required to overcome that drag is lost. Consequently the engineers focused on the aerodynamics when developing the Audi e-tron – the key factor once the mass is in motion. Thanks to sophisticated aerodynamic measures, the Audi e-tron delivers high efficiency over a range suitable for long journeys. In the WLTP cycle it does more than 400 kilometers (*248.5 mi*) on a single battery charge.

### **Every thousandth counts: drag**

The Audi e-tron is an electric SUV for sport, family and leisure. Like one of the brand's typical premium class models, it offers ample space for five people and a large luggage compartment. Its wheelbase measures 2,928 millimeters (*9.6 ft*). The Audi e-tron is 4,901 millimeters (*16.1 ft*) long and 1,616 millimeters (*5.3 ft*) high. Due to its width of 1,935 millimeters (*6.3 ft*) it has a fairly large frontal area ( $A$ ), even though its overall drag area ( $c_d \times A$ ) is just  $0.74 \text{ m}^2$  (*8.0 ft^2*), making it better than an Audi Q3.

When equipped with the standard exterior mirrors, the Audi e-tron achieves a drag coefficient of 0.28. Even with the optional virtual exterior mirrors the value is 0.27 – a top result in the SUV segment. Customers benefit directly from this low figure as the drag plays an even greater role with an electrically powered model than it does with a conventional car. Here every detail counts: Cutting a thousandth off the drag coefficient represents a range of around half a kilometer (*0.3 mi*) for a customer driving under everyday conditions.



## **Aerodynamic measures in detail**

The overall concept of the Audi e-tron with its generous space was never in question during the aerodynamics development. To achieve the low drag coefficient, the Audi engineers used a wide range of aerodynamic measures in all body areas. Some of these technical solutions are evident at first glance, while others fulfill their purpose hidden away from sight. Thanks to these innovations the Audi e-tron saves just under 70  $c_d$  points. With a typical usage profile this set-up increases the range by around 35 kilometers (*21.7 mi*) per battery charge in the WLTP cycle. To achieve this additional range simply by cutting weight, the engineers would have had to shed a half a tonne (*1,102.3 lb*).

### **Newly developed: the standard exterior mirrors**

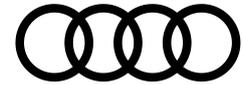
Exterior mirrors provide a rigid barrier to the airflow, making them a particular challenge when it comes to optimizing the aerodynamics. For the Audi e-tron the engineers and designers developed a new design which generates minimal resistance to the airflow. For the first time at Audi, the exterior mirrors appear to grow out of the window slot trims: Their mirror heads, designed differently for the left and right, form small diffusers with the side windows. Compared to conventional mirrors, they reduce the drag by 5  $c_d$  points.

### **World premiere: the virtual exterior mirrors**

For the first time in a volume-production car, virtual exterior mirrors are available as an option in the Audi e-tron. They reduce the drag by another 5  $c_d$  points compared with the standard aerodynamically optimized exterior mirrors and also constitute an aerodynamic and visual highlight. Their flat support incorporates a small camera at its hexagonal end. A heating function prevents the unit from misting over or freezing, thus ensuring good visibility in all weathers. In addition, each support features an LED indicator and an optional topview camera. Compared with the standard mirrors, the innovative mirrors are much narrower: They reduce the vehicle width by 15 centimeters (*5.9 in*) and also noticeably cut the nonetheless low wind noise. In the interior of the Audi e-tron their images appear on OLED displays in the transition between the instrument panel and door.

### **Fully enclosed: the underbody**

Many aerodynamic measures of the Audi e-tron make a difference in areas that the customer does not normally see. The flat, fully enclosed underbody alone accounts for 17  $c_d$  points compared with a conventional vehicle. Its main component is a 3.5 millimeter (*0.1 in*) thick aluminum plate. It protects the battery against damage from below, such as stone chipping or curbs.



The electric motors on the axles and the wheel suspension are covered with paneling made from pressed fiber-fleece material, which at the same time absorbs noise. Ahead of the front wheels, wheel spoilers mounted on the floor pan reduce irritating swirl in the wheel arches by using air baffles. These baffles specifically channel the airflow past the wheels.

The transverse links on the rear axle of the Audi e-tron are located under separate paneling. A variable diffuser below the rear bumper ensures that the accelerated air returns to ambient speed and creates as little swirl as possible. The bolting points of the high-voltage battery to the body also add small, effective details to the underbody. Similar to a golf ball, they have bowl-shaped indentations. These dimples measuring several centimeters in diameter and depth allow the air to flow through more effectively than a flat surface.

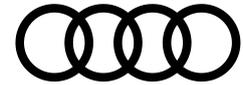
#### **Open or shut: the controllable cool-air inlet**

The controllable cool-air inlet improves drag by 15 c<sub>d</sub> points. A module with two louvers, which are opened and closed by small electric motors as required, sits between the Singleframe and the radiators. Each louver is made up of three slats. Guiding elements and molded-foam parts seal off the area in front of the controllable cool-air inlet so that the incoming air does not generate any swirl. At the same time, the foam absorbs impact energy with a collision at low speed, thus also contributing to pedestrian protection.

A control unit manages the controllable cool-air inlet to deliver maximum efficiency by factoring in numerous parameters. At speeds between 48 and 160 km/h (*29.8 – 99.4 mph*), the Audi e-tron closes both louvers where possible to improve the airflow. If cooling air is required for drivetrain components or the air conditioning condenser, it initially opens the top and then both louvers. Thanks to powerful recuperation, the hydraulic wheel brakes of the Audi e-tron are seldom used. If they are required, say, for negotiating a steep mountain pass with a full battery, the controllable cool-air inlet opens and releases two ducts which channel the cooling air into the front wheel arches to the friction brake.

#### **Standard: aerodynamically designed wheels and tires**

Wheel arches and wheels typically account for a third of the drag and, as such, are an important factor in aerodynamic efficiency. The side air inlets at the front of the Audi e-tron incorporate additional ducts, which are clearly visible from outside, to the wheel arches. These ducts channel the airstream so that it flows past the outside of the wheels. These so-called air curtains openings reduce drag by 5 c<sub>d</sub> points.



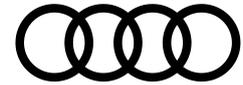
The aerodynamically optimized 19-inch wheels fitted standard on the Audi e-tron provide another 3 c<sub>d</sub> points. As an option the customer can also order the 20- and 21-inch wheels as aero wheels. Their smart design is flatter than with conventional wheels. The standard 255/55 R19 size tires stand out with their ultra low rolling resistance. Even the tire sidewalls add to the aerodynamic design – the lettering is negative instead of raised.

#### **Hugging the road: the adaptive air suspension**

The standard adaptive air suspension with controlled damping constitutes another aerodynamic factor in the suspension area. It varies the body's ride height depending on the road speed and reduces the drag by 19 c<sub>d</sub> points compared to a model with a steel-sprung suspension. The lowest level alone, which is 26 millimeters (*1.0 in*) below the normal position, accounts for 10 c<sub>d</sub> points. The rectangle, which the tires represent for the airflow and oppose the wind resistance, disappears in part in the wheel arch thanks to the lower ride height. This measure also improves handling.

#### **Tried-and-tested solutions: roof edge spoiler and diffuser**

Besides the specific components developed particularly for the Audi e-tron, the electric SUV also uses customary aerodynamic solutions. The long, three-dimensionally shaped roof edge spoiler provides a clear-cut flow separation at the end of the roof. The spoiler works together with the aerodynamic baffles on both sides of the rear window. The diffuser extends – like on a racing car – across the entire width of the rear, providing extra downforce.



## Technology Lexicon Aerodynamics

### Aerodynamics

Aerodynamics – the study of how bodies move in gases and the associated effects and forces – is crucial in automotive engineering. The aerodynamic drag increases as the square of velocity. From around 50 to 70 km/h (*31.1 – 43.5 mph*) – depending on the particular car – the drag exceeds the other driving resistances of rolling resistance and inertia. At 130 km/h (*80.8 mph*) a car will have to use around three quarters of its drive energy to overcome the drag.

### $c_d$ figure

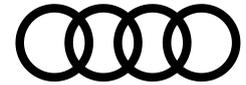
The drag coefficient ( $c_d$  figure) is a dimensionless measurement for aerodynamic drag. It describes how air flows past the car. Audi has been pushing forward development in this area for many years and has set important milestones. The 1982 Audi 100 achieved a drag coefficient of 0.30, while the A2 1.2 TDI reduced the same figure to 0.25 in 2001. Nature though offers the lowest drag coefficient figures: With a water droplet the figure is around 0.05, with a penguin just 0.03.

### Frontal area

The frontal area (A) is the car's cross-sectional area. In the wind tunnel it is normally measured with a laser system that scans the external contours together with the mirrors and tires. The Audi e-tron has a frontal area of 2.65 m<sup>2</sup> (*28.5 ft<sup>2</sup>*). By comparison, the frontal area for a motorcycle is around 0.7 m<sup>2</sup> (*7.5 ft<sup>2</sup>*), while the figure for a large truck is as much as 10 m<sup>2</sup> (*107.6 ft<sup>2</sup>*). Multiplying the frontal area by the drag coefficient ( $c_d$ ) figure gives the effective drag figure for a body.

### Controllable cool-air inlet

The controllable cool-air inlet consists of a frame behind the Singleframe with two electric louvers that can be operated independently of each other. At average speeds, they stay shut for as long as possible to prevent disrupting the airstream. In certain situations – such as when the ancillaries require cooling air or the brakes on the Audi e-tron are subject to high loads – they are opened independently of each other. Audi also uses the controllable cool-air inlet in a similar way on some models fitted with a combustion engine.



adaptive air suspension

The adaptive air suspension with controlled damping provides a wide range between smooth cruising and sporty, stable handling. It adjusts the body's ride height depending on the road speed and driver's wishes and also provides a self-leveling function.