Electric mobility

A vision becomes reality

Setting off for the future: True to its motto “Vorsprung durch Technik,” Audi also wants to become the leading premium manufacturer of electric vehicles.
Open-top sports car with plug-in hybrid drive – the Audi e-tron Spyder.

“Just as the name quattro has become synonymous with all-wheel drive, e-tron will become the Audi brand name for electric mobility.”

Rupert Stadler, Chairman of the Board of Management of AUDI AG
The future has a name at Audi. The designation “e-tron” is reserved for electric cars in the future.
“Just as the name quattro has become synonymous with all-wheel drive, e-tron will become the Audi brand name for electric mobility,” says Rupert Stadler, Chairman of the Board of Management of AUDI AG.

Electric cars are expected to no longer be a niche product, but rather a natural part of the product range in no more than ten to 15 years.
“There is no getting around electric mobility,” says Franciscus van Meel, Head of Electric Mobility Strategy at Audi.
This represents no more and no less than a fundamental system change. “Electrification of the powertrain is not simply another engine variant,” explains van Meel.
“We have to reinvent the automobile and reposition ourselves as a manufacturer.”

Audi is facing up to the responsibility. It is a matter of answers to global climate change, of alternatives to the fossil raw material petroleum and of modern mobility concepts for the fast-growing megacities of this world.

Audi is convinced that the future of mobility will be characterized for many years by the coexistence of different technologies and energy sources. Developers want to offer the best solution for each market and for each customer.

The Audi e-tron studies presented to date demonstrate the breadth of the new technologies:

- **Audi e-tron** – the supercar was a highlight of the 2009 International...
Motor Show (IAA) in Frankfurt am Main, Germany. Four motors – two each on the front and rear axles – producing a total of 230 kW (313 hp) ensure phenomenal performance and make the sports car a true quattro.

- **Detroit showcar Audi e-tron** – the compact two-seater with an aluminum body was presented in early 2010. Distinguishing features: purist design, low gross weight of 1,350 kilograms, two electric motors on the rear axle with a total output of 150 kW (204 hp); range is as much as 250 kilometers.

- **e-tron Silvretta** – in July 2010, Michael Dick, Member of the Audi Board of Management for Technical Development, and factory driver Lucas Luhr piloted the technology platform based on the Audi e-tron to a first-place finish in the first “Silvretta E-Auto Rally Montafon.” The rally against more than 20 electric cars from other manufacturers covered 167.5 kilometers. As Michael Dick explained, the victory was “the proof that we are well on our way to a production-ready electric powertrain.”

- **A1 e-tron** – the innovative Mega City Vehicle (MCV) celebrated its premiere at the 2010 Geneva Motor Show. The A1 e-tron has an electric drive with a peak output of 75 kW (102 hp), with which it drives with zero local emissions. The battery can be recharged while underway using the range extender, a compact unit comprising a single-rotor engine and a generator.

- **e-tron Spyder** – in fall 2010, Audi presented the study of an open-top sports car with plug-in hybrid drive at the Paris Motor Show. Just 1.11 meters...
tall, the exciting two-seater has a 221 kW (300 hp) twin-turbo V6 TDI engine on the rear axle and two electric motors with a combined 64 kW (87 hp) on the front axle. The e-tron Spyder can combine the strong 650 Nm of torque from its TDI engine and the total of 352 Nm of its two electric motors during acceleration in a process known as “boosting.”

**Audi is completely rethinking the electric car with the e-tron.**

Even in the Electric Age, customer requirements will develop differently. Besides the requirements of the markets, the intended purpose of the electric vehicles also plays a major role. An all-electric car will establish itself in the short-range mobility segment in the medium term. Long trips, on the other hand, are forecast to be the domain of hybrid drives.

There are still many customer suitability challenges remaining to be solved with respect to costs, range and battery recharging time, as well as the real potential for CO₂ reduction. The entire energy balance must be considered whenever talking about sustainable mobility, and this is largely a function of how the necessary electricity is generated. Conventional electricity has a CO₂ load of around 120 grams per kilometer. This corresponds to the value for a modern mid-size car featuring a combustion engine. If the electricity, on the other hand, is generated using renewable sources, this is reduced to just five grams with electric motors.

“Audi electric cars will run on sustainably generated electricity,” emphasizes Audi Chairman Rupert Stadler. “We are promoting the construction of solar and wind energy units in order to achieve this goal.” In 2010, for example, Audi entered into a partnership with the industry initiative Dii GmbH, whose long-term objective is to realize the DESERTEC vision. This vision describes the prospects of supplying Europe, the Middle East and North Africa with solar and wind energy from the deserts.

**Design, driving dynamics, efficiency and lightweight construction will continue to be decisive factors in the future.**

As a premium manufacturer, Audi must continue to further develop its core competences in the interest of electric mobility. Design, driving dynamics, efficiency and lightweight construction will continue to be decisive factors in the future. Dietrich Engelhart, who is Head of Vehicle Electrification Strategy at Audi, feels that customer delight will continue to be key to success in the future.

“Customers expect performance and emotions from Audi, and we must continue to meet this expectation in the future.”

The Audi e-tron is sure to generate enthusiasm. Audi wants to bring a limited edition of the vehicle to the roads in late 2012. The first Audi high-performance sports car with all-electric drive proves that driving in the Electric Age will not have anything to do with sacrifice, but instead will open up new dimensions of driving dynamics.

The study’s four asynchronous motors – two each on the front and rear axles – transfer the power to the wheels via a single-speed transmission and short drive shafts. With peak output of 230 kW (313 hp) and with up to 600 Nm of torque available from a standstill, the Audi e-tron delivers breathtaking performance. It catapults from 0 to 100 kilometers an hour in just 4.8 seconds.

The liquid-cooled lithium-ion battery and the power electronics lie directly behind the passenger compartment. The result is an excellent center of gravity and a load distribution of 42:58 between the front and rear axles – similar to the production R8.

The first short test drive with the e-tron Silvretta shows the potential of the electric powertrain. The high-performance sports car shoots forward as if it were being pulled by an elastic band, with turbo-like, nearly silent acceleration. An impressive driving experience, as Stefan Keller, Head of Electrification Processes, can confirm. “The response is uniformly positive at every driving event. Everyone is enthusiastic.” According to Keller, what now needs
The study of an open-top sports car demonstrates the potential of the plug-in hybrid drive. A twin-turbo V6 TDI produces 221 kW (300 hp); the two electric motors together deliver an additional 64 kW (87 hp) of power.

The A1 e-tron is an innovative Mega City Vehicle (MCV) with electric drive and a single-rotor engine with generator. The study’s total range is up to 250 kilometers.

The A1 e-tron: The next generation
Despite its complex drive technology, the innovative Mega City Vehicle study weighs just 1,200 kilograms.

“...build on the Audi core competences” on this basis. quattro permanent all-wheel drive has been a part of this for over 30 years. Electric cars offer entirely new possibilities in this field. The four electric motors fitted on the Audi e-tron can be individually controlled – a type of quattro drive for electric cars. The four motors allow what is known as torque vectoring, the selective acceleration of individual wheels and therefore active distribution of torque.

“...is superior to the majority of conventional cars at the limit.” Systematic lightweight construction is also a crucial prerequisite for the...
Fleet test
Electric mobility in practice

In order to investigate electric driving in practice more closely, Audi will be joining three project partners – the energy supplier E.ON, the Munich public utility company SWM and the Technical University of Munich (TU München) – in launching a fleet test with the A1 e-tron. The first vehicles should be hitting the road in Munich in 2011.

E.ON and SWM are installing the necessary infrastructure, E.ON primarily in the outlying areas and SWM in the Bavarian state capital. A total of 200 charging stations are to be made available. TU München will analyze mobility behavior during the term of the project. Audi also hopes to learn more about the behavior, but also the expectations of our customers regarding their dealings with electric cars from this fleet test. How intensively and in which situations is the electric car being used? What other modes of transportation are being used in normal practice? Given the increasing urbanization worldwide, there is another question to be addressed: What does a mobility concept of the future look like?

“The results of the project will help us to further expand our expertise in electrification.”

Rupert Stadler, Chairman of the Board of Management of AUDI AG.

efficiency and range of electric cars, for the batteries with their relatively high weight are still a heavy burden. The Audi engineers therefore turned to another of the company’s core competences for the Audi e-tron: The body is made of aluminum. With its Audi Space Frame (ASF) technology, it is an important reason why the Audi e-tron tips the scales at just 1,600 kg.

The Audi e-tron provides a glimpse into Audi’s corporate philosophy of electric mobility. Extending far beyond the battery technology and the replacement of an internal combustion engine by an electric driveline, the concept is holistic. The complex interplay of all components influences the key factors of efficiency, range and practicality.

The A1 e-tron, which is designed as a Mega City Vehicle (MCV) for metropolitan areas, also demonstrates this comprehensive approach. The compact two-door car is one of the world’s first all-around vehicles powered purely by electricity to have four seats and a full-sized trunk. Its electric motor produces peak power of 75 kW (102 hp), with 45 kW (61 hp) available in continuous operation.

The Audi A1 e-tron embodies an intelligent technological concept. A lithium-ion battery pack provides the energy for the electric drive. The driver generally charges the battery pack from the grid – most conveniently, from a home socket. A full battery charge is enough for a range of over 50 kilometers. “That is more than sufficient for the daily commute to work,” finds Dietrich Engelhart.

In case the driver wants to cover a longer distance, the A1 is equipped with a small rotary engine that recharges the battery if necessary for a range of roughly 250 kilometers.

At first glance, the compact two-door car is nearly indistinguishable from its “normal” sister models. The interior has been completely redesigned, however. All of the A1 e-tron’s auxiliary systems, such as the air conditioning, the power steering and the pump for the brake servo, are electric-powered.

The compact two-door car otherwise affords all the strengths of the Audi A1 model series – a small turning radius, good sightlines and high agility. Going with the trend of the future doesn’t entail the slightest sacrifice for the A1 e-tron, especially since the interior space and the luggage compartment capacity match those of series production models.

The A1 e-tron is already a big little car. The structure of its Multi Media Interface (MMI) matches that of the A8 flagship. Audi is going new ways there, as well, under the motto of electric mobility planning. Because electric powered cars still cannot match the range of combustion engines, Audi is working on information concepts that will offer the driver optimal planning capability.

The imagination knows virtually no limits when it comes to the future interaction between driver and vehicle. Examples include individual computation of range for each driver, computation of fuel consumption for different classes of roads, checking the battery charge status from outside the vehicle using a smartphone, for instance. The connection of the car to
the grid also opens the door to new comfort and safety features, such as bringing the cabin to a preset temperature before setting off.

**More than 400 specialists are currently working in the field of electric mobility at Audi.**

At Audi, the future has already begun. At present over 400 specialists at the company’s Technical Development division are working in the field of electric mobility with the support of several hundred colleagues from the widest variety of fields.

At the same time, a strategic bundling of activities is taking place. To this end, Audi has established the e-performance project house for electric driving. In addition, a team of Audi development engineers and scientists from a variety of universities, research institutions and startup companies have been working since fall 2009 on the development of a new total concept, from the body to the battery to the power electronics. This is part of the e-performance research project sponsored by the German Federal Ministry of Education and Research.

A number of substantial challenges still remain to be solved, in particular with regard to battery technology. Since the introduction of lithium-ion batteries for vehicle applications, “development has made huge strides in power density,” says Dietrich Engelhart. But a range of 250 kilometers still means 10 hours of charging time on the residential power grid. By contrast, filling up at the fuel pump takes just a few minutes.

So there is still a lot to do. Given diminishing resources and the debate about climate change, the development is unstoppable and there also seems to be no turning back.

“We don’t know today how long the petroleum reserves will last,” says Stefan Keller, “but we do know one thing: They are finite.”

**THOMAS AMMANN**

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**Design study**

A sketch of the Audi e-tron Spyder: The open-top two-seater features the most advanced and simultaneously the most consistent evolution of the current Audi design language, and provides initial hints at the design of future Audi sports cars.

**Silvretta cockpit**

The display with integrated functions of the Multi Media Interface (MMI) indicates the battery charge status. The round power meter to the left shows the overall output of the system and the respective operating states.

**Interior**

Visual and functional references to the fundamental concept of lightweight construction characterize the design of the Audi e-tron Spyder – flowing transitions between exterior and interior which produce a formal unit.